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Erratum

Unfortunately, when publishing his testimonials, the *Otago Daily Times* (23 February 1871, p. 3) erred in giving Professor Black's full name as John Gow Black. I inadvertently replicated this error. His actual name, was James Gow Black.
Soil Fertility Management in Nineteenth Century New Zealand Agriculture

Gareth Vaughan Wood

A thesis submitted for the degree of
Doctor of Philosophy
of the University of Otago, Dunedin,
New Zealand.

2003
Abstract

This research examined the practice of soil fertility management, and the rationale behind it, in 19th century New Zealand agriculture, with particular attention being paid to agriculture in Canterbury and Otago. This entailed the description of both the existing soil environment, and perhaps more importantly European perceptions of that environment, and then an exploration of fertiliser usage relative to the agricultural history of local areas, with the aim being to determine whether fertiliser use (or non-use) was respondent to environmental or economic conditions, or even behavioural transfer (in the case of immigrants). To this end, agricultural journals (and prior to that, agricultural reports in newspapers) were examined exhaustively, and this was complemented by the examination of relevant material in contemporary and secondary literature (including statistical indices such as produce prices). The relationship between European agricultural and indigenous Maori cultivation practices, and in particular, the latter's non-use of manure, was explored. The research has indicated that in general the balance between produce prices and land and labour costs determined levels of fertiliser use, although environmental factors, such as natural level of soil fertility and climate, were responsible for regional variations. The most notable of these variations was the high rate of fertiliser use around Auckland in the mid-1850s and early 1860s, caused by the predominance of poor soils. Another important finding was the way in which the construction and deconstruction of the 'biometric fallacy' - the idea that the luxuriance and height of vegetation was proportional to the fertility of the soil - led to temporal changes in the desirability of areas for agricultural settlement. This thesis therefore adds an important environmental dimension to previous economics-based explanations of soil fertility management practice in New Zealand.
Preface

This thesis has had a long and tortuous gestation. My interest in soils was awakened after attending a lecture by Professor E. M. Bridges in 1990 and this became more compelling after I had taken a course in soil science. The choice of this topic provided me with the opportunity to harness the combined knowledge accumulated while completing degrees in Chemistry, History and Geography.

In the undertaking of this thesis, I wish to recognise firstly the University of Otago for its financial support, and more especially, the supervision of Associate Professor Tom Brooking (History, University of Otago) and Dr Peter Perry (Reader in Geography, University of Canterbury). Special mention should also go to Associate Professor Judy Bennett, who provided supervision while Associate Professor Brooking was on leave, and to Professor Helen Leach and Dr Garth Cant, who commented on drafts of chapters. I also wish to acknowledge the technical advice I received from academics in several fields beyond my immediate areas of expertise, such as soil science and botany, during the course of the thesis. Foremost amongst these were Drs John Adams, Henry Connor, Ray Hargreaves, Professor Peter Holland, and Emeritus Professors T. W. Walker and Kevin O'Connor.

I would also like to thank Marney Brosnan (Geography, University of Canterbury) for help preparing illustrations, plus the library staff of the University of Canterbury Geography Department, Hocken, Macmillan Brown, Alexander Turnbull and National Libraries, museum staff of the Canterbury, Taranaki and Otago Early Settlers Museums, and archivists of National Archives Head Office, and Dunedin City Council.

Nor can I fail to acknowledge the support of the friends and colleagues who aided me in this work through a protacted period of ill health. In particular, I wish to mention Vernon Whybrow, James Beattie, Shaun Broadley, Geoff Vincent, Toby Harfield and Elliot Campbell.

My final thanks goes to medical and nursing staff of the Oncology Department and Ward 27 of Christchurch Public Hospital, and my parents and sister, without whose efforts this thesis would never have been completed.
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Where 'ibid.' is used as the primary reference in an endnote, it refers to the previous endnote.

If it is a secondary, tertiary etc. reference (normally in brackets) it refers to the last reference in the same endnote.

Maori words in common NZ usage

The following may need translation for non-New Zealand readers.

- *haka* ceremonial dance
- *iwi* tribe
- *pa* fortified settlement
- *tapu* sacred (hence 'taboo')
Location Map No. 1.
New Zealand settlement and physiographic regions c. 1850.


Readers should be aware of the following name changes which occurred after this maps' printing. In this thesis the modern versions are used.

Middle Island => South Island
South Island => Stewart Island
Petre => Wanganui
Molyneux [River] => Clutha River
Lyttelton => Christchurch
& Port Victoria => Lyttelton

Location Map No. 2.
New Zealands towns & localities, and land transport networks c.1880


Dashed lines indicate railways, undashed lines roads and tracks.
Location Map One

MAP OF NEW ZEALAND

English Mkr: 12.4 degrees

[Map of New Zealand with labels and locations marked]
Introduction

The popular image of New Zealand farming is that it is primarily pastoral. This has been valid during the twentieth century, but it is less so when one considers the nineteenth century. During the initial phase of European colonisation, agriculture - which in this thesis is taken to mean the raising of field crops - was a major economic component of the farming sector throughout New Zealand, and during the latter half of the nineteenth century it continued to be so in Canterbury and Otago. In 1872, for instance, an article in the Otago Daily Times valued the annual worth of the output of field crops, not including artificial pasturage, at approximately £900,000, while the author estimated the wool clip to be worth £2 million.\(^1\) As this thesis shows, this degree of importance was no accident. In the colonisation schemes crafted by Wakefield and others, New Zealand was envisaged as producing grain for not only its own needs but Australia's too. Agriculture also proved pivotal in environmental change, as during the nineteenth century farmers usually employed cropping in the transition from natural vegetation cover to introduced grasses, in the hope that the profits from a few years cropping would cover the financial burden of establishing new pasture. This practice occurred on a massive scale in the South Island, and it was also followed in the North Island, albeit to a much lesser extent. In the latter, inroads into the 'bush', and equally, the acquisition of Maori land, occurred fairly slowly during the nineteenth century. When the attack on both began in earnest at the end of the century, prompted by the improved opportunities for stock-rearing and dairying which resulted from refrigeration, farmers replaced this approach with a 'bush-burn' one, in which they sowed introduced grasses directly on the residual ash.\(^2\)

The overwhelming influence of pastoralism in modern times has also distorted the history of soil fertility management in New Zealand. Its consideration in a historical context has generally been confined to discussions of the 'grasslands revolution', and the celebrated close connection between superphosphate application and pasture improvement.\(^3\) The nineteenth century, and particularly the years before 1882, when the inception of frozen meat exports and local superphosphate manufacture started New Zealand on its pastoral farming and topdressing path, has been seen as being of no consequence, a *historia nullius*, so to speak. Yet the prominence of agriculture prior to 1882 poses the question of how farmers managed the fertility of their soil during this period. After all, the fertility demands placed on the soil by agriculture, whether in an
arable or mixed farming context, are more immediate than those of animal husbandry on uncultivated permanent pasture. There are also differences in the nature of those demands. In cropping, nitrogen losses are a major concern, but as organic matter tends to build under uncultivated permanent pasture, managing levels of mineral nutrients is often more significant for animal husbandry operations. Having said this, deficiencies in trace elements are not discussed in this thesis, as they were not identified in New Zealand until the twentieth century.

In a global context, nineteenth century New Zealand provides an interesting case study in the history of soil fertility management. One obvious point of difference from the regions where the history of soil fertility management has been most extensively studied - Western Europe and the northeastern United States - was that Western agriculture in nineteenth century New Zealand was entirely new. This meant that settlers coming to New Zealand did not have to fit into an existing farming pattern, but could start afresh, and thus they could resume or modify whichever practices from farming 'at home' (which generally meant Great Britain) seemed appropriate. This was not as simple as it sounds. Firstly, soil fertility management practices in the 1840s, the very time when colonists were starting to arrive in New Zealand in large numbers, were in a state of flux. The writings of agricultural chemists, such as Liebig, were transforming its theoretical underpinnings, and farmers were also being exposed to both the potential benefits and pitfalls of 'artificial' (that is, commercial) fertiliser use by the widespread introduction of guano. Secondly, there was the question of deciding what was 'appropriate' in a completely alien environment. Because of the very limited nature of Western agricultural experience in New Zealand prior to organised colonisation, new colonists had a long period of environmental learning ahead of them. In particular, the absence of any means for directly measuring the natural level of soil fertility made it difficult for farmers to form a correct judgement of it. This difficulty enabled, first, the construction, and second, the survival, of what I have termed the 'biometric fallacy' - the inference that lush vegetation meant rich soils - during the early period of colonisation.

Broadly speaking, this thesis has aimed to answer two related questions pertaining to soil fertility management. The first question is one of identification - in short, how are agriculturists, at any given place or time, attempting to manage soil fertility? This involves establishing whether they are using manure or 'artificial' (commercial) fertiliser, the type of cropping system they are using, how long their land has been in cultivation etc. Once the various soil fertility management regimes have been identified, the focus has then switched to analysis
- why have agriculturists opted, at a given time and place, to use particular soil fertility management regimes? This may involve a whole range of factors, such as the fertility of the soil, the cost of farm labour, the availability of fresh soil, the availability of manure, the financial returns from individual and sequences of crops, and the past experience (if they had any) and theoretical perceptions of the farmer. The purpose of the analysis has been to identify when and where certain factors have been pre-eminent.

I. Historiography

To date, soil fertility management has generally received only indirect attention from the historian of colonial New Zealand. If it is raised at all, it has normally been in connection with early agricultural operations in the various settlements. Two prime examples of this are Ray Hargreaves' article on farming in Taranaki before 1850, and Brad Patterson's paper on the breakdown of Wakefield's grain growing vision in Wellington in the 1840s. Harold Whitwell's thesis, which describes the operation of the 'Forty Acre' settlers scheme in North Auckland, also gives useful insights into new settlers' management practices on poorer soils. A related issue which appears in the literature is the role of soil fertility perceptions in determining the spatial pattern of agricultural development. The best published example of this kind is Garth Cant's article on the agricultural frontier in Canterbury between 1850 and 1875. Amongst theses, those of J. W. Lee on land appraisal in Canterbury up to 1853 and I. C. Bush on the settlement history of the Karaka parish also stand out. The work of Judith Johnston, who documented the excessively sanguine portrayal of soil fertility in New Zealand, and at the same time, the initial preference of settlers for wooded land, is also worth noting. Johnston erred, however, in asserting that this portrayal lacked areal differentiation. As Chapter Four shows, this had ceased to be the case by 1842.

Most historical comment on agricultural practices does not look past the first decade or so of settlement though. Atypically, farming practices in Canterbury have been examined in greater depth, by works such as the abovementioned paper by Cant, and P. R. Stephens' excellent articles on the first century of Canterbury farming, and by numerous theses, such as Terry Hearn's on nineteenth century South Canterbury agriculture. Even so, most of these theses concentrate on the post-1882 period. For other regions, however, one is often reliant on Hargreaves' Ph.D. thesis on farming in New Zealand before 1882.
and general accounts of New Zealand farming history, such as B. L. Evans' *History of Agricultural Production and Marketing in New Zealand* (1969),\(^{14}\) together with agricultural snippets from local and regional histories. Nevertheless, some material on later agricultural practices in these other regions, most notably Anthony Lynch's thesis on farming in the Lower Clutha,\(^{15}\) has included discussions on manuring and crop rotations which have proved valuable.

There is even less literature on Maori agriculture during the post-colonial period. This is unfortunate, because, as Chapters Five and Six demonstrate, Maori farmers provided a large proportion of agricultural produce at the various settlements until at least the mid-1850s. Of the secondary sources that exist on Maori agriculture during the nineteenth century, the best general accounts are in a series of articles written by Ray Hargreaves in the *Journal of the Polynesian Society*,\(^{16}\) and in Helen Leach's *1,000 Years of Gardening in New Zealand* (1984).\(^{17}\) Some theses, such as B. G. Quin's on Taranaki before 1860, and K. R. Howe's on the missionary John Morgan's activities at Otawhao, also contain detailed discussions of the transition to Western-style agriculture.\(^{18}\) Given that Maori cultivators steadfastly rejected manuring, on cultural grounds, during the nineteenth century, this paucity of literature is not as serious an impediment as it might have been. However, recent work by Paul Monin hints that excessive cultivation of European crops had begun to exhaust some Maori land.\(^{19}\) More evidence of how they modified traditional practices for restoring soil fertility, such as fallowing, to take account of this development would therefore be desirable. Ironically, the soil management practices employed by Maori before Europeans arrived have been subjected to much more scrutiny.\(^{20}\) This interest has arisen because the subtropical staples possessed by Maori cultivators were ill-suited to New Zealand's temperate climate, and thus the practices they adopted to maximise productivity were critical to the survival of settlement.

The historiography concerning 'artificial' fertilisers in New Zealand during the nineteenth century, meanwhile, is of mixed utility. The best secondary source, in terms of content relevant to this thesis, is Alan Smith's little known thesis on the New Zealand phosphate trade between 1855 and 1870.\(^{21}\) Although this does not go into great depth into the impact of 'artificial' fertiliser use, it contains invaluable information on leading fertiliser importers, especially the Auckland firm of Combes and Daldy, as well as discussing the way in which suppliers promoted fertilisers to farmers. J. S. Dennison's thesis on chemical industry in Otago before 1914 and Alan Bellamy's *BOP First in Fertiliser* (1991) are also useful in providing the historical context for the establishment of the superphosphate
industry in the Otago and Auckland regions respectively. The historic role of fertilisers in soil fertility management in New Zealand is discussed at some length by D. B. Tennant in his Ph. D. thesis on 'soil-amending technology' and the grassland farming economy in New Zealand, but for the nineteenth century Tennant relies mainly on Hargreaves' aforementioned Ph. D. An added deficiency of Tennant's thesis is the lack of attention he gives environmental conditions when analysing fertiliser use. Hargreaves, meanwhile, does base his comments on primary sources, but given the wide scope of his thesis, he has not been able to do more than make general statements, supported by representative examples. The main points made by Hargreaves are that gradually settlers discerned that New Zealand soils were not as fertile as originally thought, and in turn realised that they needed to manure them to maintain fertility levels. Even so, Hargreaves found that most settlers chose not to adopt crop rotations because there was a market for only a limited number of agricultural commodities, and they had the security of good yields, together with supplies of undeveloped land to move to later. Given its title, Lance McCaskill's thesis, 'Fertilizers in New Zealand, 1867-1929', should have been especially relevant to this thesis, but McCaskill's focus was very much on the immediate rather than distant past - hence his erroneous finding that artificial fertilisers were first imported in 1867, when in fact an import trade was underway more than a decade earlier. Unfortunately A. N. Tait's 1957 article on the historical growth of fertiliser use suffers from the same present-centredness.

Internationally, there is a far larger literature on the history of soil fertility management, with the most heavily studied area being the changes associated with the 'agricultural revolution', central to which was the increase in nitrogen supply to grain-bearing fields. This was made possible by the shift, from cropping interspersed by fallows, to either crop rotation and/or ley farming. In recent times, there has been an increasing emphasis on quantifying the effects of these changes in farm management, with a notable example of this being Mark Overton's Agricultural Revolution in England (1996). Some researchers, amongst them Chorley and Shiel, have also constructed budgets of nitrogen inputs. Consequently, a much fuller picture about the contribution of soil fertility management to rising productivity during the 'agricultural revolution' is now emerging. Unfortunately for this thesis, most of these studies conclude at the start of the nineteenth century. Since, until the mid-nineteenth century, nitrogen was the nutrient that most limited crop production, these studies naturally focus on it, and pay little attention to other nutrients such as phosphorus and potassium. As a result they do not much shed much light on the impact of widespread 'artificial'
fertiliser use on crop production after 1840. Moreover, the only quantatative fertiliser use data in the better known studies of nineteenth century British agriculture to date have been estimates of aggregate amounts used, so that in assessing their significance to individual farmers one must rely on the attitudinal evidence collected in publications such as W. M. Mathew's article on the Peruvian guano trade.

Like their British counterparts, American historians have also paid considerable attention to soil fertility management. This seems to have been initially inspired by the grave soil exhaustion problems experienced in some of the Atlantic coast states. Indeed, Avery Craven's *Soil Exhaustion as a factor in the agricultural history of Virginia and Maryland* was published as long ago as 1926. The Dustbowl also acted as a reminder of the importance of soil management. Of all the international literature, Richard Wines' *Fertilizer in America: from waste recycling to resource exploitation* (1985) is perhaps the most similar in scope to this thesis, in that it also described the evolution in methods for maintaining soil fertility during the nineteenth century. Moreover, Wines tried to not only explain changes in economic terms, but also to use environmental factors to explain spatial variations in fertility management practice, as this thesis has done. Overall, Wines found a progression over time from small-scale use of local wastes by farmers through to large-scale use of 'artificial' fertilisers. Another American study which has been valuable for comparative purposes is Margaret Rossiter's *The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840-1880* (1975). This study found that American farmers responded enthusiastically to Liebig's ideas in the 1840s, but scepticism developed when these were found to be too simplistic for practical application. Their faith in agricultural chemistry was not restored until the 1870s, when the establishment of experimental farms allowed them to see practical benefits of it firsthand. Another American work of note is the United States Department of Agriculture and Tennessee Valley Authority's collaborative volume *Superphosphate: its history, chemistry and manufacture* (1964). This includes two chapters by K. D. Jacob, which review the international usage of bone-dust and guano prior to superphosphate manufacture, followed by the early history of superphosphate.

In theory, Australian literature relating to soil management practices should be more relevant than British or American accounts. After all, the settlers who came to Australia during the 19th century had a similar cultural background to those who came to New Zealand, and the farming economies of the two were
both based on a mixture of agriculture and pastoralism, with the key export being wool which was sent 'home' to Great Britain. However, the gaps in the historiography of soil fertility management in Australia are just as large as those in the New Zealand literature. This is regrettable because, as this thesis reveals, developments in Australia often drove the course of agricultural operations and soil fertility management in New Zealand. Admittedly, the significance of soil fertility and perceptions of soil fertility to patterns of agricultural settlement has been well addressed by many authors, but discussions of soil fertility management practice in the nineteenth century following settlement tend to be much briefer. This is probably because Australian farmers were just as conservative with their use of manures as their New Zealand counterparts. By way of example, in Russell and Isbell's *Australian Soils: the human impact* (1986), the chapter on fertilisers by McGarity and Storrier, which is fairly ahistorical in any case, devotes only about a paragraph to the nineteenth century. To date, perhaps the best treatments of nineteenth century practices are those found in Edgars Dunsdorf's *The Australian Wheat-Growing Industry, 1788-1948* (1956), Michael Williams' *The Making of the South Australian Landscape* (1974), and Barr and Cary's *Greening a Brown Land* (1992).

II. Methodology and sources

As set out above, this study aims to describe the evolution of soil fertility management practice, and then to analyse the factors that shaped it. These may be loosely grouped into philosophical, economic, and environmental factors. By philosophical factors, what is meant is understandings arrived at by farmers, which are independent of their current environmental or economic situation, but which are instead derived from the mass of knowledge and customs surrounding soil fertility management practice built up in previous times, together with new insights gained through scientific discovery. In cases of unbroken longitudinal evolution, philosophical factors are generally less significant, since the inherited traditions associated with soil fertility management will be very much a product of past economic and environmental circumstances, but this study begins with an evolutionary discontinuity. Pakeha farmers were importing their soil fertility management heritage into a new environment, while their Maori counterparts found themselves confronted by a new economy.

Generally, a thesis of this type would begin by describing the state from which change is being measured. Because of the abovementioned discontinuity
there is no single starting point, but instead there is the cultural inheritance of both Maori and Pakeha to consider. Accordingly, the first step in this thesis was to explore the traditional soil management practices of pre-contact Maori cultivators, and likewise those of Western European, and more especially British, farmers, prior to the nineteenth century. In the case of pre-contact Maori agriculture, the historian is compelled to rely on archaeological and ethnographic literature, because traditional Maori culture was an oral one, that is, there was no written form of the Maori language prior to European settlement. Secondary sources were used on Western European soil fertility management practices as well, since these practices are so fully discussed in writings on the 'agricultural revolution'.

Once the nature of the two cultural 'inheritances' had been established, the next step was to ascertain the environmental context of soil fertility management practice. This had two dimensions to it, the first being the real environment, and the second being the perceived environment, which informed settlers' decision-making. Since Maori farmers had several centuries of local observation and experience in the New Zealand environment, their perception of the environment, in terms of soil fertility, became fairly accurate. This understanding, moreover, was built into their cultural inheritance. Consequently, where Maori farmers had to develop their knowledge, was in the requirements of introduced European crops. For Pakeha, meanwhile, there was a long period of environmental learning ahead, which began as soon as European explorers arrived in New Zealand. Since early perceptions were going to influence the initial approaches adopted by farmers to managing soil fertility, a large number of accounts written by explorers, traders, missionaries, and later, surveyors, were scrutinised to discern the impressions that had been formed about the environment in general, and the fertility levels of New Zealand soils in particular. As explained in Chapters Three and Four, many of these accounts are biased in some way, but because this bias itself feeds into environmental perception, this does not disqualify them from consideration. To avoid the danger that the views expressed in individual accounts were not representative, this thesis has examined a large proportion of the extent literature. As the views were generally common to a number of accounts, this suggests that they were widely held at the time.

The real environment came into play, in terms of influencing soil fertility management practices, once crops had been sown, since farmers could then reassess their environmental perceptions on the basis of crop performance. Fortunately, the importance of farming in New Zealand's economic development
has led to soil science being actively pursued, and thus many geographic areas of interest to this thesis have had their soils mapped and the physical and chemical properties of those soils characterised in considerable detail. By consulting these more specific soil surveys and maps, it has often been possible to see why particular soil fertility management practices, such as the use of phosphatic fertilisers on lands north of Auckland, should have had the results they did. These modern soil surveys also provide a point of reference against which to judge the environmental perceptions of the time, such as assessments of which soils were best suited to agriculture.

The next task undertaken in this thesis was to identify what soil fertility management practices were being employed. A wide variety of primary sources were studied, with the relative composition of those sources changing over time. During the 1840s, published settler correspondence provided examples of farming practices on individual farms, while handbooks and other texts intended for immigrants often gave more general observations on agricultural practices. Admittedly, these sources are likely to show agricultural operations in the best possible light, as they were usually published with the intention of attracting more immigrants. A less biased source are the numerous colonial newspapers, which printed the proceedings of agricultural societies, as well as giving local commentaries on agriculture, many of which discussed methods of conserving soil fertility.

In the 1850s, much less settler correspondence was published, and not so many texts were written on New Zealand either. However, because avid immigration promotion had largely run its course, what was published tended to be more objective. Generally, therefore, detail on soil fertility management must be compiled from newspaper comment. Regrettably, these reports tend to give less coverage to agricultural business during this decade, owing to their increasing focus on local political issues. Occasionally, individual farm diaries were consulted, but only when clarification was needed. As seen in Chapter Seven, fertiliser imports into New Zealand commenced in the 1850s, and consequently advertisements in the major newspapers were checked monthly from then on for evidence of imports. If advertisements were found, shipping lists were then examined in order to ascertain the quantity imported. With this information, and a knowledge of likely fertiliser application rates, which were occasionally mentioned in newspaper articles, it was possible to estimate the extent of fertiliser use. Unfortunately, no comparable application rates of farmyard manure were ever given. The officially compiled Statistics of New Zealand were also of some
help in identifying guano imports, but the returns in the custom entries were not always reliable. The reason for this lax collection was that after 1856 guano attracted no import duty, and thus imports had no fiscal significance.

Newspapers were also the main source of information on soil fertility management during the 1860s and 1870s. During these decades a greater amount of agricultural content was ensured because of the production of weekly newspapers specifically for rural readers. Harvest reports were particularly useful, in that they normally commented on yields in relation to the agricultural practices of the district. Still further commentary, albeit not in reference to any particular regions, can be found in the locally produced agricultural texts which began to emerge from the 1860s onwards. Finally, a considerable amount of material, specifically on soil fertility management, can be found in the *New Zealand Country Journal*, which first appeared in 1877, thereby making it New Zealand's first agricultural periodical. This was published by the Canterbury Agricultural and Pastoral Association, which, as Chapter Twelve reveals, was concerned about the possibility of soil exhaustion in Canterbury due to the rapid extension of wheat cultivation at the time.

In addition to these essentially qualitative accounts, another window on agricultural practices was agricultural statistics. Between 1840 and 1852, acreages and estimated yields for the main crops were recorded annually for the main settlements, and from 1868 central government collected the same data annually for each electoral district (or county from 1876). Between 1853 and 1867, acreages were normally collected with either provincial or general census returns, that is, about once every three years. Few yield estimates exist for this middle period, as some provincial governments, such as Wellington's, never recorded estimates, although others such as Otago's conscientiously recorded them every one or two years. With such a pool of data, it may be asked what purpose was served by searching through newspapers for occasional references to managing soil fertility? In answering this query, it should be borne in mind that mere crop acreages do not always give a clear indication of agricultural practices. A decline in the wheat acreage may be caused, for instance, by anticipations of a low price for wheat relative to pastoral commodities, or a cold and wet winter stopping farmers from ploughing in time to sow spring wheat, or farmers deciding that their land is exhausted and needs a rest from wheat. All three scenarios may have broadly similar outcomes as far as the crop acreages go - less land in wheat and more land in sown grass - but soil fertility management is directly responsible for only one scenario. Likewise, the recorded yield estimates were not necessarily
accurate. As the *Otago Daily Times* reflected in 1869, no farmer could for certain state the size of their crop until it had been threshed and measured out, and "inexperience, a sanguine temperament, and the vanity that so often leads men to over-estimate" meant that individual returns would always be unreliable. A particularly bad case of aggregate overestimation occurred in 1878, when the official yield estimate for the harvest in Canterbury was 23 bushels per acre, but after threshing it was found to be just 18 bushels per acre. Such errors render the yield data unsuitable for detailed statistical analysis, although they are still useful for showing trends over time, assuming that the 'estimation errors' are reasonably consistent across all years.

While describing soil fertility management approaches, attention has also been paid to changes in economic factors which may affect the approach taken. Many of these economic factors, such as the financial return for crops, and the cost of farm labour, are highly dynamic, as opposed to environmental conditions, which are relatively stable without active human intervention. Consequently, the economic context had to be continually revisited through examination of newspapers, and crop and livestock prices in the officially compiled *Statistics for New Zealand*. Unfortunately, the basis for these figures was not accurately defined, and thus an alternative set of prices, contained in J. W. McIlraith's *The course of prices in New Zealand* (1911) was used in relation to Canterbury after the 1860s. Similar market indices also received considerable attention in the *New Zealand Country Journal*. The price of 'artificial' fertilisers, which obviously effects their use, has also been determined with reasonable accuracy using newspaper advertisements.

Periodically, changes in the philosophical and environmental context have also requiring addressing. It has been necessary, for example, to be alert for newspaper comment, supported by agricultural statistics, on the extent of soil exhaustion, since as a soil becomes worn out, the potential benefits of fertilising it increase. Likewise, modifications in philosophical context, such as changes in agricultural chemistry theory, have also had the potential to affect soil fertility management practice. A notable example of this type of modification was the partial reversal in the reputation of Peruvian guano. Although it was highly prized in the 1840s, by the 1860s it was believed that it sped up soil exhaustion unless used in conjunction with phosphate-rich fertilisers. In order to keep abreast of external intellectual developments, foreign texts such as Justus Liebig's *Familiar Letters on Chemistry* (1845) and J. C. Morton's *Cyclopaedia of Agriculture* (1855) were studied, as were numerous papers in the *Journal of the Royal*
Agricultural Society of England. Secondary literature, such as that produced by E. J. Russell and Nicholas Goddard, also contributed to this task. To ascertain the most important factors in determining the approach to managing soil fertility, contemporary comment has served as an important guide. However, through careful tracing of changes in soil fertility management practices, it has been possible to make inferences as to the basis for them, even in the absence of contemporary comment. Because of New Zealand's small size, generally economic conditions were fairly similar across all Pakeha settlements in the periods under discussion. The only significant exception to this was during the 1850s when Otago and Canterbury were in 'catch up mode' as far as their economic development went, because of the long lag in the establishment of these settlements. Conversely, there are some significant environmental differences between the main settlements. Accordingly, if the same change is observed in all the other developmentally-equivalent settlements, such as a surge in fertiliser importing, it may be inferred that an economic factor is responsible. One then needs to establish what economic factor or factors have changed, and have thereby prompted this alteration in practices. Alternatively, if soil fertility management practices diverge between settlements, it may be assumed that an environmental factor is responsible. Potentially, spatial divergence could also arise from differences in cultural 'inheritance' - this would be most conspicuous immediately after the arrival of new migrants, because then the 'inheritance' would be freshest in their minds.

III. Framework

The basic structure of this thesis consists of four parts. The first part is concerned with the cultural 'inheritance' of Maori and Pakeha, as it relates to soil fertility management practice, and comprises Chapters One and Two. Chapter One is an exploration of Maori soil management practices in the pre-contact period, while Chapter Two examines those practices employed in Western Europe at the time of the 'agricultural revolution'. In the second part, meanwhile, the European/Pakeha perception of New Zealand soils and their fertility is the focus. Chapter Three considers the development of the 'biometric fallacy', and its influence on the initial course of land settlement and agricultural development, whereas Chapter Four examines the breakdown of the 'biometric fallacy' during the 1840s, and the efforts to establish alternative models for assessing soil fertility.
At this point the thesis changes its emphasis from theory to practice. In the third part of the thesis the concentration is on the North Island settlements and Nelson - areas in which agriculture died away after the early 1860s. Chapter Five is the first chapter of four component chapters, and it examines the failure of missionary farmers to adapt to the new environment, and equally, the failure of Maori farmers to adapt to the new economy. Chapter Six is the first to consider soil fertility management practices in the colonial settlements of Wellington, New Plymouth, Nelson, and Auckland. The period studied in this chapter is the 1840s. Chapters Seven and Eight examine the changes in practices in these settlements in the 1850s, with Auckland being dealt with on its own in Chapter Eight on account of its peculiar environmental conditions, which encouraged a high level of 'artificial' fertiliser use. Because 'artificial' fertilisers were introduced into all these settlements during the 1850s, there is a section on the place of 'artificial' fertilisers in Western farming in the mid-nineteenth century at the beginning of Chapter Seven.

The fourth and final part of this thesis is concerned with soil fertility management practices in Otago and Canterbury from the time of their establishment at the close of the 1840s, up until the early 1880s. These two settlements have been treated separately from the rest, firstly because of their delayed establishment relative to the other main Pakeha settlements, and secondly because New Zealand agriculture was concentrated in these two provinces from the 1860s onwards. In Chapter Nine, agricultural practices in the first decade of settlement, that is, the 1850s, have been examined, while Chapter Ten considers the period 1860-68, when agriculture developed rapidly in response to the Otago gold-rushes. Chapter Eleven, meanwhile, considers the changes in soil fertility management in the tumultuous years following the saturation of the Australasian wheat market, and the gradual emergence of mixed farming up until 1876. Finally in Chapter Twelve, the effects of the first phase of 'bonanza wheat' farming are investigated, and this is followed by a discussion on how future soil fertility management was altered by the commencement of frozen meat export and local superphosphate production in 1882.
Notes to the Introduction

1 Otago Daily Times, 23 September 1872, p. 2.
3 See, for example, Evans, B. L., A History of Agricultural Marketing and Production in New Zealand (Palmerston North, 1969); Smallfield, P. W., The Grasslands Revolution in New Zealand (Auckland, 1970).
5 The most notable case of trace element deficiency in New Zealand farming was the so-called 'bush sickness'. Its cause, cobalt deficiency, was not identified until the mid-1930s (See Clare, Norman T., 'The Bush-Sickness Saga'. In Hogan, Denis, and Williamsen, Bryce (eds.), New Zealand is different: chemical milestones in New Zealand history (Christchurch, 1999), pp. 53-61.
12 Hearn, T. J., 'South Canterbury. Some aspects of the historical geography of agriculture (Unpublished M. A. thesis, University of Otago, 1971). Two of the other notable theses which discuss later agricultural practices in Canterbury are Heller, Charles Frederick, Jnr.,


17 Leach, H. M., *1,000 Years of Gardening in New Zealand* (Wellington, 1984).


31 Amongst the responses to the Dustbowl was the 1232 page United States Department of Agriculture Yearbook Soils and Men, which examined the reasons for recent soil abuse by American farmers, and also gave a summarised the current state of agricultural chemistry.


33 Rossiter, Margaret W., The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840-1880 (New Haven, 1975).

34 Jacob, K. D., 'Predecessors of Superphosphate', & 'History and Status of the Superphosphate Industry'. In United States Department of Agriculture / Tennessee Valley Authority, Superphosphate: its history, chemistry and manufacture (Washington, D. C.,
17


37 Although some changes in soil properties since settlement began is inevitable, it should be noted that modern soil surveys have endeavoured to analyse soils which are more or less in their natural state.

38 Whereas guano imports in Nelson and Wellington, for example, are recorded for the 1854-6 period, the corresponding import table for Auckland does not have a guano category, even though its imports were much larger (Statistics of New Zealand for 1853, 1854, 1855, and 1856, compiled from official records (Auckland, 1858), Tables 8, 22 & 24.

39 Otago Daily Times, 6 October 1869, p. 2.


41 McIlraith, J. W., The course of prices in New Zealand: an enquiry into the nature and causes of the variations in the standard value in New Zealand, with an introduction by James Hight (Wellington, 1911).

The categories used in these maps are soil groups as defined according to the New Zealand Genetic Soil Classification (see Appendix One). The main features of this distribution are the prevalence of soils derived from volcanic parent material in the northern and central north Island, and the leaching gradient (from highly leached soils in the west to weakly leached soils in the sheltered east) in the South Island and southern North Island.
Figure 1.1 a

SOILS OF NEW ZEALAND

Yellow-grey earths
Central yellow-brown earths
Northern yellow-brown earths
Northern podzols
Yellow-brown sands
Yellow-brown pumice soils
Yellow-brown loams
Red-brown loams
Recent, gley, and organic soils

Auckland
New Plymouth
Palmerston North
Wellington
Napier

NORTH ISLAND

36° S
40° S

20 40 60 80 100 Miles
Figure 1.1b

SOILS OF NEW ZEALAND

Brown-grey earths
Yellow-grey earths
Southern and high-country yellow-brown earths
Podzols and podzolized soils
Brown loams
Recent, gley, and organic soils
Alpine soils, etc.

SOULS OF
NEW ZEALAND

SOUTH ISLAND
Chapter One

Breaking New Ground: Maori soil management practices during the pre-contact period

Of all the Polynesian migrations, the Maori settlement of New Zealand was one of the most challenging from a purely environmental standpoint, because it, and the Moriori settlement of the Chatham Islands, were the only instances where Polynesians settled permanently outside their tropical and subtropical habitat. Consequently, Maori faced the problem of how to sustain tropical agriculture systems in a temperate environment. This impediment not only required the Maori to be careful observers of the soil, but also drove them to become active practitioners of soil management techniques.

In terms of choosing the most appropriate soils for the crops that survived the transition (the most notable of which were the kumara (Ipomoea batatas), taro (Colocasia esculenta), gourd (Lagenaria siceraria), and yam (Dioscorea spp.)) the physical attributes of the soil, rather than the level of chemical fertility, proved the most important factor. Kumara, taro, and yams are relatively tolerant of low fertility soils, but are not tolerant of frosts. Kumara had to be over-wintered in storage, as temperatures below 5°C could kill off the tuber, while taro and yam plants could survive only light frosts, and they grew extremely slowly. To maximise the growing season for the kumara, which matured in five months, as opposed to the taro and yam which took seven and eight months respectively, Maori cultivators desired soils which warmed up quickly following winter. Consequently free-draining soils were the most prized. Equally, kumara growth required soils that were friable. This was also necessary from a tillage viewpoint, as Maori agriculturists used only wooden agricultural implements.

Many New Zealand soils (the distribution of which are depicted in Figure 1.1) do not have these characteristics, and thus were unsuitable for traditional Maori agriculture. In the case of the yellow-brown earths (a group which incorporates the vast majority of New Zealand soils not volcanic in origin), those in the south are too cold. In the north, they are warm enough for kumara growing, and the increased weathering produces higher levels of clay content, and hence enlarged storage of plant-available nutrients (because of the clay particles' high surface area-to-volume ratio), but the clays also make the soil heavy and sticky once cultivated. The podzols of superhumid environments, meanwhile, are too heavily leached to provide required levels of plant nutrients, while conversely in
warm subhumid areas such as Hawke's Bay and Marlborough, drought often afflicts the yellow-grey earths during the growing season. 

Most soils of volcanic origin were more suitable for Maori agriculture. In Northland and on the Tamaki isthmus, relatively high population densities were able to be supported on areas of young red and brown loams. Perhaps the best known of these was the Taiamai Plains. Like northern yellow-brown earths, the red and brown loams have a high clay content, but when cultivated they retain their structure (and hence good drainage and friability) because they contain large quantities of iron and aluminium oxides, derived from their basaltic parent material, which interconnect clay particles. Further south, extensive cultivation also took place on volcanic soils in the Waikato and western Taranaki, where the immature development of young yellow-brown loams provides friable soils with moderate levels of fertility, and in the Bay of Plenty, which possesses a mixture of yellow-brown loams, and their coarser counterparts, the yellow-brown pumice soils. The yellow-brown pumice soils are also found on the Volcanic Plateau, where geothermal heating enabled their cultivation around Rotorua and Taupo, which otherwise would have been precluded by altitude.

Along the east coast of the North Island, and north-eastern coast of the South Island, however, the absence of such volcanic soils made cultivation dependent on recent alluvial (and colluvial) soils. Alluvial silt loams, found in narrow bands on river flats, and on alluvial fans, were amongst the best soils for Maori agriculture, as they combine friability with high levels of natural fertility. Moreover, in coastal sites such as Anaura Bay, slopes composed of alluvial and colluvial soils provide a variety of soil microenvironments in a compact area; where temperatures allowed, this gave the opportunity to plant yams, in addition to kumara, on drier parts of the slope, and taro on the damper parts. Such soils were not always available to coastal dwellers though, and the inhabitants of the Horowhenua-Manawatu coast had to make do with yellow-brown sands. These have ideal physical qualities for kumara cultivation - because of their coarse texture they tend to be well drained and friable - but have low fertility levels. In addition, where alluvial river flats were flood prone or frost prone, steepland and hill soils were sometimes cultivated, although, for reasons of maintaining sufficient soil temperatures, planting was restricted to well-drained, north-facing slopes.

Many of these variations in soil properties and agricultural utility were incorporated in Maori soil nomenclature. Indeed, the ethnographer Elsdon Best compiled a list of 35 soil names, and believed there might be several more.
Some of these, as seen in the indicative sample given in Table 1.1, were general textural terms (e.g. sand, silt, clay etc.), and others overlap. Even so, this level of complexity in a 'classification system' is comparable with the 20 or so major soil groups used formerly by the New Zealand Genetic Soil Classification, which is described in Appendix One.

Table 1.1: Sample of Maori Soil Nomenclature recorded by Best

Oneone : Soil, earth - a general term.
Keretu : Clay.
One haruru : A light but good soil; sand and loam.
One kura : A reddish and poor soil.
One kopuru : A soil found in wet situations.
One mata : A dark coloured fertile soil.
One matua : (Stiff) loam.
One parakiwai : Silt.
One paraumu : Very dark fertile soil; friable.
One pu : Sand.
One tea : A white soil. Sandy volcanic matter.
One tuatara : A stiff brown soil, fertile, but needs pulverising and sand or gravel worked in.
Tuatara wawata : A brown, friable fertile soil suitable for kumara.

Clearly texture, which is referred to in two-thirds of the entries in Best's list, served as the main criterion for soil classification. This was to be expected, given that physical limitations of a soil were more important for cultivation than chemical ones. Even so, subdivision was also made according to colour, drainage, and friability. Within Best's list the soils regarded as best for kumara cultivation were described as being brown and friable, which is suggestive of the red and brown loams, which, as noted previously, supported extensive cultivations in the vicinity of Auckland and the Bay of Islands. The worst, meanwhile, was one kura, a term which was probably given to strongly leached volcanic loams, which exhibit very distinctive red colouration, due to iron oxide mottles. One kura was so infertile that it was assumed that it must have a high tapu status, and so it was generally reserved for sacred purposes, such as the production of the red dye, kokowai.
This nomenclature, however, was not used uniformly throughout New Zealand. In contrast to Best's list, Dieffenbach recorded that Maori agriculturists preferred the soils *tai pu* - "rich land on the sides of rivers" (that is, alluvial soils) and *one kura* - "land composed of decayed vegetables on the side of hills" (presumably referring to steepleand and hill soils).20 Obviously the definition Dieffenbach recorded for *one kura* is very different from that which Best recorded, and equally from that which is generally recognised today,21 but the kind of soils which Dieffenbach described as being the most esteemed for cultivation do seem to fit with Maori agricultural practices in areas without volcanic soils.22 It must also be remembered that soil quality was not the only factor, and sometimes not even the principal factor, in determining where cultivation took place. Other considerations, such as the availability of alternative cultivation grounds, proximity to other food sources, capabilities for defence, and *tapu* constraints, could also influence the decision.23

Maori cultivators did not just passively accept soils as they found them, however. Rather, they practised two main methods of soil improvement, one of which aimed to enhance the physical character of the soil, and the other being intended to boost soil nutrient levels (though coincidentally it also led to physical changes which made the soil better for cultivation).

The first of these two methods was the addition of material - most often gravel, though occasionally charcoal and beach sand - to form what have been termed 'Maori plaggen soils', or simply 'made soils'.24 This practice augmented the more general procedure of growing individual kumara in raised mounds (*puke*).25 These modified soils are widespread on the Waimea Plains in Nelson, and in the Waikato Basin, but they have also been found in several other locations, such as Moturua Island in the Bay of Islands, Waiheke Island, Aotea Harbour, the Waitara River, Kauri Point (in the Bay of Plenty), Black Rocks (in Palliser Bay), and Kaiapoi Pa (see Figure 1.2). Moreover, some examples are of a considerable age, with that on Moturua Island dating back to the thirteenth century.26 As with the mounds, the apparent aim of this practice was to make the soil more friable, more aerated, and, since the added material is coarsely textured, better drained.27 With improved drainage, the soil could warm up more quickly. It is possible that the soil blackening when charcoal was added also enhanced absorption of solar radiation (insolation).28 In turn, the heat capacity of gravel would have insulated the soil. This principle was employed on the soil surface, with gravelling under the foliage of the kumara being used to restrict the chances of frost damage.29
Figure 1.2
Traditional Maori agriculture and soil management

Source: Prepared by author.

As reflected in this map, Maori agriculture, and in turn, Maori population was concentrated in the northern North Island, because of the climatic requirements of kumara cultivation. Kaiapoi was almost on its southernmost limit.
Figure 1.2

- **Areas of red & brown loams**
  - A Taiaimai Plains
  - B Tamaki Volcanic Field

- **Areas where 'made soils' are found**
  - a Middle Waikato Basin
  - b Waimea Plain

- **Localities with 'made soils' mentioned in text**
  1 Aotea Harbour
  2 Black Rocks
  3 Kaiapoi Pa
  4 Kauri Point
  5 Motuma Island
  6 Waiheke Island
  7 Waitara River

- **Other localities mentioned in text**
  8 Anaura Bay
  9 Rotorua
  10 Taupo
Since the addition of material to the soil proved so labour-intensive, it seems to have been confined to specific types of soil. One account given to Best observed that this treatment was used on one matua, but not on one paraumu, which instead needed only surface gravelling for frost prevention. Maori cultivators avoided one tuatara, meanwhile, because far too much labour was required for its modification. While this account, and those of some other commentators, such as William Yate, support the view that stiff, and hence clayey, soils were treated in this way, Tony Walton has argued that in areas such the Waikato, the incidence of 'made soils' shows exactly the opposite - that is, coarse material was mixed into sandy or gravelly soils already suited to growing kumara. This may appear illogical, but Walton believes that the object in such cases may have been to provide the kumara with a 'clean' (in either a physical or spiritual sense) growing medium.

The addition of sand and gravel, however, was not the only way to make the soil more friable - and perhaps, at the same time, to 'cleanse' it. This could also be accomplished by subjecting it to the heat generated by a fire. Indeed, the pedologist Norman Taylor thought that the dark colouring included in the definition of one paraumu was probably an allusion to charred plant and soil residues. This would explain why, in the abovementioned account, this category of soil was only ever subjected to superficial gravelling.

Like many of their Polynesian counterparts, who also practised swiddening, Maori agriculturists were undoubtedly well aware of the physical improvement of the soil from burning vegetation, and, in view of their abhorrence of manure (to be discussed below), this practice also formed the basis of efforts to maintain the chemical fertility of the soil. Rather than simply burning vegetation in situ, they refined the practice by collecting up available vegetable matter, such as manuka (Leptospermum scoparium) branches, and burning it at the desired location. This practice, incidentally, has few parallels amongst modern shifting cultivators. Given this concentration of material, it seems that the resulting addition of plant nutrients would have been at least as great as that recorded after an experimental burn of in situ manuka conducted in 1954. Subsequent analyses revealed that this burn enriched the soil nutrient levels to the same extent as the application of 1000 kg of lime, 100 kg of superphosphate, and 300 kg of potassium sulphate per hectare, rates which were comparable with those of modern agriculture. Where soils were moderately to strongly acidic, as in the case of red and brown loams, the alkaline content of the ash, as well as acting as a nutrient, would also have increased soil pH. The optimum pH for kumara growing, interestingly, is the
slightly acid level of 5.8-6.2. In spite of substantial nutrient losses by leaching, especially of potassium, measurements in the aforementioned experiment ten months after the manuka was burnt (at which time 20-25% of mineral nutrients were still contained in the unburnt soil litter) indicated that the increased nutrient levels were likely to persist for at least one year, and perhaps for several. While it is difficult to extrapolate over the country as a whole - for instance, soils with high levels of aluminium and iron oxides, such as red and brown loams, could be expected to immobilize several times the amount of phosphate that was present before the fire - and the practice of mounding the soil, may, by concentrating the ashes, have prolonged the nutrient boost, these results illustrate the rationale behind the general fallowing regime practised by Maori agriculturists. This was generally one of cultivation for 2 or 3 years, followed by a 'fern land' fallow of 7-14 years, or a slightly longer bush fallow of perhaps 10-15 years. However, in some instances where fertile soils were very intensively cultivated, crop : fallow ratios of as low as 1 : 1 have been suggested.

The chief drawback of supplying plant nutrients through burning was the loss of organic matter contained in the foliage and leaf litter. What made matters worse in the case of Maori agriculture was that it was not able be to be replaced by manuring. Their "national non-usage of manure", as Colenso put it, arose because of the tapu associated with the heketua, or privy. When excrement passed the paepae, or horizontal beam, it was regarded as moving from the world of life to the world of death. They did not husband animals in any case. Consequently, Maori agriculturists had to rely on alternative nitrogen inputs to the soil in the wake of a burn. Some remained in charred vegetable material, and nitrogen was also released by the death of soil microbes during the fire. By allowing a fallow, moreover, nitrogen levels in the soil tended to build because of the presence of many leguminous species (such as tutu (Coriaria arborea) and kowhai (Sophora tetraptera)) in the early stages of vegetation succession. More deliberate additions were also made, through the composting of weeds in the kumara mounds.

One further practice carried out by Maori agriculturists which deserves mention, albeit not strictly involving soil modification, was the partial management of the New Zealand species of bracken (Pteridium esculentum). Although it grew wild, repeated firing (and harvesting) of the bracken could take place every 3-5 years. In such a short time period, forest species could not regenerate, and so bracken came to dominate the vegetation of the burnt area. Bracken was an ever reliable crop, and in many areas fern-root provided the main staple. It did not,
however, fit very easily into a fallow cycle with kumara, as once established the
dense rhizome network made it difficult to eradicate; in the well-documented case
of Tutira, for example, this took several decades. It seems therefore that Maori
harvested fern-root more as an auxiliary vegetable, from land devoted to the
purpose.

In conclusion, one can state that in the centuries prior to the arrival of
Europeans, Maori agriculturists had largely learnt to overcome the burden of
transferring an agricultural system into a climatically-unsuitable environment. This
was a burden which later migrants, from temperate Northern Hemisphere
countries, would not have to face. While agriculture must have been very
unrewarding prior to the development of indigenous adaptations (this being
perhaps best personified in the figure of Toi-kai-rakau (Toi the wood eater)),
persistence, observation, and attention to cultivation helped shape a set of
techniques for making the best out of a bad situation. Amongst these techniques,
those which physically modified the soil, and, to a lesser extent, those which
modified it chemically as well, were invaluable in helping the extension of Maori
settlement in areas (such as the northern coasts of the South Island) which would
otherwise have been well beyond the natural environmental limits of cultivation.
Notes to Chapter One

1 The Moriori settlers of the Chathams were left, in contrast, without any of the tropical crops they might have tried to take with them. King, Michael, Moriori: a people rediscovered (Auckland, 1989), pp. 25 & 31.

2 Davidson, Janet, The Prehistory of New Zealand 2nd ed. (Auckland, 1987), p. 116. Only two other imports, the ti pore, or cabbage tree (Cordyline terminalis), and paper mulberry (Broussonetia papyrifera) seem to have similarly survived.


4 Leach, Helen, 1,000 Years of Gardening in New Zealand (Wellington, 1984), p. 58; Shawcross, Kathleen, 'Fern-Root, and the total scheme of 18th century Maori food production in agricultural areas', Journal of the Polynesian Society 76(3) (1967), p. 336.

5 Leach, 1,000 Years of Gardening, pp. 57-8. Taumutu (on the southwest shore of Lake Ellesmere (Waihora)) was the southernmost point of kumara cultivation (Trotter, Michael, and McCulloch, Beverley (eds.), Unearthing New Zealand (Christchurch, 1989), p. 56).

6 Yen, The Sweet Potato and Oceania, 63; Leach, 1,000 Years of Gardening, p. 61.


8 Ibid.


13 Taylor, 'Soil Science and New Zealand Prehistory'. New Zealand Science Review 16(9-10) (1958), p. 76; Dieffenbach, Ern[e]st, Travels in New Zealand; with contributions to the Geography, Botany, Natural History of that Country (London, 1843), I, p. 186; Jones,

14 Leach, 1,000 Years of Gardening, pp. 65-6; Jones, 'Horticulture: 600 years of gardening'. In McKinnon, Malcolm (ed.), New Zealand Historical Atlas, Plate 13. One striking example of utilisation of a coastal microenvironment was the cultivation of beachfront soils at Panau Pa, on the north side of Banks Peninsula - their organic matter and phosphorus content had been greatly enriched by penguin droppings (on account of the nearby penguin colony) (Morris, L. N., 'Investigations into the Soils and Landforms of Pre-European Maori Gardens, on Banks Peninsula, Canterbury, New Zealand'. (Unpublished B. Res. Stud. (Hons.) dissertation, Lincoln University, 1994), pp. 4-5 & 58-62).


17 Best, Elsdon, Maori Agriculture. The Cultivated Food Plants of the Natives of New Zealand, with some Account of Native Methods of Agriculture, its Ritual and Origin Myths (Wellington, 1925), pp. 19-20. Best translates one matua as 'stiff loam' on p. 86, possibly on the basis of the definition given by Dieffenbach (Dieffenbach, Travels in New Zealand, II, p. 123).

18 In 1955, the New Zealand Genetic Soil Classification recognised 20 soil groups (see Pohlen, I. J., 'The Genetic Classification of New Zealand Soils'. In Soil Groups of New Zealand, 2nd printing, compiled by R. B. Miller and Janice Willoughy (Lower Hutt, 1971), p. 9). However, over time a number of changes have occurred, relative to the demarcation of groups versus sub-groups etc. (see Gibbs, H. S., 'Soil Classification Nomenclature'. In Soil Groups of New Zealand, 2nd printing, pp. 498-9).


20 Dieffenbach, Travels in New Zealand, II, p. 123.

See, for an example of such soils being preferred, Jones, 'Horticulture and Settlement Chronology of the Waipaoa River Catchment'. *New Zealand Journal of Archaeology* 10 (1988), p. 23.

For example, Colenso claimed that cultivated areas were in partly-concealed places, to avoid damage by raiding parties (Best, *Maori Agriculture*, p. 68), while Jones had argued that in the Waipaoa River catchment, access to the river and associated wetlands, which provided alternative sources of food, such as eels, was generally the most important factor in determining the site of cultivation (Jones, 'Horticulture and Settlement Chronology of the Waipaoa River Catchment'. *New Zealand Journal of Archaeology* 10 (1988), p. 48).

Leach, *1,000 Years of Gardening*, p. 48; Davidson, *The Prehistory of New Zealand* 2nd ed., pp. 120-1.

Macnab, 'Sweet Potatoes and Maori Terraces'. *Journal of the Polynesian Society* 78(1) (1969), p. 88. Macnab, it should be noted, uses the term *tupuke*, but as can be seen by reading Best, this is in fact the verb used to describe the formation of *puke* (noun form) (Best, *Maori Agriculture*, p. 78).

Leach, *1,000 Years of Gardening*, p. 49.


Macnab, 'Sweet Potatoes and Maori Terraces'. *Journal of the Polynesian Society* 78(1) (1969), p. 105. In a study of modified soils at Motueka, Challis concluded that the higher soil temperature resulting from gravelling would have extended the growing season by about a week (Challis, Aidan J., 'Physical and chemical examination of a Maori gravel soil near Motueka, New Zealand'. *New Zealand Journal of Science* 19(3) (1976), pp. 253-4).


Best, *Maori Agriculture*, p. 86. The account was provided by a member of the Ngati Kahungunu *iwi*, who were the most notable *iwi* in the Hawkes Bay and Wairararapa regions.


36 Leach, *1,000 Years of Gardening*, pp. 22, 26 & 29.

37 Best, *Maori Agriculture*, p. 70.

38 Taylor, 'Soil Science and New Zealand Prehistory'. *New Zealand Science Review* 16(9-10) (1958), pp. 76-7. This method of collecting combustible materials (of which the chitemene system in Africa is a rare modern analogue (see Warner, *Shifting Cultivators*, p. 32)) impressed early European observers. For example, Petre's *Account of the Settlements of the New Zealand Company*, said the following of it:

> I may here mention that the natives exhibit great skill in their mode of clearing wood. Their clearances reminded me of what I had seen in America; the stumps of the trees which had been cut down at some feet from the ground being left to rot. In burning the brushwood and branches, they first scatter them over the ground equally, so that every part of the soil is equally improved by the ashes. This is much better than the American practice, as the latter plan fertilizes unequally.


41 Miller et. al., 'Biological and chemical changes following scrub burning on a New Zealand hill soil'. *New Zealand Journal of Science and Technology (Series B)* 37(3) (1955-6), p. 304.

42 Gibbs, *New Zealand Soils*, p. 41; Miller et. al., 'Biological and chemical changes following scrub burning on a New Zealand hill soil'. *New Zealand Journal of Science and Technology (Series B)* 37(3) (1955-6), p. 303.


44 Taylor, 'Soil Science and New Zealand Prehistory'. *New Zealand Science Review* 16(9-10) (1958), p. 76; pers. comm., Professor Helen Leach, Department of Anthropology.
University of Otago, 14 July 1998. Leach has reported, however, that up to 25 years under fallow would have been necessary to restore nutrient levels in the low to medium fertility soils cultivated at Palliser Bay. (Leach, 1,000 Years of Gardening, p. 61). It is not clear whether these soils were recultivated or not (pers. comm., Prof. Helen Leach, October 1998).

50 Best, Maori Agriculture, p. 101; Leach, 1,000 Years of Gardening, p. 68. A study of kumara cultivation by the Wola people of Papua New Guinea has shown that the not dissimilar practice of composting grass in the kumara mound led to much increased yields, on account of the potassium it provided, and also reduced the need for long fallows (Sillitoe, Paul, 'It's All in the Mound: fertility management under stationary shifting cultivation in the Papua New Guinea Highlands'. Mountain Research and Development 18(2) (1998), pp. 124-5 & 131-2).
53 Leach, 'Incompatible Land Use Patterns in Maori Food Production', New Zealand Archaeological Association Newsletter 23(3) (1980), pp. 142-4. In 1921, Herbert Guthrie-Smith published Tutira, a monograph which documented the history of ecological change on the sheep station that he owned.
54 Leach, 'Incompatible Land Use Patterns in Maori Food Production', New Zealand Archaeological Association Newsletter 23(3) (1980), p. 143. For an example of this behaviour, see Simmons, 'Cyclical aspects of early Maori agriculture'. Records of the Auckland Institute and Museum 12 (1975), p. 86.
Figure 2.1
Soils of Europe and the Near East


This map was drawn from Hermann Stremme's 'International Soil Map of Europe'. It uses a classification system similar to Marbut's 'Great Soil Groups' system. For a simplified correlation with the New Zealand Genetic Soil Classification, see Appendix Two.

As noted in the text, outside pockets of Alluvial soils (see here in the Rhine Delta region) and Rendzinas, the best soils for agriculture were the Brown Forest soils. As seen here, in Great Britain these soils occupied southern England and the English Midlands, and the coast between Yorkshire and the Lothians. The most similar New Zealand soils to the Brown Forest Soils were South Island and southern North Island Yellow-brown Earths.
New Crops for Old Soil: the 'agricultural revolution' and soil fertility management in northwestern Europe to c.1800

In order to better understand the agricultural context of Pakeha settlement in New Zealand in the early nineteenth century, it is necessary to reflect on the tremendous changes in Western agriculture during the eighteenth century. For northwestern Europe, the eighteenth century was the 'age of Enlightenment' - an age of expanding economic, cultural and scientific horizons. Amongst the more significant transformations within the region during this period were the first phases of the so-called 'agricultural revolution', though its effects and its timing varied from place to place. This 'revolution' entailed changes to farming practices, technologies and institutions which resulted in dramatic increases in food production, and for the first time allowed European population levels to not only breach what had appeared an unalterable ceiling, but also to keep on growing. At the core of this 'revolution' was the replacement of fallowing in the management of soil fertility (and thereby soil productivity) by fodder crops.

Overall, the soils of Western Europe (the distribution of which is shown in Figure 2.1) are not particularly productive, but they can be made so with careful management. Excepting the rich alluvial soils (for which extensive drainage was often a prerequisite for their utilisation) in areas such as the Rhine delta, the most fertile soil groups early modern farmers found in the region were Rendzinas, and the Brown Forest soils (sometimes referred to as Brown Earths). The Rendzinas, formed from calcareous parent materials, were concentrated around the Massif Central, although the frequent exposure of limestone beds meant that they were scattered throughout Europe. The high calcium concentrations in these soils maintained soil pH at slightly to moderately alkaline, thereby promoting the availability of the major soil nutrients to plants (and at the same time suppressing aluminium and manganese toxicity), and they also enhanced soil structure and soil microbial activity. The Brown Forest Soils, meanwhile, covered large areas of the north European plains, together with most of southern England. These soils formed under deciduous forest, where the leaf litter had decayed to give a 'mull humus' layer, which is rich in nitrogen and base cations (calcium, magnesium, and potassium). This layer gave the soil a high initial nutrient level, and the base cations held acidity in check, so even after leaching these soils remained...
reasonably fertile. Moreover, some Brown Forest soils, such as those of the Paris Basin, had formed in areas of loess deposits. These soils were not only chemically fertile, but the resulting light texture made them ideal for cultivation from a physical viewpoint as well.

As the degree of leaching progressively increased (which, in turn, gave rise to more acid soils (lower pH) and lower levels of plant-available nutrients), Gray-Brown Podzolic soils, and lastly, Podzols formed. The former were distributed over much of Ireland, Scotland, northern England, Brittany, and a large proportion of the North German Plain. Podzols (which were associated with heathland and coniferous forest), in contrast, were restricted to much smaller areas. Often Podzols developed in sand-textured material (since sand particles had comparatively little soil surface area to bind nutrients which were in solution, and thus leaching occurred readily).

Within these regions of podzolic soils, Bog and Half Bog organic soils also developed on poorly drained sites. If left undrained these soils remained unproductive, though fen peats (found where the bog water contained dissolved alkaline salts) had sufficiently high nutrient levels to become valuable once drained. The acid peats of Ireland's blanket bogs, in contrast, were leached of mineral content, and required inorganic fertilisation as well as drainage if they were to be improved. The only other soils of significance within northwestern Europe were shallow mountain soils, referred to as Lithosolic soils. Although recently developed, these were generally unsuited to agriculture because of their stony nature, instability, low levels of organic matter, and, because of altitude, low soil temperature.

Prior to the 'agricultural revolution', the pattern of cultivation closely matched the distribution of naturally occurring soils. Wheat, because of its preference for neutral or slightly alkaline soils, tended to be grown on Brown Forest soils and Rendzinas. Additionally, wheat growth was promoted by soils which retained moisture (thereby favouring clayey over sandy-textured soils), but which did not waterlog the seedlings in winter. In England, for example, this meant that the best performing wheat soils were found to be the drier East Midlands clays.

Rye, meanwhile, was tolerant of a wide range of soil conditions, and was thus grown not only on Rendzinas and Brown Forest soils, but also on the Gray-Brown Podzolic soils. Only in the most fertile areas did wheat predominate over rye. Consequently, even in England and France, most breadstuffs were made from rye-grain. Alternatively, in the Gray-Brown Podzolic and Podzol soils of
Brittany, the Netherlands and northern Germany, buckwheat was grown. On most Gray-Brown Podzolic and Lithosolic soils, however, very acid soils and/or cold climates made oats (which tolerated both) the dominant crop.\textsuperscript{18}

Pastoral farming, in contrast, occurred over the whole gamut of soils, as even in the best arable farming areas, livestock were needed to supply power and manure.\textsuperscript{19} Potentially, they also provided fuel, food and fibre for domestic consumption, and a readily realisable asset (as opposed to crops, which had to be disposed of after the harvest).\textsuperscript{20} In general, however, the areas where pastoral farming was most widely practised were on low fertility soils, which were less remunerative for cropping purposes. Moreover, sheep-farming was most suited to drier soils (resulting from either good drainage or a dry climate) because of the danger of diseases such as foot-rot and liver-rot. Cattle-rearing and dairying, in contrast, favoured a moist, lush pasture.\textsuperscript{21}

To improve the fertility of their soils, the pre-'agricultural revolution' farmers of northwestern Europe employed a wide variety of techniques, many of which were of a considerable vintage. In the main, farmers directed the supply of nutrients on to the arable part of the farm, since pastoral agriculture was more or less self-sustaining, because of the gradual increase in soil organic matter. Having said this, where dairying had a long history, as in Cheshire, soils could become phosphate-deficient.\textsuperscript{22} Generally, arable fields were also largely self-sustaining in terms of mineral (inorganic) nutrients, since most soils contained a store of phosphorus and potassium, which was slowly replenished by the decomposition of the subsoil, far larger than the amounts needed by the relatively low crop yields. With only small contributions from manure and extraneous fertilisers, therefore, mineral nutrient levels could be successfully maintained over the medium-term.\textsuperscript{23} Consequently, the key nutrient, as far as the potential to limit crop production went, was nitrogen.

Soil fertility management in this period thus revolved around maintaining soil nitrogen levels, and more especially levels of nitrates (the form in which nitrogen is available to non-leguminous plants such as cereals);\textsuperscript{24} this required maximising inputs and minimising losses.\textsuperscript{25} This was normally effected by returning animal dung and plant wastes (the former being preferred for manure because it was in a more decomposed form), and through biological fixation of nitrogen (that is, the breakdown of atmospheric nitrogen so as to form organic nitrogen-containing compounds) by microbes living in either the soil or in the roots of legumes.\textsuperscript{26} Chorley has estimated that typically traditional inputs were approximately 30 kg of nitrogen per hectare of arable (cropped and fallow), of which farmyard manure
provided just under 30%, microbial fixation just under 60%, and the balance came from atmospheric deposition.\textsuperscript{27}

Most inputs involved the fallow. In the case of manuring, livestock could be either fed on pasture during the day and then 'folded' on the fallow at night, which was thereby fertilised by their faeces and urine, or alternatively livestock were sometimes stall-fed, and the muck resulting from the agglomeration of excrement and litter (commonly straw) would be ploughed into the fallow-field.\textsuperscript{28} Farmers also excavated turf and peat from pasture and wasteland for use in litters, because of their absorbent properties. They were also valuable as organic fertilisers when added to the soil directly.\textsuperscript{29} Post-harvest, fields which would be cropped again next year were also manured by stock grazed on the remaining stubble.\textsuperscript{30} The fallow-field itself would often be kept bare, since weeds competed for soil nitrates, although sometimes legumes such as peas or beans were also grown, so that both legumes and soil microbes built up soil nitrogen levels simultaneously.\textsuperscript{31} In England, the use of such legumes, as advocated by Roman writers, most notably Virgil, had been on the increase since the thirteenth century.\textsuperscript{32} Their cultivation was also recommended in contemporary agricultural writings, such as that of the sixteenth century agricultural bard Thomas Tusser, who referred to their effects in the following couplet:

\begin{quote}
Where peason ye had and a fallow thereon, 
sowe wheat ye may well without doong thereupon.\textsuperscript{33}
\end{quote}

The accumulation of soil nitrogen in the absence of crop production was not the only advantage of fallowing though, as during a fallow, rates of nitrification (conversion from organic forms of nitrogen into nitrate) were enhanced.\textsuperscript{34}

Throughout northwestern Europe, farmers practised a variety of fallowing regimes, but the most commonly adopted were the three-year rotation (two years cropped in grain and one year fallow), and to a lesser extent, the two-year rotation (one year cropped and one year fallow).\textsuperscript{35} The infield-outfield system used in Scotland and Namur, which divided the arable into a continuously cropped in-field and a rotated out-field,\textsuperscript{36} and shifting cultivation, which was common only in Scotland and Ireland, were at the less intensive end of the spectrum, although turf and heath cultivation was also found in areas of infertile hill country elsewhere.\textsuperscript{37} Under this regime, wasteland areas would be pared and burned, that is, the turf and heath would be ploughed up and formed into a heap, together with any hewn wood, and after burning its ashes would be spread over the resulting bare field.\textsuperscript{38}
Conversely, at the more intensive end, farmers followed rotations of about 4-6 years (found in parts of England, Friesland, and Alsace, for example) which relied on nitrogen inputs from pulses (edible legumes such as peas and beans).39

Farmers also employed numerous soil amendments and fertilising substances to improve the nutrient supply to plants. The best known of these was lime. Most soils were improved by liming, as under pasture even soils which developed on chalk or limestone formations could become acid. Since acidity inhibits the conversion of organic nitrogen into nitrate, much of the benefit of manuring was lost on an excessively acid soil.40 As far back as Roman times, the use of chalk and marl (chalky clay) on soils was recorded throughout northwestern Europe.41 Alternatively, limestone and shell sand could also be used.42 In comparison, limestone burning, to make slaked lime (calcium hydroxide), which was both less bulky and more reactive, was not practised to any extent (in England at least) until the sixteenth century. Having said this, by the mid-eighteenth century it was carried on throughout the country.43 Contemporaries still favoured marl on sandy podzols though, as its neutralising capacity was complemented by its bulking up of the soil.44 In Scotland or France, lime-burning was much less common, as transport difficulties meant it only became significant where limestone was available locally.45

The list of materials which were applied to the soil in order to supply nutrients, meanwhile, was practically endless. Indeed, in 1649 Walter Blith wrote that "anything almost that hath any liquidness, foulness, or good moisture in it, is very natural enrichment to almost any sort of land".46 Commonly used materials included night-soil from local towns, various assortments of hoof and horn, wool wastes and rags, soot, and seaweed.47 Most supplied nitrogen, though some, such as seaweed, were rich sources of inorganic nutrients, in its case potassium and sodium.48 In addition, alluvial sediments were applied to pasture via flood irrigation, a practice known as 'floating the watermeadows'. In England this technique began to be used in the sixteenth century.49 Over time, the continual addition of materials and manure could have a considerable effect. After several centuries, some Podzols in Brabant and the northern German-Dutch borderlands had been transformed into phosphate-rich 'Plaggen soils' lying up to a metre and a half above the surrounding landscape.50

While concentrated applications of manure and other fertilising materials could enrich soils at the local level, increasing overall output proved difficult prior to the 'agricultural revolution'. If the supply of extraneous fertilising materials was relatively static, then to boost crop yields, more farmyard manure was
required, and hence more pasture would be needed at the expense of the area under cultivation. Conversely, an increase in the area under cultivation meant less area in pasture, and consequently less manure and lower yields. However, from the early sixteenth century, two new farming systems emerged which raised intensity of cultivation and farm production to a new level. In the first of these, namely 'convertible husbandry' (also known as ley farming, or up-and-down husbandry), the traditional division between the permanent arable and permanent pastoral fields was abandoned, and instead the two were alternated, with say, three years of cropping, and seven years of pasture. In the first instance of conversion, the accumulated nitrogen in the permanent pasture would have supplied a grain crop for up to a decade, though in the long-term each conversion might only have produced only one good crop and would have had little advantage over normal fallowing. The second new system, which had developed in the Low Countries, united the cultivation of fodder crops and cereals, with both being grown in distinct rows which were rotated round the field, so that there was an even drain of nutrients. When coupled with heavy manuring (using night-soil from local urban centres, and the dung from livestock stall-fed on fodder crops), and intensive weeding (no small matter, since, as Overton observes, up to one-third of crop production was normally lost through weed growth), farmers were able to do without a fallow.

The critical element in the second system, which ultimately became the basis of the 'agricultural revolution', was the cultivation of clover, as well as turnips, in the place of the fallow. Farmers grew both clover and turnips as fodder crops in the Low Countries during the sixteenth century, and from there the practice spread to England, where their use was popularised in such works as Sir Richard Weston's *Discours of the Husbandrie used in Brabant and Flanders* (1645). It took another century, however, before it became common to find clover and turnips incorporated into rotations, such as the Norfolk four-course (depicted in Figure 2.2) made famous by Arthur Young, in which wheat was followed by turnips, barley, and clover. The cultivation of clover had a tremendous impact on soil fertility, as it resulted in atmospheric fixation of at least 50 kg of nitrogen per hectare, and perhaps more. Chorley estimates nitrogen inputs from clover residues were at least 100 kg per hectare, or three times that of the pulses it replaced, though about one-third of this 100 kg would have come from the soil in the first place. In addition, both clover and turnips also provided a better source of fodder for livestock than pasture, with turnips being especially valuable as winter feed, and this enabled the production of larger amounts of manure.
Readers should note that inputs through the normal process of plant root decay are not shown in the bottom diagram. As can be seen from the course of cropping, shown in the top diagram, a green and grain crop were sown alternately. Barley benefitted from following turnips, because barley is a ‘surface feeder’ which prefers light soils, and dung from stock feeding on the turnips causes available nitrogen to be concentrated near the soil surface. Apart from the extra nitrogen fixed by clover, wheat, meanwhile, enjoyed the well consolidated soil that the clover’s extensive roots leave behind.
Figure 2.2

Grass and Clover

Wheat

Oats & Barley

Turnips

Stock Yard Dung

Straw

Manure

Misc. Wastes (Seaweed, Peat, etc.)

Microbial N\textsubscript{2} Fixation

Fallen Urine

Food

Faeces Urine

Hay

Oats & Barley

Turnips

Wheat

Grass and Clover

Food

Faeces Urine

Wheat

Stock Yard Dung

Straw

Manure

Misc. Wastes (Seaweed, Peat, etc.)
Accordingly, when averaged out over the whole arable area, the aggregate nitrogen inputs (that fixed by the clover, together with the more traditional inputs, such as that fixed by soil microbes, and in farmyard manure) were in the order of 50 kg of nitrogen per hectare (that is, two-thirds more than that available under the traditional permanent arable-permanent pasture with bare fallows regime). Moreover, as permanent pasture was no longer necessary in the way it had been before the adoption of crop rotations, this allowed for an increase in the area of arable fields. Finally, turnips also acted as a 'cleaning crop', as their broad leaves quickly smothered competing weeds.

In England, the change from fallow to fodder crop, together with other changes referred to above, such as increased use of lime and marl, and the practice of convertible husbandry (in the seventeenth century) led to both extensification and intensification of farm production. Simultaneously, other factors which were not or only indirectly related to the management of soil fertility, such as selective breeding, drainage, enclosure, and even improved transport, also helped to improve farm productivity. Overall, the area of arable land in England and Wales increased from 9 million acres in 1700 to 11.5 million acres in 1800, and the area in pasture grew from 12 million to 17.6 million acres. Part of this growth came from the new utilisation of large areas of marsh and heathland, which were 'reclaimed' through the use of liming and drainage, and the cultivation of root crops, which caused nutrients to be concentrated near the soil surface. Average crop yields, meanwhile, increased about 75% between 1600 and 1800, so that by the latter date a typical farm produced around 22 bushels of wheat per acre. The increase in livestock output, while difficult to quantify, was probably even more impressive. One study on Norfolk during the first half of the seventeenth century (when clover and turnip cultivation was barely established) has found that the enhanced pasture quality resulting from sowing artificial grasses and 'floating the meadows' (which, in addition to adding nutrients, extended the growing season by raising soil temperature) was sufficient for stocking rates to double. Within England, not all areas shared equally in these improvements, however. The Midlands, with its heavy clay soils, proved ill-suited to turnip cultivation, and was thus displaced as the premier agricultural district by areas with lighter soils, such as Norfolk.

In Scotland, meanwhile, the effects of the 'agricultural revolution' on yields were even more pronounced. The improvements to yields accompanied changes to the management of fallow land, which came increasingly to be treated with copious quantities of dung and lime, and sown with 'artificial' grasses and
clover. In addition, on the fertile east coast lowlands, farmers introduced turnips into crop rotations which mirrored those in use in England, albeit with oats occupying the position in the rotation held by wheat. By the 1790s, for example, turnips were cultivated in 82% of parishes in Angus, and 65% of Fifeshire. Perhaps the most remarkable aspect was the pace of change. Thanks in part to the use of extended leases which prescribed the use of the new methods, these changes almost all took place during the second half of the eighteenth century. Indeed, the yield-to-seed ratio for oats in Scotland rose from about 4-5 in 1750 to about 10 in 1800. The same ratio in England, in contrast, only rose about 50% to 7-9 over the same period.

The progress of the 'agricultural revolution' in the rest of northwestern Europe, excepting the Low Countries, lagged well behind that in Great Britain, however. Not until about 1760 did peasants in France cultivate fodder crops, and even then they were concentrated mainly in the northeast. Indeed, the practice was sufficiently novel for the Marquise de Marbeuf to be executed during the French Revolution for growing fodder crops rather than cereals at a time when grain supplies were short. In Germany, meanwhile, the cultivation of clover by 1800 was generally restricted to the Rhine Valley, though other new legumes (sainfoin and lucerne) were grown in Thuringia and Swabia. This delayed adoption of improvements meant that wheat yields in France and Germany, at the close of the eighteenth century, only amounted to 19 and 17 bushels per acre respectively. Even so, these yields were well in advance of what had gone before. In this regard, it has been estimated that prior to the onset of the 'agricultural revolution' in northwestern Europe, wheat yields only averaged about 11 bushels per acre.

Despite these advances in the management of soil fertility, soil science had remained in a primitive state. Indeed, even describing and classifying the soil was still to be standardised. Consequently even in the mid-nineteenth century ad hoc local nomenclature was still a problem:

... the arrangement of soils into classes is of practical utility, inasmuch as it enables us ... to dispense with local and general terms, such as hazel-loam, fat-soil, brown-loam, clayey-loam, humus-soil, garden-mould, and other terms, to which different meanings are attached in different parts of the country, and to substitute for them terms of distinct definition. It is owing to an indefiniteness of this kind ... that a great deal of our agricultural literature is useless to the general reader.
For most of the early modern period, almost the sole criterion of classification remained soil texture, since this related to its ease of cultivation. Nevertheless, colour and geology were also used by some writers, and by the start of the nineteenth-century the use of geological formations to classify soils was becoming commonplace.

In the circumstances, it is not surprising that the theoretical understanding of what made a soil fertile was rudimentary at best, although observing soil ecology (what grew where) and soil productivity (how much grew) at least provided an empirical comparison. Alternatively, fertility could also be 'assessed' on the basis of quasi-scientific tests proffered by classical authorities, such as Virgil's 'pit test', or through the sensory examination of properties such as colour and texture. These impediments did not stop researchers and philosophers throughout northwestern Europe avidly pursuing the identity of the 'principle of vegetation'. The results of this search were not, however, very conclusive. As Jethro Tull, one of the leading agricultural writers of the age, observed, "it is agreed that all the following materials contribute in some manner to the increase of plants, but it is disputed which of them is that very increase or food: (1) nitre, (2) water, (3) air, (4) fire, (5) earth".

In the second half of the eighteenth century, some insights akin to the modern understanding of plant nutrition began to be expressed. The Scottish scientist, Francis Home, for example, suggested that plants take up nitrates, and his compatriot, Archibald Cochrane, noted the fertilising effects of calcium phosphates. However, the dominant hypothesis in this period regarding plant nutrition was what became known as the 'humus' theory. This was first put forward by Külbel in 1740, and elucidated further by Wallerius in his 1761 tome, *Agriculturae Fundamenta Chemica*. In brief, the theory argued that the 'principle of vegetation' (that is, the singular source of plant food) was decayed animal and plant matter in the form of mould. Other constituents in the soil, such as soil minerals and water, were lifeless and did not contribute to plant growth directly, but instead were needed to convert the humus into a form usable by the plant. Subsequently, its adoption by two giant figures in the natural history world, that is, Count Buffon in France, and Carl von Linne (the famous founder of the Linnean classification system of genus and species) in Sweden, almost guaranteed its diffusion amongst the European scientific community.

To sum up, by the end of the eighteenth century a series of changes in farming practice, led by the introduction of root crops and legumes into traditional cropping systems, had transformed, or at least were transforming,
agricultural production in northwestern Europe. With the cultivation of these crops, farmers were able to restore levels of plant-available nitrogen in the soil without resorting to either fallowing, or inputs from areas under permanent pasture, and thus they were able to farm all of their land intensively. Yet while the 'agricultural revolution' had solved the problem of nitrogen supply, it would soon pose equally vexing questions about the supply of inorganic nutrients, most notably phosphorus. A further weakness was that the advances in managing soil fertility had been empirically, rather than theoretically, based; in the absence of a sound theoretical basis (the 'humus theory' would soon be proved erroneous), it would be difficult to adapt the 'agricultural revolution' to take account of new and unfamiliar environments.
Notes to Chapter Two


5 Bacon et. al., *Agricultural Geography of Europe and the Near East*, pp. 15 & 17.


7 Bacon et. al., *Agricultural Geography of Europe and the Near East*, pp. 15 & 17.


10 Bacon et. al., *Agricultural Geography of Europe and the Near East*, pp. 15 & 17; Cruickshank, *Soil Geography*, pp. 120 & 122.


14 Bacon et. al., *Agricultural Geography of Europe and the Near East*, pp. 16-7; Cruickshank, *Soil Geography*, p. 148.


24 Cereals, in terms of composition, are not large aggregate consumers of nitrogen, but yields show a strong nitrogen response, because the short growing season means they have to take up nitrogen rapidly. Aikman, C. M., *Manures and the principles of manuring* 3rd ed. (Edinburgh, 1894), pp. 493-4.


26 Overton, *Agricultural Revolution in England*, pp.16-7; Shiel, R. S., 'Improving soil fertility in the pre-fertilizer era'. In Campbell & Overton (eds.), *Land,Labour, and Livestock*, p. 64.


35 Pounds, *An historical geography of Europe 1500-1840*, p. 34.


39 Slicher van Bath, *The Agrarian History of Western Europe*, p. 244.


45 Pounds, *An historical geography of Europe 1500-1840*, p. 184; Shaw, 'Manuring and Fertilising the Lowlands'. In Foster & Smout (eds), *The History of Soils and Field Systems*, p. 115.

Mingay (ed.), The Agricultural Revolution, pp. 33-4; Woodward, "Gooding the earth". In Foster & Smout (eds.), The History of Soils and Field Systems, p. 104.


When creating the 'plaggepts', the source area for manure and fertiliser was 10-20 times the size of the depositional area. Cruickshank, Soil Geography, pp. 204-5; Foth, Henry D. and Schafer, John W., Soil Geography and Land Use (New York, 1980), pp. 429-30.

Overton, Agricultural Revolution in England, p. 3.

Pounds, An historical geography of Europe 1500-1840, p. 35; Slicher van Bath, The Agrarian History of Western Europe, p. 244.


Overton, Agricultural Revolution in England, p. 3.


Ibid., p. 117.

Mingay (ed.), *The Agricultural Revolution*, p. 11.


Ibid., pp. 89-91.

Ibid., p. 77.


Ibid., p. 280.


Pounds, *An historical geography of Europe 1500-1840*, p. 36.


Fussell, *Crop Nutrition before Liebig*, p. 86. Virgil's 'pit test' involved the measuring of the 'fatness' of a soil by measuring the extent to which a dug out soil pit could be refilled when the excavated soil was pressed back into it (Ibid., pp. 23-4).


Krupenikov, *History of Soil Science*, pp. 90-1; Fussell, *Crop Nutrition before Liebig*, p. 120.

See, for example, Buffon's 'Histoire Naturelle', in *Ouvres Completés de Buffon: avec des extracts de Daubenton et la classification de Cuvier* (Paris, 1858-61), I, p.121.
Chapter Three

Paradise Found? The Appraisal of Soil Fertility in New Zealand 1769-c.1841

During the eighteenth century, the zeal for domestic 'improvement' within the nations of northwestern Europe (of which the 'agricultural revolution' was just one facet) was also translated into the rapid overseas expansion of the Western European mercantile, scientific, and political spheres. Often, this process concluded with colonisation. When it did, a key driver of the economic and environmental behaviour of the first wave of colonial settlers would be the knowledge that had been gained, and more importantly, the perceptions that had been created, of local natural resources, by accounts of explorers and pioneer settlers during the pre-colonial period.

I. Not a Great South, but a Fertile Land

Since, in the event of colonisation, many settlers were likely to be involved in agricultural pursuits, one of the most critical natural resources was the soil. However, the undeveloped state of European soil science, described in Chapter Two, meant that the assessment of soil fertility beyond the locally-experienced environment, or at least the local biogeographical environment, was on an uncertain footing. In the absence of familiar soils, the best reckoning method for the late eighteenth-century and early-nineteenth century explorer-naturalist was to examine the quantity of vegetable mould in the soil (an absence of which was denoted by the term earth) since, if the 'humus theory' was to be believed, the quantity of vegetable mould represented the supply of potential plant food. This required in situ field observation, so in practice it proved easier to use the amount of biomass, or even the height of the local trees (which could be readily gauged from on board ship) as a basis for soil assessment. A direct proportionality between vegetation height and soil fertility was commonly, and sometimes blindly, assumed. The finding of lush vegetation, incidentally, also ruled out an arid climate.

Such an approach was employed during the voyages to New Zealand by Cook, de Surville and du Fresne. Consequently, Cook and the scientists who accompanied him on the first voyage responded to the instruction "to observe the Nature of the Soil, and the Products thereof" by repeatedly annotating their
journals with descriptions of the luxuriant appearance of its vegetation. In judging levels of fertility, Cook took particular note of the presence of forest:

The Country Especialy on the East side [of Whitianga Harbour] is barren and for the most part distitute of wood or any other signs of fertility but the face of the Country on the other side looked much better and is in many places cover'd with wood.

Likewise, Parkinson, remarked that the country near East Cape "was divided by fine deep valleys, and had all the appearance of a rich fertile country, being cloathed with large verdant trees ...". Comments in the journals of de Surville and de Clesmeur (a companion of du Fresne) reveal that the French drew similar inferences.

Generally the reverse was also held to be true, that is, an absence of forest implied sterility. Describing the Whitianga River, Cook wrote that "the Country on the SE side ... is very barren produceing little but Fern and such other Plants as delight in a poor soil". Similarly, Parkinson, when talking of the Bay of Plenty, observed that the "coast hereabout appeared very barren ... and has very few trees upon it".

The presence or absence of woodland was not, however, the only indicator used in soil fertility appraisal. Cook, in particular, also took into consideration the presence of Maori cultivations. While off the Bay of Plenty coast, Cook noted seeing "a great deal of Cultivated land laid out in regular inclosures a sure sign that the Country is both fertile and well inhabited ...". Banks also remarked, in his summary account of New Zealand, that on the northern and eastern coasts of New Zealand he had seen "very large tracts of Ground which either actualy were or very lately had been cultivated". These were absent from the 'barren' southern and western coasts. Banks' next statements were more in keeping with a 'biometrical' approach though, as he reported seeing

Swamps, which ... sufficiently evincd the richness of their soil by the great size of all the plants that grew upon them, and more particularly of the timber trees which were the streightest, cleanest, and may I say the largest I have ever seen ...

The two indicators - tree height and extent of cultivation - were not always consistent though. While at Mercury Bay, Cook commented that "the whole is Cover'd with Woods and Verdure and looks to be pretty fertile but we saw but a few small places that were cultivated".
In contrast to these two easily observed measures, the less obvious physical characteristics of the soil, such as colour and texture, tended to be overlooked, aside from the observation being made that Maori agriculturalists used light and sandy soils. The Maori practice of textural modification, described in Chapter One, seems to have gone entirely unnoticed. Amongst Cook's companions, only J. R. Forster, who went on the second voyage, described soil texture other than in references to vegetative moulds. Their only mention of soil colour, meanwhile, was in occasional references to black moulds. In this regard the French parties were more observant, albeit only in their recording of the striking red loams and white (siliceous) sands of Northland.

The overall impression gathered by these early forays to New Zealand was that a considerable part of the North Island must be covered by rich soils, since it was under either forest or in cultivation. Hawkesworth's popular *Account of the Voyages Undertaken by the Order of his Present Majesty for Making Discoveries in the Southern Hemisphere* (1773), which was based on the journals of Cook and Banks, reported that

the hills and mountains [of *Eaheinomanwe*, i.e. the North Island] are covered with wood, and every valley has a rivulet of water; the soil in these valleys, and in the plains, of which there are many that are not overgrown with wood, is in general light but fertile; and in the opinion of Mr. Banks and Dr. Solander, as well as every other gentlemen on board, every kind of European grain, plant, and fruit, would flourish here in the utmost luxuriance; so that if this country should be settled by people from Europe, they would, with a little industry, be very soon supplied, not only with the necessaries, but the luxuries of life, in great abundance.

The construction of this assessment in part reflected the stark contrast between the denuded hardwood forests of northwestern Europe and the luxuriance of New Zealand's primaeval (and largely evergreen) vegetation, which tended to be viewed in almost Edenic terms. Parkinson, for instance, wrote that "the country round about the [Tolaga] bay is agreeable beyond description, and, with proper cultivation, might be rendered a kind of second Paradise". This contrast was further enhanced both by the exotic nature of New Zealand flora, and the fact that it represented a sensory respite from the tedium of long sea voyages.

In spite of such rapturous accounts of the North Island, the final assessment of the South Island arrived at by both Cook and Banks, and thereby found in Hawkesworth, was much less charitable; it was described as mountainous and apparently barren. This appraisal was largely reversed, however, after the coastal
explorations made at Dusky Bay and Queen Charlotte's Sound during Cook's second expedition. Following these forays, J. R. Forster pronounced in his *Observations made during a voyage round the world* (1778) that the constant creation and destruction of the forest in the "Southern parts of New Zealand", which he termed "one of the oeconomical actions of nature", had resulted in the "hoarding up" of "a precious quantity of the richest mould, for a future generation of men, who, one day or other, will live upon the rich products of this treasured soil". On the other hand, Forster's unpublished journal reveals that this mould was very limited in quantity. As he put it, "if you examine these hills & their Soil, you are surprised to see that they are all a barren rock & are only here & there thinly covered with a kind of light Soil ...".

II. Getting a better sense of the soil

The promising appraisal of New Zealand's 'virgin' soils made by European explorers on the basis of a 'biometrical' approach, which prompted the Home Office in the 1780s to assert their superiority "to the exhausted Soil of Europe", scarcely altered during the next half century. Indeed, for the first half of this period, when European recourse to New Zealand was limited to the supply of whales, seals, flax, and spars, soil fertility attracted little attention. Vancouver's journals are silent on the subject, and reports of an exploratory voyage to Dusky Bay from New South Wales in 1793, while noting the extent of humus in the soil, had nothing else to add. "So little was said of the soil", the Sydney officials observed, "that no judgement could be formed of any advantages" to be gained by its possession.

Consequently, for the time being, the published accounts of the early exploratory voyages remained authoritative. As late as 1817, John Nicholas, who accompanied Samuel Marsden in the Bay of Islands during 1814-5, chose largely to paraphrase Hawkesworth when describing the agricultural potential of the North Island:

The whole of the northern part of New Zealand, and much of the southern likewise, are admirably adapted for the growth of every kind of grain, as also of various other productions ... In fact, there is scarcely any production ... which this country, with moderate labour, could not furnish, if we except those plants which require the heat of a tropical sun to bring them to perfection.
Having said this, in the case of the South Island, Nicholas judged the Forsters' conclusions more reliable, despite not having seen it himself:

the southern island, into which we had not an opportunity of penetrating, is described by Captain Cook as mountainous and apparently barren. Yet though this part ... might have presented ... a less vivid surface than the northern quarter, still this should not be taken as a certain indicator of barrenness; and from the astonishing height of the trees growing upon it, as well as from their great abundance, it would seem the soil must be rather fertile than otherwise; ... were it properly cleared and tilled ... the husbandman, in my opinion, would have no reason to complain of its sterility.31

With the commencement of semi-permanent and permanent European settlement, however, localised amendments and additions to this overall picture began to be made. John Savage, for example, in the first published work devoted solely to New Zealand, remarked with respect to the Bay of Islands that:

The country in the immediate vicinity of the bay is almost destitute of wood, though there are immense forests at fifteen or twenty miles distance. The soil is a light vegetable mould, but rich, as it would appear from the vegetation it produces.32

In contrast to Savage, who still followed the logic of deducing fertility on the basis of the amount of covering vegetation, Nicholas, when summarising his observations made during "excursions into the [Northland] interior", was to pay more notice to the composition of the soil itself:

the soil varied in its quality, but generally appeared extremely fertile; the hills were composed, for the greater part, of a stiff clay; and the valleys consisted of a black vegetable mould, producing fern of the most luxuriant growth ...33

A similar degree of attention to soil texture, as much as vegetation, when giving an account of land is also revealed by comments in Samuel Marsden's journal of 1814-5:

... about one o'clock we set off for Wymattee [Waimate]. For the first three or four miles we passed through a rich, level, country ... It appeared to me to be good strong wheat land and was covered with fern. For the next six miles the land was of various qualities, some exceedingly good, some stony, some swampy, and some of a gravelly nature. The whole of
this tract of country, taken collectively, would form a good agricultural settlement.\textsuperscript{34}

In this regard, it is noticeable that when Marsden visited Auckland in 1820, he alluded to both soil texture and the presence of Maori cultivations when pronouncing the slopes of Mount Wellington well suited for agriculture:

I spent part of the day in walking through the potato grounds ... Near the settlement there is a very high hill ... Its top and sides have every appearance that it is the production of some volcanic eruption. On the east side the flat land for the distance of near a mile is covered with stones of various dimensions ... The soil, both amongst the stones and where there are none, is a very rich, dark brown loam and fit for all the purposes of vegetation. Agriculture by the plough might be carried on here to a very considerable extent ...\textsuperscript{35}

The increase in attention given to the physical characteristics of the various soils, reflected an increasingly familiarity with them, which was concomitant with permanent European settlement, but it may also have been influenced by a change in contemporary Western European thinking about soils. Leading the way was Sir Humphry Davy's popular treatise \textit{Elements of Agricultural Chemistry, in a course of lectures for the Board of Agriculture} (1813).\textsuperscript{36} Davy believed, in principle, in the humus theory of plant nutrition:

... are the pure earths in the soil merely active as mechanical, or indirect chemical agents, or do they actually afford food to the plant? This is an important question; and not one difficult of solution.

The earths consist ... of metals, united to oxygen; and these metals have not been decomposed; there is consequently no reason to suppose that the earths are convertible into the elements of organized compounds, into carbon, hydrogen and azote.\textsuperscript{37}

Nevertheless, Davy also perceived that physical soil properties could also affect fertility. Consequently, he stated that "the temperature of the surface, when bare and exposed to the sun, affords at least one indication of the degrees of its fertility", and "the power of soils to absorb water is much connected with fertility ... so that it affords one method of judging of the productiveness of land".\textsuperscript{38}

Given future soil classification methods, it is interesting that Davy further argued that slope position, and the textural (and, by extension, geological) nature of the underlying subsoil were also of interest, since these helped determine the levels of soil moisture, assuming climatic factors to be equal.\textsuperscript{39}
The inclusion of the character of the soil itself when interpreting soil fertility, which is apparent in the above comments of Marsden and Nicholas, as opposed to a purely 'biometrical' approach, was also evident in contemporary hearings conducted into the state of New Zealand by J. T. Bigge, the Commissioner of Inquiry into the State of New South Wales. Bigge's initial interest in New Zealand was preventing abductions of Maori by visiting ships, but when a proposal to colonise New Zealand, which asserted that it would be an ideal home for colonists on account of its "space being so ample for their industry, the soil so fertile, the climate salubrious, its capacious rivers and fine harbours", appeared in 1821, he broadened the scope of his investigations. Most of Bigge's evidence on New Zealand soils came from Ensign McCrae (84th Regiment) and Dr. Fairfowl, who visited the Bay of Islands and Wangaroa Harbour during 1820 on the Dromedary. McCrae employed colour and texture in stating that the valley soil in the Bay of Islands contained a "fine loose mould, sometimes black and sometimes red", while at Wangaroa Harbour it was "a light red sand with clay below". Fairfowl, meanwhile, added geological description. The Bay of Islands hills, he remarked, were "composed of basalt, covered with a stiff cold and poor clay, with a mixture of iron in it". Interestingly, Fairfowl also observed that "the bad soil generally exceeds the good" (which was indeed the case near the original mission stations) and that when "the fern approaches the height of six feet or so, the land may be considered to be of good quality". The latter comments were omitted from Bigge's private report to the Earl of Bathurst though, which confined itself to noting that the valley soils observed to date contained "large deposits of rich, alluvial soil", while the hills were covered by a "poor and tenacious clay, with a considerable admixture of iron". Despite such "limited information", Bigge concluded that in "rivers, harbors, soil, and natural productions, the superiority [relative to New South Wales] of New Zealand is manifest".

It may also be observed in the comments of Marsden, Nicholas, and Fairfowl that Cook's inference that 'fern' (bracken) only grew on inferior soils was no longer being adhered to. Indeed, Nicholas' remark, "we observed the land covered in most places with fern; and this is considered the best indication of its fertility", implies that land where 'fern' grew profusely was regarded as being potentially as valuable as forested land. This change in reputation seems to have been based on the opinion of local Maori engaged in wheat cultivation, and also, one may suspect, an eventual realisation by Pakeha (non-Maori) that the ecology of the New Zealand (Pteridium esculentum) and British (P. aquilinum) species of
Bracken differed significantly. As it turned out, the similar appearance of the two brackens, which are shown side-by-side in Figure 3.1, meant that the mistaken belief was not entirely extinguished for several decades. The setting of a lower limit - Fairfowl, following Nicholas' example, opted for six feet - on the frond length of 'fern' said to be on good land, moreover, avoided areas which were naturally unsuited to plant growth, or those where bracken had invaded exhausted Maori cultivation plots, as it was apt to do.

Conversely, closer observation of Maori agricultural practices suggested that the European prejudice against 'fern land' might be justified. It was established during Cook's voyages that Maori agriculturists burnt off land prior to cultivation, although the first to actually publish this finding was John Nicholas. Now it was evident that wooded and alluvial land was cleared in preference to land covered with either "heath or fern". As Richard Cruise (one of the company aboard the Dromedary) noted in his Journal of a Ten Months' Residence in New Zealand (1823), "the natives cultivate the low and the forest ground, where the land is rich; they never think of reclaiming any land that seems to be poor". This avoidance of 'fern land' by Maori agriculturists was probably due to the difficulty of subsequent cultivation, since it required the removal of the bracken's extensive root system. Apart from the problem of regrowth, the roots, if left in the ground, severely hampered tillage. Furthermore, the substitution of kumara by white potato cultivation, which is discussed in Chapter Five, also favoured organic matter-rich forest soils. Given the apparent paradox, in that what was deemed fertile might also be shunned for the purposes of cultivation, it is understandable that the correct appraisal of 'fern land' continued to be a matter of debate.

In the assessment of soil fertility in areas yet to be settled by Pakeha, where cultural interaction between Maori and Pakeha was still negligible, the biometrical approach continued to be applied, however. One example of this is the observations made by Thomas Shepherd, surveyor to the New Zealand Company of 1825, during an exploration of Stewart Island, which was clad largely with vegetation he was unfamiliar with:

Had an excursion ... into the woods ... in search of spars and found a Valley ... where one here and there were growing [trees] to the height of 40, 50 and 60 feet ... The ground in this valley is very good in quality and would make a fine garden ...55

Having said this, when he was able to do so, Shepherd described not just vegetation cover, but soil texture and colour as well, which suggests he did not
Figure 3.1
New Zealand and British bracken compared


(illustration below): Silhouette of bracken (*Pteridium esculentum*) frond from driveway of author's home.

It should be noted that *Pteris aquilina* was an earlier name for *Pteridium aquilinum*.

Although they looked very similar at first inspection, one point of difference that would have become familiar to settlers is that whereas the British bracken dies off in autumn, the New Zealand version remains green and stands upright throughout winter (see Winterbourn, M. J., 'The arthropod fauna of bracken (*Pteridium aquilinum*) on the Port Hills, South Island, New Zealand). *New Zealand Entomologist* 10 (1987), p. 100.)
trust the 'biometrical' approach entirely. At Otakou [Otago Harbour], for example, Shepherd reported that the land was "of excellent quality being a rich brownish loam capable of producing any kind of grass and corn in the greatest perfection". Similarly, he observed in the Hutt Valley a "light sandy soil earth and marshy or boggy ground with many lakes" along the shoreline, while inland from this there was "a rich loamy soil of a great depth". Ultimately, the New Zealand Company determined that the most suitable site for their colony would be the well-timbered Hokianga. However, the Company settlers who arrived at Herd's Point in the Hokianga in 1827 reacted favourably neither to what Captain Herd claimed was "its richness, and fertility and capabilities", nor to a haka performed by local Maori. Consequently, they departed for Sydney almost as soon as they had arrived.

III. Style versus substance

The failure of the first New Zealand Company's efforts did not diminish British interest in New Zealand, and more especially, its viability as the site of a future colony. Consequently, an ever-increasing number of published works on New Zealand appeared during the 1830s. The appraisal of soil fertility in these works relied predominantly on the biometrical approach, which, unlike appraisal based on geology and soil texture, suited the description of the New Zealand environment in terms which were general, rather than particular. The use of this more theoretical basis for making generalisations also helped disguise the fact that much of the information was being transmitted by authors who themselves had only a limited firsthand knowledge of New Zealand. Such a work was George Craik's *The New Zealander* (1830). In it, Craik wrote that "the quality of the soil of this country may be best estimated from the profuse vegetation with which the greater part of it is clothed, and the extraordinary vigour which characterizes the growth of its production". In a similar vein, Thomas McDonnell, stated in a speech to the Royal Geographical Society in 1834, that "the soil of New Zealand [as he termed the North Island] is uncommonly rich, and easy of culture; ... the hills, in many parts, rise with a gradual ascent, until they terminate in lofty mountains, clothed with verdure all the way up". Turning to 'Poenamoo' (the South Island), he remarked that "the land is rich, thickly wooded in some places, with abundance of level ground for all the purposes of cultivation". The artist Augustus Earle, meanwhile, was even more sanguine when it came to New Zealand's agricultural potential:
I never possessed any practical knowledge of farming, and therefore cannot give a scientific opinion or description of the different soils. In whatever direction I travelled ... the soil appeared to me fat and rich, and also well watered. From every part of it which the natives have cultivated, the produce has been immense. Here where ... the largest and finest timber grows, and every vegetable (yet planted) thrives, the introduction of European grasses, fruits, etc., etc., would be a great desideratum. Were this done ... farms would be more eagerly sought after here than they are in New South Wales. 63

Australian colonists were naturally alert to this threat to their supply of colonial capital. Amongst the few discordant notes on New Zealand was a piece in the Launceston newspaper The Independent, which asserted that the country between Hokianga and the Bay of Islands was "as sterile as it is possible for land to be". 64 As for the country as a whole, it remarked that "if the good land bore any proportion to the bad, I would say that New Zealand was one of the finest countries of the world". 65

In the meantime, the prejudice against 'fern land' in general continued to break down. As Robert Fitzroy noted during the Beagle’s visit to New Zealand,

> To see fern every where, was a remarkable peculiarity. In some places it grew thickly, and to the height of a man, in others it was scantily scattered. It is said to be an index to the quality of the soil, which is productive in proportion to the quantity. 66

A significant factor in this more optimistic assessment of 'fern land' was the finding that cattle were able to successfully feed on New Zealand bracken. Augustus Earle reported, for example, finding a herd of fat cattle at Kerikeri, which despite "having nothing but this very fern to eat" still gave "as good milk ... as when they grazed on the rich grasses of Lincolnshire". 67 It was also ascertained that land covered by bracken could quickly be turned into pasture in areas which were subject to managed burning and grazing by cattle. 68 However, it is evident from the observations made by Charles Darwin that the first thoughts of newcomers when confronted by bracken were still likely to be negative ones. In his journal, Darwin stated that "the sight of so much fern impresses the mind with the idea of sterility. This, however, is not the case; for wherever the fern grows thick and breast-high, the land by tillage becomes productive". 69

At about the same time as Darwin wrote this in his journal, which was not published until 1839, knowledge of soil-plant habitats in forested areas was being
transformed by William Yate, via his 1835 work *An Account of New Zealand*. Initially, Yate gave an appraisal of the quality of New Zealand soils in traditional biometric terms, stating that the "forest-land is peculiarly rich: indeed were it not so, it would be utterly impossible that the immense vegetation constantly going on should be supported". As for 'fern', he remarked that it grew "nine or ten feet high, in good ground", thereby making it clear that 'fern land' was not necessarily infertile. As was usual in such works, Yate also gave an extensive commentary on the agricultural potential of the new colony:

We have here almost every variety of soil. Large tracts of good land, available for the cultivation of wheat, barley, maize, beans, peas, &c.; with extensive valleys of rich alluvial soil, deposited from the hills and mountains, and covered with the rankest vegetation ... We also have a deep rank vegetable mould, with a stiff marly subsoil, capable of being slaked or pulverised by the ashes of the fern. All English grasses flourish well ...

What made Yate's observations remarkable, however, was his subsequent remarks matching tree species to particular soils - a major advance on the biometrical approach where no distinction between tree type was made. Rewarewa (*Knightia excelsa*), for example, was said by Yate to be found "in dry forests, and where the soil is loose and gravelly in its texture"; while kauri (*Agathis australis*), on the other hand, grew on "a stiff, hard, clayey soil". Land covered by kahikatoa, better known as manuka (*Leptospermum scoparium*), meanwhile, was, by inference, to be avoided; this was to be found "flourishing in clayey barren soils". While this type of ecological (or, technically speaking, edaphic) analysis had a long history in other colonial settings, it had hardly ever been used previously in a New Zealand context.

Now, thanks to Yate, the well-read emigrant could select land merely by knowing what trees (or alternatively what height of bracken) were found upon it. Yate's powers of observation in regard to soils did not end here, as he gave a highly detailed description of the soil around the mission station at Waihite, especially its physical character. Furthermore, his work contained the first published details on the Maori practices of adding sand or gravel to cultivated soils, and of adding ashes of burnt vegetation to improve fertility.

Regrettably, in the New Zealand Association's *The British Colonization of New Zealand* (1837), which provided geographical description in much more detail than previous works, the general comments by Yate were prominent, but nothing was made of his ecological insights (although they were included).
Indeed, the overall style and structure was akin to that of the brief accounts of New Zealand which appeared earlier in the decade. The description of the Motukaraka valley of the Hokianga, which amounted to an observation that "towards the source of this river there are two fine valleys of rich alluvial soil, thickly wooded with fine timber", was fairly typical. As one would expect, the information provided in areas where Pakeha experience was limited tended to be fairly sketchy, and for much of the west coast of the South Island the records of Cook's voyages were relied upon. Maori testimony was also called upon in relation to soil fertility in these areas. Such advice allowed the Association to announce in this work that Taranaki's soils were highly fertile.

Perhaps the greatest significance of this work, however, was the development of what may be termed 'wasteland theory'. Since the time of Bigge's report, comments had been made about the apparent disparity between the size of the Maori population and the supposedly abundant fertility of New Zealand soils, which seemed to indicate that the country might support a vastly increased population. This was a tenet which the colonial ambitions of the New Zealand Association made it keen to support, and it was to become one of the central justifications of their colonisation programme:

Another argument in favour of the colonization of New Zealand arises from the want of a sufficient native population for so extensive and fertile a country. There is an abundance and to spare of vast unoccupied territory, without encroaching on what is required by the native population, - a surplus which they are most desirous to sell.

The number of the inhabitants is very small, quite insignificant in proportion to the immense fertile territory they possess.

In keeping with the promotion of the fertility levels of New Zealand soils, the New Zealand Association's tome also depicted Maori agricultural practices as inefficient, to the point of asserting that the plentiful produce observed was still only one-tenth of what could be produced using European methods:

In general among the natives there is no approach to any system of agriculture, cropping or manuring. And consequently, the quantity of land under cultivation does not produce one-tenth part of what it is capable of producing; and in point of extent, compared with equally fine soil, previously brought into cultivation, but temporarily neglected and left waste, it is far less than one-tenth.
Finally, in an even more extraordinary step, the 'virgin' status of New Zealand's soils was 'restored' through the dismissal of Maori agriculture as a non-entity:

... the quantity of land brought under cultivation is a mere nothing, in comparison with the boundless primeval forests, whose magnificent timber has been thriving undisturbed, and enriching the soil with its decomposed vegetable matter, for thousands of years ... a fact most important, with a view to colonization. We have ascertained ... that in the southern islands there is no agriculture or appropriation of lands to interfere with colonization, and that in the northern island, where the missionaries are, the quantity cannot amount to more than a very few thousand acres. The inhabitants live almost entirely upon fish, birds, and roots, and the uncultivated productions of the earth. The fisheries alone, if properly conducted, would support five times the actual population. The aborigines are, in fact, no charge upon the soil.  

These arguments of the Association were soon put under close scrutiny by the 1838 Select Committee of the House of Lords on New Zealand. In the main, the evidence heard by the Select Committee was consistent with the New Zealand Association's opinions on soil fertility in New Zealand, that is, firstly, that the soils were generally rich, secondly, that they were well suited to the production of grain, and thirdly, that the Maori population was significantly smaller than the land was able to support. While it would appear from the questions asked that the Select Committee accepted these assertions, the contention that Maori had only a primitive and superficial agriculture was made doubtful by some of the witnesses' testimony. Joseph Montifiore, for instance, professed to have seen 1000-1500 acres under cultivation just in the vicinity of Kawhia. Moreover, the Committee was also informed by John Nicholas that a lack of cultivation did not necessitate a lack of proprietorship:

You state that the Land sold to the Missionaries was tabooed, and that for their own Cultivation was also tabooed? - Yes. Did you conceive that this Form made the Lands private property, and that the rest was Waste? - No; it was to prevent People from injuring the Crops and trespassing on private Property; but the uncultivated land was not considered as waste or unappropriated land; the whole was looked on as Property. The Nation have very distinct Ideas of Property in Land.

Testimony such as this, coupled with the repeated warnings of the missionary establishment that land purchases on a large scale would result inevitably in Maori-
Pakeha conflict, as well as jeopardising the good work of the missionaries themselves, caused the Select Committee to shy away from turning the colonisation of New Zealand over to the Association. Instead it declared that "the Extension of the Colonial Possessions of the Crown is a question of public Policy which belongs to the decision of Her Majesty's Government".

This setback, together with the failure of two bills brought before Parliament on its behalf, helped spell the end for the Association. Edward Gibbon Wakefield's goal of New Zealand's systematic colonisation was kept alive, however, by its successor organisation, the New Zealand Colonisation Company.

Confident that they would achieve official recognition, the directors issued a pamphlet entitled *The New Zealand Colonisation Company (1838) to be Incorporated by Charter, or Act of Parliament*. This pamphlet, which included claims that the "average nature of the soil is a rich alluvial", and that both islands were "extremely fertile and capable of the highest degree of cultivation", can be seen as the first in a series of publications over the next decade by, or in association with, the Company, which was now marketing the image of New Zealand to potential emigrants directly, rather than to Colonial administrators.

This promotion became even more earnest in May 1839, when the renamed New Zealand Land Company, after discerning that the British government was itself intending to take charge of land sales in New Zealand, dispatched an expedition to make extensive land purchases prior to the Crown's move taking effect. In the meantime, it went about on-selling the as yet unpurchased land, notwithstanding the claim in its prospectus that "very extensive tracts of most fertile land" had already been "secured".

