Climate Change, Forest Conservation and Science: A Case Study of New Zealand, 1860s-1920[1]

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Introduction

To most of its European settlers, New Zealand was a land blessed by Providence. A temperate climate and year-round rainfall, easy availability of land and myriad work opportunities attracted many to the new colony. Climate and health figured prominently in migration considerations and many writers took delight in pointing out, as propagandist John Ward did to intending migrants in 1839, that in New Zealand:

> A never-failing moisture is dispersed over the country by the clouds which collect on the mountain-tops, without the occurrence of rainy seasons, beyond storms of a few days' duration. This refreshing moisture, combined with the influence of the sea-breezes, renders the climate very favourable to the health, and development, of the human frame. And vegetation is, from the same cause, highly luxuriant, and the verdure almost perpetual.[3]

New Zealand compared favourably to its nearest neighbour – and rival migrant destination – the Australian colonies. New Zealand, observed Pacific traveller George F. Angas (1822-1886) in 1866, 'has the mild winters, the clear sky, and pure atmosphere of' Australia, but was 'free from its hot winds and long-continued droughts…and in the winter [enjoys] very heavy rains, with rough tempestuous weather'.[4] As environmental historian Don Garden notes in his fascinating study of the impact of El Niño Southern Oscillation (ENSO) on Australasia, despite localised evidence to the contrary, New Zealand's more regular rainfall largely surpassed Australia's droughty land.[5] Despite lower rainfall over the ensuing year, the *New Zealand Farmer* in 1911 still expressed confidence in the climate of New Zealand to supply the needs of its farmers. For it, drought represented an aberration to a largely temperate climate. 'When we speak of a drought in this Dominion,' it claimed, 'we do not mean that we are labouring under the rainless, agonising periods which so frequently afflict Australia; the information we intend to convey is that, for the time being, New Zealand has not been blest [sic] with the copious, energising rainfall which it usually enjoys.'[6]

As New Zealand's settlers made use of the natural and physical resources of recently acquired land, draining swamps, sowing grass seed, and converting forest to farm, several politicians, engineers and scientists began to grow alarmed about high rates of deforestation that threatened to reduce its copious, energising rainfall. Informed by overseas writing, they believed that deforestation diminished rainfall and increased temperatures. Unless prevented, they believed deforestation could render New Zealand treeless, unleashing alternating cycles

of drought and flooding. In time, they predicted, drought would choke New Zealand's agricultural productivity, plunging the economy into serious depression, while its soils would be simply washed away through devastating deluges. Excesses of settlement, by which proponents meant overly high rates of deforestation, were threatening to destroy the natural productivity of much of New Zealand while in those places not blessed by Providence proponents pinned their hopes on tree-planting's ability to improve existing climates. In expressing these concerns, New Zealand writers drew upon a rich body of international scholarship on the impact of deforestation on timber supply, health, hydrology and climate. Relying as much on anecdote and drawing upon the rich biblical and classical traditions in which their culture was steeped, many pointed to the destruction of agriculture and peoples occasioned by deforestation in the Middle and Near East. Others gleaned information from more recent experiences in South Asia, the United States (US), highland Europe and even South Africa of deforestation and its impacts, including drawing attention to detailed scientific work undertaken by French climatologists into the relationship between rainfall, temperature and trees. Suggestions for state forest conservation relied on fears of a timber famine, supplemented by arguments about climatic and hydrological change. Models came from India, France, Germany and to a lesser extent the US in the nineteenth century, switching to US and ecological models in the early twentieth century.[7]

Analysis of New Zealand parliamentary debates, official papers and scientific and popular journals reveals considerable debate on the perceived impact of deforestation on local and regional meteorological conditions. As part of broader concerns about the effects of deforestation on timber supplies, health and hydrology, climatic arguments played an important role in attempts to introduce state forest conservation into New Zealand in the nineteenth century and to thereby increase government intervention in society. This article examines these debates and how, over time, climatic arguments became decoupled from wider concerns about the effects of deforestation. More particularly, this article investigates how supporters and opponents of climatic forestry tried to legitimise their stance through recourse to ideas about science. Following American models, the scientific legitimacy of the forests-climate argument came under increasing debate; by the twentieth century the forests-climate theory no longer appeared to be 'good' science, represented by measurable, replicable experimentation supported by detailed statistical evidence. Inability to accurately measure the relationship between forests and rainfall – and therefore to meet the scientific burden of proof – undermined not only the theory but also the cultural authority of the forestry lobby which espoused it. Consequently, to maintain scientific legitimacy, scientists largely discarded the forest-climate connection. Also examined are the overseas models and connections both supporters and opponents employed to debate climatic anxieties in New Zealand.

Perceptions of New Zealand's Nineteenth Century Climate

This article begins with New Zealand's environmental history and the importance of climate, before examining the methods New Zealand's advocates of state forest conservation employed to support their standpoint and legitimate their demands. Before formal colonization, some 100,000 Maori lived throughout New Zealand, most on Te Ika a Maui (North Island). This island enjoyed milder winters and longer growing periods than the cooler Te Wai Pounamu (South Island). Formal colonization began in 1840 when the British Crown and many Maori chiefs signed the Treaty of Waitangi. Becoming part of the British Empire opened the floodgates to European settlement. Within forty years of its signing, New Zealand's European population exploded. Probably fewer than 2,000 Europeans lived in New Zealand before 1840. By 1881 well over half a million Europeans lived there. Most came to the South Island, which, until the late nineteenth century, appealed far more than the North.

Unlike the densely forested North Island, settlers encountered grasslands on the South Island's east coast, enabling them to more easily establish pastoralism and agriculture without the hassle of forest clearance. Several gold rushes – most importantly Otago's from 1861 – attracted migrants, including significant numbers of Chinese, to the South Island. Finally, the New Zealand Land Wars, waged between confederations of Maori tribes, and the Crown and its Maori allies, broke out from the 1840s and continued to challenge European settlement until well into the nineteenth century.

Massive environmental change followed settlement, on a scale perhaps globally unrivalled either in its rapidity or documentation.[8] Forests made way for farms. Grass seed replaced indigenous vegetation. Swamps disappeared. In the hunger for land, government nullified Maori customary title. Within a relatively short period, New Zealand functioned as a giant imperial farm, supplying raw materials and food to Australian, British and other markets. The South Island boomed for much of the nineteenth century. Primarily this occurred on the back of the east coast pastoral industry but also because of the gold discoveries in its central and northern areas. Fortunes – and population – shifted to the North Island in the twentieth century. Refrigeration enabled dairy and meat products to be shipped overseas to imperial consumers, generating the impetus and capital to convert much of the newly-opened North Island's lands recently prised from its Maori owners.[9]

In a country so heavily reliant on primary production for the economic and social well-being of its inhabitants, not to mention for attracting future migrants, climate – 'the sum of weather changes experienced' at a place – mattered greatly.[10] Propagandists regularly promoted New Zealand's climatic similarities to Britain. According to imperial tourist, Charles Dilke, such similarities explained why 'the English fauna and flora are peculiarly well fitted to succeed at our antipodes'. It meant, he continued, that 'our men, flies, and plants – the 'pick' of the whole world – have not even to encounter the difficulties of acclimatization in their struggle against the weaker growths indigenous to the soil'.[11] Countless others marvelled at the remarkable growth rates of crops, staggered in awe at gargantuan vegetables or marvelled at the remarkable rapidity and ease with which overseas plants, animals and people acclimatised into New Zealand. Indeed, New Zealanders began to regard their country as not simply *like* Britain, but as a *better* Britain.[12] In a large measure this rested on perceptions of the beneficial effects of its climate to the growth of both introduced plants and agricultural processes and to the growth and health of Europeans themselves.

