

The socioeconomic dimensions of biosecurity: The New Zealand experience

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The human dimensions of biological invasions have recently become the subject of serious study. Current insight suggests that socioeconomic arrangements can foster or restrict the introduction of new species, and create the conditions for alien species to flourish or fail. Conversely, the human response to species invasions varies, according to the economic and environmental impacts of the invasion and the institutional frameworks of the human groups affected. Using the example of New Zealand, the authors chart changes in public perception of introduced species, and assess the socio-political responses to the ecological and economic consequences of introduced and invasive species. The study also outlines the organisational changes that evolved to combat invasive organisms, and suggests that cultural perceptions and socioeconomic experience of benefits and threats have been the prime determinants of public policy on biosecurity. The authors conclude that biosecurity policies in New Zealand are primarily the outcome of a complex history of European settler aspirations and concerns which attempt to reconcile the country's economic advantage, as a major agricultural exporter, with a desire to conserve its native flora and fauna as a hallmark of New Zealand's unique identity and image.

Keywords: Biosecurity; European settlement; Land cover change; New Zealand

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1. Introduction

Using New Zealand as a case study, this paper traces the socio-biological nexus of species invasions since European settlement in the first half of the 19th century. The authors trace the early history of species introductions into New Zealand, and outline their ecological and socio-economic consequences. We briefly trace the major institutional responses to different species from the early beginnings of European settlement to contemporary times. It is clear that the successful naturalisation of many new species went hand-in-hand with massive transformations of the indigenous land cover from one that was predominantly forest, to open landscapes of agriculture and exotic forestry. The transformations wrought by human colonisation created conditions that suited some new species but not others. Figure 1 provides a conceptual schema of the process charted in this paper.

Insert Figure 1 Responses of European settler society to the impacts of introduced species

The responses of European settlers to invasive species were broadly of two kinds: biosecurity protection, and conservationist measures. Biosecurity protection involved border control to prevent alien organisms from entering the country, and the control of established species that were deemed plant or animal pests. Conservationist responses included prohibitions against the harvest or hunting of specific native species and setting aside special areas for preservation of native species and their habitat (Young [1]; Galbreath [2]). While biosecurity responses to pests of agricultural consequence were swift, the response to species which threatened native flora and fauna was, until relatively recently, slower and more equivocal.

Ecologists have noted the costs of invasive species (Hobbs and Mooney, 2005; Mooney and Hobbs [4]; Pimental [5]; Schmitz and Simberloff [6]; Simberloff [7]). By contrast, the study of the socioeconomics of biological invasion is relatively more recent (Jay, Morad and Bell [8]; Robbins [9, 10]). In an articulate contribution, Robbins [10, p.139] argued, "It is not species but socio-biological networks that are invasive". By this, he means that human social relations and activities largely create the conditions for the invasion; and human perceptions of exotic species determine the social response to those organisms. He notes that ecologists have identified features characteristics of 'invasiveness' and the properties of ecosystems that make them 'invadable', but questions why human and social issues have taken longer to come to the forefront of research and policy agendas.

The social perceptions of an alien species (as desirable, undesirable, or neutral) determine whether its expansion will be harnessed, resisted, or ignored; the socio-political and ecological context of a species invasion invariably leads to different effects on people, animals and other plants. These may create "alliances" between invading species and various human and non-human actors in the socio-biological network (Robbins [10, p146]. Pointing to an earlier study by Crosby [11], Robbins agrees that the relatively rapid success of the colonisation process in New Zealand was caused in large part by an alliance of colonists with a suite of northern hemisphere species, and rapid transformation of the indigenous vegetation (from forest to a pastoral landscape). He suggests that by such practices as fire and landscape clearance, human activities are to blame for establishing the physical conditions for the introduction of many weed species, which compete against natives.

Political ecology and socioeconomic analyses provide a useful perspective from which to examine the human ecology of species invasion, because they seek to identify the social and political elements that structure the way different groups within society perceive introduced species. From this perspective, we can suggest that official responses to alien species will depend on the nature and degree of benefit or

threat posed by the alien invasive to dominant political interest groups. The example of New Zealand further suggests that cultural 'knowledge' and experience may have become equally important in shaping the human response to alien organisms.

2. Biosecurity and the socioeconomics of European settlement

Since the military and political defeat of indigenous Maori in the 19th century, European political and economic agendas have dominated New Zealand responses to introduced species. Maori have only recently become a significant voice in shaping conservationist policies (Morad and Jay [12]), and their input into biosecurity measures is yet to be realised (Jay et al. [8]).