Amidst all this activity by the New Zealand Land Company (later just the New Zealand Company), Joel Polack's two volume *New Zealand* (1838), and its companion *Manners and Customs of the New Zealanders* (1840), were published. These contained several observations on the fertility (or infertility) of land throughout the northern North Island. At the Thames, for example, land was "well fitted from its fertility for the labours of the agriculturist", whereas the stiff clay soils made land in the Kaipara district "unfitted for the labours of the agricultural migrant". Upon the latter, Polack remarked, one could find only stunted fern and kahikatoa (manuka); both signs, Yate had noted, of an infertile soil. When discussing the fertility of New Zealand soils in general, Polack's *New Zealand* followed a biometrical argument:
The soil of the country differs materially in every mile of latitude; the hills are formed of a hard stiff clay, but the many valleys are filled to some depth with a nutritious mould ... that it must be of a superior nature, the vigour and luxurious growth of the various indigenous productions throughout the country, will best testify.  

This statement was quite ordinary, but it was given added significance when Polack paraphrased it in his *Manners and Customs of the New Zealanders*, in which he described the "nutritious mould" as being composed of "earthy matter washed from the hills, and the debris of leaves and decayed wood, forming a compost of excellent manure...". This analogy between leaf litter and manure was later exploited by the New Zealand Company, who used it to argue that new colonists would not, initially at least, have to manure land to keep it fertile.

**IV. Absolutely Fabulous**

For the New Zealand Company, the favourable impression of New Zealand generated by previous writings served their selling of New Zealand as a South Pacific Eden well. Indeed the first major publication by the Company, John Ward's *Information relative to New Zealand, compiled for the Use of Colonists* (1839), reproduced verbatim the compendium of favourable extracts in *The British Colonization of New Zealand* from authors such as Hawkesworth, Nicholas and Earle. To add weight to this commentary, Ward added extensive, but carefully selected, portions of the testimony from the 1838 Select Committee hearings. Basic statements on local geography were also provided. The Hokianga, for instance, was said to have "rich alluvial soil, with much fine timber", while the "shores of Cook's Straits" were labelled "a highly desirable emigration field" on account of the "uniform fertility of the soil, including much rich pasturage" and the excellent anchorages found there. At a more general level, Ward pointed out that New Zealand's surface area was almost as large as Great Britain, and, furthermore, it was believed that "at least two-thirds" were "susceptible of beneficial cultivation". Even without allowing for the superiority of its climate and soil, Ward argued, it would be capable of supporting the British population.

To show that New Zealand soils were indeed fertile, Ward used the biometrical and ecological approaches in combination. As he put it, "the excellence of the soil and climate of New Zealand will be best proved by an enumeration of
the principal of its natural productions". Rather than follow this statement with wild generalisations, Ward instead reproduced Yate's account of forest trees of New Zealand, thereby retaining one of the few truly informative sections from *The British Colonization of New Zealand*. Once again, however, the full significance of Yate's analysis for land evaluation was never explicitly stated.

Yet if Ward (who was Company Secretary) genuinely wished to educate the potential emigrant, other proponents of New Zealand colonisation - many, but not all, of them associated with the New Zealand Company - were not concerned to clutter their marketing pitch with detail. The resulting publicity material generally took one of two forms: on the one hand, there was a number of short accounts, which, presumably to gain credibility, stuck closely to existing sources, whereas on the other hand, there was less inhibited literature, in which the authors were guided mainly by their imagination.

Amongst the former type, which were kept cheap so as to make them available to members of the "labouring class", was William Young's *New Zealand described* (1840). This pamphlet duplicated Ward's claim that "the soil is of a rare fertility: two thirds of it are supposed to be capable of culture", before proceeding to give a synopsis of the general description of New Zealand soils given in *The British Colonization of New Zealand*:

The soil is varied in character. In the valleys it is a rich alluvial land ... There is also a deep mould, with a stiff, marly subsoil ... in all directions the land is fat and rich. The pasturage is said to be the finest in the world. Thus the soil is equally suited for the growth of corn and the growth of wool.

The author of *A Popular Account of New Zealand* (1839), meanwhile, simply repeated the relevant passages from *The British Colonization of New Zealand* in full. For the most part, this general information was all that was provided in such works; the only specific details on soils were invariably observations of great fertility in particular areas, such as the Hokianga and the Thames. Mention of soil colour and texture, other than those in the reproduced extracts, was practically non-existent.
Perhaps it was just as well that the authors of the aforementioned works relied so little on their own initiative. Those who did, included so much hyperbole and misinformation, either deliberately or accidentally, in their portrayals of New Zealand, that they verged on the fantastic. One of the more notable examples of this 'pulp-faction' was Patrick Matthew's *Emigration Fields: North America, the Cape, Australia and New Zealand* (1839). Like many others, Matthew saw the reputed ability of southern as well as northern European crops to grow in New Zealand as proof of a benign climate, while for evidence of the fertility of the soil, he observed that "the small portion of New Zealand already under cultivation, yields, in luxuriant abundance and perfection, all the valuable fruits and grains of Europe". Matthew concluded from this that New Zealand's indigenous population level was "quite out of all proportion to the extent of its territory". Accordingly, he thought it entirely just that migrants from "densely populated Britain" should come to this "untenanted wilderness" which could "lay claim to the name of PARADISE". Matthew's enthusiastic praise for New Zealand was tame, however, when one considers the claims made by Alexander Johnson. A report of 'the Great New Zealand Meeting in Glasgow' (one of several meetings organized in association with the New Zealand Company), records that Johnston asserted that

the islands of New Zealand were in size about equal to those of Great Britain ... possessed a soil of the richest kind, minerals of the most valuable description ... consisting of copper, lead, tin, diamonds, and coal; and they were plentifully productive of any fruit of the earth.

Given such fanciful remarks, it is no wonder that, in order to remain convincing, John Ward included in his manual for Company agents the request that they "avoid exaggerating the advantages of the colony".

This idyllic imagery was to be further built on by the Company-friendly *New Zealand Journal*, which began fortnightly publication on 8 February 1840, just in time to enthrall readers with the reports being sent home by Colonel William Wakefield, who was leading the Company's preliminary expedition. William Wakefield, who, as shown in Table 3.1, was one of several Wakefield family members intimately involved with New Zealand's colonisation, was instructed by
Table 3.1: The Wakefield family and the colonisation of New Zealand

(Individuals mentioned in Chapters Three and Four listed in bold type).

Edward Wakefield (1774-1854) m. Susannah Crush (1767-1816).
   Issue: 1. Catherine Gurney Wakefield (1793-1873)
   2. **Edward Gibbon Wakefield** (1796-1862) m. Eliza Pattie (1799-1820)
      (Founder of New Zealand Association and New Zealand Company.
       Settled at Wellington 1853-62).
      Issue: 1. Susan Priscilla Wakefield (1817-1835)
      2. **Edward Jerningham Wakefield** (1820-1879)
   3. Daniel Bell Wakefield (1798-1858)
      (Settled in Wellington 1843-58)
   4. **Arthur Wakefield** (1799-1843)
      (New Zealand Company's Resident Agent at Nelson, 1841-3).
   5. **William Wakefield** (1801-48)
   6. John Howard Wakefield (1803-62)
   7. **Felix Wakefield** (1802-75)
      (Author of *Colonial Surveying*, a text employed in the survey of the Canterbury Settlement).
   8. Priscilla Wakefield (1809-87)
   9. Percy Wakefield (1810-c.1831)

the New Zealand Company's directors to acquire further information about the nature of the country, to purchase lands for the Company from Maori, and to make preparations for Company settlements. The Company's directors declared that there was "so great an abundance" of "merely fertile land", that when Wakefield came to selecting land, he should accord more importance to criteria less readily met, such as ease of communication. Even before the expedition left, Cook Strait seemed the ideal site for its first settlement, and accordingly
Wakefield was pleased to write in his despatch home that he had found in Port Nicholson (later known as Wellington)

a territory of 40 to 50 miles in length by 25 to 30 in breadth, containing a noble harbour, accessible at all times, and in the very highway between New Holland and the Western world, land exceeding in fertility any I have seen in these islands, and equalling that of an English garden.126

Reinforcing this appraisal for the Company's directors was Chaffers' Chart of Port Nicholson, New Zealand (shown in Figure 3.2(a)), in which the annotations "Rich Alluvial Soil" and "Fine Pine Trees" were applied to the area of the Hutt Valley.127 As if this was not reason enough for celebration and, indeed, for a little smugness,128 Wakefield's reports on the coast between Port Nicholson and Taranaki provided further good news. To the north of Waikanae, Wakefield had observed large areas of level land, with soil which, "according to all accounts", was fertile, while on Taranaki's southern coast Wakefield found "a fertile undulating plain, covered with small timber and abundant vegetation".129 The expedition then continued north to Hokianga, where the Company had recently acquired a land claim.130 However, for reasons that will be discussed in Chapter Four any thoughts that the Company should establish a settlement in that district were quickly shelved.

V. Woodlands wanted

Still more promising was the numerous letters from both members of the exploring expedition, and the Company's first batch of emigrants, which regularly appeared in the New Zealand Journal. Amongst these was the following missive from the young Edward Jerningham Wakefield:

The soil is indeed prolific; the decayed vegetation of centuries covers the greatest part of the country - at least in the neighbourhood of Cook's Straits - with a sort of garden mould, in some places ten feet in depth. This reaches, though not so deep there, to the tops of the hills ...
Agriculturists from all parts of the United Kingdom speak in the highest terms of the soil: one compares it to West Hoo in Kent, and another declares it far beyond the finest forms in Mid-Lothian.131

Subsequent comparisons between the agricultural lands of Great Britain and those in the settlement, as in the letter of George Duppa, were no less propitious,
Figure 3.2

The role of soil fertility in promoting Wellington to prospective emigrants


(3.2b): [Chapman, H. S.], 'Emigration Comparative prospects of our new colonies'. Westminster Review 35(69) (1841), facing p. 178. Image enhanced (cleaned) by Marney Brosnan, Department of Geography, University of Canterbury.

It is clearly evident from comparing these maps that most of the detail from Chaffers' chart was lost in the very much scaled-down rendition which was published in the Westminster Review. The encouraging descriptions of the soil in the Hutt Valley, on the other hand, were not only retained, but were printed in sufficiently large type to make them conspicuous.
The soil is perfectly wonderful: the rapid growth of anything planted in it is something extraordinary. Every one appears to agree that it is as capable of producing from five to seven quarters of wheat per acre as any of the most highly manured soils in England. A dense forest which has enriched the soil for ages, covers the country in this district. The enormous cost of clearing - calculated at 40/- per acre - is the great apparent drawback, but as wheat fetches 10/- per quarter, and is likely to remain at that price for the next five or six years at least, it will amply repay the outlay of capital. The native potato-grounds shows what the land is; they grow enormous crops by merely scratching the surface with a sharpened stick, and returning the smallest potatoes to mother earth when they grab up the large ones.132

Likewise, Henry Bradley, Snr. wrote that "the soil is very productive, and the best of judges here declare that one acre of land cultivated in New Zealand will produce as much as two acres in England".133 Bradley's only cause for disappointment, which he shared with a number of colonists, was the hilly terrain around the harbour. There was still hope, however, of finding nearby flat land elsewhere, and failing that, reassurance in reports that "the tops of the hills are as fertile as the level ground"134 which suggested they might be used for growing grapes and olives.135

The other main impediment to agriculture, namely that much of the surrounding land was thickly wooded (as illustrated in Figure 3.3), came to be seen, in accordance with the biometrical approach, as a great virtue. This point was forcefully made by an article in the New Zealand Journal of 30 January 1841. Following on from the Swan River colony fiasco,136 it made a telling comparison between the soil of North America's hardwood forests and Australia's arid plains:

North America enjoys immense tracts of the most fertile land, thickly wooded with ancient timber trees. The manner in which a country is wooded is the American's test of soil, and it is for the most part an accurate test. Recent alluvial tracts are of course excepted, but in other respects well-grown trees are understood to indicate richness, the more especially if they be hard woods. Certain trees also denote peculiarities of soil ... and there is no doubt but that a short experience in New Zealand will teach the settlers what species of tree delight in particular soils.

If it be true that the richness of the soil is in exact proportion to the density of the forest, it follows that the clearness of the land, which is so often spoken of as an advantage enjoyed by the Australian Colonies, should be deemed a beacon to warn the prudent agriculturist from the spot; and although the expense of clearing may constitute an important addition to the price of the land ... it is an expense which is speedily covered by the superior and permanent fertility of the soil.137
The combination of fertile soils and dense forest in the Hutt Valley, which is depicted in this drawing by the surveyor Samuel Brees, seemed an ideal testament to the biometric approach to assessing soil fertility. It is interesting to note that already a Pakeha settler is 'taming' the forest at left, while the considerable Maori presence in the Hutt Valley is indicated by the Maori figure at the centre.
At the same time, almost identical comments featured in an article on colonisation written by Henry Chapman (the New Zealand Journal's editor) for the Westminster Review. While "the absence of wood" in Australia meant that its farms required "less labour at the outset", Chapman maintained that this advantage was "purchased at the expense of a comparatively poor soil". New Zealand forest soils, in contrast, were asserted to be as fertile as those of Lower Canada. These were fertile indeed; according to one report he cited Canadian soils could be cropped for 40 years in succession without manure, as each year a virgin soil could be procured simply by deep ploughing. In closing his argument, Chapman provided readers with the memorable maxim, "tell an American that Australia does not want clearing, and he will tell you it is not worth tilling". Chapman's article also provided visual reinforcement of the praise offered for the wooded Hutt Valley, in the form of a simplified rendition of Chaffers' chart (depicted in Figure 3.2 (b)). Most of the original detail was lost in the new version, but the positive comments about the Hutt Valley's soils were much enlarged.

Happily for the New Zealand Company, some settlers at Port Nicholson already accepted much of Chapman's analogy:

Some who have seen the richest tracts in America, say that New Zealand fully equals them in every respect. Indeed, it is impossible for the most unskilful person to view the country without being convinced of this.

Having said this, a letter written in January 1841 reports that settlers were still "looking for land free from timber". The hope of finding recent alluvial soils was one reason for doing so, but it seems more likely that many settlers were still not convinced that they would profit from clearing forest in the long run. In addressing this issue, the said letter writer expressed his belief that

the best land will be timbered, and some of it even heavily. There are of course exceptions, such as the Cowrie, and others of the pine tribe, which grow on cold clays, but the hard woods grow on very rich soil. This I have always found to be the case in America... If the same rule is to hold good here, we should rather set to work manfully to subdue the forest than to waste our time in seeking for land clear of wood. Mr. Molesworth and some others are acting on this principle and are clearing land; and I have no doubt that they will reap a rich reward. Others... will follow their example, as... the expense is much less than was at first anticipated.
This decision to employ a biometrical model when evaluating the fertility of lands around Wellington, was soon borne out by observations recorded by William Wakefield:

The experiments made by experienced farmers in this neighbourhood, during the spring, have led to the conclusion that too much stress has been laid upon the qualities of the level fern land of this country; and that the glutinous properties of the fern, with its innumerable roots, exhaust the land more than the most harrassing European crop; and that, therefore, several years of dressing and manure are requisite to renew its powers.

The result of this reasoning has been to induce many to turn their attention to the wooded lands, and to be inclined to follow the example of the natives, who chiefly cultivate the thickly-timbered hills. The wooded hills surrounding the valley of the "Hutt" have, consequently, risen in estimation and much clearing is in progress ...\textsuperscript{144}

Had the settlers waited a few years before making this judgement, they would have found that in many instances the apparent exhaustion of 'fern land' was only temporary. As will be discussed in Chapter Six, the presence of fresh, dead bracken material in the ground leads to nitrogen immobilisation, where microbes attacking the dead bracken temporarily sequester the plant-available soil nitrogen. Bracken fronds also remain standing after death, so that nutrients incarcerated in them were not readily recycled without the stems being severed or burnt to the ground.\textsuperscript{145} In their ignorance, however, the new colonists looked with satisfaction on the fact that forest clearance was proceeding apace. As one settler put it, "go where you will through the forests, you hear the axe, and see the sturdy tree bending and falling beneath the stroke of the sons of Britain."\textsuperscript{146}

Seemingly the only voice cautioning against unrestricted forest clearance was that of Ernst Dieffenbach, who the New Zealand Company had employed as a naturalist.\textsuperscript{147} In a letter to the \textit{New Zealand Gazette and Wellington Spectator}, which was prefaced by a statement remarkable in its own right,

\begin{quote}
In respect to the natural qualities of New Zealand, a great many mis[-]statements have been made. Parts of the land, which are unfit for a colonial enterprise on a great scale, and for a flourishing agricultural settlement, have been described as containing everything that is desirable for commerce and agriculture; other parts of the country, which unite all these qualities ... have never been visited, or overlooked.\textsuperscript{148}
\end{quote}
Dieffenbach observed that the chain of ranges running along the east coast of the North Island consisted of

a yellow clayelato, with little variation. This rock is covered by a vegetable mould ... and this mould is the only soil from which vegetation derives its nourishment. The rock itself is regarded as one of the most unfavourable and barren foundations of a cultivable land. If the trees, which have sprung up upon these barren hills in the course of centuries, and which are the only source of the fertility, are destroyed, the soil is likely to become soon exhausted; especially as ... the rains will wash down the mould from the ... steep hills; the humidity, which is the principal cause of the vigour of the vegetation, will likewise be diminished, and sterility will be the consequence.\(^{149}\)

More importantly, Dieffenbach noted that much of the hill country on both sides of Cook Strait, including the hills around Port Nicholson, was of the same character.

Regrettably, Dieffenbach's fears (which proved to be well founded) received little recognition in either Wellington or London. Such a conclusion undermined the value of the Company's land purchases, and was thus almost bound to be ignored. In any case, the Company still faced the problem of finding sufficient level land to realise its vision of an agricultural colony. The following letter shows that settlers became increasingly concerned by this:

When last I wrote ... it was pretty generally believed that except that [the Hutt] valley, which was estimated to contain less than 40,000 acres, there was scarcely a thousand acres to be found in the whole Port Nicholson districts. I always thought this notion had been taken up very rashly ... However, you know how impressions get abroad; and when everybody gives utterance to these impressions, everybody at last comes to believe them. At the end of August everybody did believe that we had no flat land.\(^{150}\)

In view of the observations by Wakefield's preliminary expedition, it appeared that the answer to this dilemma would lie in Wanganui, and more especially, in Taranaki. Accordingly, an overland surveying expedition, with the object of collecting "such information of the nature of the soil and general resources of the country as might be useful to colonists", was dispatched from Petone on 27 August 1840.\(^{151}\)

Of the two regions, Wanganui, notwithstanding the attraction of its open, level plains, appeared inferior from a purely agricultural point of view. This was a
consequence of its areas of swampy land, and perhaps, in view of the Hutt Valley experience, too much 'fern land' and too little forest. While arable farming appeared possible on the patches of richer soil, on the whole the region seemed more suited to pastoral pursuits. In contrast, Taranaki, with its lightly timbered forest, fringed by luxuriant 'fern land' (which like that in Wanganui, was available for grazing instantly), fulfilled all the Company's high expectations of its agricultural potential. In the concluding remarks of his survey report, Robert Stokes observed that the area to the northeast of Mount Egmont (Taranaki) was "the best adapted for agricultural pursuits" in the North Island, on the basis of "its soil, its climate, its extent, level character and fertility, and the little outlay as compared with other portions of the island, required for clearing and cultivation". This was some praise, given that the survey party did not see the Waitara valley, which was reputed to be the most fertile area in Taranaki, and perhaps the whole country. When it was visited five months later by another survey party, one of the members declared that its appearance "quite satisfied us that, if brought into cultivation, the banks of the Waitera might become the garden of the Pacific".

Wanganui was nevertheless chosen as the rural extension of the Port Nicholson settlement, while Taranaki was set aside for the site of the new settlement of the Plymouth Company. The latter had agreed to purchase land from the New Zealand Company, and eventually the two merged. The apparent rationale for this was the concern that there was a lack of Company-owned pastoral land near Port Nicholson. It would, therefore, have made little sense to acquire more agricultural land while settling new immigrants on land suited for grazing. Consequently, William Wakefield advised the Secretary of the Plymouth Company that:

Considering the genial climate and fertile soil, the vast space of easily available territory, the land communication with numerous settlements, and the facility of transporting produce to Port Nicholson or New Holland by means of small craft ... I cannot but recommend Taranake [Taranaki] as the most eligible place for the settlement of her offspring.

This, of course, was a boon to the Plymouth Company's new arrivals, whose evaluations of Taranaki were, as the New Zealand Journal proudly recorded, just as sanguine as those of the surveyors. One settler, for instance, after observing that the soil was composed of "a rich, dark, vegetable mould, mixed with sand, particularly near the sea, having a sandy loam of an orange colour for a sub-
stratum, the whole resting on clay or granite", commented that it appeared "to be everywhere of an excellent quality".159

With an agricultural region of such promise at its disposal, and a commercial capital at Wellington ready to act as an emporium for the produce, it finally seemed that the early pessimists had been well and truly confounded. As the New Zealand Journal, in a review of the year's achievements, triumphantly noted:

The accounts which have reached this country from settlers of all classes, moreover, shew that the favourable impressions of the country, received in the first instance, have been abundantly confirmed. Whenever the country has been examined the soil has been found to be uniformly rich; the climate is as favourable to vegetable as to animal life, and in all other respects the eligibility of New Zealand as a field for colonization is invariably admitted.160

In the circumstances, the "myth of rich soil" in New Zealand, as Hargreaves has termed it,161 now appeared almost unchallengeable. It had been first inspired by the optimistic reports that ensued from the exploration of New Zealand during the late eighteenth century, but the driving force behind it in the most recent period had been the New Zealand Company, which had vigorously propagated it in order to make their settlements more attractive than the myriad other destinations to which Britons might emigrate. In doing so, the New Zealand Company, together with other colonisation proponents, had pushed the biometric model, which had grown out of the 'humus theory' of plant nutrition, to the fore as the means for judging soil fertility. Conversely, the potentially more reliable, and certainly more discriminating, geological and ecological approaches tended to be ignored. Encouraging land sales, however, was not the only consequence of the "myth of a rich soil". While its impact on subsequent soil fertility management by settlers will be discussed more fully in Chapter Six, it is worth observing here that that notion that New Zealand forest soils were extremely fertile encouraged much wasteful destruction of forests in the early years of settlement. Indeed, settlers were told that they must not "regard timber on their land as of value", but rather as "an incumbrance".162 Still more significant was the myth's influence on the provision made by the New Zealand Company for Maori reserves. Given the belief that European farming practices might increase yields from Maori cultivation by up to ten-fold, the Company had no difficulty in claiming that the 10% of land which local Maori were left with after settlement would be more
valuable than the 100% which they had owned before. Many local Maori had expected the land to be shared, and were thus surprised to find that they were left with one-tenth of it (and not a very good tenth either). At the time, it led to Maori-Pakeha conflict, and ultimately to grievances which are still being resolved today.
Notes to Chapter Three

1 "The surface seems to consist of substances technically called earths in contradistinction to soils. The moist grounds alone are composed of that soil which is of vegetable origin". Ogle, Nathaniel, The Colony of Western Australia (1839), p. 25, cited in the New Zealand Journal 1(4) (21 March 1840), p. 45. The same distinction is made by Davy in his Elements of Agricultural Chemistry (Rossiter, Margaret W., The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840-1880 (New Haven, 1975), p. 14).


3 Joseph Banks and Daniel Solander, who accompanied Cook on the first voyage and Johann Reinhold Forster, who accompanied him on the second, were all 'apostles' of the Linnean school (Dettelbach, Michael, "A Kind of Linnean Being": Forster and Eighteenth-Century Natural History'. In Forster, Johann Reinhold, Observations made during a Voyage round the World [1778], ed. by Thomas, N., Guest, H. & Dettelbach, M. (Honolulu, 1996), lix-lx). As noted in Chapter Two, Linnaeus was amongst the most famous adherents to the 'humus theory'.

4 The Commissioners for executing the office of the Lord High Admiral of Great Britain &c., 'Additional Instructions for L James Cook, Appointed to Command His Majesty's Bark the Endeavour'. In Beaglehole, J. C. (ed.), The Journals of Captain James Cook on his Voyages of Discovery (Cambridge, 1955), I, ccxi-ccxiii.

5 See, for example, James Cook, 8, 11 & 29 October 1769, & 13 January 1770. Ibid., I, pp. 168, 173, 186 & 233.

6 Cook, 11 November 1769. Ibid., I, p. 197.


8 De Surville wrote at one point in his journal of seeing a range was "completely wooded with fine trees". He then went on to state that "there the soil must be very fertile". Jean Francois Marie de Surville, January 1770. Extracts from Journals Relating to the Visit of the French Ship St. Jean Baptiste in December 1769 Under the Command of J. F. M. de Surville, trans.
by Isabel Ollivier and Cheryl Hingley (Wellington, 1982), p. 38.

9 De Clesmeur noted in his journal that the land they had seen was covered with "a large number of trees", which was "a feature attributable to the fertility of the soil". Ambrose-Bernard-Marie le Jar de Clesmeur, July 1772. *Extracts from Journals relating to the visit to New Zealand in May-July 1772 of the French ships Mascarin and Marquis de Castries under the command of M.-J. du Fresne*, trans. by Isabel Ollivier (Wellington, 1985), p. 31.


11 Parkinson, A *journal of a voyage to the South Seas*, p. 102. The name Bay of Plenty referred to the plentiful provisions they met with in the area.


13 Joseph Banks, March 1770. *Beaglehole, J. C. (ed.), The Endeavour Journal of Joseph Banks, 1768-1771* (Sydney, 1962), II, 3. It should nevertheless be said that Banks also admitted rank grass growth to be a sign of fertility (Banks, August 1770. Ibid., II, p. 113). See also, in this regard, Jean Roux, 27 April 1772. *Extracts from Journals relating to the visit of M.-J. du Fresne*, p. 131.


15 Hawkesworth, John, *An Account of the Voyages undertaken by the order of his present Majesty for making Discoveries in the Southern Hemisphere, And successively performed by Commodore Byron, Captain Wallis, Captain Carteret, and Captain Cook, in the Dolphin, in the Swallow, and in the Endeavour: drawn up from the Journals which were kept by the several Commanders; And from the Papers of Sir Joseph Banks, Esq.* (London, 1773), III, p. 465; Banks, Joseph, March 1770. *Beaglehole, J. C. (ed.), The Endeavour Journal of Joseph Banks*, II, p. 3.

16 Leach, Helen, *1,000 Years of Gardening in New Zealand* (Wellington, 1984), p. 68.


18 Cook, James, May 1773. A *Voyage towards the South Pole and round the World: performed in His Majesty's Ships the Resolution and Adventure, in the years 1772, 1773, 1774, and 1775; in which is included Captain Furneaux's narrative of his proceedings in the Adventure during the separation of the ships* (London, 1777), I, p. 96; Leach, *1,000 Years of Gardening*, p. 65.


In England, for example, serious timber shortages were evident from the 16th century. De Vries, Jan, *The Economy of Europe in an Age of Crisis, 1600-1750* (Cambridge, 1976), p. 166.

Parkinson, *A journey of a voyage to the South Seas*, p. 97.

As George Forster observed, "so apt is mankind, after a long absence from land, to be prejudiced in favour of the wildest shore, that we looked upon the country at that time, as one of the most beautiful which nature unassisted by art can produce. Such are the general ideas of travellers and voyages long exhausted by distresses; and with such warmth of imagination they have viewed the rude cliffs of Juan Fernandez, and the rude cliffs of Tinian". Forster, George, *A Voyage Round the World in His Britannic Majesty's Sloop Resolution, commanded by Captain James Cook, during the Years 1772,3,4, and 5* (London, 1777), I, pp. 124-5.


For Forster's view on the formation of soil generally see p. 41.

The comment was made in response to an 'Anonymous Proposal for the Settlement of New South Wales', written sometime between 1783 and 1786, which is reprinted in the first volume of Robert McNab's *Historical Records of New Zealand*. However, McNab does not include any response by the Home Office, so I can only assume that Geoff Park has seen a copy of the original (to which the said response was appended). Cited in Park, Geoff, *Nga Uruora - the Groves of Life: Ecology and History in a New Zealand Landscape* (Wellington, 1995), pp. 67-8 & 342.


Collins, David, *An Account of the English colony in New South Wales: with remarks on the dispositions, customs, manners, &c., of the native inhabitants of that country. To which are added, some particulars of New Zealand; compiled by permission, from the Mss. of Lieutenant-Governor King* 2nd ed. (London, 1804), p. 232.


Ibid., II, 230. Nicholas refers to one of Forster's works in Volume II, p. 244. An equivalent passage is found in George Forster's *A Voyage Round the World in His Britannic Majesty's Sloop Resolution*, I, p. 129.

Savage, John, *Some Account of New Zealand; particularly The Bay of Islands, and Surrounding Country; with a Description of the Religion, Government, Language, Arts,

33 Nicholas, Narrative of a voyage to New Zealand, II, p. 231.


35 Marsden, 14 August 1820. 'Third New Zealand Journal ... '. Ibid., p. 280.

36 In 1840 this was split between two volumes of Davy's Collected Works so as not to interfere with sales of the 6th edition. Knight, David, 'Agriculture in Britain around 1800'. Annals of Science 33 (1976), p. 191.


41 Evidence of Ensign McCrae before Commissioner Bigge, May 1821. McNab (ed.), Historical Records of New Zealand, I, pp. 537 & 545.

42 Evidence of Dr. Fairfowl before Commissioner Bigge, May 1821. Ibid., I, p. 552.


44 Evidence of Dr. Fairfowl, May 1821. McNab (ed.), Historical Records of New Zealand, I, pp. 552-3.

45 John Thomas Bigge to the Earl of Bathurst, 27 February 1823. Ibid., I, pp. 590-1.

46 Bigge to Bathurst, 27 February 1823. Ibid., I, p. 595.

47 Nicholas, Narrative of a voyage to New Zealand, I, p. 260.

48 Ibid., p. 264.

49 In 1880 William Colenso wrote: "Twenty-five years ago experiments were made at home in England on the root of the common fern of that country - the brake, or bracken (Pteris aquilina), partly under the belief (which still obtains with some folks) that that common British species is identical with this of New Zealand; or, at all events, that both plants were but varieties of one species, which I, however, do not believe, for they differ in several different particulars, particularly in the root itself". Colenso, William, 'On the Vegetable Food of the ancient New Zealanders before Cook's Visit'. Transactions and Proceedings of
the New Zealand Institute 13(1880), pp. 24-5.

50 Evidence of Dr. Fairfowl, May 1821. McNab (ed.), Historical Records of New Zealand, I, p. 553.

51 Leach, Helen, 1,000 Years of Gardening in New Zealand, pp. 63-4.


54 Leach, 'Incompatible Land Use Patterns in Maori Food Production'. N. Z. Archaeological Association Newsletter 23 (3) (1980), pp. 139-41.


57 Thomas Shepherd, [June] 1826. Cited in Park, Nga Uruora - the Groves of Life p. 88. Shepherd gave the location as 'Whanga Nui Atara', which is a corruption of the Maori name for Port Nicholison, Whanganui-a-Tara. The date of Shepherd's visit to Port Nicholson is given in Park, Geoff, 'Edward Gibbon Wakefield's dream, Thomas Shepherd's eye and New Zealand's Spatial Constitution'. In Mason, Andrew (ed.), Edward Gibbon Wakefield and the Colonial Dream: a Reconsideration (Wellington, 1997), pp. 139-40.


60 [Craik, George Lillie], The New Zealanders (London, 1830), p. 168. Descriptions in these works also tended to be romanticized. An example of this is Craik's commentary (which features on p. 165) on the South Island:
The southern island, with the exception of a narrow stripe along its northern shore, appears to be, in its interior, a mere chaos of mountains, and the region of perpetual winter; but even here, the declivities that slope down towards the sea are clothed, in many places to the water's edge, with gigantic and evergreen forests; and more protected nooks often present themselves, overspread with the abundance of a teeming vegetation, and not to be surpassed in loveliness by what the land has any where to shew.

61 McDonnell, Thomas, 'Extracts from Mr McDonnell's MS. Journal containing observations on New Zealand'. In Hargreaves & Hearn (eds.), New Zealand in the 1830s, p. 16.
62 Ibid., p. 17.
63 Earle, Augustus, A Narrative of a Nine Months' Residence in New Zealand [1832], (Christchurch, 1909), pp. 110-1.
64 'New Zealand', The Independent, 9 August 1834. In Hargreaves & Hearn (eds.), New Zealand in the 1830s, p. 33. As an examination of Chapters Four and Five will show, much of the land in the area described is indeed relatively infertile.
65 Ibid., p. 35.
66 Robert Fitzroy, 28 December 1835. Fitzroy, Robert (ed.), Narrative of the Surveying Voyages of His Majesty's Ships Adventure and Beagle, between the years 1826 and 1836, describing their examination of the southern shores of South America, and the Beagle's circumnavigation of the globe. 3 vols. (London, 1839), II, p. 598.
67 Earle, Narrative of a Nine Months' Residence, p. 112.
68 Markham, Edward, New Zealand, or Recollections of it, ed. by E. H. McCormick (Wellington, 1963), p. 36; Yate, William, An Account of New Zealand, and of the Church Missionary Society's Mission in the Northern Island 2nd ed. [1835], with an introduction by Judith Binney (Shannon, Eire, 1970), pp. 75-6. Interestingly, Nicholas had earlier remarked that "the lands in this country, which are at present overrun with fern, might be brought to produce grasses of every description; were the experiment tried, I doubt not that it would prove invariably successful, and that the islands in general would afford as fine pasturage for sheep and cattle as any part of the known world" (Nicholas, Narrative of a voyage to New Zealand, p. 357).
71 Ibid., p. 15.
Previously, Richard Cruise had referred to 'kaikaterre', that is, kahikitea (*Podocarpus dacrydioides*), being found in low swampy ground, and 'cowry', that is, kauri (*Agathis australis*) growing on dry ground (Cruise, *Journal of a Ten Months' Residence in New Zealand* 2nd ed., p. 3). Seemingly the only earlier specific reference to soil fertility, however, was George Bennett's comment that miro (*Podocarpus ferruginea*) grew on "good soil" (Bennett, 'Coniferous Trees of New Zealand', 6 February 1832. *New Zealand Journal*, 2(37) (27 March 1841), pp. 81-2. This was no doubt extracted from Bennett's *Botany of New Zealand* (1832), which is referred to in Hocken, T. M., *A Bibliography of the literature relating to New Zealand* (Wellington, 1909), p. 51). For the use of plant-soil relationships in the American colonies, for instance, see Merrens, H. R., 'The physical environment of early America: images and image makers in colonial South Carolina'. *Geographical Review* 59 (1969), pp. 543 & 552-3.


Ibid., 156. The first ever mention by Pakeha of soil texture modification in relation to kumara cultivation appears to have been in a letter written by the missionary Thomas Chapman in 1831 (Walton, Anthony, 'Rethinking Made Soils'. *New Zealand Archaeological Association Newsletter* 25(1) (1982), p. 18.

[Wakefield, Edward Gibbon], *The British Colonization of New Zealand; being an account of the Principles, Objects, and Plans of the New Zealand Association; together with particulars concerning the position, extent, soil, and climate, natural productions, and native inhabitants of New Zealand* (London, 1837), pp. 308-9 & 310. Yate's section on forest trees was reproduced on pp. 375-88.

Ibid., p. 92.

In defence of the work, it should be noted that the lack of information on the South Island which could be drawn upon was acknowledged to be a deficiency. Ibid., pp. 126-8.

Ibid., p. 107.

Bigge reported that, "compared with the extent of the country, and the general fertility of the soil, the native population of New Zealand is not numerous". J. T. Bigge to the Earl of Bathurst, 27 February 1823. McNab (ed.), *Historical Records of New Zealand*, I, p. 589. See also, for a more explicit reference, McDonnell, 'Extracts from Mr McDonnell's MS. Journal'. In Hargreaves & Hearn (eds.), *New Zealand in the 1830s*, pp. 12 & 15-6.

[Wakefield, E. G.], *The British Colonization of New Zealand*, p. 271.

88 Amongst the witnesses to give evidence that New Zealand's soils were highly fertile were John Nicholas (Evidence of J. Nicholas, 3 April 1838. 'Report from the Select Committee of the House of Lords, appointed to inquire into the Present State of the Islands of New Zealand, and the Expediency of Regulating the Settlement of the British Subjects Therein; with the Minutes of Evidence taken before the Committee, and an Index thereto. 1838'. Great Britain. Parliament. *British Parliamentary Papers. Colonies - New Zealand* (Shannon, 1968-71), I (1837-40), p. 5) and John Flatt (Evidence of J. Flatt, 3 April 1838. Ibid., p. 33). Extracts from their evidence are given below.

**[Evidence of John Nicholas]**

Did the soil appear productive, so far as you had the opportunity of seeing? - Very productive.

Is it a heavy soil; or what you should describe it, with reference to any English soil? - It of course varies, but I should say, generally speaking, that it was a rich loamy soil. One great proof of the great fertility of the soil is the magnificence of its forest trees, many of which grow to an enormous size, and afford very valuable timber.

**[Evidence of John Flatt]**

What is the nature of the soil? - A very prolific fine stiff loam in one part, and fine vegetable mould in others.

89 Testimony to the effect that New Zealand was well suited to wheat cultivation was given by Joseph Montefiore (Evidence of J. Montefiore, 6 April 1838. Ibid, p. 60), and Francis Baring (Evidence of F. Baring, 1 May 1838. Ibid., p. 152). Their evidence on this point is reproduced in the extracts below. This perception, it should be pointed out, had already led the New Zealand Association to conclude that New Zealand should export wheat to the Australian market ([Wakefield, E. G.], *The British Colonization of New Zealand*, p. 389).

**[Evidence of J. Montefiore]**

Does it appear that the soil is adapted for the cultivation of wheat?

- Yes; for the finest wheat in the world. New South Wales is not a wheat country; but I have seen very large plump grain from New Zealand. New Zealand is not subject to droughts.
The idea that the Maori population was so small that most of it went to 'waste' was supported by testimony by Robert Fitzroy (Evidence of R. Fitzroy, 11 May 1838. 'Report from the Select Committee of the House of Lords into the Present State of the Islands of New Zealand. 1838', Great Britain. Parliament. British Parliamentary Papers. Colonies - New Zealand, I (1837-40), p. 173) and Frederick Wilkinson (Evidence of F. Wilkinson, 10 April 1838. Ibid, p. 108). See extracts from their evidence below.

[Evidence of R. Fitzroy]
Their Population being so very inconsiderable in proportion to the Extent of fertile land, very little Value was attached to the Property in Land? - Very little indeed.

[Evidence of F. Wilkinson]
When you spoke of the propriety of making a reserve of land for the natives, are you aware whether the island affords land enough to make that reserve, and still to afford land for occupation by a great many Europeans?
- Yes, certainly. The population, I have understood, at Kaipara is very trifling; for one hundred miles there are not above one hundred people; it is a very productive soil if it were well cultivated.

91 Evidence of J. Montefiore. Ibid., p. 57.
92 Evidence of J. Nicholas. Ibid., p. 10.
94 Cited in ibid., p. 62.
95 Ibid., pp. 63-4 & 72-7.
97 Burns, Fatal Success, pp.13-16.
98 Cited in Burns, Fatal Success, p. 100.
99 Polack, J. S., Manners and Customs of the New Zealanders; with Notes Corroborative of their Habits. Usages, etc., and Remarks to Intending Emigrants [1840] (Christchurch, 1976), II, pp. 193 & 195. Polack, incidentally, was a Bay of Islands-based merchant.
See Polack, New Zealand, being a Narrative of Travels and Adventures, I, pp. 140 & 200; Polack, Manners and Customs of the New Zealanders, II, pp. 203-4.

Polack, J. S., New Zealand, being a Narrative of Travels and Adventures during a residence in that country between the years 1831 and 1837 [1838] (Christchurch, 1974), I, p. 348.


Ibid., pp. 9-10 & 12-3.

Ibid., pp. 1-2.

Ibid., p. 33.

Ibid., p. 33-43.

Two such proponents without any New Zealand Company affiliation were Patrick Matthew (See, for example, the criticism of Wakefield's 'sufficient price' concept in Matthew Patrick, Emigration Fields: North America, the Cape, Australia and New Zealand: describing these countries and giving a comparative view of the advantages they present to British settlers (Edinburgh, 1839), p. 201), and Edward Campbell (in whose opinion, Edward Gibbon Wakefield was a 'land-shark' (Campbell, Edward, The Present State, Resources and Prospects of New Zealand (London, 1840), p. 7)).

Johnston, Judith A., 'Information and Emigration: The Image Making Process'. New Zealand Geographer 33(2) (1977), p. 64. In at least one pamphlet, Young's New Zealand Described, this was made explicit in the full title, which concluded with the words ... in a letter to the Labouring class.

[Young, William C. J, New Zealand Described, together with a few words of advice on the subject of Emigration in a letter to the Labouring class, 3rd ed. (London, 1840), p. 4.

Ibid., pp. 4-5.

Popular Account of New Zealand as a Field for British Colonization (Glasgow, 1839), pp. 22-3. This also included numerous extracts from Cook's writings.

Campbell, Edward, The Present State, Resources and Prospects of New Zealand (London, 1840), p. 6; Popular Account of New Zealand, p. 27.

The only reference to soil colour in these works seems to have been J. P. Johnson's comment that the soils about Cook Strait were of "a light black nature". Johnson, J. Pitts, Plain Truths, told by a Traveller, regarding our various Settlements in Australia and New Zealand (London, 1840), p. 66.

Although the title referred to a number of colonies, New Zealand was the only one discussed at any length.

118 Matthew, *Emigration Fields*, pp.116-7. Matthew only once resorted to soil description, and that was in a footnote in which he recorded that John Flatt (a witness to the 1838 Select Committee) had told him that the soils of the Waikato "were equal in extent, but richer, than the alluvial level between Cambridge and Hull", which was, as Matthew put it, "the kernel of England" (Ibid., p. 119n).

119 Ibid., pp. 118-9. According to Matthew, New Zealand's indigenous population did "not reach the one-hundredth part" of the limit set by the "means of subsistence obtainable by agriculture" (Ibid., p. 127).


123 Burns, *Fatal Success*, p. 139.


127 See comments in Park, *Nga Uruora - the Groves of Life*, p. 100.

128 The *First Report of the Directors of the New Zealand Company presented to the First General Meeting of Shareholders on the 14th May 1840* (London, 1840), made the following observation on p. 35:

It is with the most lively satisfaction that your Directors announce to you the receipt of important despatches from Colonel Wakefield ... you cannot but have derive high gratification from the communication made by Colonel Wakefield in his last despatch, on the acquirement of the valuable harbour of Port Nicholson, and the whole surrounding country, comprising a surface of nearly a million square acres. It is impossible to appreciate too highly this valuable purchase, either as regards the admirable locality of the harbour, or the fertility, salubrity, and beauty, of the surrounding country.

The area of Lieut. McDonnell's legitimate claim, which the Company purchased, was much smaller than the Company had expected. Burns, *Fatal Success*, pp. 120-2.


Much the same prediction was made previously by Dieffenbach (Extract from Dieffenbach, Ernest, 'Report to the New Zealand Company respecting the Physical Conditions and Natural History of Queen Charlotte's Sound, Cloudy Bay, Tory's Channel, Port Nicholson, and the surrounding country'. *N.Z. Journal* 1(7-Extra) (5 May 1840), p. 6).

This involved the sale of large areas of desert to emigrants after a misguided extrapolation of previous localized surveys of the Swan River Valley. Cameron, J. M. R., *Coming to terms: the development of agriculture in pre-convict Western Australia* (Nedlands, Perth, 1977). pp. 13 & 18-20.


Burns, *Fatal Success*, p. 139.


Ibid., pp. 171n.


Wm. Wakefield, [Despatch] to the New Zealand Company, [3 December 1840]. *N.Z. Journal* 2(35) (22 May 1841), p. 126. In the preamble to the Despatch, it is stated that it was written two days before the arrival of the *Cuba* from Sydney, which is subsequently listed in shipping news as having arrived on 5 December 1840 (*N.Z. Journal* 2(36) (5 June 1841), p. 141).

Dr. Trevor Partridge, Landcare Research, pers. comm., 20 May 1998. In a recent study
conducted near Nelson, it was found that a plot of bracken in summer contained 25.9 tonnes per hectare of dead above-ground biomass (including surface litter); in comparison, the living above-ground biomass only amounted to 5.3 tonnes per hectare (Evans, G. R., Nordmeyer, A. H., and Kelland, C. M., 'Biomass and nutrient pools of bracken growing under radiata pine, Nelson, New Zealand'. In Thomson, J. A., & Smith, R. T. (eds.), *Bracken Biology and Management: Papers from an international conference, BRACKEN 89, University of Sydney, 18-21 July 1989* (Sydney, 1989), pp. 188-9). By way of comparison, a 19th century wheat crop of 30 bushels per acre contained in its grain (that is, excluding the straw) some 16 lbs./acre of (anhydrous) phosphoric acid (Aikman, *Manures and the principles of manuring* 3rd ed., p. 485), whereas the bracken litter alone in this instance contained 11.5 kg/ha of phosphorus (which equates to 24 lbs./acre of (anhydrous) phosphoric acid) (Evans et al., 'Biomass and nutrient pools of bracken growing under radiata pine'. In Thomson & Smith (eds.), *Bracken Biology and Management*, p. 192).


149 Ibid.


154 Ibid., p. 134.


163 The directors of the New Zealand Company in fact instructed William Wakefield to relate this to the Maori inhabitants of Port Nicholson. Ward, *Information relative to New Zealand* 2nd ed., p. 120.
Chapter Four

Coming down to earth: the exposure of the 'biometric fallacy' and the search for a new construct c.1841-1850

If the years leading up to 1841 can be seen, in relation to soil fertility appraisal in New Zealand, as a period of 'myth-making', then the remainder of the 1840s should be viewed as a period of 'myth-breaking', or at the very least, 'myth-amending'. As this chapter will show, the notion that fertile soils were abundant in all parts of New Zealand was soon discredited by squabbling between the New Zealand Company and its critics, who included the Colonial Government. In addition, the demise of the 'humus theory' of plant nutrition in European scientific circles, and the discovery locally that the inferences made from it could be erroneous, seriously undermined the 'biometric model', and prompted geological and ecological (or edaphic) models to be revisited.

I. Sterile Auckland versus Hillbound Wellington: Part One

As seen at the close of the previous chapter, in late 1841 the New Zealand Journal pronounced that all the marvellous claims made by the Company about New Zealand had been vindicated. This sanguine appraisal was not accepted universally, however. In particular, the Company's promotion of its settlements was strongly criticised by Lieutenant-Governor (later Governor) Hobson's administration. Relations between the two started badly, since it was Hobson's Treaty of Waitangi and his subsequent proclamation of the annexation of New Zealand that prevented the Company from further purchases of land direct from Maori. Things deteriorated further when Hobson snubbed the Company by choosing Auckland as the site for the new capital. While in part this decision was designed to facilitate the supervision of the Pakeha population in the Bay of Islands, the relative situations of Auckland and Wellington also played a role.

Auckland offered a convenient harbour for the produce of the Waikato, and more significantly, the valley of the Thames. The latter had long impressed visitors (such as Sir Joseph Banks) in much the same way as the Hutt had done. One recent visitor was Samuel Martin, whose opinion of the Thames was very positive:
Nearly the whole of this immense tract is available for agriculture and grazing. Messrs. Barker and McIntosh, both practical farmers, attentively examined the soil in various places, and they agree ... that it is admirably adapted for agriculture, and far preferable to any other part of New Zealand they have hitherto visited. The soil on the top is in general a vegetable mould, evidently formed by the decay of former forests; the subsoil in the lower part of the valley is an open clay, the surface being in general a rich loam. In the upper valley the subsoil consists of decomposed pumice stone, with an admixture of clay, the lower strata being almost wholly of pumice stone.

While the extent of swampy land was an obstacle to immediate settlement, Martin believed that "with very little labour, and merely by opening out the natural drains, all these flax flats might be available; they in general contain the richest of soil". Likewise, John Bidwill found that the Thames Valley was "one of the most splendid situations for a colony, that could be found in the whole world", with its soil composition being, like "all the best soils in the country, decayed pumice". Bidwill acknowledged that it suffered from "excessive wetness", but asserted that "nothing would be easier to drain it", and as numerous watercourses ran through it, thought this "ought to be done at a very trifling expense".

On the other hand, the impression gained of Port Nicholson by Hobson's administration was much less favourable. Amongst the criticisms of the site which the (Acting) Colonial Secretary, Willoughby Shortland, reported back to Hobson was its inadequacy for an agricultural settlement. In his remarks, reported below, the influence of Dieffenbach's earlier warning about thin hill soils is clearly evident:

The bay is capacious; it is surrounded by high and broken hills, except on the north-east side, where there is an extensive valley ... its soil is very rich, but it is very heavily timbered, and subject to inundations, and the hills rise abruptly on each side ...

The land immediately available around Port Nicholson for agricultural purposes, is by no means extensive. An industrious yeomanry might gain a good subsistence, and a sufficient supply might be raised for a considerable population; but there is no field for extensive agricultural operations.

The formation of the country is clay sand and clay slate, over which there is but a thin deposit of vegetable mould, which though rich, will not bear continued cultivation, as may be seen by observing the hills, on which there is no timber; they are totally devoid of soil, and only covered with low fern and coarse grass.
Although Shortland conceded that there were "vast tracts of rich land available for agricultural purposes, and a great quantity of indigenous grass" in the outlying Waikanae and Taranaki districts, which were both claimed by the New Zealand Company, Hobson still concluded that the valley of the Thames showed the most agricultural promise. Accordingly, he informed Lord John Russell, the Secretary of State for Colonies, that one of Auckland’s advantages was in having "the richest and most available land in the Northern Island being concentrated within a radius of fifty miles".

With Hobson and his entourage giving unflattering opinions about the Company’s land at Port Nicholson, William Wakefield responded by asserting that the Thames was far too swampy to be considered the best land available in the colony. Even John Bidwill (who had heaped praise on the Thames only 17 months earlier) gave his support to this argument. According to Theophilus Heale, this change of heart was prompted by his staying with Francis Molesworth, one of the leading figures amongst the Port Nicholson settlers, at the time, rather than by honest reflection. While Bidwill still believed the Waihou plain was "very rich land ... covered with flax from ten to twelve feet high", he now declared that more than half of it consisted of "an almost impassable bog, covered with rushes; the largest remaining portion is poor fern land, and there is a considerable quantity of wet stony land, covered with rank vegetation, without bushes". Consequently, it would be as troublesome to ready it for the plough via drainage, as the Hutt would be to clear, and even then, it was "well known that bogs do not immediately become useful land, but that several years must elapse after they are reclaimed before they will bear any crops of grain".

Naturally Hobson responded adversely to this criticism of Auckland, and in November 1840 he complained to Lord Russell that the New Zealand Company had been making "most exaggerated descriptions of the land at Port Nicholson, and very incorrect statements of the extent of country at their disposal". These had "had the effect of deluding the people of England into a belief that the nature of the soil, and the facilities for cultivation throughout that district present advantages which are nowhere else to be found ...". The Company replied by arguing that it had never attempted to credit some areas and discredit others. There was some truth to this reply. To date, negative opinions of land in North Auckland, such as William Wakefield’s observation that the country near Hokianga was "over-rated for agricultural purposes", and Ernest Dieffenbach’s that the soils on which kauri forest grew "were said to be of little avail for agriculture", had featured only sporadically in published accounts. Privately, however, the
Company's officials had been rather less circumspect. Although the New Zealand Company, as discussed in Chapter Three, had a land claim in the Hokianga district, Edward Jerningham Wakefield's journal reveals that after seeing the land between Kaipara Harbour and the Bay of Islands, his uncle William Wakefield described it as "barren-looking, and interspersed with large swamps". The younger Wakefield then proceeded to make his own observation:

Wherever the kauri forest has been cut down or burnt, nothing grew but stunted fern. This unpromising appearance is described by many persons as peculiar to land on which the kauri has grown. It is probably a very exhausting crop.20

Such a finding sat awkwardly with the Company-propagated notion that almost the whole country was extremely fertile, and also cast doubt on the reliability of the biometrical approach, since tall trees (like the immense kauri shown in Figure 4.1) were not supposed to grow on infertile soils. However, in response to Hobson's effrontery, the Company abandoned its earlier position, and set about disparaging the Auckland and North Auckland regions. For example, in an article in the Colonial Gazette (which the Company's predecessor, the New Zealand Association, had helped found),21 it was said that the "land in the neighbourhood [of Auckland] is sterile".22 In a similar vein, the first post-settlement Company pamphlet, An Account of the Settlements of the New Zealand Company (1841), which Henry Chapman ghost-wrote for Henry Petre,23 claimed that the North Auckland peninsula did not contain "above one-twentieth part of the superficial area of the two islands, and a great part of the northern extremity is known to be barren".24

II. Hobson's Choice

Meanwhile, developments were occurring 'at home' which furthered strained relations between the Company and Hobson. In November 1840, Lord Russell finally gave official recognition to the Company, granting it rights to 160,000 acres in the vicinity of Port Nicholson and New Plymouth, and offering it a further 50,000 acres at a discounted price.25 Buoyed by this success, and the optimistic early reports from Port Nicholson, the Company decided to develop a 'Second Colony' requiring 201,000 acres, thereby compounding the difficulties of finding flat land the 'First Colony' had faced.26 As a consequence, William Wakefield sent Captain Edward Daniell, accompanied by George Duppa and
Figure 4.1
The immense kauri trees of Northland


This painting was produced by Charles Heaphy during the northern sojourn of the New Zealand Company's preliminary expedition. The fact that kauri forest often grew on infertile soils - the highly leached soils under their stumps are often referred to today as 'kauri podzols' - represented a spectacular failure of the biometric model.
William Deans, to look for possible sites on the South Island's east coast. Just a year earlier, Major Bunbury, who had travelled along this coast obtaining Treaty of Waitangi signatures, had reported that the "capabilities of this island for purposes of agriculture have been much under-rated". Bunbury also found that Akaroa (since settled by French emigrants) was "well adapted for farms where both arable and pasture lands are required". The account Duppa and Daniell returned with described the plains country on the margin of Banks Peninsula in glowing terms:

The soil appears to be of a recent formation, consisting chiefly of a rich, dark, vegetable mould, with a sufficient admixture of clay to form a good wheat soil; and for barley, oats, potatoes, and, in fact, for all succulent roots, ... a better description of soil could not be conceived. The substratum, which commences about a spit [the depth of a spade blade] and a half under the surface, being of a sandy nature, renders the district sufficiently dry, as a sheep pasture, to secure one against foot-rot.

The whole plain, moreover, "contained millions of acres of the richest of soil, covered with grasses of most luxuriant growth, and dotted with groves of pine-trees ...". Apart from these groves, the Canterbury Plains were practically treeless, but even so, the plain-peninsula margin was still seen as highly fertile, since it received the alluvial deposit of the forested peninsula, while being too recent a landscape to have developed its own forest cover. The combination of fertile and dry land on the Plains, moreover, made the site ideal for a combination of arable and pastoral farming.

It seemed, therefore, that the Company had again struck it lucky. Hobson, however, refused permission for a settlement to go ahead while the area was subject to competing land claims, and instead offered a combination of land for town sections at Mahurangi (just south of Warkworth) and for country sections in the Thames Valley. Given the derision now expressed by Port Nicholson settlers for the Auckland region in general, the offer was unlikely to have been accepted. Moreover, as the two sites were 110 miles apart, with Auckland in the middle, it was suspected that Hobson's real motive was to absorb the proposed colony into his own. Following a preliminary expedition to the area under Captain Arthur Wakefield (William's brother), the Company instead chose to establish their 'Second Colony' at Nelson Haven in Blind (now Tasman) Bay, despite Hobson's warning that this was also subject to competing land-claims. In addition to a sheltered harbour, Wakefield found "undulating hills or downs, with a wooded
valley of some hundred acres and gradually sloping land from it, covered with flax, grass and fern". This was a satisfactory, rather than promising, assessment, and consequently the Company observed that while "the occupation of the colonists on the northern shore [of Cook Strait] will be chiefly tillage of land", the "open plains in the vicinity of Nelson" were likely to be utilised for "the pasturage of sheep and cattle". Having said this, Hobson had left the Company with no option other than settling Nelson. It was a case of, as Arthur Wakefield remarked, "Hobson's choice".

III. Sterile Auckland versus Hillbound Wellington: Part Two

In the meantime, the New Zealand Company in London was working hard to maintain flagging public interest in New Zealand. Aiding this task were the first of a new generation of published works on New Zealand, such as Bidwill's *Rambles in New Zealand* (1841) and Petre's *Account of the Settlements of the New Zealand Company*. These not only updated those previously available, by providing first-hand information, but also, for the first time, promoted New Zealand regions as emigration destinations, rather than the country as a whole. In practice, this meant promoting those areas where the Company's settlements were based, and discrediting those areas where they were not.

Unfortunately for the Company, neither Bidwill nor Petre delivered the sort of hard-sell that was desired. Most of Bidwill's account had been written independently, and apart from its belated advocacy of Port Nicholson over the Thames, it related mainly to the author's travels in the northern and central North Island. During his Northland travels, Bidwill noted that the predominant soil around the Bay of Islands was an infertile clay, and that kauri trees normally grew on infertile soils, but he was more positive about the central North Island, as he had found better tracts there, such as the rich grassy plains of the Waikato, and the 'fern land' surrounding Tauranga. His favourable opinion of 'fern land' was in contrast to the position of the Hutt Valley settlers, but Bidwill argued that very tall growths of 'fern' (such as ten feet or more) could often be found where forest had recently been cleared, leaving behind what was potentially a very rich soil. In this respect, Bidwill's observations were closer to those of contemporaries based in the South Auckland and Northland regions. Chapman's ghost authorship of Petre's account, meanwhile, meant that it was limited mainly to generalised observations (which readers of Chapman's *New Zealand Journal* were already familiar with). Indeed, the only noteworthy comments with regard to soil fertility
were the disparaging remark about the North Auckland peninsula quoted above, and a comment endorsing previous reports of the "great fertility" of the Hutt Valley.

In contrast to the above two works, Charles Heaphy's *Narrative of a Residence in various parts of New Zealand* (1842) was infused with boundless optimism. The young draughtsman's tendency for exaggeration, while irksome for the Company's regular surveyors, proved ideal for promotional purposes. As suggested by the title, much of Heaphy's description focussed on individual regions, though he also provided a more standard assessment of soil fertility in New Zealand as a whole:

New Zealand being for the most part covered either with forest or high fern and flax, its superficial soil ... is generally of vegetable formation. The country, in every part, displays conspicuously the action of water; and in all the vallies the subsoil appears of alluvial origin.

According to Heaphy, these alluvial valleys were generally covered with a soil "productive in the extreme", and even the intervening hills, which the Auckland settlers poured scorn on, "were covered with rich mould, which at present gives root to the loftiest trees". Heaphy, drawing presumably from Bidwill's knowledge, also gave the most explicit recommendation to date amongst New Zealand Company literature of the worth of volcanic soils. As he put it, "around the various active and extinct volcanoes, and especially in the Taranaki and Taupo districts, the country is covered with a rich volcanic soil, which is very fertile".

In terms of the various regions, Heaphy naturally concentrated on the four Company settlements: Taranaki, Wanganui, Port Nicholson, and Nelson. At the latter three, the soil was described as a black vegetable mould, while Taranaki had a mixed vegetable-volcanic mould of unspecified colour. This repeated use of the descriptors 'black' and 'alluvial' in emphasising fertility mirrored contemporary literature promoting other colonies. The intention, Judith Johnston has recently suggested, was to conjure up in readers' minds a connection with the famous black chernozems of the Ukraine. Heaphy also used extravagant personal testimonials to give weight to his assertions respecting soil fertility. At one place in the Hutt Valley, for example, he had "measured a depth of thirteen feet of black vegetable mould, upon a subsoil of boulder stones in clay". Exaggerated accounts of the growth of produce, such as the claim that at Port Nicholson, "strawberries, with ripe fruit", were "growing in the sand, within ten paces of the sea" were also employed. This followed the example of the *New Zealand Journal*, which had
proudly described the giant vegetables which were shown at Port Nicholson's first horticultural exhibition. Such reports, incidentally, also served as evidence of New Zealand's munificent climate. Some quantitative statements on the productivity of the soil were also given. Hutt Valley soils, Heaphy stated, were found to yield 14 tons of potatoes per acre, or about double what could be expected in British farming, while the soils of the Chatham Islands, which the New Zealand Company had also envisaged purchasing, produced up to 16 tons per acre.

While each of the Company settlements contained rich soils, they were not, Heaphy observed, equally fertile. Taranaki was "by all parties allowed to be the most fertile ['country'] in New Zealand", although Heaphy himself believed that the Hutt Valley, on account of its "extreme fertility", would be the optimal destination for "the settler possessed of more means", who could meet the initial expense of clearing. For the "immigrant of small capital", meanwhile, the open country of Wanganui, Manawatu and Nelson, and the fringe of open land around New Plymouth seemed more suitable. Not surprisingly, when Heaphy switched his attention to regions rejected by the Company, such as Auckland and North Auckland, the assessments were much less favourable. Heaphy acknowledged that parts of the Waikato and Manukau were fertile, but there were no safe harbours nearby to access them. Conversely, where there were good harbours, that is, in Northland, the land was of so sterile a nature ... as to preclude the possibility of its ever becoming the seat of a large agricultural population; the land being, in all places where the Kauri fir grows, of a hard red clay, which yields but little on being cleared and cultivated.

As for Auckland, Heaphy maintained that it had little land available and much of it was swampy. Moreover, the Thames was too remote to be Auckland's agricultural base. Clearly the New Zealand Company thought Heaphy's use of anecdotal evidence to illustrate the excellence of the soil and climate a winning formula, as for subsequent promotional literature it produced compendiums of favourable settler correspondence. For example, in the pamphlet Latest Information from the settlement of New Plymouth (1842), John Shepherd described black soil which appeared "twelve or fifteen feet deep" on cliff faces, while an anonymous correspondent reported oats growing seven feet high in the pamphlet Letters from Settlers & Labouring Emigrants (1843). This was just what was needed to
impress prospective emigrants. In some cases, however, settlers' accounts would only have helped to confuse readers. In particular, the *Letters from Settlers* revealed the continuing uncertainty over the merits of 'fern land'. While Francis Jollie of Nelson reported that "in general one may observe over the place, as a pretty certain rule, that the finer the crop the higher had been the fern that previously grew ...", a New Plymouth correspondent opined that the "'fern land' is very inferior: nothing impoverishes land more than this most detestable of all weeds". That 'fern land' should have a poor reputation in Taranaki is particularly interesting since its topsoil was black in colour, whereas that under the Taranaki forests was brown; soil colour, therefore, was regarded as less indicative of fertility than vegetation cover in this instance.

Just as fast, however, as the New Zealand Company built up its Edenic construction, literature intent on its dismantling began to appear. As one author put it, the public should no longer be taught "to think of New Zealand only through the medium of the New Zealand Company". Leading the assault were Auckland settlers, who were now ready to respond to the Company's criticism with their own London-published pamphlets. Both Theophilus Heale (*New Zealand and the New Zealand Company: being a consideration of how far their interests are similar* (1842)), and Charles Terry (*New Zealand, its advantages and prospects, as a British colony* (1842)) strongly refuted the New Zealand Company's portrayal of the Thames as a vast bog. In Terry's view, its plain contained "more alluvial soil" and was "more available and adapted for grazing and agriculture" than "any other part of New Zealand", while Heale declared it was "admitted to be the finest and largest agricultural districts in the island". Heale also pointed to the earlier observations by Jameson, whom, Heale argued, the Company could not object to as a witness, since Jameson had, on concluding that the area was well suited to an agricultural settlement, hoped that the New Zealand Company would purchase land there. In ascertaining that the area was good for wheat cultivation, Jameson had relied on both biometrical evidence ("... it is manifest that a land which nourishes the stateliest forests and densest underwood in the world, must be eminently fertile"), and the advice of a local chief, Ngatai. Both Heale and Terry also believed that there were further extensive fertile tracts in the Waikato River catchment. As for the lands held by the Company, Heale admitted that Taranaki possessed "some excellent lands for agriculture", but he argued that the best port access was through Auckland. Port Nicholson, meanwhile, seemed a ridiculous site for settlement:
... the valley of the Hutt and a few other small valleys, is hardly of extent enough to supply the town itself with necessaries, much less to afford an export trade; and even these are so densely wooded with timber of valueless descriptions, that it is doubtful that they will pay for the cost of clearing. And internal communication across the steep and lofty mountains, with which it is hemmed in, [is] quite out of the question. 68

Whereas Heale seems to have singled out the New Zealand Company settlements for criticism, Terry was more pessimistic about New Zealand's agricultural potential in general. Rather than being the cornucopia that some accounts depicted it as, Terry described it as a mix of "uncultivated wastes", "plains and low lands covered with impenetrable high fern and shrubs" and "swamps and marshes covered with rush and flax". 69 Consequently, Terry argued that whatever "is produced from the soil in New Zealand ... must be the work of time by great labour and at much expense". 70 Lastly, like many other Auckland-based writers, Terry also tried to counter the impression that developed in Wellington and New Plymouth that 'fern land' was poor. In his view, the "lands on which fern grows to a great height" were those best adapted to cultivation. 71

The attack on the idyllic imagery of the Company did not just emanate from Auckland, however. Disgruntled settlers, such as Lieutenant John Wood, were beginning to take issue with it too. After finding one of the town sections he had purchased at Port Nicholson was part of a swamp, and his country section was in Wanganui - which illustrates just how bad the land crisis at Port Nicholson really was - Wood complained that the prevailing landscape within 30 miles of Wellington was heavily timbered mountains, covered by a thin vegetable mould which washed away if the trees were cleared. 72 Comparatively neutral observers such as William Colenso also questioned the sanguine expectations that had been built up in the minds of the public. In an account of his botanical exploration throughout the North Island during 1841-2, Colenso made the following general observation:

... the more I see of this country ... the more I feel assured that she is very imperfectly known, both in her productions and capabilities ... The soils, in particular, of New Zealand, have been represented as possessing a fertility unparalleled, and such everywhere abounding to an almost unlimited extent! Nearly ten years of residence ... has, however, convinced me, that such is far, very far, from the truth. Few ... districts ... can in any sense be termed fertile; and where such exist, the native population is generally very great. 73
IV. Post-biometric models come of age

Now that it was widely known, thanks to the publishing war between Port Nicholson and Auckland, that kauri commonly grew on poor soils, the New Zealand Company needed to find a more robust replacement for the biometric model. This model's use, in any case, would have been endangered by the discrediting of the 'humus' theory that underpinned it by Justus von Liebig's Chemistry in its Application to Agriculture and Physiology (1840). Before Liebig, the French chemist Saussure had identified flaws in it, but his work had failed to gain much recognition.74

To state his case in brief, Liebig observed that the only common definition of 'humus' was its insolubility, which made it difficult to understand how it got into the plant. Moreover, if plants lived on dead vegetable matter, then what did the first plant colonizing a bare surface live on? Finally, Liebig reasoned that if animals inspired oxygen and expired carbon dioxide, and plants expired oxygen, as had been proven, then plants must inspire carbon dioxide to maintain a stable atmosphere. From this, Liebig concluded that atmospheric carbon dioxide, rather than 'humus', was the true source of carbon in plants, and the only contribution of 'humus' was to convert it to carbonic acid (so it could enter via the roots) in the period of growth prior to leaf development.75 Regrettably the German chemist became carried away, and in 1843 went on to assert that atmospheric ammonia, rather than 'humus' supplied the plant with nitrogen. This premise was soon shown to be incorrect, although the exact sources of plant nitrogen were not established until the 1880s. Thereafter, Liebig espoused the view that the only nutritional role of the 'humus' was in facilitating the supply of mineral nutrients from the soil to plant roots.76 If one accepted Liebig's contentions as correct, then logically the abundance of organic matter, both in the soil and in the standing biomass, could no longer be regarded as a measure of the amount of available food for plants.

There were also practical reasons for the New Zealand Company to abandon, or at least play down, the biometric model. Since arable farming found a home in the Hutt Valley and Taranaki, what was needed now was open grassland for pastoral farming, an environment the biometric model was not conducive to promoting. To meet this need, the Company dispatched survey parties into the grass-covered Wairarapa (shown in Figure 4.2) and Wairau Valleys, even though the Company's claim to both was tenuous at best.77 Previous accounts of the Wairarapa had been promising, with Ensign Best's excursion into the area in 1840 finding that there were 50,000 acres of available land there, being level, of
Figure 4.2
The exploration of the Wairarapa

Source: Print of centre section of Samuel Brees' 'Plain of the Ruamahanga, opening into Palliser Bay near Wellington. This view represents about sixty miles of the length of the plain from North to South' (1843). From Edward Jerningham Wakefield's *Illustrations to 'Adventure in New Zealand'* (1845), Plate 9. Part Two. Alexander Turnbull Library PUBL-0011-08-2. Supplied by National Library of New Zealand / Te Puna Matauranga o Aotearoa.

In this centre section (one of three) a New Zealand Company are shown exploring the Wairarapa plain, through which the Ruamahanga River ran. As can be seen in the painting, these parties included Maori guides, who would have been invaluable for the application of the ecological model.
good soil and moderately wooded, well supplied with water and in many parts well clothed with excellent grass. With this in mind, Robert Stokes led an expedition into the Wairarapa in November 1841. Stokes' report, reprinted in the *New Zealand Journal* in August 1842, is significant, in that it shows a new emphasis on (and confidence in) the use of ecological criteria to judge soil fertility:

The land is for the most part covered with fern and coarse grass, easily cleared and affording ample pasturage for cattle in its present state, while on the banks of the rivers, and in different parts of the valley, are large groves and belts of trees, which the natives informed us were chiefly totara, kaikatea, rimu, mataihi, and toha toha, trees which are never found but in the best soil.

Soon afterwards, further survey parties under Charles Kettle and Samuel Brees also made their way to the Wairarapa, and came back with the same favourable impression Stokes had formed. Indeed, Brees informed William Wakefield that a "finer grazing country can scarcely be imagined for both sheep and cattle", and, in addition, there was "quite sufficient land for arable purposes to suit settlers". The news from the Wairau Valley, meanwhile, was equally auspicious. An expedition to the area by John Cotterell during November 1842 found, towards the foot of the valley, an alluvial flat about 10 miles across, which consisted of "particularly rich land covered with docks, sow thistles and other plants indicative of a good soil ...". A subsequent examination by Frederick Tuckett determined that Cotterell had overestimated the quality of land available, but there was no doubting the quality of the site. Having said this, his fellow surveyor, J. W. Barnicoat, who ventured into the Wairau separately, gave a dissenting opinion, asserting that "not only the extent but the value of the Wairoo [Wairau] plain as an agricultural district has been greatly exaggerated".

Despite the largely favourable assessments of the two valleys, Company settlements were established at neither. With respect to the Wairarapa, William Wakefield decided that the Company's failure to have its claim recognised by the Colonial Government precluded settlement, as squatters leasing land directly from Maori would undermine the Wakefieldian vision which Port Nicholson represented. The Wairau settlement proceeded further, but after the illegal surveying of the valley had been halted by Te Rauparaha and Te Rangihaeta in the ill-starred 'Wairau Affray', leaving 26 dead on both sides, it became a 'no-go' area for the Company.
Meanwhile, settlers had begun, albeit in a limited fashion, to emulate the surveyor's new use of plants as bio-indicators of soil fertility. As D. Sinclair of Wellington wrote in 1842, "the soil is good, at least I suppose it so, by there being a good deal of the tutu ... growing on it, which some of the missionaries told me was an invariable sign of good land ...." 85 Likewise, a letter from a Wellington settler describing New Plymouth noted that "the tutu bush is indicative of good soil".86 Yet while the ecological approach seemed to be gaining ground, the same could not be said of the geological approach - some Aucklanders, such as Bidwill, paid careful attention to geology when describing soils, but the vague remarks of the type made by Heaphy were more typical. This was in stark contrast to the situation in Australia, where the ascription of soil fertility on the basis of parent material, in line with modern European practice,87 was not uncommon. A recent Australian work, for example, observed that "the soil of New South Wales is good only where trap, limestone, or granite rocks occur".88 The relatively dense vegetation covering up the soil and rock surface may have been partly responsible for the limited adoption in New Zealand, but the lack of field training in geology possessed by explorers and surveyors was probably another factor.

This situation was put to right, however, by the publication of Dieffenbach's two-volume *Travels in New Zealand* (1843), which contained geomorphological description of the North Island in unprecedented detail. Dieffenbach certainly had the necessary training, becoming, on his departure from New Zealand, a Professor of Geology at Giesen (where he joined with the famous Liebig, of whom he had been a pupil).89 Just as importantly, his period of employment with the New Zealand Company had not persuaded him simply to produce the subjective drivel which was most appropriate for publicity purposes.90 Evidently, Dieffenbach placed considerable importance on soil parent material, for in a report on the Chatham Islands, he declared his intention to "make some remarks about the geology of the island, this being the most natural foundation for a description of the land, as far as it interests the agriculturist".91 In keeping with this approach, *Travels in New Zealand* contained numerous references to the relationship between soil fertility and surface geology. For example, in his description of the coast between North Cape and Parengarenga Harbour, Dieffenbach stated that one found "cliffs of volcanic conglomerate, sometimes alternating with cliffs of reddish crumbling loam; where this is the case the land is very fertile".92

When using non-geological grounds for assessing soil fertility, Dieffenbach generally resorted to the standard precepts of the biometric approach, or sought
evidence from the success of Maori cultivation, but on occasion he also relied (as Stokes and Cotterell had done) on ecological indicators. Though most frequently this meant the well-known association between kauri and poor soils, Dieffenbach augmented this observation with comments on other species, such as his statement that "the [Wairoa River] valley forms a basin of alluvial and very fertile soil, as is indicated by the coriaria, dracaena, and phormium, which only grow in the best situations". On the other hand, Dieffenbach, like Yate before him, also noted that manuka grew only where the soil was infertile. As for the 'fern land' versus forest question, Dieffenbach made no explicit comparison between the two, although as the quote below indicates, Dieffenbach believed fertility declined when 'fern' replaced forest after burning off. This said, Dieffenbach still thought that soils under tall 'fern' cover could possess a relatively high level of fertility.

In terms of his more general observations, Dieffenbach reiterated his concern that the widespread clearance of forest not only wasted valuable timber, but threatened to strip the land of its precious coating of vegetable mould:

I will make one observation here, which ... is at variance with the opinion of a great many colonists who are not farmers ... The colonists to whom I allude believe that burning the vegetation which covers the land ... improves its condition. In large tracts of alluvial soil, which is per se generally rich, as on the plains on the Mississippi, in the deltas and courses of the Rhine and Danube, the burning of the forest must certainly be the quickest way of clearing the land, and the loss of vegetable matter ... where there is a great depth of alluvial soil, cannot be of great importance: but in New Zealand the plains are not ... the produce of these rivers; they are a table-land, composed of a stiff clay ... which was deposited as we now find it ... at the original formation and heaving up of the land. ... there is only a small extent of true alluvial soil, the rest derives all the fertility it possesses from a vegetation which has covered it from the beginning, has decayed annually through ages, and has thus formed a layer of vegetable mould, in most cases very thin. If this vegetation be burnt down, the wind carries away the light ashes - another vegetation springs up, but less vigorous than the first, until by repeated conflagrations the land becomes perfectly exhausted.

Large districts in New Zealand have in this manner been rendered very poor. If the soil is originally covered with a forest, the vegetation after the first conflagration is a luxuriant underwood; if this is burnt down in its turn, high fern and flax spring up ... at last stunted fern, rushes, club-mosses, and meagre shrubs of Leptospermum are the only plants which this soil is capable of producing; and many places are even quite bare ... As the natives ... prefer, with few exceptions, the scattered hills for their
plantations, they are continually lighting fires in order to clear a road ... and these have not failed to produce their natural effect.99

The position was quite different from the traditional impression that various pamphlets on New Zealand, which lauded the virtues of its alluvial soil, had created. In a similar vein, Dieffenbach also decried the notion, which was gaining increased currency, that New Zealand's volcanic soils were inherently rich:

When we speak of a volcanic country we generally associate with it the idea of fertility; but this is true in particular cases only. If the ejected matter be mud or ashes, in forty or fifty years... it is ... fit for planting [;] but it would appear that the masses thrown up by these Polynesian volcanoes have rarely consisted of such soft substances, but have flowed out as lava, forming hard scoriae ... and it will therefore easily be understood that the lands immediately at the base of the numberless volcanic cones ... in New Zealand are not always those best suited for agricultural purposes.100

When considering the spatial distribution of fertile soils in the North Island, Dieffenbach took a neutral position. He agreed that the New Zealand Company settlements were suited to agriculture, but at the same time maintained that fertile tracts, such as the volcanic soils of the Manakau district and the Waipa Valley in the Waikato (which rivalled "in fertility the best districts of the island"), could be found elsewhere too.101 Even in Northland, where most soils, including those around the Bay of Islands, were infertile, he identified large areas fit for agriculture, such as 120,000 acres in the Awaroa Valley.102 Overall, therefore, Dieffenbach's picture of soil fertility in the North Island amounted to a patchwork of fertile and infertile terrain which in purely spatial terms defied broad generalisations as to its character.

Dieffenbach's work was a watershed in the appraisal of soil fertility in the North Island, as its level of detail made the generalisations produced using the biometric model redundant. Having said this, later explorers and surveyors, who became increasingly familiar with the niches into which various specimens of native flora fitted, tended to rely more and more on the ecological model. Their endeavours were also assisted by the growing number of opportunities to observe the cultivation (by either Maori or Pakeha) of European crops. For example, by the mid-1840s, two to three years cultivation history had demonstrated (as discussed in Chapter Six) that generally 'fern land' was not so infertile as many settlers imagined. This amended opinion was reflected in subsequent surveyors' reports. In 1850, for instance, William Mein Smith stated in his report for the New
Zealand Company on the soils in the Turakina-Rangitikei region that "much good soil will be found there, for the Fern is very high and thick. Poor soil will not produce such a crop even of Fern." Moreover, distinctions started being made between the soils on which fern grew in different parts of the country, as seen in the evidence of J. W. Child to the 1844 Select Committee on New Zealand:

You find, at [Question] No. 3177, in Mr. Kettle's evidence, a reference to fern land; will you state the different species of fern land that came under your observation; is it all of the one kind? - No; there is a white clay fern land on the hills round Wellington, and on some portion of the hills of Auckland; the sandy land of Wanganui and Manawatu; a reddish quality at the Bay of Islands; and the loam of New Plymouth.

In short, the general description of fern land does not convey, throughout New Zealand, a correct idea of the quality of land? No; the fern land at New Plymouth is very good, and in the immediate vicinity of Auckland or Wellington is quite the reverse.

As surveyors grew more confident in the New Zealand environment, they also started employing a wider range of methods for describing the soil. In the abovementioned survey, Mein Smith took advantage of the holes dug for surveying posts to describe in detail soil profiles, while Robert Sheppard, in an extraordinary series of experimental soil examinations in 1845, made rudimentary field measurements of the moisture content and root mass of a number of soil samples from the Port Nicholson area. Unfortunately, Sheppard's method of analysis was not sufficiently sound for him to make worthwhile deductions, and he ended up relying on the character of the vegetation and past cultivation history, when making his assessment of soil fertility. Interestingly, Sheppard's survey also reveals that there were still inconsistencies when applying ecological criteria. Whereas most agriculturists gave soil on which tawai (or 'black birch') grew, a bad name, Sheppard stated that "the only person whom I know to have brought it into cultivation" defended its qualities.

V. Surveying the southern settlements

This change to post-biometric approaches for assessing soil fertility was far from being solely a North Island phenomenon. It was just as evident during the extensive explorations, led by Frederick Tuckett, on the east coast of the South Island for the site of the 'New Edinburgh' colony in 1844. At the time, Governor Fitzroy's administration had been desperately short of capital, and had given
permission to the New Zealand Company to make a further purchase of 150,000 acres (subsequently increased to 400,000 acres to allow for depasturing) under governmental supervision. The 'New Edinburgh' scheme was the Company's response. At several points during the expedition, and most notably during his journey up the Aparima River, Tuckett made inferences, on an ecological basis, as to the character of the soil:

... on the west side of the Aparima, there is a continued forest ... The prevailing species of tree are remo, totara, and tall manuka, all indicative of inferior soil ... The bush-like woods on the east side are of white birch, likewise no recommendation of the soil ...

In this instance, Tuckett proceeded to predict that agriculture would not succeed until the soil was sufficiently manured by pastoral farming. This type of recommendation, which Tuckett made it more than once, was a novelty in survey reports. On occasion, Tuckett also took note of the geological and textural features of the soil, as at Moeraki beach, which he described as exhibiting "a vegetable mould" beneath which was "a yellowish loamy clay, ten to fifteen feet in depth" which in turn lay atop a "very deep bed of dark substance, probably a bituminous shale". Likewise, at Tautuku, Tuckett reporting finding a fertile soil formed from basalt at the coast, although he also saw there the parent material of an inferior "sandy and ferruginous soil", which he encountered after going inland, on which rimu (Dacrydium cupressinum), totara (Podocarpus totara), and rata (Metrosideros umbellata) grew. Soil exposures were not always so easy to come by. On the plains of Southland, Tuckett thus took the unusual step of digging profiles with a spade. Where European farming was already established, as at Waikouaiti by Johnny Jones, the quality and quantity of produce also received attention; in this case, David Monro (one of Tuckett's companions) recorded the presence of a fine crop of potatoes on land cleared of bush, but poor crops of turnips and wheat. Both Monro and Tuckett concluded, however, that the latter were more indicative of Jones' poor farm management, rather than any inherent deficiencies in the soil.

Despite the preference for Port Cooper up to this point, Tuckett's expedition chose the Otago Block (which stretched along the coast from Otago Harbour down as far as the Clutha, thereby encompassing the Taieri, Tokomairiro, and part of the Lower Clutha plains) as the site for 'New Edinburgh'. In Monro's view, the 'Port Cooper plain' possessed a "light and easily worked loam, well suited ... for potatoes, oats, barley, turnips, and similar crops", but the soil seemed too
loose for wheat cultivation. Moreover, the widespread evidence of burnt forest on the plain suggested (in accordance with Dieffenbach's contention, which even William Wakefield expressed agreement with)\(^1\)\(^1\)\(^5\)
that the richness of the soil would have been dissipated. Consequently, as Monro remarked, "whether it would yield crops plentifully at once, without fallowing or manure, is doubtful".\(^1\)\(^6\) It was nevertheless believed that this shortcoming could be remedied by pastoral farming, since the resulting dung would rejuvenate the soil. The biggest drawback, in fact, was the scarcity of local timber; the expense of obtaining it from elsewhere was viewed as too much for a new settlement to bear.\(^1\)\(^7\) In contrast, the whole Otago coast seemed to invite settlement, even if primarily on a pastoral basis.\(^1\)\(^8\)

The Lower Clutha plain, for instance, was "suitable for tillage" once drained, and inland there existed "an excellent wheat soil", while between Moeraki and the Otago Harbour (not included in the later purchase) there existed not just "a fine grazing district", but also "frequent wood and water" and "a good surface and sub-soil".\(^1\)\(^9\)

As for Otago Harbour itself, it possessed "long slopes or downs, upon which grows good grass, mixed with shrubs indicative of a strong soil".\(^1\)\(^0\)

Two years after Tuckett's expedition, Charles Kettle's survey team began setting out sections for the Otago colony, which received its first Company settlers on 22 March 1848.\(^1\)\(^1\)\(^1\)

By this time, the use of plant indicators to assess soil fertility had a sufficiently good reputation for its inclusion in a treatise on surveying in New Zealand by Arthur Whitehead. This set out the following instruction:

The daily attention of the exploring surveyor should be directed ... to the character of the timber he finds on the bush land, and the nature of the soil. After a little experience ... he will find that the different varieties of timber are proper to particular kinds of land, so that he will form a tolerably correct estimate of the latter from the nature and appearance of the former.

... the land where the \textit{totara} is found to flourish is generally rather light and sandy, consisting of rich alluvial deposits, well calculated for producing good crops of potatoes; whilst the districts where other pines, such as the \textit{rimu} and \textit{kahikitea} abound, are composed of a stiffer soil, adapted more especially for wheat and other crops of grain.\(^1\)\(^2\)

What is still more significant is that the same approach to soil assessment was passed on to would-be emigrants via Edward Jerningham Wakefield's \textit{Hand-book of New Zealand} (1848). While much of the information in this work described New Zealand's soils in a geological context,\(^1\)\(^3\) the section headlined 'Judge of
Land', which told emigrants on what basis to make their land selections, relied almost exclusively on ecological criteria:

The quality of wild land may be judged of, if timbered, by the kinds and size of the trees. That is generally the best soil, on which the Rimu, Totara, Mai, and Kahikitea pines, interspersed with Taua and Rata trees, grow to a large size. The trees should, as a general rule, be tall, and branching near the top.

If the trees be low in size, or scraggy, the soil is clayey and cold. The Mamuka tree, and the Tawai or Black birch, are commonly signs on inferior clayey or stony land. The Pukatea in abundance, or a great prevalence of the parasitical Kiekie among the branches of that and other trees, is a sign of wet and swampy lands.

Take an iron ramrod with you, sharpened at the end. By this means you can tell whether knobs or knolls, on the surface ... are caused by rocks and large stones or not. You will be able to ascertain whether the subsoil be clayey or the reverse, which you could not otherwise so readily determine, as the top of all timbered land is usually covered with the black mould of decayed vegetable matter.

The quality of fern land, or of grassy and shrub covered land, is much more easily determined by the eye. The height of the fern, the luxuriance of the grass and shrubs, are excellent guides. On inferior land, the fern is stunted, the grass grows in scattered wiry tufts, flax is very scarce and quite dwarfish, and other shrubs almost unseen. An unmixed growth of stunted mamuka is a bad sign, a quantity of ti-shrubs, commonly called the cabbage-tree, a very good one.124

At last, therefore, the New Zealand Journal's prediction of seven years earlier, that "there is no doubt but that a short experience in New Zealand will teach the settlers what species of tree delight in particular soils",125 had come to fruition.

VI. The end of the beginning

As the quote above indicates, the assessment of soil fertility in areas without forest was still fairly subjective. Accordingly, it was difficult for observers, when it came to examining the Canterbury plains, to have much confidence in their agricultural capabilities. As Wakefield's Hand-Book said of it,

The land hereabouts affords great facilities for pasturage, if distributed in extensive portions. But it does not appear adapted for tillage in small lots, the wooded portions being few and far between, and the soil of large tracts apparently of but moderate quality.126
Consequently, when Captain Thomas left for New Zealand in July 1848 to select the million acres requires for the 'Canterbury Settlement', his employer, the Canterbury Association, expected him to find it in the Wairarapa. However, upon his arrival Thomas found that the Wairarapa was still in Maori ownership, and with his own leanings towards the 'Port Cooper' plain reinforced by a favourable report from George Duppe, he headed south to consider its viability for settlement.127 In making his assessment, Thomas did not rely solely on the character of the vegetation, as he was able to call upon the experience of the Deans brothers, who had farmed at Riccarton since 1843. The Deans' replies to Thomas' enquiries, were overwhelmingly positive in regard to the quality of the land:

'Opinion as farmers upon the open land of the plain generally'

Except our garden and orchard, all our cultivations have been on an open, unsheltered part of the plain, which showed evident traces of having been heavily timbered at no distant period; but which, immediately previous to that time we broke it up, was covered with grass. Our opinion is, that in no part of the New Zealand Company's territories can equal crops of grain be grown at so small an expense as they can here on the open plain ... we feel confident that, taking an average of seasons, it will produce ... at least thirty bushels of wheat, barley, or oats to the acre; and that it will grow in perfection every grain and fruit common in England.128

This made for a very favourable comparison with the 25 bushels per acre which might be expected in Tasmania and South Australia.129 Still more important to Thomas was the Deans' reassurance that the lack of bush or forest cover did not indicate a paucity of good soil:

'As to crops on bush land'

Our opinion is, that the greatest part of the plain was covered with timber at no distant period, and that the bush land is not superior to the open land in any respect. We mean, that suppose a clump of timber was cut down ... the ground whereon that bush grew would not produce a larger crop than ... land adjacent to it, which had been covered with timber at some not very remote period; but if the timber was burned on the land, it might produce a better crop the first year than open land.130

Given these highly satisfactory accounts, Thomas felt that the Canterbury Association need look no further for its settlement.131 Although parts of the plains, Thomas admitted, were of inferior quality, the soil in general consisted of a "light loam resting on a gravel substratum of blue clay, much of it well adapted
for agricultural purposes and capable of yielding excellent crops of all kinds of grain, potatoes and European fruits and vegetables.¹³² To deflect concerns about the lack of forest cover, Thomas further observed that Auckland and Nelson settlers now showed a preference for open land anyway.¹³³ Ultimately, Thomas managed to convince not just the Canterbury Association of the wisdom of his choice, but also Governor Grey, without whose assent the scheme could not have proceeded at all, and Bishop Selwyn and William Fox, the two most senior New Zealand representatives of the Church of England and the New Zealand Company, both of which were intimately involved with the Canterbury Association's proposals.¹³⁴

Surveying of the settlement proper began in mid-1849, although funding problems prevented its completion before the arrival of the first English colonists in December 1850.¹³⁵ What was achieved in the meantime, however, showed an approach to surveying markedly different from that applied in previous settlements. In the new modus operandi, the laying out of sections was done away with, and surveyors also employed, during the so-called topographic survey, ecological labels to distinguish between the various soil types. Settlers were then free to select anywhere, after which section boundaries were drawn in using the trigonometric base lines.¹³⁶ Only a third of the land trigonometrically surveyed was examined by the topographic survey before the settlers arrived, but what was completed was depicted in the map Part of the Canterbury Settlement, which is reproduced in Figure 4.3.¹³⁷ This map conformed to the directions contained in Felix Wakefield's Colonial Surveying (1849):

> The nature of the soil, a knowledge of which is so important for intending colonists, could be expressed on the map by conventional signs used to denote the grassy plain, or land covered with timber, adding others of easy invention to indicate its qualities of sterility and fertility.¹³⁸

In their written reports, meanwhile, the Association surveyors distinguished between five general vegetation types (forest land, open grass, fern and tutu, flax bottoms, and reclaimable swamp land), although, on the aforementioned map itself, some mixing of these categories occurred (together with the addition of further categories, including raupo (Typha muelleri), anise, and manuka).¹³⁹ Interestingly, the initial instructions given to Thomas also called for soil samples to be collected and sent to England for analysis.¹⁴⁰ There is, however, no evidence to suggest this plan was implemented.
Figure 4.3
The application of the ecological model in Canterbury


This map represents the output of the topographical survey of the Canterbury settlement, in which, as can be seen, landscape units were demarcated according to their vegetation cover. The stippled areas on the map represent areas of swampy land, while drier tracts are unstippled. The map also includes the boundaries of the early land selections in Christchurch (or, as it was called in the map, Lyttelton). Although Maling notes that this particular map is that mentioned on p. 317 of the Canterbury Papers (Canterbury Papers (1850-1852) (Kiwi Publishers, Christchurch, 1995), [11], p. 317), it seems that the ecological detail was derived from earlier mapping referred to in a letter by the chief Canterbury Association surveyor, Joseph Thomas (Thomas to J. R. Godley, 15 May 1850. Canterbury Papers, [8], p. 248).
As it turned out, the ecological distinctions the Canterbury surveyors made received scant appreciation from settlers expecting to find a landscape befitting the "great and uniform natural fertility of the Canterbury Plains". Indeed, when the Association's chief 'agent', John Robert Godley arrived in April 1850 from Wellington to supervise preparations for the settlement, he noted that several of his fellow passengers were "open-mouthed at the want of luxuriant grass" upon seeing the site for the first time. Even Godley himself needed reassurance from the existing residents before he could pronounce, in a letter to the New Zealand Company, that the Canterbury site was "equal, if not superior ... to any part of New Zealand". Even then, Godley warned the Company that colonists arriving from England might be just as unimpressed as his fellow passengers had been - a prediction which was subsequently borne out. For several years after its establishment, in fact, the Canterbury settlement was forced to strenuously counter the notion that its grassy plains were a sure sign of sterile soils:

... all this is nothing to bitter, bitter disappointment, with which they behold the bog, - bare, barren, and brown ... These are the first impressions; yet what is the truth? ... The brown moor is a great extent of level land, fertile as the plains of Lombardy. He, who takes heart ... and descends, finds it lighter at every step; he soon perceives the land below is not a bog, but a good dry soil, covered with vegetation of flax, fern and grass; he takes up a handful of earth and sees in it a rich loam; he ... perceives the land adapted for growing all that can be produced by English soil.

Evidently, while the surveyors had adapted to the change of using ecological criteria to assess soil fertility, many of the prospective settlers still held on, at least in part, to the biometric notion that a lack of forested land, or at least, luxuriant ground cover, signified sterility. This is not altogether surprising. Although the finding that kauri generally grew on infertile soils had exposed the 'biometric fallacy' at the start of the 1840s, the difficulties in initial cultivation of 'fern land' had allowed it to linger on well into the second half of the decade. This meant that settlement sites with plenty of open land, such as Nelson, had remained relatively unattractive to agriculturists. Indeed, its most vigorous New Zealand proponent, the New Zealand Company, only endorsed its replacement by the ecological model in 1848. This said, the biometric model had not helped the New Zealand Company much - owing to ongoing financial problems, the Company finally surrendered its charter in July 1850, with the Canterbury 'colony' being its final contribution to New Zealand settlement history. It should also be
remembered that the ecological model was not yet reliable either. Despite the efforts of scientifically-minded observers like Colenso, botany in New Zealand was still in its infancy, and thus it was almost inevitable that some early inferences made using an ecological model would be incorrect. This said, the ecological approach had, as recent research has demonstrated, a reasonably sound basis, and accordingly it remained the standard means for assessing the fertility level of land in its 'natural' state in New Zealand for the remainder of the nineteenth century.
Notes to Chapter Four

2 Ibid., p. 138.
4 Joseph Banks, 20 November 1769 & March 1770. Beaglehole, J. C. (ed.), The Endeavour Journal of Joseph Banks, 1768-1771 (Sydney, 1962), I, pp. 435-6, & II, p. 3. While the Thames Valley did not feature much in New Zealand Company literature, the Glasgow-published Popular Account of New Zealand (1839) did refer to it, describing its banks as "remarkably fertile", with "thousands of acres of the finest flax" to be found there (Popular Account of New Zealand as a Field for British Colonization (Glasgow, 1839), p. 27). This circumstance is probably owing to the fact that the New Zealand Company had informally agreed with their Scottish affiliates that the latter would re-purchase land bought by the former, in the northern part of the North Island (Burns, Fatal Success, p. 139).
6 Ibid.
8 See Chapter Three.
10 Ibid., pp. 39-40D.
11 Hobson to Russell, 15 October 1840. New Zealand Co., Documents Appended to the Twelth Report, p. 33D.
13 Heale, Theophilus, New Zealand and the New Zealand Company: being a consideration of how far their interests are similar (London, 1842), p. 51.
15 Ibid.
20 Wakefield, E. J., Adventure in New Zealand from 1839 to 1844, with some account of the British Colonization of the island [1845], ed. by Sir Robert Stout (Christchurch, 1908), p. 137. Edward Jerningham Wakefield was Edward Gibbon Wakefield’s son (see Table 3.1).
21 Burns, Fatal Success, p. 44.
23 Burns, Fatal Success, p. 158.
26 Burns, Fatal Success, pp. 179-81.
29 Cited in ibid., pp. 331-2.
30 Ibid., pp. 330-1.
31 Hobson to A. Wakefield, 27 September 1841. New Zealand Co., Documents Appended to the Twelth Report, pp. 63-4D.
33 Allan, Nelson: A History of Early Settlement, pp. 66-7 & 69-70. For details of the Wakefield family, see Table 3.1.
37 Burns, Fatal Success, pp. 182-3.
There was an interim of more than a year between the time Bidwill wrote the last entry in his journal and his retrospective review of the Port Nicholson vs. the Thames argument, the latter of which comprised only about 5% of the total work. Bidwill, *Rambles in New Zealand*, p. 88. Aside from staying with New Zealand Company settlers while writing this section, he was connected with the Company through the fact that its sponsored the work's publication (Johnston, 'Information and Emigration: the Image Making Process', *New Zealand Geographer* 33(2) (1977), p. 62).

Bidwill, *Rambles in New Zealand*, pp. 3 & 5.

Ibid., pp. 9 & 29.

Ibid., p. 42.


Ibid., p. 28.

Ibid., pp. 80, 92, 97 & 102. Towards the start of the work (p.2) Heaphy also made the comment that in any harbour in Cook Strait one could find hills covered by a "deep black vegetable mould, which for ages has been accumulating, producing the most splendid growth of forests, many of the trees in which are of a really stupendous size".


Heaphy, *Narrative of a Residence in various parts of New Zealand*, p. 80.

Ibid., p. 32.

Ibid. By way of example, on one occasion the *New Zealand Journal* reported the growing of a cabbage 11ft in circumference (*N. Z. Journal* 2(41) (7 August 1841), p. 198). The size of this cabbage (which weighed 17 lbs) was subsequently exceeded by one of 20lbs, if we are to believe the report in J. M. Taylor's letter which appeared in *Letters from Settlers and Labouring Emigrants, in the New Zealand Company's Settlements of Wellington, Nelson, and New Plymouth* (see Johnston, 'Image and Reality: Initial Assessments of Soil Fertility...

54 Heaphy, *Narrative of a Residence in various parts of New Zealand*, p. 30; Hannam, John, 'Potato'. In Morton, J. C. (ed.), *A Cyclopedia of Agriculture, Practical and Scientific* (Glasgow, 1855), II, p. 672. The interest shown by the New Zealand Company towards the Chatham Islands had arose because they were beyond the territorial limits of Hobson's authority (Burns, *Fatal Success*, p. 136).


56 Ibid., pp. 7 & 109.

57 Ibid., p. 108.

58 Ibid.


65 Heale, *New Zealand and the New Zealand Company*, pp. 55-7; Jameson, *New Zealand, South Australia, and New South Wales*, pp. 311-3. Heale's grounds for arguing that Jameson was impartial were that he was not associated with the Port Nicholson settlement, but had quoted extensively from correspondence of its settlers.


68 Ibid., p. 40.

69 Terry, *New Zealand, its advantages and prospects*, pp. 57-8.

70 Ibid., pp. 57-9.

71 Ibid., p. 254.

Colenso, William, 'Memoranda of an Excursion made in the Northern Island of New Zealand, in the summer of 1841-2; intended as a contribution towards the ascertaining of the Natural Productions of the New Zealand Groupe: with particular reference to their Botany (Part II)'. *The Tasmanian Journal of Natural Science* 8 (1845), p. 307.


Cited in *N. Z. Journal* 2(37) (19 June 1841), p. 148; Bagnall, A. G., *Wairarapa: an historical excursion* (Masterton, 1976), pp. 26-7. The *New Zealand Gazette* of 19 December 1840 had originally stated the figure as 500,000 acres, but this was corrected a week later at Best's insistence.


'Wellington settler' to [J. Ward], Secretary of the New Zealand Company, 5 June 1842. 


It is worth noting that William Smith's famous map of 1815, *A Delineation of The Strata of England and Wales*, also incorporated (as elucidated in the map's full title), 'the Varieties of Soil according to the Variations in the Sub Strata' (Winchester, Simon, *The Map that Changed the World* (London, 2002), p. 222).


92 Dieffenbach, Ernest, *Travels in New Zealand; with contributions to the Geography, Geology, Botany, and Natural History of that Country* [1843] (Christchurch, 1974), I, p. 205.

See, for example, the comment, "In this forest the natives had cleared large patches of ground, and the vigour of the plantations showed the primitive fertility of the soil". *Dieffenbach, Travels in New Zealand*, I, p. 346.

94 At one point Dieffenbach stated that "the land on which the kauri-pine grows is, even when cleared, of no use, for any other purposes, both from the rugged nature of the ground and from the quality of the soil ... It is one of the most remarkable phenomena in botany, that an immense tree such as the kauri should be satisfied with places where one would scarcely have supposed it could have taken root." *Ibid.*, I, p. 275.

95 *Ibid.*, I, p. 260. *Coriaria* is the genus for *tutu*, as *phormium* is for *flax*.

Near Tauranga, Dieffenbach remarks that, "The vegetation everywhere indicated the richest soil, and the most prominent plants were fern, flax, and veronica". Dieffenbach, *Travels in New Zealand*, I, p. 402.

98 Ibid., I, pp. 227-8.
100 Ibid., I, p. 244.
101 Ibid., I, pp. 79, 139, 290-2 & 333.
102 Ibid., I, pp. 220-1 & 257.
105 Ibid., pp. 3 & 9. Previously, soil profiles had also been recorded by Tuckett (as will be seen later), and Dieffenbach, who observed, near the Roturua mission-house, "a black mould a few inches thick, then pumice-gravel one foot thick, below this a yellow sandy loam about six feet thick, and afterwards another bed of gravel". Dieffenbach, *Travels in New Zealand*, I, p. 392.
106 One of the problems Sheppard himself noted when making soil moisture measurements was that he had no idea when it had last rained in the area. In his observations on cultivation history, Sheppard made use of his own experience growing wheat in the Pakuratahi Valley. His crops, he declared, were as good as any from the Hutt Valley. R. Sheppard, 'Specimens of the Soil of Various Districts in the Vicinity of Port Nicholson, New Zealand', January 1845. NZC 110/1 (NAHO).
When speaking of the grass covered Taieri plain in 1844, William Wakefield stated that it had been "much deteriorated in places by extensive and repeated burnings, which impoverish the land". Wakefield to [T. C. Harington,] Secretary of the New Zealand Company, 31 August 1844. Hocken, *Contributions to the Early History of New Zealand [Settlement of Otago]*, p. 267. Harington, it should be noted, replaced John Ward as Company Secretary in 1843 (Hocken, T. M., *A Bibliography of the literature relating to New Zealand* (Wellington, 1909), p. 91).

David Monro concluded that in "the block intended for survey for New Edinburgh, it will be impossible to find the required number of sections of first-rate land, if anything like continuity is to be preserved. The great proportion will be pasture land for many years". Monro, 'Notes of a Journey through a part of the Middle Island'. Ibid., p. 259.


In order, the trees and shrubs identified are rimu (*Dacrydium cupressinum*), totara (*Podocarpus totara*), kahikitea (*P. dacrydioides*), matai (*P. spicatus*), tawa (*Beilschmiedia tawa*), rata (*Metrosideros spp.*), manuka (*Leptospermum scoparium*), kamahi (*Weinmannia racemosa*), pukatea (*Laurelia novae-zelandiae*), kickie (*Freycinetia banksii*) and ti (cabbage tree) (*Cordyline spp.*).


Ibid.


Ibid., pp. 123-30.

Ibid., p. 114.


Wakefield, Felix, *Colonial Surveying, with a View to the Disposal of Waste Land: in a Report to the New Zealand Company* (London, 1849), p. 61. It was stated in Wakefield's work that the "peculiar modes of surveying, selecting, and giving possession of land, recommended in this work, are those adopted by the Canterbury Association". Cited in Webb, L. C., 'The Canterbury Association and its Settlement'. In Hight, James, and Straubel, C. R. (eds.), *A History of Canterbury* (Christchurch, 1957), p. 167. As well as being a brother of Edward Gibbon Wakefield (see Table 3.1), Felix Wakefield was also an uncle of one of the two main surveyors working under Thomas, Charles Obins Torlesse (See C. O. Torlesse to C. G. Torlesse [nee Wakefield], 4 July 1849. Maling, Peter Bromley (ed.), *The Torlesse Papers: the journals and letters of Charles Obins Torlesse concerning the foundation of the Canterbury Settlement in New Zealand 1848-1851* (Christchurch, 1958), p. 87).
See 'Mr. Torlesse's Report [to J. R. Godley] upon the Canterbury Block'. *Lyttelton Times*, 14 June 1851, p. 6.


Burns, *Fatal Success*, p. 298.

Chapter Five

The coming of European Agriculture to Aotearoa

In the history of New Zealand's colonisation, the overwhelming imprint is that left by the settlers who arrived by way of a sequence of immigration schemes, starting with the New Zealand Company's endeavours in the 1840s, and continuing through in various forms until the 1880s. Yet well before the New Zealand Company dreamt up its schemes for bringing the teeming millions from Great Britain to New Zealand's distant shores, the first serious attempts to establish Western-style agriculture in New Zealand were already being made by mission settlers in the Bay of Islands. The mission settlers achieved little themselves, although they proved more effective in the alternative strategy of fostering the piecemeal adoption of elements of Western-style agriculture by Maori farmers.

I. For the want of a bee the clover was lost ... : the failure of mission farming

For the purposes of agriculture, the siting of the early mission stations in the Bay of Islands was not ideal. Most early accounts of the district, as seen in Chapters Three and Four, did not rate the area highly in terms of soil fertility, although Marsden himself thought Kerikeri and Waimate in particular showed great promise. As modern soil studies have shown, the poor reputation of its soils was generally well deserved. The warm humid environment in the area has created, in the main, podzolised yellow-brown earths, which are strongly leached, and thus low in mineral nutrients, with high clay content. Nitrogen levels, meanwhile, are also fairly low, even though they contain moderate levels of organic matter. This is because the acidic conditions slow decomposition, thereby building up a carbon-rich litter, known as a mor humus.

Exacerbating this paucity of fertile soils in the area was the fact that the choice of early sites was influenced more by the patronage of local Maori chiefs than by their agricultural potential. At the first station, established on the hillside at Rangihoua in 1815, the soil proved to be thin and of low fertility - so much so, in fact, that Marsden admitted in 1830 that the site was unfit for cultivation. Likewise at Kerikeri (established in 1819), the scrub-covered red and brown loams were easy to clear, but because of their mature soil development, they have low
nutrient levels. Having said this, the missionaries had more success when they started copying the local Maori practice of clearing land where puriri (*Vitex lucens*) grew, which was on younger and richer soils. On occasion, mission stations were established on more fertile sites, such as Waitangi and Kawakawa, but the threat of Maori raids caused both to be abandoned.

This lack of good land proved a major frustration. Richard Davis, the former Dorset tenant farmer who arrived in 1824 to supervise the mission stations' agricultural activities, condemned all the land within 20 miles of the Bay of Islands as "very barren" and commented that Maori cultivated what good land there was in the vicinity. Moreover, local Maori were unwilling to part with this better quality land. One Maori chief, when asked if he would sell, replied that "when that land will not produce us potatoes larger than the top of our little fingers you shall have it". From the Maori viewpoint, this response was entirely reasonable (albeit not to the missionaries), since selling land prior to its exhaustion would mean the unrecompensed transfer of the nutrients restored to the soil during the bush fallow.

As the mission land was relatively infertile, it is not surprising that the soils under cultivation quickly became exhausted. Indeed, by the mid-1820s the farm at Kerikeri yielded less grain than was being sown. As the following entry from James Kemp's journal indicates, this situation had led by 1825 to the commencement of manuring at Kerikeri:

Shunghee [Hongi] then observed that we had said that it was God who made the wheat to grow, he alluded to the wheat which was then growing in our settlement, a part of which ground had been manured and a part had not, and on which was manured it looked very well indeed, so from that he concluded that it was not God who made the wheat to grow but the manure which had been put on the ground for he said if it had been God they would have both grown alike!