A climate free of sudden vicissitudes accorded with contemporary medical advice to avoid sudden changes of temperature.[13] As the missionary The Rev. William Yate succinctly articulated soon after formal colonisation, 'New Zealand's climate renders the sickly healthy, the healthy robust and the robust fat'.[14] Chubby cheeked children impressed Augustus Earle of the goodness of New Zealand's climate on his visit to a mission station in the 1830s.[15] Tables displayed remarkably low settler morbidity and mortality rates. They commonly accompanied accounts of its climatic suitability to white settlement, never mind that much of New Zealand's settler population was disproportionably young and so unfairly skewed the figures.[16] Settlers took such images seriously. Attracted by presentations of a salubrious climate, many migrants – and many doctors – arrived in New Zealand for health reasons, often on medical advice.[17]

Images of a temperate and well-watered land aiding the growth of European productions and peoples also reinforced normative European assumptions that environments were 'naturally' productive, views coincident with post-lapsarian interpretations of the world. According to this view, before the Fall nature was bountiful and generous. Suffering was absent. Peace reigned between man and beast.[18] After the Fall 'man forfeited his easy dominance over other species.'[19] A lack of water and productivity represented wilderness.

Wilderness bore witness to the Fall of Man. It denoted a place where humanity is 'cursed above all cattle' (Genesis 3: 14), tormented by plagues of insects, attacked by wild beasts, cut by thorns, and cursed by weeds, drought and flood.[20]

This concept of wilderness – of humanity inhabiting a sinful and fallen world – impelled the improving ethos of many of New Zealand's nineteenth century European colonists, as it had so many settlers elsewhere. Improvement was shackled to the legal tradition furthered by thinkers like John Locke. When a man 'hath mixed his labour with' the land God gave him, wrote Locke, he 'thereby makes it his property'.[21] Religious ideas imbued agriculture with a morality that legal traditions and popular attitudes reinforced. Biblical injunctions to subdue the earth and make it plentiful enjoined humans to improve upon nature and thereby to, metaphorically at least, restore their relationship to God through recreating the Garden of Eden.[22] Countless settlers described New Zealand in Biblical terms. Central to realising their dreams of land ownership and meeting Christian injunctions were perceptions that Europeans were improving New Zealand through extending cultivation and making land lying idle – wasteland – productive.[23] When settlers believed human changes were actually creating a wasteland, serious anxieties resulted.

As early as the 1840s, visiting scientists drew attention to the dangers of unregulated deforestation. In 1843, German naturalist Ernst Dieffenbach, for instance, warned that firing forests threatened to destroy the very fertility of the soil itself.[24] Based on research observations in the late 1850s, Austrian scientist Ferdinand von Hochstetter censured settlers for unregulated burning removing topsoil and turning the country into a desert.[25] These represented just the tip of the iceberg of a series of unintended environmental problems that became apparent over the nineteenth century, environmental problems consequent with increasing environmental change and longer-term European observation of New Zealand environmental processes. In the 1840s some settlers warned of the need for regulation otherwise rapidly declining whale numbers would end the industry. Others at the time criticised rapid deforestation on parts of the forest-scarce South Island east coast. By the 1870s and 1880s initially popular introductions like rabbits earned themselves a reputation as the 'grey menace', a pest consuming acres of fertile fields. By this time some plant introductions, like gorse and blackberry, were running wild while the extinction of certain species signalled questionable environmental management. Growing evidence of environmental problems thus contributed to a growing culture of anxiety among scientific and some political circles,[26] anxiety that did not question development but its direction.[27]

Climatic Anxieties and Forest Conservation

Climatic anxieties about the rapid removal of New Zealand's forests appeared as early as the 1860s. Expressed by scientists, engineers and some politicians, climatic anxieties emerged alongside concerns about deforestation's impact on flooding and soil erosion, which for most were secondary to fears about loss of future timber supply.[28] Typical of concerns in the early 1870s were those expressed in 1873 by New Zealand parliamentarian Charles O'Neill. At different times O'Neill served as the parliamentary representative of two gold mining areas: first, from 1866 to 1870, Goldfields (Central Otago), which lacked readily available timber as a result of pre-European non-human and Maori deforestation, and then from 1871-1875 Thames (eastern North Island), a more densely timbered region but which still faced problems of deforestation. As an engineer O'Neill would have understood the importance of timber to gold mining, for heating and domestic needs and for pit props, but it is unclear where he obtained his interest and detailed knowledge of the processes of deforestation. In speaking before parliament, O'Neill charged that 'consideration both by the House and Government' of his 'Conservation of Forests Bill' was vitally important 'so that

history might not be able to relate that they [settlers] received a fertile country, but, by a criminal want of foresight, transmitted to posterity a desert.' O'Neill presented a fearful picture of the likely consequences of continued deforestation: timber famine, drought and flooding, decreasing rainfall, and soil erosion that would strip the country of its valuable soils, choke its waterways and bring disaster to the nation. '[E]ven in New Zealand the climate', he wrote, 'had been altered considerably by forest fires.'[29]

As a result of O'Neill's Bill, parliament requested further information about deforestation, asking land commissioners to provide information about deforestation rates and whether they considered timber loss caused climatic alteration.[30] If estimates of New Zealand's deforestation bore out O'Neill's fears, survey returns from land commissioners did not support his contention about climatic alteration. From an estimated forest area in 1830 of over 20 million acres, forest acreage fell by 5 million in 1868, a further 5 million only five years later, such that in 1873 it was estimated to be 12 million acres.[31] Most commissioners thought that climate change through deforestation had not taken place. The few who thought it had welcomed it as reducing an overly damp climate![32]

Forest conservation remained high on the political agenda in the 1870s, forming an important plank in Premier Julius Vogel's ambitious scheme to kick-start the New Zealand economy. Borrowing heavily, Vogel used money for assisted migration and to develop the nation's railway infrastructure, the latter scheme of course requiring vast amounts of timber. Forest conservation fitted in with Vogel's broader principles of economic development. The Bill generated heated discussion because of its controversial nature. Unlike O'Neill's debate, which elicited only three responses, almost half of the house spoke during the forests debate of 1874.[33] Many supporters of the maintenance of provincial power vehemently opposed it, not so much because of opposition to the principle of conservation but rather because the Bill promised to increase central government control at the expense of the provinces. Provinces had been established in 1852, with initially six and later nine (Southland became a province in 1861 but was abolished in 1870). Provincial politicians, who were responsible for such matters as health, immigration, law enforcement and the disposal of "waste lands," resented the intrusion of central government into their affairs. Particular opposition centred on Vogel's initial debt-for-land scheme. Vogel's plan involved reserving not more than three per cent of the land area of each province for forest growth in return for writing off the one per cent sinking fund provinces paid to the government for railway construction. According to Vogel's model, the revenue earned from forestry would be used to discharge the colony's debt.[34]