The first permanent human settlement of New Zealand was by Polynesians (Maori) who arrived about 800 years ago (Taylor et al. [13]). They introduced the Polynesian dog, the Pacific rat or kiore (*Rattus exulans*), and a number of tropical plants which never significantly affected the native flora and fauna. However, using fire, they caused widespread destruction of native forest cover over the drier, eastern parts of the North and South Islands. By the time of European arrival in the late 18th – early 19th century almost all native forest on the eastern half of the South Island, and large areas of the North Island, had disappeared, and 34 species of endemic land birds had become extinct (Wilson [14]).

European settlement of New Zealand began after the signing of the Treaty of the Waitangi in 1840 between Maori chiefs and representatives of the British government. With the signing of the Treaty, European settlement (mainly British migrants) grew rapidly, from some 2,000 in 1840 to about half a million in 1881. By 1858, European settlers outnumbered indigenous Maori nearly 20 times (King [15]).

For the first few decades of colonisation, importation of plants and animals was uncontrolled. The settlers introduced most of the plants and animals familiar to them from the northern hemisphere. After visiting the Bay of Islands in 1835 Charles Darwin noted "every fruit and vegetable which England produces ... I may instance asparagus, kidney beans, cucumbers, rhubarb, apples, pears ... hops, gorse for fences ... English oaks [and] many kinds of flowers" (Darwin 1896, as cited by McDowall [16, p 6]). An early biologist, Thomas Kirk, estimated that new species introduced before the signing of the Treaty numbered no more than a few dozen; but by 1870 the number had climbed to 300 and by the 1930s to more than a thousand, two thirds of which arrived between 1851 and 1900 (King [15, p 194]).

The colonists' enthusiasm for ecological change was aided by an ideology of racial and evolutionary superiority. Many regarded the destruction of native forest and the decline of native plants and animals, like the decline of Maori in the face of European diseases, as a sign of Darwinian evolutionary superiority (Galbreath [17]; McDowall [16]; Young [1]). The early settlers were strongly infused with an ideology of empire and the notion that European civilisation represented the epitome of human progress. They invoked Darwinian notions of 'survival of the fittest' and considered that the replacement of native plants and animals with European exotics was a natural and inevitable process (Clayton [18]).

By the beginning of the 20th century, European settlers and accompanying plants and animals had transformed New Zealand into an ecological 'Neo-Europe' (Crosby, 1986). A number of 'acclimatisation societies' were formed, specifically to manage the introduction of new species (McDowall [16]). Apart from the species that were unintentionally introduced, such as the Norway rat and house mouse (*Mus musculus*), and species introduced for agriculture or horticulture, some species such as skylarks, blackbirds, and nightingales were introduced for sentimental reasons; while other species such as deer, grouse and partridge were introduced for symbolic and recreational reasons (Clout and Lowe [19]; Thomson [20]).

From the beginning of European settlement, the economy had been dependent on the earnings of its primary industries; and farmers, foresters, horticulturalists, gardeners and scientists continued to import new species on experimental, commercial or recreational grounds. However, the introduced species were not always linked to primary production, as many were for retail sale as garden ornamentals. According to Green [20] there are now some 25,000 exotic vascular plants in New Zealand, the vast majority (75%) brought in as garden plants.

The new species entered a land that was rapidly transformed from forest to open grassland. Figure 2 depicts the changes in land cover that have occurred over the period of European settlement. At the beginning of European settlement in 1840, about 53% of land area was forest covered (Memon and Wilson [21]). By 1990, only 23% of the land area remained forested. Almost all land below 300m altitude had been converted from native forest or wetland to introduced pasture. Lowland forest, coastal forest, coastal dunes, estuaries, and native freshwater habitats had disappeared or been seriously modified by human action.

Insert Figure 2 Land cover change, 1840 to 1990

The changing nature of travel and the expansion of foreign trade, particularly in the last quarter, brought about faster changes in the pattern of species introductions and in social attitudes towards introduced species. Until the middle of the 20th century close social and economic ties with the settler homeland meant that, the United Kingdom was a source of most of the early species introductions. Britain's entry into the European Union in the 1970s brought a re-direction of trade. By the 1990s Australia, the USA and Japan had overtaken Britain as trade partners. External trade links have continued to intensify and broaden, opening New Zealand to new sources of alien species. Table 1 shows the increase in value and shifts in origin of imports between 1994 and 2003.