The type of manure used is this instance was not recorded, though both the small number of livestock and difficulty of collecting dung from them, since they tended to graze freely in the bush, together with the apparent lack of adverse reaction from Hongi, suggests it was not animal dung. Going on later practices at Waimate, it may have been 'fern' foliage. Davis also began manuring land at Kawakawa, while at Paihia, Henry Williams' journal records that seaweed was used to fertilise soil destined for potato cultivation. Where land being broken in was burnt off, it would also have benefitted, in the short-term, from nutrients in the ash left behind. Interestingly, Davis' long-term intention appears to have been
the replication, on the mission farms, of a fully fledged Norfolk-style crop rotation, as almost immediately after his arrival, he ordered consignments of seed for clover, turnips and mangels.14

The move to Waimate, which brought mission farming to the Taiamai Plains - long famous for their weakly leached and thus fertile red and brown loams - finally took place in 1831. Having said this, the eventual site was the second choice of the missionaries, and Waimate was on the Plains' northern margin. Consequently, Davis commented that the mission site itself "was the poorest part of this rich district".15 The site was made up of retired Maori crop land, and, like Kerikeri before, was covered with bracken and scrub, although the former vegetation of puriri trees which was evident was probably a positive sign given the Kerikeri experience.16 In later years, animal dung was employed on the mission farm to manure the land, in accordance with the Norfolk-rotation model, but initially 'fern' fronds were, as noted previously, used for this purpose.17 Yate's Account of New Zealand indicates that 'fern' ash was also used to break down "stiff marly subsoil".18 Shell-lime from Kerikeri was, incidentally, also used at Waimate, but rather than being used to correct soil acidity, it was instead used to steep the seed.19

The concept of a Norfolk-style rotation was nevertheless stymied by the fact that clover, while flourishing in the new environment, would not seed. Honey bees from Europe were not introduced until 1839,20 and there were no suitable indigenous bees to fertilise it.21 The clover therefore had to be regularly resown, using a new batch of seed. With this in mind, Davis wrote to Dandeson Coates in 1834, stating that "I am now beginning to look out anxiously for the Clover seed which was sent ... as without it the Economy of my proceedings in the preparation of your lands will be frustrated".22 Due to this obstacle, Davis signalled in this letter his preference to shift the farm from a rotational cropping regime to one based on convertible husbandry (ley farming). This amounted to laying down pasture after only one crop of wheat, and thereafter building up stock numbers, and thus also increasing the quantity of available animal dung. As he pointed out, "should we attempt to continue the whole of the land in a state of cultivation, as we break it up, we should not only lengthen out our heavy work, but we should impoverish our land for want of a sufficient quantity of manure to maintain it and which could not be procured in the present state of our progress".23 A year later a shipment of twenty ewes and two rams arrived in accordance with Davis' recommendation, and a further 100 sheep were delivered
in 1837, taking the total at the farm to 135. By 1839 meanwhile, 100 acres had been sown in English grasses.\textsuperscript{24}

Sadly for Davis, his efforts to manure the cropped land with animal dung were too little, too late. Henry Williams (then head of the mission) decided in 1838 that the Waimate farm drained too much of the mission's resources to be sustained.\textsuperscript{25} In the meantime, wheat yields at Waimate, after pests, diseases, and a climate too wet for successful grain cultivation, had taken their toll, had been fairly low. Indeed, Davis reckoned that the best that could be expected without manure was 15 bushels per acre, which was well below the contemporary English average of 22 bushels. In 1839, when yields were probably closer to the norm, the expected yield was a paltry 12 bushels per acre.\textsuperscript{26} Accordingly, when Ernst Dieffenbach visited Waimate he reported that "the produce of the missionary farm has always been at a very low ebb" and that "a great deal of land" had "been relinquished, for the very fact that it yielded nothing at all".\textsuperscript{27}

The yields at Waimate appear, nevertheless, to have been on a par with other areas of Pakeha cultivation in the Bay of Islands district.\textsuperscript{28} In the official produce returns for crops sown in 1844, estimated yields for the Bay of Islands were just 12 bushels per acre for wheat, 15 bushels per acre for barley, and 5 tons per acre for potatoes. Such miserable productivity, in comparison with other regions of New Zealand, was due, it was said, to "the soil at this place being generally exhausted".\textsuperscript{29} The limited Pakeha presence on the rich Taiamai Plains - which consisted in 1840 of the Waimate farm and some land at Pakaraka - probably contributed to this result, although by this time local Maori had also sold the relatively fertile land around Waitangi and the lower reaches of the Kerikeri River.\textsuperscript{30}

Ultimately, Hargreaves has argued, the failure of the mission farmers to adapt to local environmental and economic factors sealed its fate. The initial dogged attachment of the mission farmers to the esteemed 'high farming' methods saw not just clover being grown when there were no bees, but also many labour-intensive operations, such as dung collection, and building erection, going on, even though labour costs were much higher than anticipated. Ironically, many of the farm buildings were not needed due to the warm climate.\textsuperscript{31} These lessons could have been valuable for future settlers, but as Hargreaves has observed, they were regrettably squandered, because of the hostile relationship which developed between the missionaries and the New Zealand Company. In Edward Jerningham Wakefield's \textit{Hand-Book of New Zealand}, for example, the only mention of the
Waimate farm, in a 24-page section on North Auckland, was Dieffenbach’s abovementioned "low ebb" comment.32

II. Something old, something new: soil fertility and Maori cash-cropping

Just as the mission settlers had to learn about their new environment, Maori cultivators had to familiarise themselves with the demands of a number of novel food crops, notably wheat, maize, and the potato. The first two posed an especially difficult challenge, as the Maori cultivators had no experience of cereal cultivation. Completely new methods of both cultivation and food processing had to be developed, therefore, before they could be embraced.33 As a result, only the chiefs Ruatara and David Taiwanga showed much inclination for it during the 1810s and 1820s, despite the efforts of explorers and missionaries to promote it.34 The most common response, Davis noted, of Maori cultivators was that growing wheat put a demand on labour which could better be used elsewhere:

We cannot cultivate wheat, nor do we wish to cultivate it; because it is attended with so much labour and has to go through so many processes before it can be eaten as bread. If we clear a piece of land and plant it with sweet potatoes, we get a good crop of food which we like, and which we can eat immediately out of the ground.35

The most serious obstacle facing Maori was the initial lack of milling equipment. However, once a mill had been built at the Waimate mission station in 1834, and Maori began to possess hand-mills as well, the extent of Maori wheat cultivation increased appreciably. By 1839, Davis observed, almost all the tribes (iwi) resident in the Bay of Islands "grew a little wheat".36 In the meantime, wheat growing had also been taken up by Maori in other regions, such as the Waikato and the Bay of Plenty.37

In comparison, Maori cultivators were much quicker to incorporate maize into their cropping systems. As early as 1830 Marsden reported that at Waimate a heavy crop equal to those found in New South Wales was being grown.38 Northland’s humid summers favour maize cultivation over that of wheat, and this success inspired Richard Davis to begin growing maize at the Waimate mission farm in 1832.39 Traditional Maori root vegetables were wrapped in leaves for roasting, so the sheathed nature of the cob may also have encouraged its adoption.40 Cobs roasted in this manner were not particularly palatable, but Maori cultivators lacked the means for grinding the grains into meal, or pots for boiling
the cobs, so there were few alternatives. This situation was only improved upon when the method traditionally used for the preparation of hinau berries, that is, underwater fermentation, was copied. Once softened in this manner, the maize grains could easily be scraped off the cobs.41

The potato fitted more naturally into traditional cultivation and food preparation methods because of its similarity to the kumara (sweet potato). Having said this, its tolerance of cooler temperatures meant that potato cultivation spread rapidly throughout the country. As early as 1801 extensive potato fields were observed in the Thames district, and by 1810 potatoes were being grown about Foveaux Strait for sale to sealers. One field observed at Bluff in 1813 was more than 100 acres in extent. Exports to Australia, meanwhile, had begun from the Bay of Islands by 1806.42 It appears that potato cultivation was primarily for trading purposes, as Richard Davis asserted in 1826 that they were less palatable to the Bay of Islands Maori than either kumara, taro, fernroot, maize or turnips.43

The missionaries felt encouraged by cash cropping because they saw this an avenue for Maori economic development, and to this end potatoes were purchased rather than grown at the Waimate mission farm.44 Maize also became a significant cash crop for Maori, and in 1837, for instance, several thousand bushels of Poverty Bay maize were exported to Australia.45 However, the real boost to Maori cash cropping came once organised Pakeha settlement commenced. By the end of the 1840s, substantial areas of highly fertile alluvial soils were being devoted to wheat, maize, and potato production, most notably in the Waikato-Waipa 'delta', where according to Governor Grey, there was in "one place alone" an area of wheat 1000 acres in extent,46 and in the Motueka valley, which contained some 1000 acres of wheat and 600 acres of other crops.47 Few estimates of yield from Maori cropping exist, but those that do show that the productivity from such fertile soils was relatively high. The 480 acres of wheat at Rangiowhia in the Waikato, for instance, gave a creditable average return of 24 bushels per acre, while instances of as much as 50 bushels per acre arising from the cultivations at Otaki in the Horowhenua, were not regarded as extraordinary.48 This, in combination with the greater readiness of Maori farmers to pool labour, meant that many Pakeha settlers, such as those at Wellington, found themselves not only outproduced but undersold as well.49

Despite its success, Maori agriculture during this period had a serious flaw. While European crops had been adopted, the strategies needed to sustain their
cultivation generally had not been. As an article in the *Maori Messenger* (a Crown-sponsored bilingual newspaper) observed:

The fertility of your soil has done more for you than your skill. We say so, not to discourage but to guard you against the error of over taxing that soil by forcing it to bear crop after crop of wheat until all its natural productiveness shall have been exhausted ... We have beheld some of the finest lands of Van Diemen's Land thus tortured and taxed, until the field that has yielded its 50 bushels an acre ... has, at last, refused to return the seed ... It is to guard against and counteract such ruinous excesses that farmers study the rotation, or change, of crops, sowing for example barley on the field from which turnips have been fed off, wheat after barley, and grasses and oats in succession. The observation which tells the farmer how to apply such changes most advantageously to his field are some of the rudiments of the Agricultural system.

One wonders why Maori farmers would take heed of such advice when most Pakeha farmers (as Chapter Six reveals) failed to do so. Nevertheless, the continuous cultivation of wheat and/or potato crops was undoubtedly unsustainable without either manuring, crop rotation, or fallowing. Often wheat and potatoes were grown alternately, though nutrient loss was probably even more rapid on potato-only fields, since two crops were taken off each year.

Numerous instances demonstrate, however, that the *tapu* against manuring (described in Chapter One) remained very much in force during the 1830s and 1840s. In 1834 Richard Davis noted that Maori labourers he had employed to spread manure were under a "concern for their souls". Similarly, in 1849 Johann Wohlers found that the residents of Ruapuke Island rebuffed his advice that they might improve their potato crop by manuring. Even if the *tapu* had broken down, Maori farmers would have struggled to manure their land though, as they generally paid little attention to the keeping of livestock, with the exception of the semiferal pig. They could not, therefore, have had a regular supply of dung, and nor did they usually have the apparatus (fenced yards, carts, ploughs, etc.) for its collection and application. In this regard, one of the more practical suggestions in the *Maori Messenger* was that they could conserve soil fertility by digging in the stubble once the harvest was complete. Crop rotation, meanwhile, was probably not a very viable option either. Market demand for Maori vegetable produce did not extend much beyond the potato, and commerce, it should be remembered, was the whole point of the exercise. Moreover, if green crops were grown in a rotation, Maori farmers would have had yet more learning to do.
Fallowing was the most pragmatic strategy for Maori farmers to adopt, but instead of practising it in the European sense of the word, they continued to follow the customary pattern of cropping for 3 or 4 seasons, after which it was left to recover under bush for a decade or so. However, three important changes associated with the new Maori agriculture served to make this traditional approach difficult to sustain. Firstly, the devotion of cropland to cash cropping required that new land be cultivated in order to suffice both one's own needs and market consumption. Alternatively, one could do without domestic cultivation, a seemingly extreme course of action, but one that the Maori population of Wellington followed during the mid-1840s when their vegetable diet consisted largely of gathered fern-root. This internal competition for land was further exacerbated by the second of the perturbations to the traditional pattern of Maori cultivation - the alienation of land to settlers. The potential for Maori-Pakeha conflict over this is apparent when one considers that in Wellington in 1847, of 823 acres cultivated by Maori, 576 were on land that had been sold to Pakeha settlers. While existing cultivation rights were not always extinguished by sale, these figures show that the encapsulation of Maori cultivation sites within 'native reserves', as envisaged by Wakefield, had failed. Unfortunately, their temporary nature made efforts to distribute them in a manner that would satisfy both Maori and Pakeha in the long-term nigh on impossible.

The third factor which made traditional Maori agricultural practices less viable was the additional fertility demand placed on the soil when potatoes were grown instead of kumara. Potatoes required up to five times as much nitrogen as kumara, although the amounts of phosphorus and potassium needed were similar. Consequently, the fallowing of bush land until nitrogen levels had recovered sufficiently for kumara production would no longer do. Maori farmers had two choices: either expanding the area of their old land, while taking fewer crops from it (thereby extending the recovery time: cultivation time ratio), or alternatively, switching their cultivation to richer land - namely, areas of mature forest, which already contained the requisite amounts of nitrogen in their leaf litter. A reading of Yate suggests that most Maori farmers chose the latter option (the practise of which is depicted in Figure 5.1):

... the winter potato is planted in new ground, upon which nothing has ever before been planted. This ground is chosen on the side of a wood; the trees are burnt down, the branches consumed, and the potatoes placed between the roots, or upon any little bare spot that can be found. They tell
Figure 5.1
Maori burning forest for potato cultivation


The preference shown by Maori agriculturists for growing potatoes in burnt forest is graphically illustrated in this Heaphy drawing, for the grove set on fire is one of the few remaining wooded areas in the foreground. Apart from showing this practice, Heaphy's illustration was probably also intended to show that the foreground must be fertile, since it too had been forest-covered, like the densely wooded background, but it was now clear of forest, and thus ready for cultivation.
Figure 5.1

Mount Eruption from the North Shore of Cook's Strait, NEW ZEALAND.
us that the reason for choosing such spots ... is that the earth is all rotten leaves and branches ... the only soil in which the vegetable will flourish ... 65

The new availability of metal axes also disturbed the traditional balance between the labour requirements of weeding, which steadily increased once cultivation commenced, and forest clearance, which could now be accomplished much more easily. 66 As a result, one would expect to see weedy plots abandoned more quickly than they had been previously. This does seem to have occurred. 67 The fact that many Pakeha observers in the 1840s, such as Dieffenbach and Bidwill, found large areas of burnt over land, leading them to express grave concerns over the future of both the forests themselves and the fertility of the soil, probably reflects the nett effect of these changes in Maori agricultural patterns. 68 Not all of the fires would have been related to potato growing, as they were also used for fostering bracken growth, clearing paths, and removing cover which enemy attackers might use, 69 but it seems almost certain that the great expansion of potato cultivation was driving a significant increase in the rate of forest clearance. 70

Despite these shortcomings, it should be said that Maori agriculture had made remarkable progress by the late 1840s. In little over two decades, Maori cultivators had become so adept at growing the unfamiliar crops which Pakeha settlers had introduced that rather than just competing in the agriculture produce market, they instead dominated it. As the New Zealander observed in 1848, Maori farmers were, in the Auckland market, the "largest purveyor of foodstuffs; so large indeed as nearly to monopolize the market and exclude the Europeans from competition". 71 Likewise, of the crops sown in Wellington in 1847, those sown by Maori accounted for approximately half of the wheat acreage, and three-quarters of the potato acreage. 72 Moreover, Pakeha settlers were fortunate that Maori agricultural operations had advanced so quickly, for Maori-grown produce played a vital role in sustaining the main settlements during their first years of existence. 73

III. From heyday to decline: Maori agriculture during the 1850s

Given the solid base which had been established, there seemed every chance, at the start of the 1850s, that Maori farming would become part of a thriving New Zealand agricultural sector. For a time, it was. Two gold rushes, the first in California in 1849, and the second, which was much closer to home, in Victoria in 1851, created significant new export opportunities for New Zealand agricultural
produce, and, in consequence, local prices rose considerably. At Auckland, for example, the average price of a bushel of wheat rose from 4s. in 1849 to 11s. in 1854. Pakeha observers initially feared that Maori might flock to the goldfields themselves. If the following account in Vicesimus Lush's journal is any guide, however, it seems that Maori farmers were acutely aware that they might accrue greater profits from the provisioning trade instead:

I said [to a Maori passing by on horseback] "Shall you go to Australia to pick up the gold?" At which he grinned and said: "I not go there. I bought two horses - a cart - a plough - I sow 100 acres in wheat. I work little and send my corn to Sydney; English work hard in picking gold which they send me for my corn. So Pakehas work hard, I work little, but I pocket the gold". At which he grinned again, and after a moment's pause said, "Kapai - Kapai. It is good - it is good".

Unfortunately, an absence of statistics on Maori cropping means that the exact effect inflated prices had on acreages cannot be known. Nevertheless, as Hargreaves observed, some indication of the relative movements in acreage in the Auckland region can be gauged by examining deliveries of agricultural produce to Auckland by coastal shipping. Since few Pakeha farmers lived beyond the area serviced by overland transport, most of the shipped produce was probably Maori-grown. The combined value of wheat, maize, and potatoes arriving by coastal vessels at Auckland grew from around £30,000 in 1853 to a peak of about £70,000 in 1855, when deliveries amounted to 82,228 bushels of wheat, 29,250 bushels of maize, and 1175 tons of potatoes. Maori-grown produce, together with other provisions such as firewood, was also brought to Auckland by canoe. At its height in 1854 the total canoe trade was worth £16,000, though from the mid-1850s its value declined.

The high value of agricultural produce, together with missionary and governmental encouragement, which included localised agricultural schooling, prompted Maori communities to invest in agricultural machinery and infrastructure as well. While individuals bought up carts and ploughs, on a collective basis large amounts of capital were devoted to building flour mills, and in purchasing schooners for transporting produce to Pakeha markets. In the Waikato, for example, twelve flour mills had been completed or were under construction by 1853, while in the Waitara area in Taranaki, Maori ownership of agricultural implements rose from one cart, two drays, and a plough in 1847 to 110 carts, 102 ploughs, 45 harrows, and 3 threshing-machines in 1858.
Given that Maori cropping operations were much more extensive than they had been before, Pakeha observers became increasingly concerned about the danger of soil exhaustion. Consequently, they redoubled their efforts to convince Maori farmers to adopt suitable strategies for combating it. In their view, the traditional fallowing approach was unsuitable, as it was wasteful, and it facilitated weed infestation - so much so that in the Waikato it was estimated that 500 acres of land were being 'lost' to weeds each year. Manuring, as the Maori Messenger recognised in 1855, was not an option either, as Maori farmers were showing no signs of losing their abhorrence of it. Consequently, the Maori Messenger decided to concentrate on trying to persuade Maori farmers to convert land to pasture, which would be fed off, and thereby excreted upon, by either dairy cows or sheep:

Ever since the first publication of the "Maori Messenger", it has been one of the most anxious endeavours of its Editors to inculcate the vast riches derivable from pasture lands, and to strive to incite the native land holders to burn and clear away their fern and brush covered grounds ... and to bestow a portion of the labour which now appears to be almost exclusively occupied in growing wheat, potatoes, and pigs, in the equally beneficial, and probably far more remunerative employment of dairy and sheep farming.

Of the two, the Maori Messenger seems to have preferred sheep farming, as it stated that "no pursuit can render them [the "native land proprietors"] the same money return, or so greatly improve their soil as the farming of sheep". Although this advocacy of pastoral farming may have met with a small degree of success after prices for agricultural produce fell sharply in 1856 - the Maori Messenger claimed in 1857 that several Maori farmers in the Waikato were enquiring about grass seed to sow on their abandoned cultivations - most Maori showed little interest in it. Generally, they seemed reluctant to sow pasture for sheep and dairy cattle when pigs and 'bush cattle' were able to fend for themselves. Moreover, once pasture was sown and sheep were kept upon it, then controlling disease and keeping out harassing dogs required further effort. In addition, the unwillingness of Maori to sow down land to grass may also have had a political basis. As Donald McLean related in 1860, the first 'Maori King', Potatau Te Wherowhero, believed that sowing pasture would only encourage Pakeha to want to subdivide and then acquire (by fair means or foul) Maori lands.

Potatau's position may be seen as a reflection of the growing Maori preoccupation with indigenous nationalism, and in particular the determination to
keep their land holdings intact. This nationalism drew, in turn, from increasing
Maori disenchantment with their returns from the rural economy. From 1856,
agricultural prices were depressed due to Australia’s increasing self-sufficiency in
terms of food production. Indeed, by the start of the 1860s cheap Australian,
Californian and South American produce turned Auckland from being a grain
exporter to an importer.\textsuperscript{94} To make matters worse, Pakeha farmers responded to
the reduced local prices by substantially expanding their own cropping operations,
as they tried to shore up income.\textsuperscript{95} Consequently, Maori farmers found themselves
being squeezed out not just of the Australian market, but out of local markets as
well.

Many Maori communities, which had incurred large debts, firstly through
agriculture and subsequently through purchasing firearms, ceased to invest in
building, or even maintaining, agricultural infrastructure, which was a financial
burden at the best of times.\textsuperscript{96} At the same time, standards of cultivation also seem
to have slipped. The \textit{Maori Messenger}, for example, reported in 1859 that wheat
sent to Australia had been of inferior quality because it was grown from poor
seed. A similar story unfolded with Maori-grown maize.\textsuperscript{97} Moreover, although
showpieces of Maori farming such as Rangiowhia continued to be productive, as
well as looking the part,\textsuperscript{98} other areas began to show signs of neglect. Donald
McLean, in a trip to the Hauraki district in 1857, claimed that the soils at
Kauaeranga (the richest in the area) were "nearly exhausted by constant
cultivation[,] little attention being paid to rotation of crops", while up the Waihou
River, McLean found little evidence of improvement since his previous trip there
in 1844. While McLean’s criticism in this instance may have been a little harsh,\textsuperscript{99} it
is worth noting that in 1858 it was observed that Auckland’s Maori communities
were starting to purchase large quantities of flour from Pakeha.\textsuperscript{100}

Whatever hope Maori farming might have had of recovering was
extinguished by the New Zealand Wars. In addition to the depredations suffered
during the Crown’s operations against Maori nationalists in Taranaki during 1860-
1, and in Taranaki, the Waikato, and the Bay of Plenty, during 1863-5, most of
the better quality land in these regions was confiscated, irrespective of the
allegiance of local populations, by the Crown in 1864.\textsuperscript{101} Henceforth where Maori
had farmed would be largely a Pakeha domain.

Ultimately, Maori farming had shared the same 'dead end' fate as mission
farming. Although it had been prosperous enough during the 1840s and early
1850s, it should be remembered that the lack of competition had made it a seller’s
market; in the late 1850s, however, strong competition emerged at the same time
as the efficiency of Maori farming began to falter. Both mission and Maori farmers, despite their efforts to adapt to a new environment and new cash crops respectively, had been too wedded to their traditional agricultural models to establish, in a short space of time, new agricultural regimes which were sustainable in the long-term.
Notes to Chapter Five


9 Hargreaves, 'Mission Farming before 1830', *Proceedings of the Third New Zealand Geography Conference*, p. 72; Richard Davis to J. N. Coleman, 20 October 1824. Coleman,
134


13 Davis to Coates, 31 December 1825. Davis, 'Letters and Journals'.


18 In his discussion of soils, Yate noted the occurrence (presumably at Waimate, though no location is given) of "a deep rank vegetable mould, with a stiff marly subsoil, capable of being slaked or pulverized by the ashes of the fern". Yate, William, *An Account of New Zealand, and of the Church Missionary Society's Mission in the Northern Island* 2nd ed. [1835], with an introduction by Judith Binney (Shannon, Eire, 1970), p. 75. The likely cause for the phenomenon observed by Yate is cation replacement followed by deflocculation. In soils which are relatively rich in calcium - as a "marly subsoil" would by definition be - the clay particles are bound together by the calcium cations in structures known as flocks (McClaren & Cameron, *Soil Science*, p. 65). If the soil is saturated with a solution containing cations which bind the clay less tightly, the clay masses will break down, or 'deflocculate'. This is why river water turns cloudy when it hits the sea. The cation replacement occurring in what Yate describes is potassium (from the 'fern' ash) for calcium.

19 Davis notes in his Journal that he was "washing and liming wheat for seed". R. Davis, 16
June 1834. Davis, 'Letters and Journals'. Caustic lime in water (calcium hydroxide solution) was a traditional alternative to copper sulphate solution as a steep, which was used to protect the seed from pests (Hoos, Conrad. The New Zealand Practical Agriculturist (Dunedin, 1882), pp. 49-50).


21 Hargreaves, 'Waimate'. Agricultural History 36(1) (1962), 43. It is worth noting that in a South Island experiment on clover pollination in the late 1950s, no seed set was observed from either white or red clover in a test area remote from honey bee populations (Palmer-Jones, T., Forster, I. W., and Jeffery, G. L., 'Observations on the honey bee and bumble bee as pollinators of white clover (Trifolium repens Linn.) in the Timaru district and Mackenzie Country). New Zealand Journal of Agricultural Research 5(3&4) (1962), pp. 319, 321, & 323.

22 Davis to Coates, 20 June 1834. Davis, 'Letters and Journals'.

23 Ibid.


27 Dieffenbach, Ernest, Travels in New Zealand; with contributions to the Geography, Geology, Botany, and Natural History of that Country (London, 1843), I, pp. 247-8.


33 Leach, Helen M., 'Food Processing Technology: its role in inhibiting or promoting change in staple foods'. In Gosden, Chris, & Hather, Jon (eds.), The Prehistory of Food: appetites for change (London, 1999), pp. 129-30.


35 Richard Davis to Dandeson Coates, 10 November 1826, p. 3. Davis, 'Letters and Journals'.


38 Ibid p. 108.


40 Leach, 'Food Processing Technology'. In Gosden & Hather, (eds.), The Prehistory of Food, p. 133.

41 Leach, 'Food Processing Technology'. In Gosden & Hather, (eds.), The Prehistory of Food, p. 133; Leach, 1,000 Years of Gardening, p. 101. It seems that the use of the fermenting process on maize began in about the 1820s (Hargreaves, 'Changing Maori Agriculture in Pre-Waitangi New Zealand'. Journal of the Polynesian Society 72 (1963), p. 108).


43 Leach, 'Food Processing Technology'. In Gosden & Hather (eds.), The Prehistory of Food, p. 132.


The Maori Messenger (Ko Te Karere Maori), 31 January 1850, p. 3. See also *ibid.*, 25 April 1850, p. 2.


Richard Davis, 21 June 1834. Davis, 'Letters and Journals'.

Similar behaviour was also recorded by William Wade in 1838, and William Williams in 1848. Leach, *1,000 Years of Gardening*, p. 109.


William Wakefield, Extract from Third Despatch. *New Zealand Journal* 1(9) (23 May 1840), p. 114; William Cullen to his family, [1842]. *Letters from Settlers and Labouring*


64 Pers. comm., Professor Helen Leach, 14 July 1998.


66 Hargreaves, 'Changing Maori Agriculture in Pre-Waitangi New Zealand'. *Journal of the Polynesian Society* 72 (1963), p. 110; Leach, *1,000 Years of Gardening*, p. 68.


68 For a review of such comments, see Cameron, 'Destruction of the indigenous forests for Maori agriculture'. *New Zealand Journal of Forestry* 9 (1964), pp. 104-7.


74 *Statistics of New Zealand for the Crown Colony Period, 1840-1852*, p. 84; *Statistics of New Zealand, for 1853, 1854, 1855, and 1856. Compiled from official records* (Auckland, 1858), Table 53.

75 *The Maori Messenger (Ko Te Karere Maori)*, 31 January 1850, pp. 1-2, & 17 and June 1852, p. 3. Although some Maori did migrate to the Victorian goldfields, the numbers were
insufficient to form communities, and they did not have a lasting presence (Centre for Immigration and Multicultural Studies, Australian National University, 'Maoris'.


77 Hargreaves, 'The Maori Agriculture of the Auckland Province in the Mid-Nineteenth Century'. Journal of the Polynesian Society 68 (1959), pp. 73-4. In calculating the value of this produce, it has been assumed, on the basis of contemporary price estimates and export prices (Statistics of New Zealand, for 1853, 1854, 1855, and 1856, Tables 9 & 53), that Auckland prices for wheat, maize, and potatoes, in 1853, were 10s. per bushel, 8s. per bushel, and £5 10s. per ton respectively, while in 1855 they were 11s. per bushel, 10s. 6d. per bushel, and £10 per ton respectively. Hargreaves' observation with regard to Maori pre-eminence in the coastal trade is supported by the New Zealander's 1851 comment that Maori were likely to be the "chief producers" of Auckland's wheat (New Zealander, 6 April 1851, p. 2).


80 With respect to Maori-owned shipping in the Auckland region, see Hargreaves, 'The Maori Agriculture of the Auckland Province in the Mid-Nineteenth Century'. Journal of the Polynesian Society 68 (1959), p. 73; and Monin, Paul, This is my place: Hauraki contested, 1769-1875 (Wellington, 2001), p. 156.


82 The Maori Messenger (Ko Te Karere Maori), 1 January 1852, p. 4, and 29 January 1852, p. 2-3.
The Maori Messenger (Ko Te Karere Maori), 25 April 1850, p. 2; The Maori Messenger (Te Karere Maori), 15 December 1857, p. 2.


The Maori Messenger (Te Karere Maori), January 1855, p. 12. This did not stop the paper trying to educate Maori farmers about the benefits imparted by manure (Ibid., July 1855, pp. 3-4).

See the allusion to this in the tenth part of William Grayling's letters on agricultural chemistry in the Taranaki Herald. W. I. G. to the Ed., Taranaki Herald, 3 September 1859, p. 3.

The Maori Messenger (Ko Te Karere Maori), 10 April 1851, p. 2. See also ibid., 16 January 1851, p. 2, 21 October 1852, p. 3, & 16 December 1852, pp. 2-3.

Ibid., 27 January 1853, p. 3.

The price of flour, for instance, dropped from £33 to £18 per ton, and new potatoes experienced a similar fall in value, from £11 to £4 per ton (Monin, This is my place: Hauraki contested, 1769-1875, p. 157). In response, there was a brief boycott of the Auckland market by Maori farmers, though they resumed selling when better prices returned (Hargreaves, 'The Maori Agriculture of the Auckland Province in the Mid-Nineteenth Century'. Journal of the Polynesian Society 68 (1959), p. 75.

The Maori Messenger (Te Karere Maori), 31 August 1857, p. 1. It should be noted that advocacy of pastoral farming was a frequent theme in the newspaper during 1857.


The 'King movement' grew out of efforts by various North Island tribes (iwi) in the late 1850s to collectively curb sales and express Maori autonomy. See Ballara, Angela, 'Maori and Pakeha'. In Fraser, Bryce (ed.), The New Zealand Book of Events (Auckland, 1986), p. 31.

See the report of McLean's evidence to the official inquiry into Waikato lands in the New Zealander, 30 March 1861, p. 5.


See Chapter Eight.

Monin, This is my place: Hauraki contested, 1769-1875, pp. 159-60; Hargreaves, 'The Maori Agriculture of the Auckland Province in the Mid-Nineteenth Century'.


99 Donald McLean, 13 January 1857. Journals, Donald McLean Papers, MS Papers - 0032, Folder 9 (Alexander Turnbull Library); Monin, This is my place: Hauraki contested, 1769-1875, pp. 157-8.


Chapter Six

An Imperfect System of Culture: Soil Fertility Management Practice in New Zealand c. 1840-1850

The slow, and sometimes erratic, accrual of knowledge about New Zealand soils, described in Chapters Three and Four, played a vital role in settlers' decisions as to where they should farm. It gave less guidance, however, on the question of how they should farm. Instead, a widely held, albeit loosely defined, 'vision' of how settlers ought to farm once they had reached New Zealand developed amongst British agricultural commentators and emigration theorists. Having said this, the abstract guidelines which were set out for settlers to follow, proved, as seen in this Chapter, no match for practical realities.

1. Telling it like it should be: the colonial 'vision' of how soil fertility should be managed in New Zealand agriculture

At its most basic, the 'vision' developed for New Zealand agriculture drew on two grander contemporary concepts. The first of these was that New Zealand should have an assigned role in the imperial British economy. The role chosen for it, even before organised settlement began, was 'granary of the Southern Hemisphere'. It would provide for the food requirements of Australia, which in turn would concentrate on meeting the wool demand of Great Britain. The second 'big idea' which contributed to the 'vision' was that Western-style high input-high output farming - 'high farming' in contemporary parlance - was superior to other agricultural systems, and especially those of indigenous colonial peoples. If "the lessons of Liebig" were, as the New Zealand Journal put it, "the natural equipoise to the despondent theories of Malthus", it made sense to colonial theorists, mindful of Great Britain's own expanding population, to ensure that those lessons were learnt not just at home, but abroad too. After all, the promise of 'scientific agriculture' was that mankind might now not just "increase and multiply", but might "replenish the earth" as well.

With places like New Zealand awaiting colonisation, this promise appeared likely to be realised. As the Otago Journal told its readers:

It has been calculated ... that the earth is capable of supporting between sixteen and seventeen billions of people, or about eighteenth times more
than present reside upon its surface, supposing that the whole were cultivated only as well as the present state of agricultural science admits of, and allowing scarcely anything for vast tracts at present sterile, but which man may hereafter finds means of turning to account ... In New Zealand, for instance, there are vast tracts waiting for the reception of man ...³

Putting the lessons of Liebig to work in New Zealand, however, was not going to be a straightforward task. 'Making farming pay' had been difficult enough 'at home' - now the new settlers had to do this in completely foreign economic and environmental conditions.

In essence, the agricultural 'vision' that was dreamt up for New Zealand consisted of two stages. The first recognised that new settlers had plenty to do just establishing themselves, and thus they would rely solely on the 'superabundant' fertility of New Zealand's soils to provide a rich produce for them. This general principle was elucidated in the writings of James F. W. Johnston, a noted Scottish agricultural chemist of the day:

When a tract of land is thinly populated, like the newly settled districts of North America, New Holland, or New Zealand, a very defective system of culture will produce food not only for the wants of its inhabitants, but for the partial supply of other countries also.⁴

This hiatus in active soil fertility management was only expected to be short-term, however. Thereafter, in the second stage, an improved system of agriculture, which over time became increasingly akin to that 'at home' would be implemented. At the very least, some form of crop rotation was expected of settlers. Having said this, attempting to immediately replicate 'high farming' in its entirety, irrespective of local conditions in the new colony, was also seen as "a great mistake".⁵ Rather, what was needed was a steady improvement in the mode of agriculture. Indeed, Johnston followed the statement above with this caveat:

But when the population becomes more dense, the same imperfect or sluggish system will no longer suffice. The land must be better tilled, its special qualities and defects must be studied, and means must gradually be adopted for extracting the maximum produce for every portion susceptible of cultivation.⁶

In remarks similar to Johnston's, but targeted specifically towards New Zealand, the author of a review in the New Zealand Journal of Cuthbert Johnson's On
Fertilizers warned emigrants that the soil would "yield its produce without the aid of artificial fertilizers" initially, but they would come to learn that the "decayed organic matter which supplies the food of plants is soon exhausted". Consequently, the organic matter needed to be replenished regularly. Conversely, the reviewer thought that mineral nutrients needed only occasional top-ups, since fertilisation with these was more lasting in its effects.7

The most obvious method for adding organic matter to the soil regularly was folding livestock on the ground to be cropped (and equally, spreading muck from the feed-stall upon it). To this end, the realisation that sheep would do well in New Zealand, when it had first been thought that the humid climate made it unsuitable for them, was greeted with satisfaction by the *New Zealand Journal* in March 1842, which commented that "sheep rearing in New Zealand will, probably, be closely connected with farming, and will aid in giving fertility to the soil".9 Reinforcing this view, the correspondent 'G. T. W.', subsequently noted that "poor lands ... utterly worthless for tillage, are, by the green crop [crops which return organic matter to the soil by being fed off, or ploughed under] and sheep systems, made most remunerative", and also that those who had adopted this system in England "could not be induced to practise agriculture under the old routine and without sheep".10 The *New Zealand Journal* strengthened the case for intensive mixed farming still further by including, in the preamble to this letter, Colonel Wakefield's observation that whereas three to four acres of pasture were needed to feed one sheep in Australia, one acre would suffice for three to four sheep in New Zealand.11

During the early 1840s, the *New Zealand Journal* encouraged the adoption of more advanced and sustainable soil fertility management regimes by regularly carrying reviews of instructive works on agricultural subjects, especially agricultural chemistry.12 Such works were recommended "to our Colonial friends as especially calculated to guide their energies into the most advantageous and profitable channels"13 when embarking on farming in New Zealand. At the same time, it also published correspondence from individuals such as the Norfolk farmer J. C. Ponton, who in addition to espousing his views on crop rotation, challenged Wellington resident George Earp's observations on the merits of 'burning fern land'.14 Although Ponton was in a poor position to make a judgement, it is regrettable that more 'dialogue' between advice from 'home' and local experience did not occur. It was equally unfortunate that the existing experience of the mission farms in the Bay of Islands was also disregarded.
II. The granary that wasn't: Wellington agriculture during the 1840s

From a soil fertility standpoint, the choice of the Hutt Valley as the first agricultural base for New Zealand Company settlers was not unreasonable. As Figure 6.1 shows, most of the valley floor was derived from recent alluvial soils. These were covered by mixed podocarp and broadleaf forest, and the resulting loamy soils were well supplied with plant nutrients, although prone to excessive moisture. The depth of the "pure black or brown sandy loam" on the banks of the Hutt River was seen as a particular boon to the settlers in that, as Wakefield's *Hand-book of New Zealand* described it, its fertility seemed "almost inexhaustible". Likewise, Alexander Marjoribanks' *Travels in New Zealand* advised that the "black vegetable mould" incorporated into the soil was of such depth that it would "require no manure for many years".

Before they could cultivate it, the settlers had to figure out how to best clear the land. Two alternatives presented themselves. The first, employed by George Duppa, was to log and stump the land, which meant that the land was immediately ready for cultivation, and furthermore, the nutrients stored in the forest litter were fully retained. Duppa, as seen in Chapter Three, had asserted his land would yield some 5-7 quarters (40-56 bushels) of wheat per acre, which was as much as highly manured British farmland. The *New Zealand Journal* agreed that this approach would yield the heaviest crops, but regarded the £40 per acre cost (as calculated by Duppa) as far too expensive. It instead argued that felling and burning (following the American precept, and by the same token, Maori practice) should be adopted as the method of clearance, as the cost was as little as £4 per acre. In practice, the average cost during 1841 was £25 per acre, although this dropped to around £10 in the mid 1840s, before rising to the earlier level in the late 1840s. The *New Zealand Journal* also observed that the ashbed created by the 'bush burn' approach did much to "improve the fertility of new lands". It did indeed provide a short-term nutrient boost, since as well as the freed up nutrients in the ash, the process of burning accelerated decomposition of soil organic matter. This was counterbalanced, however, by the substantial loss of nutrients held in the biomass.

Once land had been burnt off, potatoes were normally the first crop to be grown, after which cultivation of wheat was initiated. This strategy minimised the need for ploughing, which, as Charlotte Godley observed, was impractical on land covered with tree stumps, since the potato roots pulverised the soil. Potatoes, moreover, are large consumers of potassium, and thus would have responded well
Figure 6.1
Map of distribution of soils in the vicinity of Wellington


Using the New Zealand Generic Soil Classification, the soils in Gibbs' key fit within the following groups (see Atkinson, I. A. E., Soils of Taita Experimental Station (Government Printer, Wellington, 1973), pp. 14-5; Gibbs, H. S., 'Notes on the Soils of the Hutt Valley'. proceedings of the New Zealand Ecological Society 6 (1959), pp. 35-8):

Recent Alluvial (Waikanae-Waiwhetu)
Organic (Mangaroa)
Gley (Omanuka, Gollans)
Yellow Brow Sands (Foxton-Pahautanui)
Yellow Grey Earth / Yellow Brown Earth intergrade
       (Porirua-Pukerua, Paremata-Terawhiti)

Most of the land around Wellington consists of yellow-brown earths found on either high terraces (classes 6 & 7) or on steep hillsides (classes 8-12). These are of little use to the agriculturist. However, it can be seen that the Hutt Valley contains sizable tracts of recent alluvial soils (class 1) as well as areas of poorly drained gley and organic soils (incorporated into classes 2 and 3 which can be made reasonably fertile).
Soils of Wellington District

H S Gibbs
Soil Bureau DSIR
1960
to the input from the ash.25 Francis Molesworth stated in 1844 that he had obtained a yield of 7 tons of potatoes and 44 bushels of wheat per acre (double the average English wheat yield) following this method, while a neighbour had obtained 60 bushels of wheat per acre through more intensive cultivation.26 Still higher figures were also bandied about. In 1842, the New Zealand Gazette and Wellington Spectator reported that in places the crops harvested by Molesworth had yielded 90 bushels of wheat and 18 tons of potatoes per acre. These yields were exceptional, but other settlers claimed that 60 bushels of wheat and 16 tons of potatoes per acre was merely average.27 Even Wellington's supposedly "barren hills" gave yields of 40 bushels of wheat per acre; here, it seemed, was another 'proof' of the country's ubiquitous fertility.28 The official estimates, however, put the average wheat yield at Wellington during the early 1840s, as shown in Figure 6.2, at only around 40 bushels per acre, with a maximum of 45 bushels being recorded for the crop sown in 1844. According to Molesworth, 40 bushels would have netted the grower about £20 per acre. The potato yield, meanwhile, was 10 tons per acre, although its never-changing level makes it somewhat suspect.29 After the wheat crop in the second year, a prize-winning essay delivered to the Port Nicholson Agricultural Association suggested that potatoes should be grown again. Thereafter, the essay argued that they should alternate until the soil was in a proper condition for a "four or other course system".30 With respect to the valley sides, the essayist thought these better suited to permanent pasture, although growing a crop of potatoes prior to the sowing of grass was advisable.31 Despite the good yields, the Hutt Valley did not become the granary that the Wakefield scheme had intended. The costs of land development were such that dreams of sending grain to Australia remained just that. The handful of 'gentleman' farmers in the Hutt, whose assumed prosperity the Wakefield scheme was based around, gradually abandoned their attempts to cultivate crops on a large scale.32 Much of the valley was left in the hands of either absentee landowners, or landowners who confined themselves, or at least their commercial interests, to the town at Wellington. Consequently by 1843 the extent of arable cultivation was only 380 acres (or only a tenth of an acre per resident of Port Nicholson).33 Thereafter, many of the valley's occupiers were labourers, for whom Company-sponsored work had run out. Taking up small tenancies of 2 to 10 acres, and clearing the forest for their landowner as they went, these small-scale agriculturists operated on a market gardening-type basis; the 2.25 acres of wheat, 0.8 acres of barley, 1 acre of green crops and 0.5 acres of grass cultivated by one such settler was probably typical.34 By early 1845 the number of small farmers at Port
By far the highest initial yields were obtained in Wellington, though as discussed in this chapter, yields fell away in the late 1840s once agriculturists were left to use soils that had been previously cultivated. Progressively lower yields were obtained in Nelson and New Plymouth. Originally, Auckland's agriculturists had the worst yields, but as will be seen, their returns improved considerably once they got access to better soils.

As noted in the text, official yield estimates were not particularly reliable, and they could vary significantly from local estimations. The Nelson Examiner, for example, reported estimate wheat yields of only 24 bushels per acre from the crop sown in 1845, and 20 bushels per acre from the crop sown in 1846 (Nelson Examiner, 4 April 1846, p. 2, & 27 March 1847, p. 3). In these cases, the local figures had been lowered to account for the late effects on the crop of drought. For the purposes of consistency, however, only official figures have been used in this graph.
Wheat Yields in New Zealand Settlement Areas

- • • • • • New Plymouth
- • • • • • Nelson
- • • • • • Auckland
- • • • • • Wellington

Bushels per acre

Year Sown

1842 1843 1844 1845 1846 1847 1848 1849 1850 1851 1852
Nicholson was such that the average wheat acreage per cultivator exceeded three
only in the Hutt Valley, and even there it was still under five. In Karori,
meanwhile, the acreage of green crops was almost equal to that of grain crops
combined.\footnote{35}

Simultaneously, wheat began making way for pasture on some of the more
substantial properties of the Hutt.\footnote{36} Meat and wool were much safer investments
than grain or potatoes, as cultivations were much more vulnerable than pasture to
damage from either the periodic flooding of the Hutt River, the stand-off
between dispossessed Maori and Grey’s forces, or more mundanely, roaming
cattle.\footnote{37} Furthermore, the arable farmer increasingly faced competition from both
Australian imports, and low-cost communal Maori cultivation. As early as 1844,
the price of grain at Wellington had fallen to barely half what it had been in 1842.
As Table 6.1 reveals, during the mid-1840s a similar decline was felt at New
Plymouth and Nelson, and to a lesser extent at Auckland, but even so, prices in
Wellington were probably more vulnerable to the erratic entry of Australian and
Maori produce into the market because so little of Wellington’s domestic demand
was met by crops grown by local Pakeha. In 1847, for instance, the proportion
amounted to only 25%.\footnote{38} Given these unfavourable circumstances, much of
Wellington’s investment in farming was withdrawn from the Hutt Valley
altogether, and shifted instead into the lucrative business of grazing stock on the
natural grasslands of the Wairarapa.\footnote{39}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|}
\hline
Year & Wellington & New Plymouth & Nelson & Auckland \\
\hline
1842 & 10s. & 10s. & 10s. & 10s. \\
1843 & 8s. & 12s. & 10s. & 15s. \\
1844 & 4s.10d. & 8s. & 5s. & 11s. \\
1845 & 5s. & 5s. & 5s. & 8s. \\
1846 & & & & \\
1847 & 6s. & 4s.6d. & 4s.6d. & 7s. \\
1848 & & 4s. & & \\
1849 & & 3s.8d. & & \\
1850 & & 4s. & 5s.3d. & 5s. \\
\hline
\end{tabular}
\caption{The price of wheat (per bushel) in the main centres, 1842-1850\footnote{40}}
\end{table}

Accordingly, the wheat acreage sown in the Hutt Valley (including Lowry
Bay and Wainuiomata) fell from 349 acres in 1845 to just 193 acres two years
later, while the area under pasture in Hutt Valley simultaneously increased from 85 acres (out of 584 in cultivation) to 201 acres (out of 484). As Table 6.2 shows, a similar pattern was observed in the settlement as a whole. Once under grassland, the level of organic matter in the soil, which undoubtedly declined during Table 6.2: Acreage of crops cultivated by Pakeha at Port Nicholson (Wellington) 1844-50

<table>
<thead>
<tr>
<th>Year Sown</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1844</td>
<td>599</td>
<td>78</td>
<td>82</td>
<td>136</td>
<td>205</td>
<td>n.s.</td>
<td>1203</td>
</tr>
<tr>
<td>1845</td>
<td>591</td>
<td>81</td>
<td>67</td>
<td>133</td>
<td>277</td>
<td>193</td>
<td>1063</td>
</tr>
<tr>
<td>1846</td>
<td>495</td>
<td>116</td>
<td>99</td>
<td>218</td>
<td>406</td>
<td>190</td>
<td>1523</td>
</tr>
<tr>
<td>1847</td>
<td>341</td>
<td>160</td>
<td>91</td>
<td>194</td>
<td>720</td>
<td>172</td>
<td>1677</td>
</tr>
<tr>
<td>1848</td>
<td>350</td>
<td>241</td>
<td>69</td>
<td>200</td>
<td>1318</td>
<td>n.s.</td>
<td>1617</td>
</tr>
<tr>
<td>1849</td>
<td>202</td>
<td>224</td>
<td>49</td>
<td>208</td>
<td>n.s.</td>
<td>n.s.</td>
<td>1045</td>
</tr>
<tr>
<td>1850</td>
<td>423</td>
<td>235</td>
<td>47</td>
<td>783</td>
<td>2627</td>
<td>327</td>
<td>4442</td>
</tr>
</tbody>
</table>

(n.s.) = not specified

cultivation of grain and potatoes without manure, was able to build up again. Yet while farmers on the Hutt Valley's alluvial flats had a choice in foregoing diminishing levels of crop production for stock-rearing, those cultivating its hill slopes were not so fortunate. Despite the scepticism of settlers, Dieffenbach's earlier warnings about soil erosion were borne out. Wakefield's *Hand-book* recounts that "on the hills ... a coating of rich decayed vegetable matter forms a thin surface so long as the forest remains standing, and even ... for a crop or two afterwards; but the weather soon washes this upper soil from the steepest places when clear of wood, and leaves a cold clay ... only fit for the growth of pasturage". A similar decline in soil fertility following clearing also caused concern in areas such as Karori, with Wakefield telling readers that the best prevention would be "an improved system of agriculture, by which the application of manures and a due rotation of crops shall provide against any exhaustion of the soil before it can occur". Cereal cultivation, of course, continued, but it was now concentrated on less fertile land. This was because many tenant farmers had begun growing their crops on abandoned Maori clearings, since they were unable to recover the cost of clearing forest. This was reflected in more moderate yields - as seen in Figure 6.2, in the late 1840s the estimate for wheat was a steady
30 bushels, which was one-third less than it had been earlier in the decade, though this was still comparable to the yield from an English 'wheat county' like Norfolk.\footnote{48}

Clearly, the agricultural promise of the Hutt Valley had been unfulfilled. However, the establishment of the offshoot settlement at Petre (as Wanganui was then known) allowed a second opportunity for meeting the agricultural aspirations of Port Nicholson's settlers. Originally, as was seen in Chapter Three, Wanganui was regarded by the New Zealand Company as a future pastoral centre, because it lay amidst open 'fern land' interspersed with small pockets of swamp.\footnote{49} Understandably, Francis Molesworth was somewhat perplexed by the self-assuredness of William Bell, a Scottish agriculturist, in its suitability for wheat cropping.\footnote{50} Bell had good reason to feel confident though, as in reality most of the country sections laid out at Wanganui were generously situated from a soil fertility viewpoint. To the west of Wanganui, there are large tracts of moderately fertile yellow-brown sands, while on both riverbanks, highly fertile recent alluvial soils are found for 10 miles or so upstream. Even on the rolling country to the east, the soil consists of sandstone-derived yellow-brown earths which are also moderately fertile.\footnote{51}

Accordingly, when Wanganui's residents petitioned Governor Hobson in 1845 to act on their behalf in resolving the disputed purchase of the block from Whanganui Maori, they described in "glowing terms the fertility of the soil".\footnote{52} Alexander Marjoribanks, meanwhile, declared that "like the land in the valley of the Hutt", Wanganui's deep-soiled 'fern land' would "require no manure for several years".\footnote{53} All this was rendered meaningless, however, by the New Zealand Company's failure to gain credible title to the land after its shambolic 'payment' made in February 1840. Effectively, Wanganui's residents found themselves unable to settle on their rural land, with those who did so risking eviction by the existing Maori landowners.\footnote{54} As a result, the total acreage under either cereals or potatoes during the mid-1840s never exceeded 90 acres (and half of that was on Bell's farm).\footnote{55} The Pakeha population actually decreased from 209 in 1843 to 166 in 1847, the latter year being marked by deaths on both sides as a result of conflict over land, which had been increasingly aggressive in the wake of Maori-Pakeha hostilities in the Hutt Valley.\footnote{56} Only after the restoration of peace and Donald McLean's payment of £1000 for a larger Wanganui Block in 1848,\footnote{57} did Wanganui's agriculture start to flourish, with there being 118 acres of wheat and 91 of oats grown in 1851.\footnote{58}
III. The agricultural 'vision' deferred: soil fertility management in Taranaki

The evolution of agriculture at the New Plymouth settlement was rather different from that in the Hutt Valley, although the starting point was similar. The predominant soils in North Taranaki are yellow-brown loams. At the time of the settlers' arrival, these were either under mixed broadleaf and podocarp forest, or were under 'fern land' which replaced this forest in the recent past.59 In a chemical sense these soils are only moderately fertile, with their high content of organic matter and the bases calcium and magnesium being somewhat counterbalanced by a deficiency in potassium and plant-available phosphate. From a physical viewpoint, however, their good structural development, which their high organic matter content contributed to, and light texture made them both friable and well-drained, so that they were ideal for cropping.60 More fertile alluvial soils are also found, but the only large tract is in the valley of the Waitara River.61 With these soils at their disposal, Taranaki's settlers were as complacent about maintaining soil productivity as their counterparts in the Hutt Valley. Alexander Aubrey, for example, maintained that the alluvial soils at Waitara would "not require manure for these next forty years".62 Such perceptions were not shortlived either, for as late as 1847 John French wrote that 60 bushels of wheat per acre could be grown at the settlement without manure, and that the soil would "carry wheat for many years without manure".63

The main difference between Taranaki and the Hutt Valley was that cultivation at the former was to be principally on 'fern land', even though bush land (which, until the late 1840s, was distinguished from timber-producing forest)64 was regarded as the best quality land.65 Because of this preference, the first country sections selected were on the bush-covered banks of the Waitara River, downstream from the forest.66 Hardly any selections were made within the dense forest, which was seen as only as fertile as the bush land, and more difficult to clear.67 Cultivation, nevertheless, started on the 'fern land' because it was the easiest to clear. Whereas it had initially cost £40-£60 per acre to clear and cultivate forest-covered land, on 'fern land', the combined cost was initially only one-third of that sum. This represented a significant consideration, given that many settlers had limited capital.68 'Fern land', moreover, seemed a less foreign and intimidatory environment in which to start farming. As one observer noted, "the majority of English farmers would rather hold the plough for a week than use the American axe for a day".69
Expectations of agricultural settlement in the Waitara became irrelevant, however, when Governor Fitzroy nullified the New Zealand Company's claim to this district in 1844. Instead, he ruled that only 3500 acres around New Plymouth had been legitimately purchased by the Company. Fortunately, by early 1843, the zeal for owning bush land had diminished because of the finding that although the first crop on 'fern land' was impoverished, later ones were not. As noted in Chapter Four, the first crop observed on 'fern land' was usually small because the microbes feeding on dead bracken had to sequester (or, technically-speaking, 'immobilise') plant-available soil nitrogen, since the bracken itself was nitrogen-poor (see Figure 6.3). This period of soil impoverishment ended once the bracken was consumed, as the microbes then died off, and released their nitrogen back into the soil.

Following the example set by settlers in the Hutt Valley forest, New Plymouth farmers cleared 'fern land' by burning it. The resulting ashbed was regarded as a valuable fertiliser, as that in the Hutt had been. Once burning was complete, the ideal approach was to plough and harrow the land during a winter fallow, with any roots exposed by the tillage being burnt to provide more ash. Hopefully, by the end of the fallow, the aeration of the soil would cause the roots which remained buried to have decayed enough for the soil to no longer be 'sour' (nitrogen-impoverished). The repeated ploughing also prevented bracken regeneration. Alternatively, one inspired local suggested liming 'fern land' may help accelerate the bracken's decay, but this idea does not seem to have implemented. In practice, most settlers were short of capital, and thus the fallowing strategy was largely ignored, the preference being for a reduced but immediate crop over a larger deferred one. Consequently, bracken continued to spring up amongst crops in the first few years of cultivation.

As in the Hutt Valley, potatoes (which provided a fairly reliable food supply) were commonly grown as a first crop prior to grain cultivation. Though deficient in yield, potatoes were seen as giving a better return than grains on unfallowed, and hence 'sour', 'fern land', while the use of inter-row tillage provided a further opportunity for bracken eradication. On the other hand, for well off settlers who could afford to leave the land fallow, it was believed that wheat cultivation might follow without an intervening crop. In keeping with the first course of action, potatoes were the predominant crop sown in 1842, but in succeeding years wheat cultivation outstripped all others. As seen in Table 6.3, it accounted for about half the area in crop (including sown grass) during the mid-1840s. Because
Figure 6.3
Bracken decomposition and soil nitrogen levels

In the diagram on the left dead bracken has begun to be attacked by microbes. The is plenty of carbon in the roots, but not much nitrogen, and so the microbes need to draw on soil nitrogen supplies to sustain themselves. Because there is so much bracken root to consume, microbe numbers expand rapidly. In the stage at right, the bracken is largely consumed, and starved microbes are dying off. The nitrogen which the microbes collectively took up is returned to the soil, making it once again available for plants.

Studies of New Zealand bracken have revealed nitrogen content in rhizomes of only 0.4% (Evans, G. R., Nordmeyer, A. H., and Kelland, C. M., 'Biomass and nutrient pools of bracken growing under radiata pine, Nelson, New Zealand'. In Thomson, J. A., & Smith, R. T. (eds.), *Bracken Biology and Management: Papers from an international conference BRACKEN '89* (Sydney, 1989), p. 191). In a study on British bracken, which has similarly low nitrogen levels (Frankland, Juliet C., 'Decomposition of Bracken Litter'. *Botanical Journal of the Linnean Society* 76(1-3) (1976), pp. 134-7), it took several years before there was a nett return of nitrogen to the soil.
The Life and Death of a Soil Microbe
Table 6.3: Acreage of crops cultivated by Pakeha at New Plymouth 1844-50

<table>
<thead>
<tr>
<th>Year Sown</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Turnips</th>
<th>Grass</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1844</td>
<td>635</td>
<td>75</td>
<td>129</td>
<td>99</td>
<td>37</td>
<td>95</td>
<td>38</td>
<td>1106</td>
</tr>
<tr>
<td>1845</td>
<td>674</td>
<td>64</td>
<td>123</td>
<td>131</td>
<td>41</td>
<td>107</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>1846</td>
<td>839</td>
<td>75</td>
<td>132</td>
<td>133</td>
<td>57</td>
<td>154</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>1847</td>
<td>766</td>
<td>109</td>
<td>128</td>
<td>168</td>
<td>79</td>
<td>267</td>
<td>52</td>
<td>1569</td>
</tr>
<tr>
<td>1848</td>
<td>830</td>
<td>114</td>
<td>85</td>
<td>151</td>
<td>n.s.</td>
<td>510</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>1849</td>
<td>914</td>
<td>68</td>
<td>116</td>
<td>175</td>
<td>n.s.</td>
<td>780</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>1850</td>
<td>846</td>
<td>153</td>
<td>202</td>
<td>263</td>
<td>119</td>
<td>1182</td>
<td>77</td>
<td>2842</td>
</tr>
</tbody>
</table>

so many New Plymouth settlers originated in Devon and Cornwall, and were thus used to eating bread made from barley, it had initially challenged wheat for the position of leading cereal. Despite the high export price, growing barley gradually fell out of favour because of its susceptibility to damage from caterpillars.82

Yields, meanwhile, were not particularly high. While in small, intensively-farmed areas, yields were reported of 50 bushels or more of wheat per acre, generally it was thought that 'fern land' would produce only 30 bushels per acre.83 Bush or forest land promised a higher average yield - perhaps 50 bushels an acre - but it was not until the end of the decade that bush clearance began in earnest.84 As Figure 6.2 reveals, the official estimates of wheat yield were still more pessimistic; only rarely did this statistic rise above 25 bushels per acre. The effects of caterpillar damage on the barley crop, together with the delayed sowing in order to avoid this, are also evident in official estimates. Whereas barley yields are normally similar to those of wheat, twice in Taranaki just 18 bushels an acre was recorded.85

Wheat yields were at first kept low by smut,86 but by the end of the decade, soil exhaustion posed an even more serious threat. Although it was admitted that better crops would be produced once land was put "under a proper system of cultivation and manured",87 this had not stopped farmers from failing to change their seed, and returning to the soil only the ploughed-in stubble.88 In short, the soils under cultivation seemed so fertile, they did not need any other treatment. J. Lewthwaite, for example, wrote on his return to England in 1846 that the "general opinion" of the New Plymouth settlers was that 'fern land' would "yield two or three successive crops of wheat, and continue to improve without manure for five years from its first turning".89 As late as 1849, a settler hoping to see more
evidence of rotational cropping ruefully observed that "crops of wheat are grown five or six years in succession on one piece of land".90

These views were reflected in the lack of attention paid to manuring. As Charles Hursthouse acerbically remarked, the "mere collecting, carting, and spreading manure would frequently be thought to entail too much trouble".91 The folding of sheep was reported to be another method of improving 'fern land', but the lack of natural grass meant there were not enough sheep to apply such a strategy. Sheep numbers fell from 600 in 1843 to just 263 in 1844, and did not surpass 1843 levels again until 1847.92 Fodder crops, such as turnips, were meanwhile grown only to a small extent, since cattle, the numbers of which did rise steadily, were sent out to graze 'fern land' instead.93 Evidently, some farmers also resorted to fallowing to rest soils after cropping, but in 1847 the area recorded under fallow was only 85 acres (which equated to 5% of all cultivated land). This figure potentially included land being broken-in as well.94

The consequences of the neglect of soil fertility management were encapsulated in the following commentary by the Colonial Surgeon, Dr Wilson:

... it begins to be experienced here, on those farms where a niggardly, imperfect, and greedy system of agriculture has been pursued, exhausting the free humus by successive crops of wheat, &c., that the vegetation becomes stunted and sickly, or dies away in patches, giving the fields so affected that sorry, scabbed aspect which farmers of ordinary agricultural knowledge would be greatly ashamed of.95

Not all farmers were as perceptive as Dr. Wilson, however, and as late as 1852, it was reported that "we now find that it will not do to grow wheat after wheat for 5 or 6 years in succession".96 In addition to robbing the soil of nutrients, especially nitrogen, the continuous cultivation of wheat caused a loss of structure, leaving the soil (in the absence of deep ploughing) compacted, and thus poorly drained - no small matter in Taranaki's moist climate.97 By 1849, soil exhaustion was becoming evident in areas of longstanding cultivation, which is not surprising, as by this time the boost from ashbed nutrients had long been consumed, or lost by leaching.98 Hursthouse accordingly warned emigrants against drawing conclusions on the basis of crops grown on the Fitzroy Block, which he described as having "partially exhausted soil", and urged them instead to appraise land newly purchased by the Crown at Omata and the Mongaraki.99 The higher yields on these 'virgin' areas probably counterbalanced those on exhausted tracts, as there was little change in estimated productivity per acre for the settlement overall.100
The appearance of soil exhaustion did, however, produce some changes in farming at the settlement. At a purely conceptual level, the fertility of Taranaki soils began being described in less brilliant terms. Already Wakefield's *Hand-book of New Zealand* had tried to downplay some of the earlier claims about Taranaki soils. It noted that Taranaki had "none of the comparatively barren clay-land" found in Wellington and Nelson's mountains, but equally it had hardly any tracts of "such extraordinary fertility as that enjoyed by the Hutt and other alluvial valleys". More pointedly, Hursthouse's account from 1849 stated that the "rich surface soil is comparatively shallow" and that "the peculiar adaptation of this district arises less from any extreme fertility of the soil, than from the genial and forcing nature of the climate".

A more practical modification resulted from the Crown's purchases during 1847-8 of the 10,000 acre Grey Block, the 4000 acre Tataraimaka Block, 12,000 acre Omata Block, and 2000 acre Bell Block. These purchases, the locations of which are shown in Figure 6.4, allowed arable farming to move on to the fresher tracts of soil, while land in the older Fitzroy Block was retired to pasture. In the Fitzroy Block, the acreage under field crops (excluding grass, garden, or fallow) fell from 1240 acres in 1846 to just 982 acres in 1850, while over the same period the area under pasture, which had been confined to larger farms in the main, rose from 154 to 901 acres, or 44% of all cultivated land, including garden and fallow. A further contributing factor to the swing towards intensive pastoralism, which saw sheep numbers rise from 1165 in 1848 to 1934 two years later, was the perception that sheep farming was now more profitable than grain cultivation. This formed as a result of the Wairarapa runholders' experience. Nevertheless, the evidence from the Omata Block shows that grain-growing was still favoured on new land. While most cultivation here was established on 'fern land', the return of 500 Te Ati Awa with Wiremu Kingi from Waikanae in 1848 created a sufficient labour pool for forest clearance to be commenced. By 1850 some 451 acres were under crop in the Omata Block (about one-sixth of the total within the settlement). Of this, pasture made up 114 acres, whereas wheat alone accounted for 237 acres. In describing these changes, a report from New Plymouth in the *Australian and New Zealand Gazette* of 16 November 1850 commented that "more and more of our land is being converted into pasture, and will be so, till the profits of farming and grazing are more equalized", but it also observed that the recent fine weather had "much forwarded the preparation of the timber lands for wheat".
Figure 6.4
Map of the New Plymouth settlement


Following the Colonial administration's investigation of the New Zealand Company land claim, the settlement was confined in 1845 to the area demarcated by the Fitzroy Block. The land squeeze was eased by the purchase of the Grey, Omata (labelled here as 'Omala'), Bell, and Tataraimaka Blocks in 1847-8. The latter, which is not shown here, lay beyond the Omata Block. The Hua and Waiwakaiho Blocks were then purchased in 1853. The impediment to settlement that the forest provided is reflected by the fact that the detail on the map does not extend much beyond the forest boundary, even though some of the Blocks extended well inland.
Clearly, by the end of the 1840s, the progress of agriculture in the highly regarded Hutt Valley and Taranaki had failed to come up to expectations. Certainly little progress had been made towards achieving an 'improved' system of agriculture. In the Hutt Valley, the first steps had been taken in this direction, but the attention given to soil fertility management was quickly overtaken by concerns about Maori competition for both market share and land ownership, and the attraction provided by the better returns from pastoral farming. Ultimately, these two factors prompted a shift from the arable to the pastoral sector. In Taranaki, on the other hand, the indifference to soil fertility management had left agriculture heading downhill. Its only saviour had been the purchase of fresh land from Te Ati Awa (the major local iwi), but the prospects of future sales looked poor. If New Zealand was going to be the agricultural success story that commentators had predicted, and implement the second stage of the proposed agricultural 'vision', then Nelson and/or Auckland would have to rise to the occasion.

IV. Taming the 'fern land': the soil fertility management experience at Nelson

Nelson, as seen in Chapter Four, was regarded by the New Zealand Company as a site best suited to pastoral farming, since it seemed to be the least fertile of its early settlements. The soils around Nelson generally do have relatively low nutrient levels, and only about one-seventh of the approximately 120,000 acres which were laid out into sections during 1842-3 consisted of soils of moderate to high fertility. Moreover, about half of this more fertile land was at the time under either swamp or mixed beech-podocarp forest. On the Waimea Plain's 'open fern' land, where the vast majority of the sections were located, only the alluvial Waimea soils (and anthropogenic Maori plaggen soils) on the flood plain were particularly fertile. The higher terraces of the Waimea valley, meanwhile, did not receive regular refreshment of mineral material, and thus their nutrient levels (especially of phosphorus and potassium) had fallen away through leaching. In the immediate west, the 'fern land' (interspersed with beech forest) on the yellow-brown earths of the 'Moutere Gravels' (an old alluvial formation) was even more nutrient-deficient. As Tuckett observed, the "tract between the Moutere and Waimea Rivers, is almost uniformly sterile - its surface consisting of a mixture of clay, gravel, and sand about four inches in depth, on a subsoil of stiff ochre-coloured clay, producing only stunted fern and manuka on the high ground and flax and tufts of coarse grass on the swampy land". On a
more positive note, the town of Nelson itself was sited on alluvial Waimea soils (which stretched, for a few miles at least, up the Brook Street and Maitai valleys), although the soils of the flanking eastern hills were both covered in beech forest and of only low to moderate fertility.116

Given the variation in soil types it is not surprising that the early settlers expressed widely divergent opinions on the quality of Nelson's soils. Many settlers were greatly disappointed by the apparent unproductiveness of the landscape,117 and would have concurred with the labourers' petition of 14 January 1843, which argued that instead of finding the promised "Elysian fields and Groves adorned with every beauty of Nature" they had been brought to a place of "unsightly and barren Hills and Mountains covered over with fern which has fed on the Soil for ages".118 In a similar, albeit unromantic critique three months earlier, William Dartnall stated that out of the 1100 suburban sections (which, being 50 acres in size, were designed for intensive farming operations), only 250 could be cultivated with profit, whereas 450 were likely to produce a considerable loss.119 Conversely, observers who devoted their attention to the more fertile town acres were much more sanguine in their assessments. William Cullen, for instance, was impressed enough by the soil of his town acre to write that "the soil (especially the woodland) is immensely rich, and capable of supporting crops for a great many years without manure, and without failing for the want of it".120 Even he, however, had previously dismissed the 'fern land' of the Waimea Plain as "good for nothing".121

As at New Plymouth, most Nelson settlers began cultivation on 'fern land' because it was more readily converted into farmland than wooded land or swamp.122 Certainly clearing the Waimea Plain's 'fern land' was far cheaper; the estimated cost in 1843 was £5–£6 per acre, as opposed to £10 per acre to clear wooded land (or £30 per acre to leave it free of stumps).123 This notwithstanding, some intrepid types, most notably the Greenwood and Stephens families, did opt for fertile wooded tracts at Motueka and Riwaka (which were already home to substantial Te Ati Awa cultivations).124 The flax and raupo swamps at the head of Tasman Bay, in contrast, remained largely untouched at the end of 1843, even though they were thought highly fertile once drained (an operation costing £7–£8 per acre). Subsequent experience confirmed this opinion, with Earp stating in his 1849 work that as much as 40 bushels of wheat per acre were being obtained from it.125

Inevitably, Nelson's 'fern land' farmers (like their Taranaki counterparts) quickly discovered its characteristic 'sourness'. This demolished the initial notion
some had that "on the fern land, there was nothing to be done but to burn off the natural growth, take a shallow furrow with the plough, scratch in your seed with a harrow, and that your crop was secure". This 'sourness' was evident in both the colour of grain crops, and in disappointing yields; according to a speech given by Joseph Ward in 1845, "experience had shown that, without manure, the first crop, especially if grain, was little better than a failure". This, he argued, affected the viability of the settlement as a whole, since the "disappointment which actual cultivators at first experienced had prevented others from coming out to join them". Accordingly, suggestions for improving 'fern land' were made almost as soon as cultivation began, with the Nelson Examiner advising readers to apply lime to 'fern land' as early as 3 December 1842. John Deans, for one, was entirely in agreement with this advice, having previously told Captain Wakefield that he "considered no crop would grow well ... unless it was limed and manured". In January 1843, an editorial appeared in the Nelson Examiner, further exploring the possibilities for rapid eradication of bracken roots. The two options proposed, as at New Plymouth, were repeated ploughing during a summer fallow, or inter-row tillage while cultivating a potato crop. Intriguingly, however, the editorial also suggested "the application of some dressing, which should act chemically upon the soil" as a strategy deserving of experiment. In this regard, it made the following observations:

The fern land is not deficient in substances nutritious to any of the plants ordinarily cultivated by man; it is rich in them, and has ... the material in it to make it exceedingly productive; what it wants is activity, some vivifying or rather destructive power, something which shall give a fillip to the too slow progress of decay, and consequently of reorganization. ... it does not appear to want simply mechanical manures; nutritive manures it certainly does not want, if it did we could not give them; but what it does require is undoubtedly either a summer fallow, with much tormenting, or a chemical manure which shall supply the place of this.

The substances thought best to meet this requirement were "lime, salt, saltpetre - any strong alkali", the first two of which had already been tried. So far, liming had failed to come up to expectations, but the editorial contended that this result was probably an anomaly. If no chemical dressings worked, paring and burning (the ploughing up of the surface soil, and its subsequent combustion), was proposed. There does not seem, however, to be any record of this last method being practiced.
Almost a year later, a letter to *Nelson Examiner*, signed 'Rot the Fern Root', called upon the "attention of agriculturists" to the "advantages which they would derive from the use of lime on ploughed lands". Clearly, some cultivators were beginning to heed this advice, as just a few weeks later, it was reported that Messrs. Morse, Murray and Rogers, had ordered some 140 tons (worth £350) from the Suburban South lime-kiln for use on their land in the relatively infertile Lower Moutere district. This was soon followed by news that a quarter-acre of wheat, growing in Suburban South on land previously occupied by 'fern' "of the most stunted sort", had produced a yield "equal to a good average one in the best cultivated lands of England".

Despite of the enthusiasm for liming 'fern land', the practice seems shortly afterwards to have come to an abrupt halt. Presumably farmers found that manure was able to supply the temporary shortfall in nitrogen which arose while the bracken decayed. On 'fern land' which had been manured, reported yields were as much as 40 bushels of wheat and 20 tons of potatoes per acre. This compared to the best productivity from forest clearings, which amounted to 50 bushels of barley and 12 tons of potatoes per acre. In contrast, without manure, even John Kerr, whom Captain Wakefield had described as the "most practical farmer we have here", was able to obtain yields, on the New Zealand Company's model-cum-experimental farm on the Waimea Plain, of only 23 bushels of wheat, 18 bushels of barley, 15 bushels of oats, and 6.5 tons of potatoes per acre. At the time, two-thirds of Kerr's land was in its second year of cultivation, and the remainder was in its first.

In practice, the supply of manure relied on the folding of sheep on fields awaiting cultivation. Cattle dung was also valued, but until yards were built to contain cattle, it was not so easy to accumulate. Unlike northern Taranaki, the Waimea Plain not only offered a large expanse of open land but also incorporated "large plains of grass ... which could feed sheep in quantities". Consequently, it was able to accommodate substantial flocks. Sheep numbers rose to 4782 by 1844 (which was 18 times the number in Taranaki), and perhaps as many as 16,000 by 1847. To further extend this natural grazing capacity, 'artificial' grasses (incorporating clovers and lucerne) were sown, together with fodder crops, such as vetches and turnips. Constantine Dillon, for instance, wrote in 1844 of his intention to plant next year a turnip crop on his wheat field, in accordance with the Norfolk rotation. The folding of sheep on turnips was also employed in an attempt to improve the fertility of the "very worst land of all - the clay hills between the Waimea and the Moutere", but it does not seem to have produced the
results its instigators had hoped for. Another landowner who practised crop rotation was Edward Stafford. As well as running stock with Dillon in the Upper Motueka valley, Stafford occupied a 50 acre farm on the Waimea Plain, 35 acres of which, in 1847, were used for the rotation, while the balance was kept in pasture for cattle and horses. These endeavours were only on a small scale though, and as Table 6.4 shows, it was not until 1848 that the extent of cultivated stock feed (sown grass included) was more than 10% of the area under cereal crops.

Table 6.4: Acreage of crops cultivated by Pakeha at Nelson 1844-50

<table>
<thead>
<tr>
<th>Year</th>
<th>Sown Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Turnips</th>
<th>Grass</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
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<tr>
<td>1844</td>
<td>237</td>
<td>93</td>
<td>182</td>
<td>288</td>
<td>15</td>
<td>5</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>1845</td>
<td>892</td>
<td>208</td>
<td>468</td>
<td>332</td>
<td>89</td>
<td>33</td>
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<td>1846</td>
<td>1371</td>
<td>162</td>
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<td>242</td>
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</tr>
<tr>
<td>1847</td>
<td>1551</td>
<td>157</td>
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<td>231</td>
<td>62</td>
<td>106</td>
<td>262</td>
<td>3457</td>
</tr>
<tr>
<td>1848</td>
<td>1435</td>
<td>332</td>
<td>1079</td>
<td>223</td>
<td>n.s.</td>
<td>264</td>
<td>298</td>
<td>3631</td>
</tr>
<tr>
<td>1849</td>
<td>1168</td>
<td>400</td>
<td>1052</td>
<td>198</td>
<td>n.s.</td>
<td>377</td>
<td>441</td>
<td>3634</td>
</tr>
<tr>
<td>1850</td>
<td>1339</td>
<td>470</td>
<td>749</td>
<td>317</td>
<td>n.s.</td>
<td>829</td>
<td>539</td>
<td>4242</td>
</tr>
</tbody>
</table>

The adoption of mixed farming on the Waimea Plain was hindered, however, by the high cost of establishing a sheep flock. The estimated £1000-£2000 expenditure required (two to four times as much as was needed for a purely arable farm) was no obstacle for a few well-to-do settlers such as George Duppa, who had opted to concentrate on pastoral farming originally, but such expense was beyond the means of the vast majority. Most settlers, therefore, still had to continue to rely on a well-tilled fallow as the only means of 'fern land' improvement. Having said this, W. O. Cautley, Secretary for the Society for the Promotion of Agriculture, argued that even fallowing was not always needed. Like Cautley, many of Nelson's small-holding tenants (chiefly Company labourers and new German colonists), whose crops collectively accounted for about one-third of the total at the close of 1844, probably did not fallow their land, but in their case the decision was governed by want of income and food.

Despite these limitations on some farmers' soil fertility management, overall yields at Nelson were relatively good. With respect to the crops sown in 1844, the estimates for produce per acre from the country lands were around 25 bushels for the three cereal crops, and 6 tons for potatoes. The town land produce, which
came "from gardens, and chiefly woodland", gave slightly higher returns overall,\(^{153}\) although from one property as much as as 65 bushels of wheat per acre was reported.\(^{154}\) If the returns published by the *Nelson Examiner* can be relied upon,\(^ {155}\) yields fell away in the next two years, primarily as a result of droughty conditions, although in their report on 1845 returns, the *Nelson Examiner* also cited "the very slovenly mode of cultivation which many persons adopt" (perhaps a reference to the resource-poor small-farming tenants) and the "large quantity of newly-broken land" as contributing factors.\(^ {156}\) The latter observation is borne out by the acreage statistics shown in Table 6.4, in which the combined cereal acreage sown in 1845 exceeded the total area under crop (including sown grass) in 1844. A similar relativity exists between the 1846 cereal and 1845 total acreage figures, which means that 'fern land' 'sourness' would have depressed average cereal yields in the 1846 crop too.

This rapid expansion of land under cereal cultivation came to an abrupt halt over the years 1847-50. This was probably due to the combined effects of high labour costs and Maori competition.\(^ {157}\) Yields, however, were slightly higher during this period than in previous years, with wheat and barley producing, on average, 25-31 bushels per acre, and potatoes 7-8 tons per acre.\(^ {158}\) Obviously, better weather would have had a significant influence on returns, though other factors may also have contributed to this improvement. Firstly, since hardly any land was in its first year in cultivation, average yields would not have been affected much by 'sourness'. Secondly, Nelson's small-holding 'cottier' farmers were more likely to employ practices such as fallowing, now that their economic circumstances were less desperate. By 1849, the combined holdings of 50 of them amounted to 875 acres, 1245 sheep, 956 cattle, and 1248 pigs.\(^ {159}\) Thirdly, much of the Waimea Plain had now reached saturation point in terms of stock feeding on natural pasture. This meant graziers could either seek fresh pasture for excess stock in the Wairau Valley (which was purchased in March 1847),\(^ {160}\) or intensify grazing by sowing 'artificial' grasses, the acreage of which, as Table 6.4 shows, rose sharply in the late 1840s. Consequently, the potential supply of animal manure to the now static area under cereals was greater than ever before.

The prospects for Nelson agriculture would have been further enhanced by the process of land reselection in early 1849, which provided farmers with the opportunity, if they so wished, to restart cultivation on potentially better quality land.\(^ {161}\) This process arose out of recognition that "a considerable number of the selected accommodation sections" had been "totally unfitted for agricultural purposes, some of them of so poor a quality that the most improved system of
agriculture and unlimited manure would probably not return the seed that might be sown upon them." Given that Nelson had suffered from a shortage of good quality land, which had initially led both Company officials and settlers to express misgivings about its suitability for arable farming, it was remarkable that by 1850 it was producing 60% more wheat than New Plymouth, and almost three times as much as Wellington. Moreover, with its mixed form of agriculture, Nelson's settlers had achieved more than Wellington's or New Plymouth's in terms of agricultural improvement too. Of the three main Cook Strait settlements 'planted' by the New Zealand Company, Nelson, in agricultural terms at least, was thus the unexpected star.

V. Livestock and land purchase: Auckland's twin pillars of soil fertility management

From a would-be cultivator's perspective, the Auckland environment was similar to that at Nelson, in that there was a preponderance of 'fern land', and what forest cover there was lay on the margins of the initial settlement. This was inviting to colonists who hoped to avoid the arduous task of bush clearance and begin cultivation immediately, but the ubiquity of 'fern land' suggested soils with only low levels of fertility. As Tyrone Power, a British Army officer, recounted in his Sketches in New Zealand:

The appearance of the country is barren and uninteresting. It consists of low, rolling hills, covered with fern; Mount Eden, and one or two other black, scoria-covered, volcanic hills, are in the distance, but their sterile look does not make the landscape more inviting.

The most practical limitation to the initial development of Pakeha agriculture at Auckland, however, was that land came only gradually into Crown ownership, since Hobson's administration acted more cautiously when purchasing land than the New Zealand Company, whose dubious transactions had set up claims to vast swathes of territory. Consequently, in the first few years of the Auckland settlement, agriculturists had to make do with what soils were available. The first purchase for the township itself, made from Ngati Whatua in October 1840, amounted to just 3000 acres, and reached only as far across the isthmus as Mount Eden (Maungawhau). Much of this block was designated for town allotments (first sold in April 1841), but it was also the site of the suburban allotments (of around 4 acres each) which began being sold in September of that year. These
The most fertile soils in the vicinity of Auckland, where recent alluvial soils were few and far between, are the red and brown loams, which as can be seen in this map, are overwhelmingly concentrated in the southern half of the Auckland isthmus. To the north of Auckland, the predominant soils are fairly infertile podzolised yellow brown earths and podzols, which are distinguished on this map by the density of horizontal and vertical stripes. Once the red and brown loams were occupied, therefore, the best soils left were the volcanic loams between Manakau Harbour and the Waikato River.
Figure 6.5

LEGEND

SOILS OF THE "CLAY" COUNTRY

Yellow-brown sericit
Waxy and moderately hatched

Weakly hatched

Yellow-brown sericit and products

SOILS OF THE "LIMESTONE" COUNTRY

Rutile and related soils

SOILS OF THE "BAND" COUNTRY

Yellow-brown soils

SOILS OF THE "VOLCANIC" COUNTRY

Yellow-brown""sericit"

Hone granular from volcanic soils

Hone granular that have volcanic rocks

Red and brown horizons from basaltic rocks

Hone soils from volcanic ash

SOILS OF THE RIVER PLATS AND PROXIMITY COUNTRY

Brown soils from alluvial and play soils

Organic soils

Soil drifts

"C"-shaped with yellow-brown soils and partially covered by soil indicated by "C"

SOILS OF THE AUCKLAND DISTRICT

Scale of Miles

Compiled by J. J. Parker, 1964

From 4-mile soil map of North Island.

Reprinted with permission.
were far from ideal for cultivation. The natural vegetation consisted of "very low fern", while the underlying soils were clay textured yellow-brown earths (see Figure 6.5), which were strongly leached, indicating development under mor-humus forming species like kauri. Proximity to the town gave the possibility of fertilizing by "manure and other artificial means", in accordance with the current fashion in England, but as Charles Terry observed, they were too big for this practice to have much effect.

Areas of better land came into Crown ownership as a result of three further purchases carried out in 1841 (numbered 2, 3 and 4 in Figure 6.6). The most significant was the 'Waitemata to Manakau' purchase made from Ngati Whatua in June, which encompassed 12-13,000 acres. This gave an outlet on the Manakau Harbour, and extended the purchase boundary directly southwards to Mount Roskill (Puketapapa), and One Tree Hill (Maungakiekie). Auckland's Pakeha settlers now had access to the rich red and brown loams - denoted in an 1841 survey map, reproduced in Figure 6.7, as "volcanic soil of the finest description" - which occupied almost the entire southern half of the isthmus. Because of the young age (less than 20,000 years) of the basaltic parent material, and their development under a mix of podocarp, angiosperm, and broadleaf tree species, which tends to give rise to a mulloid humus which resists leaching, the red and brown loam soils are highly fertile, with only a slightly acidic pH and hence relatively high levels of basic nutrients such as calcium and potassium. In general, these soils also contain high levels of organic matter. They are also very friable, on account of their high iron and aluminium sesquioxide content, although their not infrequently stony and/or shallow nature proved a barrier in some areas to immediate cultivation.

Not surprisingly, the Epsom area, which represented the furthest penetration, in the direction of Onehunga, of Pakeha ownership into the area of red and brown loams, was chosen for Auckland's 'Small Farms' (see Figure 6.7). Like the suburban allotments, these farms, which ranged in size from 5 to 25 acres, went on sale for the first time in September 1841. The remainder of the isthmus' red and brown loams (which had been a traditional hub of Maori food production) were alienated by private Pakeha buyers when the Crown's waived its pre-emptive right to land purchase between March 1844 and November 1846. Thereafter, Ngati Whatua were left in possession of only a small area east of the town (shown as the unnumbered area between areas 1 and 2 in Figure 6.6), consisting of Remuera, Meadowbank, and the Orakei Block.
Figure 6.6
The acquisition of land by Pakeha in the vicinity of Auckland


Crown purchases:            Alienated by Crown during settlement of Old Land Claims: (not all outstanding OLC land shown)
1. Waitemata           1840             8. Alexander Dalziel
2. Kohimarama          1841
4. Waitemata to Manakau 1841
5. Manakau Road        1842
6. Papakura            1842/43
7. Pukekohe I          1842/43

Private purchases:

10. Aggregate purchases during pre-emption waiver period (1844-6).

The rapid acquisition by either the Crown or individual Pakeha settlers of the better soils in the vicinity of Auckland can be seen by comparing this map with that in Figure 6.5. It is also noticeable how much the 'land bank' of the Auckland settlement was added to by the giant land parcel alienated by the Crown after settling Fairburn's Old Land Claim. Expansion west of the Waitemata to Manakau purchase (4), it should be pointed out, was precluded by the forested land of the Waitakere ranges.
The importance of soil fertility to settlement establishment is once again shown in this map of Auckland by Hobson's Surveyor-General, Felton Matthew. As can be seen, the initial settlement hearth was on the south shore of Waitemata Harbour, but already Auckland is expanding, in the form of its 'small farms' towards the highly prized red and brown loams on the southern half of the isthmus, which are denoted by the phrase "Volcanic soil of the finest description".
Figure 6.7

MAP OF THE HARBOUR OF WATENATA, NEW ZEALAND, and of the adjacent Country; showing the situation of AUCKLAND, the capital of the colony.

Legend of the Principal Points

Symbols:
- Towns
- Rivers
- Roads
- Roads

Scale: 1" = 6 miles.

FEFLEN MATHEW, Survey Chief (1841)

From surveys undertaken with the Flax.
In both of the other Crown purchases of 1841, namely the 6000 acre Kohimarara Block, and 9500 acre Mahurangi Block on the North Shore, further areas of red and brown loams were acquired. Indeed, when Felton Matthew recommended the area between Mount Wellington and the Tamaki River estuary (subsequently the southernmost extent of the Kohimarara Block) as the site for the township of Auckland in 1840, the fertility of its soils were one of the main reasons for his recommendation. In both Blocks, however, the prevailing soils were, as Figure 6.5 shows, strongly leached yellow-brown earths (like those of the township), or still less fertile podzolic soils. An additional tract of strongly leached yellow-brown earths also came into Crown hands after the settlement of an 'old land claim' [that is, a pre-1840 private land purchase] held by Alexander Dalziel. This last area (Figure 6.6, no. 8), together with adjacent parts of the Kohimarama Block, became in February 1842 the first area to be sold off in more sizable farm units, the 37 sections amounting to 3856 acres.

Yet more areas of red and brown loams (as well as land access between Manakau Harbour and the Waikato River) were secured by the Crown during 1842 via the 9000 acre Papakura Block and 16,000 acre Pukekohe I Block transactions (Figure 6.6, nos. 6 and 7). The other soils obtained as part of these purchases, were moderately fertile, but very friable, brown granular loams and yellow-brown loams, akin to the soils at New Plymouth. When in February 1843 the Crown began selling land south of the Tamaki River, however, it was not in either of these two blocks; rather, it was in the yellow-brown loam land (on the Tamaki's east bank) which made up part of the 75,000 acres (See Figure 6.6, No. 9) the Crown had appropriated from the settlement of Fairburn's 'old land claim'. Subsequently, sales to settlers of land held by the Crown, by 'old land claimants' (Fairburn being just one of a number who received compensatory land in the area), and by Maori during the pre-emption waiver period, led to sporadic farm development by the late 1840s throughout the Manakau district.

In 1843, with all this land accessible to Pakeha settlement, the Agricultural and Horticultural Society was able to report that within the Auckland district "a variety of soils" were "offered to the agriculturist". Each of these, readers were assured, was "adapted to some particular production, and favourable to some peculiar mode of agriculture". Amongst these soils, red and brown loams were rated the most highly (the former being assessed as "very fertile"), although it was noted that some tracts of red loam were so strewn with scoria as to be unploughable. Consequently, low tillage forms of land use, such as viticulture,
were proposed as alternatives to arable farming. Areas of woodland were also esteemed, as their soil, according to the Society, was "always of the best description, being a rich friable loam, especially suited to the growth of wheat". Its only drawback was the high cost of clearing (between £8-£16 per acre), though this was partially offset by the value of timber.

It may appear strange that woodland was viewed so highly, when non-resident commentators decried kauri forest as a sign of infertile soil, but it seems likely that 'woodland' was not a reference to kauri forest. It probably referred to the groves of trees on the isthmus itself, which grew around the shore and in gullies, and hence on small patches of recent colluvial and alluvial soil, and/or the mixed podocarp-broadleaf forest of the western extremities of the Manakau district's 'Great Hunua Forest'. Settlers probably had more contact with these wooded environments, because of the proximate transport routes, than they did with the kauri forests to the west.

Next in order of preference was the so-called 'fern and tupaki [tutu]' land, said to make up about half of the Auckland district. According to the Agricultural Society's report, the soil of these areas was a yellow clay overlying sandstone. This is suggestive of yellow-brown earths, though this category also seems to have incorporated yellow-brown loams. As Figure 6.5 shows, the two are intertwined on the western boundary of the isthmus in areas such as Avondale, where sections were being purchased from 1843 onwards. Interestingly, the report went on on to describe the 'fern and tupaki' land as "a rich deep loam, suitable for grain, green crops and grasses". In order to improve the quality of this soil the Society advised turning up the subsoil and exposing it to the air, since the high-clay content caused the soil to break up when dried. As for clearing costs, these ranged from £6 5s. and £11 10s. per acre, with the higher rates occurring where the tupaki (tutu) was most prevalent.

Bottom place, of course, went to the strongly leached yellow-brown earths and podzols, which were so infertile that they supported only stunted 'fern' and manuka. By the Society's reckoning, these accounted for as much as one-quarter of the soils in the Auckland district. As with the 'fern and tupaki' land, however, some improvement (in the physical character of the soil at least) could reportedly be achieved by turning up the soil. Some four years later a piece written in the *New Zealander* reiterated this message, stating that an "astonishing" change in the fertility of "that peculiar and infertile sandy clay, on which the kauri alone flourishes" could be achieved simply "by exposure to the air and by draining". Naturally, clearing away the stunted vegetation on these soils involved only modest expense - £5-£6 per acre - though once it was ready for
cultivation to start, the Society recommended that barley or pasture be grown rather than wheat. This was due to the relatively coarse nature of the topsoil, which was a mixture of sand and sticky white clay.\textsuperscript{199}

With so much of the available land being 'fern land', it was inevitable that one of the main problems for pioneer cultivators would be 'sourness'. To combat this problem the Agricultural Society resorted to suggesting the standard techniques of either fallowing or growing a crop that allowed intertillage:

as a general rule ... all newly broken up land should lie fallow during either the winter or summer, or should be prepared for either grains by a crop of maize or potatoes, by this means the \textit{sourness} incident to all unbroken land, particularly fern land, will be removed, and the soil either pulverised by exposure to the atmosphere, or comminuted by the roots of the above named plants, will be ready to receive either wheat or barley, and will amply repay the time thus apparently lost.\textsuperscript{200}

As at Nelson, it was quickly realised that sowing a green crop and folding sheep on it over winter was an equally effective countermeasure.\textsuperscript{201} Having said this, 'fern land' did have some useful qualities. Firstly, horses and cattle were able to readily find feed from it. This allowed Auckland's settlers to keep 3663 horned cattle, in addition to their 2883 sheep, by 1847, even though they had sown only 1398 acres down to pasture.\textsuperscript{202} In the absence of stock, 'fern land' could also supply vegetable manure. According to one of the Auckland Standard's correspondents, 'fern' fronds rotted under water provided a fine manure, which could be used as an alternative to animal dung.\textsuperscript{203} Likewise, a writer in the \textit{Southern Cross} suggested that burning 'fern' fronds mixed with sea shells would leave a deposit of fertilising ash on the land, and lime it at the same time.\textsuperscript{204}

\begin{table}
\centering
\caption{Acreage of crops cultivated by Pakeha at Auckland 1844-50}\textsuperscript{205}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
Year Sown & Wheat & Oats & Barley & Potatoes & Grass \\
\hline
1844 & 562 & 183 & 55 & 97 & 202 \\
1845 & 601 & 194 & 102 & 208 & 480 \\
1846 & n.s. & n.s. & n.s. & n.s. & n.s. \\
1847 & 365 & 291 & 285 & 247 & 1398 \\
1848 & 393 & 193 & 330 & 295 & 2743 \\
1849 & 215 & 206 & 588 & 775 & 4054 \\
1850 & 243 & 135 & 795 & 1067 & 5098 \\
\hline
\end{tabular}
\end{table}
Despite the deterrent factors of both 'sourness' and a restricted supply of land, the area sown in the three main cereals and potatoes had, as Table 6.5 shows, reached 897 acres by 1844. By the latter date, the Agricultural Society recorded, there were in the Tamaki district "several farms" on which there were "thirty acres of wheat ... in the most flourishing condition." This acreage was only about one-third of an acre per person, but it should be remembered that large nearby Maori populations made for easy access to an alternative food supply. The productivity per acre, however, was less than spectacular. While some individuals prospered, such as George Graham, who predicted a yield of 40 bushels of wheat per acre from his 1844 crop, the overall estimated yields for wheat during the years 1843-5 ranged from just 20-27 bushels per acre. As Figure 6.2 shows, this put Auckland last when it came to yields in the four main settlements during this period. These estimates were close to the projected yields published by the Agricultural Society in 1844, namely 22 bushels per acre for the first crop, and 25 bushels for the second, which suggests that the low wheat yields reported were not the result of temporary adverse conditions. Potato yields followed a similar pattern. After returning an estimated 8 tons per acre from the crop sown in 1843, the yield fell to a mere 5 tons per acre in 1844 and 1845. It is difficult to say what may have caused this dropping off in yield, although the observation, made by the New Zealander in 1847, that the 'vegetable mould' in all but the richest New Zealand soils would be exhausted in three years or less suggests that soil organic matter decline in areas already under cultivation, together with the commencement of cultivation on previously unused, and presumably inferior, 'fern land', may have been significant factors.

Pastoral farmers had more cause to be more optimistic. George Rich, for example, wrote in 1843 that "for grazing and dairy purposes, it will be equal to any part of the world I have seen, after it has been sown with English grass". This task, moreover, seemed like it would be easily accomplished, given that in Rich's opinion all grasses, and particularly Dutch clover, grew remarkably well. With cattle being suited to the humid climate and able, as noted above, to find food naturally, numbers rose from some 494 in 1843 to 1978 two years later, making Auckland second only to the Wellington settlement in cattle ownership. In contrast, numbers of sheep over the same period rose only from 712 to 3598, leaving Auckland well behind Wellington and Nelson. This difference was probably due to the high price of Leicester sheep (£2 per head), a breed more
suited to Auckland conditions than fine woolled Merinos. The Agricultural Society, nevertheless, saw the depasturing of sheep as important not just for the production of wool and meat, but as playing an integral role in agriculture too. After commenting that there was "every reason to anticipate that sheep-farming in conjunction with agriculture, will be found very profitable", the Society's Second Report went on to recommend that sheep grazing, rather than being restricted to the one-off improvement of 'sour' fern land, should be part of fully fledged crop rotations. One rotation, which was suggested for those farmers who possessed at least £790, went as follows: 1st year - wheat; 2nd - barley; 3rd - clover sown on barley stubble; 4th - wheat and winter green crop (eaten off by sheep); 5th - barley; 6th - grass seeds; 7th - potatoes and turnips. In a similar vein, in 1846 a commentary on the harvest in the New Zealander called upon farmers to grow white clover for seed, noting that "when large fields are laid down and the land well manured, by sheep depasturing, it may be anticipated that greater product would be the result".

It is not possible to state whether this or similar rotations were employed during the 1840s, but there is no doubt that the productivity of arable farming was much higher towards the end of the decade. The estimated yield for the wheat crops sown in 1847-49 lay in a range between 30 and 35 bushels per acre, which, as seen in Figure 6.2, was half as much again as the yield estimated for 1845. Nevertheless, the acreage sown in cereals in 1849 was not much more than the 1844 figure. Potato yields were more unstable, attaining 8 tons per acre from the crop sown in 1847, before falling to 6 and 5 tons per acre for the crops of 1848 and 1849 respectively. It should be noted, however, that the acreage sown in potatoes almost trebled in 1849. This expansion probably arose out of a combination of expected demand from the Californian gold-rush, and, also from the jump in the amount of land being broken-in, due to the settlement of the 'Fencibles', the military pensioners who were settled in a defensive cordon around Auckland. At this time there was also a marked increase in the cultivation of oats. Howick, the largest of the 'Pensioner Settlements', was sited on leached, clayey, yellow-brown earths, which would have suited oats better than wheat, given the former's greater acid-tolerance. Undoubtedly, the sharp rise in horse numbers would also have been a contributing factor.

The settlement's pastoral sector, or at least its cattle-raising sector, meanwhile continued to expand. By 1850, cattle numbers had reached some 7003, while the sheep flock, which fluctuated in size, stood at 3341. Similarly, the Report for 1850 by the revived Agricultural Society reported that sown pasture accounted
for 5098 acres, or 63% of the total area of cultivated land, with a further 376 acres being devoted to hay production. This situation was not welcomed by all; one correspondent to the New Zealander in 1849 complained that "the land and climate are too good for this region to be wasted in cattle runs". Since cattle were left to roam in the open, this did not necessarily provide manure for use on arable fields, however. In fact, manure appears to have been a scarce commodity. The New Zealander, for instance, advised farmers in 1847 not to rake out 'fern' (bracken) roots ("a robbery of an excellent manure from the soil"), but to leave the severed roots to decompose in the soil. It also remarked that on new land earthing up the soil around plants, as Maori farmers did, was preferable to ploughing as it wasted no organic matter. On at least one occasion, dung was also purchased from a vessel carrying sheep to New Zealand. On a brighter note, once the manure was acquired, the cultivator could reflect on the advice of the New Zealander that when growing crops, "one third the quantity of manure required in England will have an equally good effect here". Obviously, in Auckland's warm climate, crops did not need much 'forcing'. Lime was also sought after by Auckland farmers to both improve soil fertility and protect the crops from weeds and grubs, but according to an editorial in the Southern Cross its use was severely constrained by Governor Grey's withholding of permission for the development of new limestone resources. This was due, it seems, to their being on Maori-owned land.

The increase in yields in the late 1840s did not, however, take place solely on lands that was being manured. At the start of 1848, the New Zealander reported that W. Hart Snr. of Epsom had obtained a yield of 50 bushels of wheat per acre on land which was being cultivated for the first time. Likewise the Agricultural Society Report for 1850 gave estimated yields per acre, specifically for unmanured land, of 30 bushels for wheat and barley, 40 bushels for oats, 1.5 tons for clover hay, and 6 tons for potatoes. That these figures are equal to, if not higher, than the estimates made in the Government returns, which aggregated manured and unmanured land, suggests that the increase in agricultural productivity during the late 1840s related less to manuring, and more to the acquisition of the highly fertile red and brown loams from Maori. In this regard, it should be borne in mind that Grey's sceptical attitude towards the legitimacy of the pre-emption purchases probably caused farmers on this land to be wary of beginning substantial agricultural operations, and thus not much of the red and brown loam land (outside the initial 'Small Farms' area) would have been cultivated for more than a few years by 1850.
Clearly Auckland's immediate farming future, like Nelson's, lay in a mix of arable and pastoral farming, although pasture was obviously the dominant of the two. Raising cattle rather than sheep did, however, rather limit one's market to domestic consumption. In terms of arable production, Auckland in 1850 was a highly successful New Zealand settlement, being second only to Nelson in acreage, and second only to Wellington with respect to yield. This achievement had turned the tables on its New Zealand Company detractors who had branded the land north of the Thames as sterile. Yet impressive as the production gains made by Pakeha settlers at Auckland were, it seems probable that they had come largely at the expense of Auckland's Maori community, rather than through the 'improved' system of agriculture which formed the second stage of the agricultural 'vision' being embraced.

VI. Not now, not never: a post mortem on the soil fertility management 'vision' in 1840s New Zealand

What then can be concluded about the state of soil fertility management in New Zealand during the 1840s? In the initial phase, as anticipated, most Pakeha farmers repeated the pattern set in other colonies, that is, relying on the soil's natural fertility. However, during the decade little progress was made towards the second stage of the agricultural 'vision', namely the establishment of a system of agriculture which, while not exactly replicating contemporary European practices, would at least adopt some of its basic principles, such as crop rotations, soil fertilisation with either farmyard manure or 'artificial' substitutes, and supplementary feeding of stock. As seen in this chapter, instances of rotational cropping being practised were relatively rare, and while a wide variety of organic manures were experimented with, most farmers seem not to have used them either. It is therefore apt that the only explicit mention of Liebig in connection with manuring (either organic or inorganic) in New Zealand did not involve fertilising farmland, but rather the application of liquid manure to vegetable crops growing on Willis Street in Wellington.

The only recorded instances, meanwhile, of lime being used as a soil improver, which was hardly uncommon in the British context, were in Nelson and Auckland. Generally, the finding of new limestone sources did create some excitement, but normally this was because of its cement-making value, rather than its potential benefit to agriculture. A similar degree of apathy surrounded the possibility of superphosphate use. In 1845 the New Zealand Spectator prefaced
an account of bone superphosphate manufacture in Great Britain by asking why the bones of locally caught whales could not be similarly treated, and then "used for manure in New Zealand, or sent to England for this purpose," but nothing seems to have come of this suggestion. Three years later, the issue was raised again when, in response to local soil exhaustion problems, the Governor of Van Diemen's Land (Tasmania) wrote to Governor Grey, backing a move to import New Zealand sulphur (either as ore, or processed into sulphuric acid), with the aim of making superphosphate from it. Subsequently, the *Southern Cross* ran an item entitled 'The Sulphur of New Zealand', which was largely reprinted from the *Hobart Town Advertiser*, extolling the virtues of superphosphate as a fertiliser (including, incidentally, its value for clover growth). Although the preamble commented that the article contained "practical and highly useful knowledge", the *Southern Cross* never suggested that New Zealand produce its own superphosphate. As for local mineral phosphates, Robert Oxland, an analytical chemist at Plymouth, examined some minerals from Taranaki in 1842 and commented that the soil derived from a phosphate of iron sample he examined was likely to "contain phosphates that may be rendered of some considerable value for agricultural purposes". Once again, local settlers took no notice of this finding.

While local obstacles, such as the lack of land for sheep grazing at New Plymouth, and conflict over land in the Hutt Valley and at Wanganui, obviously played a part in retarding the adoption of the second stage of the agricultural 'vision', a number of generic factors were also at work. Firstly, the promotional campaigns carried out by agencies such as the New Zealand Company had imbued new settlers with the notion that New Zealand's soils were extraordinarily fertile. Consequently, there was an air of complacency about the effects of continuous cropping on the soil, which was reflected by the frequent statements that the soil was so rich it would not need any manuring for many years. An analogous sentiment which was sometimes expressed, such as at the Nelson Agricultural and Horticultural Society's autumn exhibition of 1845, was that "there was but little credit due to the successful cultivators; the land and the beautiful climate did the work for them". Significantly, amongst the four main settlements the most progress towards an improved system of agriculture occurred at Nelson and Auckland, where the depiction of soil fertility had been least exaggerated for promotional ends.

A second factor inhibiting agricultural development was the sense that what worked in Great Britain (or indeed in other colonies) might not be suited to New
Zealand. The two stage agricultural 'vision' acknowledged that current Western farming practices could not simply be replicated, but this did not alter the fact that there was no certainty about how best to make the transition from the extractive to the 'improved' stage. Works of agricultural instruction from 'home', such as Stephens' *Book of the Farm* and Johnston's *Elements of Agricultural Chemistry and Geology*, might have offered some pointers, but, as many commentators observed, previous knowledge of farming methods gave one little advantage over complete novices, since while the latter had to learn, the former often had to unlearn. Trusting in theoretical principles would also have been little help, because at this time the void between the theory of agricultural chemistry and its demonstration in practice was only starting to be bridged, and not always successfully, by contemporary scientists such as Liebig. Perhaps the only significant drawback from having large numbers of migrants with no agricultural background was, as John Deans remarked, that they tended to adopt whichever path seemed easiest to follow. This meant waiting for others to set an example for them. Practical experimentation could have served as a guide, but as seen during this chapter, few farmers possessed sufficient means to devote land and labour to speculative efforts. Moreover, even when methods, either adopted from abroad or devised in New Zealand, were found to be successful, it was difficult to disseminate them amongst the farming community. Regrettably, as Table 6.6 shows, each of the agricultural societies established in Wellington, New Plymouth, Nelson, and Auckland quickly fell into abeyance. Because of this state of institutional disarray, many articles of interest to agricultural readers

**Table 6.6: Agricultural organisations in the main settlements to c. 1855.**

**Wellington:**  - Port Nicholson Agricultural Association (1843-5?)
  - Wellington Farmers' Club (fl. 1857-8)

**New Plymouth:**  - New Plymouth Association for the Advancement of Agriculture & Commerce (fl. 1845)
  - Taranaki Agricultural Society (fl. 1852, "long latent" by 1856).

**Nelson:**  - Nelson Agricultural and Horticultural Society (fl. 1844-5, revived 1846-7)
  - Nelson Agricultural Association (fl. 1852)
Auckland: - Agricultural and Horticultural Society of Auckland (1843-5?, revived 1848-, renamed Auckland and New Ulster Agricultural and Horticultural Society c. 1851).
- Auckland Farmers' Club (c. 1853-).

Otago: - Otago Agricultural Association (fl. 1851-2).

Canterbury: - Christchurch Agricultural and Horticultural Society (1852-)

in New Zealand newspapers, such as the piece 'Impoverished Effects of Burning New Land for the First Crop' (a discourse against the loss of nutrients during combustion), sourced by the *Nelson Examiner* from the Nova Scotian journal *Colonial Farmer*;246 passed with little comment, and certainly did not prompt any action. Indeed, by the end of the decade, most New Zealand newspapers, when they did include such extracts, tended to include them amongst the space-filling miscellaneous foreign news on the back page.

A third reason for the slow pace of 'improvement' in New Zealand's agriculture was based on a crucial distinction between economic conditions in New Zealand and at 'home'. As an article in the *New Zealander* in 1847 succinctly put it, "land is dear, and labour cheap, at home; here it is the reverse".247 The manurial regimes of 'home' were to some extent founded on cheap labour. Even where only farmyard manure was utilised, one needed labour to fence in stock fed either on pasture or in stalls, labour to collect muck from feeding stalls, labour to transport and spread dung and muck, and finally labour to plough it into the soil. As Hursthouse related with respect to Taranaki, such operations were so expensive in New Zealand that farmers were reluctant to carry them out. Instead, it was much easier to follow the strategy adopted in Auckland of acquiring more cheap land - which in practice meant cheap Maori land. Where the labour requirement was felt to be less onerous, that is, in the vegetable garden, settlers seem to have been more inclined to apply manure.248 This suggests that labour considerations may have been relatively more important than perceptions of soil fertility as a rationale for non-manuring.

The fourth and final reason, which rather than obstructing the transition to the 'improved' stage of the agricultural 'vision', allowed it to be delayed without too much ill effect, was the increasing attraction of pastoral farming at a time when grain prices were generally falling, owing to Maori and Australian
competition. Even in the mid-1840s, this had caused the direction of agricultural development in the Hutt Valley to move not towards a Norfolk-style crop rotation, but instead towards convertible husbandry. By the end of the decade the expectation that New Zealand would be primarily a grain-producing colony had practically disappeared, although it lingered on in the minds of some foreign observers. Accordingly, the main repository for settler capital became pastoral farming in areas such as the Wairarapa and Wairau Valleys. This was a sector in which Maori competition was negligible. Given the potential for future soil exhaustion at Wellington, Nelson, and Auckland, it was indeed fortunate that in 1848 the London wool price, which had been dropping since 1839, started rising again, and did so until 1866. Unfortunately for New Plymouth's settlers, their lack of available open land denied them the opportunity to share in the coming 'wool age', and thus for them soil exhaustion would continue to be a pressing difficulty.

It should not, however, be thought that the new interest in 'chemical husbandry', which was exciting so much attention in Europe and the United States, had passed over the New Zealand settlers completely. Although hardly any of these settlers put its principles into practice, some at least talked in Liebigian terms. When in 1847 the New Zealander discussed the benefit of pulverizing infertile soils, it stated that the "necessity of exposure to the air" arose "from the absence in new soil, of such promoters of vegetation, as the carbonic acid, and ammoniacal gases, which the exposed soil absorbs from the atmosphere". Similarly, a letter written by 'Z' to the New Zealand Spectator in 1847, during a vehement dispute with William Swainson about eradicating 'fern' (bracken), claimed that if the fronds were regularly eaten off, this would prevent the absorption of "carbonic acid", and thus after a period "varying with the tenacity and consequent imperviousness of the soil to the air", it would die. Clearly, the theory behind the 'vision' was there, but its adoption was something for future consideration.
Notes to Chapter Six


7 N. Z. Journal, 4(65) (9 July 1842), p. 165. The great importance given by the reviewer to fertilising with organic matter, as opposed to his comments in regard to mineral nutrients, may reflect the fact that Liebig had not yet asserted that the carbon and nitrogen needs of plants could both be met by the atmosphere (Rossiter, Margaret W., The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840-1880 (New Haven, Connecticut, 1975), pp. 40-3). With respect to the lasting nature of mineral nutrients, the reviewer is correct - the application of bones may fertilise the soil for several years, whereas more soluble nitrogenous manures only improve plant growth in the year of application (Aikman, C. M., Manures and the principles of manuring 3rd ed. (Glasgow, 1894), pp. 550-1).

8 Extract from Sydney Gazette, in N. Z. Journal 1(1) (8 February 1840), p. 2. See also Southern Cross, 5 August 1843, p. 2. Another initial concern was that fleeces would be damaged whilst sheep foraged for food (see Southern Cross, 21 December 1844, p. 2).


13 Ibid., 3(65) (9 July 1842), p. 165.

settlers should be able to raise at least 8 quality wheat crops in 19 years (Ponton, J. C., 'Farmers in England and New Zealand'. Ibid., 4(101) (11 November 1843), p. 294.


16 Wakefield, Edward Jerningham, The Hand-book of New Zealand: consisting of the most recent information compiled for the use of intending colonists (London, 1848), p. 138. It appears that the soils being alluded to are the Waiwhetu soils (Atkinson, Soils of Taita Experimental Station, p. 14-5).

17 Wakefield, The Hand-book of New Zealand, p. 138. The soil texture of the valley floor soils (Waiwhetu and Pinehaven soils) (Atkinson, Soils of Taita Experimental Station, p. 68) varies from sandy to clay loam. The sany loam soils are the most fertile, and, being found on the river banks, the most conspicuous also (Gibbs, H. S., ‘Notes on the Soils of the Hutt Valley’. Proceedings of the New Zealand Ecological Society 6 (1959), p. 35).


19 G. Duppa to his father, 26 February 1840. N. Z. Journal 1(17) (12 September 1840), p. 221. The renowned ‘high farming’ practised in the Scottish Lothians, in comparison, produced yields in the order of six quarters (that is, 48 bushels) per acre of wheat (see N. Z. Journal 4(80) (4 February 1843), p. 26).