Although later commentators on the Forests Bill, such as Graeme Wynn, correctly emphasise that state intervention stood as an affront to the laissez-faire policies of the day, the fact that the principles of conservation received significant support from some quarters indicates some level of interest in government intervention.[35] Twenty-two of the thirty-four members who spoke during the Bill actually supported some form of forest conservation.[36] Even if they did not favour the establishment of a forestry department, at least they agreed in principle of the need for governmental intervention, whether central or provincial, to protect threatened forests. As many pointed out, though, the trouble with New Zealand's forest resources were that there they were unevenly spread across the country.[37] North Island surfeit contrasted with the east coast of the South Island's dearth. Debate also indicates that supporters for forest conservation furthered the notion that some kind of regulation was required to protect the public good. In this case, it meant preventing a likely timber famine and the ruination of the country's climate and agriculture. Throughout this debate, climatic arguments featured strongly both in arguments for and against forest conservation. Some members accepted climate change and feared its consequences. Some dismissed it altogether. Others accepted climate change but held its influence to be beneficial.

The Bill's tabler, Julius Vogel, as well as emphasising the need for forest conservation to safeguard timber supply and waterways, played up fears of the climatic effects wrought by deforestation. A recent visit to the South Island, he related, 'forcibly presented' to him 'how much deterioration our climate was liable to sustain' from deforestation.[38] To support his arguments, as Paul Star notes, Vogel tied together 'a string of quotes from the writings of others' on the necessity of forest conservation.[39] These vivid descriptions emphasised the wages that would be paid by a people who foolishly disforested landscapes. Vogel, drawing his arguments for forestry from American, South Asian and European sources,[40] argued that New Zealand's 'peculiar shape', its 'two long, narrow strips of land' also made it particularly susceptible to soil erosion and flooding.[41]

In the debate Charles O'Neill continued where he had left off the year before, pointing out that:

> We know that, by the destruction of forests, climate is most seriously altered. We know quite well that, in other countries, plains which were once filled with forest have had their climate much changed by the destruction of those forests by fires which have had their climates much changed by the destruction of those forests by fires which have desolated miles upon miles of country.[42]

Edward Stafford (premier, 1856-61; 1872) agreed. According to him, New Zealand required mountain reserves so as to protect its climate and soils.[43] Others, such as John Cracroft Wilson, drew heavily from personal experience of Indian forestry.[44] These doom-laden predictions moved one parliamentarian, Nelson MHR David Mitchell Luckie, to boldly declare 'I say, perish the provinces, but preserve the country'.[45]

While many entirely agreed with Vogel's climatic anxieties, not everyone gave trees carte blanche climatic control. Member of the House of Representatives (MHR) for Franklin (south of Auckland) William Buckland believed that forests only exercised local climatic influence.[46] Fellow parliamentarian Edward Richardson (west Christchurch) felt that only time would indicate the 'effect planting of trees will produce in New Zealand.'[47] Some criticised the idea outright. According to MHR Walter Johnston (Manuwatu), those 'countries the most happy in respect of climate and fertility, were precisely those which had the least percentage of forests, namely Great Britain, Holland, Spain, and Portugal.' Johnston also dismissed as 'entirely irrelevant' comparisons made with tropical countries and the US. Unlike the largely temperate, narrow landmass of New Zealand, the latter, he pointed out, had great extremes of summer and winter temperatures. Ireland, a comparably temperate and similarly sized country to New Zealand, he noted, 'broadly speaking, has no forests at all'. Great Britain, with only a sixth of New Zealand's forest, still had a productive agricultural base.[48] Wairarapa's member Samuel Andrew attacked the historical accuracy of statements about the evil effects of deforestation. Andrew pointed out, for instance, that Palestine, upheld by many supporters of conservation as offering a salutary lesson against deforestation, faced water scarcity long before deforestation began. Drought, Andrew pointed out, led to over-watering and salinisation. In Spain, he related, sugar cane grew from the seventh to eighth centuries and still grows, thus disproving the claim that deforestation decreases rainfall. Equally, he pointed out, Canada's climate 'may have become more severe, but it by no means follows that it is from disforesting.' These, and other reasoned examples, indicated to Andrew that 'the conclusion drawn by scientific men, that disforesting injuriously affects a temperate climate, are not proved so far as to justify us in passing a Bill of this kind on the strength of them.'[49]

Criticism of the forest-climate theory highlighted problems that would eventually lead scientists and lobbyists in New Zealand to drop the concept entirely. In the nineteenth century

accuracy of measurement and an ability to replicate experiments elsewhere became hallmarks of science, and qualities – or virtues – of the scientist.[50] In debates about the need for state forestry, scientific knowledge and disciplinary formation helped to extend state authority. As historian of science David Livingstone has observed on the relationship between science, scientific methods and government formation:

> Courtesy of the spirit of calculation and the impulse towards planning, the state has enlisted the methods of science not only in *making*, but also in *maintaining* national identity…alongside its role in surveying the state's territorial scope and natural assets, scientific surveillance has been harnessed to manage cultural capital and demographic resources by applying quantitative procedures to public affairs.[51]

To take just one well-known example, the 'sciences of government' (*Kameralwissenschaften* or The Cameral Sciences) that developed in the German-speaking lands from the eighteenth century demonstrate the developing nexus between science and state formation through territorial knowledge and increasing control on citizens' lives. States such as Prussia applied these methodologies to a host of government activities. Administration, surveying, tax collection, agriculture, forestry, even the mapping of disease all felt the imprint of *Kameralwissenschaften*. As a process contributing to a sense of common territorial identity, the *Kameralwissenschaften* legitimated the state's rights to tax and intervene in its citizens' lives.[52] With scientific authority resting on sound methodology, over the course of the nineteenth century, science increasingly required verifiable and replicable experiments and theories. Repeatability and accuracy (standardised measurement) fortified the totalising claims of scientific objectivity, especially above local, subjective knowledge.[53] As historian of science Vladimir Janković observes, the power of quantification in early nineteenth century meteorology rested on its ability to make 'alternatives intellectually inferior and embarrassing for the expositors.'[54] In so doing, meteorologists, like other scientists at the time, made 'their claims and practices credible…by distinguishing them from unworthy claims and practices of some nether region of *non*-science.'[55] James R. Fleming's fascinating study, *Meteorology in America*, demonstrates that that discipline 'emerged as both a legitimate science and a government service' following the American Civil War. As Fleming demonstrates of nineteenth century America, through Charles Schott's detailed statistical analysis of US rainfall and temperature records, the difficulty for advocates of the forest-climate link was that their argument relied on historical anecdote and observations, rather than verifiable data and experimentation.[56] Proving the forest-climate link through scientific means rather than observation remained a problem for its advocates, and eventually led to it dropping out of justifications for forestry as it also did in New Zealand