Insert Table 1 Change in the value of imports to New Zealand, with country of origin, 1994 to 2003

Before the 1960s, travelling between New Zealand and the rest of the world was mainly by sea. Sea passage could take many weeks and provided a de facto period of isolation or quarantine for many potential invaders. This lowered the likelihood of unintended organisms surviving the journey. Since the 1960s, there has been a growing proportion of cargo brought in by air, and large increases in the number of travellers. Furthermore, since the mid 1970s and 1980s an increasing proportion of cargo enters the country in bulk containers. Alien organisms can enter the country either on the outside of the container (if there is soil or other high-risk material attached to the container) or inside as part of the cargo or packaging material. In the year to June 2004, New Zealand Quarantine services inspected 527,942 sea containers, 39,567 consignments of personal effects, and 192,074 used vehicles (Biosecurity Council [22]).

The introduction of new species into New Zealand through the 19th and 20th century involved a dynamic socioeconomic interplay between humans, economics and the natural environment. Several factors influenced this dynamic interplay including:

- The cultural origin of the settlers, who were predominantly British or Australian. Their choice of species was influenced by historical influences of the time (a widespread popular and scientific interest in the discoveries of empire, and a variety of utilitarian and non-utilitarian reasons).
- Technologies of travel and trade. In the 19th and early 20th century, travel to New Zealand was slow and expensive; exotic species intended for introduction often had to be carefully nurtured during the sea journey. In the

latter half of the 20th century, air travel and sea containers have revolutionised the speed and efficiency with which goods and people are moved around the world and made it easier for unintended organisms to hitchhike.

- Local and global economic forces. Globalisation means that New Zealand's trade links have widened so that the origin of goods coming into the country has greatly expanded. New Zealand experiences increasing trade with the countries of east and Southeast Asia.

3. The beginnings of biosecurity in New Zealand

Although the early European settlers were eager to experiment with introduced plants and animals, it soon became clear that there were risks involved in uncontrolled importation of plants and animals, and that a growing number of the new species were a mixed blessing. Many of the plants and animals that the settlers brought with them harboured undesirable diseases or parasites, which became acclimatised, and began a history of competition with native plants and animals.

The country's early leaders also realised that if New Zealand were to compete as a producer of agricultural products with countries such as Denmark, Canada, Australia and the United States, it had to ensure quality of produce, an important aspect of which was to control agricultural pests and diseases that might reduce the country's competitive advantage. For example, in 1892 the first minister of Agriculture was committed to the aims of 'fostering national prosperity through the provision of maximum government assistance to the dairying, sheep, grain and fruit industries on the one hand and all out effort to eradicate pests on the other' (Brooking [23, p 51]). During his term as minister, he introduced the 1893 Stock Act, by which quarantine became mandatory. The 1896 Orchard and Garden Pests Act sought to prevent the introduction of any 'plant, fungus, parasite, insect or any other thing which ... is likely to introduce any disease into the colony' (quoted by Brooking [23, p 36]). The 1900 Noxious Weeds Act gave government inspectors the right to fine farmers or seed firms who encouraged the spread of undesirable weeds.

The multiplication of rabbits throughout the drier parts of the South Island gave key impetus to the evolution of biosecurity in New Zealand. As early as 1876, there was pressure on government by the large estate-holders of the South Island to 'do something', and this prompted the *Rabbit Nuisance Act*, with further amendments in 1880, 1881 and 1882. The Act and amendments enabled rabbit boards to be created. Farmers were responsible for eradicating rabbits on their property but the boards could employ special purpose hunters. Farmers paid some of the costs but received a partial subsidy from the government. Between 1883 and 1897, stoats, weasels and ferrets were introduced to control rabbit population. They had only a minor effect on the rabbits, but catastrophic effects on native birds. Until the advent of the '1080' toxin in the middle of the 20th century, all efforts to eradicate rabbits failed.

The rabbit boards can be seen as forming the basis of a domestic biosecurity framework. Their role was widened in the 1960s when the Government made them responsible for all animal pests. Further development of the biosecurity framework continued on an ad hoc basis through most of the 20th century with the creation of special purpose noxious plants authorities and multiplication of pest destruction boards. In 1950, with a rural population of about half a million, New Zealand had 145 pest destruction boards, rising to 209 in 1960 (Memon [21]). Their existence and operation served to develop a social infrastructure of knowledge and experience about invasive species and a culture of biosecurity awareness. Furthermore, since plants and pests do not respect administrative boundaries, experience taught the noxious plants and pest destruction agencies that cross-boundary co-operation was necessary for effective control.