21 Extract from New Zealand Spectator and Cook’s Strait Guardian, in Nelson Examiner and New Zealand Chronicle, 8 March 1845, p. 4; Patterson, Brad, ‘The grain mirage: ideal and reality in early Wellington agriculture’. Stout Centre Review 2(3) (1992), p. 20. It seems likely that the increased costs after the mid-1840s were due to the reduced employment of local Maori as agricultural labour, once inter-racial tensions in the Hutt Valley became serious.


23 See Russell, Sir E. J., Soil Conditions and Plant Growth 8th ed., revised by E. W. Russell (London, 1950), pp. 208-10. While the exact proportion of nutrients lost during the process of burning the forest can only be guessed at, some indication of the magnitude of the losses may be given by considering values reported for biomass nutrient losses upon combustion of Westland beech forest (66% of nitrogen, 35% of phosphorus, and 51% of sulphur) (Goh, K. M., & Phillips, M. J., ‘Effects of clearfell logging and burning of a Nothofagus forest on soil dynamics in South Island, New Zealand - changes in forest floor organic matter and nutrient status’. New Zealand Journal of Botany 29(4) (1991), p. 367), and Ponderosa pine and Douglas fir slash (90% of nitrogen, and 60% of phosphorus)


26 Evidence of Francis Molesworth, 20 June 1844. 'Report from the Select Committee on New Zealand; together with the Minutes of Evidence, Appendix, and Index [1844]'. Great Britain Parliament. *British Parliamentary Papers: Colonies - New Zealand* (Shannon, 1968-71), II (1844), p. 181. The average English wheat yield at the time was 2½ bushels per acre (Overton, *Agricultural Revolution in England*, p. 77). Incidentally, Molesworth's potato crop yield during the 1841-2 season was reported in several publications to have been 12 tons per acre (See, for instance, extract from *New Zealand Gazette [and Wellington Spectator]*, January 1842, in *N. Z. Journal* 3(64) (25 June 1842), p. 149; Earp, George B., Extract from MSS., in *N. Z. Journal* 4(102) (25 November 1843), p. 302).


30 Anon., 'Remarks on Cropping Land in the Valley of the Hutt'. *New Zealand Gazette and Wellington Spectator*, 10 April 1844, p. 3. It has been assumed that this essay was the winner of the prize given by the Port Nicholson Agricultural Association for the 'Fullest
account of the best rotation of crops on newly cleared land, and the method of putting them into the ground' (See ibid., 23 March 1844, p. 1), as it was preceded in print by an essay on the best method for clearing land (which came, in the prize categories, immediately prior to the crop rotation essay). Since potatoes are just as exhausting as wheat, it seems that improving soil structure was probably the motive behind the call for them to be alternated. A typical potato crop at the end of the nineteenth century extracted about the same amount of nitrogen and phosphorus, and about twice as much potash, as a typical wheat crop (Aikman, C. M., *Manures and the principles of manuring* 3rd ed. (Edinburgh, 1894), p. 485).

31 Anon., 'Remarks on Cropping Land'. Ibid., 10 April 1844, p. 3.

32 Patterson, 'The grain mirage'. *Stout Centre Review* 2(3) (1992), pp. 20-1 & 23-5. Even when farm establishment costs are ignored, the year-to-year costs of producing wheat have been assessed by Patterson as, at minimum, 4s. per bushel (Ibid., p. 22), which, assuming 40 bushels of wheat were needed per ton of flour (*New Zealand Gazette and Wellington Spectator*, 3 January 1844, p. 2), gives a minimum materials-only cost of flour of £8 per ton. In comparison, flour from as far away as Chile was being sold at Sydney (after milling charges, merchants fees, and shipping charges had been accounted for) for only £12-£20 per ton (Wood, *Twelve Months in Wellington*, pp. 65-6).


38 Miller, *Early Victorian New Zealand*, p. 134-5; *Statistics of New Zealand for the Crown*


40 *Statistics of New Zealand for the Crown Colony Period, 1840-1852*, p. 84.

41 *Statistics of New Zealand for the Crown Colony Period, 1840-1852*, p. 43.


43 Gibbs has noted with respect to the Hutt's Waiwhetu soils that "under cultivation, losses of humus and of structure are fairly rapid and methods of maintaining humus are required for intensive cropping use". Gibbs, H. S., 'Soils of the Wellington District'. *Proceedings of the New Zealand Society of Soil Science* 4 (1960). 4. Some agriculturists, it seems, did apply manure to potatoes, as the Port Nicholson Agricultural Association offered separate prizes for manured and unmanured specimens (*New Zealand Gazette and Wellington Spectator*, 23 March 1844, p. 1).

44 Samuel Revans to H. S. Chapman, 24 October 1841 [p. 6]. 'Revans letters to Chapman'. (Unpublished MS. [no. 1687], Alexander Turnbull Library). For Dieffenbach's concerns in regard to soil erosion on cleared land, see Chapter Three.


sections and selections at Wanganui, see Chapple, L. J. B., & Veitch, H. C., *Wanganui* (Hawera, 1939), facing p. 2.


61 Quin, 'Bush Frontier - North Taranaki', (Unpublished M.A. thesis, Victoria University, 1966), Fig. 5 (follows p.30).


64 When first surveying the site, Frederick Carrington had written, "It is one great forest round the base of the mountain between which & the coast is very many miles of Fern & Bush land" (Carrington, F. A., 8 January 1841. 'Papers of Frederick Alonzo Carrington, 1840-5'). Similarly, Stephen Gillingham wrote in a letter to his father, "There is a strip of land along the coast about 200 yards wide, covered with fern, similar to the English. Immediately behind it is a belt of bush land, as it is here called, composed of the most beautiful shrubs from five to twenty feet high, filled up with fern of the same height which is about three
miles wide. This land is considered the best; behind this commences the timber district, which I have not seen (S. Gillingham to D. Gillingham, 2 March 1842. *Letters from New Plymouth 1843*, p. 26). In accounts from the late 1840's, however, timber-producing forest and bush are conflated (See Wakefield, *Hand-book of New Zealand*, p. 287; Hursthouse, Charles, *An Account of the Settlement of New Plymouth, in New Zealand, from personal observation during a residence there of five years* [1849] (Christchurch, 1975), p. 96.


H. R. Aubrey to Thomas Woolcombe, 2 July 1842. *Letters from New Plymouth 1843*, p. 44; Quin, 'Bush Frontier - North Taranaki' (Unpublished M.A. thesis, Victoria University, 1966), Fig. 7 (follows p.52). Much of the riverbank occupied by present day Waitara, was in the words of the surveyor for the 'Plan of Proposed Town - Waitara, Taranaki' (1850 ?), covered by "small timber and underwood". Maling, Peter Bromley, *Historic Charts and Maps of New Zealand, 1642-1875* (Auckland, 1999), p. 197.

In 1844, the New Plymouth correspondent of the *Nelson Examiner* stated that "one or two settlers only have gone upon timber land, and they are sawyers. For them, no doubt, it is the best: but it seems doubtful whether timber land will produce more than the bush, while it is certain that it is much more expensive to clear". *Nelson Examiner*, 25 May 1844, p. 3.

J. Lewthwaite to the Ed., *New Zealand Journal*, 8 January 1846. Reprinted in Earp, *Handbook for intending emigrants to the Southern settlements*, p. 257. Costs were much lower by the mid-1840s, with Lewthwaite reckoning the combined costs to be £14 per acre for forested land, and £3 2s. per acre for 'fern land', at the time of his departure (Ibid., pp. 257-8). Figures similar to Lewthwaite's later estimates can be found in the *New Zealand Journal* (Quin, 'Bush Frontier - North Taranaki' (Unpublished M.A. thesis, Victoria University, 1966), p. 52n).


Opinion was divided as to whether the standing fern should be set alight, or if, if should be cut down first and allowed to dry before burning commenced. Hargreaves, 'Pioneer Farming in Taranaki'. *New Zealand Geographer* 19(1) (1963), p. 48.


Hursthouse, *An Account of the Settlement of New Plymouth*, pp. 95 & 104. As noted in Chapter Three, bracken growth was traditionally associated with acid soils, which is reflected in the use of the term 'sourness'. Potatoes do better on acid soils than wheat, with the optimum pH range for wheat being 5.5-6.5, whereas for potatoes it is 4.8-6.5 (McClaren & Cameron, *Soil Science*, p. 181).


Of the crops sown in 1842, 50 acres were in potatoes, as opposed to 14 in wheat, oats, and barley combined (*Statistics of New Zealand for the Crown Colony Period, 1840-1852*, p. 39).


90 Anon. to mother, 19 November 1849. *Australian and New Zealand Gazette* 1(3) (16 Nov 1850), p. 41.
95 P. Wilson to the Colonial Secretary, December 1849. *Australian and New Zealand Gazette* 1(7) (11 January 1851), p. 106.
96 *Otago Witness*, 20 March 1852, p. 3.
100 *Wellington Independent*, 22 December 1849, 2; *Statistics of New Zealand for the Crown Colony Period, 1840-1852*, p. 42.
102 Hursthouse inferred that the shallowness of the soil was due to the evergreen vegetation. This contrasted to the deep soil-making deciduous vegetation in the Americas. Hursthouse, *An Account of the Settlement of New Plymouth*, p. 91.
103 Ibid., pp. 47-9.


Australian and New Zealand Gazette 1(3) (16 Nov 1850), p. 40.

Chittenden, E. T., Hodgson, L., & Dodson, K. J., Soils and Agriculture of Waimea County, New Zealand (Wellington, 1966), pp. 14-48 passim. Since Tuckett was short of level land, it can be assumed that all the fertile floodplain and terrace soils of Waimea County are included in this figure. Tuckett himself thought that only one-tenth was prime land (Allan, Nelson, p. 197).

The chief areas of swampland were between Stoke and Richmond and at Wakapuaka, while alluvial soils under forest were found in the Motueka Valley. Chittenden et al., Soils and Agriculture of Waimea County, pp. 10, 14, 17 & enclosed map.

Chittenden et al., Soils and Agriculture of Waimea County, pp. 14-7; Allan, Nelson, pp. 197-8. Modern analyses give a figure for organic matter content in the topsoil of about 6-7% (Hodgson, L. & Dodson, K. J., 'Soil Chemistry'. In Chittenden et al., Soils and Agriculture of Waimea County, p. 50).

Chittenden et al., Soils and Agriculture of Waimea County, pp. 21-2.


Chittenden et al., Soils and Agriculture of Waimea County, pp. 24-8, 39-44, & enclosed map.


119 Ibid., p. 231.
120 William Cullen to Orlando Reeves, 21 October 1842. *Letters from Settlers and Labouring Emigrants*, p. 119.
121 William Cullen (to his family), [June or July 1842]. Ibid., 99. No date is given, but the surrounding letters have been printed in date order.
126 *Nelson Examiner*, 7 January 1843, p. 2.
131 *Nelson Examiner*, 7 January 1843, p. 2. At the time, the Editor was G. R. Richardson (See Allan, *Nelson*, pp. 161-4).
132 Ibid.
133 Ibid.
134 'Rot the Fern Root' to the Ed., no date. *Nelson Examiner*, 2 December 1843, p. 3.
135 *Nelson Examiner*, 23 December 1843, p. 3. The normal retail price, including delivery, was £2 10s. per ton (*Nelson Examiner*, 2 December 1843, p. 4), though it is reported that Murray, Morse and Rogers had bargained with the limeburners (presumably to get a bulk discount). The lime was applied to land on "three or four sections" (at maximum 600 acres). As the typical rate of liming in England would have been say 3-5 tons per acre (Williams, Richard, *Limekilns and Limeburning* (Aylesbury, United Kingdom, p. 11), it is probable that only about one-tenth of this would have been limed.
139 *Nelson Examiner*, 30 March 1844, 2. Subsequently, the average potato yield on
unmanured fern land in the Waimea was reported as 7 tons per acre (Nelson Examiner, 11 May 1844, p. 2).


145 Constantine Dillon to Lady Dillon, 10 April 1844. Sharp (ed.), The Dillon Letters, p. 34.

146 Nelson Examiner, 15 February 1845, p. 2. According to the Nelson Examiner the undertakers of the experiment expected a good crop from the second year. However, according to Rigg, those farmers who went on to the 'Moutere Gravels', starting with the German missionaries in 1844-5, failed to make much headway prior to 1860 (Rigg, 'The 'Moutere Gravels', Waimea County, Nelson'. In Nelson Catchment Board, The "Moutere Gravels", Waimea County, Nelson, p. 21).

147 [Extract from Edward Stafford], 22 October 1847. Wakefield, Hand-book of New Zealand, p. 249. Stafford's authorship is indicated by three statements: firstly, the author describes his purchase of sheep from New South Wales in April 1844 - Stafford is known to have returned to Nelson in May 1844 with sheep purchased in Sydney (McAloon, Nelson, p. 25); secondly, the author owns 1400 sheep running in the Upper Motueka Valley - Stafford and Dillon, had, in the form of a partnership, an exclusive right to depasture sheep in this area (Cocks, Pamela, 'The Company and the Land Question'. In Allan, Ruth M., Nelson: A History of Early Settlement, ed. by J. C. Beaglehole, and with chapters by Nancy M. Taylor and Pamela Cocks (Wellington, 1965), Nelson, p. 387); thirdly, the author's partner was to move his sheep to the Wairau in the next few weeks due to overstocking - Constantine Dillon relates in a letter, his being in the Wairau in December 1847 (Dillon to Lady Dillon, 7 February 1848. Sharp (ed.), The Dillon Letters, p. 57).

148 Nelson Examiner, 15 February 1845, p. 2, 4 April 1846, p. 2, 27 March 1847, p. 2, 15 January 1848, p. 2, 27 January 1849, p. 2, 16 February 1850, p.3, & 1 February 1851, p. 2. In the 1844 statistics (Ibid., 15 February 1845, p. 2), rather than an 'other crops' figure being provided, it was recorded that an additional 442 acres (which included land under
fallow after being broken-in) were in cultivation.


J. Dillon Bell, 10 April 1845. New Zealand Journal 5(151) (11 October 1845), p. 259;

152 During the desperate summer of 1844-5, some labourers even dug up seed potatoes in the quest for food. Allan, Nelson, pp. 363-5.

153 Nelson Examiner, 15 February 1845, p. 2.

154 Ibid., 15 March 1845, p. 3.

155 The Nelson Examiner and official returns give different yield estimates for the crops sown in 1845 and 1846. The yield estimates, in terms of produce per acre, quoted by the Nelson Examiner for 1845 and 1846 (latter year in brackets) were respectively: wheat, 24 bushels (20 bu.), barley 25 bu. (13 bu.), oats 21 bu. (20 bu.), potatoes 6 tons (2 tons) (Nelson Examiner, 4 April 1846, p. 2, & 27 March 1847, p. 2). Those given in the Government returns, generally considerably higher, are as follows: wheat 30bu. (30bu.), barley 30 bu. (20 bu.), oats 24 bu. (20 bu.), potatoes 6 tons (4 tons) (Statistics of New Zealand for the Crown Colony Period, 1840-1852, p. 42). Though there was not any intrinsic reason why the Nelson Examiner should be more reliable, it, unlike the official returns, had an opportunity for subsequent reassessment or correction.


157 While high labour costs, as noted by Stafford, made extending cultivation problematical from a commercial viewpoint ([Extract from Edward Stafford], 22 October 1847. Wakefield, Hand-book of New Zealand, p. 249), it seems likely that the large Te Ati Awa cultivations of European crops in the Motueka district (by 1850, 1000 acres of wheat were being cultivated) (McAlloon, Nelson, p. 39) would have had a similar (if perhaps less direct) effect of restricting the profit margin that could be obtained from additional cultivation.


159 Miller, Early Victorian New Zealand, p. 125.


164 See Stone, R. C. J., *From Tamaki-makau-rau to Auckland* (Auckland, 2001), p. 4; Colenso, William, 'Memoranda of an Excursion made in the Northern Island of New Zealand, in the summer of 1841-2; intended as a contribution towards the ascertaining of the Natural Productions of the New Zealand Groups: with particular reference to their Botany (Part II)'. *Tasmanian Journal of Natural Science* 2(9) (1845), p. 288; Dieffenbach, Ernest, *Travels in New Zealand; with contributions to the Geography, Geology, Botany, and Natural History of that Country* (London, 1843), I, p. 279.


168 Kalaugher, J. P., *Historical Chronicles of the Auckland Agricultural and Pastoral Association and Early Days of the Auckland Province* (Auckland, 1925), p. 9; Terry, Charles, *New Zealand, its advantages and prospects, as a British colony* (London, 1842), pp. 151-2 [N. B. The page nos. 152 & 153 have been replicated on the following two pages].


171 Terry, *New Zealand*, p. 153 [2nd of two] [N. B. The page nos. 152 & 153 have been replicated on the following two pages]


175 Pohlen, 'The Red-Brown Loams'. In *Soil Groups of New Zealand*, 2nd printing, p. 328;


Bulmer, 'Settlement patterns in Tamaki-makau-rau revisited'. In Davidson et al. (eds.), *Oceanic Culture History*, p. 642.


The Kohimarara Block was purchased from Ngati Paoa in May, while the Mahurangi Block was purchased in a convoluted transaction involving several *iwi* that began in April. Ward, *National Overview*, II, p. 127; Walsh, Tom, *An Illustrated History of Devonport and the Old North Shore from 1841 to 1924, with an Outline of Maori Occupation to 1841* [1924] (Devonport, 1986), p. 3.


Stone, *From Tamaki-makau-rau to Auckland*, pp. 300 & 336


New Zealand Government Gazette, 3(1) (4 January 1843), p. 3; Ward, Alan, Pre-1840 Purchases. In Husbands & Riddell, The Alienation of South Auckland Lands, with a chapter by Alan Ward, pp. 12 & 14. The first land from the 'Parish of Papakura' (i.e. from within the Papakura Block) was put up for auction on 19 June 1843 (New Zealand Government Gazette, 3 (20)(17 May 1843), p. 143.


Agricultural Society of Auckland, 'First Annual Report'. Ibid., 21 October 1843, p. 4, & 28 October 1843, p. 4. More than 1000 acres within the isthmus itself were still regarded as being unavailable for settlement due to this obstacle in 1847 (Governor Grey to Earl Grey, 11 November 1847. Further Papers relative to the Affairs of New Zealand: Correspondence with Governor Grey. 1848'. Great Britain. Parliament. British Parliamentary Papers: Colonies - New Zealand, VI (1847-50), p. 12).


Agricultural Society of Auckland, 'First Annual Report'. Ibid., 21 October 1843, p. 4, & 28 October 1843, p. 4. The cracking of clay soils when dried is, of course, exploited in modern-day cricket pitches.


Agricultural Society of Auckland, 'First Annual Report'. Ibid.

New Zealander, 21 July 1847, p. 2.
Contemporaries estimated that if a small amount of additional feed, such as turnips, was supplied, 1 acre would support about 4 sheep, or alternatively 1.5 cattle beasts (including calves) (Agricultural and Horticultural Society of Auckland, 'Second Annual Report'. Southern Cross, 23 November 1844, p. 3). If all the sheep had been fed on pasture, then most cattle would have little or no pasture to feed on.

'Crayon' to the Ed., Auckland Standard, 11 April 1842. Reprinted in N. Z. Journal 3(75) (26 November 1842), p. 279. This technique may have derived from the practice of the mission farmers, described in Chapter Five.


Agricultural and Horticultural Society of Auckland, 'Second Annual Report'. Southern Cross, 16 November 1844, p. 3.


New Zealander, 28 July 1847, p. 2.


Lloyd Prichard, Economic History of New Zealand to 1939, p. 47; Agricultural Society of


216 Agricultural Society of Auckland, 'Second Annual Report'. Ibid., 16 November 1844, p. 3.


220 McFarlan, E. D., 'Military Pensioners in Auckland', pp. 68 & 71; McClaren & Cameron, *Soil Science*, p. 181. In this regard, it is interesting to note that in 1850 the area defined as 'Howick, and the Country East of the Tamaki' had 156 acres of oats and 146 acres of potatoes in cultivation, while the amount of wheat grown was just 9 acres (*Statistics of New Zealand for the Crown Colony Period, 1840-1852*, p. 41).

221 Horse numbers in Auckland rose from 386 in 1847 to 698 in 1849. Lloyd Prichard, *Economic History of New Zealand to 1939*, p. 47.

222 Ibid.


227 *New Zealander*, 10 September 1851, p. 3.

228 *New Zealander*, 28 July 1847, p. 2. In a similar vein, Charles Hursthouse noted that at New Plymouth, the farmer only needed to use half the amount of manure as one did in England to get the same effect (Hursthouse, *An Account of the Settlement of New Plymouth*, p. 95).

229 *Southern Cross*, 8 April 1848, p. 2. See also 'A Ploughman' to the Ed., 21 April 1848. Ibid., 29 April 1848, p. 2. One of the prospective lime quarriers to whom a licence was declined was M. Whytlaw, who had intended to procure stone lime from Whangarei (See *New Zealander*, 27 October 1847, p. 4).

230 Kalaugher, *Historical Chronicles of the Auckland Agricultural and Pastoral Association*,
Having said this, Liebig did feature occasionally in articles describing soil fertility management overseas (see, for example, New Zealand Gazette and Wellington Spectator, 27 March 1844, p. 4).

References to limestone in literature of the period are generally adjacent to brickmaking references (such as in Wakefield, Hand-book of New Zealand, p. 251). To give some idea of the scale of its use in construction, it is worth noting that while quarterly deliveries of lime to the port of Auckland during the mid-1850s seem to have been generally in the 1000-2000 bushel range (see New Zealander, 26 January 1853, p. 3, 9 February 1856 (Supplement to), p. 4, & 9 August 1856, p. 3), Edward Markham states that more than 10,000 bushels of (shell) lime were burnt to make cement for the Stone Store at Kerikeri in the 1830s (Markham, Edward, New Zealand, or Recollections of it, ed. by E. H. McCormick (Wellington, 1963), p. 78).

New Zealander, 20 May 1848, p. 2.

Extract from Hobart Town Advertiser [& extract preamble], in Southern Cross, 7 October 1848, p. 4.

[Lecture by [Philip] Pusey, and lecture preamble]. New Zealand Spectator and Cook's Strait Guardian, 29 November 1845, p. 3.


Both titles are listed as being amongst the volumes held by Nelson's Literary Institute in 1850 (Nelson Examiner, 14 December 1850, p. 2), Stephens' work being one of those recommended to emigrants by Wakefield's Hand-book (Wakefield, Hand-book of New Zealand, p. 441). Captain Moore at Motueka, meanwhile, seems to have put his faith in Loudon's Encyclopaedia of Agriculture (Ross, John O., Capt. F. G. Moore: Mariner and Pioneer (Wanganui, 1982), p. 95. Ross gives the title as London Encyclopedia of Agriculture, but reading from copperplate writing, the two could easily be confused - moreover, no item is listed in the British Museum catalogue of printed works with the latter title.


Rossiter, Margaret W., The Emergence of Agricultural Science: Justus Liebig and the


245 See New Zealand Gazette and Wellington Spectator, 7 June 1843, p. 2; William
Swainson, 'Notes on Pastoral Agriculture' (Part II). New Zealand Spectator and Cook's
Strait Guardian, 20 March 1847, p. 4; Ibid., 14 March 1857, pp. 2-3, & 2 October 1861,
p. 2; New Plymouth Association for the Advancement of Agriculture & Commerce. 'First
Taranaki Herald, 13 October 1852, p. 3, & 20 December 1856, p. 3; Whelan, Helen, &
Smith, Dawn, 'Agricultural Organizations of Nelson, 1843-1893'. The Journal of the
Historical Chronicles of the Auckland Agricultural and Pastoral Association and Early
Days of the Auckland Province (Auckland, 1925), pp. 11, 19 & 22; New Zealander, 5
April 1851, p. 2; 'K' to the Ed. Ibid., 1 October 1853, p. 3; Otago Witness, 3 May 1851,
p. 3, 10 July 1852, p. 2, & 3 December 1859, p. 5; Lyttelton Times, June 1852, p.

246 Extract from the Colonial Farmer, in Nelson Examiner, 2 December 1843, p. 4.

247 New Zealander, 28 July 1847, p. 2.

248 See, for instance, Natusch & Swainson, William Swainson of Fern Grove, p. 112; 'Calendar
of Garden Work', extracted from Cook's Strait Almanack for 1848. Wakefield, Hand-book
of New Zealand, p. 132.

249 Extract from The Times, 8 June 1849, in Nelson Examiner, 27 October 1849, p. 3.

200n.

251 New Zealander, 28 July 1847, p. 2.

252 'Z' to the Ed., 22 March 1847. New Zealand Spectator and Cook's Strait Guardian, 24
March 1847, p. 3. In it also worth mentioning George Earp's criticism of the policy of
liming 'fern land', which he claimed was adding "alkaline salts to a soil already
impregnated with it", and hence against "all the principles of chemical agriculture".
Earp's writing was, however, that of a settler who had returned to Great Britain, and thus
would have been attuned to the needs of a British, rather than New Zealand, audience
(George Earp, MSS., 'Land and Land Clearing in New Zealand'. N. Z. Journal 4(102) (25
Chapter Seven

When there's gold there's guano: agriculture and soil management in Wellington, Nelson, and New Plymouth, c. 1850-1860

The 1850s and early 1860s were years of change in New Zealand agriculture, as farmers at Wellington, Nelson, New Plymouth, and Auckland began to move away from the extractive agriculture practised in New Zealand's colonial infancy to more sophisticated and sustainable systems akin to those practised in British farming. Many of these farmers were now prepared to transfer the scientific and technological innovations which were advancing agriculture 'at home' to New Zealand. Amongst these innovations, perhaps the most acclaimed 'at home' was the introduction of 'artificial' fertilisers. 'Artificial', in this context, did not mean synthetic, but rather, as the agricultural writer John Haxton put it, something "derived from sources extraneous to the usual produce of a farm". Of the various 'artificial' fertilisers, the three most notable, and the first three to be introduced into New Zealand, were bone-dust, guano, and superphosphate.

I. Bone-dust, guano, and superphosphate: their role in Western farming in the mid-nineteenth century.

Amongst 'artificial' fertilisers, bones were the first to be used in Western agriculture on a regular basis. Their fertilising powers had been known since Roman times, but until the cutlery industry started producing large quantities of bone waste in the late-eighteenth century, they were not utilised in Britain to any significant extent. In contrast to most animal waste products, bone manure only supplied a modest amount of nitrogen to the soil, but it did supply large amounts of phosphorus. Calcium phosphate was in fact identified as the principal component of bones in 1769.

Most soil phosphorus is held in relatively unavailable organic and inorganic nutrient pools, which drip-feed the small amounts (typically between 0.1 and 0.5% by dry matter weight) which farm crops require. Prior to the 'agricultural revolution', crop production had always been limited by the level of plant-available nitrogen in the soil, but as seen in Chapter Two, by the nineteenth century considerable progress had been made in overcoming this constraint through the incorporation of new legumes into rotations, together with fodder.
crops on which stock could be folded. Consequently, phosphatic fertilisers could now be of real benefit. Furthermore, the two crops which the added phosphate had most effect on were clover and turnips, which were at the heart of the new rotations. The phosphate enabled clover to compete against aggressive grasses which would otherwise have starved it of this nutrient, while with turnips, stimulation of root formation shortened the duration of its early growth phase, when it was vulnerable to both the ravages of the turnip-fly and to drought. Typically, turnips were grown in light-textured soils, which dried out quickly. Bone manure was also valuable for improving worn-out dairy pastures, grown on soils which had slowly been depleted of phosphorus because of its continuous removal in milk.

As a fertiliser, bones had one major defect, namely their extremely slow release of phosphate. This meant they had little effect on crop production in the short-term. The causes of this slow release were twofold: firstly, calcium phosphate is only sparingly soluble, and secondly, the greasy coating on the surface of bones is hydrophobic (water-repelling), and thus serves to keep water at bay from the mineral part of the bone. The grease also hinders microbial action on the organic content of the bone. Bones were only effective, therefore, when the soil was relatively warm and dry, since these conditions were optimum for aerobic microbial activity. In the circumstances, it made sense to begin the degradation mechanically, and to this end, bone-mills began appearing in Great Britain in the 1780s. In about 1800 chemists realised that the phosphate rather than organic tissue gave bones their fertilising power, and this led to a second method, that is, boiling and/or steaming the bones to remove the decay-inhibiting fatty tissue and collagen.

In spite of the aforementioned limitations, the use of bones as a fertiliser in Great Britain continued to grow rapidly, and by the early 1830s British farmers were applying bone manure to 100,000 acres every year. As the long-term effect of bones was reckoned to last five years, the area fertilised periodically was undoubtedly several times greater than this. Bone manuring was less widespread in Europe, but by 1831 J. C. Loudon reported that "a knowledge of their great value is spreading rapidly over the Continent." The emergence in the early 1840s of Liebig's 'mineral theory', which emphasised the role of inorganic (mineral) nutrition in general, to the extent that Liebig argued that "produce increases or diminishes, in a direct ratio, with the supply of mineral elements capable of assimilation", provided further impetus for bone manuring. This was because Liebig identified phosphorus as the most important mineral nutrient.
Accordingly, by 1850, British bone imports were sufficient for annual application to 150,000 acres. To meet the rising levels of demand, new sources of bones had to be tapped. While most were fairly mundane, such as Argentinian cattle, less savoury ones, such as the catacombs of Sicily, gave rise to Liebig's famous indictment that Great Britain was behaving like a vampire, firstly in raiding the battlefields and graveyards of Europe, and then squandering the fertility they had stolen away by letting it drain into the sewers.

The demand for bones would have been even greater but for competition from another 'artificial fertiliser', guano. This forms in an arid climate, like that of coastal Peru, when seabird excrement becomes dessicated. The residual solid, guano, deposits of which are shown in Figure 7.1, is rich in both nitrogen and phosphates, contains smaller amounts of potash, and is moderately soluble. These properties gave guano two great advantages over bones, the first being that it could be used on moist clayey soils, where bones decomposed too slowly, and the second that it was much more versatile, since it could fertilise quick-growing nitrogen-hungry crops, such as cereals, rather than just phosphate-loving root crops and clover. As the agricultural chemist J. F. W. Johnston said in 1841, it contained the "greater part of the ingredients which are necessary to the growth of every variety of crop".

The potential fertilising value of guano was revealed by chemical analysis as early as 1806, but it was not readily available until 1839, when the Peruvian government granted an export concession to the London merchant house Gibbs and Sons. Its broad similarity with dung, notwithstanding the much higher nutrient levels, meant that British farmers had no trouble employing it to advantage, and consequently it quickly became immensely popular. By the early 1850s, more than 200,000 tons of Peruvian guano were imported annually, or enough to fertilise 1-1.5 million acres. As John Morton, editor of the Cyclopaedia of Agriculture (1855), observed, guano had been "so largely imported within the last ten years, and so largely used in all parts of the country", that there was "hardly any locality whose increasing agricultural produce has not ... borne witness to its fertilising influence". Although American farmers had shown comparatively little interest in bone manuring, they were also caught up in the 'guano mania', which was at its height there in the mid-1850s.
Figure 7.1
Accumulation of guano on rocks in Peru

Source: Stidd, Charles K., 'Tradewinds and soybeans'. Oceans 4 (July 1976), p. 31 [Photograph by Mary Crowley]

On the Chincha Islands, the best known source of Peruvian guano, beds of guano had formed which were up to 200 feet deep (Aikman, C. M., Manures and the Principles of Manuring 3rd ed. (William Blackwood and Sons, Edinburgh, 1894), p. 302.
Unlike bone, guano was valued mainly for its nitrogen content (hence its contemporary description as a 'forcing' manure). Despite the disregard for nitrogen shown by Liebig's 'mineral theory', many agricultural scientists, most notably Lawes and Gilbert in Great Britain, thought that boosting soil nitrogen levels would help growing crops as well. It may seem paradoxical then, that in British farming practice, guano was chiefly applied not to cereals but to turnips, which were stimulated by its phosphatic as much as its nitrogenous content. It must be remembered, however, that manuring had typically been concentrated on the root crop in the rotation, and furthermore, by doing so, farmers could directly compare guano's performance with bone-dust's.

One characteristic of guano, however, held market demand in check - price. Until 1855, Peruvian guano sold in Great Britain for around £10 per ton, and thereafter it rose to around £13 per ton. This meant that if guano was applied to turnips in England at the recommended rate of 3-4 cwt. per acre, the material cost (that is, excluding transport and labour), even during the 1840s, was close to 40s. per acre. In Scotland, meanwhile, application rates were commonly double those in England, because of the shorter growing season. Worse still, confidence tricksters often exploited guano's natural variability, which reflected the multitude of sources, by selling fake or adulterated guano. Unsuspecting farmers, therefore, sometimes got no return from their substantial investment. Having said this, the material cost of applying half-inch bones in England was about 36s. per acre. In effect, guano users were paying the same amount for short-term nitrogen and phosphate fertilisation as bone users were for longer-term phosphate fertilisation.

Although guano largely superseded bone as a fertiliser, there was the possibility of reversing this situation if a means was found to free up the phosphate in the bone. Farmers could then concentrate its fertilising power on one crop, rather than having it spread over several. While the effect of the nitrogen in guano should not be overlooked, it is worth observing that farmers using bone on turnips were applying three times as much phosphate as those using guano. The problem was solved through the discovery that when bones were dissolved in sulphuric (vitriolic) acid, the calcium phosphate was converted into the much more soluble dihydrogen phosphate form.
Table 7.1: The manufacture of superphosphate

Ca₃(PO₄)₂ + 2H₂SO₄ + 2H₂O ⇌ Ca(H₂PO₄)₂ + 2CaSO₄.2H₂O

calcium phosphate + sulphuric acid + water

Calcium dihydrogen phosphate (monocalcic phosphate)

Gypsum

Approximate product composition (of early 'bone superphosphate'): 35% phosphate (about 20% in soluble form), 25% gypsum, 20% water (in free water, and crystalline gypsum), and 20% organic compounds (reaction products of organic matter in bone).

As Table 7.1 reveals, the resulting product from this reaction was 'superphosphate' - a collective term for a mixture containing a soluble calcium phosphate compound and gypsum. Establishing the antiquity of superphosphate manufacture is difficult, given its wide-ranging definition. It is well known that several chemists, amongst them Kohler in 1831, and Liebig in 1840, were aware of superphosphate's fertilising potential, although the first commercial patents for it were awarded to John Bennet Lawes and James Murray in 1842. Evidently, its use as a fertiliser was much earlier than this, as it was found while preparing this thesis that Archibald Cochrane commented in his turn-of-the-century treatise on agricultural chemistry that "phosphat and oxalat of lime ... may be rendered serviceable to vegetation by ... vitriolic acid, [and] vitriolic neutral salts, (especially if superacidulated)...". Technologically speaking, therefore, Lawes' operation was not new, although he was the first to shift, in the mid-1840s, from bones to rock phosphate and coprolites (fossilised dung) as the raw material. This alleviated concerns about the bone supply, as well as raising slightly the superphosphate's phosphate content, since there was no organic matter involved in the later process.

The superphosphate which Lawes and other manufacturers produced retailed at about £7 per ton, which, given the usual application rate of 3-4 cwt. per acre, meant an application cost of 20-25s. per acre. At this rate,
superphosphate users applied about 50% more phosphorus than guano users, but at half the cost. Accordingly, superphosphate quickly surpassed guano as the preferred fertiliser for the phosphorus-loving turnip. As a British review of the fertiliser trade remarked in 1858, “the superiority of superphosphate over guano for root crops [is] pretty generally acknowledged”. Moreover, in 1860 Augustus Voelcker, then consulting chemist to the Royal Agricultural Society of England, reported farmers had "found by experience" that where it was "deemed desirable to make up a deficiency of yard-manure", it generally paid better "to purchase superphosphate and similar manures for the root-crop than to buy nitrogenous manures for the white [cereal] crop". In these circumstances, British superphosphate production rose from about 30,000 tons in 1854 to 250,000 tons in 1866, the latter of which would have enabled its application on about 1.5 million acres, which equated to 10% of the arable land area in England and Wales. Conversely, guano use dropped, although imports remained at about 150,000 tons during the 1860s, as farmers still believed that it was a better phosphate fertiliser on wetter clay soils, and that nitrogen fertilisation could promote mangel growth generally, and turnip growth in colder, northern climes. Outside Great Britain, meanwhile, superphosphate manufacture had commenced in most other Western European countries, and in many eastern states of the United States, by 1860.

Undoubtedly, 'artificial' fertilisers had become, by the mid-1850s, an integral part of the farming economy in Great Britain. Use in parts of Europe and the United States was not far behind. New Zealand farmers, on the other hand, would appear to have been unlikely candidates for using 'artificial' fertilisers, since at the close of the 1840s, they rarely used even farmyard manure. The prospects were improved, however, by the introduction of guano throughout Australia's southeastern seaboard by 1855. Indeed Sydney, Melbourne and Hobart all featured as points of departure for guano shipments to New Zealand in that year. There were two good reasons for Australian farmers to start using fertilisers at the time. Firstly, soil exhaustion problems had already become apparent, particularly in Tasmania, where both potato and wheat crops were failing - hence the enquiry by the Governor of Van Diemen's Land (referred to in Chapter Six) about manufacturing superphosphate from New Zealand sulphur. Secondly, the onset of the Victorian gold-rush early in 1851 gave, in the form of highly inflated produce prices (see Table 7.2), a strong incentive for those farmers who stayed on their land, rather than leaving for the goldfields, to boost their short-term production.
Table 7.2: Australian wheat demand in the Victorian gold-rush years\textsuperscript{56}

<table>
<thead>
<tr>
<th>Year</th>
<th>Net Australian wheat &amp; flour imports (million bu.)</th>
<th>Wheat price in Sydney (per bu.)</th>
<th>Flour price in Sydney (per ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>- 0.555</td>
<td>4s.</td>
<td>£12 10s.</td>
</tr>
<tr>
<td>1851</td>
<td>0.135</td>
<td>8s.6d.</td>
<td>£20 16s.</td>
</tr>
<tr>
<td>1852</td>
<td>0.499</td>
<td>6s.</td>
<td>£20 16s.</td>
</tr>
<tr>
<td>1853</td>
<td>1.483</td>
<td>6s.10d.</td>
<td>£20 16s.</td>
</tr>
<tr>
<td>1854</td>
<td>0.614</td>
<td>11s.6d.</td>
<td>£41 14s.</td>
</tr>
<tr>
<td>1855</td>
<td>2.593</td>
<td>16s.5d.</td>
<td>£50</td>
</tr>
<tr>
<td>1856</td>
<td>1.797</td>
<td>11s.4d.</td>
<td>£39 12s.</td>
</tr>
<tr>
<td>1857</td>
<td>0.426</td>
<td>7s.3d.</td>
<td>£20 16s.</td>
</tr>
</tbody>
</table>

Although, even in these circumstances, most Australian farmers seemingly paid little attention to manuring,\textsuperscript{57} it is worth noting that Peruvian (or at least, South American) guanos was probably reasonably accessible. As well as making an ideal high-value, low-volume commodity for vessels engaged in trans-Pacific trade, Gibbs and Sons had established a Melbourne subsidiary in 1853.\textsuperscript{58} Australian farmers also had the option of trying locally-sourced guano, such as that from Flinders Island, which began to supply South Australia in the early 1850s.\textsuperscript{59}

Certainly the presence of fertilisers in Australia gave New Zealand farmers the opportunity to begin using them, but what was their motive? To answer this, it will be necessary to revisit the contemporary state of agriculture in Nelson, Wellington, and New Plymouth. In Auckland, it should be said, the motivations behind fertiliser use, and as a result, the pattern of that use, proved somewhat different, and for this reason the role of fertilisers in Auckland farming will be discussed separately, in Chapter Eight.

II. Motive and Opportunity: manuring and market forces in Nelson and Wellington

Nelson was the first New Zealand settlement to receive an import of fertiliser, with the official port returns showing the entry of five hogsheads of guano, equating to about 1.8 tons, during 1854.\textsuperscript{60} This is not surprising, since amongst all the settlements, it was the largest agricultural producer at the start of the 1850s, and its farmers (as seen in Chapter Six) had made the greatest effort to adopt modern fertilisation practices. This course of action, together with the trend
of sowing introduced grasses in order to intensify stock rearing during the late 1840s, meant that its agricultural land was still in good condition. Consequently, when local produce prices rose, as seen in Figure 7.2, in response to the onset of the Victorian gold-rush, Nelson farmers were well placed to expand their wheat production. Table 7.3 shows that they certainly did so, and in remarkably short order too – the area sown in wheat in 1851 was 59% up on the previous year. Having said this, between 1850 and 1852 the area of sown pasture

Table 7.3: Acreage of crops cultivated by Pakeha at Nelson 1850-55

<table>
<thead>
<tr>
<th>Year Sown</th>
<th>Wheat</th>
<th>Barley</th>
<th>Oats</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>1339</td>
<td>470</td>
<td>749</td>
<td>317</td>
<td>829</td>
<td>539</td>
<td>4242</td>
</tr>
<tr>
<td>1851</td>
<td>2121</td>
<td>716</td>
<td>610</td>
<td>322</td>
<td>1147</td>
<td>605</td>
<td>5522</td>
</tr>
<tr>
<td>1852</td>
<td>2042</td>
<td>993</td>
<td>852</td>
<td>415</td>
<td>1837</td>
<td>1089</td>
<td>7227</td>
</tr>
<tr>
<td>1853</td>
<td>1202</td>
<td>728</td>
<td>892</td>
<td>424</td>
<td>2775</td>
<td>836</td>
<td>6857</td>
</tr>
<tr>
<td>1854</td>
<td>2378</td>
<td>812</td>
<td>1740</td>
<td>459</td>
<td>3006</td>
<td>1042</td>
<td>9437</td>
</tr>
<tr>
<td>1855</td>
<td>3379</td>
<td>777</td>
<td>1626</td>
<td>758</td>
<td>4305</td>
<td>1323</td>
<td>12,168</td>
</tr>
</tbody>
</table>

more than doubled, which indicates that Nelson farmers were not prepared to simply substitute pastoralism for wheat cropping. Yield data suggests that much of the wheat was again grown on newly broken-in 'fern land', as the 1851 average yield mirrored previous figures of 25 bushels per acre, and grew to 30 bushels per acre in 1852. The increased yield in the second year, given that the area was almost unchanged, would accord with the improvement in 'fern land' once 'sourness' had been overcome. The bullish prospects for arable farming, and with it the sense of 'agricultural improvement', did not just manifest itself in crop returns. Suddenly the long-lapsed Nelson Agricultural Society was revived, Alexander Ogg was advertising technical instruction in agriculture at his Hope Agricultural and Industrial School, and the geological and chemical analyst William Grayling was offering 'hints on farming' in his lectures on chemistry. The Nelson Examiner also reprinted an article from the Edinburgh-based Journal of Agriculture, which gave advice on the best manner of clearing 'fern land', and recommended using lime to counteract its 'sourness' thereafter.

Unfortunately for the farmers of Nelson, their magnificent progress came to a shuddering halt during 1853. In a grim reflection on the halving in the wheat acreage in this year, the Nelson Examiner stated that:
Figure 7.2
Wheat prices in Nelson, Wellington and New Plymouth during the 1850s.

Sources: *Statistics of New Zealand for the Crown Colony Period, 1840-1852*, compiled by C. G. F. Simkin (Department of Economics, University of Auckland, Auckland, 1954), p. 84; *Statistics of New Zealand, for 1853, 1854, 1855, and 1856* (Auckland, 1858), Table 53; *Statistics of New Zealand for 1857*, Table 63; *Statistics of New Zealand for 1858*, Table 78; *Statistics of New Zealand for 1859*, Table 32; *Statistics of New Zealand for 1860*, Table 31; *Statistics of New Zealand for 1861*, Table 55.

As can be seen in this graph, wheat prices in Nelson, Wellington and New Plymouth followed a similar trend throughout the 1850s, which in turn followed that in Sydney (shown in Table 7.2) fairly closely.
Wheat Prices (s. /bu.) during the 1850s

Figure 7.2
A more forcible illustration of the urgent need ... for a fresh supply of labour could scarcely be adduced. Although the prices of produce have risen from 50 to 100 per cent., cultivation has diminished to a most serious amount, and the farmer has been compelled to suffer his land to run to waste, from the want of hands to work it.\textsuperscript{67}

The wheat acreage rebounded in 1854, but this did not mean the labour crisis was over. As the \textit{Nelson Examiner} noted in an editorial which questioned whether there would be sufficient labour for the harvest, the diversion of potential settlers to Australia threatened to make Nelson an economic backwater, since now only the pastoral sector seemed capable of producing a marketable surplus.\textsuperscript{68} As Table 7.3 shows, the growth in the area in sown grass had slowed as well though.

Scarce labour was not the only impediment to agricultural production. By the mid-1850s, the potential costs of not restoring soil fertility were becoming evident too. Whereas one Waimea West farm, after practising fallowing and deep ploughing, returned 65 bushels of wheat per acre in the 1855 harvest, many others under a ruder system of management, and which, the \textit{Nelson Examiner} bemoaned, ought to have been producing 40 bushels per acre, produced only 20 bushels per acre.\textsuperscript{69} Regrettably, the latter was probably closer to the norm, as one contemporary estimate of the average wheat yield throughout Nelson put it at 25-30 bushels per acre.\textsuperscript{70} Genial weather over the spring and summer of 1855-6 made the yield disparities between farms even more obvious in the succeeding crop of wheat.\textsuperscript{71} As the \textit{Nelson Examiner}, having regard to the 1856 harvest, pointedly observed:

Farmers must resort to the old country mode of farming and manure the soil, or else lay down a portion of land in grass, to be broken up at a future time. This is very evident if one takes the trouble to go through our agricultural districts ... the crops on newly broken-up land are of a fair average quality, and the same may be observed on those lands which have been laid down in grass for a few years, and have been broken up for grain this season; whilst in other cases, a distinct series of crops may be observed, each indicating the extent to which the land has been reduced by successive cropping, being in some places so poor as to be barely worth cutting.\textsuperscript{72}

These checks on production must have been highly frustrating to Nelson's arable farmers, especially when the average wheat and flour prices in Sydney (listed in Table 7.2) were simultaneously so high. Admittedly, Nelson's wheat price in 1855 of 12s. 3d. per bushel was well below the Sydney level, but, as Figure 7.2
shows, it was still more than double what it had been in 1850. In such circumstances, it can be assumed that Nelson’s agriculturists would have been desperate to find a means of boosting productivity, which did not entail a corresponding increase in labour. Presumably guano was seen as a solution to this quandary. As Table 7.4 reveals, nutrient concentrations in Peruvian guano were 20-100 times higher than they were in dung, which meant that manuring with

Table 7.4: Peruvian guano composition versus dung

<table>
<thead>
<tr>
<th></th>
<th>N content (average %)</th>
<th>Relative to guano</th>
<th>P₂O₅ content (average %)</th>
<th>Relative to guano</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peruvian guano</td>
<td>14.4</td>
<td>12.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horse dung</td>
<td>0.56</td>
<td>1 : 26</td>
<td>0.35</td>
<td>1 : 35</td>
</tr>
<tr>
<td>Cow dung</td>
<td>0.44</td>
<td>1 : 33</td>
<td>0.12</td>
<td>1 : 100</td>
</tr>
<tr>
<td>Sheep dung</td>
<td>0.72</td>
<td>1 : 20</td>
<td>0.44</td>
<td>1 : 27</td>
</tr>
</tbody>
</table>

guano was much more labour-efficient. The high current prices for produce also meant that guano was less expensive, in relative terms, than it had been before.

Quite why Wellington agriculturists should have wanted to try guano (2 tons were imported from Melbourne in May 1855) is less clear. In the late 1840s, as Chapter Six related, much of the investment in Wellington farming had been moving from cropping into pastoralism on account of the greater security of returns. Barring a one-off surge in potato cultivation in 1850, this trend, as seen in Table 7.5 below, continued unabated during the early 1850s. Admittedly, the increased produce prices induced by the Victorian gold rush, which saw wheat fetch 14s. per bushel in 1855 (see Figure 7.2), prompted the area sown in wheat in the vicinity of Wellington to almost double between 1850 and 1852, but by 1854 it had dropped back to less than half the 1850 figure. Even within the boundaries of the new Province, which encompassed both the Wellington and Wanganui settlements, together with the newly settled areas of Rangitikei, Turakina, Wairarapa, and Hawkes Bay, the combined wheat acreage in 1854 was less than that of Wellington district in 1852. The most likely cause for this decline was that the region’s agriculturists suffered from the same scarcity of labour which had beset their Nelson counterparts.
Table 7.5: Acreage of crops cultivated by Pakeha at Wellington 1850-4\textsuperscript{76}

a) Wellington and Hutt Valley only

<table>
<thead>
<tr>
<th>Year Sown</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>423</td>
<td>235</td>
<td>47</td>
<td>783</td>
<td>2627</td>
<td>327</td>
<td>4436</td>
</tr>
<tr>
<td>1851</td>
<td>618</td>
<td>155</td>
<td>55</td>
<td>205</td>
<td>2987</td>
<td>n. s.</td>
<td>n. s.</td>
</tr>
<tr>
<td>1852</td>
<td>707</td>
<td>231</td>
<td>88</td>
<td>326</td>
<td>3247</td>
<td>n. s.</td>
<td>n. s.</td>
</tr>
<tr>
<td>1854</td>
<td>203</td>
<td>295</td>
<td>40</td>
<td>369</td>
<td>6609</td>
<td>574</td>
<td>8090</td>
</tr>
</tbody>
</table>

b) Wellington Provincial area (Wellington and Wanganui (Petre) 1850-1)

<table>
<thead>
<tr>
<th>Year Sown</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>437</td>
<td>299</td>
<td>89</td>
<td>26</td>
<td>2685</td>
<td>329</td>
<td>4584</td>
</tr>
<tr>
<td>1851</td>
<td>736</td>
<td>244</td>
<td>105</td>
<td>257</td>
<td>n. s.</td>
<td>n. s.</td>
<td>n. s.</td>
</tr>
<tr>
<td>1854</td>
<td>572</td>
<td>727</td>
<td>61</td>
<td>543</td>
<td>803</td>
<td>689</td>
<td>10,530</td>
</tr>
</tbody>
</table>

(n.s) = not specified

In comparison, the area of sown grass within the new provincial boundaries grew threefold over the same 1850-4 period. Moreover, this expansion in sown grass cannot be accounted for solely by the inclusion of the new, more pastoral, districts. Even in the Hutt Valley, the initial agricultural core of the Wellington settlement, wheat accounted for only 184 acres in 1854, while 2645 acres were in sown grass.\textsuperscript{78} As Figure 7.3 reveals, there was now a definite contrast between farming at Nelson and Wellington - at the former cereals made up more than half the area in cultivation, whereas at the latter they made up only a quarter of it. This enabled Wellington farmers to keep plenty of livestock, and in turn produce plenty of dung, which could be applied to the arable fields. Winsome Shepherd has recorded that there were ample supplies of manure, and also that nightmen-gardeners, such as Henry Wouoldom, supplemented the supply during the 1850s by mixing night-soil with soot and ashes, to create a product sometimes called 'native guano'.\textsuperscript{79} There was, moreover, no shortage of pasture that could be broken up for cropping purposes (with the ploughed-in sward serving as a valuable source of added organic nutrient).

If Wellington farmers had wanted a phosphate fertiliser, importing guano would not have made much sense either. By early 1855 the continuing expansion of the pastoral frontier, aided by the Ahuriri (Hawkes Bay) and Wairarapa purchases by Donald McLean,\textsuperscript{80} had enabled the sheep and cattle levels to reach
Figure 7.3
Changes in area under crop in Nelson and Wellington, 1850-61.

Sources: *Nelson Examiner*, 1 February 1851, p. 2 & 31 March 1855, p. 2; *Wellington Independent*, 29 September 1855 (Supplement), p. 2; *Statistics of New Zealand for 1858*, Table 75; *Statistics of New Zealand for 1861*, Table 49.

As seen in these proportional pie graphs (in which the area of the pie grows in proportion to the cultivated area), intensive pastoralism became more and more dominant in both Nelson and Wellington during the 1850s. Nevertheless, pastoral farming was far more important in Wellington, and even in 1850 sown grass formed a higher proportion of the area under total crop there than it did in Nelson in 1861.

The respective total sown acreages are:

<table>
<thead>
<tr>
<th>Province</th>
<th>Year</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelson</td>
<td>1850</td>
<td>2904 ac</td>
</tr>
<tr>
<td></td>
<td>1858</td>
<td>17997 ac</td>
</tr>
<tr>
<td></td>
<td>1854</td>
<td>1861</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9434 ac</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22934 ac</td>
</tr>
<tr>
<td>Wellington</td>
<td>1850</td>
<td>4584 ac</td>
</tr>
<tr>
<td></td>
<td>1858</td>
<td>26024 ac</td>
</tr>
<tr>
<td></td>
<td>1854</td>
<td>1861</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10531 ac</td>
</tr>
<tr>
<td></td>
<td></td>
<td>55313 ac</td>
</tr>
</tbody>
</table>

It should be noted that the pie graphs are not proportional between the two provinces.
Figure 7.3

Crop Areas in Nelson by Years

Crop Areas in Wellington by Years
193,701 and 18,400 respectively. In the absence of refrigeration, most carcasses were largely wasted, but bones were one component which could be salvaged from them. Consequently, from 1852 at least, bones began being shipped from Wellington to Great Britain, and by 1860 a consignment of bones was regarded as being a fairly typical part of a ‘home’-bound cargo. Wellington was also a trans-shipment port, as on at least one occasion bones were sent to it from Lyttelton. Given the twentieth century dependence of New Zealand farming on Nauru phosphate, it is ironic that New Zealand's first entry into the global fertiliser economy was as a phosphate producer.

In addition, the intellectual climate in Wellington was unlikely to have promulgated guano use. In general Wellington's settlers showed a high level of apathy towards 'agricultural improvement', and accordingly there was no successor organisation to the long-lapsed Port Nicholson Agricultural Society until the Farmers' Club was formed in 1857. The Provincial Council's decision to collect agricultural statistics only in the triennial provincial census, is equally symptomatic of this intellectual neglect. As seen from the March 1855 census questionnaire, reproduced in Figure 7.4, even then only acreages were recorded.

Such indifference probably reflected the movement of the focal point of agriculture in Wellington Province away from Wellington itself. The agricultural district advancing most rapidly was Wanganui, where settlers were making up for lost time, now that the possession of their land was made secure by the 1848 reconciliation with local Maori. By the end of 1854, more land was under cereals in Wanganui than in any other district in the province. In the second census, which recorded the crops sown in 1857, this pre-eminence was maintained, though in the meantime wheat had replaced oats as Wanganui's leading grain crop. Wanganui agriculture's rapid rise in the early 1850s was undoubtedly encouraged by the high yields being obtained there. According to one resident, swampland soils produced up to 90 bushels of oats and 20 tons of potatoes per acre, and this at a time when oats and potatoes were earning 6s. per bushel and £34 per ton respectively. Another area of agricultural development, albeit in its infancy, was the Wairarapa, where four blocks of 40 acre farms at Greytown, Masterton, Carterton, and Featherston were established under the auspices of the Small Farms' Association. As the costs of cartage to Wellington meant wheat cultivation was not viable, it was envisaged that settlers would employ a cottage farming approach, raising dairy cattle and pigs, and thereby provisioning Wellington with butter, cheese, pork, bacon, and ham. Out of 413 acres under crop (excluding sown grass) by 1857, only 149 were in wheat, which suggests that farmers did

As the form illustrates, the Census, taken on 31st March 1855, collected only acreage information. A reasonable degree of compliance was ensured by the 20s fine for failing to complete the form (see p. 2 of the Act) but there was still potential for undercounting, since, as the passage at bottom left indicates, if farmers owned more than one property, and there was no one resident at the others, crops and stock on the other property were not counted.
<table>
<thead>
<tr>
<th>NAME</th>
<th>Surname</th>
<th>Sex</th>
<th>Age Under 7 years</th>
<th>Age 8 and 21 years</th>
<th>Age 21 and 31 years</th>
<th>Age Over 31 years</th>
<th>Date of Entering the Province</th>
<th>Education at Schools supported by Government</th>
<th>Franchise At other Schools.</th>
<th>Whether Qualified to be placed on the Electoral Roll.</th>
</tr>
</thead>
</table>

Persons are requested to include only such Stock, or other property, as appertain to the establishment where the Return is filled and not alone (though belonging to the same person) at a distant farm.

<table>
<thead>
<tr>
<th>Number of acres sown in:</th>
<th>Number of Horses:</th>
</tr>
</thead>
<tbody>
<tr>
<td>in Wheat</td>
<td>Mules and Asses</td>
</tr>
<tr>
<td>in Barley</td>
<td>Cattle</td>
</tr>
<tr>
<td>in Oats</td>
<td>Sheep</td>
</tr>
<tr>
<td>in Maize</td>
<td>Goats</td>
</tr>
<tr>
<td>in Potatoes</td>
<td>Pigs</td>
</tr>
<tr>
<td>in Grains, artificially</td>
<td></td>
</tr>
<tr>
<td>in Garden or Orchard</td>
<td></td>
</tr>
<tr>
<td>in any other Crops</td>
<td></td>
</tr>
</tbody>
</table>

I, the undersigned, do hereby certify, that I have filled in the above Return, and that it is correct to the best of my knowledge and belief. 

(To be signed by the Master or Proprietor, if able to write; if not, by the Collector.)
adhere to the aforementioned strategy. As at Wanganui, the available evidence suggests that this cropland was relatively productive. In January 1860, for instance, it was reported that 12 acres of wheat destroyed by fire at Greytown probably would have yielded 50-60 bushels per acre.

In short, settlers in the Wairarapa and at Wanganui had further land at hand for development, and were enjoying good yields. It is unlikely, therefore, that the guano imported into Wellington in 1855 would have been wanted at either destination. The difficulties of transporting guano overland to either the Wairarapa, which would have required cartage over the primitive Rimutaka route, or Wanganui, to which no record of any trans-shipment has been found, also seems to rule out its use in these two areas. Therefore, the most likely recipient (or recipients) for the said guano was a Hutt Valley agriculturist or horticulturist (or a small group thereof) responding to the combination of high produce prices and high labour costs. An added stimulus to guano use in the Hutt Valley may have been the shortage, and consequential high price, of agricultural land. Since rising produce prices would have pushed the value of land up even higher, eventually farmers would have found it cheaper to renovate their own land rather than acquiring someone else's.

While the identity of the guano users in both Wellington and Nelson may remain a mystery, there is no doubt that its application never got beyond the experimentation stage at either. During the 1850s, there were only two more guano shipments into Nelson, of 3 tons in 1855 and of 22 bags in 1857, and one more into Wellington, of 3 tons in 1857. Even if application rates had only been 2 cwt per acre, which was low by English standards, these three ton shipments would only have enabled its use on 0.4% and 2% of the cultivated area in crop in Nelson and Wellington respectively.

Almost certainly the reason that demand for guano never got established was the fall in arable produce prices from 1856 onwards, shown in Figure 7.2, which resulted from the substantial expansion of crop production in Australia. In Nelson, the average price per bushel of wheat dropped a full third in 1856, falling to below 8s., although in Wellington the price was more robust, and it only dropped to this level in 1858. In addition, a hike in the price of Peruvian guano towards the end of 1857 probably extinguished any residual demand. If New Zealand experienced the same £3 per ton rise which occurred in Great Britain, then, given that the first Nelson import sold for £12 per ton, it may be inferred that Peruvian guano would have cost around £15 per ton from 1858. If a mid-range application rate for cereals and turnips of 3 cwt. per acre is then assumed,
the post-1857 material cost of using guano would have been about 40s. per acre. Agriculturists might have sustained this expense while produce prices were high, but by 1858 increased wheat production of 5 bushels per acre, which equated to a 20% yield increase at Nelson, would have been required just to break even. To look at it in another way, the annual salary for labourers, excluding food and board, ranged from £30 to £50.\textsuperscript{99} Hence, from 1858, the labour cost per acre for a whole year on a typical 50-acre farm, assuming food and board was about equal in value to wages, was about the same as cost of applying guano per acre. Uncertainty of supply may also have discouraged guano use. Nelson or Wellington farmers could only access Peruvian guano through Australia, and as Australian farmers were currently putting much more effort into cropping, it is likely that demand there swallowed up all that was being supplied. Presumably, Australian-sourced phosphatic guano got snapped up as well - had it not been, this cheap alternative to Peruvian guano might have enabled Nelson and Wellington farmers to continue using some form of guano after the mid-1850s.

The effects of the lower prices for arable produce were far wider than a halt to guano use, however. As Table 7.6 shows, in 1856, Nelson farmers again increased the acreage sown in wheat and potatoes, but this was probably in a bid to shore up income by producing a larger crop, and by 1858 the corresponding

\textbf{Table 7.6: Acreage of crops cultivated by Pakeha at Nelson and Wellington 1854-61.}\textsuperscript{100}

\begin{tabular}{|c|c|c|c|c|c|c|c|}
\hline
Year & Sown & Wheat & Barley & Oats & Potatoes & Grass & Other & Total \\
\hline
1855 & 3379 & 777 & 1626 & 758 & 4305 & 1323 & 12,168 \\
1856 & 3831 & 1176 & 1334 & 826 & 5042 & 1660 & 13,870 \\
1858 & 3084 & 1709 & 2486 & 637 & 8011 & 2070 & 17,997 \\
1861 & 4395 & 1126 & 1860 & 517 & 12,156 & 2879 & 22,934 \\
\hline
\end{tabular}

\begin{tabular}{|c|c|c|c|c|c|c|c|}
\hline
Year & Sown & Wheat & Barley & Oats & Potatoes & Grass & Other & Total \\
\hline
1854 & 572 & 61 & 727 & 543 & 8031 & 689 & 10,530 \\
1857 & 952 & 96 & 748 & 699 & 16,674 & 974 & 20,142 \\
1858 & 1128 & 177 & 1397 & 702 & 21,580 & 1040 & 26,024 \\
1861 & 2285 & 219 & 1385 & 762 & 49,143 & 1518 & 55,313 \\
\hline
\end{tabular}
acreages had fallen away. As sheep values were much more stable, farmers increasingly, as seen in Figure 7.3(a), began opting for the safer returns of intensive pastoralism. Indeed, the area in sown pasture almost doubled between 1855 and 1858. Admittedly, the area in oats in Nelson also rose sharply, although this was probably owing to the proportionate increase in horse population. In Wellington Province, meanwhile, the area in cereals and potatoes continued to grow, but most of this growth, as described previously, occurred on the incipient agricultural frontiers at Wanganui and in the Wairarapa. In contrast, the sown grass acreage almost trebled between 1854 and 1858. Hence, as Figure 7.3(b) illustrates, Wellington's farmers had responded to the lower crop prices by making it more pastoral than ever.

In Nelson at least, it appears that the reduced cultivation of nitrogen-hungry potatoes and wheat was coupled with less attention to manuring. Quite simply, there was little point in maintaining farm output at near maximum when prices were low. This behaviour obviously put soil fertility at risk, which some observers were at pains to point out. Early in 1858, for instance, the Nelson Examiner noted that whereas most crops on farms where "a wiser system" had been pursued looked promising,

the system of farming pursued by many of the smaller cultivators, of taking all they can off the land, and giving it back little or nothing in return, has, in the absence of anything like adequate tillage, so impoverished their farms, that we cannot wonder at the wretched appearance which some of their crops now present. Likewise, an article written by its Motueka correspondent, despaired at the fact that "many of the farms throughout the province" were at present in an "impoverished condition" owing to the disregard of the manure heap; it then went on to state that the "greatest profits" could only be obtained through

a due observance of the sound principles of agriculture, [which ] cannot be done without manure ... and as manure cannot be had without stock, the economical management of the latter, with a view to the production of the largest quantity of the former, would necessitate such a system of annual rotation, house feeding, &c.
This criticism of farming practices, together with an upturn in produce prices in 1859,\textsuperscript{105} seems to have prompted a revival of interest in agricultural education, as demonstrated by a number of instructive articles in the *Nelson Examiner*,\textsuperscript{106} and yet another resurrection of the Nelson Agricultural Association.\textsuperscript{107} In addition, Nelson farmers re-entered the market for fertilisers in 1860, with 10 bags of bone-dust being imported from Sydney. Two years later, guano reappeared in Nelson too, no doubt in response to an expectation that the new gold-rushes in Otago would bring about similar inflation in produce prices to those experienced during the Victorian gold-rush.\textsuperscript{108}

The early 1860s were not, however, boom times for Nelson agriculture. As will be discussed more fully in Chapters Eight and Ten, the anticipated high prices for produce failed to eventuate. In any case, Nelson’s position of agricultural pre-eminence had by this time been supplanted by the new granary provinces of Canterbury and Otago. Whereas Nelson by the end of 1861 had 4395 acres under wheat, it was being grown in Canterbury and Otago on 12,785 and 4,928 acres respectively. Furthermore, arable farming forged ahead in Canterbury and Otago during the next two decades, with the area under wheat in both increasing by almost 20-fold, but no such increase occurred in Nelson. Instead, the extent of wheat cultivation in 1861 did not recur until the late 1880s.\textsuperscript{109}

Unfortunately, a continuing high level of newspaper indifference makes it difficult to assess the state of agriculture in Wellington at this time, though certainly cereal cultivation was not a priority. When, for example, the *Wellington Independent* noted in January 1860 that a "very considerable breadth" of grain had been sown along the 'West coast' [that is, between Kapiti and Wanganui], it stated that it was invariably sown with grass, with the grain crop's sole purpose being to cover pasture establishment expenses.\textsuperscript{110} As at Nelson, wheat cultivation went into a period of decline after 1861, and it was not until the late 1870s that the acreage reached this level again.\textsuperscript{111} Such was the contemporary emphasis on pastoralism, that both the Wellington Farmers' Club, established, as noted previously, in 1857, and the Pastoral and Agricultural Society, founded in 1861, seem to have had livestock improvement as their primary interest.\textsuperscript{112} Since pastoral farming is more or less self-sufficient in terms of soil fertility, and arable farming was at such a low ebb, there was unlikely to be much need for 'artificial fertilisers' during this period, although having said this, two small consignments of

\textit{...}
guano were delivered to Wellington in 1862. Presumably these imports were prompted by expectations of higher produce prices following the start of the Otago's gold-rushes. It can be inferred, however, that demand did not match even this limited level of supply, as some of this guano was subsequently on-shipped to Nelson and the Wairau.113

III. Desperate remedies: agriculture in Taranaki

The New Plymouth settlement, as seen in Chapter Six, had been the great disappointment of Pakeha colonisation of New Zealand during the 1840s. Although eulogised as the ‘Garden of New Zealand’, the effects of repeated cereal cultivation in the absence of soil fertility-restoring practices helped keep its wheat yields in the 20-25 bushels per acre range, which were the lowest of the four main settlements. Worse still, any hope of boosting sheep numbers, and thereby producing more manure, was stymied by the ever increasing unwillingness of the local iwi, Te Ati Awa, to sell land which could have been used for grazing. About the only bright spot was the recent purchase of the Bell, Grey, Omata, and Tataraimaka Blocks, which provided fresh land to which the New Plymouth settlers could transfer their arable production.

Overall, the prospects looked fairly grim, but the onset of the Victorian gold-rush raised hopes of better things to come. Certainly, it spurred on the development of the new Blocks referred to above, which were added to by two further purchases in 1853-4.114 As Table 7.7 shows, between 1850 and 1853, the area in cultivation more than doubled. Although wheat was the leading crop by

Table 7.7: Acreage of crops cultivated by Pakeha at Taranaki 1850-8.115

<table>
<thead>
<tr>
<th>Year Sown</th>
<th>Wheat</th>
<th>Barley</th>
<th>Oats</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>846</td>
<td>202</td>
<td>153</td>
<td>263</td>
<td>1182</td>
<td>196</td>
<td>2842</td>
</tr>
<tr>
<td>1851</td>
<td>1175</td>
<td>86</td>
<td>289</td>
<td>185</td>
<td>1835</td>
<td>n. s.</td>
<td>n. s.</td>
</tr>
<tr>
<td>1852</td>
<td>918</td>
<td>102</td>
<td>287</td>
<td>197</td>
<td>3311</td>
<td>n. s.</td>
<td>n. s.</td>
</tr>
<tr>
<td>1853</td>
<td>525</td>
<td>44</td>
<td>467</td>
<td>268</td>
<td>4582</td>
<td>215</td>
<td>6101</td>
</tr>
<tr>
<td>1854</td>
<td>660</td>
<td>31</td>
<td>423</td>
<td>255</td>
<td>6110</td>
<td>321</td>
<td>7800</td>
</tr>
<tr>
<td>1855</td>
<td>714</td>
<td>23</td>
<td>364</td>
<td>585</td>
<td>7505</td>
<td>412</td>
<td>9603</td>
</tr>
<tr>
<td>1856</td>
<td>864</td>
<td>123</td>
<td>267</td>
<td>384</td>
<td>7268</td>
<td>566</td>
<td>9473</td>
</tr>
<tr>
<td>1858</td>
<td>764</td>
<td>135</td>
<td>481</td>
<td>483</td>
<td>9724</td>
<td>569</td>
<td>12,156</td>
</tr>
</tbody>
</table>
area in 1850, and its price at New Plymouth rose, as depicted in Figure 7.2, from 4s. to 7s. 6d. per bushel over the years concerned,116 most of this growth was accounted for by an almost four-fold increase in the area under sown pasture. Evidently, this was caused by mixed farms moving away from cereal cropping rather than an explosion of intensive pastoral farms, as individual returns collected in 1852 showed that the growing of crops or pasture exclusively was fairly rare.117 The area in wheat had, in fact, showed strong growth only in 1851, as thereafter the yield-depressing effects of wet weather, smut, and exhausted soil in older farming areas, together with high labour costs, dampened enthusiasm for growing wheat to such an extent that in 1853 the acreage sown was the smallest since 1844.118 In the ensuing harvest, moreover, this wheat crop yielded only 17 bushels per acre.

The recurrent failure of Taranaki's wheat crop proved a stimulus for intellectual enquiry, in the same way that low initial crop yields on 'fern land' had been in the various settlements in the 1840s. A number of explanations (and potential remedies) for these failures, over and above bad weather and fungal disease, were proffered by various correspondents to the Taranaki Herald during 1852. These included the soil being deficient in magnesium phosphate, insufficient exposure of the subsoil by deep ploughing, the absence of a green crop from courses of cropping, and carelessness when sowing.120 The need for more productive agriculture also exercised minds at the Taranaki Agricultural Association, which had been revived at the beginning of the year.121 Unfortunately, the Association's deliberations on how to improve yields were not very fruitful, as the first annual report records that there had been "much difference of opinion" with respect to crop rotations and the timing of wheat sowing. More consensus was achieved when it came to manures, with the members concluding that straw-litter from the yard mixed with sea-sand performed best. Ultimately, the Association was unsuccessful in tackling the problem of inferior wheat crops, as it decided that a chemical analysis of the soil, and a microscopic analysis of diseased plant matter were needed before definitive explanations could be reached.122 Not surprisingly these analyses were never carried out by the Association, as, like its many earlier counterparts, it quickly fell by the wayside.123 Nevertheless, the mere inclusion of both manures and crop
rotation in the Association's 'discussion programme' indicates that the more innovative farmers were more concerned about soil fertility than they had been a decade earlier.

It was not until 1854 that Taranaki's farmers determined to take practical action to improve yields. Apart from the intellectual impetus, high prices for produce were also a factor. The price of wheat, which was 7s. 4d. per bushel in 1853, climbed to 12s. 6d. by 1855, while a ton of potatoes, rather than being worth £3-£4, had by 1855 climbed in value to as much as £10.124 Not surprisingly, Taranaki's farmers again extended the area under wheat in 1854, although they were more cautious with oats and potatoes, and the acreages of both stayed similar to their 1853 levels. The crop which exhibited the greatest relative growth, however, was the turnip. This is significant in that it indicates the increasing adoption of a more soil fertility-conscious cropping regime, since turnips were used as a stock feed, which meant, in turn, the production of hitherto scarce quantities of animal manure. Whereas in 1853 turnip cultivation accounted for only 88 acres, in 1854 it rose to 202 acres (about one-third of the area under wheat).125 Anecdotal evidence also supports the idea that manuring was now regarded as a critical part of farm management. The farmer George Jupp, who arrived in Taranaki in 1851, made no mention of manuring in his daily diary entries in 1852 or 1853, but he devoted six days to it in both 1854 and 1855.126

Aided by favourable weather, the wheat sown in 1854 produced a better harvest yield of 23 bushels per acre.127 In combination with the current high price, this prompted a further small rise in the wheat acreage in 1855. Conversely, the yield of the potato crop, of just over 7 tons per acre,128 was almost unchanged from 1853, but settlers still planted out more than double the area previously. While the high price undoubtedly played a large part in this expansion, it is possible that by growing potatoes settlers were also taking advantage of the extra manure procured through the turnip cultivation of the previous year. However, as growing potatoes is relatively labour-intensive, requiring dunging, earthing up, and inter-row hoeing,129 it appears that some other farm crops had less time available to be spent on them. Turnips seem to have been in this category, as the area in turnips dropped back in 1855 to 128 acres.130 Having said this, it seems that settlers still wanted to maximise their animal manure output, so the answer was to manure the turnips as well. This, presumably, was part of the rationale behind New Plymouth's first import of guano (from Sydney), which took place in October 1855. Unfortunately, the quantity cannot be readily determined, as it consisted of 22 bags,131 but it is known that some of it was applied, in
combination with 'short' (fresh) manure, by George Tate to his Swedish turnips (swedes). In line with current English convention, Tate applied 3 and 4 cwt. per acre, and reported that the field given 4 cwt. produced 49 tons per acre, which was double the Taranaki average, and that given 3 cwt. only slightly less. The land given no guano, meanwhile, produced "no crop". In conclusion, Tate stated that "this valuable manure saves labour, is easy of management, and is certain in its result". While not disputing this conclusion, P. Elliot replied by stating that folding sheep was a more convenient way of manuring the turnip-field, and that his Swedish turnips had yielded a still better 52 tons 14 cwt. per acre.

Whether all this effort was worthwhile is debatable, as during 1856 the surge in crop production in Australia described above sent prices at New Plymouth into a dive, shown in Figure 7.2. The 7s.6d. per bushel wheat fetched in 1857 was the same as its value in 1852. Potato exports, meanwhile, came to a complete halt, and in consequence the price immediately fell back to the pre-gold rush price of £2-£3 per ton. This had a disastrous effect on the New Plymouth economy, the extent of which is best illustrated by the collapse in value of overseas exports. In 1855, these were worth £20,980, or more than 80% of the value of the coastal and export trade combined, but the following year they were worth a mere £3720. Ironically, the potato crop sown in 1855 was a reasonable success, with the average yield again about 7 tons per acre, despite the large increase in acreage. Wheat, however, performed more poorly, with the yield falling away to 18 bushels per acre. The cruellest twist of fate, however, was that many farmers, in concentrating on their potato and wheat fields, had allowed the quality of their pasture to deteriorate, so that it succumbed to second growth forest and bracken, and to infestation by weeds, such as the Scotch thistle. The settlers of New Plymouth, therefore, had not only been thrust into an economic depression, but were in a position where neither the arable or pastoral sectors seemed well positioned to bring about a recovery.

The response of arable farmers was to substitute potato cultivation with wheat during 1856. Wheat was favoured because its price had not fallen so precipitously, and, being more readily stored than potatoes, it could be held on to in the hope of upturns in the market. With less potato cultivation going on, and lower crop prices generally, it would seem that the increased emphasis on manuring evident in 1855 faded away. George Jupp's diary, for instance, records that he spent in total only two days manuring during the three years 1856-8, while at a macro-scale, there were no guano imports in 1856, one (of 18 bags) in
1857, and one (of 2 tons) in 1858. Both guano shipments, incidentally, were not from Australia, but were instead ex-Auckland.141

More significantly, the farmers in the region also switched their economic focus to intensive pastoralism, with wool and livestock sales providing most of the settlement's external revenue during the late 1850s. It should be noted, however, that intensive pastoralism no longer meant simply rearing sheep. Thanks to a growing trade in supplying fat stock to Auckland, and the increasing popularity of dairying, rearing cattle now became the more profitable option.142

This was clearly reflected in the provincial census returns, in which cattle numbers rose from 2143 in June 1855 to 4052 in December 1858. At the same time, the area under sown pasture began climbing again. Sheep numbers, however, stagnated at around their 1855 level of 14,846.143 Undoubtedly, rearing cattle was more suited to Taranaki's wet climate, and cattle also had an advantage over sheep of being able to find food from the bush and deteriorated pasture.144 The tendency of cattle to roam around finding sustenance was a doubled-edged sword though, as it made concentrating or collecting their dung practically impossible. This may explain, in part, the neglect of manuring during this period.

In 1858, however, arable farming starting showing signs of a recovery. The price of wheat rose again to as much as 8s.6d. per bushel in 1858, and 12s. per bushel in 1859, and by 1858 potatoes were earning £5 per ton.145 Although a similar rise occurred in other settlements, the prospects of Taranaki's agriculturists were further enhanced by the distraction of Te Ati Awa, previously strong agricultural competitors, because of internal feuding over land sales to Pakeha.146 Despite the warnings of the Taranaki Herald that farmers ought not to depend too much on potatoes "as heretofore" they had been "an uncertain crop as regards value",147 the area in potatoes rose by around 30%. As an examination of Figure 7.5 reveals, however, this increase was only in proportion to that of sown pasture over the 1856 to 1858 period.

The recovery also prompted a new flush of enthusiasm for both the practical and theoretical sides of agricultural chemistry. Naturally, a return to better prices saw farmers wanting to raise productivity, and given that no more agricultural land was likely to be purchased from Te Ati Awa, it was up to farmers to improve what they had already. Unfortunately, the 1858 census does not include a figure for turnip acreage,148 so there is no way of knowing how many farmers were practising rotations, but it can be said that during 1859 there was a rejuvenated market for 'artificial' fertilisers, if inward shipping records and advertisements are any indication. Two shipments of guano (one of 7 bags from Auckland, and
Changes in area under crop in Taranaki, 1850-8.


The striking feature in the plot of Taranaki crop acreages during the 1850s is how decisive the move away from growing wheat in the early 1850s was. After this time, field crops varied according to reigning prices but always stayed at around one-quarter of the area under crop.

The respective total sown acreages are:

<table>
<thead>
<tr>
<th>Year</th>
<th>Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>2842 ac</td>
</tr>
<tr>
<td>1853</td>
<td>6101 ac</td>
</tr>
<tr>
<td>1856</td>
<td>9473 ac</td>
</tr>
<tr>
<td>1858</td>
<td>12156 ac</td>
</tr>
</tbody>
</table>
Crop Areas in Taranaki by Years

1850
- Wheat: 77%
- Oats: 9%
- Potatoes: 3%
- Grass: 14%
- Other: 1%

1853
- Wheat: 80%
- Oats: 6%
- Potatoes: 6%
- Grass: 9%
- Other: 4%

1856
- Wheat: 75%
- Oats: 8%
- Potatoes: 4%
- Grass: 30%
- Other: 5%

1858
- Wheat: 9%
- Oats: 4%
- Potatoes: 6%
- Grass: 4%
- Other: 2%
subsequently 22 bags from Sydney) were recorded, while at the same time bone-
dust, "available in any quantity", was being advertised for sale by S. Ford. Presumably the latter was brought in from elsewhere as general cargo, as a comment by William Grayling (see below) indicates that no bone-mill existed in Taranaki at this time. Given the nature of Ford's offer, it could be presumed that demand was not insignificant, and equally, that it would be a continuing one. Interestingly, another of Ford's advertisements explicitly referred to the agricultural use of lime, stating that it was "suitable for wheat land".

As far as theoretical interest in agricultural chemistry was concerned, the main feature was a series of eighteen letters written by William Grayling, and published in the Taranaki Herald between June and October 1859. These were complemented by lectures he gave in 1858 and 1859. Grayling stressed that although agricultural chemistry was not an "unerring guide to the agriculturist", farmers could avoid a lot of trial-and-error experimentation by having soil or plant ash analyses conducted. Grayling preferred plant ash analysis, as he was aware that not all soil nutrients were plant-available. As the analyses for wheat and European ferns were similar, Grayling argued that undecayed bracken locked up the mineral nutrients required by wheat. Soil analysis was expensive, and accordingly his letters relied almost solely on overseas examples. He did, however, advertise a soil testing service from mid-1859 onwards in both Taranaki and Auckland.

With respect to fertilising the soil, Grayling focussed his discussion on mineral nutrients. It was not, however, his intention to "throw aside the use of farm yard manure"; indeed, he declared that feeding stock on turnips "was the foundation of all good farming". Grayling was happy to see farmers using bone-dust, as he believed that Taranaki's soils were deficient in phosphates, and he complained that the absence of a local bone-mill meant bones were going to waste. He also suspected, while noting that soil testing would be needed to confirm it, that local soils were deficient in sulphur. In this case, vitriolised bones (superphosphate) would prove an even better fertiliser than bones. Grayling also subscribed to the erroneous argument that the superphosphate's gypsum component would attract ammonia to the soil. As sulphur could be obtained from White Island, he foresaw the coming of "large buildings ... set apart solely for the manufacture of artificial manures", but in the meantime, he proposed that farmers spray sulphuric acid directly onto the soil. If applied at 30 lbs. per acre, this would cost just 15s. Conversely, when it came to guano, Grayling was far less positive. In his view, crops grown using ammoniacal manures were
enfeebled, because they were unable to take up mineral nutrients at a proportionate rate. Grayling also worried about farmers' tendency to buy cheap ineffective guanos.\textsuperscript{164}

The advice Grayling was most emphatic about, however, was that farmers ought to apply lime. As well as expediting bracken decay, oxidising the noxious protoxide of iron (FeO), and destroying weeds and grubs,\textsuperscript{165} Grayling claimed that lime freed up nutrients held in the feldspars which were found in Taranaki's volcanic soil.\textsuperscript{166} In this last instance, he was employing an argument made previously by Liebig.\textsuperscript{167} Owing to the light texture of Taranaki's soils, Grayling thought that as little as 5-8 bushels per acre would be sufficient.\textsuperscript{168}

Unfortunately, the influence of Grayling's letters is impossible to determine, as the agricultural situation in Taranaki was about to be turned upside down. The cause of this upset was the coming to a head of settler anger at not being able to purchase or lease Maori land. This was best expressed by a leader in the \textit{Taranaki Herald}:

\begin{quote}
The want of runs for the flocks and herds has been more than usually forced upon our attention by the late drought ... This want we have suffered year after year with growing severity, and waited most patiently to see redressed. Such continued neglect of the pastoral interest in Taranaki is at variance with the Governor's expressed sentiments on the subject. His Excellency ... saw no objection to native lands sufficiently remote from settled districts being used under proper conditions as sheep and cattle runs. The obstruction then to our progress would seem to be offered by the Native department, but it is one notwithstanding that must be met once and for ever by the settlers themselves.\textsuperscript{169}
\end{quote}

While the \textit{Taranaki Herald}'s leader went on to anticipate that the local settlers and Te Ati Awa could come to their own amicable arrangement, the mood of the piece indicates the the situation was nearing a crisis point. That point was reached when land at Waitara, which had been sold without the consent of some of its owners, amongst them the Te Ati Awa chief, Wiremu Kingi, began being surveyed. Kingi had the survey work sabotaged, but viewing this as rebellion, Governor Gore Browne declared martial law on 22 February 1860. Thereafter hostilities commenced on 17 March 1860 when British troops seized an abandoned pa which had been built on the disputed land.\textsuperscript{170} Not surprisingly, the resulting war, which ended an uneasy truce in March 1861,\textsuperscript{171} severely damaged Taranaki agriculture. During that year, wheat and potato cultivation amounted to just 61 and 166 acres respectively.\textsuperscript{172} Further clashes occurred during 1863-4, at
the same time as hostilities were engulfing the Waikato, but by 1865 the Crown felt strong enough to confiscate Maori landholdings throughout province. Intermittent hostilities nevertheless continued in South Taranaki for some years to come. In the circumstances, it is understandable that agricultural chemistry would be the least of the settler's worries. Even Grayling, hitherto its champion, seems to have given up on agricultural chemistry for the new and more exciting field of oil exploration. Quite simply, by the time Taranaki's settlers recovered from the wars, it was clear that arable farming no longer had a major part to play in Taranaki's farming future.

IV. Bowing Out

What might be termed the 'arable farming phase' of farming history in Nelson, Wellington, and Taranaki, had now ended. So too is the contribution of these settlements to this thesis, since its object is to examine soil fertility management in relation to agriculture, rather than soil fertility management in relation to pastoral farming alone. Nonetheless, the brief flowering of agriculture and agricultural chemistry in these three provinces during the 1850s does offer valuable insights into what encouraged farmers to take soil fertility management seriously, and more particularly, what attracted them to 'artificial' fertilisers.

In regard to farmers wanting to use 'artificial' fertilisers, two factors stand out. The first is the value of farm produce. So long as the price of 'artificial' fertilisers did not rise faster than the value of farm produce, any increases in the value of that produce were likely to encourage fertiliser use. Equally, falls in produce value, such as those which occurred in the three settlements in the late 1850s, discouraged fertiliser use. Secondly, as the evidence from this chapter shows, what really spurred farmers into using 'artificial' fertilisers was high labour costs operating in conjunction with high prices for farm produce. Had labour costs been low, they could have responded to high prices just as easily by applying farmyard manure, which was bulky, but cheap. This was particularly the case in Wellington, where farmers probably had ample access to farmyard manure and unprocessed bones. Interestingly, the relative levels of intellectual activity amongst farming communities would seem to be much less important than these economic factors. Admittedly, some emulation of the 'guano mania' sweeping Great Britain and the United States at this time may explain why some farmers sought to try guano, while ignoring locally-available bones. Equally, the fact that Nelson was the first port of entry for guano was indicative of the greater
eagerness for 'agricultural improvement' amongst its farmers than those of Wellington or Taranaki. However, in subsequent years, the amounts coming into the three settlements did not greatly differ, and remained very small.

With respect to soil fertility management as a whole, agriculturists at all three settlements seem to have made considerable progress during the early 1850s towards more sustainable agricultural systems, though for differing reasons. The frustration of low yields at a time of increasing produce prices appears to have been the motivation in both Taranaki and Nelson, although only in Taranaki were the low yields induced in large part by soil exhaustion. On the other hand, in Wellington the low demands on the soil were an indirect, almost accidental, effect of the dominance of the intensive pastoral sector. As described above, 'artificial' fertilisers had been introduced into all three settlements when produce prices were at their height, but the fall in produce prices from 1856 meant that this 'opportunistic' demand did not develop to any extent. With lower economic returns on offer in the late 1850s, farmers in the three settlements generally relaxed their efforts at maintaining soil fertility, but this was countered by the shift towards intensive pastoralism. Nevertheless, at the very end of the decade, Nelson and Taranaki farmers renewed their interest in agricultural chemistry. While in Nelson this can be put down to the upturn in produce prices, the especially strong nature of the revival in Taranaki probably reflected the fact that its farmers, who were without the option of expanding on to new land, and who did not produce much manure from their pastoral operations, were eager to find alternative means for maintaining the fertility of what they had already. War cut short this agricultural revival, while the hopes of one in Nelson and Wellington were dashed when the boom in produce prices, expected in the wake of the Otago gold-rushes, failed to materialise.
Notes for Chapter Seven


very dry conditions, decomposition of the bone did not proceed either, however (Aikman, *Manures and the Principles and Manuring* 3rd ed., p. 366). This possibly explains rare reports, as in an Australian article describing English farming, that bones failed to 'answer' on sandy soils (Extract from *The Farm and Garden*, in *Taranaki Herald*, 3 December 1859 (Supplement), p. 2). But for the presence of the grease, the bones would have broken down fastest in moist conditions.


Thompson, F. M. L. 'The Second Agricultural Revolution, 1815-1880'. *Economic History Review* (2nd series) 21(1) (1968), pp. 69-70. By comparing Thompson's estimates for fertilised acreage and bone supply (Ibid., p. 75), it may be calculated that Thompson is assuming an application rate of about 0.4 tons per acre. This accords well with the account given by John Hannam, who observed that application rates of bone manure fell from around 60 bushels per acre in the 1810s to only 16 bushels per acre in 1850. Each bushel, it should be noted, weighed about 48 lbs. (which means that 16 bushels equated to about 0.35 tons). On some dairy pastures, however, Hannam noted that up to 2 tons per acre were being used (Hannam, 'Bone Manure'. In Morton (ed.), *A Cyclopededia of Agriculture*, I, pp. 273-4, 289, & 301). On occasion higher rates for arable land were still recommended though, with the Doncaster Agricultural Association suggesting that agriculturists apply 25-30 bushels per acre. The beneficial effects of this were said to last four years. As for pasture, the Doncaster Association thought 25-40 bushels appropriate, though its effects were said to last for eight years (see *Weekly Press*, 29 April 1865, p. 11).

Thompson, 'The Second Agricultural Revolution, 1815-1880'. *Economic History Review* (2nd series) 21(1) (1968), pp. 69-70. It has been estimated that one-sixth of steamed bone-dust remains unutilized after three years in arable crops (or four years in pasture). Vanstone, *Fertilizers and Manures*, pp. 24-5.

Loudon, J. C., *An Encyclopaedia of Agriculture* 7th ed. (London, 1871), p. 337. The quote given here can be dated to 1831 (the year of the first edition) because later editions continued to use the full text of the first, which was updated via the use of supplementary notes. One of the first European regions to embrace bone manuring was Saxony, where two bone-mills were established by 1838 (Jacob, 'Predecessors of Superphosphate'. In United States Department of Agriculture & Tennessee Valley Authority, *Superphosphate*, p. 10).

Liebig, Justus, *Familiar Letters on Chemistry, and its relation to commerce, physiology,*


17 During the 1850s, annual imports were about 40,000 tonnes, and during the 1860s, they were almost 70,000 tonnes. Thompson, 'The Second Agricultural Revolution. 1815-1880'. Economic History Review (2nd series) 21(1) (1968), pp. 69 & 75.

18 Ibid., 69. Liebig's commentary seems to have appeared in editions of his Chemistry in Its Application to Agriculture and Physiology from around 1860. See extracted from the North British Agriculturist, in Otago Witness, 21 March 1863, p.6. One can understand Liebig's offence at such matter-of-fact remarks as John Hannam's that it was probable that some bone imports "have once been a portion of the human frame, and have been filched from the charnel-house, or gathered from the unconsecrated burial grounds of armies - the battle fields of Europe" (Hannam, 'Bone Manure'. In Morton (ed.), A Cyclopedia of Agriculture, I, p. 272).


20 Ibid., 304-6. With respect to Peruvian guano, about one-third of the nitroglycer one-quarter of the phosphate, and all of the potassium was water soluble (and thus immediately available to the plant).


23 The concession to Gibbs and Sons was in return for loan guarantees. Jacob, Predecessors of Superphosphate'. In United States Department of Agriculture & Tennessee Valley Authority, Superphosphate, p. 12; Jordan, Weymouth T., The Peruvian Guano Gospel in the Old South'. Agricultural History 24(4) (1950), p. 214.

24 Aikman, Manures and the Principles and Manuring 3rd ed., pp. 296-7. According to J. C. Morton, Peruvian guano was applied at a rate of 2-5 cwt per acre (Morton, J. C., 'Guano'. In Morton, J. C. (ed.), A Cyclopedia of Agriculture, Practical and Scientific (Glasgow, 1855), I, p. 1015). Peruvian guano imports, meanwhile, were in the 200,000-300,000 ton range during the 1850s. Annual imports of a competing African guano peaked at 255,000 tons in 1845, but by 1847 supplies of this Ichaboe guano had run out (Mathew, 'Peru and the British Guano Market'. Economic History Review (2nd series) 23(1) (1970), pp.113-5).


26 American guano imports peaked at 176,000 tons in 1854. Jacob, 'Predecessors of Superphosphate'. In United States Department of Agriculture & Tennessee Valley


30 Mathew, 'Peru and the British Guano Market'. *Economic History Review* (2nd series) 23(1) (1970), pp. 117 & 120. It should be pointed out that some cheaper guanos, such as Saldanha Bay guano, had double the amount of phosphate, but they seem to have been far less popular than Peruvian guano, as they contained almost no nitrogen (Way, John Thomas, 'Guano', & Morton, J. C., 'Guano'. In Morton, J. C. (ed.), *A Cyclopedia of Agriculture, Practical and Scientific* (Glasgow, 1855), I, pp. 1013-4 & 1016).

31 J. C. Morton gave per acre application rates for Peruvian guano of 2-5 cwt. per acre, while another agricultural writer, J. C. Nesbit advised rates of 3-4 cwt. per acre for turnips (although up to 6 cwt. was suitable on heavy clay soils), and 2-4 cwt. per acre for wheat and grass. Morton, 'Guano'. In Morton (ed.), *A Cyclopedia of Agriculture*, I, p. 1015; Nesbit, J. C., 'On Peruvian Guano: its history, composition, and fertilizing qualities; with the best mode of its application to the soil'. *New Zealander*, 29 October 1856, p. 3.


John Hannam, writing in Morton’s *Cyclopedia of Agriculture*, gives a price per quarter of 18s, for ‘half-inch’ bones, while the price graph constructed by Mathew indicates that this price was fairly stable throughout the 1840s and early 1850s. As stated in footnote 12, a typical application rate of ‘half-inch’ bones on turnips was 16 bushels (or two quarters) per acre, which thus works out to 36s. per acre. Hannam, ‘Bone Manure’. In Morton (ed.), *A Cyclopedia of Agriculture*, I, p. 274-5; Mathew, ‘Peru and the British Guano Market’,*Economic History Review* (2nd series) 23(1) (1970), p. 120.

If we assume an application rate for Peruvian guano of 4 cwt. per acre, this equates to about 0.2 tons per acre, of which about 25% (i.e. 0.05 tons per acre) consisted of ‘earthy phosphates’ (Way, J. Thomas, ‘Guano’. In Morton (ed.), *A Cyclopedia of Agriculture*, I, p. 1012-3). ‘Earthy phosphates’ refers to calcium and magnesium phosphates (both metals being part of the ‘alkaline earths’), but for the purpose of simplicity it has been assumed that the whole 25% was composed of calcium phosphate (Ca₃(PO₄)₂). In the case of bones, 16 bushels equates to approximately 0.35 tons (see footnote 12 above). Since calcium phosphate (Ca₃(PO₄)₂) comprises about half of the mass in bones (see footnote 3 above), this means that the rate of calcium phosphate being applied was about 0.15-0.2 tons per acre.


Jacob, ‘History and Status of the Superphosphate Industry’. In United States Department of Agriculture & Tennessee Valley Authority, *Superphosphate: its history, chemistry, and

This is one of the earliest (if not the earliest) published references to superphosphate use as a fertiliser. Cochrane, Archibald, the Earl of Dundonald, *A Treatise shewing the Intimate Connection between Agriculture and Chemistry* 2nd ed. (London, 1803), p. 167. Unfortunately, it has not been possible to establish whether this statement appeared in the first edition, which was published in 1798.


Vanstone’s 1947 figures for ‘soluble phosphoric acid’ (which refer to P2O5) levels in ‘bone superphosphate’ and phosphate rock-derived superphosphate are 15-16% and 18% respectively; the ‘bone superphosphate’ also contained 2-3% nitrogen (Vanstone, *Fertilizers and Manures*, pp. 16 & 26).

About a dozen superphosphate manufacturers in Great Britain were established in Great Britain within a decade of Lawes obtaining his patent. Jacob, ‘History and Status of the Superphosphate Industry’. In United States Department of Agriculture & Tennessee Valley Authority, *Superphosphate*, pp. 28 & 30.


Although the actual amount of ‘calcic phosphate’ being applied in both cases amounts to about 1 cwt. (0.05 tons) per acre, the phosphorus accounts for 50% more of the weight in the monocalcic form (Ca(H2PO4)2) than it does in the tricalcic form (Ca3(PO4)2).

John Keen, ‘Review of the Trade in Manures and Oil-cakes during 1858’. *Farmers'
Magazine (3rd series) 15 (1859). Cited in Mathew, 'Peru and the British Guano Market'.


51 Jacob, 'History and Status of the Superphosphate Industry'. In United States Department of Agriculture & Tennessee Valley Authority, Superphosphate, pp. 30-2 & 34.

52 For a list of early United States superphosphate manufacturers, see Wines, Fertilizer in America, pp. 175-6.

53 Nelson Examiner and New Zealand Chronicle, 18 August 1855, p. 2; New Zealand Spectator and Cook's Strait Guardian, 2 June 1855, p. 3; New Zealander, 4 July 1855, p. 3; Taranaki Herald, 10 October 1855, p. 2. Contemporary remarks nevertheless suggest that it had only just begun to be used in New South Wales at this time (See extract from Sydney Morning Herald, 8 November 1855, in New Zealander, 28 November 1855, p. 3; Southern Cross, 29 March 1861, p. 3).


57 Dunsdorfs, The Australian Wheat Growing Industry, 1788-1948, p. 143 & 143n. Dunsdorfs notes that the response to the finding of phosphatic guano on Flinders Island in 1853 was a fairly muted one.
The main interest of the Melbourne office seems, however, to have been finding ships to take guano from Peru to Great Britain. Mathew, W. M., *The House of Gibbs and the Peruvian Guano Monopoly* (London, 1981), p. 120.


*Statistics of New Zealand for 1853, 1854, 1855, and 1856, compiled from official records* (Auckland, 1858), Table 28 [unpaginated]. The approximate tonnage was calculated using the definition of a hogshead as a volume measure containing 50 imperial gallons (Sykes, J. B. (ed.), *Concise Oxford Dictionary of Current English* 7th ed. (Oxford, 1982), p. 474), together with the specific gravity (1.5-1.7 (c.f. 1.0 for water) of Peruvian guano (Way, John Thomas, 'Guano'. In Morton (ed.), *A Cyclopedia of Agriculture*, 1, p. 1014).

*Nelson Examiner*, 1 February 1851, p. 2, 28 February 1852, p. 3, 26 February 1853, pp. 2-3, 31 March 1855, p. 2, 19 April 1856, p. 2; *Statistics of New Zealand for 1853, 1854, 1855, and 1856, Table 52.*


*Nelson Examiner*, 26 February 1853, p. 2. Given his earlier contribution to the *Lyttelton Times* ('[William, I[rvin, G[rayling]',' On the Capabilities and Natural Productions of the Middle Island of New Zealand. Lyttelton Times*, 28 August 1852, p. 5), it is reasonable to assume that Grayling's 'hints concerned' the use of lime to free up mineral and organic nutrients.

Extract from *Journal of Agriculture*, in *Nelson Examiner*, 28 May 1853, p. 4. The article in question seems to have gone through several reincarnations. The *Journal of Agriculture* had taken it from Chambers' *Emigrant's Manual*, though this in turn seems to have derived it from various New Zealand sources; the first quotation for instance, is taken from Hursthouse's *Account of the Settlement of New Plymouth* (see Hursthouse, Charles, *An Account of the Settlement of New Plymouth* [1849] (Christchurch, 1975), pp. 92-3). After the *Journal of Agriculture* reprinted it, it also reappeared, with editorial comment added, in the *Otago Journal* under the title, 'The Value of Lime in New Zealand Husbandry' (*Otago Journal* 8 (August 1852), pp. 117-8).

Ibid., 20 May 1854, p. 2.

Extract from *Nelson Examiner*, [3 December 1854 ?]. Fitton, Edward Brown, *New Zealand:

Attempts to locate this extract has not succeeded so possibly, Fitton used the incorrect date, or took the item from a newspaper reporting on news in the Nelson Examiner.

69 Nelson Examiner, 8 August 1855, p. 2.


71 During November 1855, the fine condition the crops were in led to anticipation that maximum yields could be as high as 55 bushels of wheat per acre. Nelson Examiner, 14 November 1855, p. 2.

72 Ibid., 26 December 1855, p. 2.

73 Jacob, 'Predecessors of Superphosphate'. In United States Department of Agriculture & Tennessee Valley Authority, Superphosphate, p. 12n; Fream, Elements of Agriculture 9th ed., p. 108. Soil scientists use P2O5, which is described as 'phosphoric acid', to compare phosphate levels in different phosphate compounds. Chemists it should be noted, use phosphoric acid when referring to H3PO4. The two are related by the equation 1.5 H2O + 0.5 P2O5 = H3PO4.

74 New Zealand Spectator and Cook's Strait Guardian, 2 June 1855, p. 3.

75 According to the official returns, the area sown in potatoes at Wellington during 1850 was 783 acres, whereas the equivalent figures in 1849 and 1851 were 208 and 265 acres respectively (Statistics of New Zealand for the Crown Colony period, 1840-1852, p. 40). This might make it seem suspicious, though the fact that it is confirmed in both the New Zealand Government Gazette (New Zealand Government Gazette (Province of New Munster), 4(23) (6 September 1851), p. 144) and in a retrospective newspaper comparison (where, it should be noted, the figures for Wanganui and Wellington have been combined) (Wellington Independent, 10 October 1855 (Supplement), p. 2) suggests that this statistic is not an erroneous one. In light of this, the most likely explanation is that Wellington's agriculturists, like those of Auckland, intended to supply potatoes to the Californian goldfields (See New Zealander, 18 March 1854, p. 2).

76 Statistics of New Zealand for the Crown Colony period, 1840-1852, pp. 38 & 40; Wellington Independent, 29 September 1855 (Supplement), p. 2. It should be noted that in the official returns, the figures given for 1855 (Statistics of New Zealand for 1853, 1854, 1855, and 1856, Table 52) should, following the practice used with other entries, have been entered under 1854, since the census was taken on 31 March 1855.

77 Fitton notes that the want of labourers was severe enough for the Wellington Provincial Council to start offering inducements to attract more of them. Fitton, New Zealand: Its Present Condition, Prospects and Resources, p. 92.
78 Wellington Independent, 29 September 1855 (Supplement), p. 2.
81 Wellington Independent, 10 October 1855 (Supplement), p. 2.
82 New Zealand Government Gazette (Province of New Munster), 5(17) (29 July 1852), p. 112; Statistics of New Zealand for 1853, 1854, 1855, and 1856, Table 25; Wellington Independent, 2 March 1860, p. 3.
84 New Zealand Spectator and Cook’s Strait Guardian, 14 March 1857, pp. 2-5. That no similar organisation existed in the interim is borne out by Dr. Curl’s comment at the Club’s second ever meeting that “an Agricultural Society was once tried here and did not prosper”. Interestingly, Dr. Curl, one of the initiators of the new Club pointed to the fact that the lack of collective discussion of agricultural matters during this period had led to many new settlers being given conflicting advice (Dr. Curl’s address to Wellington Farmers’ Club, 4 March 1857. Cited in Wellington Independent, 17 June 1857, p. 3).
85 Wellington Provincial Council, Acts of the Provincial Council of Wellington 1854-5 - Session II (Wellington Provincial Council, Wellington, 1855), No. 4. ‘An Act for taking a Census of the Province of Wellington’, p. 1. The last set of figures for average yields during this period for Wellington (not including Wanganui) was for the crops sown in 1851. Of these wheat averaged 30 bushels, and potatoes 8 tons, per acre (Statistics of New Zealand for the Crown Colony period, 1840-1852, p. 42). According to comments made in 1854, the following year’s crops gave similar yields, though those sown in 1853 were somewhat reduced, at least as regards cereals, due to the dry weather (New Zealand Spectator and Cook’s Strait Guardian, 11 January 1854, p. 4).
86 At the end of 1854 the wheat and oats acreages at Wanganui were 193 and 349 acres, while at the end of 1857 they were 325 and 236 acres respectively. Wellington Independent, 29 September 1855 (Supplement), p. 2; Wellington Provincial Gazette, 8 Nov 1858 (Appendix).
89 ‘Progress’ to the Ed. Wellington Independent, 18 January 1854 (Supplement), p. 2; Wellington Independent, 12 August 1859, p. 3.
Wellington Provincial Gazette, 8 Nov 1858 (Appendix). A comment, in a 'state of the province' review in January 1857, that the Small Farm settlers were devoting too much attention to raising cattle and not enough to cultivation, is further evidence that they were indeed practising mixed farming (Wellington Independent, 3 January 1857 (Supplement), p. 1). In a later set of statistics, from individual farms in the Carterton area, the wheat acreage was double that in sown grass, but it should be noted that it was only the second year of cultivation there, and it is likely that settlers would grow potatoes and/or wheat prior to sowing grass (See John Ashmore to the Ed. Wellington Independent, 16 November 1860, p. 3).

Wellington Independent, 24 January 1860, 3. John Ashmore expected the wheat sown in Carterton in 1860 to realise 30 bushels per acre (John Ashmore to the Ed. Ibid., 16 November 1860, p. 3).

In April 1855, the Wellington Independent reported during the next summer the 'Remutaka' road would be completed to a standard where a dray could pass. Wellington Independent, 21 April 1855, p. 3.


Nelson Examiner, 18 August 1855, p. 2; & 28 Oct 1857, 2; Wellington Independent, 19 September 1857, p. 2. An advertisement subsequent to the 1857 shipment at Nelson refers to the delivery of a "few Tons" of guano (see Nelson Examiner, 2 January 1858, p. 4).

It was assumed in both cases that the 3 tons could have been applied to 30 acres of crop land. Cf. total acreages recorded in Nelson Examiner, 19 April 1856, p. 2; Wellington Provincial Gazette, 8 Nov 1858 (Appendix).


Extract from Melbourne Argus, in New Zealander, 27 March 1858, p. 2.

The 1.8 tons imported in 1854 were valued at £22. Statistics of New Zealand for 1853, 1854, 1855, and 1856, Table 28.

Extract from Nelson Examiner [?, early 1855 ?]. Fitton, New Zealand: Its Present Condition, Prospects and Resources, 126. Some idea of the order of the increases which might have been achieved with guano can perhaps be gained by considering later experiments. The average yield increment in wheat obtained from applying 1 cwt. of superphosphate per acre (calculated from trials on the east coast of the South Island prior to 1934) was 4.1
bushels per acre. A further 3.2 bushel per acre increment was obtained when 1 cwt. of nitrate of soda was applied with the superphosphate (Hudson, A. W., & Woodcock, J. W., 'Wheat-manuring Experiments in the South Island'. *New Zealand Journal of Agriculture* 48(6)(1934), pp. 322, 324-5, & 329).

100 *Nelson Examiner*, 19 April 1856, p. 2, 9 December 1857, p. 4, & 20 April 1859, p. 2; *Wellington Independent*, 29 September 1855 (Supplement), p. 2; *Wellington Provincial Gazette*, 8 Nov 1858 (Appendix); *Statistics of New Zealand for 1858* (Auckland, 1859), Table 75 [unpaginated]; *Statistics of New Zealand for 1861, including the results of a Census of the Colony taken on the 16th of December that year* (Auckland, 1863), Table 49 [unpaginated].

101 *Statistics of New Zealand for 1853, 1854, 1855, and 1856*, Table 53; *Statistics of New Zealand for 1857*, Table 63; *Statistics of New Zealand for 1858*, Table 78.

102 The number of horses owned by Pakeha in Nelson in 1855 and 1858 were 1504 and 2266 respectively. *Nelson Examiner*, 19 April 1856, p. 2, & 20 April 1859, p. 2.

103 *Nelson Examiner*, 9 January 1858, p. 2.

104 Ibid., 24 April 1858, p. 2.

105 The average price per bushel of wheat in Nelson was 9s. 6d. in 1859, and 9s. in 1860. *Statistics of New Zealand for 1859* (Auckland, 1860), Table 32; *Statistics of New Zealand for 1860* (Auckland, 1861), Table 31.

106 See, for example, extract from the *Journal of Agriculture* [Edinburgh], in *Nelson Examiner*, 1 September 1858, p. 4; Extract from the *Journal of the Royal Agricultural Society of England*, in ibid., 14 May 1859, p. 4; Extract from the *Genesee Farmer*, in ibid., 17 December, 1859, p. 3.


112 *Wellington Independent*, 15 May 1858 (Supplement), p. 2; *New Zealand Spectator and Cook’s Strait Guardian*, 27 November 1861, p. 3.

113 *Wellington Independent*, 30 May 1862, p. 3, 1 July 1862, p. 2, 16 September 1862, p. 4;
Although the purchase of the Hua and Waivvakaiho Blocks doubled the area in Pakeha occupation, settlers regarded them as being of little value because only a fraction of the two Blocks was not forest covered. Quin, Brian G., ‘Bush Frontier - North Taranaki, 1841-1860: a study in economic development’ (Unpublished M. A. thesis, Victoria University, 1966), pp. 109-11.

Governor Grey to Earl Grey, 31 March 1851 (enclosure no.1). ‘Further Papers relative to the Affairs of New Zealand. 1854’, p. 4. Great Britain.Parliament. British Parliamentary Papers. Colonies - New Zealand, IX (1852-4) [unpaginated]; Statistics of New Zealand for the Crown Colony Period, 1840-1852, pp. 38-9; Taranaki Herald, 28 June 1854, p. 4, 7 November 1855, p. 4, 17 January 1857, p. 3, 29 August 1857, p. 3; Statistics of New Zealand for 1858, Table 75. It should be noted that the official returns ascribe the 1854 figures to the year 1855 (See Statistics of New Zealand for 1853, 1854, 1855, and 1856, Table 52), although the fact that the data come from a census taken for the year ending in June 1855, clearly indicates that it corresponds to the crops sown in 1854. As a result the figures used in this thesis for 1855 match those in the official returns for 1856, and so forth. Synchronicity between this thesis and the official returns is restored in 1858, when the agricultural statistics were collected in December. This could have led to two separate sets of agricultural statistics being included in the official returns for 1858, but this did occur, as no statistics were collected from the crops sown in 1857.