State Forestry: 1876

Despite some stringent criticism, a watered down version of Vogel's Act passed, establishing a new state forests department, supported by a £10,000 budget.[57] In 1876, its first Conservator of Forests, Captain Inches Campbell Walker, arrived. Previously deputy conservator in Madras Presidency, India, Walker brought with him a wealth of conservation experience. Embarking on a survey of the colony's forests, Walker's arguments for their conservation appeared in 1876 and 1877.[58] At their core, Walker advocated scientific forestry. Mindful that the main thrust of government policy was land settlement, Walker emphasised the protection conserved forests gave agriculture as well as their economic

benefits. Removing forestry from direct competition with agriculture on the lowlands, he argued for its development on highlands. Quoting European, Indian and American authors, he associated forests, through their regulation of climate and soils, with the preservation of New Zealand's climate. Destruction of high altitude forests, cautioned Walker, would mean bidding 'farewell to the smiling fields in the vallies [sic] below and abundant pasture on the lower slopes of the hills'.[59]

Climatic anxieties thus buttressed his arguments for forest conservation and for government to take an increased role in society. Since a key plank of Walker's arguments rested on the forests-rainfall theory, he attempted to settle any uncertainty about it in New Zealand by examining temperature records and matching these up with deforestation rates. Walker hoped his research would shore up his belief that deforestation 'exercises an injurious effect on both [climate and permanent water supply], whilst the formation of plantations in dry and arid regions ameliorates the climate and renders the water supply more copious and permanent.' Consulting records of New Zealand's average rainfall between 1866 and 1875, however, revealed that mean rainfall had actually risen slightly despite accelerating rates of deforestation.[60] Walker dismissed the reliability of such figures. According to him, meteorological observations had improved significantly in this period, rendering his attempt unscientific.[61] Walker's efforts to measure the effects of deforestation on climate perhaps reflected attempts to increase the legitimacy of state forestry through recourse to statistics. Experience in India may have prompted Walker. Foresters in India only began to accept climatic theories in the face of observational evidence.[62] As with other climatic conservationists, however, intuition and observation ultimately informed his belief in the powers of forests to attract rain: these would ultimately lead to the dismissal of climatic anxieties in scientific circles later in the century.

If saving existing forests was important to Campbell Walker, then so too was creating new ones. Tree-planting should go ahead, he continued, since he had 'little doubt that' they had already ameliorated the colony's climate.[63] According to him, 'all along the East Coast with bare plains and comparatively little timber, we have but a scanty rainfall, whereas in the densely-wooded West Coast we have a rainfall greatly in excess of the average.' Confusing cause with effect, the Conservator asked rhetorically: 'why should not rain have fallen and forests been created on the eastern slopes of the mountains, on which the clouds, laden with moisture from the Pacific, first impinge'?[64]

Although the Act was revoked due to financial difficulties, over half a million acres was reserved for climatic purposes under the 1877 Land Act. Significant support for climatic arguments - which appeared together with hydrological and timber famine concerns – came from several quarters, including engineer F.S. Peppercorne. Peppercorne wrote the 'Influence of Forests on Climate and Rainfall', first published in the *Transactions* in 1879 and later privately in 1880.[65] 'It appears to be not generally known that, within certain limitations, climates (like soils) may be made good or bad by human agency', explained Peppercorne, 'and that one great agent in diffusing a general and uniform moisture, is the growth of forest trees, whose roots, branches, and leaves serve as reservoirs in times of rain, to be given forth again in dry weather.'[66] Peppercorne expounded in great scientific detail, the precise influence of trees on the surrounding air and groundwater, citing scientific experiments undertaken by overseas experts in support. Quoting from the French forestry expert, Professor Macarel, for instance, Peppercorne demonstrated that 'All the wants of life are closely related to their conservation: agriculture, architecture, and most industries, seek therein their ailment and resources'. He also used the research of M. Mathieu and pupils of the Schools of Forestry, Nancy, to argue that forests increased both underground springs and the volume of underground water, also lowering evaporation rates and temperatures. Based on the historical examples and research cited, Peppercorne confidently argued that 'one of the

first duties of an enlightened Government' concerned '[t]he preservation of the forests of a country'.[67] Many other articles appeared on this topic in the 1880s, including in recently-published farming journals, indicating the support of some in this sector. In 1880 A. Lecoy, a retired French forester, published his advice.[68] Lecoy implored the New Zealand Government, for the sake of the climate, to increase the extent of state forests. Private individuals, he pointed out, would not leave forests standing for the benefit of society as a whole. Only state forestry, he noted, offered the way forward, bringing financial gain as well as climatic and hydrological stability.[69]

Chamberlain's challenge: the climatic lobby in the 1880s

Although the extent of forest conservation increased in the 1880s, the conservation lobby in parliament remained vocal in the 1880s in the face of continuing deforestation elsewhere. In 1882, Henry Chamberlain, Auckland's MHR, presented a quite extraordinary discussion of conservation and settlement exclusively reliant on the forests-climate link. Based on Lecoy's report (see above), Chamberlain noted that in Germany and France, both countries that 'had for long ages studied the advantages of maintaining and retaining their forests', the 'desirable quantity' of forestland was one quarter of the total area. In Canterbury, Chamberlain instanced that the area was only two per cent; in Auckland, seven per cent. Deforestation in a region with a 'moist hot climate' such as Auckland's, Chamberlain noted, was particularly dangerous for 'the climate would become very different, and scarcely anything would be able to be produced there.'[70] Chamberlain advocated drawing up maps showing highland areas and forest areas and then using this information to inform forest legislation. In his discussion, the MHR ascribed to forests almost exclusive control over climate:

> Persons seeing the amount of forest and forest reserve would be able to judge what kind of climate any particular district would be likely to possess, which would influence them in choosing a place to settle in, and people would be also able to see where they could purchase forest land whenever Government might have it for sale.[71]

Interestingly, unlike most other advocates who left the lowlands to agriculture, Chamberlain favoured integration of forestland with farming. Although sympathetic and recognising that wasteful deforestation 'was a deplorable fact', Richard Oliver, Minister without portfolio, replied that 'very often there was no option between letting the lands lie idle and sacrificing valuable trees.'[72] Land settlement triumphed over forest conservation.

The following year Chamberlain, undaunted, introduced another bill aimed at protecting forested areas from 'the wooded ranges to the plains and lowlands' specifically for climatic and catchment reasons. Bolstered by rainfall statistics, Chamberlain demonstrated that deforestation had dried up the colony's climate (Table 1).

Table 1. Chamberlain's Findings on New Zealand Rainfall Decline

Region	Decline in Rainfall over last seventeen years (measured in inches over five year periods)		
	1867-1872	1872-1877	1877-1882
Auckland	48	43	40
Southland	46	41	42
Canterbury	27	25	22

Based on NZPD, 1 August, vol.45, 1883, p.212.