The biosecurity systems of the early and middle 20th century (border quarantine controls and weed control through government-subsidised measures) largely focused on threats to primary industry. They were the response of a society that was dependent on external trade in primary products. Agriculture was widely perceived as New Zealand's economic mainstay and politically 'farmers were kings' (Roche et al. [24]). Although many New Zealanders were aware of the drastic consequences of invasive species for native fauna and flora (Young [1]), there were no official attempts to restrict the inflow of species on specifically ecological or environmental grounds.

4. Modern biosecurity frameworks

The biosecurity framework of the 20th century was effective in limiting the introduction of economically important diseases; but by the late 20th and beginning 21st century, it was viewed as inefficient and insufficient. In part, this inadequacy was due to changes in the nature of travel, trade and transport technology; but was also increasingly spurred by a shift in cultural values within New Zealand society, which gave greater value to native fauna and flora as symbols of identity. These changes influenced the way that invasive species have come to be viewed and dealt with in 'postcolonial' New Zealand (Morad and Jay [25]).

The Biosecurity Act of 1993 prohibited the imports of any plants, plant products, animals and animal products to New Zealand unless an import health standard had been issued. The Act, which introduced the term 'biosecurity' into legislation for the first time, created a clear regulatory framework and formalised the division of responsibilities between central and regional government. With responsibility for the nation's external trade and foreign relations, central government retained pre-border and border biosecurity roles, while domestic weed and pest control were allocated to regional government. The legislation further provided for the creation of a Minister of Biosecurity, a central source of public funds, and the formation of a Biosecurity Council (Biosecurity Council [22]).

While the 1993 Biosecurity Act provided a legal framework for an overall biosecurity policy, with linkages between key agencies and institutions, the links remained relatively weak, particularly in relation to the prioritisation of pest surveillance and the funding of emergency eradication programmes. The Ministry of Agriculture and Forestry retained the most 'muscle' in practical terms because biosecurity sat functionally within it. The Ministry also retained responsibility for quarantine inspections at airports and seaports, and for the biosecurity regulations associated with imports and exports of goods. However, notwithstanding New Zealand's commitment to the World Trade Organisation's principles of free trade, the role of any New Zealand biosecurity authority is limited so long as the impact of invasions cannot be reduced by "tackling their economic externalities" (Perrings et al. [26, p 212]).

The institutional arrangements created by the legislation of the Biosecurity Act of 1993 allowed for faster and more efficient conduct of trade, but not effective control of environmental pests. Through the 19th and much of the 20th century, a focus on pests of agriculture, horticulture and forestry was consistent with broad societal attitudes of support for farming and the primary sector. Although most New Zealanders live in cities, the majority of them have friends or relatives living on farms, and are conscious of the country's economic dependence on agriculture and its green image. By the beginning of the 1970s, environmental issues had gained widespread recognition within New Zealand society and the environmental movement began to enjoy significant political support (Buhrs and Bartlett [27]). There had also been significant changes in the structure of the New Zealand economy

(such as growth in tourism), which shifted the balance of power from primary producers to urban policy makers.

Within this context of economic and social change, attitudes towards biosecurity and perceptions of invasive species also changed. A major report published by the Parliamentary Commissioner for the Environment (PCE [28]) was highly critical of the operational weight placed on economic objectives to the detriment of environmental objectives. It stated that New Zealand's biosecurity framework needed a set of clearly articulated directions, "particularly in relation to native flora and fauna, biodiversity, and ecosystem and public health" (PCE [28, p7]).

The government responded with a re-structuring of the biosecurity framework that was intended to address the concerns of environmentalists and others. The new arrangement creates greater integration of biosecurity functions and tighter responsibility for policy and operations although it remains under the Director General of Agriculture and Forestry. A new biosecurity strategic unit was created, together with a separate division within the Ministry, *Biosecurity New Zealand*. The strategic unit operates as an independent group providing strategic advice on the biosecurity system as a whole. It is intended to ensure that biosecurity operations take into account the full range of social, economic, cultural and environmental objectives (MAF [29]). Biosecurity New Zealand is the operational arm of central government machinery charged with standard setting and regulation and day-to-day operations (MAF [30]).

5. Conclusion

The New Zealand biosecurity experience is broadly consistent with the notion that the dynamics of inter-species and intra-societal responses often create socio-biological 'alliances' between invading species and various human and other institutional actors. For much of New Zealand's settler history, there has been relative consistency in attitudes toward introduced species: from an early eagerness to experiment with new species, to a growing realisation that introduced species could become harmful. For the most part, conflicts arise less from whether to control or eradicate pests so much as the methods to be used (e.g. aerial poisoning versus trapping).