Statistics of New Zealand for the Crown Colony Period, 1840-1852, p. 84; Statistics of New Zealand for 1853, 1854, 1855, and 1856, Table 53.


A Well Wisher to the Settlement’ to the Ed. Taranaki Herald, 25 August 1852, p. 3; ‘N. P.’ to the Ed. & ‘Attornatus’ to the Ed., 14 September 1852. Ibid., 22 September 1852, p. 3; p. S. Ford to the Ed. Ibid., 27 October 1852, p. 5. See also Wm. Harrison to the Ed. Ibid., 6 October 1852, p. 3.

Ibid, 13 October 1852, p. 3.

First Annual Report of the Taranaki Agricultural Society'. Ibid., 4 May 1853,p. 3.

Ibid., 20 December 1856, p. 3.


Taranaki Herald, 7 November 1855, p. 4.


Ibid., 7 November 1855, 4.

In English conditions, potato cultivation typically cost about £8 per acre, versus about £3 per acre for wheat (Haxton, John, 'Potato' & 'Wheat'. In Morton, John C. (ed.), *A Cyclopaedia of Agriculture, Practical and Scientific* (Glasgow, 1855), II, pp. 678 & 1146-7. Although in New Zealand potato cultivation was probably more rudimentary, the type of operations listed in the text all still had to be carried out (see Hay, David, 'The Management of the Garden, and Orchard in New Zealander'. In Chapman, George T. (ed.), *Chapman's Hand-Book to the Farm and Garden* (Auckland, 1862), pp. 28-30).

**Taranaki Herald**, 17 January 1857, p. 3.

Ibid., 10 October 1855, p. 2.

See Nesbit, J. C., 'On Peruvian Guano: its history, composition, and fertilizing qualities; with the best mode of its application to the soil'. *New Zealander*, 29 October 1856, p. 3.

Geo. Tate to the Ed., 7 August 1856. **Taranaki Herald**, 9 August 1856, p. 3. The average yield produced by the turnips sown in 1856 was 25 tons per acre (Ibid., 17 January 1857, p. 3).

P. Elliot to the Ed., 13 August 1856. Ibid., 16 August 1856, p. 3.

Statistics of New Zealand for 1857, Table 63.


**Taranaki Herald**, 17 January 1857, p. 3.


**Taranaki Herald**, 21 November 1857, p. 5, & 28 August 1858, p. 2. The second shipment would have enabled guano use on about 15 acres (assuming a 3 cwt. per acre application rate).

University, 1966), pp. 118-20, 143-4, & fig. 13 (follows p. 140).

143 *Taranaki Herald*, 7 November 1855, 4, 17 January 1857, p. 3, & 29 August 1857, p. 3; *Statistics of New Zealand for 1858*, Tables 74 and 75.


148 *Statistics of New Zealand for 1858*, Table 75.

149 *Taranaki Herald*, 6 August 1859, 2, 17 September 1859, 2, & 1 October 1859, 2.

150 Ibid., 2 July 1859, 2.

151 Ibid., 4 December 1858, pp. 1 & 3, 25 December 1858, pp. 2-3, 3 September 1859, 2, & 1 October 1859, p. 3. The description of the course used here is from Grayling’s advertisement of 20 August 1859, p. 2.

152 W. I. G[rayling]. to the Ed. Ibid., 2 July 1859, p. 3.


155 The contemporary cost in the United States of even a basic soil analysis was $10, while a complete quantative analysis cost $25-30. Rossiter, *The Emergence of Agricultural Science*, p. 115. In comparison, Grayling only wanted £1 10s. for “a complete analysis of soil, including determination of alkalis and phosphates”, and 10s. for a quantative determination of a single ingredient (*New Zealander*, 9 November 1859, p. 5), which suggests his testing methods were much less rigorous. At the time, it should be noted that the exchange rate was effectively $5 to £1 (Grey, Alan H., *Aotearoa and New Zealand: a historical geography* (Christchurch, 1994), p. 220.


Grayling’s offering of the service may well have been prompted by a similar offer which Dr. Ferdinand Hochstetter (leader of the Austrian Scientific Expedition in the *Novara*) made while in Auckland (*New Zealander*, 16 July 1859 (Supplement), p. 1).
Grayling's assertion was based on past estimates (greatly exaggerated) of the amount of ammonia in the atmosphere; in reality, the level is such that the actual effect is negligible (Aikman, *Manures and Manuring*, p. 463).

Grayling stated that plants responded to the flush of organic matter given by guano in the same manner as people who had overindulged in alcohol (W. I. G[rayling]. to the Ed. *Taranaki Herald*, 23 July 1859, p. 3).

Grayling thought that FeO would use up the oxygen in being oxidised to Fe2O3 which would otherwise convert organic C[arbon] into C02 (thereby feeding the plant). Elsewhere, however, Grayling maintained that Fe2O3 was potentially injurious to crops because it trapped organic matter in its pores (and hence supplied it to the plant in excess) (W. I. G[rayling]. to the Ed. *Ibid.*, 2 July 1859, p. 3).

Liebig had noted that when feldspar was treated with sulphuric acid, there was no reaction, but when a little lime was added to the mix, the feldspar disintegrated. Grayling assumed that the lime reacted with the feldspar, thus freeing up the feldspar's nutrients for "assimilating powers of the plant", which he saw the sulphuric acid as being representative of (W. I. G[rayling]. to the Ed. *Taranaki Herald*, 9 July 1859 (Supplement), p. 1). In reality, the disintegration of the feldspar was caused by the heat of reaction between the lime and sulphuric acid (Pers. comm. Dr Jack Fergusson, retired Lecturer in Chemistry, University of Canterbury, March 2000).
172 Statistics of New Zealand for 1861, Table 49.
173 Ballara, 'Maori and Pakeha'. In Fraser (ed.), The New Zealand Book of Events, pp. 33-6.
174 William Grayling to James Hector, 18 June 1866. MU 147 (Colonial Museum: Hector, James (Director) - Unregistered Inwards Correspondence, 1865-1913 (loose letters)), Box 1/Record 173. Te Papa Archives.
Chapter Eight

Making two blades of grass grow where none grew before: soil fertility management in Auckland Province c. 1850-63

During the early 1850s, the course of agricultural development in Auckland mirrored that at Nelson, Wellington, and New Plymouth. This commonality extended to the introduction of 'artificial' fertilisers in the mid-1850s. However, whereas 'artificial' fertiliser use never got past the experimentation stage in the latter three settlements, they became, for reasons that are discussed in this chapter, an integral part of Auckland agriculture.

I. Pastoral progress

In 1850, the Pakeha farmers of Auckland had a number of advantages over their counterparts in the other main settlements. The extent of their agricultural operations was not limited by steep terrain, as it was in the Hutt Valley, or confined, to nearly the same degree, by the cordon of Maori-owned land, as it was at New Plymouth. As seen in Chapter Six, the success of the Auckland settlers in acquiring the richest land in the vicinity during the 1840s, had enabled its farmers to enjoy the second highest crop yields in the country. Equally, they were not troubled by the close and daunting embrace of the forest, which was another obstacle to Hutt Valley and New Plymouth agriculture. Perhaps the sole shortcoming of agriculture in Auckland was the limited production of manure, which resulted from pastoral farming being geared towards 'free-range' cattle, rather than enclosed sheep.

To date, the drain on Auckland's soils from arable cropping had been fairly light; only Wellington, of the main settlements, had a higher percentage of cultivated land under sown grass. Consequently, its soils were in good condition to support the large increase in cereal cultivation which occurred when the Victorian gold-rush pushed up produce prices. The most striking growth was in the area under wheat, which, as Table 8.1 shows, rose seven-fold between 1850 and 1852. In comparison, the area under sown pasture only doubled over the same period. Potato cultivation, meanwhile, showed very little growth, but then
Table 8.1: Acreage of crops cultivated by Pakeha in Auckland 1850-61

a) Auckland only (includes only civilian settlers in 1852 and 1853)

<table>
<thead>
<tr>
<th>Year Sown</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>243</td>
<td>795</td>
<td>135</td>
<td>1067</td>
<td>5098</td>
<td>746</td>
<td>8083</td>
</tr>
<tr>
<td>1851</td>
<td>933</td>
<td>807</td>
<td>350</td>
<td>879</td>
<td>6854</td>
<td>n. s.</td>
<td>n. s.</td>
</tr>
<tr>
<td>1852</td>
<td>1559</td>
<td>801</td>
<td>337</td>
<td>1159</td>
<td>11,606</td>
<td>1837</td>
<td>17,299</td>
</tr>
<tr>
<td>1853</td>
<td>1181</td>
<td>1552</td>
<td>133</td>
<td>2162</td>
<td>13,048</td>
<td>1511</td>
<td>19,581</td>
</tr>
</tbody>
</table>

b) Northland settlements

<table>
<thead>
<tr>
<th>Year Sown</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>32</td>
<td>4</td>
<td>5</td>
<td>116</td>
<td>970</td>
<td>105</td>
<td>1232</td>
</tr>
<tr>
<td>1851</td>
<td>114</td>
<td>7</td>
<td>4</td>
<td>80</td>
<td>2377</td>
<td>n. s.</td>
<td>n. s.</td>
</tr>
<tr>
<td>1852</td>
<td>134</td>
<td>23</td>
<td>9</td>
<td>100</td>
<td>2286</td>
<td>n. s.</td>
<td>n. s.</td>
</tr>
</tbody>
</table>

c) Auckland Provincial area

<table>
<thead>
<tr>
<th>Year Sown</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1854</td>
<td>1224</td>
<td>2108</td>
<td>207</td>
<td>2125</td>
<td>19,622</td>
<td>1852</td>
<td>27,138</td>
</tr>
<tr>
<td>1856</td>
<td>2256</td>
<td>1549</td>
<td>132</td>
<td>2016</td>
<td>55,648</td>
<td>1469</td>
<td>63,070</td>
</tr>
<tr>
<td>1858</td>
<td>2323</td>
<td>2698</td>
<td>153</td>
<td>2509</td>
<td>50,320</td>
<td>1959</td>
<td>60,202</td>
</tr>
<tr>
<td>1861</td>
<td>3892</td>
<td>2330</td>
<td>224</td>
<td>3553</td>
<td>62,817</td>
<td>3109</td>
<td>75,916</td>
</tr>
</tbody>
</table>

again the area in 1850 was already inflated on account of farmers responding to the Californian gold-rush. The rate of increase was still, moreover, in line with that of Auckland's population. Nevertheless, the change that potentially was most significant for this thesis was that civilian settlers living within 14 miles of Auckland had started raising more sheep than cattle (8686 versus 7631 in 1852). This reversed the previous trend, which had reflected the lack of natural grass around Auckland on which sheep could graze. Increasingly, enclosed, artificially-grassed, and intensively-stocked paddocks replaced the open 'fern land' of a few years earlier (see Figure 8.1). William Swainson gave the following description of the new landscape in 1853:

At Epsom, distant about two and a half miles from the town, and in the Tamaki district distant six miles, there are grass and clover paddocks as
Figure 8.1
Auckland under grass

Source: John Kinder’s 'Semi panoramic view taken from the master's house attached to the Grammar School, Auckland, New Zealand, looking over Hobson Bay, 1858'. Supplied by Hocken Library - Uare Taoka o Hakena (neg. 01265).

This view, from a central position on the isthmus looking northeast, shows the almost complete replacement close to the town of open ‘fern land’ by enclosed pasture. The lack of trees is also evident.
large, as rich, as well laid down, and as substantially fenced, as any grass land in England. 7

In keeping with this more advanced state of pastoral management, it appears that farmers also placed greater emphasis on supplementary feeding. Whereas the crop returns for 1850 gave the area devoted to hay production as 376 acres, and turnips failed to merit a separate category, by 1852 grass sown for hay and turnips accounted for 1314 and 103 acres respectively. 8 Admittedly these acreages were small compared to the area in sown pasture, but it must be remembered that supplementary feed was not needed in the warm Auckland climate. 9 It is not clear, however, whether this feed was grown in order to restore fertility to the soil via sheep-folding. This and other methods of managing soil fertility, are not mentioned in contemporary publications intended for a Pakeha readership, 10 and neither did they receive any attention from the Auckland and New Ulster Agricultural and Horticultural Society. This was more concerned with exhibiting livestock, 11 although given that Auckland's humid climate is hardly ideal for grain-growing, this was not an unreasonable concern. 12 Curiously, the forum in which sheep-folding and manuring were discussed extensively was the bilingual newspaper The Maori Messenger - Ko te Karere Maori. 13

The author of the exhortations to manure land in The Maori Messenger might have been better served directing them towards Pakeha farmers, as 1853 saw an astonishing reduction in the growth of supplementary feed. Hay production still accounted for 1115 acres, but the area in turnips had diminished to just 6 acres! 14 Even the cultivation of wheat made way for the rush to grow more potatoes. The inspiration for this was a rise in the export price from an average of £6 in 1853 to £9 per ton in 1854. 15 This shift in emphasis proved ill-fated, as while the reduced area in wheat gave a luxuriant harvest, the return from the potato crop proved so poor, owing to the dry summer, that many farmers "scarcely recovered the amount of seed they had sown". 16 Fortunately, Auckland farmers continued to intensify their pastoral operations, with cattle and sheep numbers rising to 11,568 and 14,193 respectively, despite the modest increase in the area under sown pasture. 17

Not surprisingly, the near failure of the potato crop prompted calls for a rethink of the direction of farming in Auckland. In a post-harvest address to the Auckland and New Ulster Agricultural and Horticultural Society, Alfred Buckland asserted that rather than look to the short-term profitability of the Australian market, local farmers should instead focus their efforts on the more enduring
market for wool in Great Britain. Given the reliance of pastoral farming in Auckland on the sowing of introduced grasses, the continuing growth of this sector hinged on land ownership steadily increasing. Accordingly, its prospects were greatly improved by Governor Grey's decision to lower the price of waste lands (outside those in the Canterbury and Otago Blocks) from 20s. to either 10s. or 5s. per acre in 1853, which was enacted through the Waste Lands Act of 1854. Even by the close of 1854, the sown grass acreage in the new Auckland Province was one-third higher than the preceding Auckland and Northland figures combined for 1852, whereas the respective areas in wheat and potatoes had barely altered.

It was over the next two years, as Table 8.1 reveals, that the new focus on raising livestock was to take full effect. By 1856, the area in sown pasture in the province had risen to almost three times that of two years earlier. In turn, the total cultivated area of Auckland Province, now 63,070 acres, had more than doubled, even though its settler population had in the meantime grown only from 11,919 to 15,335. The area devoted to arable crops, in contrast, remained almost unchanged, although its composition was radically different from that in 1854. Due to changes in relative crop prices (which are discussed below), the area in wheat had doubled, but simultaneously the acreage in oats had fallen sharply, and there was also a slight drop in the acreage devoted to potatoes.

Given that the area in cultivation was expanding so rapidly, and equally that most of the expansion was accounted for by sown pasture, it would be reasonable to have assumed that farmers would pay less attention to agricultural chemistry than they had before. Previously when the agricultural frontier had expanded rapidly at New Zealand settlements, as in Auckland during the late 1840s, there had been a corresponding waning of concern about soil exhaustion. Often the motivation behind the rapid development of a new agricultural area had been that it contained land better than, or comparable to, that around the settlement hearth. In such cases, pioneer settlers traded off between distance from the settlement and quality of the soil. In 1850s Auckland this was certainly not the case. Since the fertile loams of the Tamaki volcanic field had been sold off already, would-be purchasers of new freehold land were forced to look to outlying areas with poorer soils, such as the Karaka district, where the choice of soils was largely restricted to either low to medium fertility yellow-brown and brown-granular loams, or even less fertile podzolized yellow-brown earths. In these circumstances, it is not surprising that Joseph May chose to deliver, to the Auckland Farmers' Club in December 1854, a paper "on the various soils around Auckland". During the
course of this he described, with the aid of specimen soil samples, "their respective capabilities, and the means of improving their powers of productiveness". Unfortunately, May's paper does not seem to have been published, although the New Zealander reported that it commanded an "attentive hearing". This was to be expected, given the crucial role soil fertility would play in determining the subsequent worth of a land purchase.

II. Getting an appetite for guano: the cropping boom of the mid-1850s

In 1855, however, farmers' prospects of taking on infertile soils were improved by the introduction of 'artificial' fertilisers, in the form of guano. As at other settlements, the immediate cause for its introduction was that farmers had sought to maximise crop yields at a time when labour was scarce and produce prices were particularly high. As indicated in Figure 8.2(a), the wheat price at Auckland in 1855 was 11s. per bushel. Having said this, Auckland newspapers gave much more publicity to the potential of guano, through editorials and articles such as 'The Gold to be Derived from Guano', than newspapers at other settlements. This level of attention suggests that Auckland's settlers saw benefits beyond just short-term economic opportunism.

Fittingly, the first guano imported into Auckland, like the abovementioned article, was sourced from Hobart. This original shipment must have been used principally to test the strength of demand, as it consisted of only a single ton of guano, and was auctioned off in one cwt. lots. Presumably demand was strong, as by the end of 1855, there had been several more imports, and newspapers advertisements for guano had been placed by multiple vendors. Many early shipments were recorded not as tonnages but as numbers of bags, and this, together with discrepancies between shipping lists and advertisements, makes it difficult to ascertain how much guano was imported in the first few years of the trade. There is no doubt, however, that imports were on a far larger scale at Auckland than at Nelson, Wellington, or New Plymouth. In June 1856, for instance, no less than 220 tons of guano were imported, in a single shipment, direct from Peru by the Auckland merchant C. J. Stone. Only 80 tons became available to local agriculturists though, as the remainder was on-shipped to Australia when the New Zealand Parliament ignored a petition by the Auckland Farmers' Club (and protestations by the New Zealander) which called for guano to be immediately added to the schedule of goods exempt from duty.
The mid-1850s surge in wheat price led to the introduction of guano in large quantities, but import levels tailed off following the price drop. At the end of the decade, prices and imports both rose again but the Otago gold rush seems to have failed to deliver the expected price increase which inspired the 1862 imports.
Figure 8.2

Auckland Wheat Prices sh./bu

Guano Imports to Auckland 1855-62
Interestingly, one of the arguments made by the New Zealander for lifting the duty was that "the advantages of guano as a manure for our volcanic soil" were, even by this time, "generally appreciated" in a way they had not been before.\textsuperscript{32} If this statement is a fair assessment, then the agriculturists using the small amounts of guano available in 1855 must have obtained excellent yield responses from their crops. The comments by Tamaki-based farmer William Atkins would also indicate this. On the basis of his experience applying 3 cwt. per acre of guano to his meadow land in 1856, Atkins stated that it was "one of the most valuable fertilizers to the clay soils of this province".\textsuperscript{33} The benefit Atkins observed was due to the composition of the yellow-brown loams, which are found at the head of the Tamaki River, and on its eastern bank. These are formed from water-sorted andesitic ash, and contain high levels of the clay mineral allophane. This mineral binds phosphate so strongly that plants suffer from phosphate-deficiency, even though the soil itself contains moderate amounts of phosphorus. Therefore, crops growing on these soils show a marked response to phosphate fertilisation.\textsuperscript{34}

With demand for arable produce from Australia steadily diminishing as its own production came onstream, the inflated market for produce began to collapse in 1856. Even in this year the average price paid for export potatoes was just £5 per ton, which was half that of the previous year, and less, in fact, than it had been in 1853. The average price of wheat, remained high during 1856, but dropped to 7s. 6d. per bushel in 1857, a level at which agriculturists would have struggled to break even.\textsuperscript{35} Not surprisingly, these price movements plunged Auckland into an economic depression, the gravity of which can be seen clearly by comparing the province's agricultural statistics of 1858 with those of 1856. Despite the fact that its population had grown about 20% in the interim, the area in cultivation (including sown grass) actually fell slightly, to 60,202 acres. In essence, almost 5% of cultivated land had been abandoned.\textsuperscript{36} Admittedly, the area in arable crops had grown by about a quarter, but most of this rise was accounted for by the increased cultivation of oats, presumably used to feed rising numbers of horses and cattle.\textsuperscript{37} With respect to other fodder crops, such as turnips, the picture is confusing. Although the agricultural statistics for 1858 suggest a large increase in their cultivation - since 1856 the acreage of the 'other crops' category had risen from 247 to 935 acres\textsuperscript{38} - and there was no shortage of comment, derived both locally and from overseas, to the effect that crop rotation incorporating fodder crops was a central element of successful farming,\textsuperscript{39} on more than one occasion it
was asserted that Auckland farmers devoted far too little effort to growing root crops.40

As Figure 8.2(b) demonstrates, guano imports consequently fell away during this period, despite the belated inclusion of an exemption for manures in the customs tariff declared in August 1856.41 Even when the produce market had been at its height, it was observed by one commentator that the prospects for 'artificial manure' use were not great, as the agriculturists who employed it were likely to be out-competed by those locating themselves on "the superior maiden land that will be annually brought under cultivation in the neighbourhood of all existing or new inland towns". Now that produce prices had fallen, this commentator's prediction that "the manures that will be principally used in this colony for many years yet, will be obtained from the farmyard, the folding of sheep on turning lands, and the ploughing in of green crops in the spring of the year, preparatory to a summer fallow", was even more pertinent.42 Nevertheless, the amounts of guano coming into Auckland during these lean years were still in excess of the maximum historical import levels at other settlements. Advertisements show that at least 40 tons were offered for sale during 1857,43 a quantity which, at the application rate of 2 cwt. per acre specified by William Martin in 1857 in a report to the Auckland Farmers' Club, could have enabled its use on around 400 acres of potatoes, or about one-fifth of the total crop.44 In the following year only about 12 tons were imported,45 following a price hike imposed by the Peruvian government, which probably raised the local price of guano to about £15 per ton.46 This, however, probably represents the minimum point as regards the guano supply in Auckland.

III. Making the best of a bad situation

The new scarcity of guano, as opposed to the plentiful supply Auckland farmers had at their disposal in the mid-1850s, raised two distinct, though related, questions. The first of these was how soil fertility might be improved without using 'artificial' fertilisers. To this end, when the Mechanics Institute announced their schedule for prize essays in 1857, their agricultural section called for not just an account of the best method for clearing and cultivating fern land and forest, but also for an essay "on manures in general, and manures more especially available in this province". Another subject chosen for essayists to tackle, albeit of lesser priority, was "the requisite manures for improving the fertility of the respective soils in this province, according to the different agricultural products".47
Of the materials that were available locally, lime seemed the best candidate for improving soils in the absence of 'artificial fertiliser', especially after the discovery of a large limestone supply in the Hunua Ranges in 1858. Its most ardent advocates even suggested that farmers would be better served liming their land than applying guano to it. However, at the time it was regarded as too expensive for agricultural purposes. When it came to the potential of recycling farm waste, meanwhile, the only aspect that received close scrutiny was the disposal of stubble. As it happens, the same Farmers' Club meeting which had heard William Martin speak about guano, also heard an address from James Baber on stubble burning. Baber noted that Liebig's mineral theory had given new credence to this practice, since the inorganic nutrients in the ash, such as potassium, were made rapidly available to the plant, but his personal view was that Auckland farmers should plough in the stubble. This was because decaying straw would aid soil drainage by abetting the formation of soil pores, a virtue that was not amiss on Auckland's heavy clay soils. A subsequent letter to the *New Zealander* espoused this view even more strongly, and went on to argue that manure mixed with straw litter could fertilise the soil much more cheaply than guano, but no more appears to have heard on the issue until 1861, when regret was expressed over the continued burning of straw. This suggests that Baber's call for intact incorporation of straw into the soil, rather than straw burning, was no more effective than the calls for greater agricultural use of lime. While these recommendations may have been futile, they nevertheless reveal a growing consciousness amongst farmers of the importance of managing soil fertility, and also illustrate the difficulties settlers had in trying to find a substitute for guano.

The second question to be highlighted by the diminished guano supply was this - how fertile were the soils in the countryside beyond Auckland? Now that settlers could not rely on fertilisers to compensate for deficiencies in soil fertility, it became critical for farmers to procure land with good quality soil. Accordingly, advertisements for farm land started giving basic soil descriptions, rather than relying on the vague epithet, "good soil". From 1858 onwards this question took on further significance because of the development policy embarked upon by the Auckland Provincial Council. Broadly speaking, this was to use immigration to fund an economic recovery via the fresh injection of capital, labour, and also consumer demand. At its core was the Auckland Provincial Waste Land Regulations of 1858, and the ensuing 'Forty Acres' scheme, which entailed a free grant of 40 acres being made to immigrants who paid their own passage, together with further land grants for family members and accompanying passengers whose
passage had also been paid for by the grantee. While there was never any shortage of land available for the ‘Forty Acre Settlers’, with the 632,081 acres of unsold Crown land within Auckland Province in 1859 being more than was granted during the nine-year duration of the scheme, much of what was in the land ‘bank’ was not well suited for farming purposes. An examination of contemporary maps, such as that depicted in Figure 8.3, shows that the Crown’s holdings were composed largely of a wide belt of land stretching almost unbroken up the east coast from Auckland to Whangarei, and the surrounds of the Kaipara and Manukau Harbours. Unfortunately for would-be settlers, the predominant soils in these areas (as can be seen in Figure 6.5) are podzolised yellow-brown earths and podzols, which generally have low to very low levels of soil fertility.

In the circumstances, is is not surprising that the merits of the ‘Forty Acre’ scheme quickly became a topic of vigorous debate in Auckland, with the two leading local newspapers, the New Zealander and the Southern Cross, taking opposite sides on the issue. The New Zealander supported the scheme, although it did not go so far as to claim, as the New Zealand Bradshaw did, that merely average ‘country lands’ around Auckland, under “rude colonial farming”, yielded 25 bushels of wheat per acre. Rather the New Zealander considered that claims that agricultural settlement was not viable on such land were mischievous creations of the politically disaffected and indolent. In the New Zealander’s opinion, ignorance of farming methods appropriate to the new environment had more to do with farming failures than the environment itself. Accordingly, it frequently included correspondence giving practical farming advice during 1859 and 1860.

Conversely, within the Southern Cross practical farming advice was a rarity. In its view, the combination of small allotments and inferior soils made the farming endeavours of the ‘Forty Acre Men’ a lost cause. Some of Auckland’s leading farmers, amongst them Major M. G. Nixon, John Grigg, and Every Maclean, shared in this view, and accordingly they complained to the Colonial Secretary that “the land hitherto acquired from the Natives” was “insufficient in quantity, indifferent in quality, and quite inadequate to the increasing wants of the public”. As proof of this, they could have pointed to the Auckland Provincial Council’s own land returns, which stated that 210,217 out of a total of 632,081 acres on the books were too infertile for settlement, and further impediments, such as unresolved land claims, ruled out another 77,620 acres from survey and sale. As these farmers saw it, the only hope for Auckland
Most purchases, and most negotiations for land purchase, concerned land on the east coast north of Auckland. This land was not particularly fertile. Better land could be found to the south of Auckland, but as this map shows, hardly any land in this area was under negotiation, which reflected the hostility of local Maori to further land sales.
MAP of NEW ZEALAND, showing approximately THE EXTENT OF LAND acquired from the Natives.

Andrew Sinclair, Lt. Surveyor

Land acquired from the Natives

Land under Negotiation

Land claimed by the Natives
farming was the pastoral sector, since Auckland's soils, which they asserted were now collectively producing an average wheat yield of only 12 bushels per acre, were obviously too poor to support cereal cultivation. Since there were no areas of natural grass in the vicinity of Auckland to depasture sheep on, it followed in their view that its farmers could only compete with South Island graziers by obtaining access, either through 'direct purchase' or leasing arrangements, to pasture in the Thames Valley. After all, J. C. Firth (later proprietor of the famous Matamata estate) observed during a reconnaissance that these farmers had organised that the Valley's grassy plain contained as much as 200,000 acres of fertile land. Their appeals to allow 'direct purchase' were nevertheless rebuffed by the Colonial Government, which noted in its defence, that the fierce Maori opposition to further land sales, which had been drawn together by the Kingitanga, made the peaceful opening up of the Thames and the Waikato for settlement an impossibility.

With this avenue for development blocked, new settlers were left with little choice but to try and make farming succeed on the existing parcels of Crown land. In doing so, they could turn to existing settlers for advice, but as there was little agreement between the settlers themselves, this was not particularly helpful. As one would-be counsellor to the newcomers remarked, "those amongst us who have most knowledge of farming - have hardly as yet hit upon the most advantageous way of applying that knowledge". Into the breach stepped the recently formed Otahuhu Agricultural Association, which looked to agricultural chemistry, and more particularly soil analysis, to put Auckland's farming on a sounder, and more scientific, footing. The probable inspiration for this development was Ferdinand Hochstetter's Austrian Scientific Expedition, which undertook researches "into the mineral and agricultural resources of the Province" during early 1859. Indeed, one of Hochstetter's last actions before his departure had been to offer settlers "a chemical analysis of their land with a view to aid them in the cultivation and tillage of the same". In addition, the activities (discussed in Chapter Seven) of Taranaki's budding agricultural chemist, William Grayling, had also been receiving attention in Auckland, to the extent that his first letter on agricultural chemistry to the Taranaki Herald was reprinted in the New Zealander. Subsequently Grayling matched Hochstetter's offer of carrying out soil analyses. The Otahuhu Agricultural Association's own efforts with respect to agricultural chemistry began with a lecture from a Mr. Ludbrooke, in September 1859, which provided an overview of its principles and the benefits agriculturists had derived from it to date. The key shortcoming of this lecture, which
Ludbrooke freely admitted, was his lack of local examples of either soil analysis or fertiliser experiments. Mindful of this, the Association's Secretary, Henry Smythies, raised the issue of employing an agricultural chemist within the province during its next two meetings. At the very least, Smythies noted, the services of an agricultural chemist would help prevent farmers using expensive fertiliser on soils that did not need them. Smythies' concept received general approval, but his colleagues were less enthusiastic about finding a salary from the Association's funds, and eventually his motion failed by a "majority of one".

IV. Phosphates to the rescue

A second factor stirring the Association into action, which Smythies had alluded to when framing his motion, was renewed interest in using guano. During 1859 imports into Auckland - which, it seems, may not always have been of high quality - amounted to about 60 tons. While a small upswing in crop prices probably contributed to this market revival, another factor was the new settlement occurring in areas where the relatively infertile podzolized northern yellow-brown earths and podzols predominated. These soils contain low levels of topsoil nitrogen, and low to very low levels of phosphate. Settlers applying guano to these soils were thus likely to obtain much improved yields. This was reflected in the strong recommendation contained in some advice intended for newcomers that guano should be used when growing the first crops on previously uncultivated land. The rationale behind this recommendation was that if they could produce good initial crops with the help of guano, they would recover their set-up costs (temporary housing, fencing, etc.) much much quickly. If the land was covered in bracken, the application of guano soon after cultivation began would also have helped the farmer overcome the temporary nitrogen deficiency known as 'sourness'.

On bush land, the benefits of applying guano so soon after cultivation began were probably less pronounced, since a 'bush burn' would have freed up potassium and phosphorus previously held in the vegetation, together with nitrogen from dead soil biota. The general fertilising effects of 'burning off' were certainly well known, but many settlers regarded its effect on the physical character of the soil - that is, making the heavy clays more friable - as being of greater benefit. Possibly guano application was seen as replenishing the nitrogen lost in combustion, and also as a more reliable means of phosphorus delivery. After all, the ash layer produced by a burn off could easily be washed away, and there
was no guarantee that the burn would go to plan; 'bad burns', in which the leaf litter was burnt, while logs were only charred, were not uncommon. Bush land, incidentally, was increasingly being sought after, as its 'unploughability' was no longer such a drawback now that there was a greater emphasis on intensive pastoralism.

In May 1859, a second 'artificial' fertiliser, bone-dust, was introduced from Australia. The irony of this, which was quickly pointed out, was that for some time bones had been exported from Auckland to Great Britain. Almost certainly, some of this would have been turned into bone-dust. Happily, this state of affairs was rectified when, in New Zealand's first ever foray into 'artificial' fertiliser manufacture, the Epsom bone-mill was opened in August 1859. With a retail value of only £9 per ton, the bone-dust was considerably cheaper than guano, and almost immediately a farmer from Mangere ordered 2 tons. Unfortunately, there are no records of its production, so it is impossible to judge subsequent demand, although the potential of bone manuring certainly received a good deal of publicity. Both the New Zealander and Southern Cross printed an extract on the practice from a leading farming text, J. C. Morton's Cyclopaedia of Agriculture, and Albyn Martin also gave a lecture on the subject to the Otahuhu Agricultural Association in October 1859.

A number of other local materials also featured in suggestions for replacing imported fertiliser. One of these was a local form of guano, identified by William Buckland, and found on small islets which lie near Great Barrier Island. The Otahuhu Agricultural Association approved Buckland's proposals for further investigations at their November 1859 meeting, but there is no record of its subsequent use. A still more ambitious proposition, which was the offspring of a review of sanitation, was that the "town-sewage" of Auckland could be converted "into one of the most valuable substances for the advancement of our agriculture". Such schemes were in vogue in Great Britain at the time, but it was far too futuristic for the small Auckland settlement. Seaweed, meanwhile, was also put forward as a manure for root crops and grasses in the second of about twenty articles on farming, written by 'A Cockatoo Settler' for the New Zealander, during 1861. However, when seaweed's potential as a manure was referred to in Charles Morey's Speed the Plough (1863), arguably the first ever agricultural text to be written in New Zealand, it was noted that settlers made no use of either it, or a number of other fertilising substances, such as lime, nightsoil, and fish scraps, on account of their being "very difficult to procure in
this country at present". Of all the alternatives proposed, therefore, bone-dust was the only one to emerge as a locally produced substitute for imported guano.

Consequently, demand for guano remained fairly stable, with total imports being not less than 80 tons in 1860, and 60 tons in 1861. Since bone-dust was still being imported, albeit in small quantities, when a local manufacturer was operating, it must have been in considerable demand too. With respect to their usage, bone-dust seems to have been applied, at a rate of about 5 cwt. per acre, almost solely to turnips and potatoes, while guano, reflecting its general purpose nature, was variously applied to wheat and oats at 1-2 cwt. per acre, to grass at 2-3 cwt. per acre, and to potatoes at 3 cwt. per acre. Lesser amounts could be used when the two fertilisers were used in combination. These rates of guano application are less than those suggested in Great Britain at the time, but then again the warmer Auckland climate, and in turn, longer growing season, meant that crops did not need forcing to the same extent. To this end, it is worth recalling the comment from Chapter Six, that Auckland farmers could obtain the same benefit as their British counterparts from only one-third of the amount of manure. By 1861 guano was also costing up to £20 per ton, a price which was about 50% higher than that in Great Britain. On the basis of contemporary comment, it seems that guano, when it was applied to wheat at 1-2 cwt. per acre, probably raised yields by about 10 bushels per acre - at the price levels of the time, about 4 bushels per acre would have been sufficient to cover the material cost of the guano.

It should, however, be made clear that 'artificial' fertiliser use did not take place at the expense of farmyard manure. Rather, the two were complementary. For instance, when a 'Cockatoo Settler' advised settlers beginning farming operations to apply bone-dust to their turnip crop, he expected the dung produced from cattle fed on the turnips would form the initial basis of the farmers' manure heap. Likewise, in another article, the same author remarked that a mixture of half guano and half dung would produce far more benefit than the equivalent amounts of guano or dung alone. On the occasions when the two were compared, meanwhile, in spite of frequent assertions such as "guano is and must continue an indispensible requisite with us for profitable farming", the balance of comment favoured the idea that farmyard manure was the farmer's best asset when it came to maintaining soil fertility. As Joseph May observed,

one thing all farmers ought to do ... [is] to make as much manure as possible on the farm, and take care of it. This after all is his
In keeping with this sentiment, many Auckland farmers went to considerable lengths to maximise their manure supply. According to an article in the *New Zealander* in 1860, several made "a practice of stockyarding their cattle every night, for the sake of accumulating manure for their arable land". Even so, few would have had the commitment of 'An Independent Settler', who, during the summer months, regularly wandered around his property bagging up the droppings left by his bullocks.

Clearly, in the absence of stall- or box-feeding like that 'at home', it was not easy for farmers to collect manure. Moreover, the difficulties of cartage across undulating terrain with an undeveloped road network severely circumscribed the option of augmenting the manure heap with extraneous refuse materials such as night-soil. Herein lay the great advantage of guano and bone-dust - as highly concentrated sources of key soil nutrients, they reduced the burden of cartage to a minimum, and also, as noted above, they extended the efficacy of a limited manure supply.

Nevertheless, the overall significance of guano and bone-dust in Auckland farming at this time should not be overestimated. In consequence of the aggressive promotion of immigration and land settlement, Auckland's population climbed from 18,177 in 1858 to 24,420 in 1861, while the cultivated area rose to 75,916 acres, which amounted to 25% growth, over the same period (see Table 8.1). While sown grass still accounted for four-fifths of this total, the proportion under arable crops, as Figure 8.4 illustrates, was the highest since the early 1850s. Thanks to the improved prices and their use as 'pioneer crops' by new settlers, the wheat acreage almost doubled, and the potato acreage rose by 40%. If all the guano imported in 1861 had been applied to land under wheat, at the frugal rate of one cwt. per acre, only 1200 acres, or just under one-third of the wheat acreage, could have been fertilised. Moreover, an examination of contemporary farming comment suggests that many farmers paid little or no attention to farmyard manure. In truth, a large proportion were merely getting one or two crops off their land before laying it down to pasture - Joseph May, for instance, when speaking at the Otahuhu Agricultural Association in 1860, described this practice as "very common" - but some were cropping their land successively without manure. For example, 'A Practical Settler', dismissed complaints that the price of labour precluded profitable farming, and instead stated that farmers' poor
Figure 8.4
Changes in area under crop in Auckland, 1850-61.

Sources: New Zealand Government Gazette (Province of New Munster), 4(23) (6 September 1851), p. 144; Statistics of New Zealand, for 1853, 1854, 1855, and 1856 (Government Printer, Auckland, 1858), Table 52; Statistics of New Zealand for 1858, Table 75; Statistics of New Zealand for 1861, Table 49.

As in most other centres, the dominant theme over the whole 1850s was the increase in the proportion under sown pasture. The revival in cropping at the end of the 1850s helped to stem this, but only a little.

The respective total sown acreages are:

<table>
<thead>
<tr>
<th>Location</th>
<th>1850</th>
<th>1854</th>
<th>1858</th>
<th>1861</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auckland</td>
<td>8083 ac</td>
<td>27138 ac</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>60202 ac</td>
<td>75196 ac</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Auckland: Relative Crop Areas by Year

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Wheat</th>
<th>Oats</th>
<th>Potatoes</th>
<th>Pasture</th>
<th>Other</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat %</th>
<th>Oats %</th>
<th>Potatoes %</th>
<th>Pasture %</th>
<th>Other %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>63%</td>
<td>13%</td>
<td>10%</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>1854</td>
<td>72%</td>
<td>8%</td>
<td>8%</td>
<td>5%</td>
<td>8%</td>
</tr>
<tr>
<td>1858</td>
<td>84%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>1861</td>
<td>83%</td>
<td>5%</td>
<td>3%</td>
<td>5%</td>
<td>4%</td>
</tr>
</tbody>
</table>
incomes resulted from an "absence of anything like a system of rotation in cropping" and "a want of attention to the most ordinary farm operations for the production and economy of manure". Similarly, 'A Cockatoo Settler' distressingly observed that Auckland's agriculture was practically bereft of the green crops inherent to crop rotation, because the ordinary system, if it may be called, is to take as many white crops from the soil as it will give, and then when exhausted to throw the land into pasture, until such time as it may again be able to bear another scourging series of crops.

Unfortunately, while estimates exist for yields that could be obtained by farmers in the newly settled out-districts (generally of 15-25 bushels of wheat per acre, though individual claims of up to 50 bushels were made), there do not appear to be any for areas of more longstanding cultivation. Consequently the extent of soil exhaustion in Auckland at this time is unclear. Nonetheless, the amount of concern being expressed by agricultural commentators like Joseph May, whose abovementioned lecture to the Otahuhu Agricultural Association was entitled 'On the Exhaustion and Renovation of Soils', suggests that many settlers were wearing out their soils at a rapid rate.

V. False hopes

If farmers were struggling to 'make farming pay', then their prospects must have seemed suddenly brighter after mid-1861. Firstly, demand for produce locally would have been increased by the arrival, in June 1861, of five British regiments fresh from the conflict in Taranaki. Together with their family members, these soldiers boosted Auckland's population by about 6000. Secondly, Gabriel Read's gold discovery in May had set off the Otago gold-rushes. Given the consequences of the Victorian gold-rush a decade earlier, farmers probably expected produce prices to increase considerably, allowing them to spend more on fertilisers. Accordingly, Auckland's merchants began to import guano at unprecedented levels. Altogether imports totalled perhaps 390 tons in 1862, and 200 tons in 1863. Not all of this guano stayed at Auckland, due to the emergence (or re-emergence) of much smaller-scale demand for guano at other settlements. During 1862, for example, about 15 tons flowed from the Auckland hub through an internal distribution network (shown in Figure 8.5) that stretched as far south as the Wairau Valley.
This map shows the clear dominance of Auckland, and within Auckland, of Combes and Daldy, in the guano trade at this time. In addition to the large amounts entering Auckland, small transshipments from Auckland were also made to New Plymouth (Southern Cross, 10 January 1862, p. 3), Napier (Southern Cross, 4 March 1862, p. 3; New Zealander, 7 May 1862, p. 6), Kawhia (New Zealander, 19 July 1862, p. 3; Daily Southern Cross, 16 October 1862, p. 3), Whangarei (New Zealander, 23 August 1862, p. 2), and Wellington (Wellington Independent, 30 May 1862, p. 3, & 16 September 1862, p. 2). Subsequently, some of the guano delivered to Wellington was onsold at Nelson (Nelson Examiner, 25 October 1862, p. 2) and the Wairau (Wellington Independent, 1 July 1862, p. 2). Further south, Otago and Canterbury both received guano direct from Australia (Otago Daily Times, 11 November 1862, p. 4, Lyttelton Times, 19 March 1862, p. 4). New Plymouth also received a small Australian import (Taranaki Herald, 23 August 1862, p.2).
Spearheading the resurgent market for guano was the Auckland firm of Combes and Daldy. Rather than sourcing Peruvian guano or Australian phosphatic guano from the Australian market, as other merchants continued to do, in 1861 Walter Combes and William Crush Daldy combined with James Burtt, a local farmer, and William Hardwick, an American whaling captain, to exploit the guano resources of Coral Queen (now Starbuck) Island. Unlike Peruvian guano, Coral Queen Island guano was phosphatic in character, with 70-80% of its weight consisting of phosphate of lime, whereas organic matter accounted for less than 10%. When the first 40 ton shipment arrived in October 1861, the New Zealander enthusiastically remarked that because of its high phosphate content, it was the most valuable of all fertilisers to the clay soils around Auckland, and as it can be obtained in large quantities, of a vastly superior quality, at a much lower price than the best Peruvian guano, there can scarcely be a question of its large and continuous importation.

The Southern Cross was more circumspect, stating that "we require some cheap fertiliser, and if this guano be found to suit the requirements of our poor soils, there is no question of it being obtained in sufficient quantity and at low rates". During 1862, Combes and Daldy shipped about 320 tons of this guano to Auckland, which mostly sold for £8 per ton; in contrast, some Peruvian guano sold in Auckland the following year retailed for £16 per ton. Price was not the only advantage phosphatic guano had over Peruvian guano though, as there was a growing perception that the latter contained more nitrogen than was desirable, and if used alone it would exhaust the soil, because the soil could not supply minerals at the same rate. The new esteem for phosphate-only fertilisation is also pointed to by the importing of perhaps 100 tons of bone-dust from Australia in 1862. Having said this, farmers still valued nitrogenous fertilisation, and when one nitrogen-rich shipment of Coral Queen Island guano arrived in Auckland, Combes and Daldy accordingly raised its price to £10 per ton.

'Agricultural improvement' was starting to manifesting itself in fields other than fertiliser use as well. For the first time, locally-based agricultural societies began to appear in outlying districts, such as Papakura and Mangapai. Meanwhile, the role of leading agricultural forum passed from the Otahuhu Agricultural Association to the more grandly titled New Zealand Agricultural Association. Underscoring the unusually large supply of fertiliser at this time, the latter body opted, for its anniversary meeting of 1863, to hear a paper on 'artificial manures'.
This paper focussed mainly on sources of nitrogen and phosphoric acid, such as the various guanos, although some discussion also referred to less significant nutrients, such as potassium and magnesium. The amount of locally-derived content, however, was, as with previous papers on agricultural chemistry, fairly limited.\textsuperscript{133} The amount of locally-produced agricultural literature was, nonetheless, on the increase. Although, surprisingly, there were no candidates for yet another essay competition on the best local farm management practices,\textsuperscript{134} Auckland farmers were soon able to turn for advice to \textit{Chapman's Handbook to the Farm and Garden} (1862), and Charles Morey’s 168-page farming guide \textit{Speed the Plough} (1863). New agricultural machinery also lent weight to the mood of local 'improvement'. As a report of the New Zealand Agricultural Society’s cattle and implement show in 1862 opined, once improved machinery, adapted for indigenous conditions, was introduced, it would "be seen that skilful farming in this province will pay better than the loose system which has hitherto prevailed"\textsuperscript{135} An artificial manure distributor amongst the implements on display,\textsuperscript{136} provided yet another indication of the new significance of 'artificial' fertilisers.

The economics of Auckland during 1862 and 1863 were not as favourable as settlers hoped, however. While there was an ample supply of fertiliser - the guano supply alone in 1862 was probably sufficient to apply 2 cwt. per acre to the entire wheat crop\textsuperscript{137} - it is unlikely that farmer incomes improved that much. Instead of rising, as expected, the price of wheat slumped to 6s.6d. per bushel during 1862 and remained at this level during 1863. The cause of this slump was the enormous quantities available for import from Australia, which produced huge harvest surpluses in these two years.\textsuperscript{138} Consequently, in 1862, total imports of wheat amounted to 188,931 bushels, which was probably treble the amount produced locally, while in 1863 they amounted to 111,624 bushels.\textsuperscript{139} The disappointment locals must have faced on finding that cheap Australian wheat was undercutting their output, when other circumstances should have dictated inflated prices, probably contributed to a rejuvenation of the acrimonious newspaper debate over the 'Forty Acres Scheme' during 1863.\textsuperscript{140} Again a lack of road access and poor soil - according to a 'Country Settler' it was only fertiliser inputs that kept many farms viable - were the main feature, with the \textit{New Zealander} yielding some ground to the \textit{Southern Cross} position by admitting that some of the 'Forty Acre Settlers' had been offered infertile land.\textsuperscript{141}

Not surprisingly, this debate was eclipsed by war breaking out between Government troops and Maori allied to the \textit{Kingitanga} movement in July 1863.\textsuperscript{142}
This turn of events brought about two major upheavals in Auckland agriculture. The first of these was the widespread abandonment of farms between Manakau Harbour and the Waikato River, owing to its being the site of numerous skirmishes, during late 1863. Although farmers were able to return to this land the following year, the foregoing of the wheat crop in the south of the Province, which had contained 1666 out of Auckland’s 3892 acres sown in wheat in 1861, helped push the wheat price in 1864 up to 9s.3d. per bushel. Small crop acreages in 1864 indicate that farmers recognised this price as exceptional, and instead expected a return to the pre-war situation, where rearing stock, as Joseph May observed in late 1862, was more profitable than growing grain. Just 856 acres were sown in wheat in 1864, and of this total, the war-ravaged south contributed a mere 279 acres. Admittedly, the area under oats, had risen from 2330 acres in 1861 to 3411 acres, but this was probably due to the high demand prompted by the large number of draught animals in military service at the time. Fertiliser importing, meanwhile, seems to have been unaffected by the war, almost certainly because the area where they were most needed, that is, the poorer soils north of Auckland, was not directly involved in the war. Nevertheless, there was a noticeable shift in demand from guano to bone-dust to which reduced cereal cultivation may have contributed.

VI. The future is grass

The second and ultimately much more significant change in the agriculture of Auckland Province was the confiscation, in a proclamation dated 17 November 1864, of more than a million acres in the Waikato. At last the 'direct purchase' advocates would have access to districts in which, as Firth had reported in 1859, "clover takes with the utmost readiness in a soil admirably adapted for it". Having said this, farming in the Waikato was constrained for some years by its initial development as a military settlement. It can nevertheless be said that the acquisition of the Lower and Middle Waikato Basins decisively changed the character of Auckland farming, because its climate, soil, and natural vegetation together formed an environment which was far more conducive to the establishment of intensive pastoralism than the southern half of the North Auckland Peninsula had been.

The enormous land acquisitions did not mean, however, that Auckland farmers lost their appetite for fertilisers - far from it in fact. In 1867, for example, 467 tons of guano (worth £3895) and 608 tons of bones (worth £3629) were
imported into Auckland.\(^{152}\) By 1880, meanwhile, it appears that 3828 tons of fertiliser, out of 4599 tons brought into New Zealand, were imported through Auckland.\(^{153}\) It is not surprising, therefore, that as early as 1879, superphosphate was being produced within Auckland Province by J. A. Wilson, who was dissolving bones in acid sulphur pools on White Island.\(^{154}\) Wilson's venture was not a commercial success, but his lead was followed by the New Zealand Manure and Chemical Company Ltd., which began superphosphate manufacture at Tauranga in 1884, and by Kempthorne, Prosser & Co's New Zealand Drug Company's Westfield works (located in Otahuhu), where manufacture began in 1887.\(^{155}\) The Epsom bone-mill, meanwhile, which was probably jointly operated by Bycroft and C. J. Stone, had relocated to Onehunga by 1863. A second bone-mill was built by J. J. Soppet at Freeman's Bay by 1865.\(^{156}\) Presumably Bycroft's mill did not survive, as only one bone-mill was recorded for Auckland Province in the census returns of 1867, 1871 and 1874. In the 1878 census, however, the presence of three bone-mills were recorded.\(^{157}\)

While demand for fertilisers steadily expanded, the same could not be said of the arable and mixed farming sectors, which struggled to find their feet again after the New Zealand Wars. Having stood at 6346 acres in 1861, the combined cereal acreage (excluding oats grown for fodder) within Auckland Province amounted to only 7828 acres some twenty years later. The area in sown grass in the meantime had grown from 62,817 to 532,815 acres, and by 1881 even the acreage under turnips and rape had reached 12,898 acres.\(^{158}\) In short, the farming sector in Auckland Province had come to be overwhelmingly based on intensive pastoralism, and as a result, fertiliser use increasingly had less to do with preventing soil exhaustion and more to do with pasture establishment and encouraging clover growth.\(^{159}\) The future story of fertilisers and soil fertility management in Auckland can thus be seen, to some extent, as the first steps towards the 'Grasslands Revolution'. Since this thesis, as noted at the conclusion of Chapter Seven, is primarily concerned with the interrelationship between soil fertility management and agriculture in its arable cropping-sense, the remainder of this thesis will concentrate on the post-1860s heartland of arable and mixed farming in New Zealand, namely Canterbury and Otago.

In review, soil fertility management practice in Auckland had been transformed in little more than a decade. From a situation where most farmers were happy to rely on the natural fertility of their land at the start of the 1850s, by the mid-1860s many farmers seem to have regarded the combined application of 'artificial' fertilisers and farmyard manure as almost indispensable. While the
entrepreneurship of merchants such as C. J. Stone and Combes & Daldy facilitated this, there is no doubt that the driving factor behind this transition was the infertility of Auckland's soils. Whereas at the other main settlements, experimentation with guano fizzled out as quickly as the price of wheat dropped, at Auckland the difference in productivity between fertilised and unfertilised soil, was evidently too great to ignore. Perhaps there is no more succinct statement of this than that made by Albyn Martin, in his lecture on bone manure, to the Otahuhu Agricultural Association in 1859 - "It is quite certain that we cannot grow wheat or turnips without manure".¹⁶⁰
Addenda to Chapter Eight

[Shortly after the submission of this thesis for examination, the following two pieces of evidence came to light. In order to make the thesis as accurate a statement as possible, it was decided by the author, in conjunction with his examiners, to incorporate them into the thesis by way of this addenda.]

Addendum One:
Joseph May's paper to the Auckland Farmers Club was eventually published in the *Southern Cross* on 2 January 1855. May first noted the difficulties settlers had in selecting land with untried soil, and then proceeded to give a lengthy review of soil categories employed in the Agricultural Society's Annual Report in 1843 (see Chapter Six). The main criticism he had of its findings was that it had been too optimistic about the agricultural capability of the 'dwarf manuka and fern land'. He concluded by stressing the potential benefit of geological surveys and chemical analyses in discriminating between land with fertile and infertile soil (*Southern Cross*, 2 January 1855, p. 3).

Addendum Two:
According to a report in the *New Zealand Weekly News*, the Auckland firm of W. J. Hurst and Co. began producing its own superphosphate fertiliser in 1876 (*New Zealand Weekly News*, 14 July 1877, p. 4). It had already been experimenting with fertiliser mixtures (Ibid., 15 April 1876, p. 18), and it is not clear whether the 'new' fertilisers it began advertising (see ibid., 19 August 1876, p. 3) used superphosphate of its own or foreign manufacture.
Notes to Chapter Eight

1 During the 1840s, total Crown purchases of Maori land in the Auckland region are estimated to have amounted to about 106,000 acres. A further 234,000 acres were acquired by the Crown in settling pre-emption waiver and pre-1840 land claims (including Fairburn's), while the claimants themselves were given titles to an area which totalled 283,000 acres (Ward, Alan, National Overview [Waitangi Tribunal Rangihaua Whanui Series] (Wellington, 1997), III, pp. 5-6, 6n & 10). In comparison, the total area fenced in Auckland Province, as recorded by the census of 31 March 1855, was only 43,762 acres (Statistics of New Zealand, for 1853, 1854, 1855, and 1856 (Auckland, 1858), Table 52 [unpaginated]).

2 New Zealand Government Gazette (Province of New Munster), 4(23) (6 September 1851), p. 144; Statistics of New Zealand for the Crown Colony period, 1840-1852, compiled by C. G. F. Simkin (Auckland, 1954), pp. 38-9; New Zealander, 18 March 1854, p. 4; Statistics of New Zealand, for 1853, 1854, 1855, and 1856, compiled from official statistics (Auckland, 1858), Table 52 [unpaginated]; Statistics of New Zealand for 1858 (Auckland, 1859), Table 75 [unpaginated]; Statistics of New Zealand for 1861, including the results of a Census of the Colony taken on the 16th December that year (Auckland, 1863), Table 49 [unpaginated].

3 New Zealander, 18 March 1854, p. 2.


5 New Zealander, 18 March 1854, p. 4.


7 Swainson, William, Auckland, the Capital of New Zealand, and the Country Adjacent; including some account of the Gold Discovery in New Zealand [1853] (Auckland, [1971]), pp. 36-7. See also comments on the ubiquity of enclosed pasture in [Kennedy, Alexander], 'Notes of a short Tour into the Interior of the Northern Colony in New Zealand, in March and April 1852'. New Zealander, 15 May 1852, p. 3.


9 Agricultural and Horticultural Society of Auckland, 'First Annual Report'. Southern Cross,

10 There is, for instance, no mention of sheep-folding (or, indeed, manuring) in either William Swainson’s Auckland, the Capital of New Zealand, and the Country Adjacent (1853), or in contemporary issues of the New Zealander.

11 See comments on the early shows of the New Ulster Agricultural and Horticultural Society in Kalaugher, J. P., Historical Chronicles: Auckland Agricultural and Pastoral Association and Early Days in Auckland Province, from 1826 to 1893 (Auckland, 1925), pp. 32, 36-7, 38, 40 & 42. During the last years of the decade, only livestock shows seem to have been held (Ibid., pp. 46-7 & 70).

12 Wheat-growing is most suited to areas which have annual precipitation of around 500-750mm (20-30in), though smaller crops can adequately be grown where rainfall is in the 375-500mm (15-20in) bracket (Copland, D. B., Wheat Production in New Zealand: a study in the economics of New Zealand Agriculture, with a chapter by F. W. Hilgendorf (Auckland, 1920), p. 27). Auckland, however, experiences average annual precipitation in the order of 1200mm (48in) per year (New Zealand. Department of Statistics, New Zealand Official Yearbook 94th ed., p. 12).

13 For locally-derived remarks on the benefits of folding sheep on turnips, see The Maori Messenger - Ko te Karere Maori, 16 December 1852, p. 3, or for general comments on the importance of fertilising the soil, see ibid., 29 January 1852, p. 3; Extract from the Times in Ibid., 27 January 1853, p. 3. In one issue, the basic theory of agricultural chemistry was also introduced, by way of an American-sourced extract (Ibid., 29 January 1852, p. 3).

14 New Zealander, 18 March 1854, p. 4.

15 Statistics of New Zealand, for 1853, 1854, 1855, and 1856, compiled from official statistics, Table 9. The prices stated are the average for potato exports during 1853 and 1854 respectively.

16 Extract from Sydney Morning Herald, [?] October 1854. Fitton, New Zealand: its present condition, resources, and prospects, p. 63.

17 New Zealander, 18 March 1854, p. 4.

18 Alfred Buckland (speech to the Auckland and New Ulster Agricultural and Horticultural Society), 18 March 1854. Ibid, p. 3.

19 Extract from Australian and New Zealand Gazette, 1 September 1854. Fitton, New Zealand: its present condition, resources, and prospects, p. 74.

20 This decision did not extend to waste land within the Canterbury and Otago Blocks. Morrel, W. P., The Provincial System in New Zealand, 1852-1876 2nd ed. (Christchurch, 1964), p. 82.

22 *Statistics of New Zealand, for 1853, 1854, 1855, and 1856*, Table 1.

23 At Auckland, this shift, as seen in Chapter Six, was from the low fertility yellow-brown earths on the southern shore of the Waitemata, to the rich red and brown loams of the Tamaki volcanic field. A further instance of this type of shift to better soils in outlying regions will be seen in Chapter Nine, with the movement of arable farming in Otago, from Dunedin's western hills (mainly yellow-grey earths, interspersed with recent alluvial soils) to the Taieri Plain (recent alluvial soils). A shift to similar fertility soils, though with diminishing physical obstacles to cultivation, can be observed in Chapter Six with respect to arable farming in Wellington (from the recent alluvial soils of the Hutt Valley to similar soils at Wanganui).

24 In the map contained in William Swainson's *New Zealand and its Colonization* (1859) (reproduced in Maling, Peter B., *Historic Charts and Maps of New Zealand, 1642-1875*, 2nd ed. (Auckland, 1999), p. 201 [Plate 87] the Karaka district, on the southern side of the Manakau harbour, is shown, by way of coloured shading, to be one of the major areas around Auckland into which settlement had extended. Some 8642 acres in the area were freeholded in the district in 1854 alone (Bush, I. C., 'The Aggregation, Subdivision, and Transfer of Land in Karaka Parish' (Unpublished M.A. Thesis, University of Auckland, 1974), p. 20). As Bush has noted, the district's soils consisted mainly of low to medium fertility yellow-brown loams and brown granular loams, though there were also small pockets of low fertility yellow-brown earths, together with tracts of low fertility saline soils along the shore of the Manakau, and higher fertility recent alluvial soils along stream banks (Ibid., pp. 12-6 & 48-9). The 'Karaka brick-dust' soil, which quickly gained a notorious reputation for sterility (see, for instance, *New Zealander*, 1 November 1856, 3; 'Settler' to the Ed., 24 September 1859. *Southern Cross*, 4 October 1859, p. 3) appears, on the basis of a contemporary description, to have been the appellation given to podzolised northern yellow-brown earths (*New Zealander*, 17 November 1860, p. 5. Cf. McClaren, R. G., & Cameron, K. C., *Soil Science: An introduction to the properties and management of New Zealand soils* (Auckland, 1990), Colour Plate 2d [between. pp. 184 & 185]). The exposure of the early settlers to such soils was probably magnified by their frequently being located around the edges of land covered by yellow-brown loams. As the district's forest grew on the latter soils, settlers hoping to access otherwise scarce supplies of timber for building etc. naturally looked to locate themselves on clearer areas nearby (Bush, 'The Aggregation, Subdivision, and Transfer of Land in Karaka Parish' (Unpublished M.A. Thesis, University


26 Statistics of New Zealand, for 1853, 1854, 1855, and 1856, Table 53; Extract from Sydney Morning Herald, [?] October 1854. Fitton, New Zealand: its present condition, resources, and prospects, p. 65.

27 In this article, Tasmanian farmers testified that using guano had brought about much greater crop yields. Extract from Hobart Town Courier, in New Zealander, 9 May 1855 (Supplement), p. 2. For other references encouraging guano use, see extract from Victoria Rural Magazine, in Southern Cross (Extra), 2 June 1855, 1; Nesbit, J. C., 'On Peruvian Guano: its history, composition, and fertilizing qualities; with the best mode of its application to the soil'. New Zealander, 29 October 1856, p. 3.


30 Rather than landing 311 tons of guano (as recorded in the shipping list), the Imperial almost certainly landed, as stated by an advertisement heralding the consignment's arrival, 316 bags (Ibid., 20 October 1855, pp. 1 & 2). This was probably about 30 tons, given a bag : tonnage ratio of about 10 : 1, which seems to hold roughly true for shipments where both figures are known (Ibid., 1 May 1858, p. 2, 25 April 1860, pp. 1 & 2, & 28 April 1860, p. 2). While the above discrepancy is easily accounted for, one cannot say the same for a 20 ton shipment which Gilfillan and Co. advertised as being expected on the Algerine (Ibid., 6 October 1855, p. 1). The cargo list for the Algerine, when it arrived, contained no guano (Ibid., 10 October 1855, p. 2), and nor was any record found of a shipment on a subsequent voyage by the same vessel from Australia. However, by March 1856, Gilfillan & Co. were advertising guano for sale (Ibid., 26 March 1856, p. 1).


32 New Zealander, 9 July 1856, p. 2.

33 William Atkins to the Ed., 5 November 1856. Ibid., 10 December 1856, p. 3.


35 Statistics of New Zealand, for 1853, 1854, 1855, and 1856, Table 9. According to one estimate which appeared in the New Zealander in mid-1856, the cost of wheat growing on a
farm of average fertility was around £11 16s. per acre, which, if a yield of 28 bushels per acre is assumed, gave a production cost of 8s. 5d. per bushel (Anon. to the Ed. New Zealander, 28 June 1856, p. 3). It should be remembered that much of this production cost was dependent on the cost of labour, so this probably fell to some extent during the depression years.

36 Auckland Province's Pakeha population in 1856 and 1858 was 15,335 and 18,177 respectively. Statistics of New Zealand for 1853, 1854, 1855, and 1856, Table 1; Statistics of New Zealand for 1858, Table 1.

37 Cattle numbers rose from 24,555 at the close of 1856 to 31,700 two years later, while horse numbers rose from 2894 to 3839 over the same period. Statistics of New Zealand for 1853, 1854, 1855, and 1856, Table 51. Statistics of New Zealand for 1858, Table 74. The use of oats as fodder for cattle and horses was described in The Maori Messenger - Ko te Karere Māori, 10 March 1853, pp. 2-3.

38 Statistics of New Zealand for 1853, 1854, 1855, and 1856, Table 52; Statistics of New Zealand for 1858, Table 75. 'Other crops' excluded sown grass, wheat, oats, barley, potatoes, maize, and garden & orchard crops.

39 For locally-derived encouragement of rotation of crops, and particularly the value of turnips, see 'F. C. J.' to the Ed., 10 May 1859. New Zealander, 11 May 1859, p. 2; 'Rack-renter' to the Ed., 4 July 1859. Ibid., 6 July 1859, p. 3; John Grigg, 'Sheep' (paper to the Otahuhu Agricultural Association), 7 March 1859. Ibid.; 3 August 1859, p. 3. See, for examples of British and Australian advocacy of rotational cropping, in extract from the Times, in ibid., 11 May 1859, p. 2; Extract from Victorian Agricultural and Horticultural Gazette, in ibid., 18 May 1859, p. 3.


41 New Zealander, 6 August 1856, p. 2, & 9 August 1856, p. 2.

42 Anon. to the Ed. Ibid., 28 June 1856, p. 3.

43 Ibid., 1 April 1857, p. 4, & 8 April 1857, p. 1.

44 Martin had carried out experiments with the guano on his farm at Tamaki. William Martin, 'Guano as a manure' (paper to Auckland Farmers' Club, 6 June 1857). Ibid., 17 June 1857, p. 3. There is no corresponding potato acreage figure for 1857, though it seems reasonable to assume it would have been roughly between the 1856 and 1858 figures (2016 and 2509 acres respectively) (Statistics of New Zealand, for 1853, 1854, 1855, and 1856, Table 52; Statistics of New Zealand for 1858, Table 75.

45 New Zealander, 1 May 1858, p. 2, & 27 October 1858, p. 3. For the purpose of this calculation, it has been assumed that the 26 bags which arrived in October would have
contained approximately 2 tons of guano.

46 See extract from *Melbourne Argus, New Zealander*, 27 March 1858, p. 2. This assumes that the earlier price rises imposed in Britain, which lifted the sale price from about £10 to £13 per ton during the mid-1850s (Mathew, W. M., 'Peru and the British Guano Market'. *Economic History Review* (2nd series) 23(1) (1970), pp. 117 & 120) were matched by the change in price at Auckland. In late 1856, it should be noted, Peruvian guano had cost £12 per ton (*New Zealander*, 11 October 1856, p. 4).


48 'Damon' to the Ed., 13 September 1858. *New Zealander*, 22 September 1858, p. 3; Ibid., p. 5 January 1859, p. 3.


50 James Baber, 'Burning of stubbles' (paper to Auckland Farmers' Club, 6 June 1857). Ibid., 17 June 1857, p. 3.


52 ['A Cockatoo Settler']. *New Zealander*, 19 January 1861, p. 3. The 'Soils of the Province of Auckland' series, of which this is the second number of about twenty appears, on the basis of comments made by a contemporary, to have been the work of one of the *New Zealander*’s regular correspondents, 'A Cockatoo Settler' (See 'Old Practical' to the Ed. Ibid., 27 February 1861, p. 5).


56 In addition to the state of land purchasing seen in Figure 8.3, the areas in cultivation at this time are shown in Willis, Gann & Co., 'A New Map of the Province of Auckland' (1859). See also Royal, Te Ahukaramu Charles, 'Te Whemua Rangatira: notions of Maori nationhood'. In McKinnon, Malcolm (ed.), *New Zealand Historical Atlas* (Auckland, 1997), Plate 36, for purchases up to 1860.

57 Pohlen, 'Soils of the Auckland District'. In Kermode (ed.), *Science in Auckland*, p. 28.


59 Ibid., 23 April 1859, p. 3, & 3 December 1859, p. 3.

60 Ibid., 5 October 1859, p. 3.

61 Many of these letters were reprinted in the pamphlet *Voices from Auckland*. See 'Old Practical' [to the Ed. of the New Zealander], 'A Cockatoo Settler' [to the Ed.,
29 September 1859], J. C. Firth [to the Ed.], 'Pioneer' [to the Ed., 23 August 1859], 'Old Practical' [to the Ed.], 'Old Practical' [to the Ed.], Anon. [to the Ed.], J. C. Firth [to the Ed., 6 September 1859], Anon. [to the Ed.]. Alex F. Ridgway & Sons (ed.), Voices from Auckland, New Zealand. Reliable information for intending emigrants to that Province; to which are added the latest waste land regulations with explanatory notes 2nd ed. (Auckland, 1861), pp. 66-74, 76-80, 81-4, 85-94. See also, within the newspaper itself, 'F. C. J.' to the Ed., 10 May 1859. New Zealander, 11 May 1859, p. 2; T. E. Evans to the Ed. Ibid., 18 February 1860, p. 3. It is worth noting that another competition for the best essay on working newly settled land seems to have been announced in late 1859 (New Zealander, 7 January 1860, p. 3).

62 One rare example is 'Pioneer' to the Ed. Southern Cross, 4 March 1859, p. 3.

63 See, for example, Southern Cross, 20 September 1859, p. 3, & 30 September 1859, p. 3. For examples of correspondence critical of the 'Forty Acres' contained in the Southern Cross, see W. C. Dalby to the Ed., 16 June 1859. Ibid., 17 June 1859, p. 3; 'A Settler' to the Ed., 27 June 1859. Ibid., 5 July 1859 (Supplement), p. 1; 'An Immigrant' to the Ed. Ibid., 17 February 1860, p. 4; Thomas Turnbull to the Ed., 24 August 1860. Ibid., 28 August 1860, 4. While a lack of road is more frequently mentioned than quality of land as a cause of hardship in these letters, it should be remembered that early 'Forty Acre' settlers probably got a better choice of land at this time than latecomers. Even so, it is worth noting that in the 1950s small mixed farms in Otamatea County (which lay to the northeast of Kaipara Harbour) were in the order of 200-400 acres (Whitwell, The Forty Acre Men' (Unpublished M. A. thesis, University of Auckland, 1954), p. 134). It is little wonder then that out of a sample of 100 'forty acre men' who possessed grants to land in blocks which were in the same general area, 26 of these (whose grants averaged 108 acres in total) either forfeited or sold their land within the first year of occupation (Ibid., Table VIII (follows p.121)).

64 [Major] M. G. Nixon, W. Mason, Thomas Shepherd, John Grigg, Frederick E. Brathwaite, Albin Marin, Thomas Cawkwell, J. Hargreaves, & Every Maclean, to the Colonial Secretary [E. W. Stafford], 24 May 1859. Southern Cross, 12 August 1859 (Supplement), p. 1. Nixon, it is worth noting, was then President of the Otahuhu Agricultural Association, while Nixon, Mason, Shepherd, Grigg, Martin and Maclean were all members of the Auckland Farmers' Club's show committee in 1858 (Kalaugher, Historical Chronicles: Auckland Agricultural and Pastoral Association and Early Days in Auckland Province, from 1826 to 1893, p. 47). South Island promoters were even more scathing of the land available - the Southern Provinces' Emigration Agent in London, for example, was alleged to have stated that Auckland's hills were "not worth cultivating even if they can be had for nothing" (New Zealander, 16 February 1859, p. 3).

65 Enclosure to J. Williamson (Auckland Provincial Superintendent) to the Colonial Secretary

66 Nixon et al. to the Colonial Secretary [E. W. Stafford], 24 May 1859. Ibid. An account of the expedition was subsequently published, by way of articles in the New Zealander, by J. C. Firth (J. C. F[irth], 'Notes of a Visit to the Thames and Waikato Districts'. New Zealander, 17 December 1859, p. 3, 24 December 1859, p. 3, & 21 January 1860, p. 5).

67 The Kingitanga was a confederation of iwi (tribes) which combined together during the late 1850's to oppose alienation of land to Pakeha, and to preserve rangitiratanga (Maori sovereignty), which was vested in the person of the chosen Maori 'king'. Royal, 'Te Whenua Rangatira'. In McKinnon, New Zealand Historical Atlas, Plate 36.


69 'F. C. J' to the Ed. New Zealander, 19 February 1859, p. 3. See also J. C. Firth to the Ed., 6 September 1859. New Zealander, 7 September 1859, p. 3.

70 The Association first met in February 1858. Ibid., 23 March 1859, p. 3.


73 Extract from Taranaki Herald, in ibid., 20 July 1859, p. 3. See also, for evidence of Auckland interest in Grayling's lectures, Taranaki Herald, 8 October 1859, 3.

74 New Zealander, 9 November 1859, p. 5.


76 Ibid., 19 October 1859, p. 3, & 19 November 1859, p. 3.

77 Ibid., 16 February 1859, p. 2, 7 April 1859 (Extra), p. 1, 13 April 1859, p. 2, 29 June 1859, p. 3, 27 August 1859, p. 2, & 21 December 1859, p. 3. It is noticeable that in the wake of the jump in the price of guano, there seems to have been anxiety that low-grade guano was being (or might be) sold in Auckland (see 'Damon' to the Ed., 13 September 1858. Ibid., 22 September 1858, p. 3; Joseph May, 'The Exhaustion and Renovation of Soils' (paper to the Otahuhu Agricultural Association, 3 September 1860). Southern Cross, 18 September 1860, p. 3). The low price (£11 per ton) of one guano shipment (New Zealand, 27 August 1859, p. 2, & 24 September 1859, p. 6) suggests that some of the imported guano was indeed 'inferior'. However, since Peruvian guano was valued according to its ammonia content, inferior sorts of guano might simply be those were rich in phosphate, rather than nitrogenous compounds (see, for example, extract from [Melbourne] Argus, in New
Zealander, 3 December 1859, p. 3). The latter would not benefit cereals so much, but would have been just as efficacious, if not more so, on turnips and clover.

78 The price of wheat per bushel at Auckland rose from 7s. in 1858 to 8s. in 1859. Thereafter it peaked at 8s.6d. in 1860, before falling to 7s.6d. in 1861. Statistics of New Zealand for 1858, Table 78; Statistics of New Zealand for 1859 (Auckland, 1860), Table 32 [unpaginated]; Statistics of New Zealand for 1860 (Auckland, 1861), Table 31 [unpaginated]; Statistics of New Zealand for 1861, Table 55.


80 'Pioneer' to the Ed., 23 August 1859. New Zealander, 27 August 1859, p. 3; 'Old Practical' to the Ed. Ibid., 10 September 1859 (Supplement), p. 2; Ibid., December 1860, p. 5.

81 See, for example, 'Pioneer' to the Ed. Southern Cross, 4 March 1859, p. 3; New Zealander, 19 December 1860, p. 3.

82 'Pioneer' to the Ed., 23 August 1859. New Zealander, 27 August 1859, p. 3; Joseph May, 'The Exhaustion and Renovation of Soils' (paper to the Otahuhu Agricultural Association, 3 September 1860). Southern Cross, 18 September 1860, p. 3. Interestingly, May notes that in one experiment where scrub on fern land was burnt in situ on the one hand, and heaped together on the other, after which the heap of ashes was spread around, only the crop where in situ burning took place exhibited much benefit. That burning, rather than mineral fertilisation, seems to have been the cause of the observed benefit, is additional evidence for 'sourness' being due to nitrogen deficiency - as noted in Chapter One, fire causes the death of soil microbes, resulting in a temporary flush in soil nitrogen.

83 See New Zealander, 17 November 1860, p. 5; 'A Practical Settler' to the Ed. Ibid, 2 February 1861, p. 8.

84 The importance of allowing felled timber to dry before burning was frequently stressed in advice to settlers. See, for example, 'Pioneer' to the Ed. Southern Cross, 4 March 1859, p. 3; 'Cockatoo Settler' to the Ed., 2 January 1860. New Zealander, 7 January 1860, p. 3; T. E. Evans to the Ed. Ibid., 18 February 1860, p. 3; Ibid., 12 December 1860, p. 3.

85 See, for example, 'Pioneer' to the Ed. Southern Cross, 4 March 1859, p. 3; New Zealander, 7 January 1860, p. 3; T. E. Evans to the Ed. Ibid., 18 February 1860, p. 3. Even the traditional prescription against selecting land under kauri forest was amended to repeatedly burnt over land previously under kauri forest (Ibid., 12 December 1860, p. 3).

86 See New Zealander, 4 May 1859, p. 2, & 28 May 1859, p. 2.

87 Ibid., 7 September 1859, p. 7. In 1857, for instance, 40 cwt. and 1200 individual pieces of bone and hoof were exported from Auckland (Statistics of New Zealand for 1857, Table 16). It was observed in the lecture given by Ludbrooke, referred to previously, that at the
time the supply of bone to fertiliser manufacturers in Great Britain was unable to meet demand (Ludbrooke (paper to Otahuhu Agricultural Association, 5 September 1859). Ibid., 10 September 1859 (Supplement), p. 2.

88 *Southern Cross*, 12 August 1859, p. 3.


90 Albyn Martin (paper to Otahuhu Agricultural Association, 3 October 1859). New Zealander, 19 October 1859, p. 3.

91 Ibid., 19 November 1859, p. 3.

92 *New Zealander*, 15 October 1859, p. 3. For the review on Auckland’s sanitation, see *Southern Cross*, 9 August 1859, p. 3.


94 Despite ongoing advocacy of the 'sewage farming' concept (See, for example, Dr. Philson to the Auckland City Board of Commissioners, 14 July 1863. New Zealander, 18 July 1863, p. 3; Bush, G. W. A., *Decently and in Order: the Government of the City of Auckland 1840-1971* (Auckland, 1971), p. 119), the sort of sewage works envisaged in the original proposal was not to be built for another half century (See Barr, John, *The City of Auckland, New Zealand, 1840-1920*, with a chapter by George Graham (Auckland, 1922), p. 203).

95 ['A Cockatoo Settler']. New Zealander, 19 January 1861, p. 3. The authorship of the series of articles, collectively entitled 'Soils of the Province of Auckland', was ascribed to 'A Cockatoo Settler' in a commendatory letter by 'Old Practical' ('Old Practical' to the Ed. Ibid., 27 February 1861, p. 5).

96 The ascription of Morey's authorship here to *Speed the Plough* is based on that in the New Zealand National Biography. [Morey, Charles], *Speed the Plough; or, The Colonial and New Zealand farmers' guide* (Auckland, 1863), p. 26). For a case where night-soil was being removed for manurial purposes, see New Zealander, 18 July 1863, p. 3.


In a similar vein, the New Plymouth settler Charles Hursthouse described, in his work *New Zealand, the 'Britain of the South*', the genial New Zealand climate as having a "manure-acting" character (Hursthouse, Charles, *New Zealand, the 'Britain of the South*', with a chapter on the native war, and on future native policy 2nd ed. (London, 1861), p. 193. This phrase was subsequently repeated in the first of the articles by 'A Cockatoo Settler'.


In the example given by 'A Practical Settler', part of the wheat field to which guano (together with dung) was applied at a cost of 30s. per acre, which would equate to about 1.5 cwt. per acre, gave a yield which was 12 bushels per acre more than another part to which no manure was applied. 'A Practical Settler' to the Ed. Ibid., 9 January 1861, p. 3. In that wheat yields in the outlying districts were in the order of 15-25 bushels (see footnote 116), this seems consistent with the comment of 'A Cockatoo Settler' that guano use increased wheat yields by a third (['A Cockatoo Settler']. *New Zealander*, 30 January 1861, p. 5).

['A Cockatoo Settler']. *New Zealander*, 23 February 1861, p. 3. See also, in relation to producing manure by feeding 'artificially'-fertilised turnips to sheep, ibid., 13 November 1861, p. 3.

['A Cockatoo Settler']. Ibid., 30 January 1861, p. 5.

May, Joseph, 'Farm Management'. In Chapman, George T. (ed.), *Chapman's Handbook to the Farm and Garden* (Auckland, 1862 ?), p. 57. See also ['A Cockatoo Settler']. *New Zealander*, 20 August 1861, 3; [Morey], *Speed the Plough*, p. 23. For a contrary view, see Spencer, 'Artificial Manures' (paper to the New Zealand Agricultural Society, 2 March 1863). *Daily Southern Cross*, 17 March 1863, p. 5.
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108 New Zealander, 8 December 1860, p. 5.
109 'An Independent Settler', 20 December 1860. Ibid., 26 December 1860, 3.
110 ['A Cockatoo Settler']. Ibid., 19 January 1861, p. 3.
112 Statistics of New Zealand for 1861, Table 1.
113 May. 'The Exhaustion and Renovation of Soils' (paper to the Otahuhu Agricultural Association, 3 September 1860). Southern Cross, 18 September 1860, p. 3. See also New Zealander, 12 December 1860, p. 3, & 19 December 1860, p. 3.
114 'A Practical Settler' to the Ed. New Zealander, 9 January 1861, p. 3.
115 ['A Cockatoo Settler']. Ibid., 9 January 1861, p. 2. It should be said, in the defence of those who were being criticised, that many settlers had been discouraged from turnip cultivation on account of crops being ruined by blight ([Morey], Speed the Plough, p. 28).
116 New Zealander, 17 November 1860, p. 5; 'A Practical Settler' to the Ed. Ibid., 22 December 1860, p. 3; 'An Independent Settler' to the Ed., 20 December 1860. Ibid., 26 December 1860, p. 3; ['A Cockatoo Settler']. Ibid., 1 June 1861, p. 5, & 22 June 1861, p. 3.
117 See also ['A Cockatoo Settler']. Ibid., 9 January 1861, p. 2; 'A Practical Settler' to the Ed. Ibid., 9 January 1861, p. 3.
118 One regiment out of the six remained in Taranaki. Gibson, Tom, The Maori Wars: the British army in New Zealand (Wellington, 1974), p. 93. At the time, New Zealand's military population stood at 7294 (including 1458 family members)(Statistics of New Zealand for 1861, Table 1).
120 The figure for 1862 was compiled through a combination of shipping lists, monthly customs records, and figures for shipments made by Combes and Daldy. Entries for tonnages in shipping lists (Southern Cross, 4 March 1862, p. 3; New Zealander, 7 June 1862, p. 2, & 17 December 1862, p. 2) add up to 240 tons, and leave two monthly customs returns (New Zealander, 6 August 1862, p. 5; Daily Southern Cross, 30 September 1862, p. 4) outstanding. The September customs return states guano worth £640 was entered in the port, and this seems to coincide with a Combes and Daldy reference to an 80 ton shipment being made in that month (Smith, 'The Beginnings of the New Zealand Phosphate Trade, 1855-1870' (Unpublished M. A. thesis, University of Otago, 1966), p. 45). The remaining return amounts to £522, and it has been assumed that this corresponds to about 60 tons worth of guano. Finally, there are two small imports in
shipping lists not otherwise counted: one was of 56 bags (Southern Cross, 8 April 1862, p. 5), and the other of 85 bags (Daily Southern Cross, 20 October 1862, p. 3). Adding these together would make about 10 tons guano. Totting it all up we have

240 tons + 80 tons + 60 tons + 10 tons = 390 tons.

The combined value of imported guano, calculated from monthly customs returns (Daily Southern Cross, 31 January 1863, p. 4, 6 April 1863, p. 4, 30 April 1863, p. 3, & 1 August 1863, p. 4) amounted to £2070. Given that some of this was expensive Peruvian guano (see subsequent text of chapter), an average price of £10 per ton has been assumed in estimating the tonnage.

See, for example, the advertisements of J. Drury (Southern Cross, 1 April 1862, p. 2), Alfred Buckland (New Zealander, 17 May 1862, p. 1) and Henderson & Macfarlane (New Zealander, 2 August 1862, p. 7).


For analyses of Coral Queen Island guano see [Morey], Speed the Plough, p. 25; New Zealand Exhibition 1865. Reports and Awards of the Jurors (Dunedin, 1866), pp. 422-3.

See the discussion in footnote no. 120. It should be noted that this total is not in accordance with the figures used by Combes and Daldy in correspondence with the Colonial Office (Smith, 'The Beginnings of the New Zealand Phosphate Trade, 1855-1870' (Unpublished M. A. thesis, University of Otago, 1966), p. 45). However, some shipments made by Combes and Daldy (e.g. New Zealander, 17 December 1862, p. 2) are not listed in the return. It is not clear why the discrepancy should arise - if intentional, it may indicate that Combes and Daldy were obtaining similar guano from other islands, or perhaps they may have downplayed shipping volumes in order to get a more sympathetic licence agreement.

Southern Cross, 11 April 1862, p. 4; Daily Southern Cross, 29 October 1863, p. 5.

Extract from Melbourne Agricultural Gazette, 23 June 1861, in New Zealander, 24 July 1861, p. 2; [Morey], Speed the Plough, pp. 23-4.

Using monthly customs returns (Southern Cross, 8 April 1862, p. 2; New Zealander, 6 August 1862, p. 5; Daily Southern Cross, 6 September 1862, p. 4, 30 September 1862,
p. 4, & 31 October 1862, p. 4). It can be calculated that at least £755 worth of bone dust was imported in Auckland during 1862. The largest individual shipment comprised of 352 bags (New Zealander, 20 August 1862, p. 2), was entered when the customs value for the month was £290. If it is assumed, on the basis of past evidence, that each bag contained about one-tenth of a ton, then this would make the value of bone dust around £8 per ton, and thus total imports, would have been in the order of 100 tons.

Daily Southern Cross, 17 September 1862, p. 2.

See ibid., 14 February 1863, p. 3.

Spencer, 'Artificial Manures' (paper to the New Zealand Agricultural Society, 2 March 1863). Ibid., 17 March 1863, p. 5. See also ibid., 28 February 1863, p. 3.

The Auckland Provincial Council had offered a £25 prize. Southern Cross, 25 February 1862, p. 4; Daily Southern Cross, 1 January 1863, p. 4.

Daily Southern Cross, 13 November 1862, p. 3.

Ibid., p. 4.

There is no data for the area sown in wheat in 1862, so it has been assumed that it was similar to the 3892 acres sown in wheat in 1861.

Dunsdorfs, Edgars, The Australian Wheat Growing Industry 1788-1948 (Melbourne, 1956), p. 475. It is likely that the large Australian surplus also caused wheat from other producing regions, such as Chile (see Hursthouse, New Zealand, the 'Britain of the South' 2nd ed, p. 188-9) to be diverted to New Zealand.

Statistics of New Zealand for 1862, Table 18; Statistics of New Zealand for 1863, Table 18.


Between 1859 and 1863 there does not seem to have been so much public debate over the scheme, although it had flared up from time to time in the Auckland Provincial Council (See, for example, New Zealander, 30 January 1861, p. 3).


See Craig, Elsdon, Breakwater Against the Tide: a History of Papakura City and Districts (Papakura, 1982), pp. 73 & 128.

Statistics of New Zealand for 1861, Tables 49 & 50; Statistics of New Zealand for 1864, including the results of a Census of the Colony taken in December of that year (Auckland, 1866), Part Two - General Statistics, Table 42 [unpaginated]. The 1666 acre figure is based on the fact that the area where fighting took place
roughly equates to areas of Pakeha settlement within what were the Frankland and Raglan electoral districts (See McRobie, Alan, *New Zealand Electoral Atlas* (Wellington, 1989), p. 32).

145 *Daily Southern Cross*, 13 November 1862, p. 4.


147 *Statistics of New Zealand for 1861*, Table 49; *Statistics of New Zealand for 1864*, Part One - Census Results, Table 23. At its height, the number of draught animals in military service was 2244 (Cowan, James, *The New Zealand Wars: a history of the Maori campaigns and the pioneering period* [1922] (Wellington, 1983), I, p. 244).

148 The total value of bone-dust entered into Auckland, according to monthly customs returns, was at least £2500 (See *Daily Southern Cross*, 30 April 1864, p. 4, 31 May 1864, p. 4, 30 June 1864, p. 4, 31 October 1864, p. 9, 30 November 1864, p. 3, & 31 December 1864, p. 3). The comparative value in 1862 was only about £750 (see footnote no. 130). Concern about guano adulteration may also have a factor in this large increase in bone dust imports (See 'Agricola' to the Ed., 14 July 1863. *New Zealander*, 18 July 1863, p.3). Nevertheless, clearly there was still a large market for guano in Auckland - one shipment, made by Combes and Daldy in August 1864, consisted of some 230 tons (*New Zealander*, 31 August 1864, p. 2).


150 J. C. F[irth], 'Notes of a Visit to the Thames and Waikato Districts'. *New Zealander*, 21 January 1860, p. 5.


152 *Statistics of New Zealand for 1867. Including the Results of a Census of the Colony, taken in December of that year* (Wellington, 1869), Part Two (General Statistics), Table 18.


155 Bellamy, *B.O.P. First in Fertiliser*, p. 5; Tait, A. N., 'The Growth of Fertiliser Use in New

156 Daily Southern Cross, 8 June 1863, p. 1, & 30 September 1865, p. 10. It appears a small bone-mill may also have operated at Warkworth for a time in the 1860s (See Royal, T. K., 'The Phosphate Manufacturing Industry in New Zealand' (Unpublished M. A. thesis, University of Auckland', 1967), p. 27).

157 Statistics of New Zealand for 1867, Part One (Census) - Table 30. Results of a Census of New Zealand, taken for the Night of the 27th of February 1871 (Wellington, 1872), Table 31 [unpaginated]; Results of a Census of the Colony of New Zealand, taken for the Night of the 1st of March 1874 (Wellington, 1875), p. 270; Results of a Census of the Colony of New Zealand, taken for the Night of the 1st of March 1878 (Wellington, 1880), p. 347. The survival of Soppet's mill, at least until the mid-1870s, is indicated by advertisements (New Zealand Herald, 8 August 1877, p. 1).


159 See, for the early history of topdressing of pasture in Auckland Province, Miller, J. M., 'Topdressing'. New Zealand Journal of Agriculture 75(1) (1947), p. 27. It is interesting to note that in 1860 Joseph May commented that clover growth was not as luxuriant as it had been in earlier years. May, 'The Exhaustion and Renovation of Soils' (paper to the Otahuhu Agricultural Association, 3 September 1860). Southern Cross, 18 September 1860, p. 3. It is not clear though whether this clover deterioration was caused by insufficient phosphate levels in the soil, or 'clover-sickness' (See Frem, W., Elements of Agriculture 9th ed., ed. by J. R. Ainsworth-Davis (London, 1914), p. 350).

160 Martin (paper to Otahuhu Agricultural Association, 3 October 1859). New Zealander, 19 October 1859, p. 3.
Chapter Nine

The late developers: farming practice and soil fertility in Otago and Canterbury before 1860.

By the start of the 1850s, the older main settlements in New Zealand were already beginning the transition from soil-exhausting agricultural systems to those where fertility was largely conserved, but the final New Zealand Company settlements, Otago and Canterbury, were only just getting established. As this chapter will show, the course of agriculture and soil fertility management practice in Canterbury and Otago essentially replicated that in the settlements to the north, except for two decades of development being compressed into one.

I. Getting started: the Otago experience

Like Nelson and Auckland before it, the site of the Otago settlement consisted largely of open land, with the limited forest cover being confined to the hilly margins. As seen in Chapter Four, this led to its being seen as primarily suited to pastoral farming. Happily for the Otago Association, the agricultural operations of the whaler John Jones at Matanaka (near Waikouaiti) nevertheless demonstrated that fertile soils and good yields could be obtained within the region.

By the mid-1840s, in addition to stock numbering 2000 sheep, 200 cattle and 100 horses, Jones' farm had about 100 acres under crop, half of which was wheat. Much of the farm's soil, as Dr. Monro found during his visit in 1844, was "rather sandy", but "where the trees had been cleared away", it was "of a rich loamy quality". In the latter, a weakly leached soil, derived from calcareous sandstone, which is highly fertile, Jones grew potatoes which Monro described as "exceedingly fine". His wheat crop, however, was in poor condition when Monro and Frederick Tuckett saw it; this Monro put down to bad seed and insufficient tillage. These deficiencies had been rectified by 1847 though, as it was reported that Jones' wheat yield that year was 70 bushels per acre. Similarly, in early 1849 William Fox remarked that Jones' previous crop, grown on "land which had never been manured", amounted to 60 bushels of wheat per acre. This afforded, as he put it, "a very practical refutation of some suggestions formerly made ... in England, as to the insufficiency of the Otago climate for the growth of wheat".
The lack of manure use alluded to may have resulted from early failures growing turnips; what Tuckett observed in 1844 was only "a shadow of a crop".8

That these wheat yields were equivalent to those obtained in the renowned Hutt Valley must have given the Otago Association high hopes for the previously unfancied 400,000 acre Otago Block.9 Under the New Zealand Company plan, 144,600 acres suitable for agricultural settlement were subdivided into 2400 individual parcels of 60.25 acres (consisting of 0.25 acre, 10 acre, and 50 acre allotments which formed the town, suburban and rural sections respectively), while the remainder was set aside for the depasturing of stock.10 Within the areas encompassed by the suburban sections, the locations of which are shown in Figure 9.1(a), the best soils were found on the undulating forest-covered slopes on both sides of Otago Harbour. These are a mixture of yellow-brown earths, derived from loess, and brown granular loams, derived from weathered basalt. Where the basaltic component is greatest, the soils possess medium to high levels of natural fertility, together with good structural durability during cropping, on account of their high aluminium and iron oxide content.11 The same slopes, however, were also badly exposed to blustery winds funnelling along the harbour.12 Nevertheless, the Otago Association's Scottish settlers were as impressed with them as Tuckett had been during his 1844 reconnaissance.13 As Thomas Burns, the settlement's first Presbyterian minister, observed in mid-1848 "the soil on these hills, and all around generally, is remarkably rich". Moreover, Burns discovered the hilltops were covered by not by "rock and heath", as in Scotland, but by "the same soil as at the bottom of the hills".14 Subsequently, he again extolled the quality of the soil, describing it as "an excellent wheat soil, that would probably bear a long succession of cropping, with little or no manure".15 Similarly, William Duff, in a letter home, noted that the soil was "very rich".16

The hillslope soils at the head of the harbour, meanwhile, are mainly yellow-grey earths.17 Although these soils are also derived from loess, in the absence of any basaltic component, they are generally only moderately fertile. Typically soil acidity is usually moderate to high, with levels of basic nutrients being low. These soils also suffer from the formation of a fragipan (a dense subsoil horizon where the veins in the blocky soil structure have been filled up with grey-coloured clays). The fragipan impedes soil drainage, thereby making them more prone to waterlogging than the climate (in which precipitation is under 1000mm per annum) would suggest. Lastly, the poorly developed subsoil structure also makes these soils highly prone to erosion once cultivated.18 Despite these shortcomings, the Hand-book to the Suburban and Rural Districts still found enough promise in
Figure 9.1
The lay-out of sections in the Otago Settlement


As Figure 9.1(a) shows, all the 10-acre suburban sections were situated around the head of the harbour, or in valleys (Kaikorai Valley and Green Island) behind Dunedin. At left are the rural sections, the full extent of which are shown in Figure 9.1(b). To the west of the sections in the Tokomairiro was what Charles Kettle described as 'extensive undulating grassy country' (Kettle, Charles, 'Map of the Settlement of Otakou, New Zealand. 1847'.)

Figure 9.1

[Map showing Maori settlements and boundaries in Otago Block, New Zealand.]
these soils to describe them as being "for the most part of good quality". They also had the advantage, over the soils on the Otago Peninsula at least, of not being wooded, making them easy to clear.\(^{19}\) The suburban sections also took in recent alluvial soils in the Kaikorai, North-East or Green Island Valleys. These were acknowledged by settlers to be highly fertile, but there were no great expectations of their immediate agricultural productivity since, as the Otago News reported, the valleys were "frequently swampy", and therefore would need to be drained before they could be "worked with advantage and profit".\(^{20}\) The same problem afflicted the low-lying alluvial soils of the South Dunedin flats. In some places waterlogging has been sufficient for peaty soils to develop.\(^{21}\)

The issue of fertility versus drainage was even more central to the desirability of the rural sections. As seen in Figure 9.1(b), these stretched southwest in a discontinuous strip, running from the Taieri Plain, via Lake Waihola and the Tokomairiro valley, to the Clutha Plain (then known as the Molyneux district). As Figure 9.2 indicates, the floodplain and river flats of the Taieri and Clutha both contain sizable areas of alluvial soils, which are moderately to highly fertile,\(^{22}\) while yellow-grey earths, which are moderately fertile,\(^{23}\) predominate in the Tokomairiro Valley. Consequently, after viewing the Taieri in 1849, one Green Island settler, stated that the "land is the best I ever saw, from five to seven feet deep of the finest soil, and as level as a table".\(^{24}\) Likewise, an Otago News correspondent in 1848 stated that the Molyneux district would be "the district par excellence of the Otago settlement ... The soil everywhere is excellent".\(^{25}\) The esteem for the Clutha district did not rest solely on hyperbole, moreover, as in correspondence in the Otago Journal (the official journal of the Otago Association)\(^{26}\) an early settler, after declaring that it was a "fine country for wheat, barley, oats, and potatoes", reported having obtained a yield of 60-80 bushels of wheat per acre there.\(^{27}\)

The fertility of these tracts was unquestionable; what was open to doubt was the degree to which poor drainage prevented their use. Drainage proved a problem for two reasons: firstly, because of low elevation - parts of the Taieri Plain are below sea level - and frequent flooding,\(^{28}\) and secondly, because of the development, to varying degrees, of fragipans in the soils. Where fragipans were at their worst, the soils were also rendered prone to summer droughts, since the fragipan reduced the effective soil depth.\(^{29}\) The settlement's surveyor, Charles Kettle, attempted to avoid the most swampy areas, as is evident from the near absence of sections on the west Taieri Plain, but a number of critics, amongst them H. B. Graham, editor of the Otago News,\(^{30}\) regarded all the level parts of
Within Otago, there are only two significant areas of recent alluvial soils, namely the Clutha and Taieri Plains. In the former these soils occupy approximately 25,000 acres, and in the latter they occupy 40,000 acres (Molloy, Les, *Soils in the New Zealand Landscape: the living mantle* 2nd ed. (Lincoln, 1993), p. 197). As a comparison with Figure 9.1(b) shows, the recent alluvial soils on the Clutha Plains were almost entirely taken up the Otago Association's rural sections, though much of their extent on the Taieri Plains was not included within the section boundaries because of their excessive moisture. The other soil group which was widely employed in agriculture during the nineteenth century in Otago were yellow-grey earths, especially those in the Tokomairiro district, in the suburban districts around Dunedin, and in North Otago (that is, surrounding Oamaru). It should be noted that these soils were intermixed with brown granular loams (derived from basalt) in the vicinity of Otago Harbour, and with rendzinas (calcium-rich soils) south of Oamaru.
MAIN SOIL GROUPS OF Otago

- Brown-grey earths
- Yellow-grey earths
- Yellow-brown earths
- Yellow-brown earths podsol complex
- Rock, ice and scree
- Recent alluvial soil

Figure 9.2
the rural districts as initially unfit for profitable agriculture. Despite assertions to the contrary, most notably by William Cargill, the New Zealand Company's Resident Agent,31 and also in literature promoting immigration - Earp's *Handbook to the Southern Settlements*, for instance, depicted the swamps as desirable pockets which would "soon yield to the energy of the agriculturist"32 - few settlers were convinced that drainage would be easily accomplished. This, coupled with the shortage of timber and the lack of roads, meant that hardly any began their farming on rural sections.33

Instead, the settlers of 1848 chose to locate their initial agricultural and horticultural operations mainly on suburban sections in the North-east Valley, Kaikorai Valley and at Half-way Bush. These were close to the town, and combined open land with forest; the open land enabled limited running of stock, while the forest provided timber for fuel and building. Once cleared, forested areas were also immediately available for crop production.34 This was probably more significant at Dunedin than at most other settlements, as the colder climate and dampness of the poorly drained soils would have slowed bracken decomposition, and thus 'fern land' would have been 'sour' for longer.35 The downside of starting out on these 10-acre sections was that the settlers soon ran out of room. Many began by practising cottage farming, growing an acre or so of foodstuffs and keeping small numbers of livestock, such as poultry, pigs and dairy cows,36 and while unoccupied land remained available for common grazing, their sections had been perfectly adequate. By mid-1849, however, the *Otago News*, which had previously condemned the sections as being too small, and thereby a waste of labour and investment that could have been better used elsewhere,37 noted "that people are beginning to complain of want of space for their cattle".38 Similarly, from August 1849 settlers were grumbling that they could not grow more cereals because of damage by roaming pigs.39

These obstacles, together with slow land sales, retarded the initial growth of agriculture of the settlement.40 In the census of March 1850, as reported in the *Otago Journal*, the population numbered 1149, but there were just 291 acres under cultivation.41 Of this, one-third was under fallow in preparation to cropping, while of the remainder, potatoes formed the principal crop. The acreage in cereals, meanwhile, stood at a mere 41 acres, with two-thirds of this total being in oats, a reflection of both the cool climate and Scottish origin of the migrants.42 In stark contrast, sheep numbers already stood at 4667 (and that excluded an estimated 14,000 at Waikouaiti), thereby bearing out earlier predictions that Otago's future lay in pastoral farming.43 Presumably the *Otago News* thought that
agriculture needed some encouragement, as prior to its demise in late 1850, it began reprinting articles on 'Practical Agriculture' from the *Sydney Morning Herald*. As for yields, official estimates put these at 40 bushels per acre for wheat and 8 tons per acre for potatoes. These were higher than estimates for the other main settlements, but it is worth remembering that settlers probably began cultivation on the best portions on their sections, and that Dunedin’s soils had not been run down by previous cropping by either Pakeha or Maori. Alternatively, the official estimates may simply have been overoptimistic, as the model farm accounts published by the Otago Agricultural Association in 1851 used lower yields of 31 bushels and 5 tons of potatoes per acre. Evidently, there were also wide variations in individual yields; in 1850 the *Otago News* reported a range for wheat of between 28 and 62 bushels per acre.

II. A case of liming and dunging

Despite these good yields, the frustration of Dunedin’s settlers at having to fallow ‘fern land’ while waiting for it to become ready for crop production seems to have stimulated their interest in agricultural chemistry. As seen in Chapter Six, Nelson settlers had previously tried liming to remedy ‘sourness’, and some Otago settlers were quick to employ the same tactic. Admittedly, liming was soon superseded by dunging at Nelson, but animal dung was probably in short supply in Dunedin’s suburban districts, given the lack of room available to graze sheep or cattle. By 1850, lime had been discovered in the Waihola district, and it was being used for “agricultural purposes”, but carriage costs to Dunedin of lime from this source proved prohibitive. However, Dunedin got its own lime-kiln in mid-1851 with the opening of Macandrew’s Caversham works. While its main purpose was to service the construction sector, when an advertisement in the *Otago Witness* (reproduced in Figure 9.3) announced the kiln’s opening, it also invited farmers to inspect the lime being produced, which, it was asserted, “must prove an excellent Manure”. In an almost simultaneous development, the Otago Agricultural Association was established. Since the vast majority of Scottish migrants to Otago in these years came from Midlothian, which was widely recognised as the heart of progressive agriculture in Scotland, this might seem unremarkable, but for the formation, in the first institutional recognition of agricultural chemistry in New Zealand, of a Mineralogical and Agricultural Chemistry sub-committee. Interestingly, Daniel Macandrew, the kiln’s co-proprietor, became the sub-committee’s first convenor.
Macandrew's first lime-kiln, going by the text of a subsequent advertisement, was built "at Pleasant Villa, Caversham Vale" (*Otago Witness*, 19 July 1851, p. 1), that is, just to the south of the town. According to a report in the *Otago Witness*, this kiln was unable to keep up with demand, so Daniel and James Macandrew decided to build another which was capable of producing 150 bushels per day (Ibid., p. 2). This was built in the Kaikorai Valley (Ibid., 1 November 1851, p. 2). An advertisement for this second lime-kiln, which appeared in 1852, noted the "importance of this valuable ingredient for securing a crop in a newly broken up open land". (Ibid., 1 May 1852, p. 2).
GREY SEA-STONE LIME. — Builders, Farmers, and others, are invited to inspect the LIME turned out from a Kiln erected by the Subscribers on Captain Blackie's Sections, which, from its hydraulic properties, is a strong Cement, and must prove an excellent Manure. It is far superior to "Shell Lime" for all sorts of Masonry, Plastering, and external Painting.

Wholesale Prices for Cash on delivery, in quantities not less than 22 Bushels, or one cubic yard:—Sixpence per Bushel at the Kiln, and Ninepence per Bushel at the Store. Retail Prices:—Ninepence per Bushel at the Kiln, and One Shilling per Bushel at the Store.

JAMES MACANDREW, & Co.
As the *Otago Witness* records, the message that 'fern land' should be limed, which is not an unreasonable one, was reiterated several times in the succeeding months. A correspondent signing himself as 'An Agriculturist', for example, pronounced that the luxuriant wheat crop growing on wet ground he had limed, as opposed to that on unlimed ground, had "completely removed" the "considerable doubts of the fertilizing properties of Otago lime" he had had previously. William Cargill, meanwhile, exhorted others to follow the lead of his farm manager, Francis Marshall, who, having harvested an area of oats and potatoes (the latter of which had been slightly manured with cow dung), subsequently applied 22 bushels of lime to the entire cultivated area. For later migrants, the drumming in of the message to lime 'fern land' began even before they left Scotland. Within the 1851 edition of the *Emigrant's manual* produced by the Edinburgh publishing house Chambers, there was a lengthy discussion of 'fern land' 'sourness' and the role lime could play in accelerating the decay of "inert vegetable matter", which drew upon the role it placed in reclaiming peat-mosses 'at home'. This was reprinted in the Edinburgh-published *Journal of Agriculture*, and later in both the *Otago Journal* and the *Otago Witness*.

Even after such prompting, lime or manure application continued to be uncommon though. As at previous New Zealand settlements, overconfidence in the capabilities of the soil probably contributed to this carefree approach. Certainly, this is suggested by a paper delivered by Septimus Braithwaite to the Otago Agricultural Association in July 1852. In it, Braithwaite declared himself most anxious to disabuse the minds of the public at home from the very prevalent idea that the lands of New Zealand are so very fertile that no manure is required. The fallacy of such a statement ... has already been fully proved by all those who attempted to cultivate "open land", or even bush land, after the third year. From the present system adopted in this colony without manure, I am not surprised at the cry "that farming will not pay".

Local farmers, in their defence, could have asked where this manure was going to come from, since, in addition to stock having been squeezed out of the suburban districts, hilly terrain and poor roads made carting dung from elsewhere difficult. Pre-empting such a response, Braithwaite went on to say that:

Your cattle and sheep constantly on their runs, how do you propose to restore organic and mineral constituents your crops are carrying off your soil? You must have recourse to artificial manures; and with
their aid ... the limit of the productive powers of the soil of New Zealand under such a climate can neither be predicted nor foreseen ...

Braithwaite then observed that local farmers could employ, for the purposes of fertilisation, not just lime but charcoal too. This assertion was based on the then commonly held, albeit erroneous, belief that charcoal absorbed copious amounts of atmospheric ammonia, thereby making the supply of nitrogen through farmyard manure unnecessary.60

Braithwaite was probably fighting a losing battle, as enthusiasm for agricultural chemistry was already beginning to wane. Indeed, when 'An Agriculturist' submitted a list of nineteen questions to the Otago Witness in May 1853, raising such pertinent issues as how long 'fern land' ought to be fallowed before growing grain crops, how many crops of grain could be obtained without manure, and what caused the deficiency in the previous year's potato crop, it failed to attract any answers.61 Almost certainly, this incipient apathy was a consequence of the increasing movement of settlers on to their rural sections, and also on to similarly sized sections north of Dunedin. The latter land, incidentally, had been in Crown hands since 1848, and W. B. D. Mantell began disposing of it after his appointment as Commissioner of Lands in 1851, much to William Cargill's disgust.62 As early as 1854, 669 acres of wheat were being cultivated beyond the bounds of the suburban districts as opposed to only 408 acres within them.63 Since, as related above, the soils of the rural sections were generally more fertile than those on the suburban ones, farmers had greater leeway to carry on soil-exhausting agricultural practices than before. Moreover, the dispersal of the farming community caused the Dunedin-based Otago Agricultural Association, which had been the main (and perhaps only) forum for discussion of agricultural chemistry, to become defunct. Thereafter, settlers could still converse about agricultural matters at communal meeting points such as churches, but only on an ad hoc and informal basis.64

The short-term abundance which attended this migration to the rural sections is evident in the comment of Thomas Bannatyne Gillies in 1857, who, heading south from Dunedin, reported that he had found "well authenticated instances of from 18 to 22 tons per acre of potatoes being grown, and several heavy wheat crops in succession being obtained from the same piece of land without manure".65 Likewise, John Cargill stated, in his 1860 pamphlet aimed at intending emigrants, that "50 to 60 bushels of wheat per acre have been obtained without manure off lands at Waikowaite [Waikouaiti], the Clutha, and Taieri", 
and in one instance, 23 acres in the Tokomairiro left fallow during the previous summer had yielded 90 bushels per acre. Although these are extreme cases, crop yield estimates for the province as a whole were indeed higher during the mid- to late 1850's, with the estimates for wheat being around 35 bushels per acre. In such favourable circumstances, it is not surprising that the acreage of crop land expanded rapidly, as illustrated in Table 9.1. Despite this expansion, cereal cultivation did not pose any challenge to the dominant position of pastoralism, as it too had forged ahead. Indeed, by 1859 stock numbers in Otago had climbed to more than 24,000 cattle and 332,000 sheep.