He also charged that deforestation increased flooding and pointed out that conservation would extend the timber trade.[73] Eight other MHRs spoke during the debate, of whom five supported Chamberlain's espousal of the forests-climate link.[74] J.W. Barnicoat (Nelson) argued that by enacting forest conservation humans:

> had it to some extent in their power to transmit the soil and the climate, in all their richness and excellence, that they themselves now enjoyed; for forests had an influence on the atmosphere, on the waters that fertilized the earth, and even on the crust of the earth itself…. When the forests were destroyed the streams dried up, the floods became sudden and violent, and the earth became arid and barren.[75]

According to Barnicoat, the ability of forests to influence climate and hydrology gave humans the power to transform the earth so as to maintain a region's fertility. Mathew Holmes (Otago) agreed. Tree-planting in dry districts like North Otago and the Waimea Plains, he believed, could double the amount of existing rainfall and increase the value of the land.[76]

As with the earlier conservation debates doubters either questioned the occurrence of climatic deterioration or attacked the rainfall-forests theory. Much forest remained in the country, observed Henry Scotland (Taranaki); that removed had not caused appreciable rainfall decline.[77] The relief of the mountains, not trees, pointed out James Richmond (Nelson, Legislative Council), accounted for the surfeit of rain on the South Island's west coast and its deficit on the east.[78] Frederick Alexander Whitaker (Waipa) dismissed Chamberlain's contention of rainfall decline, and noted the practical difficulties of reserving land in Canterbury since most of it lay in private hands.[79]

Another attempt at conservation, the 1885 State Forests Act, established three types of reserved forest land. Provision remained for the forest-climate idea. Under the Act, Class I forests acknowledged '*Climatal* [sic] *or Mountain Reserves, to include all Forests reserved for Shelter, for the Conservation of the Water-supply, or for Climatic Reasons, irrespective of Altitude*'.[80] Only two MHRs, in fact, discussed climatic conservation.[81] It is surprising, on the face of it, that not more time passed discussing the climatic principles of the Bill. After all, this comprised a major part of the Bill. Silence and lack of criticism of these ideas, suggests that parliamentarians accepted the forests-climate link. A closer look at the actual legislation reveals another important difference from earlier climatic legislation. Although most of the reserves were gazetted in highland areas, the Act also provided for the reservation of lowland areas. This suggests that parliament had realised the importance of lowland, as well as highland, protection. Perhaps, too, it realised that rather than planting trees after forest had been removed, it was a lot cheaper and less labour intensive to reserve existing areas of lowland forest. The 1885 Act followed that of its predecessor. In 1887, despite criticism of this move by T. Kirk, Conservator of State Forests, a new government withdrew Crown funding.[82] In 1888, signalling a departure in policy from conservation to use, parliament passed the 'State Forests Act Amendment' which allowed the Governor to withdraw land from State Forest areas.[83] During debate on this Bill, some parliamentarians protested against the opening up of forests, warning that this would prove detrimental to both New Zealand's climate and soils. Yet withdrawing land from State forests, as historical geographer Michael Roche notes, reflected the Liberal Government's programme of closer land settlement.[84] The 1890s witnessed a concerted settlement 'push' by the newly-elected and reform-minded Liberal Government (1891-1912) that signalled increased government role in society.

Through legislation and loans, the Liberals encouraged closer land settlement, part of their policy of breaking up the larger estates and obtaining Maori land. The push for development – particularly in the forested North Island – accelerated deforestation, heightening fears of an impending timber famine at the same time as a move took place to reserve other forests areas for scenic purposes.[85]

As elsewhere, in New Zealand, science played a crucial role in legitimising government and increasing its role in society.[86] The Liberal Government created, and later expanded, new departments like those of Labour, Education, Health and Agriculture, coming to direct small but growing coteries of scientists and bureaucrats that ultimately culminated in the creation of the Department of Scientific and Industrial Research in 1926.[87] In contrast to the growing Department of Agriculture, attempts throughout the nineteenth century to establish forestry as a professional, state supported discipline in New Zealand failed, largely because of the overwhelming emphasis placed upon agricultural development. Lack of scientific credibility and government unwillingness to interfere overly in society also played a part. New Zealand's appointment of a biologist as 'Conservator of Forests' in 1885, for instance, elicited criticism from a visiting representative of the apogee of professional, scientific state forestry, the Indian Forestry Service (IFS): 'the colonists have no one who really understands what forestry is, or how extensive forest areas should be managed.' [88]

Gradually, forestry lobbyists in New Zealand dropped the forest-climate link, realising that this did not help their claims to scientific and professional legitimacy. In doing this, it reflected the new popularity of US models, where previously they mainly looked to European and South Asian examples. US engineers and meteorologists questioned the scientific legitimacy of the forests-rainfall arguments put forward by foresters. In response, foresters dropped the forest-climate argument because it appeared to rest on dubious, unproven scientific claims. Association with it did their prospects of increased government support no good.[89] Instead, in the early twentieth century United States Forestry Service (USFS) officials 'invoked the authority of science' to play up the woeful consequences of deforestation on flooding and soil erosion, deliberately embarking 'on a crusade to convert the country to conservation'.[90] They deliberately shied away from climatic arguments because it proved impossible to gain accurate scientific data on the connection between forests and rainfall or temperature change. This aligned with experience elsewhere, most notably in Australia.[91]

New Zealand scientists relied on US examples of soil erosion science, as well as ecological and aesthetic arguments tailored to images of New Zealand's growing national identity: these influences, added to the background of a new generation of scientists with a strong grounding in soil sciences and ecology, contributed to the shift away from climatic arguments. The US reliance was clearly illustrated in New Zealand's 1913 Royal Commission on Forestry.[92] Dr. C.A. Cotton praised the American work, *Denudation and Erosion in the Southern Appalachian Region and the Monongahela Basin, 1911* as 'of special value because it contains a very careful study of the results of reckless clearing in a climate which appears to be very similar to ours.'[93] The report also referenced other international research: Professor I. Bowman's *Physiography of the United States, and Principles of Soil in Relation to Forestry* (1911); Copenhagen Professor, Eugenius Warming's *Oecology of Plants* (1909); and Dr. B.E. Fernow's *Economics of Forestry* (1902).[94] Compared to earlier scientifically untrained advocates of the forests-climate connection, Cotton and pioneer ecologist Leonard Cockayne both had a strong grounding in sciences which emphasised local-scale environmental change. Cotton read for a MSC in geology from The University of Otago and, after a spell in mining, was appointed to the first lecturership in Geology at Victoria University College, Wellington (later, Victoria University of Wellington).[95] Research into geomorphology emphasised the importance of study of landforms and processes, and this, combined with a strong scientific education (he was awarded a DSc in

1915) meant that unlike the amateurs who advocated the climate-forests link, Cotton would not support scientifically unsound theories. Cockayne, although self-taught, became a leading advocate of ecology in New Zealand and relied on sound scientific experiments to conduct surveys into environmental processes, both perspectives which did not favour the forests-climate link.[96] Meteorology in New Zealand was also much weaker than in the US, forming a different set of social and political circumstances under which science took place, differences which reinforce David Livingstone's assertion that locality profoundly affects the meaning and reception of science.[97]