The relative homogeneity of public attitudes in New Zealand towards introduced species is no doubt influenced by New Zealand's geographical isolation as cluster of islands nearly 2000kms from the nearest land mass. This pattern has allowed native flora and fauna to evolve very distinctive characteristics, and has provided a distinct demarcation of to their distribution. In addition, as New Zealand has become increasingly 'postcolonial' and more closely integrated into the globalised economy, it is increasingly common for New Zealanders to perceive their native fauna and flora as symbols of a distinct identity.

However, New Zealand's relations to introduced organisms have shifted over time, reflecting a complex interaction of cultural, economic and environmental factors and consequences. The nature of the species that were introduced, and the ways that they were subsequently managed, reflected cultural values and evolving political, economic and social conditions. At the beginning of European colonisation, settlers brought in a host of species that were thought necessary for the settlers' survival or pleasure; and the species they chose reflected the settlers' cultural background and knowledge. Moreover, a range of institutional and technological counter-measures were developed subsequently for organisms that challenged the interests of influential settler groups such as farmers and, later, environmentalists.

Organisationally, these biosecurity adjustments and control-measures evolved from 19th century ad hoc responses, through increasing border controls, co-ordination of weed and pest management, and centralising responsibility for

surveillance and incursion response, coupled with internal co-ordination of pest responses at regional and local levels. More and more, the counter to invasive species entails a wide-ranging response involving trade agreements with other countries (pre-border agreements and protocols) and co-operation between different departments of central and regional government.

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Table 1 Change in the value of imports to New Zealand, with country of origin, 1994 to 2003

	1994	2003	% change 1994-2003
	\$millions	\$millions	
Australia	3942	7278	85
USA	3,321	4067	22
Japan	2,928	3876	32
China	570	2687	371
Germany	807	1713	112
United Kingdom	1112	1120	.7
Taiwan	518	700	35
Malaysia	222	864	289
Italy	481	826	72
Korea	297	832	180
Other countries	4269	8196	92
Total	18467	32159	74

Source: Statistics, 2000 p. 531; 2004 p. 427.

Figure 1 Responses of European settler society to the impacts of introduced species.

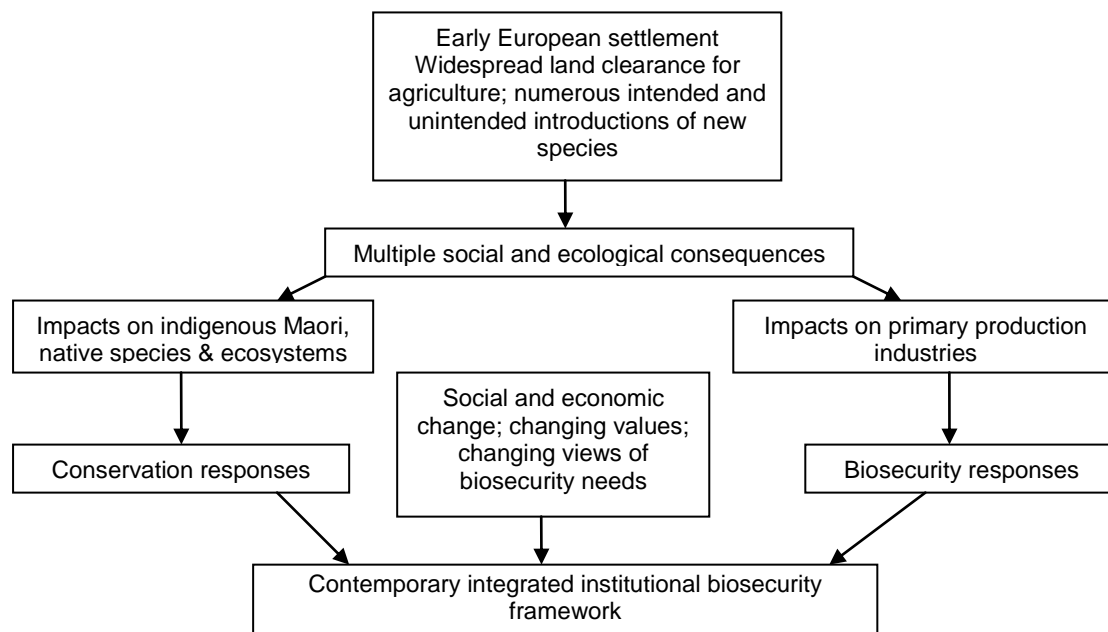


Figure 2 Land cover change, 1840 to 1990