If the content of the Otago Witness is any indication, it seems that concerns about managing soil fertility nevertheless revived in Otago at the end of the decade. Cargill's aforementioned pamphlet is further evidence of this, as it advised prospective emigrants that the cited cases of high yields from unmanured land were exceptional, and that those in less auspicious situations would have to improve their soil "by manure and labour" to obtain similar yields. As was seen in Chapters Seven and Eight, the older main centres saw a similar revival during the late 1850s, although in those centres it was a reaction to the expedient measures taken by agriculturists cashing in on the inflated prices brought about by the Victorian gold-rush. This was less relevant in Otago, as even at the height of Victorian-inspired demand, local produce prices were still falling from the levels reached when the settlement was established. Another external influence which highlighted the dangers of soil exhaustion was recent publications on the state of American agriculture. One condemnation of poor farming methods in Otago, submitted to the Otago Witness in July 1858, in fact drew an explicit parallel between the fate of America's soils, and what might happen to those in Otago:

Table 9.1: Acreage of crops cultivated by Pakeha in Otago 1853-9

<table>
<thead>
<tr>
<th>Year Sown</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Other</th>
<th>Total</th>
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<td>1753</td>
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<td>9321</td>
</tr>
<tr>
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<td>3234</td>
<td>76</td>
<td>487</td>
<td>3958</td>
<td>915</td>
<td>11,274</td>
</tr>
</tbody>
</table>
... our present system of agriculture cannot continue. While a virgin soil spontaneously yielded its crops at the tiller's bidding we reaped without a care; but the most fertile land, like some of the states of the American Union, must become exhausted, and then we must have recourse to manure. This involves an organic change, for manure necessitates stock, and stock can only be kept where the rotation system of crops is adopted ... 74

Despite such views, crop rotations were not widely practised in Otago, as Chapter Ten demonstrates, until the mid-1860s. Even so, some agriculturists, amongst them the Clutha's Edmund Bowler, were starting to restore soil fertility by applying manure. This strategy was aided by the emergence of dairying in the late 1850s, an activity which the poorly drained soils were well suited to, since the penning of cows allowed their dung to be collected fairly easily. 75 Having said this, applying the dung, which was often put on the potato field, was still an expensive and labour-intensive process - on Bowler's farm in 1860, it took a whole week. 76 An alternative strategy for land that was no longer able to produce remunerative crops was to rest it under pasture. Given that by the late 1850s some rural sections may have been in cultivation for nearly a decade, it may not have been just the favourable economics of wool production 77 that prompted the rapid increase in the sown pasture acreage after 1856.

In conclusion, it appears that most of Otago's agriculturists in the 1850s were not prepared to undertake the burdensome task of manuring in order to maintain soil fertility on crop land. Aggregate yields had been high since the move on to the rural sections, and if individuals were in danger of exhausting their soil, they could instead rely on the gradual build-up of soil fertility under pasture. While doing so, they could expand their pastoral operations, which, at the time, were highly profitable. As this would in many instances have followed several years of high arable productivity, Otago's agriculturists seemed to be on to a good thing. However, their big test was just around the corner, as the massive influx of population associated with the gold-rush would put at risk the sustainability of Otago cropping.

III. A fleeting French foray

In the history of early Pakeha settlement in New Zealand, Canterbury's foundation was atypical. Organised settlement came to Canterbury not once but
twice - firstly with the Nanto-Bordelaise Company in 1840, and secondly with the Canterbury Association in 1850. While only the latter was ultimately significant from an agricultural viewpoint, the former is worth examining as it represented the first attempt to bring European agriculture to the region.

French interest in establishing a settlement at Akaroa began with the alleged 'purchase' of Banks Peninsula by the French whaling captain Francois Langlois in 1838. After Langlois returned to France, the Nanto-Bordelaise Company was formed to take advantage of this 'purchase', with the Company's objective being to establish a settlement from which it would buy up Maori land and then on-sell it to settlers. The French government also backed the project, as it hoped to establish a naval presence there. 78

When the Company's 57 settlers arrived in Akaroa in August 1840, they found themselves surrounded by lowland podocarp forest, which almost reached the water's edge in places. 79 The soil there is an intergrade between yellow-grey earths and yellow-brown earths (that is, with properties straddling the two soil groups) derived from loess. It is moderately fertile, but as with the yellow-grey earths in Otago, its weakly developed structure makes it slow-draining. 80 Since immigrants were required, in return for their free passage, to clear and cultivate five acres within five years, with the threat of forfeiture if they failed to do so, most French settlers avoided forested areas. The dozen Germans, meanwhile, were unable to fit in the small area of open land at Akaroa and moved north along the harbour to Takamatua. 81 As at other settlements, the returns from breaking in 'fern land', which proved especially difficult at Akaroa because there were no draught animals for ploughing until March 1841, 82 were initially disappointing. For instance, when the New Zealand Company surveyor William Mein Smith came across such land near Takamatua in 1842, and asked about its productivity, he was told that "the first year it yielded so little, that it was scarcely considered worth sowing a second". 83 The settlers found, however, that its 'sour' condition did not last long:

The Germans then commenced clearing some of the wooded land ... but this required much time, and they were induced to try the fern land a second year, when it produced so well that they were determined to retain it, and the third year it has produced a much larger crop than it did in either of the former years. 84

As was usual, the ever-reliable potato was the first crop grown to any extent, though by 1843 the French settlers' principal crop was wheat. 85 Yields were
relatively high, with as much as 80 bushels per acre being obtained from the best land, and average estimates being generally above 30 bushels an acre during the mid-1840s. An account written in 1845, meanwhile, records that potato yields ranged from 5.5 to 8 tons per acre, depending on the soil. Since there was probably little opportunity for manuring, as the small numbers of livestock at the settlement were mainly grazed at the head of the harbour, the high wheat yields probably reflect its cultivation on 'virgin' soils, together with the eradication of smut through the treatment of the seed with burnt shell lime. Yet impressive as these yields were, Akaroa did not have much of an agricultural future. After New Zealand was claimed by Great Britain through the Treaty of Waitangi, the French settlement was effectively confined to its base on Banks Peninsula. This had only limited areas of level land; indeed, the combined area cultivated at Akaroa and Takamatua, and in other parts of the Peninsula by additional Pakeha settlers, never amounted to much more than 100-150 acres during the 1840s. Not surprisingly, after the Treaty the Nanto-Bordelaise Company quickly shelved its colonisation plans, and in 1849 sold its land rights to the New Zealand Company.

IV. Turning swampland into farms: agriculture comes to the Canterbury Plains

With French influence removed, the role of managing organised settlement in the region fell solely to the Canterbury Association. Since it too was associated with the New Zealand Company, the theoretical basis for its plans closely mirrored that of the Otago Association, although Canterbury was to be an Anglican rather than Free Presbyterian settlement. The environmental setting, which was predominantly open land clothed in 'fern', lowland tussock, and flax, was also similar that in Otago. The ubiquity of this natural pasturage, situated close to the port, assured success for graziers, but the almost treeless plains were far from encouraging for arable farmers. Even Edward Jerningham Wakefield's *Hand-Book* admitted that the Canterbury Plains "did not appear adapted for tillage in small lots", and that "the soil of large tracts" appeared to be of "moderate quality". This unflattering view was probably derived from the conclusions of Tuckett and Monro, who speculated that repeated conflagrations, which were evident in the number of charred stumps they found, had exhausted the vegetative capacity of the soil. The Canterbury Association, meanwhile, advised would-be land purchasers that once the land had been "well cleared, fenced, and cultivated for..."
two or three years, it may be laid down for several years into pasture, to which the soil and climate are so well adapted". This endorsement of convertible husbandry not only recognised the commercial reality of the profitability of sheep farming - an economic activity ill-suited to the Wakefieldian principle of close settlement - but also indicates that, in sharp contrast with the approach taken at other settlements, the Canterbury Association took a fairly objective view when it came to portraying the fertility of the site's soil.

This poor reputation for cropping was, thankfully for the Canterbury Association, largely overturned by the experience of the brothers William and John Deans. They began farming at Riccarton in mid-1843, following its abandonment by Australian settlers who had arrived in 1840. In this respect, the Deans brothers played a parallel role to John Jones in Otago. When questioned about the farm's productivity by the Association's chief surveyor, Captain Thomas, the Deans brothers reported that to date their wheat yield, despite the lack of manuring, had never fallen below 20 bushels per acre, and in one year, had been as high as 60 bushels per acre. Likewise, their potato yield had been no less than 7 and as high as 20 tons per acre. Evidently, they had originally intended to manure the potato field, presumably with dung collected from the stockyards, but the correspondence to Thomas suggests that by 1849 this was not being practiced. This change of plan probably resulted from the shift in the focus of the farm to raising stock, because of the absence of a market for crops before 1850. Nevertheless, the Deans brothers did grow green crops prior to sowing 'artificial' grass. Irrespective of their intent, dung from sheep folded on these crops would have raised organic matter levels on the farm's 'fern land'.

When it came to the capabilities of the Canterbury Plains as a whole, the Deans brothers opined that the "greater part of the plain" would produce, on average, "at least thirty bushels of wheat, barley, or oats to the acre". This prediction, if realised, would have made Canterbury's cropland as productive as any in the existing northern centres. On this basis, Thomas estimated that the profit in the first year from 50 acres (the minimum size for a rural section under the Canterbury Association plan), divided into a 40 acre wheat-field and 10 acre potato-field, would almost meet the land purchase price, despite its being set at a high £3 per acre. Thomas nevertheless concluded in his report to the Canterbury Association, that the "Port Cooper district is and will be for many years to come principally pastoral". This is not surprising, given how successful the Deans brothers stock-rearing operations had been, as they told Thomas, "all kinds of stock thrive
amazingly". In this regard, William Deans observed in 1849 that the average fleece weight of young sheep at Riccarton was 4.75 lbs., and every lb. of wool produced a clear profit of 1s. Against a price per head of £1 5s or more, this 4s.9d. profit per fleece was not large, but then there was natural increase to consider. If the lambing (and subsequent survival to adulthood) percentage was 80%, which was quite conceivable, given that the Deans brothers reported a lambing percentage of 105% to Thomas, then, in a five-year period the flock size could easily increase four- or five-fold. Thus five years after an initial investment on stock of say, £300, a single wool clip could realise a £250 profit.

Within the 2.5 million acre Canterbury Block, bounded by the Waipara and Ashburton Rivers, and the eastern margin of the Southern Alps, Thomas' survey team identified 500,000 acres suited to agriculture. Of this total, 325,000 acres were divided amongst the districts of Lincoln, Ellesmere, Stratford (Christchurch), Mandeville, Ashley and Oxford, while the remaining 175,000 acres were located in the so-called 'Intermediate Country', which was a catch-all term for the unsurveyed dry tussock lands on the eastern margin of the foothills. However, when the Company suspended surveying works, due to a shortfall of funds, only 300,000 acres, in the form of a strip 10-15 miles wide between the Ashley and Selwyn Rivers, had been topographically surveyed. This area was subsequently depicted in the map Part of the Canterbury Settlement (see Figure 4.3).

The predominant soils in the Christchurch area are recent alluvial soils, formed on the low terrace of the Waimakariri River fan. These soils, which are highly fertile, are hemmed in to the east by dune soils formed along the coast, to the west by older terraces of the Waimakariri River, and to the southeast by loess and basalt-derived soils of the Port Hills. To the northwest, meanwhile, are a tract of gravelly soils which form the last Waimakariri floodplain, which are moderately fertile in a chemical sense, but are normally too undeveloped physically to support cultivation. When the Canterbury Association's settlers began arriving in late 1850, they found that the recent soils of the low terrace were generally swampy. Indeed, at Mairehau and Marshland, drainage was so poor that organic soils (peats) had formed. The settlers therefore tended to distinguish between dry swamp areas, such as the levees of the Heathcote and Avon Rivers, where swamp herbs and lowland tussock were found, and wetter areas where flax and raupo were more common. A third type of vegetation found on these swampy recent alluvial soils was lowland forest, but this was limited to small areas at Riccarton and Papanui.
Beyond Christchurch, the belt of swampy recent soils on the low terrace, indicated by dashed lines in Figure 9.4, continues southwards through the Lincoln district, where it runs along the course of the Halswell River. The same soils occur north of the Waimakariri River in an arc between Kaiapoi, Woodend, and Rangiora, but their extent is limited owing to their confinement between duneland and the older terraces created by the Eyre, Cust, and Ashley Rivers. As Figure 9.4 shows, there were also large areas of swampland when the settlers arrived in the Ohoka and Leeston areas, but the soils of these swamps are derived from older alluvial terrace material than those underlying Christchurch.

Most of the surface of the two older alluvial terraces was covered by 'grassland' (short lowland tussock species), which in places was mixed with 'fern' (bracken). Of these the high terraces (denoted by the stony pattern in Figure 9.4) held the least attraction for agricultural settlers. These terraces are remote from Christchurch, and their yellow-brown stony soils, found on all but the loess-mantled northern fringes, suffer from low natural fertility. Moreover, these soils are excessively drained, which exacerbates the dry summer climate, and facilitates leaching, which has made them fairly acidic. Greater agricultural potential was shown, however, by the recent soils of the intermediate terraces. In the Mandeville district, these are sandwiched between the high terrace and the Kaiapoi-Woodend-Rangiora swampland arc, and include the Ohoka swampland referred to above, while south of the Waimakariri, they form a skirt of varying width between the high terrace and the Halswell River swampland. The nature of the soils on these intermediate terraces varies according to landform history. Soils formed from coarse deposits, such as in old river channels, have properties similar to those on the high terraces, while those formed by overflow deposits mixed with loess have relatively high nutrient levels, together with good drainage. The soils in low-lying sites on old floodbasins are yet more fertile, but their clayey texture impedes drainage—hence the development of the Leeston and Ohoka swamps.

There was little else to interest the would-be agriculturist. Sand dune sequences, on which infertile yellow-browns sands lay, occupied the shoreline north of Banks Peninsula, and along Kaitorete Spit, while around the inner shore of Lake Ellesmere (Waihora) and the Avon-Heathcote Estuary there were saline gley soils, which even today cannot be use for much other than grazing on salt-tolerant pasture species. Banks Peninsula, meanwhile, had areas of better soils, and although it lay outside the area which the Association had surveyed, the Pakeha settlement history gave some guide to potential selectors. At the heads
As this soil-landform map shows, Christchurch was sited on dry alluvial soils which straddled the belt of swampland soils between Lake Ellesmere and Rangiora. Since it clustered around the edges of this belt, initially agricultural settlement showed a similar north-south orientation. Almost all of these swampland soils were formed on the low river terraces (formed in the last 3000 years), although there were two largest blocks of swampland (at Ohoka and Leeston swamps) formed on the intermediate terrace (developed from alluvium 10,000-3000 years ago). The densely-speckled pattern was exclusively occupied by the high terraces (which formed 10,000-20,000 years ago). Immediately south of the Waimakariri River, and immediately to the west of Christchurch was the modern Waimakariri floodplain, made up of 'soils' formed in raw deposits laid down in the last few centuries (In reference to terrace ages, see Molloy, Les, *Soils in the New Zealand Landscape: the living mantle* 2nd ed. (Lincoln, 1993), pp. 180-1).
Figure 9.4

SOILS OF THE MANDEVILLE, CHRISTCHURCH & LINCOLN AGRICULTURAL DISTRICTS.
of its valleys are pockets of deep, fine-textured alluvial soils, but these were small in size, and fairly inaccessible, other than by sea. Closer to Christchurch, the mixture of loess and basalt colluvium also produced highly fertile soils in the valleys on the north side of the Port Hills. Finally, as the French demonstrated at Akaroa, the gentler harbour slopes covered by loess-derived yellow-grey earths could also be productive.127

Whereas in other New Zealand settlements, sections had been laid out for settlers to choose from, in Canterbury settlers could select land from anywhere within the Block.128 Despite the wide variety of soils described above, the Association's settlers were overwhelmingly attracted by proximity to the town site of Christchurch, and almost all the rural sections chosen in February 1851 were less than five miles from the town centre.129 Most early selectors also chose the minimum 50 acres, although 28 of the 196 land-buyers in 1851 purchased parcels of 200 acres or more.130 Subsequent buyers also concentrated their selections around the town site, so that by mid-1855, 25,000 out of the 36,000 acres sold within the Block boundaries were in the Christchurch district (see Figure 4.3).131

Within Christchurch itself the most popular areas were tracts of recent alluvial soils along the banks of the Heathcote and Avon Rivers, though by 1854 the intervening land had all been bought up. Land along the road corridor to the north, and to the south along the Halswell River was also sought after, and by 1854 purchases along these axes extended continuously as far as Halswell and Belfast respectively. In stark contrast, by mid-1853 no settlers had selected land from the peaty soils or within the dune formations on the eastern side of Christchurch. Of the land selected by mid-1853 beyond Christchurch, most was in small purchases made in the valley bottoms of Banks Peninsula, although on the Plains themselves, some individuals had selected as far afield as Rangiora, in order take advantage of the Rangiora Bush. Ecclesiastical and educational reserves also encompassed much of the swampy alluvial land between Kaiapoi and Woodend. Conversely, the settlers avoided, without exception, the dry and stony soils of the terraces.132

Despite the land sales described above, and the initial rapid increase in immigrant numbers, which saw the Canterbury Block's Pakeha population rise to 3300 by the time of the November 1851 census,133 farming itself experienced mixed fortunes. In short, while the pastoral sector went from strength to strength, to the extent that by November 1851 there were 20,000 sheep being grazed within the Block (excluding Pigeon Bay and Akaroa) and a further 13,000 being grazed outside the Block, the arable sector languished. Indeed, the area in cultivation,
including garden crops, within the Block (excluding Pigeon Bay and Akaroa) was only 771 acres. Even after the Akaroa and Pigeon Bay populations were subtracted, this equated to less than 0.3 acres in crop per settler. Outside the Block, meanwhile, there were only 73 acres in crop. This lacklustre start was probably caused by the shortage of agricultural labour which arose when many settlers left to try their luck on the Victorian gold-fields. Subsequently, clearing and cultivating operations not only took longer, but proved more expensive too. Rather than costing the £3 per acre to clear and cultivate that Thomas has predicted, clearing alone of dry swampland growing flax and 'grass' cost about £4 per acre, and where tutu was found, which was typically on the fertile soils of the intermediate terrace, the expense of breaking roots by hand could raise costs to as much as £12 per acre. With fencing and ploughing costs also higher than anticipated, the resulting set-up cost for an arable farmer, could be as much as £14 per acre. Even at the high crop prices then reigning in Canterbury, these start-up costs, exclusive of the minimum £3 per acre for land purchase, equated to the gross revenue from a 25 bushels per acre wheat crop. Moreover, while these high prices helped settlers recoup their expenditure, they also precluded 'export' to other New Zealand centres. With almost no external market, there was no incentive to expand production beyond that required by internal demand. Of the crops grown within the Block in 1851, potatoes, which accounted for 250 acres, were again the chief pioneering staple, while oats and wheat came next, with their acreages amounting to 187 and 135 acres respectively. The large area in oats relative to wheat probably reflects the delays experienced in cultivation operations, which meant sowing was late, although according to the settler Robert Paul, many farmers found that they could obtain fair crops of oats from newly cultivated land, which would normally have been fallowed. Since oats were often sown when farmers were making the transition from field crops to sown pasture, this may also have promoted its cultivation.

V. Mixing grass and grain

Things looked decidedly brighter, however, across the whole rural sector when a census was taken in March 1854. While Canterbury's pastoralists still dominated the farming scene - within the province as a whole, sheep now numbered almost 100,000 - the area under crop had now reached, as Table 9.2
Table 9.2: Acreage of crops cultivated by Pakeha in Canterbury 1853-8.139

<table>
<thead>
<tr>
<th>Year Sown</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Other</th>
<th>Total</th>
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</tbody>
</table>

shows, 2920 acres. This amounted to 0.75 acres per Pakeha settler.140 More than half the total consisted of wheat and oats, and sown grass accounted for less than one-tenth. The latter was presumably sown by dairy farmers, then engaged in a small 'export' trade.141 The yields, meanwhile, which were being obtained simply by relying on the soil's natural fertility were reasonably high. In February 1852, for instance, the Lyttelton Times commented that the yield "of both wheat and green crops in the low-lying lands is ... equal if not superior to the average of the old country, a fact that is sufficiently encouraging when the newness of the soil and its consequent sourness and impurity is taken into consideration".142 Regrettably, crop estimates were not officially collected at this time, but given contemporary English yields, the above statement suggests a yield for the 1851-2 season in the order of 30-40 bushels of wheat per acre. This would accord with William Wilson's remark in 1853 that most agriculturists had obtained wheat yields of 40-50 bushels per acre before a quarter of the crop had been destroyed by smut, and equally, with Robert Paul's statement that six quarters (48 bushels) per acre represented a good wheat crop.143 References to potato yields are less frequent, but Paul gives a normal figure for "good rich soils" of 6-10 tons per acre.144 Individual extremes, which were frequently quoted, were naturally much higher. On cleared forest at Pigeon Bay, Ebenezer Hay harvested 22 tons of potatoes per acre,145 while on his farm on the Avon, William Brittan obtained 70 bushels of wheat per acre without the use of manure. In a preamble to Brittan's letter which described this achievement, the Lyttelton Times exuberantly proclaimed that "seventy bushels and upwards of wheat to the acre is now un fait accompli, and considering that this has resulted from nature alone ... we may well have reason to rejoice, and foresee a future when the plains around Christchurch shall teem with abundance".146

The mid-1850s, therefore, seemed full of promise in Canterbury. As Henry Sewell, who had been appointed to wind up the Canterbury Association's affairs, expressed it:
A country with fertile soil ready for the plough, with a market open for wheat at 10s. per bushel, potatoes from £6 to £10 a ton and other produce in proportion, with 200,000 sheep multiplying at the rate of 80 per cent annually, cannot fail to grow rich rapidly ...  

Sewell had good reason for being so optimistic. The pastoral frontier was now expanding at an unprecedented rate, thanks to the new land regulations passed by Governor Grey in 1853, which lowered the price of waste land outside the old Block boundaries to 10s. per acre. By the end of 1855, the area occupied by sheep runs reached the edge of the Canterbury Plains, and it encompassed most of the foothills the following year. On account of the gradual build up of stock on these runs, by December 1858, the provincial sheep population had risen to 343,000. The cropland frontier also underwent renewed expansion, albeit at a slower rate, helped along by the lowering of the land price within the old Block to £2 an acre in 1856. Again the new purchasers favoured the dry swampland, with a line of new small farms snaking their way along the Halswell River valley as far as Taitapu, and another belt filling the unoccupied land between Kaiapoi and Rangiora. The progressive breaking in of land on both these and existing farms meant that 13,612 acres were under crop by the close of 1858.  

In the years since 1854, many agriculturists had begun to practise intensive mixed farming. While wheat remained the largest crop by area in Canterbury in late 1858, it was now almost matched by 'artificial' grass. This certainly accorded with the Canterbury Association's earlier advice that land would be more profitable if retired to pasture after two or three successive wheat crops, and likewise with Paul's comment that "if the soil is good ... two or three successive crops of wheat may be taken from the same land". This advice was quite sensible, as the organic matter content in the topsoil on the drier soils of the Canterbury Plains is generally less than 7%, which is fairly low by New Zealand standards, and accordingly wheat crops in Canterbury today need nitrogen fertilisation to give good yields once 3 or 4 crops have been taken off land previously under pasture. However, rather than the rejuvenation of organic matter levels under pasture being uppermost in the farmer's mind, agricultural economics may have been the crucial factor. During the late 1850s, the grain price slumped to only 6s. per bushel, or half of what it had been in the early 1850s, while the price of sheep remained fairly stable at around £1 5s. per head. If Paul's account from 1857, which was at the beginning of the slump, was already urging farmers to "lay down the greater portion of your land in artificial grasses,
as opportunity serves", on the basis that wool was both a more remunerative export and less dependent on labour for its production,\textsuperscript{156} then it is to be expected that increasing numbers of farmers would sow pasture once prices worsened. The Lyttelton Times, meanwhile, fought a rearguard action, reminding farmers that wheat had been the only agricultural export tried to date, and farmers should look to other crops, rather than giving up agriculture altogether.\textsuperscript{157} According to Paul, root crops has turned out well so far, but despite this, and the calls for diversification, their cultivation attracted little interest. As he observed, "turnip growing will not answer here, until it is found necessary to fold sheep on the ground to manure for a wheat crop; and this is a stage not likely to be reached by this colony for many years to come."\textsuperscript{158} So long as wheat yields remained close to the 35 bushels per acre level there was little need to consider such practices. However, the partial failure of the wheat crop sown in 1858, which yielded around 15 bushels per acre, probably served as a reminder to farmers not to let their attention to animal husbandry cause their crop management to slip.\textsuperscript{159}

As in Otago, agriculturists in Canterbury had adopted a course of farming which did not include manuring, but instead relied at first on natural soil fertility, and later on the restoration of organic matter by the sown pasture which formed part of their mixed farming operations. Apart from this, however, Canterbury's farmers did little, other than through standard cultivation techniques, to improve the condition of their soil. Liming is a case in point. Although Christchurch advertisements for Macandrew's lime pointed out its potential as a manure, just as those in Dunedin had, perhaps the only independent suggestion that cropland in Canterbury should be limed was made in a newspaper article written in 1852 by the chemical analyst William Grayling.\textsuperscript{160} Similarly, the suggestion by W. B. Bray (later to become one of Canterbury's foremost engineers), in a letter to J. R. Godley, the Canterbury Association's Resident Agent, that the chemical composition of the soils near Christchurch ought to be analysed - Bray having hypothesised that they were rich in potash and phosphates - was never heard of again.\textsuperscript{161} Evidently, the new colonists were not so proactive in this area as the Canterbury Association, who included the elements of agricultural chemistry in their curricula for the future Christchurch College,\textsuperscript{162} had envisaged them to be. In part, this apathy towards applying agricultural chemistry can be put down to the type of soils found in Canterbury. Since settlers could concentrate their farming almost solely on alluvial swampland soils, where acid- and moisture-tolerant oats were used as the 'breaking-in' crop, they could escape the necessity of a fallow, whereas agriculturists in other centres cultivating 'fern land' could not. Moreover,
as there was no need to expedite bracken decay, there was no incentive to lime land. The prospects for expansion of both the pastoral and arable sectors also seemed good at the end of the 1850s, since there was plenty of scope for boosting stocking rates on pastoral runs, and much of the swampland corridor was still to be occupied. Canterbury was thus well placed when the gold-rush in Otago brought about an unexpected surge in meat and grain demand in the early 1860s.

How then did soil fertility management in Otago and Canterbury during the 1850s compare with that of the northern settlements during the 1840s. Again, a primitive, extractive fertility management regime seems to have been the norm, though both Canterbury and Otago had an advantage over their northern predecessors, since raising sheep, a benign activity in terms of soil fertility, had been a better money-making option than cropping from the start. By the late 1850s, however, many farmers in both settlements seem to have begun modifying their thinking, if not their practices, although it must be said that Otago's farmers were giving greater consideration to 'high farming'-style fertility management practices, such as crop rotations, than their counterparts in Canterbury were. It is nevertheless difficult to generalise, as the 'compressed' time-scale settlers were operating on, since they were trying to do in one decade what northerners had done in two, exaggerated differences in their rates of 'improvement'.

As in the northern settlements in the 1840s, the high labour costs involved seems to have been a crucial deterrent to the application of 'high farming'-style fertility management practices in Otago or Canterbury during the 1850s. The retarding effects of perceptions of near inexhaustible soils, in contrast, were a less significant factor, because the initial representations of soil fertility at Otago and Canterbury were generally not so flattering. The response of settlers, meanwhile, to externally-based practice and theoretical discourse, differed between Canterbury and Otago. Whereas Otago quickly established an agricultural society, with a special sub-committee devoted to agricultural chemistry and mineralogy, in Canterbury the Agricultural, Botanical, and Horticultural Society (formed in mid-1852) seems to have restricted its activities almost solely to produce exhibitions.163 The Guardian and Canterbury Advertiser might have filled this gap, given its intention to report "the important discoveries so constantly being made in the application of chemistry to agriculture", but it remained in circulation only from July to September 1852.164 Outside this shortlived publication, the agricultural material included in Canterbury newspapers was to be limited almost solely to local harvest reports. Thus, whereas Otago's newspapers
and farming institutions, perhaps inspired by their Scottish antecedents, acted as a spur for the application of the new methods, the same agencies in Canterbury served only as monuments to indifference. Yet ultimately, the market explosion created by the gold-rush overcame both Otago's inertia and Canterbury's apathy. In such circumstances, the drive towards more productive methods proved irresistible. Both Otago and Canterbury were about to join, if a little belatedly, the fertiliser age.
Notes to Chapter Nine


3 Campbell, I. B., *Soils of Waikouaiti County* (Wellington, 1977), pp. 46-7 & 'Soil Map of Waikouaiti County' (accompanying map & extended legend, Sheet 3).

4 Monro, 'Notes of a Journey through a part of the Middle Island'. Hocken, *Contributions to the Early History of New Zealand*, p. 241.

5 Ibid. Tuckett's journal states that "a poor crop of smutty wheat had been harvested" (F. Tuckett, 21 April 1844. Ibid., p. 211).


7 W. Fox to the Secretary of the New Zealand Company [T. C. Harington], 15 February 1849. *Otago Journal* 5 (November 1849), p. 70. See also 'G. G. to F.', 22 April 1849. Ibid., p. 73.


9 See, for instance, the statement in one Free Church pamphlet that Otago seemed better suited for agriculture than any other part of New Zealand (Scheme of the Colony of the Free Church at Otago, New Zealand (Edinburgh, 1845), p. 45. See also *Otago Journal* 2 (June 1848), p. 26. Cf. the poor opinion some had of Otago alluded to by William Fox (Fox to the Secretary of the New Zealand Company [Harington], 15 February 1849. *Otago Journal* 5 (November 1849), p. 70.


13 Tuckett observed that good timber was abundant and the soil appeared to be fertile. F. Tuckett, 27 April 1844. Hocken, *Contributions to the Early History of New Zealand*, pp. 212-3.

15 Burns to the Secretary of the Otago Association [John McGlashan], 28 January 1849. *Otago Journal* 5 (November 1849), p. 69. Burns refers, in the crude profile description he gives, to a "strong, rich, yellowish clay, which... passes in many places into a strong fine earth of the same colour as our red earthy clay at home". In the soils around Dunedin, red horizons occur only in profiles of brown granular loams and related soils (See Tomlinson & Leslie, *Soils of Dunedin City and Environs*, pp. 28-65).


17 Tomlinson & Leslie, *Soils of Dunedin City and Environs*, 'Soils of Dunedin City and Environs' (accompanying map).


19 The *Hand-Book to the Suburban and Rural Districts of the Otago Settlement*, [p. 5]. This work was a compilation of several articles which had previously appeared in the *Otago News* (See *Otago News*, 16 June 1849, pp. 2-3, 23 June 1849, pp. 2-3, 30 June 1849, pp. 2-3, 7 July 1849, pp. 2-3).

20 *Otago News*, 4 April 1849, p. 3.

21 Tomlinson & Leslie, *Soils of Dunedin City and Environs*, p. 20 & 'Soils of Dunedin City and Environs' (accompanying map).


25 'Agricola', 'The Otago District'. *Otago News*, 27 December 1848, p. 3.


27 Anon [to friend], no date. *Otago Journal* 2 (June 1848), p. 27.


30 Graham's unflattering observations in one editorial created such a sensation that it was subsequently known simply as 'No. 5'. Hocken, *Contributions to the Early History*
of New Zealand, pp. 111-2. The editorial in question (Otago News, 7 February 1849, p. 2) was followed up by a second in which Graham addressed criticisms by Cargill (Ibid., 21 March 1849, p. 3). For other examples of criticism of rural lands, see 'A Colonist' to the Ed. Ibid., 24 January 1849, p. 3; 'A Settler of No Party' to the Ed. Ibid. 21 March 1849, p. 5.


35 Whereas North Island commentators reported that three to four months was required for fern root to decay, once exposed to the atmosphere to decay (See New Zealander, 28 July 1847, p. 2; Hursthouse, Charles, New Zealand, the 'Britain of the South', with a chapter on the native war, and on future native policy 2nd ed. (London, 1861), p. 194), one Wakari resident instead wrote in 1851 that it needed to be turned over for two or three seasons before it was consumed (Anon., 2 June 1851. Otago Journal 8 (August 1852), p. 122). Likewise, according to the Otago News, this process took "several months" to complete (Otago News, 21 March 1849, p. 3).

36 See, for instance, W. Duff to W. R. Douglas, 4 May 1849. Otago Journal 5 (November 1849), p. 74; Anon., 7 January 1850. Otago Journal 6 (November 1850), p. 86. As Hocken observed, "almost every person cultivated a little" (Hocken, Contributions to the Early History of New Zealand, p. 130). To this end, it was fitting that amongst the library on the Phillip Laing, which was the second of the Otago Association's immigrant ships, was a copy of Cobbett's Cottage Economy (Brooking, And Captain of their Souls, p. 53).

37 Otago News, 21 March 1849, p.3. A lower section purchase price (the three components of each land parcel being initially indivisible) and denser concentration seem to put paid to the suggestion that suburban and rural sections be 20 and 80 acres respectively, which had been originally put forward by the Otago colony's progenitor, George Rennie (Brooking, And Captain of their Souls, p. 32).

38 The Hand-Book to the Suburban and Rural Districts of the Otago Settlement, [p. 5]. As noted in footnote no. 19 this was compiled from Otago News articles.
39 John Cargill to the Ed., 29 August 1849. Otago News, 1 September 1849, p. 3. Subsequent to the appearance of this letter, a meeting to address the pig problem was held (Ibid., 6 October 1849, p. 3).

40 Brooking, And Captain of their Souls, p. 87.


42 Otago Journal 7 (May 1851), p. 107. The mean annual temperature at Dunedin is 11°C. (Tomlinson & Leslie, Soils of Dunedin City and Environs, p. 8). For the origins of the migrants by country, see Brooking, And Captain of their Souls, p. 118.

43 Otago Journal 7 (May 1851), p. 109. Whereas H. B. Graham had stated in 'No. 5' that "our prosperity as a town must entirely depend upon herds of cattle and flocks of sheep" (Otago News, 7 February 1849, p. 2), Cargill sought to maintain the settlement's agricultural character through splitting their investment between the two sectors, rather than investing in pastoralism alone (Cargill to the Secretary of the Otago Association [McGlashan], 23 September 1848. Otago Journal 4(2nd ed.) (August 1849), p. 56; Brooking, And Captain of their Souls, p. 88).


46 Otago Agricultural Association, 'Report by the Agricultural Committee... upon cases relating to the occupation of land, submitted to them by Captain Cargill'. Otago Journal 8 (August 1852), 117n.

47 Otago News, 6 April 1850, p. 3.

48 See Fox to the Secretary of the New Zealand Company [Harington], 2 April 1850. Otago Journal 6 (November 1850), p. 93; Otago Journal 7 (May 1851), p. 99. While it is not stated what "agricultural purposes" were, it seems reasonable to assume that it would have been applied to the soil (given the subsequent record of lime usage).


50 Brooking, And Captain of their Souls, p. 120; New Zealand Journal 4(80)(4 February 1843), p. 25-6. It should be said, however, that few of the early migrants had a farming background (Brooking, And Captain of their Souls, p. 56).

51 Otago Witness, 3 May 1851, p. 3.

52 Ibid. The first advertisement for the lime-works (Otago Witness, 3 May 1851, p.1) gives the proprietor as James Macandrew & Co., but in subsequent references D. & J. Macandrew
was employed (e.g. Ibid., 19 July 1851, p. 2). Correspondence featuring in the Otago Witness (William Elliott to D. Macandrew [appended to the lime-works advertisement]. Ibid., 7 June 1851, p. 1; 'The Settler's Friend' to the Ed. Ibid., 21 June 1851, p. 3) also suggests that Daniel Macandrew managed the running of the works.

53 Because many soil micro-organisms involved in breaking down organic matter only thrive in non-acid conditions (McClaren, R. G., & Cameron, K. C., Soil Science: an introduction to the properties and management of New Zealand soils (Auckland, 1990), p. 151), liming would normally expedite this process.

54 'An Agriculturist' to the Ed. Ibid., 30 October 1852, p. 3.


56 See Harvey, Paul, Sir (ed.), The Oxford Companion to English Literature 3rd ed. (London, 1946), p. 150. William Chambers, one of the co-founders, was in fact the first to suggest the settlement's town be called Dunedin (McLintock, The History of Otago, p. 199).

57 Extract from the Journal of Agriculture, in Otago Journal 8 (August 1852), pp.117-8. See also, for the same extract, Otago Witness, 11 December 1852, p. 4.

58 S. Braithwaite (speech to the Otago Agricultural Association), 15 July 1852. Otago Witness, 17 July 1852, 3.

59 See the editorial with respect to Braithwaite's address in Otago Witness, 24 July 1852, p. 2.

60 This belief gained wide acceptance in the early 1840s because of initial espousal by Liebig. It is ironic in this instance that charcoal's supposed powers were disproved by the Scottish chemist Thomas Anderson in 1851 (Rossiter, Margaret W., The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840-1880 (New Haven, Connecticut, 1975), pp. 36-8).

61 'An Agriculturist' to the Ed. Otago Witness, 28 May 1853, p. 3.

62 McDonald, K. C., History of North Otago (Oamaru, 1940), pp. 21-2; McLintock, The History of Otago, p. 260; Brooking, And Captain of their Souls, p. 95. Cargill was originally appointed as Commissioner for Lands within the Otago Block, but with the establishment of provincial government in Otago, this position was disestablished in 1853 (McLintock, The History of Otago, pp. 264 & 295).

63 Otago Witness, 31 March 1855, p. 2. See also, for errata in these returns, Otago Provincial Government Gazette 2(23) (1 May 1855), p. 61.


Otago Witness, 23 August 1856, p. 6, 11 July 1857, p. 5, 8 May 1858, p. 2; Extract from Otago Provincial Government Gazette, in ibid., 21 July 1860, p. 4.

Statistics of New Zealand, for 1853, 1854, 1855, and 1856, compiled from official records (Auckland, 1858), Table 52 [unpaginated]; Otago Witness, 31 March 1855, p. 2, 23 August 1856, p. 6, 11 July 1857, p. 5, 8 May 1858, p. 2; Extract from Otago Provincial Government Gazette, in ibid., 21 July 1860, p. 4. See also, for errata in the 1854 returns (printed in Otago Witness, 31 March 1855), Otago Provincial Government Gazette 2(23) (1 May 1855), p. 61.

Extract from Otago Provincial Government Gazette. Ibid., 21 July 1860, p. 4.

For examples of articles and correspondence relating to the management of soil fertility (excluding those referred specifically to below), see Otago Witness, 23 May 1857, p. 6, & 6 November 1858 (Supplement), p. 4; Extract from Manchester Guardian, in ibid., 6 June 1857, p. 8; 'A Nobody' to the Ed. of the New Zealander, 14 July 1857. Reprinted in ibid. 20 March 1858, p. 6.


Statistics of New Zealand, for 1853, 1854, 1855, and 1856, Table 53.

See, for growing anxiety about soil exhaustion in America, Rossiter, Margaret W., The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840-1880 (New Haven, Connecticut, 1975), p. 3. Otago settlers were made well aware of this soil exhaustion by articles reprinted in the Otago Witness (See extract from the Mark-Lane Express, in Otago Witness, 30 May 1857, p. 7; Extract from Daily News, in ibid., 5 February, 1859, p. 6).

Anon. to the Ed. Otago Witness, 10 July 1858, p. 6.


Tremewan, Peter, 'The Nanto-Bordelaise Company'. In Cant, Garth, & Kirkpatrick, Russell (eds), Rural Canterbury: celebrating its history (Lincoln, 2001), p. 25.


Jacobson, H. C., *Tales of Banks Peninsula* 2nd ed. (Akaroa, 1893), pp.99-100. The margins of the forest were, however, regarded as the most fertile areas of soil, no doubt because of the deposition of forest leaf litter (Tremewan, Peter, *French Akaroa: an attempt to colonise southern New Zealand* (Christchurch, 1990), p. 143).


Ibid., p. 234.

Tremewan, Peter, *French Akaroa: an attempt to colonise southern New Zealand* (Christchurch, 1990), p. 179.


Tremewan, *French Akaroa*, pp. 179 & 339. In this year, the 'official' returns show an estimate of 6 tons per acre. During the mid-1840s the range reported by these returns was 6-15 tons per acre (*Statistics of New Zealand for the Crown Colony Period, 1840-1852*, p. 42).


*Statistics of New Zealand for the Crown Colony Period, 1840-1852*, p. 40. It would seem that the higher acreage figures given for 1847 and 1848 must have resulted from the inclusion of cultivations in other parts of the South Island, as according to Tremewan, the market for Akaroa produce in fact fell away during the second half of the 1840s (Tremewan, *French Akaroa*, pp. 203-4).


Yet in their correspondence to Thomas in 1849, the brothers Deans wrote that "we never now manure this crop" (W. & J. Deans to Thomas, 20 January 1849. Canterbury Papers (1850-1852), [1 & 2.] p. 25).


settlers; in particular, one 'Suffolk Farmer' was amazed to find "fifty bushels of splendid wheat per acre, sixty bushels of the finest barley I ever saw, and 100 bushels of oats from one ploughing, without muck" ('A Suffolk Farmer' to 'A Gentleman in England', 3 May 1851, *Canterbury Papers (1850-1852)*, [12], p. 346).


108 *Statistics of New Zealand, for 1853, 1854, 1855, and 1856*, Table 53; W. & J. Deans to Thomas, 20 January 1849. *Canterbury Papers (1850-1852)*,[1 & 2,] p. 27. William Deans related an even higher lambing percentage for 1849, of 125%, to his brother James (W. Deans to Js. Y. Deans, 8 December 1849. Deans, John, III (ed.), *Pioneers of Canterbury: Deans Letters 1840-1854*, p. 160). Cf. a detailed estimate of this type, with an 80% lambing rate, and only a 3.5 lb. fleece weight, drawn up by 'A Sheep Owner' in 1855 ('A Sheep Owner' to the Ed. *Lyttelton Times*, 5 May 1855, p. 5).


115 Raeside & Rennie, *Soils of the Christchurch region*, p. 6, 9 & 29. See also Cant, R. G.,
'The Agricultural Frontier in Miniature: a microstudy on the Canterbury Plains, 1850-75'.

New Zealand Geographer 24(2) (1968), pp. 157 & 159.


Cant, R. G., 'The Agricultural Frontier in Miniature: a microstudy on the Canterbury Plains, 1850-75'. New Zealand Geographer 24(2) (1968), pp. 158-9. The site chosen by Thomas for the town centre of Christchurch was one of the dry swamp margins which was close to the navigational limit of the Avon (Straubel, 'Maori and European to 1850'. In Hight & Straubel (eds.), A History of Canterbury, 1 (to 1854), pp. 131-2).

Kear et. al., Soils of the Plains and Downs, Canterbury and North Otago, 'Soils of the Plains and Downs, Canterbury and North Otago, New Zealand' (accompanying maps, sheets 1 & 2); Ministry of Works and Development, Environmental Design Section (Christchurch), Natural Resources of the Canterbury Region: a Survey and Evaluation for Management (Christchurch, 1983), p. 63.


Cox, Soils and Agriculture of Part Paparua County, p. 27; Harris, 'Soils in Canterbury'. New Zealand Grassland Association. Proceedings of the Tenth Conference. [1948], pp. 24-6. The only significant exception to the tendency for poor soils on the high terraces are the northern margins adjacent to the major rivers, as these derive a thick mantle of loess which is blown from the river bed in the dry northwesterly winds (Vucetich, 'Soils of Canterbury'. In Knox (ed.), The Natural History of Canterbury, p. 63; Molloy, Soils in the New Zealand Landscape 2nd ed., p. 181).

Molloy, Soils in the New Zealand Landscape 2nd ed., p. 181; Kear et. al., Soils of the Plains and Downs, Canterbury and North Otago, 'Soils of the Plains and Downs, Canterbury and North Otago' (accompanying maps, sheets 1 & 2).

Kear et. al., Soils of the Plains and Downs, Canterbury and North Otago, pp. 40-1; Cox, Soils and Agriculture of Part Paparua County, pp. 19-20.

Kear et. al., Soils of the Plains and Downs, Canterbury and North Otago, pp. 50-2 & 'Soils
of the Plains and Downs, Canterbury and North Otago' (accompanying maps, sheets 1 & 2).

125 Ironically, the nutrient levels in these soils were fairly high. Kear et al., *Soils of the Plains and Downs, Canterbury and North Otago*, 'Soils of the Plains and Downs, Canterbury and North Otago' (accompanying map, sheet 2); Harris, 'Soils in Canterbury'. *New Zealand Grassland Association. Proceedings of the Tenth Conference*. [1948], p. 23; Raeside & Rennie, *Soils of the Christchurch region*, pp. 36-7.


127 Vucetich, 'Soils of Canterbury'. In Knox (ed.), *The Natural History of Canterbury*, pp. 65-6; Raeside & Rennie, *Soils of the Christchurch region*, p. 34. See also footnote no. 80.


130 Ibid., facing p. 106.


132 Lee, 'Assessment of Land Capability in Early Canterbury Settlement, 1848-53', pp. 95 & 97-8, & Figure 8 (follows p.95); Cant, 'The Agricultural Frontier in Miniature'. *New Zealand Geographer* 24(2) (1968), pp. 160 & 163.


134 Ibid., pp. 246-7.


139 Paul, Robert Bateman, Letters from Canterbury, facing p. 128; Canterbury Standard, 12 June 1856, p. 4, 9 July 1857, p. 4, 28 April, 1859, p. 3.

140 Paul, Robert Bateman, Letters from Canterbury, facing p. 128.


142 Lyttelton Times, 21 February 1852, p. 5


146 W. G. Brittan to the Ed. (& preamble). Lyttelton Times, 19 March 1853, p. 6. Brittan's farm was opposite 'the Bricks' (the furthest inland wharf on the Avon), adjacent to the current Barbadoes St bridge. McIntyre, W. David, 'Outwards and Upwards - Building the City'. In Cookson, John, & Dunstall, Graeme (eds.), Southern Capital: Towards a City Biography 1850-2000 (Christchurch, 2000), p. 90. The significance of Brittan's yield appears to have been later questioned by 'Canterbury Farmer' in 1865. This correspondent maintained that a 75 bushel per acre yield obtained early in the settlement's history was due to the cropped field having been sited on an old stock-yard ('Canterbury Farmer' to the Ed., 25 July 1865. Lyttelton Times, 29 July 1865, p. 2).


149 Canterbury Standard, 28 April 1559, p. 3.


152 Ibid. See also, for evidence, of a shift towards intensive pastoralism, Lyttelton Times, 16 December 1857, p. 4.

154 See McClaren, R. G., & Cameron, K. C., Soil Science: an introduction to the properties and management of New Zealand soils (Auckland, 1990), p. 151 (Figure 10.5); Haynes, R. J., & Francis, G. S., 'Effects of mixed cropping farming systems on changes in soil properties on the Canterbury Plains'. New Zealand Journal of Ecology 14 (1990), p. 74.

For the organic matter content of the various soils on the Canterbury Plains, see the %C[arbon] figures in New Zealand, General Survey of the Soils of the South Island, New Zealand, pp. 94-157 passim., and multiply by 1.7.

155 Statistics of New Zealand, for 1853, 1854, 1855, and 1856, Table 53; Statistics of New Zealand, for 1857 (Auckland, 1858), Table 63 [unpaginated]; Statistics of New Zealand, for 1858 (Auckland, 1859), Table 78 [unpaginated]; Statistics of New Zealand, for 1859 (Auckland, 1860), Table 32.


158 Paul, Letters from Canterbury, p. 100.

159 Canterbury Standard, 9 June 1859, p. 4. According to the Lyttelton Times, which reported a range of wheat yields between 12 and 32 bushels per acre, the reason for the poor crop was uneven ripening. In many, but not all cases, this had arisen from the wheat being self-sown (Lyttelton Times, 16 February 1859, p. 4).

160 W[illiam]. I[rwain]. G[rayling]., 'On the Capabilities and Productions of the Middle Island of New Zealand'. Lyttelton Times, 28 August 1852, p. 5. It was not as if lime was not available - one vendor that advertised it for sale regularly was G. W. Hills, proprietor of a lime-kiln in Ferry Rd (see, for example, Canterbury Standard, 11 August 1859, p. 2).


162 Canterbury Papers (1850-1852), [4], p. 102.

163 Notice of its first horticultural exhibition was first given on 30 July 1852 (Lyttelton Times, 21 August 1852, p. 11). Its exhibitions, moreover, were not always well supported; the wheat samples submitted to the autumn exhibition of 1855 numbered just six, and those of barley two. (Ibid., 16 May 1855, 6).

Chapter Ten

Instilling a sense of system: the evolution of agriculture in Otago and Canterbury, 1860-1868.

From a purely spatial perspective, the early to mid-1860s proved to be a revolutionary period for New Zealand agriculture. Due to war in the North Island, gold-rushes in the South Island, and surplus produce emanating out of Australia, the formerly remote settlements of Otago and Canterbury became the new agricultural core, while the other main settlements became the agricultural periphery. Together Otago and Canterbury contained 44% of the nation's 13,706 acres in wheat sown in 1858, but 82% of the 47,774 acres sown in 1867.1 Since agriculture swallowed up more and more land, and furthermore, that land was generally inferior to the rich recent alluvial soils utilised in the 1850s, it was inevitable that greater consideration should be given to making cropping operations more sustainable.

I. Add new land and a pinch of guano: agriculture in Otago during the early gold rush years.

As seen in Chapter Nine, by the late 1850s the Taieri and Clutha Plains had been occupied for several years, and consequently Otago farmers were becoming more conscious of the risk of soil exhaustion. Typically, settlers had retired worn out land to pasture, but some also applied dung to their land. This created a potential market for guano, and when the wheat price at Dunedin shot up to 9s. per bushel in 1860, due almost certainly to a shortfall in Australian production,2 guano was imported into Otago for the first time. This first shipment was obviously experimental, as it comprised only 17 bags, and since it was an Australian phosphatic guano, it was also cheap, selling for only £10 per ton.3 When compared with some of the prices seen in Chapters Seven and Eight for Peruvian guano, this low cost was probably a valuable selling point. A month after the first delivery in September, a second cargo of 50 bags arrived,4 which probably brought the total amount imported to about seven tons. Apparently this satisfied the curiosity of Otago’s more innovative agriculturists, as the vendor, H. P. Morse, was still advertising ‘Flat Island guano’ in May 1861,5 despite there having been no further shipments in the interim. If the acreage sown in turnips in 1860 had been similar to the 395 acres sown in 1859,6 these seven tons could have
been applied, at a rate of 2 cwt. per acre, to about 20% of the total crop. The additional manure, however, produced from stock fed on the fertilised turnip crops was unlikely to have affected cereal production much, as the combined acreage sown in wheat and oats in Otago, recorded in the census of 1861, stood at 9448 acres.7

Evidently, Otago's agriculturists did not see much need for guano. This is understandable, when, according to a pamphlet written on the province in 1862, mid-range yields per acre for wheat, oats, and potatoes, were 35 bushels, 45 bushels, and 6.5 tons respectively.8 If the flood of immigrants into Otago when gold was discovered in 1861 had translated into higher wheat prices, demand for guano might have strengthened, but in actual fact, the wheat price fell. Official records show the wheat price in Dunedin during 1861 and 1862 was only 7s. per bushel, and in 1863 it dropped back further, to 6s.6d. per bushel.9 Once again, surplus Australian production (which is plotted against the Otago wheat price in Figure 10.1(a)) seems to have been the driving force in the wheat market, as following on from the smallest domestic shortfall in supply in ten years in 1861, record harvest surpluses of 1.7 million bushels occurred in both 1862 and 1863.10 Since the gold-rush increased demand for cartage, and hence horse-feed, the price of oats, in contrast, rose during the early 1860s. Indeed, the average price paid for imported oats in 1863 was 6s.9d. per bushel.11 With oats now worth more than wheat, and also being "the best maiden grain crop on new lands",12 it is not surprising that the growth in the oats acreage accounted for half of the increase in the area under crop between 1861 and 1864. Conversely, as Table 10.1 shows, the area sown in wheat barely increased.

Table 10.1: Acreage of crops cultivated by Pakeha in Otago, as recorded in the December census returns.13

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Garden</th>
<th>Other</th>
<th>Total Sown</th>
</tr>
</thead>
<tbody>
<tr>
<td>1861</td>
<td>4929</td>
<td>4519</td>
<td>166</td>
<td>668</td>
<td>8220</td>
<td>504</td>
<td>250</td>
<td>19,255</td>
</tr>
<tr>
<td>1864</td>
<td>5817</td>
<td>21,088</td>
<td>848</td>
<td>3068</td>
<td>15,895</td>
<td>1321</td>
<td>1120</td>
<td>49,158</td>
</tr>
</tbody>
</table>

During these years, Otago's agriculturists would have had little to fear from soil exhaustion, since the entire acreage sown in wheat and oats in 1864 could conceivably have been contained within the area broken in since 1861, and much of it probably was. The financial returns from agriculture were also likely to have...
This graph indicates that during the early 1860s large Australian wheat exports coincided with low local wheat prices and vice versa. The inverse relationship seems to break down in the late 1860s, although the Dunedin graph is suggestive of a one-year time lag developing, which may well have occurred if merchants were storing imported wheat for release the following year.

It should be noted that the balance of the Australian wheat trade in 1868 was close to zero, and thus does not feature on the graph.
Figure 10.1

**Australian wheat exports vs. Dunedin wheat price (d./bu.)**

- Australian surplus (000bu)
- Wheat price (p)

**Australian wheat exports vs. Christchurch wheat price (d./bu.)**

- Australian surplus (000bu)
- Wheat price (p)
been small - even at the price it reached in 1863, a crop of oats would have provided agriculturists with a smaller gross income per acre than wheat had in 1860. Neither of these circumstances were conducive to boosting fertiliser demand. Moreover, cultivation of turnips, on which 'artificial' fertiliser was most likely to have been used, was actually declining at the start of the gold-rush period. As Table 10.1 shows, the acreage in ‘Other Crops’ in 1861, of which turnips probably made up the bulk, was 249 acres, or 1.3% of the total area under crop. In comparison, turnips alone accounted for 395 acres, or 4.2% of the total under crop, in 1859. Presumably, farmers had thought growing cereals would prove more remunerative, though given subsequent price movements, retaining turnip cultivation for the purpose of producing meat and dairy products may have been a better option.

Not surprisingly, the quantities of fertiliser imported in Otago continued to be small. In 1862, only 13 bags were shipped to Dunedin, and in 1863, imports totalled 52 bags of guano, and 6 tons of bone-dust. 'Artificial' fertiliser use, therefore, must have remained the preserve of a small minority of farmers. Amongst them was Major J. L. C. Richardson, Otago's Provincial Superintendent during 1861-3, who in 1863 spread guano on his mangold, swede and turnip crops. The availability of guano in Dunedin was transformed, however, by a monster shipment brought in direct from South America by the firm Douglas, Alderson & Co. in October 1864, containing 950 tons of nitrogen-rich Peruvian guano, 700 tons of which was put up for auction. The reserve price of £18 per ton was obviously too much for most prospective buyers though, as the auction report in the Otago Daily Times observed "a lack of spirit amongst buyers"; consequently, "only a limited quantity was sold". Although the rise in the wheat price at Dunedin to 8s. per bushel in 1864 probably helped inspire the shipment, the subsequent lack of buyer enthusiasm, together with the far smaller scale of other fertiliser imports during 1864, supports Alan Smith's belief that Douglas, Alderson & Co.'s main motivation for procuring the shipment was a temporary interruption of the Peruvian government's guano monopoly.

During late 1864, small portions of the cargo began to be delivered up and down the coastline of the South Island, with expectations of demand in the Clutha district being sufficient for a guano store to be built at Port Molyneux. The largest of the distributive shipments was 739 bags sent south to Invercargill, some of which was almost certainly destined for Douglas, Alderson & Co.'s own landholdings in the Oteramika district of eastern Southland. When James Melvin visited the area in 1867, he observed that with guano application the land, which
by then had been sold to the New Zealand and Australian Land Company, was producing, or at least had been made capable of producing, heavy crops of turnips and sixty bushels of oats per acre. John Murray may also have been alluding to this when he commented in his 1867 pamphlet on Southland that land needed to be "well fallowed and lifted and slightly top dressed" when introduced grasses were sown. Fertiliser application was especially necessary in this area because many of the yellow-brown earths of the Mataura Valley in eastern Southland have a high level of phosphate retention, that is, the capacity of the soil to bind phosphates and keep them out of solution, where they are available to plants, is high. These soils have also lost most of their basic mineral nutrients, such as potassium, through leaching.

In theory, high labour costs and cartage rates in the early to mid-1860s should have encouraged the use of a concentrated fertiliser such as guano rather than bulkier alternatives like farmyard manure. Therefore, if farmers did not use much guano it can be inferred that farmyard manure was not used extensively either. Although some farmers, such as Edmund Bowler, continued to employ dung in preparing land for cropping, the move by Dunedin's Town Board to create a manure depot, for the purpose of dumping night-soil and other urban waste, suggests that in general such materials were not in great demand. The opening of this facility, apparently in 1862, was controversial, however, as one Town Board member, John Cargill, declared that as manure depots "were not allowed in the home country", they should not be tolerated locally. In making his case, Cargill asserted that he knew "parties on the hills and in the north-east valley, who would be willing to purchase it by cartloads". These areas were within the realm of the 10-acre suburban sections (see Chapter Nine), where demand for manure was probably higher than in the rural districts, due to the greatest intensity of cultivation. Even here, the profits on manure use must have been marginal though, as otherwise these 'parties' would have been taking advantage of Dunedin's wastes already. Another proposal at the time for employing town waste in the farming interest was to irrigate with sewage the sandy soils which lay along South Dunedin's shoreline. Not surprisingly, this idealistic vision, driven by contemporary British enthusiasm for such ventures, never got beyond the pages of the newspaper.

While acknowledging that cereal cultivation was not remunerative enough to allow agriculturists to purchase 'artificial' fertiliser or other manures, agricultural commentators were nevertheless loathe to simply let the soil be worn out by continuous cropping. Accordingly, in May 1863 the Otago Witness asked why
"the colonists of New Zealand, and of Otago in particular, persist in the conventional system of growing grain crops, when, as a rule, it would pay them much better to turn their attention to stock-feeding?" \(^{35}\) Nine months later, it adopted a more prescriptive tone, declaring that it was “certain that we cannot compete, in Otago, with other colonies in the production of grain”, and therefore cereal cultivation “should now be made an auxiliary to the production of meat” \(^{36}\). Apart from the income generated by meat, and perhaps dairy, production, a mixed farming approach also promised, it was argued, better crop yields. To this end, the ‘Farmer’s Calendar’ - a monthly column that appeared in both the \textit{Otago Witness} and the \textit{Otago Daily Times} - for September 1863 reproduced Charles Hursthouse’s statement that he, and "every other practical man who has paid attention to agricultural matters" believed that "if farming in New Zealand was carried on more in conformity with the first principles of British agriculture, the yield of wheat and all our grain crops might be increased full thirty per cent". \(^{37}\)

Throughout 1863 and 1864, the 'Farmer's Calendar' and various extracts from foreign journals repeatedly reminded farmers that continuous cereal cropping impoverished the soil, whereas the combination of stock rearing and crop rotation could enrich it. \(^{38}\) Farmers were thus encouraged to cultivate both clover and turnips, which, in the words of the ‘Calendar for August’ in 1863, imported "into the surface soil fertilising properties which were not there before", \(^{39}\) and to pay special attention to generating manure. In the latter regard, the ‘Calendar for June’ in 1864, after declaring that manure must be “procured at any sacrifice”, asserted that “the chief use of cattle on an arable farm, besides those which are necessary for the operations of husbandry, is to produce manure for the land”. For the purpose of producing this manure, farmers were advised to conserve their straw and incorporate it into cattle dung. \(^{40}\) Folding of sheep on root crops was also suggested in another ‘Calendar’, \(^{41}\) although no such comments on manure production were made. Presumably it was assumed that the cattle (unlike the sheep) were being fed in the yard, thereby enabling their dung to be readily collected. Interestingly, 'artificial' fertilisers rarely featured in the various ‘Calendars’ during this period. \(^{42}\) This, no doubt, was in part a reflection of their limited availability prior to Douglas, Alderson & Co.'s massive guano shipment in October 1864. It also accorded with the notion that they were only supplementary to "the excrements of animals", which were, as one ‘Calendar’ put it, “the first and most important class of manures” \(^{43}\).
In retrospect, the appeals to Otago’s settlers to adopt mixed farming proved a limited success. Table 10.1 shows that the area in sown grass at the close of 1864 was almost double that of three years earlier, but at the same time, the total area under crop had grown two-and-a-half fold. Although the rapidly expanding agricultural frontier partly accounts for this, since in new areas cropping was traditionally dominated by cereals and potatoes, it is noticeable that even in the long-settled suburban districts of Dunedin the proportion of total area under crop accounted for by sown grass actually fell from 70% in 1861 to 55% in 1864. With respect to root crops, it is true that the acreage of the category ‘Other Crops’ had risen more than fourfold, but this was still less than one-twentieth of that under cereals. In this regard, it is worth observing that on David Andrew’s farm in Green Island, which was thought representative of those in the vicinity by the Otago Witness, oats were being cultivated on 35 acres in February 1864, whereas the combined area of potatoes, turnips, and mangold wurtzel was just 4 acres. While some farmers may have been discouraged from growing root crops by the proneness of turnips to aphids and blight, it is clear that the many of them had no intention of adopting more than a token British-style crop rotation while high yields were being obtained. In low-lying districts, the estimated yields for the crops sown in 1864 were 50-70 bushels of oats, 45-65 bushels of wheat, and 8-10 tons of potatoes per acre. Having said this, towards the end of 1864 the Otago Witness did state that it believed that "farmers are giving more attention than heretofore to means of increasing the fertility of the soil". The efforts of agricultural observers to convince Otago’s settlers that they must adopt the principles at the heart of ‘improved’ farming at ‘home’, if they wanted to maintain long-term prosperity, were not, therefore, completely in vain.

II. Grain gives way to grass: Canterbury farming in the early 1860s

At first glance, one might have expected the agricultural community in Canterbury to have been more receptive to the need for ‘improvement’ in the early 1860s, given that the crop yields they were obtaining were well below those in Otago. For example, the wheat crop sown in 1860 gave a yield, after an "average" season, of only about 25 bushels per acre. To date, however, the Canterbury settlers had lagged behind those of Otago when it came to recognising the danger of soil exhaustion, and taking preventative action via manuring. This may have been partly due to their not sharing the omnipresent Scottish enthusiasm for agricultural science. Certainly, the previous record of agricultural societies...
shows that they had found a much firmer footing in Otago than in Canterbury. The most recent Canterbury manifestation, the Christchurch Farmers’ Club, expired from lack of interest after four years in mid-1861.\textsuperscript{52} The apparent lack of concern regarding soil fertility in Canterbury at the start of the 1860s was also a consequence of the rapid outward expansion of the agricultural frontier at this time. Whereas only 13,613 acres had been in cultivation in December 1858, by December 1861 the comparative figure was 32,807 acres,\textsuperscript{53} meaning that 60\% of the total cultivated land in 1861 had been broken-in in the last three years. Moreover, since the unsold supply of ‘dry swamp’ land between the Waimakariri River and Lake Ellesmere, on which the soils were both fertile and readily cultivable, did not run out until about 1860,\textsuperscript{54} it is likely that much of the 19,194 acres added to the area in cultivation during this period was composed of such tracts. On these soils, farmers could have produced reasonably good cereal yields, in the first few years or so, simply by relying on their natural fertility. Prompted by the high price for wheat - 7s.6d. per bushel in Christchurch in 1860\textsuperscript{55} - it would appear many did just that, as the expansion in wheat acreage was even faster than that of cultivated land. From a figure of 4238 acres in 1858, it had trebled to 12,786 acres in 1861.\textsuperscript{56} Close to Christchurch, land had a longer cropping history, and thus yields were likely to be lower, but farmer's incomes would have been maintained because of the lower costs of transport. However, as one perceptive correspondent to the \textit{Lyttelton Times} in 1861 pointed out, once the railway arrived, peri-urban farmers would be fully exposed to competition from newer areas of cultivation:

... if the railroad is to do any good it must be continued into districts now too distant for agriculture, which will tend to make the land ... as near the ship's bottom as the very farms that have hitherto been paying best; then the question arises - What is to become of the land in the immediate neighbourhood of Christchurch that has been cropped and cropped with cereals till it will hardly bear a new corn for an old one? I can justly anticipate the answer that may be given, - lay it down to grass. But my experience goes to prove that land worn out with corn crops is next to useless for grass. This is a question ... worthy of the attention of small farmers near town, who do nothing to their land but plough, sow, and reap, without stock, without artificial manure, as long as the land is to be kept in cultivation to pay the cultivator; and what is to be done with it after?\textsuperscript{57}

Canterbury’s farmers were not to be ‘without artificial manure’ for much longer, as in March 1862, 2.25 tons of guano were imported from Sydney.\textsuperscript{58} The
experience in other provinces suggests it was not soil exhaustion prompting this import though, but rather farmers testing it on their crops now that the Otago gold-rush was underway. However, as in Otago, overseas grain surpluses held wheat prices below 6s. per bushel throughout 1861-3.\textsuperscript{59} Clearly, this was enough to persuade farmers that guano use was not economically viable, and there were no further guano shipments during the rest of 1862, or the whole of 1863. Given that uncultivated ‘waste land’ could be purchased in Canterbury for as little as £2 per acre, it is not surprising that agriculturists chose not to use guano, since the material cost alone - that is, excluding cartage and labour - of applying guano was probably greater than this. Consequently, farmers could just as easily set aside worn out land for pasture and fallow, and purchase new land, if it could be found locally and was of reasonable quality, for their cropping operations.

Although this provided a ‘safety valve’ against soil exhaustion, it is noticeable that from mid-1863 a steady stream of comments designed to inspire improved farming methods, and in turn, conserve the fertility of the soil, began appearing in the \textit{Lyttelton Times}. Amongst the first was an essay entitled ‘Farming Notes’ which observed that the “system hitherto practised in Canterbury”, that is, “the repetition system of growing cereals for a series of years, until the soil became totally exhausted and unfit for the production of grasses”, was inevitably attended by great loss to the farmer, and perhaps even ruin. It went on to note that exhaustion must be “continuously guarded against, particularly in New Zealand, where the application of manure on a large scale is out of the question”, and accordingly advised farmers that they should follow the lead of more experienced settlers in limiting successive cereal cropping to three years, or two on light-textured soils, and then alternating this with five years or so under pasture to rejuvenate the soil.\textsuperscript{60} In this and subsequent articles, farmers were also urged neither to burn their straw, as was the prevailing fashion, nor use it as winter fodder for cattle, but to use it as litter in the stockyard, so that it would ultimately be recycled via the manure heap; the latter policy, readers were told, had allowed English agriculturists to continuously enrich their land to the point where “we apparently can fix no limit to its improvement”.\textsuperscript{61} As in Otago, commentators also pressed for a greater adoption of crop rotations incorporating roots and other cattle feedstuffs, such as hay. Such a change, one ‘Agricultural Report’ remarked, “would effect an immense advance in our farming prospects”.\textsuperscript{62} Even so, there were not the same calls in Canterbury as there had been in Otago to make stock-rearing the main purpose of the farm.
One further avenue for the "manufacture of manure" - a subject which the 'Agricultural Report' of May 1864 observed had hitherto been given insufficient attention - which was explored was the recycling of Christchurch's sewage. According to the correspondent 'X. Y. Z', once deodorised and mixed with earth, via an earth closet, the sewage would prove itself "a valuable commodity for enriching the already half impoverished land not very far away from the city". Likewise, F. E. Wright declared that the drainings from the town would, "if properly distributed over the surrounding country, bestow upon it unbounded abundance and fertility". Given the position of Canterbury farming at the time, these ideas, which were borrowed from England, and to a lesser extent, from Victoria, seem rather advanced, but it must be remembered that the "sluggish" Avon, as F. E. Wright described it, did not offer the same 'natural flush' as Otago Harbour. Nonetheless, it is hardly surprising that Canterbury authorities did not put any of these proposals into practice.

On the basis of a comparison of 1861 and 1864 census data alone, one would have to say that Canterbury's agriculturists took more heed of these exhortations to improve farming practices than their Otago counterparts. As seen in Table 10.2, during this intercensal period the wheat acreage grew only marginally, and although there was a more than threefold increase in the area of oats, the area of sown grass rose at almost the same rate. Overall, this meant that the proportion of total area under crop constituted by sown grass rose from 32% to 46%. However, other evidence suggests that a response to soil exhaustion was probably not the primary factor behind these changes. According to the 'Agricultural Report' in the Lyttelton Times for June 1864, the failure of the "last splendidly promising wheat crop" from 'blight' (probably the fungal disease known today as 'take-all') had "given a fresh impetus to the movement for throwing arable land out of tillage". Furthermore, in an interim return of the crops sown during 1863 the area recorded for sown grass was only 37% of the

<table>
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<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Garden</th>
<th>Other</th>
<th>Total</th>
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<tr>
<td>1861</td>
<td>12,786</td>
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<td>2432</td>
<td>1753</td>
<td>31,671</td>
<td>2200</td>
<td>2672</td>
<td>68,727</td>
</tr>
</tbody>
</table>
total area under crop. Hence, a large-scale conversion from cropland to pasture took place in the census year of 1864. A more gradual climb ought to have occurred if concerns about soil exhaustion had been primarily responsible. Lastly, what the census described as ‘Other Crops’, which root crops would have been a major component of, fell as a proportion of the total area under crop from 4.1% in 1861 to 3.7% in 1864. If farmers had been striving to adopt British-style crop rotations this figure ought to have increased. Having said this, the effect of the shift from cereals to pasture, was more important than the rationale behind it. Soil organic matter levels are, as noted in Chapter Nine, naturally fairly low in soils on the Canterbury Plains, and they fall further when under cereal cultivation. However, if they were cropped for no more than about three years, at which point yields started tailing off, the level of organic matter would quickly revive under pasture. To some extent, therefore, the worst fears of the critics of Canterbury’s agricultural practices had been allayed.

The same critics were probably pleased to see the return in 1864 of ‘artificial’ fertiliser shipments to Canterbury too. These consisted of 25 tons out of the 950 ton cargo of Peruvian guano brought to Dunedin by Douglas, Alderson & Co., and 10 bags of bone-dust, imported from Sydney. The latter consignment was the first of its kind to enter Canterbury, although the significance of this is tempered by the fact that Canterbury was still exporting bones in large quantities. The revival of the ‘artificial’ fertiliser market, together with the partial shift away from continuous cropping, serves as evidence that by the mid-1860s agriculturists in Canterbury had largely caught up with their Otago counterparts as far as their progress towards ‘improved’ farming went. However, both still fell well short of the ‘high-farming’ goal that agricultural commentators had set for them.

III. Wanted - cheaper fertiliser!

The huge size of the previous year’s shipment by Douglas, Alderson & Co., and the return of the wheat price in Otago to a more normal level of 7s. per bushel, meant there were no commercial guano imports into Dunedin during 1865. However, two types of phosphatic guano, namely Combes and Daldy’s Ceral Queen Island guano, and Dr. Crowther’s Bird Island guano from Tasmania, were shown at the New Zealand Exhibition in Dunedin in 1865. In mid-1865 there was also a small bone-dust import from Australia, and what was probably New Zealand’s first advertisement for superphosphate appeared in the Otago
Collectively, this gives a sense that farmers were beginning to perceive phosphatic fertilisers as preferable to Peruvian guano.

There were three main reasons why this perception might have arisen. The first of these was price - in the case of two trial bone-dust shipments which arrived at Christchurch in 1865, it was sold for £10 per ton, whereas, as seen above, the minimum price for Peruvian guano in Dunedin was £18 per ton. Admittedly, the higher application rate of bone-dust, which in British recommendations ranged from about 16-40 bushels (8-20 cwt.) per acre, meant that the initial application cost was greater than that for Peruvian guano, which Otago farmers probably used at a rate of around 2 cwt. per acre, but bone-dust only needed to be applied once in a four year rotation, and its effects lasted even longer where the field was kept in pasture, whereas the yield boost produced by the nitrogen in Peruvian guano probably lasted for only one year. Secondly, there was now an increasing level of concern that using Peruvian guano on its own could speed up the loss of soil fertility, on account of the imbalance between the levels of nitrogen and phosphorus it contained. Although, as seen in Chapters Seven and Eight, this notion had been around for some years, during late 1864 and early 1865 Dunedin newspapers reproduced articles in which agricultural chemistry heavyweights such as Justus Liebig and Augustus Voelcker (the Royal Agricultural Society of England’s consulting chemist) added their voices to this assertion. This message also featured in an article in the third issue of Christchurch’s *Weekly Press*, which was put together by the *Press* from 1865 for its rural readers. Thirdly, the growing distinction being made between cereals needing nitrogenous fertilisers, and grasses and root crops needing phosphatic and potassic fertilisers, may also have contributed to slowly growing demand for specifically phosphatic fertilisers. Significantly, in articles discussing turnip fertilisation which appeared regularly in the *Otago Witness* from 1864 onwards, agriculturists were advised to supplement their farmyard manure with bone-dust, or bone-dust and guano together, rather than guano alone. By using both 'artificial' fertilisers, the farmer got a short-term nitrogen response and medium-term phosphate response, and the extra phosphate in the bone-dust balanced out the excess nitrogen in the Peruvian guano. Alternatively, one article suggested that ashes be mixed with guano, which would have had a similar effect.

The market for 'artificial' fertilisers in Otago, judging by the frequency of newspaper advertisements, was even worse in 1866. Again the likely cause was a decline in the wheat price, which plummeted to just 5s. per bushel. As Figure 10.1(a) indicates, this was below anything seen in Otago previously. The export
price of oats, in contrast, rose slightly to 4s.3d. per bushel from the 1865 figure of 3s.9d., but then again the 1865 price was already low - barely half, in fact, of that paid in 1863. It appears that the reason for these low grain prices was not Australian competition this time - as Figure 10.1 shows, in a plot of wheat prices in Canterbury and Otago against the Australian wheat surplus during the 1860s, 1866 was the odd-year-out - but instead was probably a reflection of increasing local agricultural production, particularly in the goldfields, and the cessation of hostilities in the United States, which prompted an expectation that much Californian and Chilian grain, previously required by the Atlantic coast consumers, would again be available for consumption in Pacific rim nations. In addition, the partial restoration (or imposition) of the Pax Britannica reduced the North Island's dependence on externally-sourced agricultural produce, thereby diminishing a potential market for South Island agriculturists.

The one thing still in Otago farmers' favour, however, was that average yields continued to be high. The Provincial Government's enumeration of the crops sown in 1866, for example, gave estimated wheat and oats yields of 37 and 44 bushels per acre respectively. Although it is true, given that the area recorded under crop (more than 82,000 acres) was 64% more than in 1864, that much of the land in crop must have been relatively new to cultivation, even in the long-settled 'Central District' (which encompassed the coastal area between Lake Waiholo and Waikouaiti) the per acre yield estimates were, at 37 and 46 bushels respectively, above the average. This may have been due to farmers' draining, and subsequently cultivating, more of the fertile clays of the Taieri floodplain. As Figure 10.2 shows, this had been largely subdivided into farms by this time. Such yields made it easy for Otago's farmers to ignore the continuing, but perhaps less frequent, appeals for a mixed-farming approach to be adopted. Certainly, the statistics for the 1866 crops give no indication that mixed farming was becoming more prevalent, as the proportions of the total area under crop made up by both sown grass and root crops were almost identical to those from the 1864 census. Accordingly, a new tactic was employed in attempts to restore flagging interest in fertilisers, namely the locally-sourced testimonial. In letters published by Douglas, Alderson & Co., the Dunedin nurseryman George Matthews, for instance, declared that the increased "growth of corn, grass, potatoes, peas, beans ... is surprising, and on new soils, where there is any risk of the crop not coming away, Peruvian guano is all but indispensable to a good result". Likewise, Thomas Murray observed, albeit in the testimonials in the Weekly Press rather than the Otago Witness, that of all the manures available, "guano and dissolved bones will
Figure 10.2
The Taieri Plains in 1867

Source: George O'Brien's The Taieri Plains, 1867. Taken from the Upper or Halfway Bush Road leading down to the North Taieri. Supplied by Hocken Library - Uare Taoka o Hākena (neg. 00604).

In this view, which looks southwest towards Lake Waihola in the distance, the foreground has been entirely broken up into small farms. The long line stretching southwest in the centre of the painting was the main road south of Dunedin.
be the cheapest, costing less than the price of carting and spreading the less concentrated and more bulky manures taken from the stockyard or straw heap, when labor is at the present high rate".\textsuperscript{96} As for farmyard manure, it seems likely that the high labour cost alluded to by Murray,\textsuperscript{97} together with the lack of attention to raising stock in conjunction with cropping, meant that most farmers did not use much of it. But then, as one complainant about the persistent nuisance created by Dunedin’s manure depot remarked, “in and about Dunedin, the rich virgin soil does not require manure”.\textsuperscript{98}

IV. Nothing doing without dunging: responses to soil exhaustion in Canterbury

Compared to their counterparts in Otago, Canterbury’s agriculturists were in a much worse position. Although produce prices were still high in Canterbury in 1865, much angst was expressed that its agriculturists were unable to cash in on them, because production levels were so poor. Indeed, both the yield, estimated to be at most 20 bushels per acre,\textsuperscript{99} and quality, of the wheat harvested in early 1865 were said by the \textit{Weekly Press} to have been the worst on record.\textsuperscript{100} All observers agreed that this was evidence of worsening soil exhaustion, but there was little consensus about how best to respond to it. One essay in the \textit{Weekly Press}, for instance, blithely dismissed the problem as common to all wheat-producing regions, and argued that while there was still undeveloped land fit for cultivation, each farmer should continue “to plant every acre of wheat his land is capable of bearing”.\textsuperscript{101} Generally, however, commentators took the opposite view, maintaining that farmers ought to mend their ways by adopting a mixed-farming approach. According to another \textit{Weekly Press} essay, "growing green crops" was "a subject demanding immediate attention" as they were a means for both "fattening stock to supply our West Coast goldfields" and originating "a proper course system of cultivation, and a supply of manure; for without a supply of manure, farming is a farce".\textsuperscript{102}

Yet, as ‘Canterbury Farmer’ pointed out in the \textit{Lyttelton Times}, while it was easy to malign continuous cropping, it was more difficult for farmers to find realistic alternatives to it.

They would ... deserve to be upbraided ... if it were possible to carry out any one of the English rotations; but, in the absence of special manures, and in competition with native pasture, held at a
nominal rental, how can a farmer make it pay to have, say, one-fourth of his land every year in turnips or similar crops? A stream of correspondence to the *Lyttelton Times* followed, in which a variety of potential rotations were postulated. Perhaps the easiest to adopt was the four year cycle proposed by Robert Rickman (formerly a leading figure in the now defunct Farmers' Club) which entailed two years grain-growing, followed by almost two years under pasture and clover, and finished off with a summer fallow. Overall, the *Lyttelton Times* noticed that such thinking was beginning to have a positive effect:

That it is so we judge from the rapid multiplication of small flocks of sheep on the arable farms in the neighbourhood of Christchurch. Green forage crops seem also here and there to be coming slowly into use. We look to their general adoption on a large scale as the best hope of the arable farmer in contending with the excessive dearness of labour, and the low prices of grain which have ruled the market of late years.

Meanwhile, the *Weekly Press* set out to improve productivity through agricultural education. To illustrate the problem, it noted that farmyard manure was being used as a topdressing rather than being incorporated into the soil. Such exposure to the weather, it asserted, caused the manure to lose its efficacy. This complaint was justified, as when manure breaks down nutrients are readily lost through surface run-off or volatilisation. To curb such ill-informed practices, the *Weekly Press* began featuring instructive essays (usually serialised) designed for the local rural community. One of the first was a discussion of Schübler's system of classifying soils. To make it relevant locally, this included comments on which crops did best on each soil class, as well as the extent of each soil class on the Canterbury Plains. Subsequent serialised essays included one on modes of 'allotment farming', and one on wheat cultivation.

Manuring was an obvious remedy to soil exhaustion, and accordingly contributors to the crop rotation debate discussed it at length too. Most contributions, however, consisted only of a reiteration of well-established precepts relating to the production and use of farmyard manure, such as saving straw for litter. Although 'Canterbury Farmer' discussed liming, and argued that the 30s. cost, including labour, of applying it at 20 bushels per acre, was well worth it on Canterbury's naturally acidic swampland soils, correspondents devoted hardly any comment to 'artificial' fertiliser use, because, presumably, of their limited availability. The two previously mentioned bone-dust imports during
1865 each consisted of just a ton,¹¹⁴ which together enabled its application to about seven acres of turnips.

Even when farmers recognised the danger of soil exhaustion, the cost of labour made farmyard manure use of questionable short-term economic benefit. According to the *Lyttelton Times*, the cost of replicating best English manurial practice from England in Canterbury would have been about £6 per acre.¹¹⁵ If this meant applying Peruvian guano, then at English application rates of around 3-4 cwt. per acre, the guano itself would have cost about £3 per acre; hence the remaining £3 per acre would have been taken up by cartage, and the labour employed in its application. This entailed broadcasting it or drilling it in at the same time as the seed.¹¹⁶ Farmyard manure was likely to be fetched from a much smaller distance than guano, but its bulkier nature would have increased the cartage rate, as well as the application cost - ideally, once it was spread, it had to be ploughed in too. It seems reasonable, therefore, to assume that the non-material cost of employing farmyard manure would also have been about £3 per acre. This was almost equal to the value of 10 bushels of wheat, and not dissimilar to the prices for which farmland was selling; a study of farm sales in Springs County, for example, shows that in all 11 transactions recorded in the 1860-6 period, the land price was under £5 per acre.¹¹⁷ For farmers without manure, and there was none available for sale,¹¹⁸ subsoiling was another option for rejuvenating the soil, since the plant roots gained access to fresh soil. As with manuring, however, the cost, in this case of both labour and implements, was probably prohibitive.¹¹⁹

If these options for restoring soil fertility were marginal, economically-speaking, in 1865, then they must have been untenable in 1866 after the average wheat price in Canterbury plummeted from the previous year's 6s. to just 4s.6d. per bushel.¹²⁰ At the same time, however, the necessity of fertility-improving measures probably seemed less dire, as the wheat yield, while not high, was better than it had been in the previous two years.¹²¹ Consequently, imports of fertilisers through Lyttelton came to a complete halt, although some Peruvian guano was still available for purchase.¹²² As a result, farmers' only practical option for restoring soil fertility was converting their crop land into pasture. Financially, this was no bad thing, as in 1866 the prices of beef, bacon and cheese were all at or near their post-1860 peaks.¹²³ Apparently, it did wonders for subsequent yields too. Some farmers who had made this conversion, and now gone back into wheat, were reporting yields of 50 bushels per acre.¹²⁴ The limited range of alternatives for conserving soil fertility did not stop continuing efforts to find more though. Indeed, when the 'Northern Agricultural and Pastoral Association' was formed
late in 1866, its first specific object was "to procure reliable analyses of soils and manures, with a view to increasing the productive powers of the country". As bad as the economic squeeze on Canterbury's crop farmers was in 1866, it got even tougher in 1867. Due to an unprecedentedly large wheat surplus in Australia, amounting to be more than 4 million bushels, the average price in Canterbury fell to a paltry 3s.9d. per bushel, a level at which cultivation ceased to be profitable. Clearly some significant changes needed to be made if arable farming was to return to any sort of prosperity. Contemporary comment and export returns suggest that the price of wheat also dropped in Otago, and thus its farmers were quick to take on board the mood for change now apparent amongst their northern counterparts.

V. British markets and bone-mills: reshaping agriculture in Canterbury and Otago after the wheat crash

From the ensuing discourse, three main options quickly emerged: firstly, the disposal of surplus grain in the English rather than the Australasian market; secondly, a shift away from cereal-based farms to mixed-farming operations; and thirdly, diversification into crops which had hitherto been largely ignored, such as sugar beet. Still another option, though not one which farmers could execute themselves, was to revive grain prices by imposing a tariff on imports. Of all the four, the most initial excitement was created by the export of grain to England. To test its feasibility, trial shipments of wheat were dispatched from Lyttelton, Timaru, and Oamaru during early 1867. Both the ex-Lyttelton and ex-Oamaru wheat shipments arrived in a sufficiently good condition to be sold for more than 8s. per bushel, and as a result, the Kaiapoi-based 'Canterbury Grain Export Company' and 'Oamaru Agricultural Export Company' were both established soon afterwards. Yet, as the Otago Daily Times pointed out, this remedy had its downsides too. Apart from exposing the farmer to increased risk, since New Zealand was now a small player in a global market, the export of wheat to England also represented a nett loss of the nation's soil fertility. Moreover, as a Mr. Gifford opined at a meeting of the Oamaru company, the 4s. per bushel which the trade promised as a return to farmers was insufficient to allow for manuring. Given these circumstances, the Otago Daily Times concluded that a greater emphasis on rearing stock, or the adoption of novel crops, were far better alternatives than continuing to grow cereals. Clearly, the Provincial Government of Otago thought along similar lines, as they became keen supporters of
extending sugar beet and malting barley cultivation, and asked Otago’s various agricultural societies whether the sugar and malting industries deserved financial aid.\textsuperscript{136} Christchurch’s \textit{Weekly Press}, meanwhile, steered clear of offering an opinion on what path farmers should take, perhaps because of the strong advocacy of the grain-exporting option by the Provincial Superintendent, W. S. Moorhouse, although it did observe that the reassessment of the current slovenly farming practices could only be beneficial.\textsuperscript{137}

The farmers themselves also appear to have had serious doubts about the wheat-exporting concept. Some indication of their sentiments can be gathered from a meeting held at Milton in October 1867 to discuss “the most profitable way of employing the land, considering the present low prices”. In the resulting discussion, no one challenged an assertion that it was now impossible “to follow the ruinous practice of growing grain alone”, and the only debate was over whether farmers should be putting their energies into rearing sheep or cattle. For low-lying areas cattle got the nod, partly because, as D. McMaster noted, the keeping of cattle for manure “was the least expensive way of improving impoverished land”.\textsuperscript{138} Such views cannot have been atypical in Otago, as the first of a series of annually compiled crop reports reveals that while, in almost every district, less wheat was sown in 1867 than in 1866, there had simultaneously been much more land going into pasture. Some farmers even forewent the usual grain cropping on newly broken-in land and laid down pasture straight away. Where farmers had decided to stick with cereal cultivation, moreover, they had overwhelmingly grown oats.\textsuperscript{139} Consequently, in the agricultural statistics collected by the 1867 census, reproduced in Table 10.3, sown grass accounted for 43% of the 122,209 acres under crop in Otago.

\begin{table}
\caption{Acreage of crops cultivated by Pakeha in Otago, as recorded in the \textit{December census returns}.\textsuperscript{140}}
\begin{tabular}{|ccccc|c|c|}
\hline
Year & Wheat & Oats & Barley & Potatoes & Grass & Garden & Turnips & Other & Total & Sown & \& Rape \\
\hline
1864 & 5817 & 21,088 & 848 & 3068 & 15,895 & 1321 & n. s. & 1120 & 49,158 \\
1867 & 12,541 & 42,973 & 3342 & 3343 & 52,902 & 1617 & 1787 & 3582 & 122,209 \\
\hline
\end{tabular}
\end{table}

As seen in Figure 10.3(a), this was close to the proportion it had been in 1861. Wheat and oats, meanwhile, made up 10% and 34% of the 1867 total respectively. A similar story can be found in Canterbury, where a comparison of
Figure 10.3
Changes in area under crop in Otago and Canterbury, 1861-7.

Source: Statistics of New Zealand for 1861 (Auckland, 1863), Table 49; Statistics of New Zealand for 1864, Part 1 (Census Results), Table 23; Statistics of New Zealand for 1867, Part 1 (Census Results), Table 21.

Although the gold-rush in Otago saw a surge in the proportion under field crops, in 1864, especially in Otago, over the 1861 to 1867 period the proportion under sown grass still increased.

The respective total sown acreages are:

<table>
<thead>
<tr>
<th>Province</th>
<th>1861</th>
<th>1864</th>
<th>1867</th>
</tr>
</thead>
<tbody>
<tr>
<td>Otago</td>
<td>19255 ac</td>
<td>49158 ac</td>
<td>122209 ac</td>
</tr>
<tr>
<td>Canterbury</td>
<td>32807 ac</td>
<td>68727 ac</td>
<td>152711 ac</td>
</tr>
</tbody>
</table>

It should be noted that the pie graphs are not proportional between the two provinces.
Figure 10.3

Relative Crop Areas in Otago by Years

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Grass</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1861</td>
<td>42%</td>
<td>24%</td>
<td>26%</td>
<td>8%</td>
</tr>
<tr>
<td>1864</td>
<td>32%</td>
<td>43%</td>
<td>12%</td>
<td>13%</td>
</tr>
<tr>
<td>1867</td>
<td>60%</td>
<td>9%</td>
<td>9%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Crop Type: Wheat, Oats, Grass, Other

Relative Crop Areas in Canterbury by Years

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Grass</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1861</td>
<td>12%</td>
<td>33%</td>
<td>41%</td>
<td>14%</td>
</tr>
<tr>
<td>1864</td>
<td>26%</td>
<td>19%</td>
<td>8%</td>
<td>17%</td>
</tr>
<tr>
<td>1867</td>
<td>48%</td>
<td>23%</td>
<td>11%</td>
<td>17%</td>
</tr>
</tbody>
</table>

Crop Type: Wheat, Oats, Grass, Other
1866 acreage returns for cereals, and 1867 census statistics, for the area north of the Waimakariri, shows that although the total acreage in cereals increased slightly, the acreage in wheat fell from 10,671 to 7526 acres. Even at Kaiapoi, home of the Canterbury Agricultural Export Company, support for wheat-growing must have been fairly weak, as an October 1867 meeting of the Company had a disappointing attendance. A decided swing towards intensive pastoralism is also suggested by the 'Farm Calendar' for October in the Weekly Press, which remarked that “we understand that feeding off with sheep, and stall feeding of cattle, is likely to be carried out to a considerable extent next winter”. As Table 10.4 shows, this swing raised the proportion of area under crop in Canterbury which was in sown grass to 48%. This, as seen in Figure 10.3(b), was higher than it had ever been in the past.

Table 10.4: Acreage of crops cultivated by Pakeha in Canterbury, as recorded in the December census returns.

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Grass</th>
<th>Garden</th>
<th>Turnips</th>
<th>Other</th>
<th>Total &amp; Rape</th>
</tr>
</thead>
<tbody>
<tr>
<td>1864</td>
<td>13,328</td>
<td>14,672</td>
<td>2432</td>
<td>1753</td>
<td>31,671</td>
<td>2200</td>
<td>n. s.</td>
<td>2672</td>
<td>68,727</td>
</tr>
<tr>
<td>1867</td>
<td>26,683</td>
<td>35,382</td>
<td>5868</td>
<td>2401</td>
<td>73,709</td>
<td>2800</td>
<td>831</td>
<td>6037</td>
<td>152,711</td>
</tr>
</tbody>
</table>

These changes to farming practices coincided with a new wave of support for agricultural education. If farmers were to apply new methods or adopt new crops, with which they had no previous experience, then theory had to step into the breach. While the Canterbury's agriculturists had to make do with the new Farmers' Club for the dissemination of the latest insights from agricultural science, the Provincial Government of Otago, mindful that a Board of Agriculture and experimental farm had been established in Victoria, consulted with local agricultural and pastoral societies on whether Otago needed similar institutions. The Otago Daily Times went even further, suggesting that establishing a School of Mines and Agricultural Chemistry should be a greater priority than a University, because, as its 'agricultural correspondent' put it, "to know the dead languages is very good, but to be able to make two blades grow for one is still better". The response from farmers to these suggestions was mixed, however. Scepticism about how a model farm would be managed proved fatal to its prospects, but the idea of attaching an Agricultural and Industrial Museum to the forthcoming university, and appointing a Chair in Chemistry and
Technology, was endorsed by Otago's agricultural societies. The offer of free soil analyses, meanwhile, made by the recently established Colonial Laboratory in Wellington, was only taken up by three farmers in Otago and none in Canterbury.

Naturally, the shift towards mixed farming had practical implications for soil fertility management practices too. Although, as the Otago Daily Times' 'agricultural correspondent' reflected, many farmers remained reluctant to grow root crops because they were not a direct source of profit, and as for fertilisers, "the bones of the country have been cast aside as of no account, and guano and other portable manures little heard of", the expansion in the acreage under sown grasses and root crops which occurred during 1867 was sufficient to kick-start local phosphatic fertiliser production. In this year, the first bone-mills in Canterbury and Otago, namely Edward Reece's Colombo St mill in Christchurch, and W.R. Douglas' equivalent establishment on the banks of the Leith in Dunedin, were both established.

Henceforth bone-dust use on an unprecedented scale would be possible - according to a Weekly Press report, Reece's mill in Christchurch had 200 tons of bones stockpiled, which, if complete conversion to bone-dust is assumed, could have been applied, at Reece's suggested rate of 5 cwt. per acre, to around 800 acres of root crops or grassland. This compared with the 2035 acres in root crops in Canterbury recorded by the 1867 census. Douglas probably should have stockpiled bones too, as the supply to his mill was, at least initially, "somewhat irregular and small". Consequently, for a time in early 1868 there was no bone-dust in Dunedin available for purchase. Within Otago at least, other cheap potential fertilisers also came under scrutiny. Although its soil analysis offer had drawn a poor response, the Colonial Laboratory did receive from Dr. Eccles three specimens of mud dredged from Otago Harbour, who wished to ascertain their "economic value as manure". Similarly, in October 1867 two separate applications were made to the Waste Land Board respecting permits to extract 'guano' from Solander Island, although this product never seems to have been offered for sale.

It appears that many farmers were also starting to cultivate legumes, thereby reducing their dependence on farmyard manure when it came to replenishing nitrogen levels depleted by cereal cultivation. In 1867 peas and beans were being cultivated in Canterbury on 2678 acres. In Otago, peas and beans were cultivated to a much smaller extent (555 acres in total), but this was probably owing to the cold climate cutting short the growing season. The limited growth potential of these two legumes probably inspired the renewed attention paid in
Otago to the problem of acclimatising the bumblebee (or humblebee), as this was needed to fertilise another nitrogen-fixer, red clover.\textsuperscript{161} If it could be achieved, this promised to open up a new avenue for Otago farmers to restore the fertility of their soil.

By 1868 it is clear that many farmers in Otago and Canterbury regarded the management of soil fertility as too important to ignore. This was a far cry from the situation at the start of the decade when agricultural chemistry had been something confined largely to the foreign textbook and 'artificial' fertilisers were nowhere to be found. The high cost of labour, stemming in large part from the gold-rushes, continued to deter farmers from using farmyard manure in the early and mid-1860s, but simultaneously the promise of inflated produce prices helped to overcome the previously inhibited approach of farmers to 'artificial' fertiliser use. Indeed, for a time in 1864, when wheat was at its highest price, it seemed that demand for 'artificial' fertilisers was rapidly gaining in strength. However, once produce prices began falling again, demand fell away just as quickly. Ironically, it was the harsh economic realities of 1866 and 1867, when grain cultivation ceased to become profitable, rather than the good times beforehand, that finally persuaded farmers of the need to adopt practices that were more sustainable from a soil fertility viewpoint. In this case, the obvious solution was to shift to a greater emphasis on rearing stock. This in turn prompted extensive root crop cultivation, and in support of it, the beginnings of a local phosphate fertiliser industry. The extent of this change was such that in late 1867 one member of the Canterbury Farmers' Club expressed a fear that the province "would soon become a wool producing one only".\textsuperscript{162}

Yet, just when the future direction of farming in Otago and Canterbury seemed settled, the fickle hand of world commodity markets threatened to turn the tables. In 1868 Australia failed to produce a wheat surplus, and consequently the price in both Otago and Canterbury rebounded to a much healthier 5s. per bushel.\textsuperscript{163} The price of wool, which had been erratic since the middle of the decade, meanwhile went into a steep decline. After having been a steady 12.75-13.25d. between 1861 and 1866, the average price per pound in Canterbury, after discounting for freight, fell to just 8.75d. by 1869.\textsuperscript{164} Suddenly, agricultural commentators were left wondering whether farmers should still adhere to the catch-cry "get everything under grass; ploughing won't pay".\textsuperscript{165}
Notes to Chapter Ten

1 Statistics of New Zealand for 1858 (Auckland, 1859), Table 75 [unpaginated]; Statistics of New Zealand for 1867. Including the results of a Census of the Colony, taken in December of that year (Wellington, 1869), Pt. 1 (Census Results), Table 21 [unpaginated].


4 Ibid., 3 November 1860, p. 4. As in Chapter Eight, an approximation of 10 bags to 1 ton has been used in this chapter, until shipment details suggest otherwise.

5 Ibid., 4 May 1861, p. 7.


7 Ibid., 5(200) (6 August 1862), p. 50.

8 Extract from [Richardson, J. L. C.,] Descriptive Sketch of the Province of Otago, in Otago Daily Times, 27 October 1862, p. 4. Richardson's authorship is indicated by a preamble to extracts from an earlier version of the same pamphlet (Ibid., 17 March 1862, p. 3).

9 Statistics of New Zealand for 1861, including the results of a Census of the Colony taken on the 16th December in that year (Auckland, 1863), Table 55 [unpaginated]; Statistics of New Zealand for 1862 (Auckland, 1864), Table 42 [unpaginated]; Statistics of New Zealand for 1863 (Auckland, 1865), Table 42 [unpaginated].


11 Statistics of New Zealand for 1863, Table 18. This compares with the value of 4s. per bushel of oats (and 6s. per bushel of wheat) given in the 1862 pamphlet Descriptive Sketch of the Province of Otago (Extract from [Richardson, J. L. C.,] Descriptive Sketch of the Province of Otago, in Otago Daily Times, 27 October 1862, p. 4).


13 Otago Provincial Government Gazette 5(200) (6 August 1862), p. 50; Statistics of New Zealand for 1864, including the results of a Census of the Colony taken in December of that year (Auckland, 1866), Pt. 1 (Census Results), Table 23 [unpaginated].

14 Otago Provincial Government Gazette 4(116) (18 July 1860), p. 57; Ibid., 5(200) (6 August 1862), p. 50. It is worth noting that in the Clutha district (which was closest to the Tuapeka goldfields, where the rush began (Hearn, Terry, & Ng, James, 'After the Rush: Central Otago 1860s-1940s'. In McKinnon, Malcolm (ed.), New Zealand Historical Atlas (Auckland, 1997), Plate 45), and was thereby the best situated for providing meat and dairy produce, which are less amenable to carriage than grain or flour), the proportion of turnips to total under crop in 1859 was 1.1%, while 'other crops' accounted for 2.3% of the total in crop in 1861.
The average price per lb. of beef in Otago rose from 7d. in 1860 to 1s. in 1863, and was still as high as 9d. in 1865 (Statistics of New Zealand for 1860, Table 31, Statistics of New Zealand for 1863, Table 42, & Statistics of New Zealand for 1865 (Auckland, 1867), Table 42 [unpaginated]).

Otago Daily Times, 11 November 1862, p. 4.

The respective shipments consisted of 6 tons of bone-dust (Ibid., 11 July 1863, p. 4) and 52 bags of guano (Ibid., 17 September 1863, p. 4).


Otago Daily Times, 3 October 1864, p. 4, & 7 October 1864, p. 3.

Ibid., 15 October 1864, p. 4. For comments on the reserve price and later sales, see ibid., 18 October 1864, p. 4.

Statistics of New Zealand for 1864, Pt. 2 (General Statistics), Table 42.

The other fertiliser imports into Dunedin during 1864 consisted of 24 casks of guano (Otago Daily Times, 11 June 1864, p. 4), 54 bags of guano (Ibid., 27 August 1864, p. 4), 242 bags of bone-dust (Ibid., 4 October 1864, p. 4), 94 bags of phosphates (Ibid., 11 October 1864, p. 4), and 68 bags of guano (Ibid., 24 October 1864, p. 4).


Shipments were made from Dunedin to Oamaru, Christchurch, Nelson, Picton, Invercargill, and Port Molyneux. Otago Daily Times, 27 October 1864, p. 4, 2 November 1864, p. 4, 5 November 1864, p. 4, 12 November 1864, p. 4, & 25 November 1864, p. 4.

Bruce Herald, 17 November 1864, p. 4.

Extract from Southland News, in Otago Daily Times, 11 June 1864, p. 4; Ibid., 12 November 1864, p. 4.


[Murray, John], The new field for Pastoral and Agricultural Pursuits, being a description of the Province of Southland, New Zealand (London, 1867), p. 15.

McIntosh, P. D., Soils for horticulture in Southland (Dunedin, 1992), pp. 15 & 39; Bruce, J. G., Soil Resources of the Southland Region, New Zealand (Wellington, 1984), pp. 10-1 &
20-l, and 'Soil map of Southland Region, New Zealand' (accompanying map).

30 Otago Witness, 3 December 1864, p. 19.

31 Lynch, 'The Garden of Otago: a history of small-scale farming in the Clutha area' (Unpublished M. A. thesis, University of Otago, 1989), pp. 115-6. Lynch does not state (on p. 115) what sort of 'fertiliser' Bowler used on his oats in 1863, but the diary entry of Bowler which Lynch refers to states that Bowler "dunged" the field (Pers. comm., Otago Early Settlers Museum Research Librarian, 19 June 2002), so on this basis it has been assumed that dung was being used.

32 Otago Daily Times, 24 June 1862, p. 5. John Cargill, one of William's sons, had polled third highest in the Town Board election at the end of 1861 (Ibid., 31 December 1861, p. 4).

33 Extract from Otago Witness, in ibid., 2 August 1862, p. 6.


35 Otago Witness, 16 May 1863, p. 4.

36 Ibid., 27 February 1864, p. 11.


38 See ibid., 16 May 1863, p. 4; Extract from North British Agriculturist, in ibid., 25 May 1863, p. 6; Ibid., 11 July 1863, p. 3; Extract from Yeoman, 18 July 1863, p. 6, in ibid., 7 August 1863, p. 6; Extract from Ballarat Star, in ibid., 20 February 1864, p. 17; Ibid., 27 February 1864, p. 11, & 23 July 1864, p. 15.

39 Ibid., 7 August 1863, p. 6.

40 Ibid., 28 May 1864, p. 3.

41 Ibid., 27 February 1864, p. 11.

42 'Artificial' fertilisers were mentioned in the 'Calendar' for September 1863 (Otago Witness, 11 September 1863, p. 6), which advocated the application of nitrate of soda to cereals, following the practice begun in Great Britain in the 1830s (Fussell, G. E., 'The Early Days of Chemical Fertilizers'. Nature 195 (4843) (25 August 1962), pp. 751-2), and in the 'Calendar' for May 1864 (Otago Witness, 29 April 1864, p. 14), which suggested that bone-dust be used to manure grass and clover pastures. Presumably the writer of the former was anticipating a future supply of nitrate of soda, as there is no record of any being in Dunedin at this time. In addition, an article on turnip sowing commented on the beneficial effects of bone-dust (Ibid., 29 October 1864, p. 15). Although it is not a fertiliser as such, applying lime was also recommended in two 'Calendars' as a way of improving turnip and pasture growth and preparing land for cereal cropping (Ibid., 5 December 1863, p. 6, & 29 April 1864, p. 14). By contrast, it is noticeable that some extracts of British agricultural literature which appeared in the Otago Witness made mention of a wide range of 'artificial' fertilisers (see, for example, extract from a pamphlet by J. B. La[wes]. Ibid., 11 April 1863,
p. 6; Extract from Mark-Lane Express, in Ibid 25 July 1863, p. 6. In the reproduction, it gives the pamphlet's author as J. B. Larne, but as there is no author with this name listed in the Library of Congress' National Union Catalogue pre-1956 Imprints, it seems reasonable to assume that this was a transcription error by the printer).

43 *Otago Witness*, 28 May 1864, p. 3.

44 One part of the 'agricultural frontier' where acreages can be examined in detail, is that part of Wallace Electorate which was on the Otago side of the provincial boundary between Otago and Southland - this area would have contained settlement along the south bank of the Kawarau River, and along the south bank of the Clutha River, from the Kawarau confluence to just downstream from Roxburgh (McRobie, Alan, *New Zealand Electoral Atlas* (Wellington, 1989), p. 35. Cf. McKinnon, Malcolm, & McKinnon, John, 'Colonial Government: centralisation and uniformity, 1860-1890'. In McKinnon, Malcolm (ed.), *New Zealand Historical Atlas* (Auckland, 1997), Plate 51 for Southland Province boundary. By subtracting the relevant data for Southland Province (*Statistics of New Zealand for 1864*, Pt. 1 (Census Results), Table 24), from that for Wallace Electorate (*Statistics of New Zealand for 1864*, Pt. 1 (Census Results), Table 25), it is found that the areas sown in oats, potatoes and sown grass at the close of 1864 were 187, 81 and 51 acres respectively. These figures coincide with those given for Wallace in an otherwise incomplete census return for Otago published in the *Otago Daily Times* (*Otago Daily Times*, 2 February 1865, p. 4).

45 For the purposes of this comparison, the 1861 figures have been compiled from data for the Provincial Electorates of Port Chalmers, Western, and Eastern (*Otago Provincial Government Gazette* 5(200) (6 August 1862), p. 50), which together encompass an area which coincides approximately with the area encompassed by the General Electorates of Dunedin & Suburbs North, and Dunedin & Suburbs South. The 1864 figures for the latter are taken from *Statistics of New Zealand for 1864*, Pt.1 (Census Results), Table 24. For the General Electorate boundaries, see McRobie, Alan, *New Zealand Electoral Atlas* (Wellington, 1989), p. 35, while for the Provincial Electorate boundaries, see *Otago Provincial Government Gazette* 2(15) (11 December 1854), p. 3. Given the locations of polling booths in later provincial elections (see *Otago Provincial Government Gazette* 3(86) (20 July 1859), p. 233), it seems that the boundaries of these particular Provincial Electorates probably remained unchanged.

46 *Otago Witness*, 27 February 1864, p. 11.

47 Ibid., 6 June 1863, p. 6, & 27 February 1864, p. 11.

48 *Otago Daily Times*, 18 April 1865, p. 6.

49 *Otago Witness*, 5 November 1864, p. 5.

By 1834, there were some 136 agricultural societies within Scotland, whereas England in 1835 had only about 90. Wilmot, Sarah, 'The Business of Improvement': Agriculture and Scientific Culture in Britain, c.1700-c.1870 (Reading ?, 1990), p. 9.

52 Lyttelton Times, 6 July 1861, p. 4.
53 Canterbury Standard, 28 April 1859, p. 3; Lyttelton Times, 7 June 1862, p. 3.

55 Statistics of New Zealand for 1860 (Auckland, 1862), Table 31.
56 Canterbury Standard, 28 April 1859, p. 3; Lyttelton Times, 7 June 1862, p. 3.
57 Lyttelton Times, 31 August 1861, p. 4. Interestingly, in an address given in 1863, Superintendent Moorhouse noted that his railway schemes would assist in the adoption of modern 'high farming'-style practices, by allowing the ready transport of purchased feedstuffs and manure (W. S. Moorhouse (speech of farewell from Superintendency), 3 March 1863. Ibid., 7 March 1863, p. 4).

58 Ibid., 19 March 1862, p. 4.
59 Statistics of New Zealand for 1861, Table 55; Statistics of New Zealand for 1862, Table 42; Statistics of New Zealand for 1863, Table 42. Apart from Australia, Chile and California also competed with New Zealand in the production of grain (See, for example, Otago Daily Times, 18 April 1865, p. 6; Otago Witness, 19 August 1865, p. 5).

60 Lyttelton Times, 13 May 1863, p. 2.
61 Ibid., 13 October 1863, p. 4, & 14 November 1863, p. 4.
62 Ibid., 14 January 1864, p. 6. See also Ibid., 12 August 1863, p. 3, & 13 October 1863, p. 4.
63 Ibid., 14 May 1864, p. 5.
65 F. E. Wright to the Ed. Ibid., 25 October 1864, p. 5.
66 Wright referred explicitly to schemes for dealing with sewage in both London and Melbourne. News of these developments could be found in articles reproduced in the Lyttelton Times. See extract from Morning Post, in ibid., 29 April 1863, p. 2; Extract from Melbourne Leader, in ibid., 4 October 1864, p. 5; Extract from Times, 10 September 1864. in ibid., 29 November 1864, p. 3.
The report (given in the Lyttelton Times, 14 January 1865, p. 4) states that the as-yet unidentified 'blight' left circular patches of darkened straw. This corresponds well with Hilgendorf's description of take-all (Hilgendorf, F. W., *Wheat in New Zealand* (Auckland, 1939), pp. 78-9. Moreover, an item in the Otago Daily Times in 1869 referred to 'take-all blight' (Otago Daily Times, 17 April 1869, p. 2).

Lyttelton Times, 14 June 1864, p. 5.

In it interesting to note that many Canterbury farmers still apply a similar system (2-4 years under crop alternating with 2-4 years under pasture) today (Haynes, R. J. & Francis, G. S., 'Effects of mixed cropping farming systems on changes in soil properties on the Canterbury Plains'. *New Zealand Journal of Ecology* 14 (1990), p. 73).

Lyttelton Times, 8 November 1864, p. 4.

See, for example, an export of 10 tons of bones in September 1864. Ibid., 15 September 1864, p. 4.

Statistics of New Zealand for 1865, Table 42.

New Zealand Exhibition, 1865. Reports and Awards of the Jurors. And Appendix (Dunedin, 1866), pp. 422-3. Combes and Daldy's involvement in the guano trade is described more fully in Chapter Eight. For background on Dr. Crowther's guano business, see Crowther, W. E. L. H., 'The development of the Guano Trade from Hobart Town in the Fifties and Sixties'. *Papers and Proceedings of the Royal Society of Tasmania* (1938), pp.213-220. It should be noted that Bird Island guano was already being sold in Dunedin and Invercargill in mid-1864 (see Otago Daily Times, 18 June 1864, p.1; Southland News, 29 June 1864, p. 3). It was retailed in Invercargill for £10 10s. per ton.