In the US criticism of the forest-climate link from meteorologists and engineers discredited the theory, forcing foresters to drop it entirely. In contrast to the US, in New Zealand state meteorology was underdeveloped and struggled for funding for much of the nineteenth century and into the early decades of the twentieth. Staff of the New Zealand Meteorological Service (NZMS, 1906-1992), including its director, Rev. D.C. Bates (director, 1909-1927), were not scientifically-trained meteorologists. As historian J.F. de Lisle observes, until the appointment of Bates' successor, Dr. Edward Kidson, a trained meteorologist, in 1927, 'the science was very much in its infancy' with '[t]he resources available in the struggling and often impecunious new colony' only 'able to provide for only the most rudimentary meteorological services.'[98] The NZMS was therefore decades behind the US, having still to build up more rigorous instrumentation and forecasting methods and justify its usefulness to the state. On occasion New Zealand's meteorologists in the late nineteenth and early twentieth centuries even supported the idea that trees could influence local climatic conditions. Although holding that elevation and latitude, prevalent winds and mountains, ground slope and soil character and proximity to sea influenced rainfall distribution in New Zealand, meteorologist John Meeson in 1890 noted that both forests and cultivation had localised effects on climate.[99] '[D]ense neighbouring woods', he observed, 'will diminish local temperature, and so, to some extent, attract rain.' Blenheim settlers, he continued, 'attributed [the slight increase in Blenheim's rain] – rightly or wrongly – to increased cultivation and arboriculture.'[100] In 1907, Bates recommended tree planting to increase rainfall in droughty North Otago. Rather than critiquing forest-climate ideas, New Zealand meteorologists used opportunities such as rainmaking activities to enhance their authority and draw up boundaries between science and non-science.[101] The process of professionalisation in meteorology took place much earlier in the US than in New Zealand. New Zealand's meteorology bureau relied upon non-scientifically trained staff, which perhaps explains the latter's continuing support of the forest-climate connection, a position only really maintained by non-professional groups. Significantly, when in the early 1920s New Zealand created its State Forests Service (SFS), a professional North American trained forester took over the position. Forestry's aim became to ensure regular supply of timber and prevent soil erosion and flooding.[102]

Conclusion

In response to overseas arguments and in light of increasing deforestation, climatic anxieties emerged in New Zealand in the 1860s. Over that century several scientists, engineers and politicians drew attention to the perceived or likely impact of deforestation. Unregulated felling, they argued, variously resulted in rainfall and temperature change, timber scarcity and flooding. Unless prevented through state forest management, climate change and altered hydrological regimes threatened to bring terrifying cycles of drought and flooding. Contestations over the meaning of science exhibited through forest-climate debates in New Zealand from the 1860s to the 1920s evince the importance of scientific methods in supporting a group's claims to authority. For some, climate-forest science meant government

should increase its role in society and establish state forest conservation. Others challenged such claims to scientific authority, questioning the methodology and use of measurement. Both proponents – and detractors – of the forest-climate connection invoked the language and methodology of science to press their claims to authority. In the 1870s, for instance, some politicians questioned the climate-forests idea. It was, they charged, based on anecdote and observation, not hard, observable scientific fact. To rebuke such criticism, New Zealand's recently appointed Conservator of Forests attempted to measure the impact of increased deforestation on rainfall, but without success. In the early twentieth century the forest conservation lobby in New Zealand turned to American forestry precedents, discarding its reliance on the forest-climate connection to press for government intervention on the basis of stronger scientific evidence of timber depletion and soil erosion. In America, meteorologists and engineers successfully discredited the forest-climate connection put forward by foresters. They pointed out its unscientific evidence and reliance on historical examples and unsubstantiated observation instead of scientific data and experimentation. Now associated with non-science, scientifically-trained forest supporters dropped the forest-climate theory in favour of the hydrological impact of deforestation, a theory that they could more easily support scientifically. Reinforced by growing ecological ideas that favoured preservation of indigenous nature as central to national identity, lobbyists for New Zealand state conservation also followed US models and precedents in arguing for the hydrological impact of forests. If the example of colonial forestry in New Zealand emphasises the importance of overseas and local models in initiating state conservation, it also evinces the equally significant role of boundary disputes over science in framing conservation arguments.

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[3] John Ward, *Information Relative to New-Zealand for the Use of Colonists* (London: Smith, Elder & Co., 1839), p.10.

[4] John Angas, *Polynesia: A Popular Description of the Physical Features, Inhabitants, Natural History, and Productions of the Lands of the Pacific…* (Christchurch: Capper Press, reprint, 1973), p.131.

[5] Don Garden, 'El Niño, Irrigation Dams and Stock Banks: Examining the Repercussions of the 1876-78 El Niño in Australia and New Zealand', *History of Meteorology*, 4, (2008), pp.1-26. Note, too, Emily O'Gorman, 'Colonial Meteorologists and Australia's Variable Weather', *University of Queensland Historical Proceedings*, 16, (2005), pp.67-87.

[6] *New Zealand Farmer* (henceforth, NZF), 32, 10 (October, 1911), p.1175.

[7] On this vast literature, note: Richard H. Grove, *Ecology, Climate and Empire: Colonialism and Global Environmental History, 1400-1940* (Cambridge: Cambridge University Press, 1997); Clarence Glacken, *Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the end of the Eighteenth Century* (Berkeley: University of California Press, 1967); Jane Costlow, 'Imaginations of Destruction: The "Forest Question" in Nineteenth-Century Russian Culture', *Russian Review*, 62, (January, 2003), pp.91-118; Charles A. Kutzler, 'American Myth: Can Forests Bring Rain to the Plains', *Journal of Forest History*, 15, (October, 1971), pp.14-21; D.W. Meinig, *On the Margins of the Good Earth: The South Australian Wheat Frontier, 1869-1884* (Chicago: Rand McNally and Company, 1962).

[8] Pawson and Brooking, eds., *Environmental Histories*.

[9] Gordon McLauchlan, *The Farming of New Zealand: The People and the Land* (Auckland: Viking, 2006); James Belich, *Making Peoples: A History of the New Zealanders from Polynesian Settlement to the End of the Nineteenth Century* (Auckland: Allan Lane & Penguin, 1996).

[10] Michael J. Bradshaw, *Earth: The Living Planet* (London: Hodder and Stoughton, 1977), p .84.

[11] Charles Dilke, *Travellers' Tales of Early Australia & New Zealand: Greater Britain, Charles Dilke visits her new lands, 1866 & 1867*, ed. Geoffrey Blainey (North Ryde [N.S.W.]: Methuen Haynes, 1985 [1868]), pp.76-77.

[12] Belich, *Making Peoples*.

[13] Mark Harrison, *Climates and Constitutions: Health, Race, Environment and British Imperialism in India, 1600-1850* (New Delhi: Oxford University Press, 1999).

[14] Yate, cited in *Scheme of the Colony of the Free Church at Otago New Zealand* (Glasgow: Scottish Guardian Office, 1845), pp. 18-19.

[15] William Swainson, *Observations on the Climate of New Zealand…* (London: Smith, Elder and Co., 1840), p.56.

[16] Belich, *Making Peoples*, p.300.

[17] Linda Bryder, '"A Health Resort for Consumptives": Tuberculosis and Immigration to New Zealand, 1880-1914', *Medical History*, 40, (1996), pp.459-464.

[18] John Delumeau, *History of Paradise: The Garden of Eden in Myth and Tradition*, trans. Matthew O'Connell (New York: Continuum, 1995), p.6.

[19] David. J. Herlihy, 'Attitudes Toward the Environment in Medieval Society', in Lester J. Bilsky, ed., *Historical Ecology: Essays on Environment and Social Change* (Port Washington, N.Y.: Kennikat Press, 1980), p.103.

[20] Keith Thomas, *Man and the Natural World: A History of the Modern Sensibility* (Oxford: Oxford University Press, 1983), pp.17-20.

[21] John Locke, 'The Second Treatise of Civil Government', Chapter V, verse 27, cited in Henry Reynolds, *The Law of the Land*, 2nd ed. (Ringwood: Penguin, 1992), p. 25.

[22] Richard Harry Drayton, *Nature's Government: Science, Imperial Britain, and the 'Improvement' of the World* (New Haven: Yale University Press, 2000).

[23] James Beattie and John Stenhouse, 'Empire, Environment and Religion: God and Nature in nineteenth-century New Zealand', *Environment and History*, 13, 4 (November, 2007), pp.413-446.

[24] Ernst Dieffenbach, *Travels in New Zealand with Contributions to the Geography, Geology, Botany, and Natural History of That Country*, vol. 1 (Christchurch: Capper Press, reprint, 1976 [1843]), pp. 367-368.

[25] Ferdinand von Hochstetter, *New Zealand: Its Physical Geography, Geology and Natural History with special reference to the results of Government Expeditions in the Provinces of Auckland and Nelson*, trans. by Edward Sauter (Stuttgart: J.G. Cotta, 1867), pp. 142, 255-254.

[26] See, Michael Bagge, 'The ambivalence of Gorse in New Zealand 1835-1900' (B.A. Hons. Dissertation: University of Otago, 2000); Neil Clayton, 'Settlers, Politicians & Scientists: Environmental Anxiety in a New Zealand Colony (B.A. Hons. Dissertation: University of Otago, 1998); Beattie, 'Conservation and Science in Southern New Zealand: A Reconsideration', draft MS.

[27] Beattie, *Empire and Environmental Anxiety*.

[28] Beattie, 'Environmental Anxiety in New Zealand, 1840-1941: Climate Change, Soil Erosion, Sand Drift, Flooding and Forest Conservation', *Environment and History*, 9, 4 (2003), pp.379-392

[29] *New Zealand Parliamentary Debates* (henceforth, NZPD), 1 October, 1873, pp.1545-1546.

[30] Roche, *History of Forestry* (Wellington: Government Print, 1990), p.84.

[31] M.M. Roche, *Forest Policy in New Zealand: An Historical Geography, 1840-1919* (Palmerston North: Dunmore Press, 1987), p.78.

[32] 'Papers relating to state forests, their conservation, planting, management, &c.', *Appendices and Journals to the House of Representatives* (henceforth, AJHR), H-5, Vol. 2, 1874, pp.18, 30-32.

[33] 34 out of a total of 78 members spoke. Roche, *History of Forestry*, p.86.

[34] M.M. Roche, *History of Forestry*, Wellington, 1990, p.86.

[35] See Graeme Wynn, 'Conservation and Society in Late Nineteenth-Century New Zealand', *New Zealand Journal of History*, 11, 2 (October, 1977), pp.130-4. As Bryce put it succinctly, 'I said we should let the people alone.' NZPD, 31 July, 1874, p.367.

[36] Calculated from NZPD, 14 July, 1874, pp.79-94; 31 July, pp.350-381; 4 August, pp.399-426.

[37] See, for instance, Rolleston, NZPD, 4 August, 1874, pp.404-405.

[38] NZPD, 14 July, 1874, p.79.

[39] Paul Star, 'The Place of Native Forest in New Zealand's Mental Landscape', in John Dargavel and Brenda Libbis, eds., *Australia's Ever-Changing Forests IV: Proceedings of the Fourth National Conference on Australian Forest History*, Canberra, 1999, p.94.

[40] On this, note Wynn, 'Destruction under the Guise of Improvement? The Forest, 1840-1920', in *Environmental Histories*, p. 114; Vogel, NZPD, 14 July, p. 80.

[41] NZPD, 4 August, p. 424.

[42] O'Neill, NZPD, 31 July, p.356.

[43] Stafford, NZPD, 31 July, p.365.

[44] See, Beattie, 'Tropical Asia and Temperate New Zealand: Health and Conservation Connections, 1840-1920', in Brian Moloughney and Henry Johnson, eds., *Asia in Making of New Zealand* (Auckland: Auckland University Press, 2007), pp.36-57.

[45] Luckie, NZPD, 4 August, pp.409-410.

[46] NZPD, 4 August 1874, p.403.

[47] NZPD, 31 July 1874, p.374.

[48] Johnston, NZPD, 4 August 1874, p.408.

[49] Andrew, NZPD, 4 August 1874, p.412.

[50] Scott, *Seeing Like A State*.

[51] David Livingstone, *Putting Science in Its Place: Geographies of Scientific Knowledge* (Chicago and London: University of Chicago Press), p.128.

[52] Some of the many studies on this topic and the relationship between state and science include: Tore Frängsmyr, J.L. Heilbron, and Robin E. Rider, eds., *The Quantifying Spirit of the 18th Century* (Berkeley: University of California Press, 1990); Alison Bashford, 'Epidemic and Governmentality: Smallpox in Sydney, 1881', *Critical Public Health*, 9, 4 (1999), pp. 301-316; Nicholaas A. Rupke, ed., *Medical Geography in Historical Perspective* (London: Wellcome Trust Centre for the History of Medicine at UCL, 2000).

[53] James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven and London: Yale University Press, 1998); as a sophisticated examination of the local-focussed nature of scientific endeavour, note Livingstone's fascinating study: *Putting Science in its Place.*

[54] *Reading the Skies: A Cultural History of English Weather, 1650-1820* (Manchester: Manchester University Press, 2000), p. 161.

[55] Thomas F. Gieryn, *Cultural Boundaries of Science: Credibility on the Line* (Chicago: University of Chicago Press, 1999), p. xii.

[56] James R. Fleming, *Meteorology in America, 1800-1870* (Baltimore: Johns Hopkins, 1990), pp.128-9, 174. On ideas of landscape meteorology in the US, see Kenneth Thompson, 'Forests and Climate Change in America: Some Early Views', *Climatic Change*, 3, (1980), pp.47-64; 'The Question of Climatic Stability in America Before 1900', *Climatic Change*, 3, (1980), pp.227-241.