Otago Daily Times, 8 June 1855, p. 4.

Otago Witness, 10 June 1865, p. 19. If this advertisement is genuine, which given the frequency of fraud involving 'artificial' fertilisers (see, for example, Aikman, C. M., *Manures and the principles of manuring* 3rd ed. (Edinburgh, 1894), pp. 318-20; Otago Witness, 25 November 1865, p. 3, & 17 February 1866, p. 14), cannot be said with certainty, it would have had to be imported from Great Britain, as there were no superphosphate manufacturing plants in Australia or on the Pacific coast of the United States at this time (Jacob, K. D., 'History and Status of the Superphosphate Industry'. In United States Department of Agriculture & Tennessee Valley Authority, *Superphosphate: its history, chemistry, and manufacture* (Washington, D. C., 1964), p. 34; Wines, Richard A. *Fertilizer in America: from waste recycling to resource exploitation* (Philadelphia, 1976), pp. 175-6). Unfortunately, shipping lists did not itemise goods coming in with British cargoes, so it is impossible to check this.


In three testimonials provided by notable Otago settlers on Peruvian guano (George Matthews to Douglas, Alderson, & Co, 25 August 1866, Thomas Murray to same, 9 August 1866, & Donald Reid to same, 18 August 1866. Weekly Press, 20 October 1866, p. 7), the rates employed per acre were 2 cwt. on potatoes, 1-2 cwt. on pasture, and 2.5 cwt. on turnips. This is lower than recommended English rates, which were generally about 3 cwt. per acre (see Nesbit, J. C., ‘On Peruvian Guano’. New Zealander, 29 October 1856, p.3). In Scotland, meanwhile, about 6 cwt. per acre on turnips was not uncommon (Aikman, Manures and the principles of manuring 3rd ed., p. 317).


Extract from Australasian, in Weekly Press, 11 March 1865, p. 7. According to its initial statement of intent, the Weekly Press was “specially designed for circulation in the country districts”. Ibid., February 1865, p. 1.

Otago Witness, 10 April 1865, p. 6, & 21 October 1865, p. 4.

Ibid., 29 October 1864, p. 15, 2 December 1865, p. 21, & 21 April 1866, p. 4. In addition, one article in the Otago Daily Times asserted that nitrogen could be got more cheaply from cattle dung than from 'artificial' manures (Otago Daily Times, 23 June 1865, p. 6).

Otago Witness, 24 February 1866, p. 3. As noted in Chapter One, ash contains large amounts of potassium, together with lesser amounts of phosphorus. In view of this, one Otago Witness article claimed that ash from burnt bush was as valuable a fertiliser for grass as £2 worth of bone-dust per acre (Ibid., 13 July 1866, p. 4).

Statistics of New Zealand for 1866 (Wellington, 1868), Table 42 [unpaginated].

Statistics of New Zealand for 1866, Table 21; Otago Witness, 19 August 1865, p. 5.

for agricultural leasehold land under the Goldfields Act was raised (effective from early
1866) from 10 to 50 acres (Ibid., p. 106).

91 *Otago Witness*, 21 April 1866, p. 4. Previously, it had been anticipated that wheat prices
would remain high for some time (see ibid., 19 August 1865, p. 5).

92 *Otago Daily Times*, 15 July 1867, p. 4.

93 Ibid., 20 April 1867 (Supplement), p. 1. No statistics were collected for cultivations within
towns or on pastoral runs.

94 In the Lower Clutha area, which has similar soils, farmers were actively draining their land
at this time. Cutler, E.J.B., Richards, J., & Collie, T.W., *Soils of the Lower Clutha Plains*

95 Approximately 1300 acres were sown in root crops, and 31,000 acres were under sown grass.

96 Strangely, Murray's did not appear in the *Otago Witness*, but it did appear in the *Weekly
1 September 1866, p. 11; Thomas Murray to same, 9 August 1866. *Weekly Press*, 20 October
1866, p. 7. See, for additional comment of this type, although not so much in an advertising
context, extract from *Oamaru Times*, in *Otago Witness*, 11 August 1866, p. 5.

97 Such was the extent of the labour shortage that the enumeration of farm crops included a
farm labour survey. *Otago Daily Times*, 19 April 1867, p. 5, & 20 April 1867 (Supplement),
p. 2.

98 'A Citizen' to the Ed. Ibid., 7 November 1866, p. 5.


100 *Weekly Press*, 15 April 1865, p. 4.

101 Ibid.

102 Ibid., 3 June 1865, p. 2. Because of the difficulty traversing the Southern Alps, the great
bulk of supplies which sustained the West Coast gold-rush communities came not from
Canterbury, but from Victoria, and to a lesser extent from Nelson (Grey, Alan H.,


104 'Canterbury Farmer' to the Ed. Ibid., 20 July 1865, p. 2; Robert Rickman to the Ed. Ibid.,
25 July 1865, p. 2; Samuel Lock to the Ed. Ibid., 28 July 1865, p. 2. See also 'Small
Farmer' to the Ed., 25 July 1865. Ibid., 27 July 1865, p. 3.

105 Robert Rickman to the Ed. Ibid., 25 July 1865, p. 2. Rickman Bros. were frequent
contributors to the 'Agricultural Report' in the monthly summaries of the
*Lyttelton Times* (see, for instance, ibid., 14 January 1865, p. 4).

106 Ibid., 18 September 1865, p. 2.

Presumably farmers wished to save on the ploughing expense. *Weekly Press*, 7 October 1865, p. 3. See also Samuel Lock to the Ed. *Lyttelton Times*, 8 September 1865, p. 3.


*Weekly Press*, 10 June 1865, p. 3, 17 June 1865, p. 3, 24 June 1865, p. 3, & 1 July 1865, p. 3.

The series on 'allotment farming' was prompted by a Workingmens' Association scheme to purchase small blocks of rural land for their members. *Ibid.*, 10 March 1866, pp. 3-4, 17 March 1866, p. 4, 24 March 1866, p. 3, 7 April 1866, pp. 3-4, 14 April 1866, p. 4, & 21 April 1866, p. 4.


Weston, I. W., *Farm Economic Survey of Springs County, Canterbury, New Zealand* ([Leeston, 1934]), pp. 29-30. Springs County was located between Lincoln and Lake Ellesmere.


Samuel Lock to the Ed. *Lyttelton Times*, 8 September 1865, p.3; *Weekly Press*, 6 January 1866, p. 4, & 17 March 1866, p. 4. Unfortunately, it is not always made clear whether the term subsoiling is referring to just breaking up the subsoil, or bringing it to the surface too.

*Statistics of New Zealand for 1865*, Table 42; *Statistics of New Zealand for 1866* (Wellington, 1868), Table 42 [unpaginated].

*Weekly Press*, 20 January 1866, p. 3. See also *Lyttelton Times*, 12 February 1866, p. 4.

*Weekly Press*, 13 October 1866, p. 1. See also *ibid.*, 20 October 1867, p. 7. It should be noted that the 25 ton shipment of Peruvian guano delivered to Canterbury in 1864 was not unloaded at Lyttelton, but rather at the Heathcote wharf. Unfortunately there are no cumulative records of deliveries to the latter.

In price series for butter and cheese during the years 1861-1910, 1866 had the highest butter and second highest cheese price. In a price series for beef during the years...

125 Ibid., 20 October 1866, p. 6.
127 *Statistics of New Zealand for 1867*, Pt. 2 (General Statistics), Table 42; *Weekly Press*, 20 April 1867, p. 3, & 25 May 1867, p. 7.
128 *Statistics of New Zealand for 1867*, Pt. 2 (General Statistics), Table 19; *Otago Witness*, 26 July 1867, p. 12. It would appear that the quoted value for wheat, given in the *Statistics of New Zealand for 1867* of 5s.6d. is incorrect. The reduction in the wheat price in Southland, which not surprisingly tended to follow that in Otago, would also suggest this (*Statistics of New Zealand for 1867*, Pt. 2 (General Statistics), Table 42).
130 See *Otago Daily Times*, 23 July 1867, p. 4.
133 *Otago Daily Times*, 12 October 1867, p. 4, 6 November 1867, p. 4, & 29 November 1867, p. 4
134 See the report of the meeting, based on that in the *Oamaru Times*, in ibid., 7 November 1867, p. 5.
135 Ibid., 12 October 1867, p. 4, 6 November 1867, p. 4, 7 November 1867, p. 4, & 29 November 1867, 4.
136 Ibid., 29 November 1867, p. 4. See also *Otago Witness*, 24 October 1868, p. 16.
137 *Weekly Press*, 15 June 1867, p. 3. For Moorhouse's view, see the report on his speech at Kaiapoi on 16 May. Ibid., 25 May 1867, p. 7. It should be noted that the *Press* had played a key role in fomenting opposition to Moorhouse prior to his resignation from his first Superintendency in 1863 (Pitcaithly, Alan C., *The History of Canterbury, New Zealand, 1861-1867* (Unpublished M. A. thesis, Canterbury University College, 1935), p. 94).
139 *Otago Daily Times*, 17 February 1868, pp. 4-5.
The 12,541 acres recorded as sown in wheat in 1867 was considerably less than the 14,808 acres recorded in the provincial agricultural statistics collected for the previous year’s crop, even though the 1866 figure did not include cultivations in towns or on pastoral runs (Ibid., 20 April 1867 (Supplement), p. 1).

Weekly Press, 24 August 1867, p. 6; Statistics of New Zealand for 1867, Pt. 1 (Census Results), Table 22. For the sake of comparison, the area encompassed by the Electorates of Cheviot, Ashley and Kaiapoi (see McRobie, New Zealand Electoral Atlas, p. 37) has been regarded as equivalent to that described in the 1866 data as ‘north of the Waimakaniri’.

Weekly Press, 12 October 1867, pp. 3-4.

Ibid., 5 October 1867, p. 3.

Lyttelton Times, 28 January 1865, p. 4; Statistics of New Zealand for 1867, Pt. 1 (Census Results), Table 21.


Otago Daily Times, 29 November 1867, p. 4. See also ibid., 12 October 1867, p. 4.

Ibid., 11 December 1867, p. 4, & 27 February 1868, p. 4. On the educative potential of agricultural societies, see ibid., 18 October 1867, p. 4, & 2 December 1867, p. 4.

John Bathgate, for example, warned that it "would prove a source of waste and extravagance". J. Bathgate [to Provincial Secretary], cited in Otago Witness, 4 April 1868, p. 14.

Otago Daily Times, 10 April 1868, p. 5.

Ibid., 25 June 1867, p. 5; Hector, James (ed.). Third Annual Report on the Colonial Museum and Laboratory, together with a Report on the Results of the analyses of Soils from various parts of the Colony (Wellington, 1868), p. 14. The individuals who submitted soil samples were W. Parker (two) of Oamaru, H. T. Millar of Oamaru, and Major Cargill of Green Island.

Otago Daily Times, 20 March 1868, p. 4.

Weekly Press, 31 August 1867, p. 5; Otago Daily Times, 10 April 1867, p. 4.

Reece intended to sell the processed bone-dust for £10. per ton. Weekly Press, 31 August 1867, p. 5. For Reece’s recommended rate of application, see his later advertisement in the Timaru Herald (Timaru Herald, 13 October 1869, p. 2).]

Reece’s supply appears to have been collected by way of an advertisement, directed towards to the unemployed, which offered payment for any bones they could find (Lyttelton Times, 19 January 1866, p. 1). This last advertisement requested the bones be brought to the Birmingham and Sheffield Warehouse, which is the same name which Reece gave in the Timaru advertisement as the point-of-sale for his bone dust.
Statistics of New Zealand for 1867, Pt. 1 (Census Results), Table 21. 831 acres of this total, as seen in Table 10.4, were made of ‘turnips and rape’, while the remaining 1194 acres was composed of ‘mangold, beet, carrots, parsnips, or onions’.

Douglas’ mill had a production capacity of 2 tons per day, but initially at least operated at less than half this figure. Otago Daily Times, 10 April 1867, p. 4. See also James Kennedy to Messrs. Driver, Maclean and Co. Ibid., 23 September 1867, p. 5.


Otago Daily Times, 1 November 1867, p. 4.


Otago Daily Times, 5 August 1867, p. 5.

Weekly Press, 23 November 1867, p. 5.

Statistics of New Zealand for 1868 (Wellington, 1869), Table 43.


Otago Witness, 22 February 1868, p. 7.
Chapter Eleven

An Age of Improvement: the expanding use of fertilisers and crop rotation in Otago and Canterbury c.1868-1876

The end of the 1860s marks the first great turning point in New Zealand farming since colonisation. Henceforth the premier position of extensive pastoralism would be increasingly challenged by intensive pastoralism, producing both wool and meat, and intensive cropping, producing wheat for export. In terms of soil fertility management, this provided both opportunity and threat. With the change to intensive stocking rates, 'high farming' practices such as yard-feeding and folding became much more viable, and the ability to collect manure was thereby enhanced. If the area under crop (not including sown pasture) also expanded, however, this manure, as well as supplementary fertilisers, would be needed more than ever.

I. If not wool, then what?

It was not obvious to contemporaries that this change was taking place. The initial response of the Otago Daily Times, for example, to the severe downturn in wool prices which occurred during 1868 was denial, as it resolutely declared "there can be no limit to the demand for wool".1 Similar reassurance came from the Timaru Herald, which argued that growing grain might be profitable this year, but there was no guarantee that it would be in future years.2 Nevertheless, the Otago Witness remarked that farmers' misgivings had led them by October 1868 to form "a general resolution" that "grain growing should be abandoned and the paddocks laid down to grass".3

The statistics for crops sown in 1868 indicate, however, that Otago's farmers were not ready to forego wheat-growing just yet. Due to the rebound of the wheat price to 5s. per bushel referred to in Chapter Ten, in most of Otago the wheat acreage stayed the same, and in the Oamaru district it surged ahead, on account of estate owners like Matthew Holmes and the New Zealand and Australian Land Company taking the opportunity to break-in land. This process was also encouraged in the Oamaru district by the fact that its lime-rich loams were fast developing a reputation as fine wheat soils.4 Overall, the Otago-wide
wheat acreage, as seen in Table 11.1(a), was 61% more than the previous year’s, whereas the area under sown grass had grown only by 58%.

Table 11.1(a): Acreage of crops grown by Pakeha at harvest time within Otago Province.5

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat Sown</th>
<th>Oats</th>
<th>Barley Sown</th>
<th>Potatoes</th>
<th>Turnips</th>
<th>Other Sown</th>
<th>Total Sown</th>
<th>Grass &amp; Rape</th>
</tr>
</thead>
<tbody>
<tr>
<td>1867</td>
<td>12,541</td>
<td>42,973</td>
<td>3342</td>
<td>3343</td>
<td>52,902</td>
<td>1787</td>
<td>122,209</td>
<td></td>
</tr>
<tr>
<td>1868</td>
<td>20,142</td>
<td>40,821</td>
<td>2604</td>
<td>3033</td>
<td>83,782</td>
<td>n. s.</td>
<td>2186</td>
<td>152,568</td>
</tr>
</tbody>
</table>

(n.s.) = not specified

In Canterbury, the financial encouragement to grain-growing proved even more persuasive. Whereas the area sown in grass during 1868 differed little from that in 1867, the area put into wheat, as recorded in interim statistics collected in November 1868, was 51% up on the previous year’s figure. This increase had dropped back to some 24%, nonetheless, by the time final returns were collected in February. The likely reason for the discrepancy between the two sets of data, which are reproduced below in Table 11.1(b), was that some farmers reacted to drought (referred to in notes to the interim returns) by ploughing up their crops prior to the final returns being collected.

Table 11.1(b): Acreage of crops grown by Pakeha within Canterbury Province.6

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat Sown (as of December 1867)</th>
<th>Oats</th>
<th>Barley Sown (as of December 1867)</th>
<th>Potatoes</th>
<th>Turnips</th>
<th>Other Sown</th>
<th>Total Sown (as of December 1867)</th>
<th>Grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>1867</td>
<td>26,683</td>
<td>35,382</td>
<td>5868</td>
<td>2401</td>
<td>73,709</td>
<td>8218</td>
<td>152,711</td>
<td></td>
</tr>
<tr>
<td>1868</td>
<td>40,378</td>
<td>29,868</td>
<td>9941</td>
<td>1693</td>
<td>78,307</td>
<td>2266</td>
<td>162,453</td>
<td></td>
</tr>
</tbody>
</table>

The revival in the fortunes of cropping in 1868 also prompted, as it had in 1864, a huge 'artificial' fertiliser import. The fertiliser concerned was Howland Island guano, 550 tons of which was delivered to Bluff in September 1868. A
month later a further 400 tons were discharged at Dunedin. This particular guano is a phosphatic guano, which might have limited its utility largely to root crops, but its Dunedin vendors, George Gray Russell & Co., rendered it valuable for grass establishment and grain cropping too, by selling it together with nitrate of soda, for £15 per ton. This was the first instance of nitrate of soda being advertised in Otago. Adding nitrate probably helped differentiate the product from the bone-dust being produced at Douglas' mill too. This local competition in Dunedin, together with the low phosphate levels in some Southland soils (referred to in Chapter Ten), may explain account for Bluff getting the greater share of the cargo, as it could not have been justified on acreage alone - there were only about 32,000 acres under crop in Southland at this time. Evidently, Dunedin should have got more, as George Gray Russell & Co. had practically run out of its stock by the end of 1869, whereas the Southland supply was still being advertised in March 1870.

By the end of 1868, with the price of wool showing no signs of recovery, the possibility of exporting grain to England again reared its head. The Timaru Herald, in particular, quickly reassessed its earlier position, and now wondered whether "for men of capital ... it would not be as profitable to cultivate grain on a large scale, as to breed sheep, and grow wool". According to the Otago Witness, support for the grain export trade was stronger in Canterbury than Otago, because of the former's large grain production surplus, although the reservations expressed by the Lyttelton Times and editorial silence by the Weekly Press suggest that its strongest advocates may have been Timaru farmers such as W. G. Beswick, whose letter, republished in both the Weekly Press and the Otago Daily Times, asserted that the trade would return to farmers 4s. 8d. per bushel. Both the Otago Daily Times and Otago Witness continued to oppose the idea, with the former paper stridently stating its wish "never to see the day when the export of wheat will become one of the staple trades of this country".

The primary objection of the two Dunedin newspapers was that New Zealand should not export wheat while simultaneously importing other foodstuffs, especially when there was no guarantee of even a wheat surplus. They could easily, as they had in 1867, have pointed to concerns about maintaining soil fertility as well. In February 1869, a letter written by Sam Jones to the Otago Witness did just that. After reminding readers that "wheat is the most exhaustive of crops, and unless some equivalent is returned, greatly impoverishes the land", Jones proceeded to observe that "there is no hope that the profits resulting from the growth of wheat will ever leave the grower any surplus to invest in manure."
These comments were reinforced by the editorial in the Otago Witness' next issue, which accompanied the second annual series of reports on the harvest in each district. This remarked that "we already have in this young country the complaint that land is in many places becoming exhausted by the way in which repeated crops - especially of grain - are taken from it, without anything being returned to it, and even without the old-fashioned, but very sensible, relief to it of a rotation of different crops". The reports themselves noted that soil exhaustion was already reducing yields markedly in the Green Island and Tokomairiro districts.

Further newspaper articles during 1869 indicate that soil exhaustion was evident near Lawrence and on the Taieri Plain too. Only in the Frankton and Arrow districts was it still said that soils would "stand repeated cropping without manure", and even there, with the supply of high fertility soils having run out, farmers were converting land to grass, in order to rest it, and to try out dairy farming. Evidently, Canterbury also suffered from worn-out soils. In April 1869, the Weekly Press chastised its farmers, stating that "we notice land in every district that is gradually being rendered worthless by overcropping year after year with one or other kind of grain".

As fears were held for both the economic and environmental sustainability of wheat cultivation, commentators were quick to identify alternatives. The aforementioned letter by Sam Jones, for example, encouraged agriculturists to turn to either dairy farming, since cows generated "great quantities of manure", or to flax cultivation, which "in all probability" would "leave a profit to the grower sufficient to enable him to cultivate and manure his farm, so as to increase instead of diminishing its fertility". Another high-profit crop to feature in newspaper discussions was malting barley. For Sam Freer of Shag Valley, meanwhile, the solution to continuous cropping, which he described as "suicidal madness", was the inter-row cultivation of wheat and turnips, with the latter being fed off by sheep. In contrast, no specific suggestions on alternative crops were made by the Weekly Press, but it did insist that crops should be grown in a rotation. Perhaps anticipating that farmers would not heed this call, it also observed that "by the help of artificial manure", then little used, "the fast deteriorating soils ... may be made to last a little time longer ...". Generally, the Weekly Press seems to have wanted to encourage greater use of home-made manures and 'artificial' fertilisers, as it published several articles which discussed their merits during late 1868 and early 1869.

If the new-found attraction of mixed farming systems, combining sheep-rearing and cropping, was to be maintained, the pastoral side could not rely solely
on wool to generate income. The obvious solution was meat preserving. In February 1869 the Canterbury Meat Export Company was established at Christchurch (although a year passed before it became operational), while at Waivera South a Dunedin firm was curing mutton for export by June. Buoyed by the success of the Melbourne Meat Preserving Company in Australia, newspapers in both Otago and Canterbury responded to these local initiatives with unbounded optimism and enthusiasm. The *Otago Daily Times*, for instance, declared that there was no industry "better suited to the circumstances, and none so certain or so profitable in its results".

Ultimately, these efforts failed to curb the zest of farmers for cereal cultivation. Although the House of Representatives defeated a grain tariff measure by 25 votes to 21 in August 1869, which made "unprofitable prices likely to rule in the future", the Northern Agricultural and Pastoral Association stated that there was "little prospect of even a small number of them giving up the production of wheat". This judgement proved well founded, as the statistics for crops sown in 1869, reproduced in Table 11.2(a), show that while the total area under crop (including sown grass) in Canterbury was 50% greater than in 1868, the area sown in wheat had grown by an even more remarkable 59%. In Otago, meanwhile, the acreage in cereal cultivation had not grown by nearly as much, but then again, as Table 11.2(b) shows, neither had the area in sown grass. This suggests that Otago farmers put their farming operations on hold while awaiting a resolution of the debates in both Parliament and the Otago Provincial Council over the Hundreds Regulations Act. This legislation determined the future availability of agricultural land for sale, as well as modifying rentals for lands held under pastoral lease.
Table 11.2(b): Acreage of crops grown by Pakeha at harvest time within Otago Province.

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Sown Grass</th>
<th>Oaten Hay</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1868</td>
<td>20,142</td>
<td>40,821</td>
<td>2604</td>
<td>3033</td>
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</tr>
<tr>
<td>1869</td>
<td>20,958</td>
<td>42,400</td>
<td>5743</td>
<td>2981</td>
<td>91,557</td>
<td>5178</td>
<td>3020</td>
<td>171,837</td>
</tr>
</tbody>
</table>

II. Making the most of manure

While agricultural critics may not have altered farmers' cropping behaviour, it seems they had more success when it came to manure use. In its local agricultural report in August 1869 the Weekly Press stated that "improved systems of farming are being adopted", and furthermore, that "manuring has been resorted to more generally". Helping to facilitate this increased manuring was W. H. Mein's recently established boiling-down works in Christchurch, from which Mein offered "valuable manure for sale cheap". While the harvest brought forth occasional instances where crop yields appeared to have been reduced by continuous cropping, overall the return of 28 bushels of wheat, and 33 bushels of oats per acre from the crops sown in 1869 represented, as shown by Figure 11.1, a fairly good result compared to previous years. Encouraged by these results, the Lyttelton Times postulated that New Zealand was unlikely to suffer the severe soil deterioration now evident in South Australia. Here, it observed, greater care was taken of quality agricultural land because there was less of it, the climate suited 'artificial' (introduced) grasses, and intensive pastoralism was just as economically viable as cereal cultivation, now that meat-preserving had prompted a recovery in the price of store sheep.

In Otago, progress towards maintaining soil fertility was also being made. Leading the way was Green Island, where leases were being adopted that required tenants to convert fields into grass pasture once two grain crops had been taken off. Similar restrictions were also starting to be established in the Clutha district. Apart from these prescriptive measures, efforts were also made to provide better information to farmers about the chemistry of their soils. Robert Gillies was keen to see the free soil analysis service by the Colonial Laboratory given more publicity, but the Provincial Council went further in June 1870 when it decided to approve, at the suggestion of the Superintendent, James Macandrew, £300 funding towards the establishment of a Chair of Mineralogy and Agricultural
Figure 11.1
Crop yields in Canterbury and Otago 1866-7 to 1875-6.

Sources: Otago Daily Times, 20 April 1867 (Supplement) p. 1; Weekly Press, 24 August 1867, p.6; Statistics of New Zealand, 1868-75.

As this graph shows, Canterbury and Otago farmers were afflicted with low yields throughout the early 1870s. This proved an important catalyst for farmers to take up mixed farming towards the middle of the decade.

It should be noted that the 1866/7 Canterbury yield (reported in the Weekly Press) was derived only from North Canterbury farms.
Figure 11.1

Wheat yield estimates 1866/7-1875/6

Oats yield estimates 1866/7-1875/6
Chemistry at the new University of Otago. Judging by the number of advertisements, there was also a fairly steady, albeit small, demand for fertilisers near Dunedin. Its farmers could now choose between bone-dust, phosphatic guano (that is, Howland Island guano), and phosphatic guano combined with nitrate of soda. It appears that farmers were making greater use of dung too. Those in the Taieri, for instance, reportedly gave "a good deal of manure to the land" prior to post-harvest ploughing.

Nevertheless, accounts of Otago farming still tended to be pessimistic about the battle to maintain soil fertility. After the wheat sown in 1869 produced, on average, just 29 bushels per acre, one Otago Daily Times article, entitled 'Facts for Intending Emigrants' contended that newcomers should anticipate wheat yields of just 25-30 bushels per acre. This was some 5-10 bushels per acre lower than the equivalent predictions made a decade or so earlier. The Otago Witness, meanwhile, pointed to a steep decline in farm values as evidence of deteriorated farmland, and remarked that "if, as is reported, not a few farms throughout the province are already ... exhausted, they must, in order to make them reproductive, have restored to them the materials which have been abstracted by crops already produced". To make matters worse, "the present low price of produce, the expense of artificial manure, and the absence of farm-made manure" caused it to conclude that "it may prove a matter of some difficulty to restore the 'run out' farms to their original fertility, or to a condition fit for producing crops of payable abundance". The Otago Witness then asserted that the best practical remedy was to use turnip-fed sheep to supply manure while also resting cropped out land under pasture. In a previous article, feeding sheep on rape, and increased clover growing, had also found favour. Meanwhile, efforts to find new local fertilisers continued. Coal ash, for example, was being tried as a fertiliser in South Otago, and near Alexandra, Chinese miners were selling a guano-like substance for as much as £40 per ton. There were also high hopes that fertilisers would become more widely available once the boiling-down and meat-preserving plants, such as that at Kakanui, which included a mill for grinding up bone manure, became widely established. According to the Otago Witness, for every 500 sheep processed by a boiling-down works, "about a ton of dry manure, second only in quality to Peruvian guano" would be produced, and its likely cost would be only £4-£5 per ton. Improved accessibility was only part of the solution to getting farmers manuring their land though - the high cost of labour in both Otago and Canterbury was another obstacle to be overcome. Indeed, its bearing on farmers' thinking can be gauged by the comment in the Otago Witness reminding them that
"even with the present high rate of wages, it is not impossible to use manure to a certain extent".58

Amidst all this talk of soil exhaustion, farmers were confronted with another reason to desist from cereal cultivation - a fall in the price of wheat, which matched that in the English market.59 In Canterbury, the drop in price to under 4s. per bushel60 persuaded many farmers to shift towards stock-rearing and dairying. The statistics for the crops sown in 1870, reproduced in Table 11.3(a), show that while the acreage in permanent grassland had once again grown substantially, the total area in cereals grown for grain was actually slightly lower than it had been in 1869. In Otago, the statistical picture is obscured by its

Table 11.3(a): Acreage of crops grown by Pakeha at harvest time within Canterbury Province.61

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Sown Oaten</th>
<th>Other (Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sown</td>
<td></td>
<td></td>
<td></td>
<td>Grass Hay</td>
<td></td>
</tr>
<tr>
<td>Sown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1869</td>
<td>52,425</td>
<td>39,952</td>
<td>16,063</td>
<td>1947</td>
<td>102,367</td>
<td>1709</td>
</tr>
<tr>
<td>1870</td>
<td>46,074</td>
<td>44,370</td>
<td>13,190</td>
<td>1553</td>
<td>142,068</td>
<td>n. s. 4168</td>
</tr>
</tbody>
</table>

reunion in 1870 with the largely pastoral province of Southland. Having said this, a breakdown of crop acreages, which is reproduced in Table 11.3(b), into those areas formerly occupied by Otago and Southland, shows that the combined cereal acreage in only the area formerly occupied by Otago was 17% higher than that of 1869. In comparison, the area under sown pasture had grown by 15%.

Table 11.3(b): Acreage of crops grown by Pakeha at harvest time within Otago and Southland Provinces.62

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Sown Oaten</th>
<th>Other (Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sown</td>
<td></td>
<td></td>
<td></td>
<td>Grass Hay</td>
<td></td>
</tr>
<tr>
<td>Sown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(within Otago boundary before amalgamation)</td>
<td>1869</td>
<td>20,851</td>
<td>42,404</td>
<td>5743</td>
<td>2950 91,741</td>
<td>5189 3115 172,003</td>
</tr>
<tr>
<td>1870</td>
<td>21,402</td>
<td>55,581</td>
<td>3676</td>
<td>2629</td>
<td>105,445</td>
<td>n. s. n. s. n. s.</td>
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<tr>
<td>(within Southland boundary before amalgamation)</td>
<td>1869</td>
<td>1023</td>
<td>8302</td>
<td>2005</td>
<td>544 22,180</td>
<td>1249 1372 36,676</td>
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<tr>
<td>1870</td>
<td>1410</td>
<td>10,636</td>
<td>1061</td>
<td>572</td>
<td>33,555</td>
<td>n. s. n. s. n. s.</td>
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</tbody>
</table>
(within Otago and Southland combined)

<table>
<thead>
<tr>
<th>Year</th>
<th>1869</th>
<th>1870</th>
<th>1871</th>
<th>1872</th>
<th>1873</th>
<th>1874</th>
<th>1875</th>
<th>1876</th>
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</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>21,885</td>
<td>22,811</td>
<td>23,841</td>
<td>24,726</td>
<td>25,565</td>
<td>26,384</td>
<td>27,176</td>
<td>28,025</td>
</tr>
<tr>
<td>Oats</td>
<td>52,706</td>
<td>62,217</td>
<td>67,999</td>
<td>70,508</td>
<td>72,789</td>
<td>73,906</td>
<td>74,658</td>
<td>73,874</td>
</tr>
<tr>
<td>Barley</td>
<td>7748</td>
<td>4736</td>
<td>5947</td>
<td>241,911</td>
<td>4486</td>
<td>5947</td>
<td>241,911</td>
<td>4486</td>
</tr>
<tr>
<td>Produce</td>
<td>3494</td>
<td>3200</td>
<td>4486</td>
<td>208,678</td>
<td>5947</td>
<td>241,911</td>
<td>4486</td>
<td>208,678</td>
</tr>
<tr>
<td>Value</td>
<td>113,921</td>
<td>139,000</td>
<td>n. s.</td>
<td>n. s.</td>
<td>n. s.</td>
<td>n. s.</td>
<td>n. s.</td>
<td>n. s.</td>
</tr>
</tbody>
</table>

At last, the uncontested march of grain across the farmland of Canterbury and Otago appeared to have been halted. Meanwhile, the poor yields obtained from the harvest in 1871 - estimates of the average wheat yield in Otago (which hereafter includes Southland) and Canterbury were 29 and 22 bushels per acre respectively - gave further ammunition to critics remonstrating against the narrow focus on cereal cultivation many farmers exhibited. As the North Canterbury correspondent of the *Press* facetiously remarked:

> It is to other causes than [a] favorable spring, early sowing, and genial atmosphere, that is assignable the deficient growth, short straw, and ill-fed ears. It is to the habit of constant cropping that this is principally due.

This correspondent went on to comment that some farmers had even recklessly wasted their straw by burning it, rather than converting it "into manure in some shape or other". The *Otago Daily Times* also drew attention to the effects of continuous cropping, observing that "in some of the oldest farming districts, where the soil is naturally of a rich quality, the falling off [of yields] is most perceptible". Having said this, the *Otago Daily Times* did, unlike its Canterbury counterpart, find that many farmers had started taking steps to avoid soil exhaustion. After noticing its Green Island correspondent's statement that "farmers are also beginning to see that land cannot bear repeated crops without being reinvigorated by manure, and every effort is now being made to have a suitable supply given to the soil", it concluded that the increased proportion of sown pasture amongst cultivated land in Otago was not only a sign of low produce prices, but also revealed the "necessity which exists for giving rest to the over-cropped soil". Once grass had been laid down, the best means, according to the *Otago Witness*, for both improving the soil and turning a profit was dairying. Previously, fattening stock for meat-preserving had also been strongly recommended, but enthusiasm for this had now been tempered by a recovery in wool prices. Where cereal cultivation continued, meanwhile, farmers were called upon, even if they opted not to manure their land, to ensure their soils were properly drained. Apart from increasing the effective depth of the soil, this *sine*
"qua non of good farming, the Otago Witness observed, also helped free up nutrients in the soil. According to a parliamentary speech given in 1872 by William Murray, where drainage had been tried in Otago, the results proved remarkable, with farms that had been yielding 10-12 bushels per acre of wheat subsequently producing 40 bushels per acre. However, as the cost of drainage was, according to one estimate, some £10-£14 per acre, it is unlikely that this operation, hitherto "much neglected in Otago", would have been carried out by farmers while government credit could not be called upon to finance it.

This growth of intensive pastoralism at the expense of cropping did not last long. In the wake of the Franco-Prussian war, farmers in Canterbury, and presumably Otago as well, had good reason to expect a rise in the wheat price. This was reflected in the figures, reproduced in Table 11.4, for the crops sown in 1871. In Canterbury, the area in sown grass grew only slightly, while the area under wheat was 36% more than the previous year. Similarly, in Otago (including Southland) the area in sown grass increased only 5%, while that in wheat leapt by some 48%.

Table 11.4: Acreage of crops grown by Pakeha at harvest time within Canterbury and Otago Provinces.

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Sown Grass</th>
<th>Sown Oaten</th>
<th>Other Grass</th>
<th>Other Hay</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(in Canterbury)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1870</td>
<td>46,074</td>
<td>44,370</td>
<td>13,190</td>
<td>1553</td>
<td>142,068</td>
<td>n. s.</td>
<td>4168</td>
<td>251,423</td>
<td></td>
</tr>
<tr>
<td>1871</td>
<td>62,842</td>
<td>58,106</td>
<td>7025</td>
<td>1543</td>
<td>147,002</td>
<td>25 i0</td>
<td>3242</td>
<td>282,270</td>
<td></td>
</tr>
<tr>
<td>(in Otago)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1870</td>
<td>22,811</td>
<td>66,217</td>
<td>4736</td>
<td>3200</td>
<td>139,000</td>
<td>n. s.</td>
<td>5947</td>
<td>241,911</td>
<td></td>
</tr>
<tr>
<td>1871</td>
<td>33,660</td>
<td>71,340</td>
<td>3323</td>
<td>3630</td>
<td>146,630</td>
<td>9369</td>
<td>6565</td>
<td>274,517</td>
<td></td>
</tr>
</tbody>
</table>

For conserving soil fertility, this degree of expansion of wheat cultivation was not ideal, although in Otago at least, farmers increased their manuring to compensate for it. Close to Dunedin, they availed themselves not just of farmyard manure and bone-dust, but of a range of industrial wastes too. In Green Island, for example, bones and offal from the new meat-preserving works in the district began being applied to crops, and after initial doubts as to their efficacy, they were judged to be the equal of any 'artificial' fertilisers. Similarly, while the majority of Kaikorai farmers were said to give their land "the merest scraping and no
manure", some of them used refuse lime, animal matter and bark from the local tannery and fellmongeries to restore soil nutrients and improve soil texture. They could also have used the animal wastes sold locally as manure by Boenicke's glue factory. Most Blueskin district farmers also used little manure, but those with good access to the Dunedin road made "a point of bringing manure from Dunedin when they can get it" and "using the refuse from flax mills besides". Perhaps mindful that the supplies of such fertilising materials would only go so far, the Member of Parliament for Bruce, William Murray, also wrote to Dr. Hector at the Colonial Museum in December 1871 to establish whether or not it would be possible to cheaply import, on a large scale, nitrate of soda from Peru or Chile (see Figure 11.2). As Murray put it, for the cost of a mere 2 cwt. per acre, it would be possible to 'double' agricultural and pastoral production by means of enhanced production of green crops. Comparatively, there appears to have little interest amongst Canterbury's agriculturists in used industry wastes as fertiliser. Moreover, the only 'artificial' fertilisers that seem to have been available for sale in Christchurch were James Macmickan & Co's "celebrated Australian manures".

Employing external inputs to fertilise the soil was not the only sign that farmers were now placing more emphasis on conserving soil fertility. A report on the Warepa district, for instance, in the Otago Daily Times, noted that straw, which previously was burnt, was now preserved for incorporation into manure. In addition, the effects on soil fertility of the increasing wheat acreage in the Oamaru district, by now the principal cereal growing area in Otago, was limited by the widespread application of the 'two crop' system. Under this system, large landowners engaged tenants to take first two grain crops off previously uncultivated land, with part of the harvested crops being used as rent, and then to sow the land down to pasture. For the landowner, this policy promised to cover the costs of the land's 'improvement', without overly wearing out the soil. Perceived breaches of the 'two-crop' principle sometimes provoked court action.

In the battle to stop soils being exhausting by overcropping, real progress was thus beginning to be made. Nevertheless, much more needed to be done to make manure use by farmers the norm. According to many of the more innovative farmers and agricultural commentators, this situation would not improve until farmers had greater exposure to agricultural education, both through discourse within local agricultural and pastoral associations, which hitherto had confined their activities to holding shows and ploughing matches, and through training at agricultural colleges. At the recently established University of Otago, small steps in this direction were already being made, in that the new Professor of Mineralogy
Figure 11.2
W. A. Murray's enquiry about nitrate of soda

Source: W. A. Murray to James Hector, 8 December 1871. MU 94/1
(Colonial Museum and Geological Survey - Hector, James (Director):
Registered Inwards Correspondence 1871-1883), Letter no. 1871/412.
Museum of New Zealand - Te Papa Tongarewa Archives.

The image shown is of the first page of Murray’s three page letter. The passage of interest starts in the second paragraph, and reads as follows:

I have somewhere read that there are in Peru or Chili [Chile] large deposits of nitrate of Soda which is one of the most valuable of manures & if it cd. [could] be at a moderate price introduced

[continuation on second page]
here it wd. [would] be of incalculable advantage in stimulating and rendering profitable agricultural and pastoral pursuits by doubling production for the mere cost of applying some 2 cwt. per acre of the Soda & enabling green to be cheaply produced which wd. [would] at once fatten stock and fertilise the soil.
November 21, 1877

To: Robert

Wellingto

Dear Sir,

I will be glad to hear from you that you have some of the Californian
true seeds unparalled by the
Government. Arranged for
the illustraste in this throune.
Now you propose to deal
with these.

I have some seed that
true is in form of
Chili large deposits
intake of soda which is one
of the most valuable
memories if so the above
modulate face introduced.
and Agricultural Chemistry, the Edinburgh University-educated John Gow Black, offered practical instruction in water, mineral, soil and manure analysis. Admittedly, this was of little immediate benefit to most practical farmers, but it improved the quality of technical advice that scientifically-minded farmers could call upon. In an even more proactive step, the Philosophical Institute of Canterbury passed in June 1871 a motion "that samples be obtained of the different soils of the province, with a view of their being analysed for the purpose of ascertaining what manure is most desirable of application to each kind of soil". Regrettably, the action taken subsequently did not extend beyond setting up a committee.

III. The case for 'convertible husbandry'

The fortunes of agriculturists, meanwhile, took a turn for the worse in 1872. The price of wheat remained low, despite Parliament's imposition of a duty on imported grain, and the crops sown in 1871 were badly affected by drought, with their only redeeming feature being the quality of the grain. The resulting wheat and oats yields, which, in Otago, were estimated to be 26 and 31 bushels per acre respectively, and which in Canterbury were 22 and 23 bushels per acre, were amongst the worst on record. Following a spate of mortgagee sales, agricultural commentators and farmers themselves began re-examining farming's current state and future direction. Most of these reviews offered little that was new, but one notable exception, which earned praise from newspapers in both Canterbury and Otago, was J. N. Tosswill's address to the Lincoln Farmers Club.

In formulating his address, Tosswill had set out to answer the question of "what system of farming will yield the greatest amount of profit, and at the same time diminish the fertility of the soil as little as possible". Of the three options for intensive farming - permanent pasture, rotational cropping, and 'convertible husbandry' (the periodic interchanging of pasture and cereals) - Tosswill asserted that 'convertible husbandry' was by far the best for meeting these ends. Sowing permanent pasture was the easiest path to implement, but as Tosswill noted, settlers had been unable to halt the rapid deterioration in pasture quality, and this option had, "in most cases, been abandoned". Rotational cropping, he argued, was not a viable option either, as the two circumstances which enabled British farmers to liberally manure their root and green crops, that is, dearness of meat (which, in turn, made stall-feeding cost effective) and cheapness of labour, were not found here. 'Convertible husbandry', in contrast, posed no such difficulties - the soil was
rejuvenated under pasture by both the droppings of livestock, and the absorption by clover of atmospheric nitrogen (mistakenly believed to be in the form of ammonia). At the same time, the pasture never became so old that it deteriorated significantly. Ideally, Tosswill thought that "the best rotation possible after breaking up grass land would be to take but one crop of grain, and then sow down again". Realising, however, that farmers would struggle financially if every year of cereal cultivation was separated by growing pasture, he proposed a modified system. In this, two successive cereal crops were followed by three years of grass and red clover, or alternatively, one year of turnips and two years grass and red clover.

It is difficult to say how widely Tosswill's conclusions were shared, but an examination of the statistics for the crops sown in 1872, reproduced in Table 11.5, does show that while the areas under sown grass in Otago and Canterbury had risen relative to the previous year by 17% and 33% respectively, the combined area under cereal cultivation in Otago had remained almost unchanged, and in Canterbury it had fallen sharply. In particular, the amount of oats grown for grain had slumped dramatically in both provinces, principally because of the unremunerative price. There were local variations from this trend, as in the Taeri district, where the 'Otago Daily Times' correspondent noted that "a good many fields of lea are being lifted for wheat this year", although even here farmers were planting grass extensively on land reclaimed through drainage by Bathgate, Cargill & Reid's Henley Estate Company. This would have been welcome news for the 'Otago Daily Times', which continued to exhort farmers to pay drainage more attention. The other main acreage changes, which were

<table>
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<tr>
<th>Year</th>
<th>Wheat Sown (in Canterbury)</th>
<th>Oats Sown</th>
<th>Barley Sown</th>
<th>Potatoes Sown</th>
<th>Sown Grass</th>
<th>Other Hay</th>
</tr>
</thead>
<tbody>
<tr>
<td>1871</td>
<td>62,842</td>
<td>58,106</td>
<td>7025</td>
<td>1543</td>
<td>147,002</td>
<td>2510</td>
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<tr>
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<td>68,463</td>
<td>37,173</td>
<td>6810</td>
<td>1883</td>
<td>195,420</td>
<td>3184</td>
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<table>
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<th>Oats Sown</th>
<th>Barley Sown</th>
<th>Potatoes Sown</th>
<th>Sown Grass</th>
<th>Other Hay</th>
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</thead>
<tbody>
<tr>
<td>1871</td>
<td>33,660</td>
<td>71,340</td>
<td>3323</td>
<td>3630</td>
<td>146,630</td>
<td>9369</td>
</tr>
<tr>
<td>1872</td>
<td>50,781</td>
<td>51,695</td>
<td>4897</td>
<td>4027</td>
<td>170,958</td>
<td>12,629</td>
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<th>Oats Sown</th>
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<th>Potatoes Sown</th>
<th>Sown Grass</th>
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<tr>
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<td>37,173</td>
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<td>1883</td>
<td>195,420</td>
<td>3184</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat Sown (in Otago)</th>
<th>Oats Sown</th>
<th>Barley Sown</th>
<th>Potatoes Sown</th>
<th>Sown Grass</th>
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<tbody>
<tr>
<td>1871</td>
<td>33,660</td>
<td>71,340</td>
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<td>3630</td>
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<tr>
<td>1872</td>
<td>50,781</td>
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</tbody>
</table>

unremunerative price. There were local variations from this trend, as in the Taeri district, where the 'Otago Daily Times' correspondent noted that "a good many fields of lea are being lifted for wheat this year", although even here farmers were planting grass extensively on land reclaimed through drainage by Bathgate, Cargill & Reid's Henley Estate Company. This would have been welcome news for the 'Otago Daily Times', which continued to exhort farmers to pay drainage more attention. The other main acreage changes, which were
driven by the greater emphasis being paid to rearing stock, were the rises in the area under oats cultivated for green feed, and under 'other crops', in both provinces. In Otago, the latter category now made up 3.3% of the total area under crop, although in the Mataura and Clutha Electorates their proportion was up to 6.7% and 7.2% respectively, due to the large-scale sowing of turnips for winter feed. Significantly, it had been found that introduced grasses did not handle the winter as well as indigenous ones, so that farmers were advised to supply extra feed once they had sown down the former.

Much of the farmland in the Mataura Valley has, as noticed in Chapter Ten, low phosphate levels, so it is likely that the expanded turnip cultivation generated increased phosphatic fertiliser use. Having said this, farmers continued to look for cheap alternatives to the imported Peruvian guano and locally produced bone-dust which were already available. After poor crops in the previous two seasons, their motivation to find them would have been even greater. A 'guano' sourced from Akaroa, which chemical analysis showed to have excellent fertilising properties, provided one such alternative. It was exhibited in Christchurch in late 1871, but it does not seem to have been advertised for sale until mid-1872, and the quantities sold appear to have been quite small. In a more speculative vein, a suggestion was made that farmers in the Blueskin district might apply sand from the bay to their clays. This sand would lighten the soil, but it was hoped that it might fertilise it too, since it incorporated shells, decaying seaweed, and fish matter.

The current hard times also prompted stronger calls for farmers' practical knowledge of agricultural chemistry to be enhanced through education. In August 1872, W. Perryman delivered a paper to the Lincoln Farmers' Club on "the desirability of establishing an agricultural training school in this province", the object of such a school being to "teach our young men the best way to farm on the most modern and approved principles". Included among its varied curriculum would be the training of farmers in the "analysis of the different soils and plants of New Zealand". Almost simultaneously, the Otago Daily Times also considered agricultural instruction to farmers, and it concluded that existing agricultural institutions had been ineffective in this regard, and thus a state-funded model farm was needed, and sooner rather than later. Although it was tempting to note that Otago's "supply of virgin soil is large", the exhaustion of vast tracts of land in South Australia and the eastern United States proved that Otago did not have "too much land fit for agriculture". It was therefore imperative that Otago's settlers "should endeavour without delay to make the most of what we have".
Subsequently, a correspondent using the sobriquet 'Advance New Zealand' went even further, asserting that in addition to a model farm, branch laboratories, which would provide "means of analysing soils and manures", and preparing "manures from substances now overlooked", should be set up as well. Another necessity this writer identified was a local agricultural journal. Finally in December 1872, some of this advocacy was translated in action, albeit back in Canterbury, with A. C. Knight's motion to the Canterbury Provincial Council that it make an endowment of 100,000 acres of pastoral land for a school of agriculture. Its success was the first step in the history of Lincoln Agricultural College.

This development promised much for farming's long-term future, but by early 1873 the immediate prospects also looked much brighter. The price of wool had by now fully recovered from the 1867-69 slump, and in addition, wheat prices had also firmed to 4s.9d. per bushel in Christchurch, and 5s.6d. in Dunedin, on account of a rise in the English market. As seen in Figure 11.3, these were the best prices obtained since 1868. Consequently, agriculturists must have been disappointed when poor weather late in the growing season dashed expectations of a bumper harvest - indeed, the per acre yields in Otago, which amounted to 29 bushels of wheat and 30 bushels of oats, and in Canterbury, which were 22 bushels of wheat and 24 bushels of oats, were not much better than the previous year's. In only a few cases, such as in the Lincoln district, were low yields blamed on exhausted soil. The acute shortage of agricultural labour compounded the poor crops, as railway construction had absorbed much of the mobile labour pool.

As the *Lyttelton Times* observed, grain cultivation was much more vulnerable to labour shortages and unfavourable weather than rearing sheep for wool, and consequently, there was a marked increase in emphasis on pastoral farming when crops were sown in 1873. Despite the improved wheat market, the wheat acreage barely changed from that in 1872, whereas the sown grass rose, as Table 11.6 shows, by more than 50,000 acres, in both provinces.
Figure 11.3  
Farming commodity prices, 1868-75.

Sources: McIlraith, J. W., *The Course of Prices in New Zealand*, pp. 51-3;  
*Statistics of New Zealand* 1868-75.

Over this period, wheat prices tended to go from high to low, whereas the wool  
prices went from low to high. This was a further incentive to switch to  
mixed farming.
Farming commodity prices, 1868-75

Year

Canterbury Wheat price
Otago Wheat price
Canterbury Wool
Table 11.6: Acreage of crops grown by Pakeha at harvest time within Canterbury and Otago Provinces.\(^{120}\)

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat Sown (in Canterbury)</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes Sown</th>
<th>Other Grass</th>
<th>Hay</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1872</td>
<td>68,463</td>
<td>37,173</td>
<td>6810</td>
<td>195,420</td>
<td>3184</td>
<td>5726</td>
<td>318,659</td>
</tr>
<tr>
<td>1873</td>
<td>71,827</td>
<td>38,983</td>
<td>9201</td>
<td>245,518</td>
<td>4615</td>
<td>10,179</td>
<td>382,179</td>
</tr>
</tbody>
</table>

(in Otago)

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat Sown</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes Sown</th>
<th>Oaten Grass</th>
<th>Other Hay</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1872</td>
<td>50,781</td>
<td>51,695</td>
<td>4897</td>
<td>170,958</td>
<td>12,629</td>
<td>10,155</td>
<td>305,142</td>
</tr>
<tr>
<td>1873</td>
<td>50,069</td>
<td>60,204</td>
<td>8891</td>
<td>227,985</td>
<td>11,132</td>
<td>10,715</td>
<td>372,299</td>
</tr>
</tbody>
</table>

Agricultural critics were quick to point out the soil fertility benefits of this swing towards intensive pastoralism. For instance, the Oamaru correspondent of the *Otago Witness*, in the harvest report produced in early 1874, expressed his satisfaction that settlers are generally more inclined to keep sheep than formerly; and so long as wages of farm labourers continue high, the depasturing by sheep, in connection with the more regular cultivation of rape and growth of red clover, seems the most judicious and least expensive mode of recreating lands worn out by the repetition of grain crops ...\(^{121}\)

In Canterbury, where rotational cropping was also in vogue, the *Lyttelton Times* similarly commented in their 1874 harvest report that "it was pleasing to observe the painstaking care with which most of the agriculturists now rotate their crops; that is to say, grow wheat, oats, root crops, and grass alternately, and allow the land to rest in the latter for several seasons".\(^{122}\) At the same time, the practice of stubble burning, long the bane of agricultural critics,\(^{123}\) appears to have been on the decline in Canterbury. As the *Weekly Press* remarked, "every attention, so far as enquiries extended, is now being paid to economising the straw and manure, which used to be burnt, so as to add fertility to the soil".\(^{124}\)

Not all agriculturists adopted 'convertible husbandry' or rotational cropping approaches, however. On many of the small farms just to the south of Christchurch, for instance, continuous cropping was persisted with as a matter of necessity. After several poor harvests, these farmers were now dependent on the financial return from another grain crop to save them.\(^{125}\) Farming novices were another group who tended to grow grain crops without interruption, though more
because of ignorance and overconfidence.\textsuperscript{126} E. W. Trent, meanwhile, also rejected the idea of growing pasture, as he claimed that a combination of subsoiling and his own rotation, entailing four chicory crops, two cereal crops, and a rape crop fed off by sheep, would pay farmers "better in the long run" than three cereal crops followed by five years of pasture.\textsuperscript{127}

In commenting on Trent's letter, the \textit{Lyttelton Times} observed that "feeding off with sheep appears to be the Canterbury farmer's substitute for manuring".\textsuperscript{128} One of the reasons why manure was so little used was that fattening stock on root crops had not occurred to any great extent in Canterbury to date. According to the \textit{Lyttelton Times}, growing root crops had been unattractive, both because of the labour-intensive nature of their cultivation, at a time when wage rates were high, and the relatively poor remuneration for fat stock\textsuperscript{129} - by this time, a glut had developed in the domestic market.\textsuperscript{130} Farmers' experience of cultivating root crops had also been disappointing in recent years, as they suffered during the droughts.\textsuperscript{131} It appears that rather than using manure to restore nitrogen levels, many Canterbury farmers were once again cultivating peas and beans.\textsuperscript{132} This behaviour was first observed in the mid-1860s (and was described in Chapter Ten), but the low 'other crops' acreages during the late 1860s and early 1870s suggests that the two legumes were not grown much in these intervening years.\textsuperscript{133}

\section*{IV. Turning towards turnips}

If Otago's agriculturists preferred rotational cropping over 'convertible' husbandry, they had little choice but to grow root crops. As noted in Chapter Ten, the province's cold climate was ill-suited to the cultivation of peas and beans, and accordingly when crop acreages were taken as part of the Census of Population in 1874, the ratio of the 'turnips and rape' acreage to 'peas and beans' acreage in Otago was 70 to 1, whereas in Canterbury it was only 6 to 1.\textsuperscript{134} Since peas, in stark contrast to turnips and rape, do not benefit from applying phosphate,\textsuperscript{135} one would expect, given their similar 'other crops' acreages, that phosphatic fertiliser demand was stronger in Otago than in Canterbury. Close to Dunedin, at least, this does seem to have been the case. The Green Island correspondent of the \textit{Otago Daily Times}, for instance, reported that, in response to the limited supply of farmyard manure, bone-dust from Townsend's mill at Burnside would "be largely used in this district during the coming season".\textsuperscript{136} Furthermore, when Goldsmith & Co.'s Dunedin mill burnt down in 1873, it was upgraded via the importing of improved bone crushing machinery, which suggests increased demand in the future.
was anticipated.\textsuperscript{137} Aside from bone-dust, guanos were also being sold by at least two Dunedin establishments at this time.\textsuperscript{138}

Further afield from Dunedin, however, it seems that fertiliser use within Otago was far less frequent. Endeavouring to change this situation, Thomas Murray wrote to the \textit{Bruce Herald} in April 1873, stating his belief that "if agriculture is to flourish in these provinces, the soil must be made to give its increases by the intelligent use of manures, and a system of alternate husbandry [rotational cropping]". Just two months later, a frustrated Murray observed that one subsequent correspondent did not understand what 'alternate husbandry' meant.\textsuperscript{139} Such ignorance as this, going on Murray's comments, and those of W. Dalrymple, was a significant barrier to fertiliser use. Another was cost; in the opinion of both writers, farmers needed their soil tested, if possible, before applying fertiliser, so that none of it went to waste.\textsuperscript{140} In the longer term, Murray looked forward to the day when there would be "manure works at each of the meat preserving establishments and bone mills all through the country",\textsuperscript{141} thereby bringing fertiliser costs down. As for more immediate solutions, he referred to the efforts of his brother William to establish the practicality of local superphosphate manufacture using North Island sulphur, and also to William's enquiry to Dr. Hector (discussed previously) about importing nitrate of soda, which would serve as a cheaper substitute for Peruvian guano.\textsuperscript{142}

The growing rail network also promised to lower costs of fertilising land in outlying districts by making fertiliser cartage cheaper. A newspaper article on the impending Moeraki-Waitaki railway, for instance, predicted that manure - in the form of seaweed, and refuse material from the Kakanui Meat Preserving works - would be an important freight item on the line. This was a timely development, as the writer noted that "manure must soon be applied to much of our land, or it will soon be exhausted".\textsuperscript{143} Another projected freight item on this line was lime from the Awamoa kiln. Already this was being used to a small extent to dress land infested with sorrel.\textsuperscript{144}

Despite the future benefits that the farming community would accrue from railways, Canterbury's Provincial Government agreed to suspend construction for a time in early 1874, because the labour was needed for getting in the harvest.\textsuperscript{145} The crops sown in 1873 had proved to be the heaviest for some years, with yields of wheat and oats in Otago amounting to 30 and 33 bushels per acre respectively, while in Canterbury the equivalent statistics were 24 and 26 bushels per acre.\textsuperscript{146} What made it even better was that wheat and oats were fetching fairly good prices.
According to the *Weekly Press*, the current prices in Christchurch were 4s. 6d.-4s. 9d. per bushel for wheat and 4s. per bushel for oats.147

The buoyant wheat market did not last, however, as by the end of 1874 reports were received of an above average harvest in Great Britain.148 This was bad news, but fortunately the winter in Canterbury and Otago was exceptionally cold, which delayed sowing, and thereby encouraged agriculturists to grow oats instead.149 Overall, the wheat acreage in Canterbury fell slightly, and in Otago it almost halved. The statistics for the crops sown in 1874, reproduced below, also show that farmers in Canterbury and Otago continued to press ahead with the rearing of stock, as the area under sown grass in both provinces increased as a proportion of the total area under crop. Incidentally, the Ashburton-South Rakaia

<table>
<thead>
<tr>
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<th>Oaten Grass</th>
<th>Other Hay</th>
<th>Total</th>
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<td>4615</td>
<td>10,179</td>
</tr>
<tr>
<td>1874</td>
<td>69,848</td>
<td>63,823</td>
<td>8006</td>
<td>2343</td>
<td>299,613</td>
<td>3869</td>
<td>23,154</td>
</tr>
</tbody>
</table>

and Levels districts now constituted the principal growing areas of sown wheat in Canterbury.151 This reflected the tremendous extension of cultivation made possible following the bridging of the Rangitata River in 1872 and the Rakaia River in 1873.152

In Canterbury, however, the most significant growth occurred in the category of 'other crops', the acreage of which more than doubled. In reviewing this change, the *Press* remarked that "the objectionable successive cropping is giving way for rotation systems".153 The harvest reports compiled for each Canterbury district show that many agriculturists had at last opted to sow extensive areas of turnips, thereby providing winter feed for stock.154 In and around John Grigg's Longbeach estate, for instance, more than 1000 acres of turnips were sown.155 In the circumstances, it is not surprising that the cultivation of root crops formed the subject of one of the first papers delivered to the newly
formed Kaiapoi Farmers' Club. According to the paper's author, long-time Kaiapoi Island farmer Joseph Clark, the increase in wool growth alone - quite apart from its stock-fattening potential - justified replacing one-tenth of the area in grass on mixed farms with turnips. Turnip cultivation was not confined to land previously worn out by grain cropping though, as much of it occurred on land being broken in, thereby preparing it for wheat in its second year under cultivation. Another development associated with supplementary feeding, which also promised to increase the production of manure, was the initiation of feeding on oil-cakes. This was practised extensively in Great Britain, but the lack of discussion concerning it in New Zealand agricultural literature indicates that it did not catch on here.

This increased attention given to root crop cultivation, and crop rotation generally, was also reflected in Canterbury agriculturists taking more interest in fertiliser use and agricultural chemistry than they had previously. John Grigg, for example, employed 90 bags of bone-dust on his turnip crop, which he obtained from the Papanui bone-mill established by Daniel Maydwell in 1873. The Christchurch firm of Miles & Co, meanwhile, announced in August 1874 the import of further bone-mills "adapted to horse, water or steam-power". Then in November, Maydwell exhibited two bags of bone-dust at the Canterbury Agricultural & Pastoral Association's show, and Alexander Bickerton, the recently appointed Professor of Chemistry at Canterbury College, gave what appears to have been his first public lecture on agricultural chemistry. Fittingly, given Grigg's endeavours, and more generally, the southward shift of the 'centre of gravity' of arable farming, this took place in Ashburton. In this lecture, Bickerton stressed the value of a "certain knowledge of chemistry, as well as other sciences, in order ... to tell what state the land was in as regards to its component parts", and accordingly, he advised the farmers present to send their children to the College for scientific training. As for immediate practice, Bickerton emphasised the benefits of drainage and the restorative powers of lime. These points would have been particularly relevant to Ashburton farmers, since much of the land to the seaward of Ashburton, including that occupied by Grigg's Longbeach estate, comprises of poorly drained soils (denoted by categories 5 and 6 in Figure 11.4), which are in places moderately to strongly acidic.

Other than the substitution of oats for wheat, the state of arable farming in Otago, in contrast, differed little from what it had been the previous year. Even so, the gradual elimination of continuous cropping from the Otago farming scene continued. It only warranted mention in one out of 26 district harvest reports for
As seen in this map, large areas of recent alluvial soils (classes 4 and 5), the most suited to wheat cultivation out of the eight classes, were located between the Rakaia and Rangitata Rivers. Accordingly, there was scope for tremendous expansion of the wheat acreage once the Rakaia River was bridged. Having said this, the soils on the seaward side of Ashburton were, as stated in the text, in need of drainage (which is indicated the prevalence of classes 5 and 6 - the latter being organic soils). While most other features of the map should be recognisable to readers of Chapter 9, such as that the classes 1 and 2 equate to the high terraces' yellow-brown stony soils and yellow-brown sands, and class 7 to saline gley soils, it is worth noting that the recent Waimakariri floodplain (the area labelled class 1 to the west of Christchurch, and south of the Waimakariri River) is easily distinguished on this map, whereas it is not distinguished from the dry low and intermediate terrace soils in Figure 9.4.
SOIL FERTILITY MAP RANGITATA RIVER-ASHLEY RIVER EXPRESSED AS WHEAT GROWING PROPERTIES OF THE SOIL.

LEGEND

Very shallow or very sandy soils, droughty, liable to wind erosion, little or no wheat grown.


Irrigation may affect future of crops.

Higher rainfall phase of 2. Most parts building.

Soils less droughty than 2. Good wheat land. Wide fertility range.

Soils with adequate in excess moisture. Some lodging.

Very wet soils and peats. Little wheat.

Strongly salty soils.

 Downs and hilly soils. Great variation in fertility. (Indicable on this scale.) See page...
1875, and the offending district, was that of Long Bush (formerly in Southland), where intensive farming had only been practised for about a decade. In the long-settled Tokomairiro, meanwhile, a subsequent article in the *Otago Witness* observed that the "exhaustive process of persistently impoverishing the land by successive croppings with grain has almost become a thing of the past, while feeding off with stock has to a very considerable extent been substituted". With the acreage in turnips increasing generally, another phosphatic fertiliser producer appeared in the Dunedin market; Boenicke's glue factory, previously a vendor of manure made from animal wastes, started selling steamed bones too.

It seems, nevertheless, that there was an increasing focus in Otago on finding ways of restoring soil nitrogen. As the *Otago Witness* observed in 1875, most land in Otago was not yet "in a sufficiently forward state of cultivation to give a heavy enough yield of clover to afford much nourishment to the wheat crop". This may have been owing to the low populations of *Rhizobia*, the bacteria which clover use to fix nitrogen, in some Otago soils, or alternatively, that the newly tilled seedbed was too rough for clover. Because clover has small seeds, a rough seedbed causes many seeds to be sown too deep, or to sit loosely in soil cavities - either result would depress overall clover growth. The article's phrase 'state of cultivation' seems to suggest the latter explanation. Since peas and beans could not be grown easily either, some agriculturists began experimenting with alfalfa (lucerne), which was another legume on which stock could feed.

Near Dunedin, meanwhile, agriculturists could also take the fertiliser route, as the firm of Barron, Grant, & Co. starting selling nitrate of soda in early 1874 for £18 per ton. Alternatively, they may have been able to try their luck with Dunedin's urban refuse. After many years of criticism, the Dunedin City Council finally decided in mid-1874 to close the Manure Depot, and tendered for its removal onto farmland south of the city. Unfortunately, it is not clear whether the tenderer was supposed to keep it, or could sell it off as manure. Christchurch City Council, incidentally, was almost simultaneously concerned with finding an economic outlet for the city's waste, but ultimately public health fears, arising from a typhoid outbreak in early 1875, caused plans for its private agricultural utilisation to be abandoned.

Following on from the good harvest in 1874, the harvest in 1875 proved even better. In Canterbury, the estimated yields for wheat and oats were 26 and 35 bushels per acre respectively, and in Otago the corresponding estimates were 35 and 37 bushels per acre. Pasture and root crops growth, moreover, was also excellent. Perhaps the only downside for arable farmers was finding a market...
for their surplus produce. In line with the falling English price, the price of wheat in Canterbury had dropped 6d. to 4s.2d. per bushel.

As Table 11.8 shows, farmers in Otago and Canterbury responded to these price changes, when it came to sowing crops in 1875, by reducing the acreage in wheat for the second year running. Nevertheless, the total acreage under cereals in both provinces remained almost unchanged from the 1874 values, because in Otago the reduction in wheat acreage had been fairly small, while in Canterbury it had been counterbalanced by more oats and barley cultivation. Conversely, the area in sown pasture continued to forge ahead, despite a fall in the price of wool, which was on a par, in relative terms, with that experienced by wheat. This was nevertheless compensated for by good prices for meat.

Table 11.8: Acreage of crops grown by Pakeha at harvest time within Canterbury and Otago Provinces.

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Sown Grass</th>
<th>Oaten Hay</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(in Canterbury)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1874</td>
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<td>63,823</td>
<td>8006</td>
<td>2343</td>
<td>299,613</td>
<td>3869</td>
<td>23,154</td>
</tr>
<tr>
<td>1875</td>
<td>57,500</td>
<td>72,522</td>
<td>16,820</td>
<td>3140</td>
<td>352,851</td>
<td>5508</td>
<td>42,420</td>
</tr>
<tr>
<td>(in Otago)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1874</td>
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<td>244,466</td>
<td>8606</td>
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<tr>
<td>1875</td>
<td>25,977</td>
<td>79,392</td>
<td>6815</td>
<td>4173</td>
<td>291,125</td>
<td>13,934</td>
<td>30,254</td>
</tr>
</tbody>
</table>

In Otago, for example, the average price per lb. of mutton rose from 3d. in 1874 to 4.5d. in 1875, and the average price per lb. of beef rose from 4d. to 5.75d. Accordingly, the cultivation of turnips, for the purpose of fattening stock, gained still more attention. This was reflected in the acreage figures for 'other crops', which almost doubled in Canterbury, and more than doubled in Otago. Indeed, in Otago the 'other crops' acreage now surpassed that of wheat.

Another factor encouraging root crop cultivation was the perception, expressed by the Otago Witness, that land which had been cultivated for many years could no longer be put into a condition fit for wheat just by putting it under pasture for a year or two. When, however, wheat was grown after turnips there was still every chance of a large crop, thanks to both the ground being well worked and consolidated, and the extra fertilisation. Much the same could be said of wheat grown after clover, but as noted above, many farmers could not grow...
clover well. Once again, more root crop cultivation meant in turn more 'artificial' fertiliser demand - after all, as John Beharrell observed in a lecture on manures to the Kaiapoi Farmers' Club in January 1875, of all crops, it was roots that were "most likely to repay" the use of 'artificial manure', and the 30s. per acre cost he estimated was comparatively little when their fertilising effects might last for three or four crops. Interestingly, Beharrell took the opposite view with respect to farmyard manure, as he asserted that it would "never, at anything like our present rate of wages, pay any farmer to cart upon his land". Unfortunately, there is no evidence of bone-dust demand other than vendor's advertisements, although it is known that 400 tons of Peruvian guano, with a declared value of £6000, arrived in Dunedin during 1875. Even if the entire 'other crops' acreage in Otago had been composed of turnips, say, and the Peruvian guano had been applied to them at the fairly liberal rate of 3 cwt. per acre, this supply would have been sufficient for at least 10% of their acreage to be fertilised. Since farmers applied bone-dust to turnips at a similar rate, and it cost only £6 per ton, or well under half that for Peruvian guano, in Otago at least, phosphatic fertiliser was probably applied to much more than 10% of the area in root crops.

V. Looking ahead to a mixed farming future

During 1875, there was also a noticeable resurgence in efforts to enhance farming practices through agricultural education. This might seem strange given the healthy recent harvests, but it should be remembered that at the time large numbers of new settlers, unfamiliar with New Zealand farming, or perhaps farming at all, were arriving thanks to Vogel's pro-immigration policies. The year when the flow peaked, moreover, was 1874. A notable example of these efforts was the publication of a series of seven locally-written feature articles giving instruction on cereal and bean cultivation in the Otago Witness during April and May. These were followed by two further articles, albeit in a different format, devoted to turnip-growing in July and August. The farmers of North Canterbury, meanwhile, had the benefit of a series of three lectures on agricultural chemistry given in May by Professor Bickerton. In spite of the evident popularity of Bickerton's lectures, and the importance ascribed to them by the Lyttelton Times, neither the Weekly Press nor the Lyttelton Times reported the text of these lectures. Nevertheless, prior to the first lecture the Lyttelton Times did provide a summary of their content, which shows that the first lecture dealt with the chemical composition of the plants, the second dealt with soil chemistry
and the effects of various crops and fertilisers upon it, while the third dealt with various mechanical processes regarding the soil, such as ploughing and drainage.\textsuperscript{197} This shows that the course was very similar to another one Bickerton gave in 1877 - this perhaps explains why the 1875 lectures were not printed in full. On the basis of the 1877 lectures,\textsuperscript{198} it is likely that Bickerton would have reiterated the themes of his Ashburton lecture, namely the value of draining and applying lime to land, although he probably added to this the suggestion that farmers employ some sort of phosphate fertiliser.

How much good this burst of agricultural education did is open to question, although the returns from the bumper harvest in 1876 suggests that any impact it had must have been positive. In Canterbury, the estimated yields for wheat and oats were 31 and 38 bushels per acre respectively - perhaps the best since organised settlement began. The crops in Otago were abundant too - the respective estimated yields of wheat and oats there were 37 and 39 bushels per acre.\textsuperscript{199} Although the good condition of the crops was attributed principally to a combination of favourable weather and the infrequency of serious damage from diseases and pests,\textsuperscript{200} district harvest reports indicate crop rotation also played a part in producing such high yields. In the Long Bush area, for instance, reporters noted that the yield of wheat sown on land previously occupied by turnips was around 40 bushels per acre, as opposed to an estimated 28 bushels per acre for the remainder of the wheat acreage.\textsuperscript{201} Similarly, it was observed that the best crops of oats were generally grown on either new or ex-turnip land in the East Malvern and Rakaia districts.\textsuperscript{202}

For the observer of farming in Otago and Canterbury, it must, by 1876, have seemed almost inevitable that the only future for cereal cultivation would be as an auxiliary to intensive stock-rearing, or as a temporary interlude on new land intended for pasture. This was in stark contrast to the situation in 1868, when a relatively high wheat price, as opposed to a low wool price, and the prospect of a potentially profitable export trade to Great Britain, made growing grain an attractive option. In the ensuing years, however, the erratic wheat price, and a series of poor harvests, meant that cereal growers struggled to make a profit. The price of wheat was now falling again, and the situation with oats was even worse, as they were now fetching not much more than a shilling a bushel.\textsuperscript{203} In the meantime, the area under sown pasture had, as seen in Figure 11.5, grown larger and larger. Overall, in the past eight years the acreage devoted to sown grass had almost trebled in Otago and grown five-fold in Canterbury, whereas the area under cereals had merely doubled in Canterbury and risen by just one-half in Otago.
Figure 11.5
Changes in area under crop in Otago and Canterbury, 1867-75.

Source: *Statistics of New Zealand for 1867*, Part 1 (Census Results), Table 21; *Statistics of New Zealand for 1869*, [Appendix], p. 5; *Statistics of New Zealand for 1872*, Appendix, Table 1; *Statistics of New Zealand for 1875*, p. 211.

In both provinces the proportion of cultivated land under sown grass continued to grow during this period. There was marked fluctuations in the relative acreages in wheat and oats which were driven by price change.

The respective total sown acreages are:

<table>
<thead>
<tr>
<th>Province</th>
<th>1867</th>
<th>1869</th>
<th>1872</th>
<th>1875</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canterbury</td>
<td>152711 ac</td>
<td>318659 ac</td>
<td>217528 ac</td>
<td>550761 ac</td>
</tr>
<tr>
<td>Otago</td>
<td>122209 ac</td>
<td>171837 ac</td>
<td>451670 ac</td>
<td></td>
</tr>
</tbody>
</table>

Note that the pie graphs are not proportional between the two provinces.
Figure 11.5

Relative Crop Areas in Canterbury by Years

1867

11% - 48%
17% - 23%

1869

11% - 47%
24% - 18%

1872

6% - 64%
22% - 12%

1875

12% - 64%
10% - 13%

Crop Type
- Wheat
- Oats
- Grass
- Other

Relative Crop Areas in Otago by Years

1867

35% - 10%
43% - 11%

1869

53% - 25%
12% - 10%

1872

17% - 17%
56% - 10%

1875

64% - 18%
6% - 12%

Crop Type
- Wheat
- Oats
- Grass
- Other
Thanks to the swing to intensive pastoralism, which was likely to gain even more momentum in the future, since it seemed it was only a matter of time before a method of preserving meat by refrigeration was perfected, the dangers of soil exhaustion, which loomed large when smallfarmers' livelihoods had been dependent on cereal cultivation, had largely been avoided. Since 1872 in particular, the economically viable prices for fattened stock had encouraged many farmers, who might previously have successively cropped land and then retired it under pasture, to take up rotational cropping. This had generally involved growing turnips, although peas and beans formed an alternative fodder crop in parts of Canterbury. The much greater use of fodder crops, which is starkly illustrated by the growth of the 'other crop' category in Figure 11.5, meant that farmers were able to create much more farmyard manure, but at the same time the cultivation of more fodder crops, and root crops in particular, drove up demand for 'artificial' fertilisers. In addition, farmers increasingly started to use waste products, such as the refuse from freezing works, to fertilise their farm. Both factory wastes, and 'artificial' fertilisers, could now be got to the farm more cheaply because of the expanding rail network. In short, the apparently inexorable progress of farming from continuous grain cropping to mixed farming, in which the emphasis was more on animal produce, seemed to suggest that worn out soils might, unless caused by overstocking, be a thing of the past. However, at the end of 1876 this comfortable prospect would be shattered by an abrupt drop in the price of wool.
Notes to Chapter Eleven

5. *Statistics of New Zealand for 1867. Including the Results of a Census of the Colony taken in December of that Year* (Wellington, 1869), Pt. 1 (Census Results), Table 21 [unpaginated]; *Statistics for New Zealand for 1868* (Wellington, 1869), 'Agricultural Statistics of the Colony of New Zealand, in February 1869' [Appendix], pp. 2 & 5.
6. *Statistics of New Zealand for 1867*, Pt. 1 (Census Results), Table 21; *Press*, 26 January 1869, p. 3; *Statistics for New Zealand for 1868*, 'Agricultural Statistics of the Colony of New Zealand, in February 1869' [Appendix], pp. 2 & 5.
p. 3. Reprinted in the Weekly Press, 6 February 1869, p. 8, and in the Otago Daily Times, 2 February 1869, p. 2.

15 Otago Daily Times, 9 February 1869, p. 2.


19 Ibid., 20 February 1869, p. 21. With respect to soil exhaustion in Green Island, see also ibid., 20 March 1869, p. 6.


21 Otago Daily Times, 16 July 1869, p. 3.

22 Ibid., 18 March 1869, p. 3.

23 Weekly Press, 10 April 1869, p. 10.

24 Otago Witness, 20 February 1869, p. 13. See also Chapter Ten.

25 Sam Freer to the Ed. Ibid., 28 August 1869, p. 21.

26 Weekly Press, 10 April 1869, p. 10, & 17 April 1869, pp. 10-1.

27 Ibid., 10 April 1869, p. 10.

28 See extracts from the Agricultural Gazette, in ibid., 1 August 1868, pp. 3-4, 15 August 1868, p. 3, 22 August 1868, p. 3, 29 August 1868, pp. 3-4, 5 September 1868, pp. 3-4, & 12 September 1868, p. 3; Ibid., 28 November 1868, p. 8; Extract from J. A. Whitney 'Artificial Manures' (paper to the American Farmers' Club). Ibid., 2 January 1869, p. 8; Extract from Australasian, in ibid., 23 January 1869, p. 8. Incidentally, Whitney's paper was reprinted in full by the Otago Witness (Otago Witness, 12 December 1868, p. 16, & 19 December 1868, p. 16).


30 Otago Daily Times, 1 November 1869, p. 2. See also extract from [Melbourne] Argus, in ibid., 4 November 1869, p. 3.

31 Otago Daily Times, 1 November 1869, p. 2.

32 See, for comment on its failure, Weekly Press, 18 September 1869, p. 10.

33 Ibid., 4 September 1869, p. 8.
34 Statistics for New Zealand for 1868, 'Agricultural Statistics of the Colony of New Zealand, in February 1869' [Appendix], pp. 2 & 5; Statistics for New Zealand for 1869 (Wellington, 1870), 'Agricultural Statistics of the Colony of New Zealand, in February 1870' [Appendix], p. 5.


36 Statistics for New Zealand for 1868, 'Agricultural Statistics of the Colony of New Zealand, in February 1869' [Appendix], pp. 2 & 5; Statistics for New Zealand for 1869, 'Agricultural Statistics of the Colony of New Zealand, in February 1870' [Appendix], p. 5.

37 Weekly Press, 28 August 1869, p. 10.

38 Press 8 July 1869, p. 4. See also Loach, A History of the New Zealand Refrigerating Company, p. 20.

39 Press, 22 November 1869, p. 2.

40 Lyttelton Times, 17 March 1870, p. 2.

41 Ibid., 13 May 1870, p. 2.


43 Otago Daily Times, 3 November 1869, p. 2.

44 Ibid., 9 June 1870, p. 3. James Macandrew was elected Superintendent in 1867 and continued in that role until the abolition of Provincial Government in 1876 (McClintock, A. H., The History of Otago: The Origins and Growth of a Wakefield Class Settlement (Dunedin, 1949), pp. 505 & 619.

45 Otago Daily Times, 1 July 1869, p. 4, 7 August 1869, p. 4, & 1 November 1869, p. 4.

46 Ibid., 31 March 1870, p. 2. These observations were based on comments which had previously appeared in the Bruce Herald.

47 Ibid., 21 March 1870, p. 3.

48 Ibid., 21 February 1870, p. 6. Cf. extract from [Richardson, J. L. C.,] Descriptive Sketch of the Province of Otago, in ibid., 27 October 1862, p. 4.


50 Ibid., 1 October 1870, p. 13.

51 Ibid., 24 September 1870, p. 13.


53 Otago Daily Times, 7 September 1869, p. 2; 'Indoctus' to the Ed., 14
September 1869. Ibid., 16 September 1869, p. 3.

Otago Witness, 9 October 1869, p. 22. This may have been a Bk (calcium-rich) soil horizon from a brown-grey earth (Pers. comm., Dr. John Adams, Department of Soil Science, Lincoln University, November 2002). Its mixed white and brown colour would have been similar to some traditional guanos.

Otago Daily Times, 27 April 1870, p. 6.

Otago Witness, 7 May 1870, p. 13.

See, for instance, Otago Daily Times, 11 February 1870, p. 2; Press, 28 September 1869, p. 2; Weekly Press, 29 January 1870, p. 10.

Otago Witness, 7 May 1870, p. 12.

Otago Witness, 30 April 1870, p. 12; Copland, D.B., Wheat Production in New Zealand, with a chapter by F. W. Hilgendorf (Christchurch, 1920), p. 158.

McIlraith, J. W., The course of prices in New Zealand: an enquiry into the nature and causes of the variations in the standard value in New Zealand, with an introduction by James Hight (Wellington, 1911), p. 51. See also Press, 29 October 1870, p. 2.

Statistics for New Zealand for 1869, 'Agricultural Statistics of the Colony of New Zealand, in February 1870' [Appendix], p. 5; Results of a Census of New Zealand, taken for the night of 27th February, 1871 (Wellington, 1872), Tables 21 & 23A [unpaginated]; Statistics of New Zealand for 1871 [Appendix], p. 6. The 1870 figures were constructed, at that time, from a mixture of the agricultural statistics collected during the General Census, and the agricultural statistics collected annually. In February 1871 the latter compiled information on acreages of wheat, oats, barley, and potatoes, but did not include acreages of sown grass or 'other crops'. When these figures were published, for retrospective comparison, the following year, it is interesting to note that the annual agricultural statistics data was used in preference to the Census data where two figures existed. This is understandable, as the Census data was a compilation of agricultural holdings owned by each household, so that, for example, if a Canterbury farmer owned land in Otago, any crops growing on that land would be included in the acreage returns for Canterbury.

See preceding footnote.

Results of a Census of New Zealand, taken for the night of 27th February, 1871, Table 23A.

Press, 10 January 1871, p. 2.

Otago Daily Times, 28 February 1871, p. 4.

Ibid., pp. 4 & 6.
68 Otago Witness, 30 September 1871, p. 16; Otago Daily Times, 2 February 1872, p. 2.
70 William Murray (speech to the House of Representatives in relation to the Agricultural Drainage Bill), cited in Otago Daily Times, 19 August 1872, p. 3.
71 Otago Witness, 8 October 1870, p. 13.
72 Lyttelton Times, 13 May 1871, p. 2; Press, 7 June 1871, p. 2.
74 See Goldsmith & Co.'s advertisement in Otago Daily Times, 1 February 1872, p. 1. Goldsmith & Co. had begun milling bones in about 1870. Ibid., 2 October 1873, p. 2.
75 Ibid., 25 July 1871, p. 3, & 30 November 1871, p. 3.
76 Ibid., 10 February 1872, p. 3.
77 Ibid., 31 October 1871, p. 2.
78 Ibid., 13 December 1871, p. 2.
79 Murray to Hector, 8 December 1871, Te Papa Archives, MU 94/1 (Colonial Museum and Geological Survey: Hector, James (Director) - Registered Inwards Correspondence, 1871-1883), 1871/412. Bruce Electorate, it should be noted, encompasses what would be termed the Tokomairiro district.
80 Weekly Press, 1 July 1871, p. 12.
82 Ibid., 6 September 1871, p. 3. See also ibid., 13 February 1873, p. 6, and in relation to this system's operation in the Moeraki district, ibid., 8 November 1872, p. 3.
83 Ibid., 23 August 1871, p. 2.
84 See Otago Witness, 28 October 1871, p. 13; Weekly Press, 18 November 1871, p. 5.
85 One of Black's testimonials (see Otago Daily Times, 23 February 1871, p. 3) came, incidentally, from the chemist Lyon Playfair, who was one of Liebig's pupils, and his English-language editor. (Russell, E. John, Sir, A History of Agricultural Science in Great Britain 1620-1954 (London, 1966), pp. 97-114).
86 Otago Daily Times, 12 January 1872, p. 2.
87 Press, 8 June 1871, p. 2, & 6 July 1871, p. 2.
88 See the debates in the House of Representatives on 1 November 1871. New Zealand Parliamentary Debates, 11 (29 September - 16 November 1871), pp. 701-19. A similar tariff was put in force at the end of June 1870 (Otago Daily Times, 5 July
1870, p. 2), but it soon lapsed, following the failure of the Tariff Amendment Bill in September 1870 (see *Otago Daily Times*, 19 September 1870, p. 3, & 30 September 1870, p. 3).


90 *Otago Daily Times*, 24 February 1872, p. 2.


93 Many simply reiterated old arguments, such as that farmers should pay more attention to meat production and dairying. See, for example, *Otago Witness*, 13 January 1872, p. 13, & 24 February 1872, p. 13.

94 J. N. Tosswill, 'Farming best adapted under existing circumstances to this province' (paper to Lincoln Farmer's Club). *Weekly Press*, 20 July 1872, p. 2. See also the comments in *Otago Daily Times*, 4 January 1873, p. 2.

95 *Statistics of New Zealand for 1871*, 'Agricultural Statistics of the Colony of New Zealand in 1872' [Appendix], p. 6; *Statistics of New Zealand for 1872* (Wellington, 1874), 'Agricultural Statistics in February, 1873' [Appendix], Table 2 [unpaginated].

96 *Otago Daily Times*, 10 May 1872, p. 3, & 17 June 1872, p. 3. See also ibid., 23 September 1872, p. 3.

97 Ibid., 16 May 1872, p. 2.

98 Ibid., 10 May 1872, p. 3.


100 Ibid., 4 January 1873, p. 2.

101 Ibid., 22 March 1873, p. 3. See also the harvest reports for Kaihuku and Mokarita (Lower Mataura) in ibid., 13 February 1873, p. 6.


103 See *Otago Daily Times*, 29 June 1872, p. 4, & 1 November 1872, p. 1.


105 *Otago Daily Times*, 18 November 1871, p. 2; *Lyttelton Times*, 30 May 1872, p. 1.

106 A shipment of 27 bags from Akaroa to Lyttelton was recorded in July 1872, and another, of 20 sacks, followed in April 1873. *Weekly Press*, 13 July 1872,

The average price paid for wool in 1872 had been 15d. per lb., as opposed to 8.75d. per lb. three years earlier. Stephens, P.R., 'Farming in Canterbury' (Pt. 1). *New Zealand Journal of Agriculture* 81(5) (1950), pp. 419-20.

McIlraith, *The course of prices in New Zealand*, p. 51; *Statistics of the Colony of New Zealand for the year 1873* (Wellington, 1874), p[156]. See also *Timaru Herald*, 17 February 1873, p. 2.


Otago Daily Times, 20 February 1873, p. 2; *Lyttelton Times*, 13 January 1873, p. 2.

Statistics of New Zealand for 1872, 'Agricultural Statistics in February, 1873' [Appendix], Table 2.

*Lyttelton Times*, 13 January 1873, p. 2.

*Timaru Herald*, 17 January 1873, p. 3; *Otago Daily Times*, 27 January 1873, p. 2.

*Lyttelton Times*, 13 January 1873, p. 2.

Statistics of New Zealand for 1872, 'Agricultural Statistics in February, 1873' [Appendix], Table 1; *Statistics of the Colony of New Zealand for the year 1873* (Wellington, 1874), p. [182].

*Otago Witness*, 21 February 1874, p. 7. In a similar vein, the Queenstown correspondent of the *Otago Daily Times* noted that local agriculturists would derive great benefit from spelling crop land under pasture in that district, "as the sheep will act as capital fertilisers of the soil - thus attaining the first object of the farmer" (*Otago Daily Times*, 19 May 1873 (Supplement), p. 1).
According to the agricultural statistics collected with household data in the General Census in 1874, Canterbury farmers had 1902 acres under 'peas and beans' (Results of a Census of the Colony of New Zealand, taken for the night of 1st of March of 1874 (Wellington, 1875), p. 257).

Still another alternative which was put forward as a way of rejuvenating the soil was growing mustard and then ploughing it in ('J. N.' to the Ed., 8 January 1874, Lyttelton Times, 12 January 1874, p. 3). Mustard is not a legume, but serves much the same purpose as a root crop, that is, it is a fast growing crop which can be fed off by sheep (Fream, W., Elements of Agriculture 9th ed., ed. by J. R. Ainsworth-Davis (London, 1914), p. 186).

Unfortunately, there appears to be some double counting of 'turnips and rape' in the Census data, since their acreage alone exceeds that of the figures for 'other crops' in the corresponding set of agricultural statistics (Statistics of the Colony of New Zealand for the year 1873 (Wellington, 1874), p. [182]). As a result, the ratios themselves will be inflated, but the relativity between the ratios for Canterbury and Otago remains. The likely reason for this double counting is that the Census would have recorded the turnip and rape crops sown, as was the norm, in November and December (see Joseph Clark, 'Root Crops' (paper to Kaiapoi Farmers' Club). Weekly Press, 24 October 1874, p. 7, & 7 November 1874, pp. 12-3), but it would also have included the sowings of white turnips, used for late winter and summer feed, during February 1874, which were too late for the annual agricultural statistics collection corresponding to the crops sown in 1873. In this respect it is worth noting that Brett's Colonists Guide observed that the "common white turnip can be sown at any favourable time..."

135 Experimental work has shown that pea vines lengthen after phosphate application, but the size of the pea crop itself does not normally change. As a result, phosphate fertiliser is only needed on infertile soils. McLeod, C. C., 'Use and misuse of fertilisers on peas'. In Germyn, W. A., & Wratt, G. S. (eds.), *Peas: management for quality* ([Lincoln], 1987), pp. 30-1.

136 *Otago Daily Times*, 22 March 1873, p. 3. It appears, on the basis of advertisements, that this mill began operation in 1869 (See ibid., 7 August 1869, p. 4).

137 Ibid., 2 October 1873, p. 2. The burning down of this mill may explain why the 1874 Census only recorded one operational bone-mill in Dunedin (*Results of a Census of the Colony of New Zealand, taken for the night of 1st of March of 1874*, p. 270). One factor which may have encouraged Goldsmith about the prospects of future demand was the sowing of 2000 acres of rape crop on the Henley estate (*Otago Witness*, 28 February 1874, p. 1).

138 *Otago Daily Times*, 1 September 1873, p. 4; *Otago Witness*, 6 September 1873, p. 13.

139 Thomas Murray to the Ed. *Bruce Herald*, 29 April 1873, p. 7; Murray to the Ed. Ibid., 24 June 1873, p. 3.

140 Murray to the Ed. Ibid., 29 April 1873, p. 7; W. Dalrymple, Snr., to the Ed. Ibid., 23 May 1873, p. 7.

141 Murray to the Ed. Ibid., 24 June 1873, p. 3.

142 Ibid.

143 *Otago Daily Times*, 25 April 1873, p. 3. See also, for concerns about soil exhaustion in the Oamaru district, extract from *North Otago Times*, in ibid., 27 October 1873, p. 2.

144 Ibid., 25 April 1873, p. 3.


146 *Statistics of the Colony of New Zealand for the year 1873*, p. [183].


149 See ibid., 3 October 1874, p. 10, 17 October 1874, p. 15, 24 October 1874, p. 9; *Lyttelton Times*, 19 January 1875, p. 3. An additional factor behind the rise in oats cultivation at the expense of wheat was the substitution of oats
for wheat in the second year of cultivation under the 'two crop' system (Ibid., 20 February 1875, p. 10).

156 *Statistics of the Colony of New Zealand for the year 1873*, p. [182];
*Statistics of the Colony of New Zealand for the year 1874* (Wellington, 1875), p. 197.

151 The Levels district occupied the area immediate to the south of the Rangitata River. See sub-electorai returns in *Press*, 9 March 1875, p. 3.


153 *Press*, 27 January 1875, p. 3.


155 Ibid., 19 January 1875, p. 3.


159 The *Otago Witness* Christchurch correspondent was encouraged to "notice consignments of oil-cake knocking about" (*Otago Witness*, 12 December 1874, p. 5). In Otago, meanwhile, an advertisement was placed in the *Otago Witness in 1876 advertising a "large quantity for sale" (Ibid., 30 September 1876, p. 1). For an account of oil-cake use in Great Britain, see Thompson, F. M. L., 'The Second Agricultural Revolution, 1815-1880'. *Economic History Review* (2nd series) 21(1) (1968), pp. 66-8 & 70-4.

160 *Otago Witness*, 12 December 1874, p. 5.

161 See *Lyttelton Times*, 24 May 1878, p. 2. Undoubtedly, the bone-mill recorded as being in operation in Canterbury by the Census in 1874 is Maydwell's (*Results of a Census of the Colony of New Zealand, taken for the night of 1st of March of 1874*, p. 270).

Maydwell's bone-dust was "highly commended". Ibid., 14 November 1874, p. 15.

Bickerton arrived in Christchurch to take up the position of Professor of Chemistry in June 1874. Burdon, R. M., Scholar Errant: A Biography of Professor A. W. Bickerton (Christchurch, 1956), pp. 21-2.

Weekly Press, 7 November 1874, p. 10. Greater use of lime was also supported by the correspondent 'T. K.' ('T. K.' to the Ed. Lyttelton Times, 21 February 1874, p. 3).


Otago Witness, 20 February 1875, p. 11.

To illustrate the point, the article went on to describe the workings of a 2400 acre farm in the district, where the farmer alternated 240 acres of cultivated land between wheat, grass (with clover), and turnips. The turnips in this case were manured with a mixture of farmyard manure and bone-dust. Ibid., 5 June 1875, p. 18.

Ibid., 27 March 1875, p. 18.

Ibid., 1 October 1874, p. 13. Steaming removed from the bones the organic matter, which, it may be recalled from Chapter Seven, reduced their rate of decay, and thus the availability of phosphate to plants.

Ibid., 3 April 1875, p. 18.


Otago Witness, 30 May 1874, p. 4.

Ibid., 28 February 1874, p. 15.

Ibid., 16 May 1874, p. 17.

Press, 1 December 1874, p. 2; Weekly Press, 3 April 1875, p. 5. The Council's Sanitary Committee were surprised to find that "farmers and market gardeners" were neglecting to use the "large and valuable deposits" at the Sandhills Reserve in Bromley (See report of the Council Sanitary Committee, cited in Press, 1 December 1874, p. 2). These were apparently being added to at a rate of nine tons per day (A. W. Bickerton, James S.

177 *Statistics of the Colony of New Zealand for the year 1874*, p. 198.

178 *Otago Witness*, 20 February 1875, p.10, & 27 March 1875, p. 18; *Press*, 27 January 1875, p. 3.

179 *Press*, 20 February 1875, p. 2; Extract from *Mark-Lane Express*, 21 December 1874, in *Weekly Press*, 27 February 1875, p. 8; *Otago Witness*, 3 April 1875, p.18.

180 McIlraith, *The course of prices in New Zealand*, p. 51.

181 In Canterbury, the price of wool dropped from 14.5d. per lb. in 1874 to 13d. Ibid., p. 52.

182 *Statistics of the Colony of New Zealand for the year 1874*, p. 197; *Statistics of the Colony of New Zealand for the year 1875* (Wellington, 1876), p. 211.

183 *Statistics of the Colony of New Zealand for the year 1874*, p. 170; *Statistics of the Colony of New Zealand for the year 1875*, p. 181.

184 *Otago Witness*, 17 July 1875, p. 18.

185 Ibid.

186 Ibid., 3 April 1875, p. 18.


188 Cf. records for imports by commodity, and imports by country of origin and destination port. *Statistics of the Colony of New Zealand for the year 1875*, pp. 133 & 170. It appears that this guano was sold by the firm of Goldsmith & Co. (see *Otago Witness*, 1 January 1876, p. 22).

189 Donald Reid, for instance, employed 2.5 cwt. of Peruvian guano per acre of turnips. Donald Reid to Douglas, Alderson & Co., 18 August 1866. *Weekly Press*, 20 October 1866, p.7. See also Chapter Seven.

190 *Otago Witness*, 5 June 1875, p. 18.

191 See, for example, *Lyttelton Times*, 30 March 1875, p. 2.


193 *Otago Witness*, 3 April 1875, p. 18, 10 April 1875, p. 18, 17 April 1875, p. 18, 24 April 1875, p. 18, 1 May 1875, p. 18, 8 May 1875, p. 18, & 22 May 1875, p. 18.

194 Ibid., 17 July 1875, p. 18, & 14 August 1875, p. 18.

195 Reports on the second and third lectures in the *Press* commented that they were well attended. *Press*, 21 May 1875, p. 2, & 28 May 1875, p. 2.

196 *Lyttelton Times*, 13 May 1875, p. 2. See also 'Common Sense’ to the Ed. Ibid., 31 May
1875, p. 3.

197 Ibid., 13 May 1875, p. 2.

198 Ibid., 6 August 1877, p. 3, 3 September 1877, p. 3, 8 October 1877, p. 3.

199 *Statistics of the Colony of New Zealand for the year 1875*, p. 212.

200 Farmers were helped in the struggle against pests by the acclimatisation of several insectivorous birds. *Otago Witness*, 18 March 1876, p. 9; *Lyttelton Times*, 29 January 1876, p. 3.

201 *Otago Witness*, 18 March 1876, p. 9. While no comparative yields were included in it, the Oamaru district harvest report was happy to note that the principle of rotational cropping was now "generally admitted" in the Oamaru district. Nevertheless, no rotation had been fixed on as yet. Ibid, p. 10.

202 *Lyttelton Times*, 3 February 1876, p. 2.


The Great Grain Drain: managing soil fertility in Canterbury and Otago during the first 'bonanza' wheat boom, c. 1876-1883.

After all the progress made during the previous decade towards the establishment of mixed farming and intensive pastoralism, the late 1870s and early 1880s saw a relapse to the bad old days of continuous cropping. First prosperity, and then austerity, helped propel farmers towards the first phase of a two decade period which has since become known as the 'bonanza' wheat boom. As a result, the soil resources of Canterbury and Otago were placed under far greater strain than ever before. In the meantime, mixed farming continued to be vigorously advocated, although without much success until new technologies, in particular refrigeration, made it more feasible. By 1883, therefore, the blueprint for Canterbury and Otago's mixed farming future was already taking shape, even if it had not yet been implemented.

I. Making farming pay ... scientifically

The commencement of the 'bonanza' wheat boom was brought about by a combination of factors, but the fall in the price of wool did most to initiate it. Due to international oversupply the price of wool went into sharp decline after 1874 and by late 1876 the average wool price in Canterbury of 11.75d. per lb. was some 20% less than it had been when the market peaked in 1872. Farmers rearing stock were insulated from this fall during 1875 by the coincident strengthening of the meat price, but when this stabilised in 1876, the continuing decline in the wool price began to be severely felt. As land prices were rising, due to the large numbers of recently arrived immigrants who wished to purchase land, many owners of lowland estates, which were more accessible now due to the emerging railway network, decided it would be an opportune time to subdivide their land.

Ordinarily, the fall in value of pastoral production, coupled with the improvement of transport, for both people and produce, and subdivision of land suited to agriculture, should have prompted an immediate surge in the acreage devoted to cereal cultivation. However, the market for cereals in early 1876 was not, as noted in Chapter Eleven, particularly favourable. Overselling of grain,
prompted by an overestimation of yields at harvest time, raised wheat prices to 6s. per bushel later in the year, but the small swing back from stock-rearing to cropping failed to rate much comment in the 1877 harvest reports. The area sown in wheat in Canterbury was, as seen in Table 12.1, 60% higher in 1876 than in the previous year, but the increase in cereals combined was still only about half of the increment in the area under sown grass. Moreover, the area in 'other crops' in Canterbury also grew by 15,831 acres, which indicates that many farmers, while perhaps preparing their land for wheat crops in the future, were content to keep fattening stock in the meantime. Having said this, some farmers, amongst them the runholder G.H. Moore, who decided to sow 3000 acres of turnips anew, planned to follow turnips with sown grass. In Otago, meanwhile, the switch back to wheat growing was more tenuous than that in Canterbury, with the increase in the area under wheat being almost entirely cancelled out by the decline in the area growing oats. Increments in the area under sown grass and 'other crops', in contrast, were of similar size to those in its northern neighbour.

Table 12.1: Acreage of crops grown by Pakeha at harvest time within Canterbury and Otago Provinces.

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat (Canterbury)</th>
<th>Oats (Canterbury)</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Sown Oaten (Canterbury)</th>
<th>Other Total (Canterbury)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1875</td>
<td>57,500</td>
<td>72,522</td>
<td>16,820</td>
<td>3140</td>
<td>352,851</td>
<td>5508 42,420 550,761</td>
</tr>
<tr>
<td>1876</td>
<td>92,417</td>
<td>70,032</td>
<td>16,047</td>
<td>3419</td>
<td>407,895</td>
<td>5322 58,251 653,383</td>
</tr>
<tr>
<td></td>
<td>(Otago)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1875</td>
<td>25,977</td>
<td>79,392</td>
<td>6815</td>
<td>4173</td>
<td>291,125</td>
<td>13,934 30,254 450,670</td>
</tr>
<tr>
<td>1876</td>
<td>40,799</td>
<td>65,882</td>
<td>6051</td>
<td>4805</td>
<td>356,131</td>
<td>17,084 46,000 536,752</td>
</tr>
</tbody>
</table>

In the circumstances, it is not surprising that fertiliser use continued to become more commonplace. This was especially true in Otago, where it was reflected in their regular mention in the Otago Witness' revamped 'Farm Calendars'. One calendar in late 1876 advised farmers to employ, "in the absence of other manure", superphosphate or bone flour on turnips, while others that year espoused the use of Peruvian guano or nitrate of soda on grass and wheat, and common salt on mangolds, respectively. Furthermore, in the Longbush district, where any form of manuring had been almost unknown a couple of years earlier, harvest reports now commented favourably on farmers' use of bone-
dust, some of which was probably derived from whalebone. Some Otago farmers also started making use of lime from the Milburn kiln, which had opened in 1875.

Farmers in Canterbury, however, still showed much less inclination for using fertilisers than those in Otago, and if anything, the disparity between them was widening. Seemingly the only supply in Canterbury at this time was the output of Maydwell's Papanui bone-mill, whereas in Otago, a number of firms were now engaged in selling either bone-dust, superphosphate, or Malden Island guano. In one case, a local 'guano' was also obtained from an islet just out of Dunedin.

One reason for this disparity, discussed in Chapter Eleven, was the greater feasibility of growing peas and beans in Canterbury as against Otago, but another factor, which would have become increasingly significant as the acreage in root crops rose, was the difference in the type of root crops grown in the two provinces. In Otago, farmers commonly grew Swedish turnips (swedes), and rape was extensively cultivated in North Otago, but in Canterbury the soft-fleshed white turnip predominated. The reason for this geographical differentiation is that white turnips flourish on light-textured soils, and cope well with a dry climate, whereas swedes struggle on such soils, and prefer a cool climate. What makes this of significance, from a fertiliser demand viewpoint, is that swedes require, as William Reid noted in an 1881 essay on farming in Otago, "more manure than the other sorts". Unfortunately Reid did not go into details, but a New Zealand Department of Agriculture pamphlet published in 1926, stated that whereas the best fertiliser for soft turnips was 1.5-2 cwt. of basic superphosphate (and perhaps 1 cwt. of bone-dust on poor land), swedes required an additional 1-1.5 cwt per acre. Consequently, Southland farmers growing swedes could have been using twice as much phosphatic fertiliser as their Canterbury counterparts growing white turnips. Similarly, Connell and Hadfield, in their 1919 text on New Zealand agriculture, stated that rape, depending on the soil, needed 1-3 cwt. of superphosphate per acre - this again represented as much as double the white turnip requirement.

Of the fertilisers available in Dunedin, bone-dust was produced locally, whereas the Malden Island guano brought into Dunedin in mid-1876 had come, like the Peruvian guano imported the previous year, by way of a 400 ton direct shipment. The source of superphosphate, however, is less clear. It seems that a Melbourne agent sold some of British manufacture, but intriguingly, an Otago Witness article from March 1876 on the bone-mill owned by Sydney Goldsmith reported that "he also makes super-phosphates for manure".
true, it would identify this as the first site of superphosphate manufacture in New Zealand.

Another noteworthy development in fertiliser use was that manure drills were coming into use at this time. This promised to reduce the fertiliser requirement, on a per acre basis, since it placed the fertiliser in close proximity to the seed, rather than distributing it through the topsoil, or on the soil surface. Because of the scarcity of application rate information, it is difficult to say whether this occurred in practice, although when farmers were quizzed about their application rates in 1881, they distinguished between rates for broadcast and drill-sown crops. Even so, the amount of farmyard manure used in conjunction with the 'artificial' fertiliser appears to have had a greater bearing on the application rate. Incidentally, by 1881 turnips were normally sown with the drill rather than by broadcasting, on account of the larger crops obtained.

Some farmers, in their readiness to apply the principles of agricultural chemistry, did not stop at fertiliser use, however. The new 'Chats with Farmers' column in the *Otago Witness* records at least two instances in 1877 where Otago farmers opted to have soil analyses conducted on their soil. Presumably analyses had also been undertaken in the Longbush district, given the following comments which appeared in the 1877 harvest report:

> The general composition of the soil, too, is unfavourable to the production of this crop [wheat]. It contains almost no silica, very slight traces of phosphates or nitrates, and with the exception of bush land, it shows a very small percentage of organic or vegetable matter. These must, therefore, be supplied to the soil in the shape of mineral and vegetable manures ...

This more technical approach to managing soil fertility, raised new questions about the appropriateness of the hitherto *ad hoc* approach to agricultural education. Given that some Otago settlers had begun using agricultural chemistry as a guide to their farming operations, the subsequent failure of Otago institutions to take remedial action is surprising, though perhaps the size of other economic sectors in Otago, such as mining, made the successful prosecution of farming seem less vital. Indeed, when the Royal Commission on the University of New Zealand in 1879 questioned Professor Black of the University of Otago, on the opportunities for tuition in agricultural chemistry, he explained that the subject was not specifically taught, although aspects of it came up in his chemistry lectures from time to time.
Conversely, in Canterbury, further progress was being made towards establishing an agricultural college. After the Provincial Council was dissolved in 1876, the land endowment set aside for agricultural education purposes in 1872, in recognition of the importance of agriculture to the province's future prosperity, passed into the hands of Canterbury College. Accordingly, the College's Board of Governors formed a committee in November 1876 to determine how it should best be used. Initially the provision of rural scholarships for students to attend Professor Bickerton's lectures at the College, or alternatively, a series of lectures in rural centres, were favoured options, but when the committee found that the endowment conditions did not allow either, they recommended instead that a School of Agriculture, coupled with an experimental farm, should be established within 15 miles of Christchurch. With the site so close, it was thought that College staff, most notably Professor Bickerton, would be able to give lectures at both institutions. Subsequently, the Board approved this scheme in March 1877. Meanwhile, the Canterbury Agricultural and Pastoral Association decided to do its bit for disseminating agricultural knowledge by establishing the *New Zealand Country Journal*. This periodical was first mooted by Robert Wilkin in July 1876, and in line with his suggestion, the first issue was published in January 1877.

II. The 'bonanza wheat' bandwagon

When it came to harvest time in 1877, agriculturists in both provinces found themselves blessed by good crops for the third-year running. In Canterbury, the respective yields for wheat and oats were 28 and 29 bushels per acre, while in Otago, the equivalent figures were 30 and 35 bushels per acre. The rise in the wheat price, illustrated in Figure 12.1, to its highest level for some years, made these yields doubly rewarding. Thanks to the overselling of wheat in 1876 described above, the quantity of stored wheat, which normally acted as a buffer against price fluctuations, was quite low, and hence when the English price was driven up by the outbreak of the Russo-Turkish war and the partial failure of the Californian crop, the wheat price in Canterbury rapidly climbed up to around 6s. per bushel. In addition, strong Australian demand early in the year also led to a firming in the price of oats, since stocks on hand were run down as a result.

Farmers responded to the strong grain market by devoting a much enlarged area to cereals, and wheat in particular, when they sowed crops in 1877. As Table 12.2 shows, in Otago the wheat acreage almost doubled, and the increase in the
Figure 12.1
Farming commodity prices, 1876-83.

Sources: McIlraith, J. W., *The Course of Prices in New Zealand*, pp. 51-3; *Statistics of New Zealand* 1876-83.

This graph clearly illustrates the sharp increase in wheat price which led to the furious 'land mania' of 1877-8. It also shows how much more stable the wool price was in comparison during this late 1870s-early 1880s period.
Farming Commodity Prices 1876-83.

- Canterbury Wheat Price
- Otago Wheat Price
- Canterbury Wool Price
area under cereals was twice as much as the increase in the area under sown grass. In Canterbury, meanwhile, the wheat acreage grew by more than half, but the huge corresponding increase in sown grass meant that as a proportion of the area in crop, wheat only just held its own, and for cereals as a whole, the proportion fell. It should be said that harvest reports for Canterbury districts in 1878 indicate that large amounts of crop land were still being retired to pasture, and conversely, much of the area sown in wheat was land being cropped for the first time.  

Table 12.2: Acreage of crops grown by Pakeha at harvest time within Canterbury and Otago Provinces.  

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Sown Grass</th>
<th>Oaten</th>
<th>Other</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Sown</td>
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<td></td>
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<tr>
<td>(Canterbury)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1876</td>
<td>92,417</td>
<td>70,032</td>
<td>16,047</td>
<td>3419</td>
<td>407,895</td>
<td>5322</td>
<td>58,251</td>
<td>653,383</td>
</tr>
<tr>
<td>1877</td>
<td>147,255</td>
<td>86,815</td>
<td>13,757</td>
<td>4419</td>
<td>624,038</td>
<td>9638</td>
<td>64,294</td>
<td>950,216</td>
</tr>
<tr>
<td>(Otago)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>1876</td>
<td>40,799</td>
<td>65,882</td>
<td>6051</td>
<td>4805</td>
<td>356,131</td>
<td>17,084</td>
<td>46,000</td>
<td>536,752</td>
</tr>
<tr>
<td>1877</td>
<td>76,628</td>
<td>87,924</td>
<td>3027</td>
<td>4360</td>
<td>382,030</td>
<td>12,737</td>
<td>64,768</td>
<td>621,474</td>
</tr>
</tbody>
</table>

For reasons which will be discussed below, an even more significant impact of the apparent prosperity of arable farming was the frenzy of land buying that it initiated. This reached its height, in Canterbury at least, in mid-1878. This mania for land was reflected by sharp rises in both the number of holdings and the price of land. Around Christchurch and Timaru, for example, land worth as little as £2 per acre a few years earlier now sold for £20 or more. Amongst the purchases to be affected were those for the new School of Agriculture at Lincoln. The first parcel of 42 acres was bought in September 1877 for around £11 per acre, but in five further purchases during the period November 1878 - July 1879, the price paid ranged from £19 to £45 11s. per acre.  