[57] Michael Roche, *History of Forests* (Wellington: Government Printer, 1990), p.87.

[58] Campbell Walker, 'Report of the Conservator of State Forests', AJHR, C3, vol. 1, 1877, pp.12-49; 'State Forestry: Its Aim and Object', *Transactions and Proceedings of the New Zealand Institute* (henceforth, TPNZI), 9, (1876), pp.187-203; 'The Climatic and Financial Aspect of Forest Conservancy as applicable to New Zealand', TPNZI, 9, (1876), pp.xxvii-xlix.

[59] Walker, 'Climatic and Financial', p.xxxix.

[60] Ibid., pp.xxviii-xxix.

[61] Walker, 'Report', p.49.

[62] Satpal Sangwan, 'Making of a Popular Debate: *The Indian Forester* and the Emerging Agenda of State Forestry in India, 1875-1904', *Indian Economic and Social History Review*, 36, 2 (1999), p.198.

[63] Campbell Walker, 'The Climatic and Financial Aspects', p.xxxviii.

[64] Campbell Walker, 'The Climatic and Financial Aspects', p.xxxix.

[65] 'Influence of Forests on Climate and Rainfall', TPNZI, 12, (1879), pp.24-32; *On the Influence of Forests on Climate and Rainfall*.

[66] S. Peppercorne, 'Influence of Forests on Climate and Rainfall', pp.24-32; *On the Influence of Forests on Climate and Rainfall*, Napier, 1880, p.3.

[67] Peppercorne, 'Influence of Forests on Climate and Rainfall', p.25.

[68] Note: Aherne, *New Zealand Country Journal* (NZCJ), 6, 6 (November, 1882), pp. 405-8. See also T. A. Patrick, 'Encouraging Tree Planting of Farms', NZCJ, 9, 5 (September, 1885), p.410; 'Trees Adapted for thin and poor soils and elevated situations', 7, 4 NZCJ (July, 1883), p.336.

[69] A. Lecoy, 'The Forests Question in New Zealand', TPNZI, 12, (1879), 3-23; 'Suggestions on Forests in the Colony of New Zealand', AJHR, H3, 1880, pp.1-12.

[70] NZPD, 7 June 1882, pp.316-317.

[71] NZPD, 7 June 1882, p.317.

[72] NZPD, 7 June 1882, p.317.

[73] NZPD, 1 August, vol.45, 1883, pp.212-213.

[74] These were Barnicoat, G.R. Johnson, Mathew Holmes (Otago), and William Hugh Nurse (Otago) and James Williamson (Auckland).

[75] NZPD, 1 August 1883, vol.45, p.214.

[76] NZPD, 1 August 1883, vol.45, p.218.

[77] NZPD, 1 August 1883, vol.45, p.215.

[78] J.C. Richmond, 1 August 1883, vol.45, p.218.

[79] NZPD, 1 August 1883, vol.45, pp.215-216.

[80] T.H. Kirk, 'Progress Report of the State Forests Department', AJHR, C3D, vol. 1, 1886, p.3.

[81] Two MHRs did discuss climatic conservation. George Beetham, Wairarapa North MHR, denied that forest clearance had caused a drier climate: Beetham thought that the converse, in fact, had occurred despite significant deforestation in the North Island. George Beetham, NZPD, 26 June, 1885, p.206. New Zealand's former Governor, Sir George Grey, summarised the Bill as 'necessary for climatic reasons' and for future timber supplies. Sir George Grey, NZPD, 7 July, 1885, p.448.

[82] Brown, *Forestry Era*, p.12.

[83] 'State Forests Act Amendment, 1888', *The Statutes of New Zealand*, Wellington, 1888, pp.71-72.

[84] Roche, *History of Forestry*, p.137. See also Brooking, Brooking, Tom, *Lands for the People? The Highland Clearances and the Colonisation of New Zealand: A Biography of John McKenzie by Tom Brooking*, Dunedin, 1996, pp.176-178.

[85] Beattie, 'Environmental Anxiety'.

[86] M.E. Hoare, 'The Relationship between Government and Science in Australia and New Zealand', *Journal of the Royal Society of New Zealand*, 6, 3 (1976), pp.381-394; A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities* (Baltimore and London: Johns Hopkins University, 1986).

[87] Ross Galbreath, *DSIR: Making Science work for New Zealand…*(Wellington: Victoria University Press, 1998); Tony Nightingale, *White Collars and Gumboots: A History of the Ministry of Agriculture and Fisheries, 1892-1992* (Palmerston North: Dunmore Press, 1992); Derek A. Dow, *Safeguarding the Public Health: A History of the New Zealand Department of Health* (Wellington: Victoria University Press; Ministry of Health; Historical Branch, Department of Internal Affairs, 1995).

[88] 'Three Months' Privilege Leave to New Zealand', *Indian Forester*, 12, (December, 1886), pp. 560, 557.

[89] Schiff, *Fire and Water*.

[90] Ashley L. Schiff, *Fire and Water: Scientific Heresy in the Forest Service* (Cambridge, Mass.: Cambridge University Press, 1962), pp. 165, 4-5. On US meteorology, see Fleming, *Meteorology in America*.

[91] Beattie, *Empire and Environmental Anxiety*.

[92] AJHR, C12, 1913, pp.1-87.

[93] Cotton, 'Report of the Royal Commission', p. 82.

[94] 'Report of the Royal Commission', p. xiv.

[95] G. R. Stevens, 'Cotton, Charles Andrew 1885 – 1970', *Dictionary of New Zealand Biography*, updated 22 June 2007: URL: http://www.dnzb.govt.nz/

[96] On Cockayne, see Paul Star, 'Ecology: A Science of Nation? The Utilization of Plant Ecology in New Zealand, 1896-1930', *Historical Records of Australian Science*, 17, 2 (2006), pp. 197-207.

[97] Livingstone, *Putting Science in Its Place*.

[98] J.F. de Lisle, 'The New Zealand Meteorological Service – The Beginnings, 1861-1927', in M.E. Hoare and L.G. Bell, eds., *In Search of New Zealand's Scientific Heritage* (Wellington: Royal Society of New Zealand and Alexander Turnbull Library, 1984), p.17.

[99] John T. Meeson, 'The Rainfall of New Zealand', TPNZI, 23, (1890), pp. 546-569.

[100] Meeson, 'The Rainfall of New Zealand', p.553.

[101] Beattie, 'Rethinking Science, Religion and Nature in Environmental History: Drought in Early Twentieth-Century New Zealand', *Historical Social Research/Historische Sozialforschung*, 29, 3 (November, 2004), pp.82-103; Matt Henry, 'Trans-Tasman Meteorology and the Production of a Tasman Airspace, 1920-1940', *ENNZ: Environment and Nature in New Zealand*, 4, 1 (April, 2009), pp.14-36; N.G. Robertson, 'The Organization and Development of Weather Observation in New

Zealand', in *New Zealand Weather and Climate*, ed. by B.J. Garnier (no place: New Zealand Geographical Society, 1950), pp.7-25.

[102] Roche, *History of Forestry*, pp.175-265.