Lincoln met the criteria of being close to Christchurch and accessible by rail, but the increased expense of land meant that another objective, that is, having an attached model farm which encapsulated a variety of soil types, was only partially fulfilled. Regrettably, the Lincoln site was deficient in light plains land, which would prove a major drawback in terms of gaining farmer support, since this constituted more than half of the Canterbury Plains. Aside from providing "a thoroughly practical education in colonial farming ... at a moderate cost", the
School (shown in Figure 12.2) also intended "to afford facilities ... for instruction in agricultural chemistry, and other sciences directly connected with agriculture". It was fitting, therefore, that the manager selected to run the conjoined School and Farm, William Ivey, had not only several years farming experience, but was also a trained chemist - indeed, immediately prior to his appointment, Ivey had concurrently held the posts, within Victoria's Department of Agriculture, of Chemist and Scientific Superintendent & Director of the Experimental Farm.

In the meantime, however, educating Canterbury's farmers in matters of agricultural chemistry had remained the ambit of Professor Bickerton. Starting in August 1877, Bickerton gave, as he had done in 1875, a course of three lectures in Christchurch which were open to the public, although newspaper reports indicate that the audience consisted mainly of farmers. Significantly, lecture transcripts did not just appear in Christchurch newspapers. The Ashburton Mail, for instance, published the first lecture in full. In the first lecture Bickerton dealt with the chemical composition of various crop plants, and the sources of their nutrition, while the second was devoted to the benefits of drainage, such as increased soil warmth, expedited decay of vegetable matter and manure, and reduced soil acidity. After reiterating these benefits at the start of the third lecture, he then described the properties of various soils and the effects of manures. Yet while Bickerton made several observations in regard to fertilising the soil, such as the value of phosphate of lime for root crops, and the role of clover in restoring soil nitrogen levels, he believed that farmers should not rush into using fertilisers unless individual circumstances dictated it.

A request from the Kaiapoi Farmers' Club for Bickerton to give a lecture at Kaiapoi too prompted a new series of agricultural chemistry lectures in early 1878, which the College decided to wholly subsidise. These were held in Kaiapoi, Leeston, Ashburton, and Timaru, and drew crowds of around 150 each, except in Timaru, where the harvest was at the time in full swing. During these lectures Bickerton related to farmers the reasons for using both nitrogenous manure (to increase wheat production) and bone manure (to replace phosphates lost in both crops and animal produce), though again he suggested farmers exercise caution when applying fertilisers. To this end, he noted that a small number of Canterbury soil analyses requested by local farmers had shown much higher levels of phosphate than had been anticipated. Consequently, their need for phosphatic fertiliser was not as great as had been previously thought. Bickerton himself was intrigued by these results, and it is apparent that he envisaged carrying out "an extended series of soil analyses" - in effect, a soil survey - within Canterbury, in
Figure 12.2
Ivey Hall, Lincoln

Source: Photograph by A. M. Wood.

This is the facade of the original building which housed the School of Agriculture. Today it has survived to be Lincoln University, with the reconstructed Ivey Hall housing its library.
order to compile sufficient information about the fertility of each soil for farmers to use it in their decision-making. Yet despite Bickerton's enthusiasm for this research, and the apparent level of farmer interest in his lectures, the College, presumably in their zeal to avoid any duplication of roles, ceased to support Bickerton's input in the area once the School of Agriculture had been established. Despite the earlier plans that Bickerton would lecture at it, a chagrined Bickerton told the 1879 Royal Commission on the University of New Zealand that he had "never been consulted in the slightest degree" about the School of Agriculture.

While Bickerton's lectures shied away from imperative direction to farmers, the same could not be said of the Canterbury Agricultural and Pastoral Association's New Zealand Country Journal. The rapid rate at which farmers broke up the light plains land for cropping, which owing to its dry, low fertility soils had previously been the domain of pastoral pursuits, caused some anxiety for the Association's members, and it therefore began vigorously promoting the extension of rotational cropping. The opening salvo of the campaign took the form of a short paper entitled 'On the Cultivation of Light Land' which appeared in the New Zealand Country Journal's October 1877 issue. After rejecting the use of farmyard manure to sustain grain cropping because of the large size of farms and the high cost of labour, it reiterated the argument that growing turnips or rape in conjunction with wheat was the best policy, since the sheep dung provided the necessary manure, and the tread of the sheep consolidated the light land, making it more suited, mechanically-speaking, for wheat growing. Subsequently this argument was expanded upon in two articles by Michael Murphy, who from 1878 was both editor of the Country Journal, and Secretary of the Association. In the first, which reviewed the history of agricultural science, Murphy remarked that green crops could not be grown without manure other than on 'maiden' soils, and since "farmyard manure, however carefully collected", could not "supply the requisite quantity for extensive cultivation", farmers must turn their attention "to the artificial stimulants". For Canterbury farmers, Murphy thought the best of these would be crushed bones or bone-dust. When Murphy readdressed the issue in a paper on turnip culture, he repeated this view even more forcefully. In a critique of 'convertible husbandry', Murphy asserted that whereas a trial of the sheep and fertilised turnip system would demonstrate "that bones and guano applied to carefully cultivated crops will pay", putting worn out land into grass simply provided an opening for weeds to grow. Irrespective of how well manured they might be, subsequent crops would be overtaken by those weeds, leading the farmer "in the end to the Insolvency Court".
Despite these grim forebodings, the current mania for land raised hopes that the ultimate outcome for Canterbury agriculture was likely to be a prosperous one. Even Murphy could not escape this optimistic mood. Within the conclusion of his narrative history of agricultural science, he stated that "with a fertile soil, a model farm, the chemistry of agriculture offered to us gratis, the farmers of this province have a great future before them, if they appreciate the many advantages offered them". In retrospect, however, the economic basis for the cropping boom was a fairly shaky one. Although the farmers of Otago reaped a very respectable 32 bushels of wheat and 36 bushels of oats per acre from the 1878 harvest, in Canterbury the estimated yields of wheat and oats were, on account of drought, only 23 and 28 bushels per acre - as Figure 12.3 shows, this was the worst wheat harvest in Canterbury since 1873. Moreover, while the large scale introduction of combination reaper and binders lowered harvesting costs by some 6s. or more per acre, the return of peace in Europe caused wheat prices to tumble to just above 4s. per bushel. With the price of meat and wool being almost unchanged from the previous year, only oats growers had much reason to smile. Low levels of supply, together with high domestic demand for stock feed following the drought, had pushed the oats price up - indeed, by the end of 1878 it was higher than the price of wheat.

These setbacks did nothing, however, to deter puffers like Sir Julius Vogel from trying to sustain the land mania. Vogel's address to the Colonial Institute in London in 1878 was little short of a sales pitch, as he stressed the advantages, such as high yields, of arable farming in New Zealand as opposed to that in other colonies and the United States. The Weekly Press had no dispute with this argument in general, but it denounced Vogel's enunciation of a claim that a single year under pasture in Canterbury could replenish the soil condition lost in growing two crops of wheat. While this provided proof of the "extreme fertility of the soil", the Weekly Press opined that the "short-sightedness of those who practice so suicidal a method" was equally evident within it. Indeed, the land boom made the adoption of sustainable crop rotations even more necessary than before, since, as the Weekly Press remarked, "virgin soil" was now "a thing of the past". Quite simply, the mania for land purchase had swallowed up practically all of the unsold agricultural land in Canterbury, and most of that in Otago too. Accordingly, farmers could no longer extend their operations on to 'virgin soil', which had previously been a sort of 'overdraft facility', for a quick burst of cereal production. Henceforth, they would instead have to grow grain on land that had already been cropped. The effects of this change are manifest in the statistics for
Figure 12.3
Crop yields in Canterbury and Otago 1871/2 to 1882/3.

Sources: Statistics of New Zealand 1871-82.

As seen in this graph, wheat yields tended to gradually decline from the mid-1870s onwards.
crops sown in 1878, shown below in Table 12.3. For the first time on record the area under sown grass in Canterbury fell, and, more significantly, the area of sown grass on previously unploughed land within Canterbury almost halved, from 206,038 acres the previous year to 115,354 acres. Since the area of 'other crops', which comprised mainly of fodder crops, had grown by more than 50%, it appears that this drop was not due to Canterbury farmers withdrawing from stock-rearing operations, but rather to unploughed grassland being the next best thing to 'virgin' land.

Table 12.3: Acreage of crops grown by Pakeha at harvest time within Canterbury and Otago Provinces.

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Potatoes</th>
<th>Sown Oaten Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Canterbury)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sown Grass Hay</td>
<td></td>
</tr>
<tr>
<td>1877</td>
<td>147,255</td>
<td>86,815</td>
<td>13,757</td>
<td>4419</td>
<td>624,038</td>
<td>9638</td>
</tr>
<tr>
<td>1878</td>
<td>173,895</td>
<td>128,384</td>
<td>17,062</td>
<td>4614</td>
<td>595,079</td>
<td>15,188</td>
</tr>
<tr>
<td>(Otago)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sown Oaten Other</td>
<td>Total</td>
</tr>
<tr>
<td>1877</td>
<td>76,628</td>
<td>87,924</td>
<td>3027</td>
<td>4360</td>
<td>382,030</td>
<td>12,737</td>
</tr>
<tr>
<td>1878</td>
<td>66,941</td>
<td>123,508</td>
<td>5181</td>
<td>4390</td>
<td>416,208</td>
<td>19,073</td>
</tr>
</tbody>
</table>

Regrettably, agriculturists now needed to grow wheat more than ever. Despite continuing advocacy of rotational cropping in the New Zealand Country Journal, and, during late 1878, from essayists in the Weekly Press as well, small farmers, who had incurred high levels of mortgage debt when purchasing land, required a high rate of short-term profit in order to meet their liabilities. Prices for fat stock were not high enough for intensive pastoralism to suffice, so farmers had to rely on cropping instead. After reviewing a hypothetical case where a purchaser had paid £15 per acre, with a 20% deposit, and five years to clear the remainder, the Otago Daily Times concluded that there was little choice when it came to crops either:

Only one crop can do it ... namely, wheat - and then only if a thirty bushel crop is obtained and five shillings a bushel at place of shipment. Owing to exceptional causes - among other things to the very low freights to London which have ruled for some time past - wheat has maintained an exceptionally high value; but will it do so for the next three years?
The dangers of farmers reverting to continuous cropping were, moreover, already palpable - for example, in Geraldine County, which encompassed the agricultural districts around Timaru, several instances of exhausted land were noticed in the reports of the harvest in 1878. Presumably local farmers who had begun grain cropping in the mid-1870s, after the bridging of the Rakaia and Rangitata Rivers (discussed in Chapter Eleven), had decided that the high price made growing it for a little longer worthwhile. Although similar comments were not recorded about other parts of Canterbury, it seems unlikely that South Canterbury farmers were especially slovenly, particularly when bone-dust had begun to be produced by the Washdyke meat-preserving works in 1878. The situation in Otago, meanwhile, is difficult to assess, since both the Otago Daily Times and Otago Witness ceased producing annual district harvest summaries in 1877. However, the Otago Witness' remark in September 1878 that, after a year in which farmers had "rushed into wheat", they were "now making up their minds to conduct their business according to well recognized principles", suggests that most Otago farmers had been careful to avoid wearing out their soil by overcropping.

The contrasting approach taken by many Canterbury farmers was to be exposed, especially on light plains land, by the 1879 harvest. In an article entitled 'On the Theory and Management of our Light Soils' in the New Zealand Country Journal it was observed that

> the result [of continuous cropping] is already apparent in the broad hungry looking country to be met with in many places, which were a few years ago tolerably fertile, and might have remained so if subjected to a more enlightened system without additional expense, and which would now be producing remunerative crops of corn, roots and grasses.

One practice deemed particularly foolhardy was the use of naked fallows as opposed to growing green crops and pasture, on light soils prior to wheat cultivation. As the abovementioned article put it, these "bare and loose lands" had shown that they were "subject to be denuded of their soil by sweeping winds".

Serious wind erosion was only one of the calamities, both natural and man-made, that befell the agriculturists of Canterbury and Otago in late 1878 and early 1879. The first misfortune to occur was the failure of the City of Glasgow Bank. This had a direct effect on Scottish investment in New Zealand, and in particular, on the New Zealand and Australian Land Company, in which the Bank was one of the largest shareholders. At the time of its amalgamation with the Canterbury and
Otago Association in 1877, this Company had been proprietor of no less than 16 estates in Canterbury, Otago, and Southland. However, what made this bank's failure even more significant was the way it unsettled other British banks, causing them to call-in £2 million worth of loans to New Zealand institutions. This led to a New Zealand-wide 'credit crunch', and with borrowable capital scarce, the inflated market for land in Canterbury and Otago collapsed - in Canterbury the average price paid for rural land fell from a record £28 in 1878 to just £11 4s. per acre in 1879. As land values plummeted, the weather dealt a double blow to agriculturist's fortunes. In Canterbury, a second successive drought restricted yields to a miserable 21 bushels of wheat and 25 bushels of oats per acre. Paradoxically, many of Otago's farmers escaped the drought, but had their hopes dashed by the worst floods on record. The overall yields in Otago, nevertheless, were a fair to middling 28 bushels of wheat and 35 bushels of oats per acre. Finally, even the markets seemed to have conspired against farmers - the prices of both wheat, which fell below 4s. per bushel, and wool, of about 9d. per pound, were the lowest they had been since 1870.

Not surprisingly, this sharp fall in farm incomes flowed through to reduced wages for agricultural labourers. This should have favoured the use of farmyard manure rather than 'artificial' fertiliser, since the labour-saving derived from using the latter was less significant, in monetary worth, than it had been in earlier years. An inspection of the 'Chats with Farmers' series, which documented operations on individual farms or estates, in the Otago Witness during late 1878 and 1879, seems to bear this out. Admittedly this sample was probably biased towards farmers which were thought to be exemplary, which probably explains why most were carrying out rotational cropping and making the most of their farmyard manure, but even so, bone-dust and/or guano was used in only a few instances. Although good quality guano was, according to a Weekly Press article, "plentiful" in Dunedin, and, as there were four bone-mills within Otago by this time, bone-dust was probably easily obtained as well, the only 'artificial' fertilizer being advertised in the Otago Daily Times during 1878 and 1879 was George Blyth's bone-dust. This suggests that fertilizer vendors did not have high hopes of expanding the market. Goldsmith & Co., which in 1876 had been Dunedin's leading fertiliser manufacturer, seems to have disappeared altogether.

Nevertheless, Otago's farmers still appear to have outstripped Canterbury's when it came to 'artificial' fertiliser use. Only one bone-mill, no doubt Maydwell's, was recorded by the Census of 1878 as existing in Canterbury, and Maydwell went bankrupt in late 1879, most likely as a result of losses incurred during a fire...
which destroyed the mill in May 1878. The supply of bone-dust to Canterbury farmers continued, however, with the establishment of the Washdyke bone-mill mentioned above. While the use of bone-dust, such as by David Dick of Loburn in a trial with oats in 1879, earned much praise, according to an article entitled 'Fertilizers for our soils' in the September 1879 issue of the *New Zealand Country Journal*, many local farmers remained sceptical about its worth - with produce prices low, they obviously still regarded the outlay of around £8 per ton as more than they could afford. Evidently, Canterbury farmers cannot have used much, if any, guano either. The same *Weekly Press* article which had described the supply of good quality guano in Dunedin as "plentiful" observed that in Christchurch it was "not yet procurable".

**III. Stemming the Stripping Tide?**

With farmers having fallen upon hard times, the question arose as to how they would extricate themselves from this position. There was never any doubt, as the *Otago Witness* remarked, that farming would "still go on upon a large scale", but equally there was no obvious panacea on the immediate horizon to the current depression. The best farmers could do, in its view, was to economise in the short-term, and hold out for better prices in the future.

Farmers with large mortgages, however, had to practise not just economy but expediency too. As the *Canterbury Times* (the *Lyttelton Times*’ weekly equivalent) observed:

> No doubt a good deal of land was sown to wheat, which, according to the rules of good farming, should have gone to oats, or possibly to grass or turnips, but then ... this is an exceptional year. In a great number of cases farmers have heavy arrears to pull up, which cannot be accomplished except by straining the resources of the land to the utmost.

In numerical terms, the area in wheat in Canterbury, as seen in Table 12.4 below, increased by 11%. Happily this gamble of persisting with wheat cultivation
Table 12.4: Acreage of crops grown by Pakeha at harvest time within Canterbury and Otago Provinces.\textsuperscript{106}

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat Sown (Canterbury)</th>
<th>Oats Sown (Canterbury)</th>
<th>Barley Sown (Canterbury)</th>
<th>Potatoes Sown (Canterbury)</th>
<th>Sown Grass (Canterbury)</th>
<th>Oaten Hay (Canterbury)</th>
<th>Other (Canterbury)</th>
<th>Total (Canterbury)</th>
</tr>
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<tbody>
<tr>
<td>1878</td>
<td>173,895</td>
<td>128,384</td>
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<td>595,079</td>
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</tr>
<tr>
<td>1879</td>
<td>193,784</td>
<td>153,742</td>
<td>37,095</td>
<td>5655</td>
<td>715,138</td>
<td>11,662</td>
<td>85,359</td>
<td>1,202,435</td>
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</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat Sown (Otago)</th>
<th>Oats Sown (Otago)</th>
<th>Barley Sown (Otago)</th>
<th>Potatoes Sown (Otago)</th>
<th>Sown Grass (Otago)</th>
<th>Oaten Hay (Otago)</th>
<th>Other (Otago)</th>
<th>Total (Otago)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1878</td>
<td>66,941</td>
<td>123,508</td>
<td>5181</td>
<td>4390</td>
<td>416,208</td>
<td>19,073</td>
<td>70,825</td>
<td>706,126</td>
</tr>
<tr>
<td>1879</td>
<td>53,771</td>
<td>143,165</td>
<td>10,114</td>
<td>5290</td>
<td>459,158</td>
<td>21,743</td>
<td>80,528</td>
<td>783,769</td>
</tr>
</tbody>
</table>

paid off - excellent weather during the growing season\textsuperscript{107} pushed the estimated yield up to 28 bushels per acre. In addition, the wheat price recovered slightly, to 4s.2d. per bushel.\textsuperscript{108} In Otago, the estimated yield was up to 32 bushels per acre,\textsuperscript{109} though as Otago's farmers had reduced their wheat acreage by 20\%, they did not benefit fully from it. The area in oats, meanwhile, had increased by 19\% and 16\% in Canterbury and Otago respectively. To some extent, this increase was forced by the wet winter, which had delayed sowing,\textsuperscript{110} but in North Otago it also reflected adherence to "the ordinary rotation",\textsuperscript{111} in which oats followed wheat prior to the land being spelled under pasture or a green crop.\textsuperscript{112} Ultimately, the additional oats was not as remunerative as wheat might have been, for although the estimated yields were also extremely good - some 38 and 37 bushels per acre in Canterbury and Otago respectively - the combination of unsold supplies from the previous year and high levels of Australian production in the current season glutted the Australasian market, forcing prices down to only 1s.6d. per bushel, which was well below the cost of production.\textsuperscript{113} Large increases also occurred in the area under sown grass, especially in southern Canterbury.\textsuperscript{114} These were encouraged by an upturn in the wool price, which was driven by new American interest in the London market.\textsuperscript{115} Conversely, the acreage in both oaten hay and 'other crops' in Canterbury dropped, suggesting a decreased emphasis on fattening stock, and also diminished production of farmyard manure. Given that this drop was most pronounced in Ashburton County, where the area in 'other crops' fell from 40,834 to 26,489 acres,\textsuperscript{116} it is no wonder that John Grigg, proprietor of Longbeach, felt compelled to condemn the continuous cropping practices of the new small-scale agriculturists, whom he termed 'strippers', during an address to the Ashburton Agricultural & Pastoral
Association. In his hard-hitting paper, which was subsequently printed by the *New Zealand Country Journal*, Grigg produced hypothetical farm accounts to show that a proper rotation of crops was profitable in the long-term, whereas the repeated cultivation of grain crops could only be so while the soil remained unexhausted. Moreover, at the present low prices for oats, even this seemed to be doubtful. At the same time, by replacing barley with oats in his hypothetical six year rotation, Grigg perhaps intentionally contradicted earlier comments made by the *Canterbury Times* that the current low prices of both oats and meat were liable to render complex Norfolk-style rotations unaffordable.

Grigg was not alone in his attempt to steer farmers away from continuous cropping. Although the *Canterbury Times* had expressed doubts over the viability of rotational cropping in the current economic climate, it was equally sure that successive wheat cropping could not be sustained for long in New Zealand, because agriculturists here did not employ deep tillage and fertiliser to maintain the fertility of the soil. Consequently both it and its sister publication, the *Lyttelton Times*, were happy to pass on advice on turnip cultivation contributed by a Mr. Garland of Cust. As the *Lyttelton Times* observed, growing turnips had "now become an essential part of a Canterbury farmer's study". Since thorough tillage was needed for their cultivation, turnips not only provided winter feed, but they also facilitated the 'cleaning' of the ground of weeds - this took on added significance, now that weeds threatened to invade exhausted farmland. This same thoroughness, may, however, have impeded their cultivation in the past. One estimate of the cost of turnip growing in 1878, before the depression in farm wages, put the cost at £7-8 per acre. The management of pastures, meanwhile, also attracted scrutiny. According to the *Canterbury Times*, the usual policy of sowing grass down as cheaply as possible often proved a false economy, as it led to a scanty covering that was barely adequate as stock feed. Instead, it suggested that even in these depressed times, use of manures to stimulate grass growth should be given consideration. Having said this, it cautioned farmers against rushing into stock fattening once the frozen meat trade to Great Britain began, as it believed that this would be too risky in the short-term for farmers to rely upon it for their income.

In the meantime, higher education had also been railing uninterrupted grain growing. Accompanying Grigg's paper in the *New Zealand Country Journal* was an article by W. E. Ivey, Director of the newly opened School of Agriculture at Lincoln, in which it was observed that
the army of "strippers" is gradually spreading over the country, ... leaving behind them land which will in the future want farming and not "cropping", if the colony is to carry its existing agricultural population and continue its grain export at the present rate.  

Herein lay the value of the School of Agriculture - as the _New Zealand Country Journal_ observed, it would teach farmers, or perhaps their sons, "how to obtain the largest possible returns from the soil, at the least possible expense, and at the same time preserving the fertility of the soil". In keeping with these objectives, the chemistry of soils and manures constituted a significant component in the curricula of both Agriculture and Chemistry at the School. For instance, the Winter Term Examination of 1880, which was the first year in which students were admitted, asked questions on such subjects as the mineral ingredients of different soils, the value of 'humus' in a soil, and how to detect the presence of ammonia. The School also undertook manuring experiments on root crops. Meanwhile, George Gray, Professor Bickerton's assistant at the Canterbury College, had begun to contribute a series bearing the title 'The Chemistry of Manures' to the _New Zealand Country Journal_. This sixteen part series, which ran until May 1882, firstly discussed plant nutrition, and then proceeded on to the composition and use of farmyard manures, sewage, and all of the principal 'artificial' fertilisers. Apart from the obvious reminders that farmers must replenish nutrients lost in their crops by manuring, the main point made during the series was that farmers should match their manure use to both the soil and the type of crop being fertilised; with respect to the latter, the general principle was that cereals needed nitrogenous fertilisers, roots needed phosphoric fertilisers, and legumes potassic fertilisers. Timing of fertiliser application also featured largely in the discussions, with the aim being to prevent loss of unutilised nutrients in drainage water. As with Bickerton's lectures in the past, there were few explicit recommendations to local farmers, though one exception to this was Gray's comment that the light plains land of Canterbury, which contain low levels of organic matter, would benefit from more frequent green manuring, that is, the ploughing-in or feeding off of crops grown specifically for the purpose of returning organic matter, and in particular, nitrogen, to the soil.

In Otago, 'stripping' appeared to be less prevalent, and consequently the focus of contemporary agricultural comment in its newspapers was directed in the first instance towards finding solutions to the depressed market for oats rather than preventing soil exhaustion. Nevertheless, the maintenance of soil fertility was still viewed as an important, if secondary, consideration. Now that the feasibility
of sending refrigerated goods from Australia to Britain, had been demonstrated by the voyage of the *Strathleven*,[^137] John Drew Atkin, for example, advised farmers to keep growing oats (within a rotation), and then to employ the crop as feed for cattle. The meat and dairy goods produced, Atkin argued, had not only a higher value, but their lesser bulk also facilitated transport.[^138] In the meantime, Atkin remarked, the "tillage land" would be "kept in the highest state of fertility from the extraordinary quantity of manure gathered from slaughteryard, stalls, byre, stable, piggery, and poultry yard."[^139] In another very different plan the cultivation of oats was to be abandoned, and - in line with what was described as the practice "of all good farmers in the Old Country" - beans (or peas) were to be cultivated in their place. In support of this approach, it was maintained that beans or peas were better preparatory crops than oats for wheat and barley, but rather than alluding to their nitrogen-fixing capacity, it instead argued that they required better tillage and allowed the ground to be cleaned of weeds.[^140] Compared to the situation in Canterbury, there was not much effort devoted to educating Otago farmers about the use of manures either. The only local contribution seems to have come from the Dunedin clergyman, William Jenner,[^141] who had trained within the British agricultural college system, and intended setting up a private agricultural school.[^142]

Whether farmers, when sowing their crops in 1880, responded more to the criticisms of 'stripping' or the rising prices for wool is difficult to say, but there is no doubt that together they had a marked effect. In particular, the acreages under 'other crops' increased on those of the previous year by 33% and 37% in Canterbury and Otago respectively (see Table 12.5 below). Grigg would have been especially pleased to see that 'turnip and rape' cultivation now accounted for 43,540 acres of cropland in Ashburton County, which equated to about half of the combined acreage in wheat and oats.[^143] With respect to the total area under cereals, a substantial reduction occurred in Canterbury, but it was almost unchanged in Otago. In both the wheat acreage increased, while the area devoted to oats dropped away sharply in accordance with its uneconomic value. The area in sown grass, meanwhile, remained fairly stable in Canterbury, but had risen by 22% in Otago, although most of the expansion in Otago was confined to Southland and Waitaki Counties.[^144]
Table 12.5: Acreage of crops grown by Pakeha at harvest time within Canterbury and Otago Provinces.145

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley</th>
<th>Sown Grass</th>
<th>Hay &amp; Rape</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Canterbury)</td>
<td>1879</td>
<td>193,784</td>
<td>153,742</td>
<td>37,095</td>
<td>715,138</td>
<td>11,662</td>
<td>83,359</td>
</tr>
<tr>
<td>1880</td>
<td>208,561</td>
<td>89,280</td>
<td>28,640</td>
<td>716,280</td>
<td>15,331</td>
<td>105,197</td>
<td>14,350</td>
</tr>
<tr>
<td>(Otago)</td>
<td>1879</td>
<td>53,771</td>
<td>143,165</td>
<td>10,114</td>
<td>459,158</td>
<td>21,743</td>
<td>n. s.</td>
</tr>
<tr>
<td>1880</td>
<td>90,125</td>
<td>107,882</td>
<td>8607</td>
<td>572,936</td>
<td>18,851</td>
<td>104,202</td>
<td>12,129</td>
</tr>
</tbody>
</table>

(n.s.) = not specified

This swing back towards mixed farming came too late to stop the ill-effects of overcropping from being all too obvious in the 1881 harvest. After a fairly uneventful growing season, the estimated yields of grain in Canterbury were fairly mediocre - 24 bushels of wheat, and 27 bushels of oats per acre146 - and reports of the harvest in the *Lyttelton Times* contained numerous comments on the detrimental impact of soil exhaustion on these yields.147 The effects were particularly bad on the light plains land to the west of Christchurch. At Weedons, for example, it was said that together with the dry start to spring, the "fallacious method of over-cropping, or robbing the land, year after year, prohibits a successful harvest".148 Estimated crop yields in Otago, meanwhile, were 30 bushels of wheat per acre and 38 bushels of oats per acre.149 These were quite reasonable, historically speaking, but here too, as the following comment from the *Otago Witness* indicates, soil exhaustion was occasionally prominent:

The older agricultural districts, leaving out reclaimed swamp land, are not so prolific now as when they were first settled upon. Where in former years there were fields of strong and healthy grain, are now seen scanty crops and poor pastures interspersed with many patches of sorrel. ... The original stock of fertilising matter in the soil is in a great measure exhausted, and whatever may be the mode of renovating the land, the returns cannot be so great in proportion to the labour expended as they were at first.150
Similarly, in the first of a series of articles entitled 'Tillage and Stock Farming', it was observed that it was "notorious that on the older cultivated holdings the yield of grain for the last few years has been annually and seriously diminishing".\textsuperscript{151}

This new state of affairs gave cause for critics of 'stripping' to redouble their efforts. That root crop cultivation had expanded so much, when simultaneously the area in cereals had shrunk, was clearly grounds for encouragement, since it meant that large numbers of agriculturists had taken heed of their clamour for rotational cropping. The rising level of scepticism about the capacity of exhausted soil to recover its fertility solely by being put into pasture probably also contributed this change. An example of this scepticism came in James Allan's address to the Taieri Agricultural Society in October 1881:

> There were some who did not acknowledge that the system of cropping for four or five years and then laying down in grass was a bad one, and they consoled themselves with the thought that the spell under grass would soon restore the fertility of the soil. This, however, was an error ... Even after the land had lain in grass for about six years under such a system, it would be found that the soil had not been restored to its original state of fertility, for the grasses were of the same family of plants as cereals, and abstracted the same properties from the soil. Another objection ... was that no provision was made for the eradication of weeds.\textsuperscript{152}

Rising in tandem, as always, with the increased attention given to root crops was the demand for 'artificial' fertilisers. As the \textit{Southland Times} declared, "yearly the fact is forcing itself into greater prominence that a crop of turnips, treated with say, 2 cwt. of Malden Island guano, and consumed on the ground by sheep, is necessary to enable it to withstand white cropping".\textsuperscript{153} Given such reports, it is understandable that supplies of Malden Island guano in Dunedin were apparently bought up faster than they could be replenished.\textsuperscript{154} Farmers also seem to have been showing strong interest in using bone-dust at this time. Although the 1881 Census recorded the presence of only three bone-mills in operation in Otago, as opposed to four in 1878, the opening of a bone-mill at Invercargill, which seems to have lacked one previously, suggests industry consolidation rather than retrenchment.\textsuperscript{155} That no less than five vendors exhibited bone-dust at the Otago Agricultural and Pastoral Association exhibition in late 1879 also hints at a growing rather than shrinking market.\textsuperscript{156} In Canterbury, there can be even greater certainty that demand for bones was growing, as the 1881 Census had recorded four bone-mills in that province, as opposed to just one three years earlier.\textsuperscript{157}
Nevertheless, perhaps the most graphic sign of the renewed market for 'artificial' fertilisers was James Gibbs and Co.'s decision to advertise their manures on the cover of Wise & Co's New Zealand Directory 1880-81 (as shown in Figure 12.4). Having said this, the significance of the growing popularity of 'artificial' fertilizers should not be overestimated. As an examination of the Otago Witness' farming pages show, most farmers still regarded them as supplementary to farmyard manure. George Johnston of Kaihuku's description of their utility on his farm was fairly typical:

With turnips the stable and byre manure is applied as far as possible, after which bone-dust and Peruvian guano is applied. The guano forces on the young plants, and prevents them from being destroyed by any insects of the fly tribe.\textsuperscript{158}

The agricultural potential of lime was also gaining more attention.\textsuperscript{159} The expanding rail network probably played a part in this, since it gave farmers distant from kilns better access to it. Both the Lyttelton Times and the New Zealand Country Journal printed Dr. James Hector's findings in relation to the chalk deposits at Malvern Hills in Canterbury, which noted that "as a manure to many kinds of land, the chalk would be useful in its natural state, and owing to its friable nature could be profitably applied".\textsuperscript{160} The potential of the limestone resources of South Canterbury also started to be developed, through lime-kilns such as that featured in Figure 12.5. Lime from the Milburn kiln at Tokomairiro, meanwhile, had been employed for several years, but now that much farmland was exhausted, its use was once again being promoted. According to an item in the Otago Daily Times, "a field which had been cropped until it would scarcely grow anything" had, after liming, produced ... "one of the heaviest crops ever seen in the district".\textsuperscript{161}

While these modifications to farming practice were heartening, some worn out land now needed remedial action more than ever. By way of illustration, thistle growth was so bad on the most run-down properties that some individuals were giving serious consideration to their use as a 'green manure' crop.\textsuperscript{162} The Otago Witness, meanwhile, had now resorted to recommending that farmers whose depleted land was badly infested by weeds should employ a bare fallow to 'clean' it.\textsuperscript{163} Thomas Acland, nephew of Thomas Dyke Acland, then one of the foremost agricultural chemists in England,\textsuperscript{164} also proposed a bare fallow, when land had deteriorated badly, prior to the implementation of his more general suggestion, namely the growing of a 'green crop', such as turnips, mustard or
As *Wise's Directory* was the main national business directory of the day, an advertisement such as this would have received a lot of exposure. Unfortunately, it has not been possible to check any connection between James Gibbs and the London firm of Gibbs and Sons, famous for its guano monopoly.

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This limekiln at Kakahu, which lies northwest of Timaru, was built around 1880-1, but fell into disuse around 1890 (South Canterbury District Committee of the New Zealand Historic Places Trust, *South Canterbury Historical Guide* (Timaru, 1991), p. 23.)
Figure 12.4
clover.\textsuperscript{165} This was a far cry from the situation two years earlier, when the use of bare fallows prior to wheat cultivation had been condemned in the \textit{New Zealand Country Journal}.

Acland's ultimate recommendation was that agriculturists must adopt a rotation of crops,\textsuperscript{166} and given that 'convertible husbandry' had now fallen from favour, this was the general consensus of other agricultural commentators too.\textsuperscript{167} The \textit{Otago Witness} helped spread this message by holding a 'Essays on Small Farming' competition in which one of the themes for discussion was the 'succession of crops'.\textsuperscript{168} It then published the best essays during the autumn of 1881.\textsuperscript{169} Even so, there was little agreement amongst the commentators as to what rotations should be employed, with suggestions ranging from the simple dictum that green and grain crops should be alternated, through to the six and eight year schemes proposed by William Reid. Having said this, most of the longer rotations were essentially modified versions of the Norfolk four-course.\textsuperscript{170}

In part, this lack of prescription resulted from a recognition amongst commentators that, for the time being, paying off debt quickly was a higher priority for many farmers than long-term sustainability.\textsuperscript{171} As these commentators observed, 'artificial' fertilisers were beyond the means of financially-stretched farmers,\textsuperscript{172} which left few options for restoring soil fertility other than growing a green crop. Since the green crop was generally eaten by stock, thereby producing farmyard manure for use on other crops, the conservation of that manure also received attention.\textsuperscript{173}

This continuation of the campaign against the 'army of strippers', as Ivey termed them, during 1881, had decidedly mixed results. As Table 12.6 below shows, the acreages sown in wheat and oats in Canterbury both increased by 14\%, which was in line with the growth of the total area under crop. In Otago, meanwhile, the area under wheat and oats grew by 8\% and 10\% respectively, whereas the total area under crop rose by 12\%. These relatively small rises in wheat acreage were a victory for the critics of repetitive cereal cropping, given that the price of wheat rose during August and September to as high as 4s.10d per bushel, following reports of poor American and European harvests.\textsuperscript{174} Moreover, the extensive cultivation of turnips the previous year would have meant that many agriculturists would have had fields in a good condition to grow wheat. In contrast, those preaching the message of crop rotation had less to show for their efforts. In both Canterbury and Otago, the relative growth of the area under sown grass had been greater than that for turnips, and in Canterbury, the growth in turnips had not even kept pace with the total area under crop. It appears
that where land had been retired from cereals, it had been put under grass, in line with the 'convertible husbandry' approach, rather than being put into a green crop, as rotational cropping suggested.

Table 12.6: Acreage of crops grown by Pakeha at harvest time within Canterbury and Otago Provinces

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Oats</th>
<th>Barley Sown</th>
<th>Oaten Turnips</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Canterbury)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1880</td>
<td>208,561</td>
<td>89,280</td>
<td>28,640</td>
<td>716,280</td>
<td>15,331</td>
<td>105,197</td>
</tr>
<tr>
<td>1881</td>
<td>237,015</td>
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<td>17,728</td>
<td>850,945</td>
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<tr>
<td>1880</td>
<td>90,125</td>
<td>107,882</td>
<td>8607</td>
<td>572,936</td>
<td>18,851</td>
<td>104,202</td>
</tr>
<tr>
<td>1881</td>
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<td>4943</td>
<td>650,479</td>
<td>24,552</td>
<td>120,533</td>
</tr>
</tbody>
</table>

IV. Freezers and Fertilisers

At this point in time, the contest between a small-farming economy based primarily on grain cultivation and one based primarily on intensive pastoralism was fairly evenly poised. However, during 1882, there were two developments which, firstly, by improving the economic prospects of stock-rearing operations, and secondly, by increasing access to 'artificial' fertiliser, ultimately transformed the future of mixed farming, and equally, soil fertility management in New Zealand.

The first of these two developments was the initiation of frozen meat exports to Britain. As is well known, this began with the departure of the Dunedin from Port Chalmers for London on 15 February 1882. As Simkin described it, this event prompted a revolution in New Zealand farming, and hence in the economy as a whole. Such a shipment had been regarded almost as un fait accompli since mid-1880, following the first successful transit of refrigerated meat from Sydney to London on the Strathleven, but difficulties in guaranteeing a regular supply of carcasses for shipment, because of fluctuating prices in the competing domestic market, appear to have deterred the necessary investment beforehand. Nonetheless, contemporaries were well aware of its potential significance for both the future composition of the farming sector, and the ongoing management of soil fertility. As the Timaru Herald observed in June 1881:
The soil cannot be expected to give forth heavy crops year after year under the existing methods of farming, and our agriculturists have had plain and unmistakeable hints to this effect the last few seasons. ... as a means of escape from the dilemma in which they find themselves placed ... the meat freezing process stands prominently forward.

The New Zealand Country Journal expressed a similar view:

> The pre-eminence which we have hitherto enjoyed as corn growers (so far as bushels per acre go) cannot be maintained under our present disregard to a proper rotation of crops. ... in the past there was little inducement to farming differently, as corn was the only farm produce offering any prospect of remuneration; but with new prospects, based on a remunerative market for our possible surplus stock, coupled with a climate admirably adapted for the production of grass and root crops, we may still maintain our high corn averages without deterioration to the soil.

The advent of refrigeration also created much better prospects for exporting dairy produce. This had been tried several times before, using various insulating materials, but collectively the attempts had met with only limited success. It was debatable, however, whether dairy farming improved or reduced soil fertility. John Drew Atkin, for example, in a catechismal article in the Otago Witness in October 1881, answered this question by stating that "the export being a condensed form, everything is left behind in the shape of manure upon the land - ergo, enriching it". Yet readers turning to the previous page saw a contradictory statement made by William Jenner:

> We must always remember that milk selling is, for the land, a most exhaustive process, and unless the poor land is enriched by supplying the animals with rich, nourishing, supplemental food it will become more and more poor, and the milk less and less rich in the necessary elements for good cheese and butter. Where the land is of medium quality, and circumstances justify the settlers in turning their attention to dairying, the evil of taking much fertilising matter away in milk may be modified by keeping a moderate amount of fattening stock.

Jenner's cautionary note added to one made few months earlier by George Gray, who was soon to be both Lecturer in Chemistry at the School of Agriculture and...
Consulting Chemist to the Canterbury Agricultural and Pastoral Association. In reference to dairying, Gray remarked that "a milch cow, yielding three gallons of milk per day, would in fourteen days remove in the milk alone more mineral matters than one sheep would during its lifetime". This may be overstating the case, as Gray's calculation for sheep losses included only the carcase and not fleeces; nonetheless, in a modern study, annual mineral losses from a dairy cow were estimated to be about eight times that from a ewe plus one lamb.

The second development which changed the pattern of soil fertility management was the initiation of large-scale industrial manufacture of superphosphate. Almost certainly small-scale manufacture had already occurred in New Zealand, as, in addition to the Sydney Goldsmith case referred to above, the Auckland businessman J. A. Wilson produced it by immersing bones in sulphuric acid pools on White Island (an offshore volcano in the Bay of Plenty) in 1879. However, Goldsmith's business, as seen previously, probably succumbed to the post-1878 economic depression, and the Tauranga-based company established in 1883 to scale up Wilson's superphosphate production was wound up in 1886 owing to a lack of custom.

Since there was no shortage of bones, the chief obstacle to superphosphate manufacture to date had been the cost of sulphuric acid. As a correspondent to the *Lyttelton Times* pointed out in early 1880, at the current price of 4d. per lb., a hundredweight (cwt.) of superphosphate could not be made for less than 26s. Consequently, when a Colonial Industries Commission was established in 1880, Evan Prosser, of the Dunedin-based chemical company Kempthorne, Prosser & Co., called for government assistance to be made available for domestic sulphuric acid production. This was forthcoming in February 1881 with the announcement of a £500 bonus to be paid for three consecutive years for the manufacture in each year of 50 tons sulphuric acid. Almost immediately Kempthorne, Prosser & Co.'s New Zealand Drug Company began erecting a sulphuric acid works, and production at the new Burnside plant had begun by August. In Canterbury, meanwhile, T. C. Moorhouse & Co. started work on its sulphuric acid works at Belfast, and by the end of the year both companies had applied for the £500 bonus. From here it was but a small step to superphosphate manufacture - almost literally, as both the Belfast and Burnside plants (for the latter see Figure 12.6) were built right next to freezing works, thereby giving easy access to the necessary bones. Samples of superphosphate from the Belfast factory were displayed at the New Zealand Exhibition in Christchurch, which ran from April to June 1882, and by September it was on
In this photograph, the 'industrial complex' formed by the meat and fertiliser industries can be seen. By comparison with an aerial photograph of the area taken in the 1960s (Loach, Cyril, *A History of the New Zealand Refrigerating Company* (Caxton Press for the New Zealand Refrigerating Co. Ltd., Christchurch, 1969), p. 131), it is possible to identify the freezing works in the foreground, Kempthorne and Prosser's fertiliser works (also with smoking chimney) to the rear at left, and the city abattoir in the centre background. With careful examination it is also possible to see saleyards in front of the abattoir, and the main south railway line, running along in front of the saleyards. A similar 'industrial complex' existed at Belfast (see photograph, dated c. 1895, in Macdonald, G. R., *The Canterbury Frozen Meat Company Ltd.: the first seventy-five years* (Whitcombe and Tombs, Christchurch, 1957), between pp. 22-3).
sale to the public (see Figure 12.7). Things did not go so smoothly for Kempthorne, Prosser & Co., as construction delays meant that its factory was not completed until October. Superphosphate manufacture, which had been contemplated in the company prospectus as early as 1878, probably began around December 1882, as at that time Kempthorne, Prosser & Co. began advertising for more bones. Incidentally, the price of superphosphate sold by T. C. Moorhouse & Co., was £9 per ton, which was only a third of the 26s. per cwt. costing referred to above.

Despite the promise of significant benefits from local superphosphate manufacture in the future, most agriculturists were probably more concerned with the yields from the 1882 harvest. Unfortunately drought again hit the crops, particularly in North Otago, and consequently harvest returns proved to be the worst in a decade. In Otago, the estimated wheat and oats yields were 26 and 32 bushels per acre, while in Canterbury they were a meagre 21 bushels of wheat and 25 bushels of oats per acre. Worse still, after these estimates had been compiled, fierce northwesterly winds hit the grain awaiting harvest, with as much as one-third of the crop being lost.

While these yields were disappointing, there was hardly any adverse comment with respect to soil exhaustion in district harvest reports. Reduced yields from worn out land would have been less conspicuous in a drought-affected year, but this absence may be a further indication that agriculturists had, as was suggested above, grown their cereal crops on either new land or land refreshed by green crops in the previous year. Even so, calls for farmers to desist from continuous cropping showed no sign of coming to a halt during 1882. These did not add much to what had been said before, but it is interesting that the criticism of 'stripping' was at its fiercest during parliamentary debates concerning William Rolleston's Land Act 1877 Amendment Bill. The aim of Rolleston's Bill was to advance closer settlement by allowing settlers to lease small farms, but during the debate Sir John Hall (MP, or, strictly speaking, MHR, for Selwyn) pointed out that this could lead to the same sort of successive wheat cropping that had occurred in the late 1870s. The problem with the Bill, as Hall, and others
Moorhouse's superphosphate of lime.

Source: Lyttelton Times, 9 September 1882, p. 2.

In addition to superphosphate and sulphuric acid, Moorhouse's Chemical Works produced a number of other freezing industry by-products, most notably tallow (Symes, L. P., 'Some technical notes'. In Macdonald, G. R., The Canterbury Frozen Meat Company Ltd.: the first seventy-five years (Whitcombe and Tombs, Christchurch, 1957), p. 68.
Business Notices.

THE FARMER'S FRIEND.

MOORHOUSE'S SUPERPHOSPHATE OF LIME

Gained the highest awards of Gold and Silver Medals at the New Zealand International Exhibition of 1862, held at Christchurch.

This is the best Manure known for general purposes, especially Turnips, Cereals, Clovers, Grasses, &c., &c.

Sole Agent—MORITZ BOWRON, No. 45, Cathedral Square, Christchurch, who is prepared to receive orders, and will gladly afford enquirers full information regarding the above.

H.R.—Sample of the Manure can be seen at Mr Bowron's office.
who subsequently echoed his opinion, saw it, was that it was in the lessee's interest to extract as much crop production as he or she could prior to the lease's expiration. Alternatively, if the lease was renewed, the exhausted state of the land at the time of renewal would substantially lower the new rental. In defence of the Bill, James Rutherford (MP for Bruce), sensing an attempt to put cropping restrictions on would-be tenants, asserted that continuous cropping posed no risk to soil fertility so long as 'artificial' manures were supplied to the leased land; at the time, it should be said, agricultural scientists and writers were still debating this point. Rutherford's assertion merely prompted a reply, however, from Richard Turnbull (MP for Timaru), that no tenant could be expected to spend the £5 per acre necessary for manuring land. Eventually, the Bill passed without any cropping restrictions, although Hall did win the inclusion, within the definition of improvements requiring compensation at the cancellation of a lease, the phrase "in any way improving the character or fertility of the soil" - such was the first ever legislative recognition in New Zealand of the value of conserving soil fertility.

Meanwhile, there was a further marked shift from cereal cultivation to intensive pastoralism in Canterbury and Otago. As Table 12.7 indicates, in Canterbury, the area under sown grass increased in 1882 by 129,137 acres, which amounted to a 15% rise on the 1881 total, while in Otago a mammoth 172,484 acres had been added, which amounting to a 27% increase. Primarily this burst of growth is explained by the new interest in rearing sheep inspired by the start of the frozen meat trade, but as the New Zealand Country Journal's 'Livestock Report' observed, it was also true that "on a great deal of the overcropped land of the [Canterbury] Province, owners and occupiers are finding the absolute necessity of returning to the soil through the medium of their flocks that which excessive grain growing has taken out of it". Even so, the areas under both wheat and oats still expanded slightly. This was probably due to high local prices during the first half of 1882. A reasonably strong English market helped sustain wheat prices of up to 4s. 9d. per bushel, while the price of oats rose, in response to dwindling local stocks, to as high as 3s.6d. per bushel, which was more than twice what it had been a couple of years earlier.
Table 12.7: Acreage of crops grown by Pakeha at harvest time within Canterbury and Otago Provinces.214

| Year | Wheat | Oats | Barley | Sown Oaten Turnips Other Total Sown Grass Hay & Rape |
|------|-------|------|--------|----------|---------|-----------------|-----------------|-----------------|-----------------|
| (Canterbury) |       |      |        |          |         |                 |                 |                 |                 |
| 1881 | 237,015 | 102,370 | 17,728 | 850,945  | 19,633  | 109,625 | 16,033 | 1,353,349 |
| 1882 | 249,163 | 136,487 | 14,443 | 980,082  | 14,015  | 122,352 | 15,994 | 1,532,536 |
| (Otago) |       |      |        |          |         |                 |                 |                 |                 |
| 1881 | 97,021  | 118,730 | 4943   | 650,479  | 24,552  | 120,533 | 9419  | 1,025,677 |
| 1882 | 104,804 | 157,093 | 4646   | 822,963  | 33,032  | 132,328 | 9102  | 1,263,968 |

Given the exciting prospects for fattening stock, one might have expected the area devoted to 'turnips and rape' to grow more than it did. Since, however, these crops were often grown as a preparatory crop for cereals, because stock feeding on them left the ground well manured, it is possible that the collapse in the wheat market, in late 1882, dissuaded agriculturists from sowing them. American wheat flooded the English market, causing a 6d. per bushel drop there in the space of a couple of months.215 Ultimately, an excellent growing season, as far as turnips were concerned, meant that there was no shortage of winter feed for stock though.216 This was ideal for the debut of T. C. Moorhouse and Co.'s and Kempthorne, Prosser and Co.'s superphosphates in what had become a crowded 'artificial' fertiliser market, and both reputedly produced good results for the farmers that tried them.217 The weather was less favourable to cereal cultivation. While the estimated yields of 26 and 29 bushels of wheat and 30 and 37 bushels of oats in Canterbury and Otago respectively were quite reasonable,218 prolonged wet spells around harvest time reduced the quality of the harvested grain. Together with the lowering in English prices noted above, this pushed the local price down to just over 4s. per bushel. Limited demand in the Australasian market also dragged the price of oats down to just over 2s. per bushel.219

V. Retrospect and Prospect

In the history of wheat cultivation in New Zealand, the largest ever surplus was produced by the 1883 harvest - nett exports that year amounted to 4.8 million bushels. In each of the following three years, the area sown in wheat in Canterbury and Otago fell,220 as the depression in wheat prices worsened. By
1885, it had dipped below 3s. per bushel, and consequently agriculturists in the two provinces sowed the smallest area in wheat since 1877. The year 1885 therefore marks the end of the first of three cycles which together comprise the period of 'bonanza' wheat farming.

Compared to the roller-coaster ride which characterised the course of farming in Canterbury and Otago between 1868 to 1876, the years 1876 to 1883 were fairly straightforward. In the first part of this cycle - 1876 to 1878 - settlers responded to a short-lived conjunction of low wool prices and high grain prices with a burst of land-buying and grain-growing. Admittedly, the rapid land subdivision allowed for substantial growth in the area in sown grass as well, but as Figure 12.8 shows, in relative terms cereal cultivation had expanded at the expense of sown grass. At the same time, the proportion made up by 'other crops' also grew. The existing trend, prior to 1876, of increasing adoption of rotational cropping was accelerated by the larger financial returns from cereal cultivation, since agriculturists were able to 'invest' in green crops and 'artificial' fertilisers, which would be repaid by larger grain crops in the future.

The second part of this period - roughly 1878 to 1880 - was the 'bust' following the 'boom'. The economic crash of late 1878 meant that small farmers were compelled to keep growing wheat, even at the risk of ruining their land, because of the need to service their mortgages. At the same time, many turned to laying down pasture and bare fallowing rather than crop rotation to restore soil fertility. Consequently, soil deterioration began to become a serious problem in some areas, most notably on the light-textured dry land of the Canterbury Plains. Agricultural scientists and commentators, who had seen farmers taking greater note of the lessons offered by agricultural chemistry during the mid-1870s, were alarmed to see this regression, and accordingly, began to call vociferously for agriculturists to restore nutrients to their soil by growing some sort of green crop. As they pointed out, there were no more 'virgin' soils to boost future yields, and convertible husbandry was failing to revive soils which were worn out. These exhortations helped slow the expansion in the area under cereal crops after 1879, thereby making it a smaller proportion of the total area under crop.

The final period of the first 'bonanza wheat' cycle lasted from 1880 to 1885. Although this chapter only extends as far as the crops sown in 1882, it is clear from looking at Figure 12.8 that already a marked shift to intensive pastoralism was underway. The successful pioneering of frozen meat exportation to Great Britain led farmers to not only break in more land - which led to the short-lived jump in the area under cereals - but to sow more and more land in pasture. This
Figure 12.8
Changes in area under crop in Otago and Canterbury, 1875-82.


During this period, the proportion of cultivated land under grass remained fairly stable. It is also worth noting how rapidly turnip acreage grew in Otago.

The respective total sown acreages are:

<table>
<thead>
<tr>
<th></th>
<th>1875</th>
<th>1878</th>
<th>1880</th>
<th>1882</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canterbury</td>
<td>550761 ac</td>
<td>1031383 ac</td>
<td>1177639 ac</td>
<td>1532536 ac</td>
</tr>
<tr>
<td>Otago</td>
<td>451670 ac</td>
<td>706126 ac</td>
<td>914732 ac</td>
<td>1263968 ac</td>
</tr>
</tbody>
</table>

Note that the pie graphs are not proportional between the two provinces.
Figure 12.8

Crop areas in Canterbury by Years

Crop areas in Otago by Years
transition also encouraged expansion of root crop cultivation, since such crops provided winter feed for the stock destined for the freezing works. The stock then provided the manure to restore soil organic matter in preparation for more cereal crops, but in turn the root crops created more demand for 'artificial' fertilisers. While such fertilisers continued to be imported after the early 1880s, increasingly they were replaced by locally manufactured superphosphate, produced using the bones of stock sent to the works - thereby completing the circuit.

Although there were two further wheat-growing cycles, between 1886-94 and 1895-1901, during the 'bonanza wheat' period, cereal cultivation never accounted for as much of the total area under crop as it had during the first cycle. This reflected the lower subsequent wheat price, which generally struggled to reach even 4s. per bushel. Instead, farmers gradually came to devote more and more effort to stock rearing - so much so that in 1894 John Grigg declared that the production of mutton, lamb, and wool, had displaced wheat as the first goal of the agricultural system. Over time, 'artificial' fertiliser use also increased. In the course of the debate over the Manure Adulteration Bill in 1892, which was itself a sign of this development, Hugh Valentine (MP for Tuapeka) remarked that "down South the quantity used was increasing enormously, ... within the next ten years they would hardly find a farmer who was not using manure in the cultivation of his land". Otherwise the crop rotation approach developed during the first wheat-growing cycle was largely unchanged, but for the introduction of the bumblebee (bumblebee) in 1885. This facilitated red clover growth, as bumblebees are adapted to pollinating its flowers, whereas other insects are not. In these later years, 'artificial' fertiliser use became more necessary, as wheat yields, averaged out over ten years, declined from about 24 and 28 bushels per acre in Canterbury and Otago respectively during the mid-1880s, to 22 and 27 bushels per acre in the early 1890s. Since in the early 1880s, some of the cultivated soils would still have had their 'virgin' fertility, whereas by the early 1890s, almost all of the soils employed in wheat cultivation would have been in the second 'cycle' of cultivation, these results are not surprising. Yet by the mid-1890s wheat yields, on average, had begun to rise again, and they continued to do so during the third wheat-growing cycle. Clearly, when it came to soil fertility management, the lessons from the first wheat-growing cycle had been well learnt.
Notes to Chapter Twelve


3 Extract from Canterbury Times in Otago Witness, 19 August 1876, p. 18.

4 Copland, D. B., Wheat Production in New Zealand (Christchurch, 1918), pp. 102 & 104.


8 Otago Daily Times, 10 April 1877, p. 6-7; Press 27 January 1877, p. 3; Lyttelton Times, 23 January 1877, p. 3; 26 January 1877, p. 3; 27 January 1877, p. 3; & 1 February 1877, p. 3.

9 Weekly Press, 21 October 1876, p. 10.

10 Statistics of the Colony of New Zealand for the Year 1875 (Wellington, 1876), p. 211; Statistics of the Colony of New Zealand for the Year 1876 (Wellington, 1877), p. 199.

11 Otago Witness, 2 December 1876, p. 18.

12 Ibid., 2 September 1876, p. 18, & 7 October 1876, p. 18.


14 In a query to the editor, an Oteramika resident had asked about making bone-dust from whalebone. 'J. C'. ['query' to the Editor]. Otago Witness, 16 December 1876, p. 13; Ibid., 23 December 1876, p. 14.

15 Otago Witness, 14 August 1875, p. 16; Otago Daily Times, 3 February 1877, p. 2, based on report in the Bruce Herald.

16 As noted in Chapter 11, the Census of 1874 recorded the presence of only one bone-mill in Canterbury (Results of a Census of the Colony of New Zealand, taken for the Night of the 1st of March 1874 (Wellington, 1875), p. 270). As there does not appear to have been any bone-dust advertisements in the Weekly Press, and Maydwell was the only bone dust exhibitor in the 1876 Canterbury A. & P. Show (Weekly Press, 11 November 1876, p. 10)
it is probable that there were no other importers either.

17 See Otago Witness, 15 April 1876, p. 24, 1 July 1876, p. 24, 7 October 1876, p. 23, 11 November 1876, p. 1, & 2 December 1876, p. 23.

18 Timaru Herald, 10 April 1876, p. 3. This was originally reported in Dunedin's Evening Star.

19 Reid, William, 'Small Farming in Otago'. Otago Witness, 21 May 1881, p. 6; Otago Daily Times, 10 April 1877, p. 6; Parker, O. G. 'Cultivation of Roots' (paper to the Courtenay Farmers' Club). N. Z. Country Journal 4(6) (1880), p. 357. See also, for contemporary comment on the varieties of turnips grown in Otago and Canterbury, Otago Witness, 29 October 1881, p. 7; N. Z. Country Journal 4(2) (1880), p. 138. A breakdown of Brassica crops by geographic regions for 1967-8 shows a similar pattern with 57% of the total in Southland being composed of swedes, whereas in Otago the chief 'turnip' crops were swedes (29%), white-fleshed turnips (29%) and rape (14%). In Canterbury, on the other hand, white-fleshed turnips accounted for 43% of the total, with the minor placings, so to speak, going to rape (19%) and swedes (18%) Claridge, J. H., Arable Farm Crops of New Zealand (Wellington, 1972), p. 185.


21 Basic superphosphate, which is produced when superphosphate is reacted with quick-lime (calcium oxide), was not available until 1901. This reaction, as well as neutralising excess acid, causes the soluble monocalcic phosphate (Ca(H2PO4)2) to revert to insoluble dicalcic phosphate (CaHPO4). Connell, R. P., and Hadfield, J. W., Agriculture (Auckland, 1919), p. 176.


23 Ibid., p. 274.

24 Otago Daily Times, 16 August 1876, p. 2. Strangely, customs returns, as recorded in the Statistics of the Colony of New Zealand, give the source of the import as the Marquesas Islands, and the size of the import as 382 tons (Statistics of the Colony of New Zealand for the year 1876 (Wellington, 1877), pp. 91 & 149). Advertisements give the source as being Malden Island. (Otago Witness, 7 October 1876, p. 23).


26 Ibid., 4 March 1876, p. 3.
27 Extract from *American Cultivator*, in ibid., 26 December 1868, p. 16; Ibid., 14 August 1875, p. 18. Comment in contemporary articles suggests that using a drill to sow seed with manure was fairly novel. This was partly due to turnips often being cultivated as the first crop on new land, which being uneven, was more suited, or so it was argued, to hand-sowing methods (Ibid., 5 June 1875, p. 18 & 14 August 1875, p. 18).

28 See ibid., 15 January 1881, p. 6; extract from *Southland Times*, in ibid., 26 March 1881, p. 7; Extracts from ,9 April 1881, p. 7; 'Agricola','Chats with the Farmers'. Ibid., 9 July 1881, p. 7; 'Agricola','Chats with the Farmers'. Ibid., 20 August 1881, p. 7.

29 As Mark Mitchell observed drill-sown crops had to be heavier than broadcast-sown crops to compensate for the extra labour involved, Mitchell, Mark, 'Small Farming in Otago'. Ibid., 16 April 1881, p. 8. See also Murray, J. U., 'Small Farming in Otago'. Ibid., 26 March 1881, p. 6; Smythies, Henry, 'Small Farming in Otago'. Ibid., 23 April 1881, p. 7; 'Agricola','Chats with the Farmers'. Ibid., 20 August 1881, p. 7; 'Agricola','Chats with the Farmers'. Ibid., 3 September 1881, p. 7.

30 Ibid, 22 September 1877, p. 18, & 20 October 1877, p. 18. In one instance, the analysis itself has been printed (Ibid., 20 October 1877, p. 18).

31 *Otago Daily Times*, 10 April 1877, p. 6.


33 Evidence of J. Tossw'll, 16 April 1879. Ibid., p. 205.

34 *Press*, 22 November 1876, p. 2.


36 Ibid., 3 March 1877 (Supplement), p. 2.

37 Ibid., 28 July 1876, p. 2. At first this periodical was a quarterly, as Wilkin had envisaged but after its first year it was published bi-monthly.

38 *Statistics of the Colony of New Zealand for the year 1876: with abstracts from the agricultural statistics of 1877* (Wellington, 1877), p. 200.


41 Ibid., 1(1) (1877), p. 65, & 1(3) (1877), p. 211.


43 *Statistics of the Colony of New Zealand for the Year 1876*, p. 199; *Statistics of the Colony of New Zealand for the year 1877* (Wellington 1878), p. 203.
In Canterbury, after fluctuating at around 4000 during the mid-1870s, the number of rural holdings climbed to 4473 in early 1877, and 5069 in early 1878. Statistics of the Colony of New Zealand for the year 1877, p. 203.


Press, 3 March 1877 (Supplement), p. 2.

Ivey was also a Fellow of the Chemical Society, London. W.E. Ivey to the Chairman, Canterbury College Board of Governors, 7 December 1877 & 2 January 1878. Canterbury College Board of Governors - Inwards Correspondence No. 774.

Lyttelton Times, 6 August 1877, p. 3, 3 September 1877, p. 3, & 8 October 1877, p. 3.

Ashburton Mail, 10 August 1877, p. 2.

In this regard, Bickerton suggested soil analysis was useful in that it helped prevent farmers from using fertilisers to supply nutrients which the soil might already have a surfeit of. Lyttelton Times, 6 August 1877, p. 3.

Ross, W. A. (Secretary, Kaiapoi Farmers Club) to the Chairman, Canterbury College Board of Governors, 11 October 1877. Canterbury College Board of Governors - Inwards Correspondence No. 751.

Professor Bickerton to the Chairman, Canterbury College Board of Governors, 24 January 1878. Canterbury College Board of Governors - Inwards Correspondence No. 793.


Professor Bickerton to the Chairman, Canterbury College Board of Governors, 29 January 1878. Canterbury College Boards of Governors - Inwards Correspondence No. 794; Lyttelton Times, 2 February 1878, p. 3.

Evidence of Professor Bickerton, 14 April 1879. New Zealand. Parliament. Appendix to the Journals of the House of Representatives (1879, 1st Session), II, H-1, 'Report of the Royal Commission into the operations of the University of New Zealand', p. 184. See also


65 Murphy, 'Agriculture, Past and Present (Pt. 3)'. *N.Z. Country Journal* 2(1) (1878), p. 17.

66 See, for example, *Lyttelton Times*, 24 January 1878, p. 3.

67 *Statistics of the Colony of New Zealand for the year 1877*, p. 198.


70 McIlraith, *The course of prices in New Zealand*, p. 52.


72 Extract from Sir Julius Vogel (speech to the Colonial Institute). *Weekly Press*, 26 October 1878, p. 5.

73 Ibid., 2 November 1878, p. 6.

74 Ibid.


77 *Statistics of the Colony of New Zealand for the year 1877*, p. 203; *Statistics of the Colony of New Zealand for the year 1878*, p. 206.


79 Over a twelve month period Canterbury landowners (urban and rural) increased their mortgage debt by £1.05 million. *Otago Daily Times*, 8 October 1878, p. 2.


81 *Otago Daily Times*, 31 July 1878, p. 2.
82 Lyttelton Times, 24 January 1878, p. 3.
84 Otago Witness, 7 September 1878, p. 3.
86 Ibid., p. 139.
87 After post-amalgamation sales, it should be noted, only ten estates were retained.
89 Calculated from Copland, Wheat Production in New Zealand, p. 299.
90 N. Z. Country Journal 3(3) (1879), pp. 158.
91 Statistics of the Colony of New Zealand for the year 1878, p. 201.
92 Otago Daily Times, 23 October 1878, p. 2.
93 McIlraith, The course of prices in New Zealand, pp. 51-2.
95 For instances of 'artificial' fertiliser use, see Otago Witness, 21 December 1878, p. 4, 8 March 1879, p. 4, & 24 May 1879, p. 4. Though many farmers were using manure, the Otago Witness still opined that more care was needed in saving and then storing it (Ibid., 28 September 1878, p. 3).
96 Results of a Census of the Colony of New Zealand, taken for the Night of the 1st of March 1878 (Wellington, 1880), p. 347.
97 See, for example, Otago Daily Times, 1 December 1879, p. 4.
98 The location of Goldsmith's bone mill is recorded in the mid-1870s as being located in Princes St (Fielding, H. Thomas (ed.), Wise's Directory of New Zealand for the years 1875-6 (Dunedin, 1875), Otago Directory - Dunedin - Pt. 2 - D, p. 6), but by the late-1870s this has disappeared (cf. Wise & Co. 's Directory for the Years 1878-9 pp. 111-2). Moreover, Sydney Goldsmith allegedly lost his electoral qualification shortly thereafter (See Otago Daily Times, 8 May 1879 (Supplement), p. 1). However, he does appear on later electoral rolls (see, for example, General Roll of Persons entitled to Vote for Members of the House...
of Representatives of New Zealand. 1902 ([Wellington, 1902]), 'City of Dunedin', p. 120.


100 Lyttelton Times, 29 November 1879, p. 4.
102 Lyttelton Times, 29 November 1879, p. 4.
104 Otago Witness, 17 May 1879, p. 15.
108 McIlraith, The course of prices in New Zealand, p. 51.
109 Statistics of the Colony of New Zealand for the year 1879, p. 197.
114 In Ashburton and Geraldine Counties - the latter, it should be noted, incorporated Timaru at this time - the area in sown grass rose by almost a third. Cf. Statistics of the Colony of New Zealand for the year 1878, p. 203; Statistics of the Colony of New Zealand for the year 1879, p. 199.
116 See data for Ashburton County for crops sown in 1878 and 1879. Statistics of the Colony of New Zealand for the year 1878, p. 203; Statistics of the Colony of New Zealand for the year 1879, p. 199.
118 Grigg, [ 'Can farming be made to pay at present prices in this provincial district in New Zealand'] (paper to the Ashburton Agricultural and Pastoral Association). N. Z.
It is very probable that Grigg had read this article before giving his lecture, since both it and Grigg's lecture (see p. 280) use the phrase 'necessity is the mother of invention,' when considering how farmers should respond to the uneconomic price of oats.

Extract from *Canterbury Times*, in *Lyttelton Times*, 13 February 1880, p. 3.

The first item based on Garland's instructions in the *Lyttelton Times* merely paraphrased it (*Lyttelton Times*, 30 January 1880, p. 3), whereas the second seems to have printed it in full ([A. Garland, 'Turnip Culture']. Ibid., 17 April 1880, p. 3). A third article, alluded to at the end of the second, appears only to have been printed in the *Canterbury Times* (see *Lyttelton Times* advertisement in ibid., 12 June 1880, p. 6). See also extract from *Canterbury Times*. Ibid., 18 March 1880, p. 6; Parker, O. G. (paper to the Courtenay Farmers' Club), 'Cultivation of Roots'. *N. Z. Country Journal* 4(6) (1880), pp. 357-61.

Lyttelton Times, 17 April 1880, p. 3.


Extract from *Canterbury Times*, in ibid., 13 February 1880, p. 3.


Ibid., pp. 274-5.

Ivey, W. E. to Chairman, School of Agricultural Committee, 23 October 1880. Inwards Correspondence - Canterbury College Board of Governors, no. 1578.

It seems reasonable to conclude that Ivey had begun manorial experiments by this time since he had already sought (and been given) approval for them (W. E Ivey to Chairman, School of Agricultural Committee, 5 October 1878 (and annotation thereto), and Ivey to Chairman, School of Agriculture Committee, 23 January 1879. Inwards Correspondence - Canterbury College Board of Governors, nos. 1096 and 1178). Moreover, subsequent investigations into the operation of the School of Agriculture show that superphosphate worth £39 10s was purchased during the June 1878 - March 1879 period, and further manure purchases to the value of £59 10s. were made in the twelve months following (New Zealand. Parliament. *Appendix to the Journals of the House of Representatives*

Blair, *The seed they sowed*, p. 12n.


See *Lyttelton Times*, 4 February 1880, p. 5, & 6 February 1880, p. 4.


Ibid., 28 August 1880, p. 6.


Ibid., 18 September 1880, p. 6.


*Statistics of the Colony of New Zealand for the year 1879*, p. 199;


*Statistics of the Colony of New Zealand for the year 1879*, p. 202;


*Statistics of the Colony of New Zealand for the year 1880*, p. 206.


Ibid., 16 February 1881, p. 6.

*Statistics of the Colony of New Zealand for the year 1880*, p. 206.


Ibid., 23 April 1881, p. 7.


154 *Otago Daily Times*, 16 September 1881, p. 2. During 1881, imports into Dunedin from Malden Island were valued at £3082 (Statistics of the Colony of New Zealand for the year 1881 (Wellington, 1882), p. 71). The advertised price was £8-9 per ton (*Otago Witness*, 7 January 1882, p. 5). Peruvian guano was also on sale at this time in Dunedin (See Bright Bros. advertisement, *Otago Daily Times*, 6 April 1881, p. 4) at a cost of £14 per ton. (Gray, 'The Chemistry of Manures'. *N. Z. Country Journal* 4(4) (1880), p. 260).

155 Results of a Census of the Colony of New Zealand, taken for the Night of the 3rd of April, 1881 (Wellington, 1882), p. 299; Wise & Co's *New Zealand Directory for 1880-1881* (Dunedin, 1880), p. 741. In the previous Directory, the mill-owner, Joseph Hatch, was listed only as a chemist (Wise & Co's *New Zealand Directory for 1878-79* (Dunedin, 1878), p. 155).

156 *N. Z. Country Journal* 4(1) (1880), p. 33. Nevertheless, George Blyth still seems to have been the only Dunedin vendor advertising bone-dust regularly in the *Otago Witness* or *Otago Daily Times* (*Otago Daily Times*, 2 January 1881, p. 4, & 6 April 1881, p. 4).


158 'Agricola', 'Chats with the Farmers'. *Otago Witness*, 3 September 1881, p. 7. See also Murray, J. U., 'Small Farming in Otago'. Ibid., 26 March 1881, p. 6; Extract from *Southland Times*, in obid., 26 March 1881, p. 7; Extracts from Mitchell, Mark, 'Small Farming in Otago'. Ibid., 9 April 1881, p. 7; 'Agricola', 'Chats with the Farmers'. Ibid., 20 August 1881, p. 7. For a contrary view, which seems to suggest replacing manure with 'artificial' fertiliser, see ibid., 31 January 1880, p. 4.

159 It was not until the 1890s, when lime began used extensively on the Edendale estate, that lime use could be said to have been on a large scale though. Hunt, W.D., 'Lime and Liming in the South'. *New Zealand Journal of Agriculture* 13(2) (1916), pp. 87-8.


161 *Otago Daily Times*, 25 April 1881, p. 3. See also *Otago Witness*, 20 August 1881, p. 6.


Christchurch firm of Acland, Barns & Co. subsequently became South Island agents for J. B. Lawes' 'chemical manures' (*N. Z. Country Journal* 8(3) (1884), p. xvii). It seems likely that this agency was acquired thanks to the elder Acland's connection with Lawes; amongst his agricultural publications was the volume *Meat, Wheat, and Milk... to which is added a Review of the Questions at issue between Mr. Lawes and Baron Liebig* (1857) (Stephen, Leslie, and Lee, Sidney (eds.), *Dictionary of National Biography* (London, 1909), XXII (Supplement), p. 13).

166 Ibid., pp. 131 & 133.
168 See *Otago Witness*, 8 January 1881, p. 6.
169 Jacksons, George, 'Small Farming in Otago'. Ibid., 19 March 1881, pp. 6-7; Murray, J. U., 'Small Farming in Otago'. Ibid., 26 March 1881, pp. 6-7; Extracts from Mitchell, Mark, 'Small Farming in Otago'. Ibid., 9 April 1881, pp. 6-7, & 16 April 1881, pp. 8-9; Smythies, Henry, 'Small Farming in Otago'. Ibid., 23 April 1881, pp. 6-7, & 30 April 1881, p. 7; Reid, William, 'Small Farming in Otago'. Ibid., 14 May 1881, p. 7, & 21 May 1881, pp. 6-7.
173 William Jenner was concerned that nutrients might be ‘lost in runoff’ from unprotected manure heaps (Jenner, William, *New Zealand Country Journal*, 5(4) (1881), pp. 232-3). Though Mark Mitchell believed that this problem could be ameliorated by placing the manure heap on a high point of the farm, so that nutrients carried away from it by runoff would fertilise lower-lying parts of the property (Extracts from Mitchell, Mark, 'Small Farming in Otago'. *Otago Witness*, 9 April 1881, p. 6).


See, for example, the confident assumptions in *Otago Witness*, 10 July 1880, p. 6; *Otago Daily Times*, 7 February 1881, p. 2; T. K. Dow, 'Farming for Exportation' (speech at Oddfellows Hall, 6 April 1881). Ibid., 7 April 1881, p. 3. The *Strathleven* reached London on 2 February 1880 (McClintock, *The History of Otago*, p. 649).


Since an average gallon of milk weighs about 10.32 lbs. (Fream, W. (ed.), *Elements of Agriculture* 9th ed., ed. by J. R. Ainsworth-Davis (London, 1914),p.557), the milk produced in a fortnight by a cow giving three gallons per day would weigh 460.3 lbs. The mineral (ash) content of milk is about 0.7% of the total (ibid., p. 552), so that the amount removed in a fortnight would come to about 3.2 lbs. By way of comparison, Gray gives in his article the composition of a stereotypical sheep weighing 75 lbs., in which the mineral matter weighs 2.6 lbs. (Gray, 'Wool versus Wheat'. *N. Z. Country Journal* 5(4) (1881), p. 226). See, in reference to the modern study, During, C., *Fertilisers and Soils in New Zealand farming* 3rd ed. (Wellington, 1984), p. 4.


191 See Messrs. Kemphorne, Prosser & Co. to the Secretary, Chamber of Commerce, Dunedin, 14 April 1880 (forwarded to the Commissioners). New Zealand. Parliament. Appendix to the Journals of the House of Representatives (1880), II, H-22, 'Colonial Industries Commission (Report of the)', p. 82. Like-minded representations were also made by J. A. Wilson, and by the candle-making firm, McLeod brothers (Evidence of Mr. [A.] McLeod, 18 May 1880, and evidence of J. A. Wilson, 10 May 1880. Ibid., pp. 82 & 127).


193 Ibid., pp. 35-6.

194 The local bone supply was not sufficient in either case though, with the Belfast factory having to source additional bones from the North Island and Queensland, not to mention whalebones from Kaikoura, while at the Burnside factory bones were apparently imported from New South Wales. Otago Witness, 10 February 1883, p. 6; Dennison, 'The History of Chemical Industry in Otago up to 1914' (Unpublished M. A. thesis, University of Otago, 1948), p. 105.)


196 Minutes for 17 August 1882, 28 September 1882, & 26 October 1882. 'Fair Minutes of Board and Annual Meetings' (1881-85). Kemphorne, Prosser and Company Limited Archives, AG 120 / A no. 2 (Hocken Library, Dunedin).


198 Otago Witness, 10 February 1883, p. 6.


200 Otago Daily Times, 12 January 1882, p. 2; Extract from Canterbury Times. Lyttelton Times, 7 January 1882, p. 3.

201 Statistics of the Colony of New Zealand for the year 1881, p. 211.

202 N. Z. Country Journal 6(3) (1882), pp. 219-20

203 See, for example, Gray, George, 'On the Rotation of Crops'. N. Z. Country Journal 6(4) (1882), pp. 221-5; Otago Witness, 8 April 1882, p. 6.

It should be pointed out that New Zealand then had a bicameral legislature, and strictly speaking the MPs were in fact MHRs (Members of the House of Representatives). The Selwyn electorate was centred around Leeston and Southbridge (McRobie, Alan, *New Zealand Electoral Atlas* (Wellington, 1989), p. 49.


James Rutherford (speech on the Land Bill), 18 July 1882. Ibid., p. 410-1.


*N. Z. Country Journal* 7(1) (1883), pp. 80-1, & 7(2) (1883), p. 159

Ibid., 7(1) (1883), p. 81.


*Statistics of the Colony of New Zealand for the year 1881*, pp. 215 & 218; *Statistics of the Colony of New Zealand for the year 1882* (Wellington, 1882), pp. 219 & 222.

*N. Z. Country Journal* 6(6) (1882), p. 459. The risk posed to price levels by the massive stocks of grain held in America were raised, incidentally, in a market report at the start of the year (Ibid., 6(1) (1881), p. 74).

Ibid., 7(2) (1883), p. 159.

At the Annual General Meeting of Kempthone, Prosser & Co.'s New Zealand Drug Co. in March 1883 it was stated by the Chairman, Basil Sievwright, that the manures produced had been "greatly appreciated by all that had used them so far". *Otago Daily Times*, 22 March 1883, p. 2. With reference to Moorhouse's superphosphate, see *N. Z. Country Journal* 7(2) (1883), p. 292.

*Statistics of the Colony of New Zealand for the year 1882*, p. 215.

*N. Z. Country Journal* 7(3) (1883), p. 244.

Copland, *Wheat Production in New Zealand*, pp. 299-300. It should be noted that the year-index used by Copland in his tables is the year in which the crop was harvested, rather than the year in which the crop was sown.

McIlraith, *The course of prices in New Zealand*, p. 51; Copland, *Wheat*
Production in New Zealand, p. 300.

See Copland, Wheat Production in New Zealand, p. 300. Cf. 'Area under Cultivation' data, which equates to total area in crop plus area broken-up but not under crop, in Agricultural and Pastoral Statistics of New Zealand 1861-1954, compiled by B. L. Evans (Wellington, 1956), p. 11.

McIlraith, The course of prices in New Zealand, p. 51.


See the decennial moving averages in Copland, Wheat Production in New Zealand, p. 301.
Conclusion

By the early 1880s, soil fertility management in New Zealand agriculture had already undergone a remarkable degree of change. In the early 1840s, most farmers used no farmyard manure or 'artificial' fertiliser, and paid no attention to conserving fertility through measures such as crop rotation. In contrast, by the early 1880s crop rotation has become common, and sufficient demand for 'artificial' fertiliser had developed for local manufacture to be initiated. In short, the two 'agricultural revolutions' identified by F. M. L. Thompson as having occurred in Great Britain, the first involving new crops and hence new courses of cropping, and the second the introduction of 'artificial' fertilisers, were rolled into one in New Zealand. Having said this, many settlers in 1880s New Zealand were still behaving like their antecedents had in the 1840s.

In this thesis, the aim was firstly to identify the course of this transformation in soil fertility management, and secondly to explain why changes in soil fertility management took place. In the traditional argument, employed by Hargreaves, Evans, and Tennant amongst others, a combination of economic circumstances, such as high fertiliser costs, and a limited range of saleable farm commodities, were regarded as having dissuaded farmers from employing soil fertility management regimes involving crop rotation and 'artificial' fertilisers. It follows then that once circumstances became more favourable, adoption of such regimes became more common. At a fairly crude level, this argument is sound enough, but as this thesis has demonstrated, environmental and philosophical factors, such as the natural level of soil fertility, the perceived level of soil fertility, and perceived best farming practice, are also critical in explaining ongoing variations in the soil fertility management practices used by the various sectors of the agricultural community. Changes in economic factors could lead to temporal changes in the soil fertility management regime, but whether those changes were persisted with was very much dependent on crop response - hence the strong influence of environment in spatial variations. Furthermore, if the environment itself changed, as it did when the soil became exhausted, for instance, this could induce temporal changes in soil fertility management too. Combating soil exhaustion became more significant in soil fertility management after the late 1870s, as in Canterbury and Otago the supply of unsold cultivable land ran out. From this point on agriculturists had to keep re-using the land they already had.
I. Synopsis

As the first practitioners of Western-style agriculture in New Zealand, Maori farmers and mission farmers both drew more heavily than later groups on their respective 'agricultural' heritages when determining practices for managing soil fertility. Ultimately, their weddedness to these heritages proved to be their downfall, as the novel agricultural ecology created when settlers brought European crops to New Zealand proved ill-suited to both heritages. The mission farmers were unable to implement a Norfolk-style crop rotation because there were no bees to fertilise clover, and in any case the humid climate and poor soils kept cereal yields low. Likewise, the continued rejection by Maori farmers, on spiritual grounds, of manure use posed problems for the substitution of kumara by potato cultivation, since potatoes demanded more nitrogen from the soil. Maori farmers tried to counter this by more forest clearance and expanding areas under fallow, but these steps created conflict with Pakeha settlers used to agriculture being confined within designated property boundaries. Ultimately, however, it was not flaws in the approach to soil fertility management that marginalised Maori agriculture. Instead, Maori farmers became disillusioned in the late 1850s, when crop prices collapsed, and then in the mid- and late 1860s the government confiscations of large tracts of land following the New Zealand Wars crushed the chances of its revival.

Philosophical esteem for their agricultural heritage was also significant in the minds of the wave of Pakeha settlers who came to New Zealand in the 1840s, but it was soon countered by environmental perception. On the one hand, settlers thought that if 'scientific farming' was the object of agriculturists 'at home', then something along similar lines ought to be practised here. Certainly the New Zealand Journal tried to maintain this 'improving' spirit by publishing news of recent developments in agricultural chemistry in the early 1840s, and the early establishment of local agricultural societies at each settlement also reflected this ideal. Having said this, experiences such as that of George Duppa, whose lost a vast sum preparing land, English-style, for cultivation, discouraged settlers from replicating in full British farming practices here. On the other hand, the 'biometric fallacy', which correlated luxuriant vegetation with rich soils, and which, ironically, bodies such as the New Zealand Company had propagated, suggested to farmers that New Zealand's forest and alluvial soils were so much richer than those 'at home' that they did not need any manuring. The same could not be said of other soils, though even these were rarely perceived as having low fertility.
The pattern observed in the early 1840s suggests that settlers accepted the 'biometric fallacy', and managed their soil fertility accordingly. At Nelson and Auckland, which possessed little forest, farmers began applying lime and dung to their land almost immediately, whereas at Wellington and New Plymouth, both forested areas, farmers commenced continuous cropping while not bothering to manure their land. Wellington and New Plymouth settlers did, however, manure their vegetable gardens, which indicates that they regarded manuring cropland as an inefficient use of their resources, rather than being unnecessary altogether. The real as well as perceived environment also encouraged the initial differences in approach at the four settlements. Farmers bringing 'fern land' into production suffered from depressed crop yields in the short-term, because of nitrogen immobilisation during bracken decay, while, conversely, farmers bringing forest soils into production benefitted from the temporary nutrient boost provided by the ash and detritus left by the 'bush burn'.

Once this breaking-in phase was complete, crop yields at the various settlements began showing signs of convergence, and a common approach to soil fertility management also began to emerge. This commonality suggests that economic factors had superseded philosophical and environmental ones as determinants of soil fertility management regimes. During the early 1840s, the high cost of labour was a disincentive to manuring, and by the late 1840s, it became even less favoured because of falling prices for agricultural produce. This created a risk of soil exhaustion, but fortunately rising wool prices encouraged the conversion of worn out crop land to pasture instead. Pasture did not pose great demands on the fertility of the soil, and in addition, stock grazed on it could be folded on arable fields, thereby enriching them without the need for much human intervention. Auckland and Nelson farmers, who had previously put considerable effort into manuring their land, now joined with their Wellington and New Plymouth counterparts in resorting to this 'convertible husbandry'-type approach of cropping fresh land and spelling worn out land under pasture. Auckland farmers were also helped by the acquisition from Maori of rich volcanic soils in the mid-1840s. Consequently, the only significant soil exhaustion seems to have occurred at New Plymouth, where stock numbers remained low relative to the area in crop, essentially because of the limited availability of natural and sown grass.

By the early 1850s, farmers sought a new approach to soil fertility management, which could accommodate the large increases in the acreage of cereals and potatoes inspired by the Victorian goldrush. Growth of turnips in
Taranaki and Auckland indicates the beginnings of a move towards rotational cropping, but it is likely that the severe labour shortages hampered use of farmyard manure. For this reason, when produce prices peaked in 1854 and 1855, merchants imported Peruvian guano into four main settlements for the first time. Although guano was expensive, its concentrated nutrient content relative to bulky organic alternatives allowed users to revive soil fertility without expending much labour. Then in 1856, agricultural prices dropped back due to rising Australian output, and guano imports to the three main centres other than Auckland almost ground to a halt. In addition, settlers again switched their attention to wool production. While this shift in emphasis was driven primarily by economics, undoubtedly the increased appearance of soil exhaustion during the late 1850s also encouraged it. At New Plymouth, where, as mentioned previously, a lack of pasture constrained sheep numbers, heightened interest in agricultural chemistry emerged in the late 1850s, but agricultural development halted when the New Zealand Wars engulfed the area in 1860-1. At Nelson and Wellington, meanwhile, agriculture, together with guano importing, had a brief revival at the start of the 1860s, but thereafter settlers at both places chose to concentrate almost all their efforts on intensive pastoralism.

The one main settlement to deviate from this pattern was Auckland. The cause of this deviation was environmental - namely the infertile nature of the soils which Auckland farmers developed after the mid-1850s, once the fertile soils at its hub had been taken up. The soils at the agricultural frontier were deficient in both plant-available nitrogen and phosphate, and it proved impractical for farmers to cart bulky organic manures to such remote places. When farmers used guano, however, they obtained much improved yields. Large quantities of first Peruvian guano, and then phosphatic guano, were thus imported in Auckland from the mid-1850s onwards. Typically, in a year when agricultural prospects were good, more than 100 tons were imported into Auckland, whereas at the three other main settlements, imports rarely reached the level of 10 tons. By the late 1850s, farmers also began looking for cheaper local substitutes for guano, of which bone-dust proved the most successful. It should be said, however, that this use of 'artificial' fertiliser did not change the broad strategy of Auckland farmers when it came to managing soil fertility, that is, cropping new land for a few years and then converting it to pasture. In this case farmers used guano to boost crop yields while they prepared their land for grass sowing. After 1863, when the outbreak of the New Zealand Wars created havoc for agricultural operations to the south of Auckland, Auckland farmers switched their focus almost entirely to intensive
pastoralism, though phosphatic fertilisers continued to be used to a large extent, because of the helpful role they played in pasture establishment.

The initial approach taken by settlers to soil fertility management in Otago and Canterbury mirrored those in older settlements during the 1840s. In Otago, the difficulty of producing crops from 'fern land' once again proved a spur to liming and manuring in the early years, but by the mid-1850s, farmers moved onto richer alluvial soils, and they were happy simply to rely on their natural fertility. In Canterbury, however, 'dry swamp' soils were available for cultivation almost immediately, and so even at the start at settlement, when the traditions of English farming should have been freshest in the minds, farmers showed little propensity to use manure. This shows that the influence of the 'biometric fallacy', which would have suggested that Canterbury soils were infertile, had started to wane. Then, in the late 1850s, Otago and Canterbury farmers both began moving away from continuous cropping towards intensive pastoralism. Falling prices for agricultural produce probably drove this more than soil exhaustion, although Otago settlers had become more conscious of the latter.

After the Otago gold-rush in the early 1860s, the alluvial plains of Canterbury and Otago became almost the sole regions of importance in New Zealand agriculture. The rush also transformed local economic conditions, although not in a way that encouraged manure use. While transport and labour costs climbed steeply, surplus Australian agricultural produce kept local prices from rising proportionately. Moreover, the rapid expansion of the agricultural frontier meant that most land being cropped was relatively new to cultivation. In consequence, imports of guano, which began to Dunedin in 1860 and Christchurch in 1862, remained at a low level until 1864, when the wheat price reached unusually high levels. The much larger population base created by the influx of migrants did, nonetheless, create a market for meat and dairy produce, which in turn began to lead to a more mixed farming approach in Otago in the mid-1860s. In Canterbury, meanwhile, farmers had run into trouble when they tried to take the 'convertible husbandry'-type approach which they had employed since the late 1850s beyond the areas of 'dry swamp', which had all been taken up by about 1860. On the drier soils of the Canterbury Plains, they learnt that the naturally low organic matter levels would not support good pasture growth after three or more cereal crops had been taken off them. Soil exhaustion had become common by 1865, and consequently, agriculturists adjusted their management regime to include green crops. The momentum behind mixed farming in both Otago and Canterbury grew even more in 1867, when a huge Australian wheat
surplus convinced farmers that the Australasian market for grain had reached saturation point. The prospect of farmers growing more root crops led in turn to the initiation of local bone-dust production in both Dunedin and Christchurch in 1867.

The loss of the Australian grain market was felt throughout the late 1860s and early 1870s, as small farmers tried to find successful alternatives to this trade. Amidst fluctuating prices for wheat and wool, some moved almost exclusively to intensive pastoralism, others fell back on convertible husbandry, and another group turned to crop rotation. This option involved cultivating wheat - now grown for the English market - in tandem with pasture and green crops, used for raising stock to produce meat and dairy goods, as well as wool. Ultimately, therefore, the soil fertility management regime which farmers adopted depended on their expectations of the relative prices of grain and pastoral produce. Meanwhile, the development of local industry, such as meat preserving works, and the expansion of the railway network allowed increasing supplementation of farmyard manure with factory wastes. Nevertheless, in areas remote from industry, shortages of manure continued to be suffered - this serves as a reminder of the 'contribution' of transport to fertiliser application costs.

Agricultural education also started playing a key role in encouraging farmers to conserve soil fertility at this time. Because of their uncertain prospects, farmers were keener than usual to discover how agricultural chemistry might help them, and accordingly scientific and educational institutions began to undertake agricultural instruction and conduct soil analyses.

Environmental factors, meanwhile, ensured that more phosphate fertiliser was used in Otago than in Canterbury. This was especially true after 1872, when root crops began to be grown extensively. The root crops grown in Otago and Southland tended to be swedes, which need more phosphate than the turnips grown in Canterbury. In addition, the cool climate in Otago prevented its agriculturists from successfully growing peas and beans instead of root crops. Some Canterbury farmers did grow these legumes, enabling them to supply nitrogen to the soil directly, rather than having to manure their land with the dung from stock fed on the root crops. Lastly, parts of the Mataura Valley, an important farming area in Southland, also contained soils that were deficient in plant-available phosphate.

In the last era in which this thesis examined agriculture in Otago and Canterbury, namely the mid- to late 1870s and early 1880s, the relative prices for wheat, wool and meat continued to be the major determinant of the approach
farmers took when managing soil fertility. Although large numbers had embraced rotational cropping in the mid-1870, a coincident rise in the wheat price and fall in the wool price saw small farmers rush into wheat cropping. This, together with the newly improved access to land that the railway provided, caused a short-lived land boom that collapsed in 1878. Because the supply of cultivable land was running out, many settlers in Canterbury, and to a lesser extent in Otago, borrowed heavily to finance land purchases during the boom. These settlers usually ended up with large debts which compelled them to grow wheat, because it alone could provide the fast profits needed to meet their liabilities. As the land concerned was often not very fertile, much of it quickly became exhausted, but the above mentioned economic imperatives hampered farmers' adoption of more fertility-conscious cropping regimes.

Gradually, the attention drawn to this problem by agricultural commentators encouraged farmers to resume rotational cropping, and manuring with a combination of farmyard manures and 'artificial' fertilisers. Having said this, only the successful inception of refrigerated meat export in 1882 removed the risk of serious environmental deterioration across large areas of Canterbury and Otago. This trade made it possible for farmers to earn a good return throughout a crop rotation, rather than having to rely on the years when they were growing cereal crops. In a related development, local superphosphate manufacture also began in the same year, thereby ensuring the availability of phosphatic fertiliser for use on root crops. The scene was set, therefore, for a more sustainable agricultural system, based around rotational cropping, to operate in the future.

II. General Remarks

In looking back over the entire time period covered by the thesis, it is clear that changing economic conditions were most often the cause of change in soil fertility management regimes. This not particularly surprising, given that agriculture is a commercial activity, and that economic conditions changed more frequently than environmental or philosophical conditions. Nevertheless, environmental factors did result in a lot of spatial variation in the regimes, such as the high rates of phosphatic fertiliser use around Auckland, and the greater cultivation of legumes in Canterbury than in Otago. In the early years of settlement, the unfolding process of environmental learning also led to numerous temporal changes, either through changes in environmental perception, such as the exposure of the 'biometric fallacy', or through the settlement frontier crossing
ecological boundaries, as in Canterbury in the 1860s, when farmers found that the
light plains land soils were not as amenable to successive wheat cropping as the
neighbouring 'dry swamp' soils.

It is also noticeable that the propensity of farmers to employ rotational
cropping, and to manure their land, generally increased during the period
examined, although relapses did occur in the late 1850s and late 1870s. This
suggests that farmers believed manuring was more profitable in the 1880s than in
the 1840s. There were both environmental and economic reasons for this change.
Although quantatative analysis of benefits and costs of manuring land has not
been attempted in this thesis, because of the lack of data which would support
such an analysis, it is appropriate to make some comments on the various factors
that increasingly favoured it.

As an examination of any fertiliser response curve shows, as the crop yield
drops away from the maximum yield, the crop response when a given amount of
fertiliser is applied is larger. Accordingly, the chief environmental reason why
manuring and crop rotations became more common over time was declining soil
fertility. This could be induced through settlers wearing out their soil, and the
increasing frequency of complaints about exhaustion indicates that they did so,
but it also occurred simply via the expansion of the cultivated area. After a decade
or so, most of the best soils in the various settlements had been occupied, so new
settlers ended up on progressively less fertile soils, or soils, that for reasons such
as poor drainage, were more difficult to bring into cultivation. The potential
impact of spreading cultivation across a large rather than small area may be
illustrated by examining the statistics collected in Otago relating to the crops sown
in 1866, which seem to be the only instance in which yield class by area figures,
suitable for constructing a Lorenz curve, were collected.2 The average wheat yield
in that year was 37 bushels per acre, but if only the yields from the best yielding
5817 acres (the harvested area of wheat sown in 1864) are taken into account, the
average yield would have been 46 bushels per acre. Incidentally, the fact that
expansion of the agricultural frontier might depress aggregate yields, when yields
within the old frontier were identical, was another reason for relying on
contemporary comment more than yield data when making assessments of soil
exhaustion in this thesis.

A related issue, which was both environmental and economic, was the
availability and price of cultivable land. Up until the 1860s, 'virgin' land was
normally so cheap that it could be purchased for about the same cost of manuring.
Most settlers seemed to prefer the former option, but when 'virgin' land was not
readily available, as in Taranaki in the late 1850s, there was a noticeable upsurge in interest in agricultural chemistry. As noted above, in 1879 the supply of 'unsold 'virgin' land in Canterbury, and to a lesser extent in Otago, ran out. Since agriculturists thereafter were re-using their existing soils, it encouraged them to be more conscious of preventing their exhaustion. Moreover, those farmers who failed to do so were probably displaced in time, since cultivated but unproductive land would after 1879 have been the cheapest on the market.

Although past investigators have also pointed to the rising fortunes of commodities like meat and dairy produce as an explanation for the growth in rotational cropping and manuring, the cause-and-effect in this case was not a straightforward one. While the increasing domestic population and prospects of an export trade to Great Britain gave farmers greater confidence in the marketability of these products, and thereby to expand production of them, this diversification did not raise incomes, as supply largely kept up with demand, and thus prices of pastoral commodities did not increase. Notwithstanding some marked short-terms variations, the price of wool in the early 1880s (of around 10d. per lb) was much the same as it had been in the late 1840s, while the price of mutton in Canterbury stayed at around 2.5-3d. per lb. between the late 1860s and early 1880s. Jumps in the price of wheat, meanwhile, did prompt bursts of fertiliser use in the mid-1850s, mid-1860s, and mid-1870s, but the net change over the whole period was, as with the wool price, fairly negligible. It can be said, therefore, that price increases may have led farmers to commence manuring, but when prices dropped back farmers did not always stop manuring.

Alternatively, if the expenses involved in manuring dropped this could also have encouraged farmers to carry it out. The cost of manuring was composed of three separate items: the cost of the fertiliser itself, the cost of the labour expended in applying it, and the cost of cartage. As discussed above, farmers could choose either to use farmyard manure, which if produced on the farm had almost no material cost, but because of its bulk, resulted in high labour and cartage costs, or alternatively, they could use 'artificial' fertiliser, which had a high material cost, but much lower labour and cartage costs.

It is difficult to say whether labour costs went down or not, other than through 'artificial' fertiliser use expanding relative to farmyard manure use, since there is so little evidence of manuring costs. Mechanical devices such as manure drills and manure spreaders would have begun to lower labour costs towards the end of the period, but these had still not come into widespread use by this time. It should be noted that the 'traditional' economic explanations for why manuring was
not carried out much have not paid much attention to the cost of labour, even though contemporaries identified it as a serious impediment to the practice. There can be more certainty over cartage costs, as aside from the improvements to roads, the expanding rail network greatly facilitated overland transport. It may be recalled from Chapters 11 and 12 that commentators noted that railways would make the transport of manures much easier. Again there is no contemporary quantatative evidence of cost reductions though. This lack of data should not be taken, however, as a sign that cartage costs and labour costs of application were insignificant. It is worth remembering that two of the great boons for superphosphate and lime use in New Zealand during the twentieth century were subsidised rail cartage and aerial topdressing, which were directed at lowering these costs.

Material costs of 'artificial' fertiliser, meanwhile, definitely fell. Like other countries, New Zealand witnessed a range of fertiliser 'substitutions' in the nineteenth century. The first substitution here was Peruvian guano for farmyard manure, but most fertilisers which replaced Peruvian guano, such as phosphatic guanos, superphosphate, and nitrate of soda, were cheaper and more specific in action, that is, they contained a high concentration of one nutrient rather than more modest amounts of several nutrients. Factory wastes, meanwhile, were probably no more specific in action than Peruvian guano, but they were a lot cheaper. Interestingly, the timing of the introduction of each of these replacement fertilisers closely matches that in the eastern United States. The only major difference, was that in the eastern United States, nightsoil and stable manure from the cities began to be used for manuring in the early nineteenth century, whereas attempts to make use of the output of these materials from New Zealand towns in the 1860s and 1870s never got off the ground.

Except in the cases of Maori farming, where the rejection of manuring constrained their cultivation options, and mission farming, where an attempt was made to simply imitate English farming, philosophical considerations did have much impact on soil fertility management practices. Many settlers did not have much farming experience from 'home' to call on, and thus had no particular attachment to British farming practices, and the level of 'peer pressure' on farmers to adopt or abandon practices, simply because it was what 'model' farmers would do, remained fairly weak in New Zealand. This was due to the fragile nature of agricultural institutions, and to the lack of agreement on the 'proper' course for farmers to take. As the proportion of tenant farmers in New Zealand was fairly small, it was also more difficult to impose 'improvements' through prescriptive
lease conditions as landlords could in Great Britain. The only time when criticism
does seem to have affected practices was in the 1870s and early 1880s, when the
large influx of migrants in the early 1870s were repeatedly advised to adopt
'scientific farming'. The advocacy became especially intense after many of them
were tempted into successive wheat cropping during the mid-1870s.

In the circumstances, it can be argued that the existing understanding of the
role of soil fertility management in nineteenth century New Zealand agriculture
needs considerable amendment. Although recognised economic impediments such
as the availability of new land, and the limited scope for selling the produce from
rotational cropping, did indeed limit use of crop rotations and manure, the
obstacles posed by high costs of labour and transport are rarely mentioned. Good
crop yields have also been seen as discouraging efforts to restore soil fertility, but,
as this thesis has shown, localised instances of exhausted soils could still prompt
adjustments in soil fertility management regimes. The existing literature has also
given little indication of the very significant spatial variations in soil fertility
management regimes, let alone explain why they occurred. The environmental
context of soil fertility management thus needs to be addressed much more fully
than it has in the past.

One final observation that is worth making is that even in the same location,
the attitude of farmers to manuring varied significantly. In part, this heterogeneity
reflects the fact that individuals usually managed and operated farms, which sets
them apart from commercial enterprises engaged in many other economic
activities. Having said this, there were two key generic reasons why some farmers
would not apply manure, even when macroeconomic and environmental
circumstances suggested that they should. The first was cost. Typically, migrants
who came to New Zealand to become farmers invested most of their capital in
buying land, and consequently many of them could not often meet the short-term
expense that manuring entailed. Secondly, the results obtained when land was
manured were not always certain. A poor season, in terms of climate, or other
impediments to plant growth, such as a soil pan, meant that a manured crop might
be no larger than an unmanured one. Moreover, farmers might pick the wrong
type of fertiliser; there was little to be gained in applying nitrate of soda, on its
own, to a soil with a severe phosphate deficiency, or applying Peruvian guano to a
soil that was strongly acid. Admittedly, soil testing had begun by the end of the
period under study, but the primitive methods meant that it did not always give a
ture picture of levels of plant-available nutrients. Consequently, identifying the
best fertiliser, and how much of it should be used, was largely a matter of
individual trial-and-error, which was something that only better off farmers could afford. Together the uncertainty and expense meant that many farmers did not manure their land until soil fertility declined to a point where they had no other option.

III. Future directions

Identifying the personal circumstances of farmers who did and did not actively manage the fertility of the soil has not been carried out in this thesis, because time did not permit such detailed work on individual farm accounts and farm diaries, but it may be a useful extension of this work in the future. Hopefully, others may also advance this study further in time, by examining the early history of topdressing pasture with phosphatic fertilisers, which became the basis for the 'grasslands' revolution, and the environmental implications of the commencement of the frozen meat trade. Another worthwhile research direction which this thesis has put a spotlight on is the role of the agricultural interest, and its appraisal of soil resources, in regard to indigenous land policy. While it is generally accepted that lands confiscated after the New Zealand Wars were of better quality than the norm, it would be interesting to examine in detail the exact level of existing environmental knowledge about the confiscated lands, so that the expectations that prompted their acquisition can better appreciated.

In terms of adding to the international literature on the history of soil fertility management, nineteenth century New Zealand represents an excellent case study because of the lack of an existing Western-style agricultural system, into which new systems would have had to be fitted. Despite this point of difference, the patterns of agriculturist behaviour corresponded closely to that observed in the United States by Richard Wines. On this basis, it could be inferred that these patterns will be exhibited wherever Western agricultural settlement was introduced into a colonial or quasi-colonial economic setting, in which land was cheap and labour was dear, during the nineteenth century. Hopefully, future research in similar settings, such as Canada or Australia, will be able to prove or disprove this hypothesis.

What then are the broader lessons that can be taken from this thesis? The first is that, in an examination of human management of the environment, the role played by environmental perception, learning, and experimentation should be neither forgotten nor underestimated. As the 'biometric fallacy' shows, the learning process was by no means a straightforward one either. The second is that soil
fertility management is a creation of a number of factors. While the elastic nature of fertiliser demand means that economic factors are the most visible, this thesis has shown that the situation of the farm could be just as important as the circumstances of the farmer. After all, while caring for the environment is seen as a modern concept when it comes to business generally, for the nineteenth century agriculturist in New Zealand, whose livelihood depended on the health of his or her soil, ultimately economic sustainability rested upon the maintenance of environmental sustainability.
Notes to the Conclusion


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Appendix One

The New Zealand Genetic Soil Classification

The New Zealand Genetic Soil Classification was first proposed by Norman Taylor in 1948. In the last decade or so, a new soil classification system has been developed in New Zealand, but as the New Zealand Genetic Soil Classification is likely to be more familiar to readers, and is used in most of the soil publications consulted, it has been employed in this thesis. A comparison with some international classification systems is given in Appendix Two.

The highest category in the New Zealand Genetic Soil Classification system is the Order.

All soils are divided into three Orders:

i) Zonal: This incorporates soils with an A (topsoil), B (subsoil), and C (unconsolidated mineral material) horizons, or layers, where the primary influence on soil development has been climate, as opposed to other soil-forming factors, such as parent material.

ii) Intrazonal: This incorporates soils with an A, B, and C horizon, where parent material, or relief (and thereby drainage status), has had the primary influence on soil development. It therefore includes the volcanic soils, calcareous soils, saline soils, peaty soils, saline soils, and most soils developed under permanent waterlogging.

iii) Azonal soils: This incorporates soils which are too young to have developed a subsoil, and thus have A and C horizons only.

Each order is then divided into groups, which are listed below, together with some typical soil profile designations (for those readers familiar with soil horizon notation) for the most notable New Zealand soil orders. Since most countries have their own classification system, an international correlation table is given in Appendix Two.

In the zonal order, groups are determined chiefly by mean annual rainfall, with further subdivision into subgroups according to mean annual temperature, whereas in the intrazonal order, the groups are defined by a combination of parent material, age (for soil formed from volcanic material), and relief. The two azonal groups are separated according to drainage status.
i) Zonal

Typical Soil Profile

Brown-Grey Earth (Mean Annual Rainfall (M. A. R.) < 500mm)
Yellow-Grey Earth (M. A. R. 500-1000mm) (Ah/Bg/Bx/C)
Yellow-Brown Earth (M. A. R. 1000-2000mm) (Ah/Bw/C)
Podzolised Yellow-Brown Earth & Podzol (M. A. R. 1500-2000mm) (O/Ah/E/Bs/C)
Gley Podzol (M. A. R. 2000mm+)
Subalpine gley and organic

ii) Intrazonal

Yellow-Brown Pumice Soil (soils from tephra 900-3500 yrs old) (Ah/Bw/C)
Yellow-Brown Loam (soils from tephra 3500-25,000 yrs old) (Ah/Bs/C)
Brown-Granular Loams & Clays (soils from tephra 25,000 yrs old+)
Red and Brown Loams (soils formed from basalt)
Yellow-Brown Sand (soil with aeolian sand parent material)
Rendzina (soil with calcareous parent material)
Gley Soil (soil with permanent high water table)
Organic Soil (parent material peat)
Saline Soil (soil with 0.15% soluble salt content)

Azonal

Recent Soil
Gley Recent Soil


See also, more generally, Gibbs, H. S., New Zealand soils: an introduction (Wellington, 1980).
Appendix Two

The New Zealand Genetic Soil Classification in international context

Correlation of names of soil groups (approximate equivalent).

<table>
<thead>
<tr>
<th>New Zealand</th>
<th>U. S. A. New (Soil Taxonomy)</th>
<th>U. S. A. Old (Great Soil Group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown -grey earth</td>
<td>Ustalf / Argid</td>
<td>Non Calcic Brown soil</td>
</tr>
<tr>
<td>Yellow-grey earth (Sthn.)</td>
<td>Ochrept / Aquept</td>
<td>Grey-brown podzolic soil</td>
</tr>
<tr>
<td>(Central)</td>
<td>Ustalf / Aqualf</td>
<td>Grey-brown podzolic soil</td>
</tr>
<tr>
<td>Yellow-brown earths (not Nthn)</td>
<td>Ochrept</td>
<td>Brown forest soils</td>
</tr>
<tr>
<td>Northern yellow-brown earth</td>
<td>Udult / Aqualf</td>
<td>Red yellow podzolics</td>
</tr>
<tr>
<td>Podzol</td>
<td>Orthod / Aquod</td>
<td>Podzol</td>
</tr>
<tr>
<td>Gley podzol</td>
<td>Aquod</td>
<td>Groundwater podzol</td>
</tr>
<tr>
<td>Subalpine gley</td>
<td>Aquept</td>
<td>Tundra soil</td>
</tr>
<tr>
<td>Subalpine organic soil</td>
<td>Histosol</td>
<td>Tundra soil</td>
</tr>
<tr>
<td>Recent soils from volcanic ash</td>
<td>Psamment / Andent</td>
<td>Lithosol</td>
</tr>
<tr>
<td>Yellow-brown pumice soil</td>
<td>Vitrandept</td>
<td>Regosol</td>
</tr>
<tr>
<td>Yellow-brown loam</td>
<td>Andept</td>
<td>Brown latosolic</td>
</tr>
<tr>
<td>Brown granular soils</td>
<td>Andepts / Hamults</td>
<td>Brown latosolic</td>
</tr>
<tr>
<td>Brown loam</td>
<td>Humult Orthox</td>
<td>Litosols</td>
</tr>
<tr>
<td>Red loam</td>
<td>Andept</td>
<td>Red latosols</td>
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<tr>
<td>Recent soils from alluvium</td>
<td>Fluvent</td>
<td>Alluvial soil</td>
</tr>
<tr>
<td>Yellow brown sand</td>
<td>Psamment/Psammept</td>
<td>Regosols</td>
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<tr>
<td>Gley soil</td>
<td>Aquent / Aqualf</td>
<td>Humic gley soils</td>
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<tr>
<td>Saline soils</td>
<td>Halaquepts</td>
<td>Solonchak/Solonetz</td>
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<tr>
<td>Organic soils</td>
<td>Histosol</td>
<td>Bog soils</td>
</tr>
<tr>
<td>Rendzina soils</td>
<td>Rendol</td>
<td>Rendzina</td>
</tr>
</tbody>
</table>