New Zealand biosecurity legislation and the naturalization of exotic weeds

Peter A. Williams[A], **Ian Popay**[B] and **Hazel A.W. Gatehouse**[C]
[A] Landcare Research, Private Bag 6, Nelson, New Zealand
[B] Department of Conservation, PO Box 112, Hamilton, New Zealand
[C] Bio-Protection Research Centre, Lincoln University, Lincoln, New Zealand.

Abstract

New Zealand biosecurity legislation is world renowned, yet we still have many naturalized weeds to control. We present an historical outline of the New Zealand plant biosecurity legislation and examine whether it might have had an effect on naturalization rates over the period of European occupation. We used a pool of 669 weeds, that is, species that are controlled in some way, classified as agricultural weeds, conservation weeds, or weeds common to both sectors. The arrival of agricultural weeds peaked before 1900 and most naturalized before 1950 so that the cumulative total has barely increased since the late 1900s. Until the early 1900s there were twice as many agricultural weeds as conservation weeds which were slower to naturalize, with a peak in the period 1941–1980. They are continuing to naturalize, primarily from horticulture, but the rate also appears to be slowing. While it is not the only cause, the legislation has probably contributed to these major differences between agricultural and conservation weeds. The longer the existing regulations governing the entry of new species continue to operate, the more pronounced the flattening of the naturalization curve is likely to be.

Introduction

New Zealand biosecurity legislation has an impressive international reputation. Nevertheless, authorities responsible for weed control in New Zealand still seem to be inundated by new weeds. We therefore investigated whether New Zealand legislation was actually having an effect on weed naturalizations; were we winning at least one battle (reducing naturalization) in the war against weeds (Hulme 2003)? What we found was a rare good news story which we present here, together with an historical outline of the legislation and its possible contribution to the naturalization of weeds.

Methods

We obtained lists of all the naturalized species from volumes 3–5 of the Flora of New Zealand and subsequent published additions (including both casual and fully naturalized species) (sources listed in Williams and Cameron 2005). These we divided into species controlled in one way or another by the Department of Conservation (Clayson Howell personal communication), termed conservation weeds, and those that were known by us to be controlled somewhere in the productive sector, urban gardening, public parks and gardens, transport corridors, or for human health reasons. These we termed agricultural weeds.

We classed the origin of these weeds as coming from accidental introductions, urban horticulture, or agriculture/forestry. The last group includes species both deliberately introduced, e.g. kiwi fruit (*Actinidia deliciosa*), and those dispersed as seed contaminants with agricultural crops.

For the summary of the legislation, we used our own knowledge and involvement in parts of the process.

Results

Naturalizations

From a world pool of about 260 000 species NZ has imported about 25 000 species, of which about 10%, or 2200, are casual in the wild or fully naturalized (Figure 1). This number of naturalized species now exceeds the number of native species. But these invasions are a staged process – not all species are at the same stage and relatively few have reached anything like their potential range, even at a provincial scale (Williams and Cameron 2005).

From this pool of naturalized species we considered 377 as agricultural weeds, 384 as conservation weeds, and 92 as common to both sectors, giving a total of 669. Thus, a third of all naturalized plants in New Zealand are controlled in some way.

The arrival of agricultural weeds peaked before 1900 (Figure 2), soon after the initial period of European colonization and land clearance, and most naturalized before 1950. The cumulative total has been fairly constant since the late 1900s (Figure 2). Until the early 1900s there were twice as many agricultural weeds as conservation weeds (Figure 2). Conservation weeds were slower to naturalize, with a peak in the period 1941–1980 (Figure 3). They are continuing to naturalize but the rate is beginning to slow also (Figure 3).

Turning to the mode of introduction, agricultural weeds arrived primarily by accident, often as contaminants. Horticulture contributed the second most important tranche, while some agriculture plants have also become weeds (Figure 4). Conservation weeds derived primarily from horticulture, almost from the beginning, and this trend has continued to the present day (Figure 5).

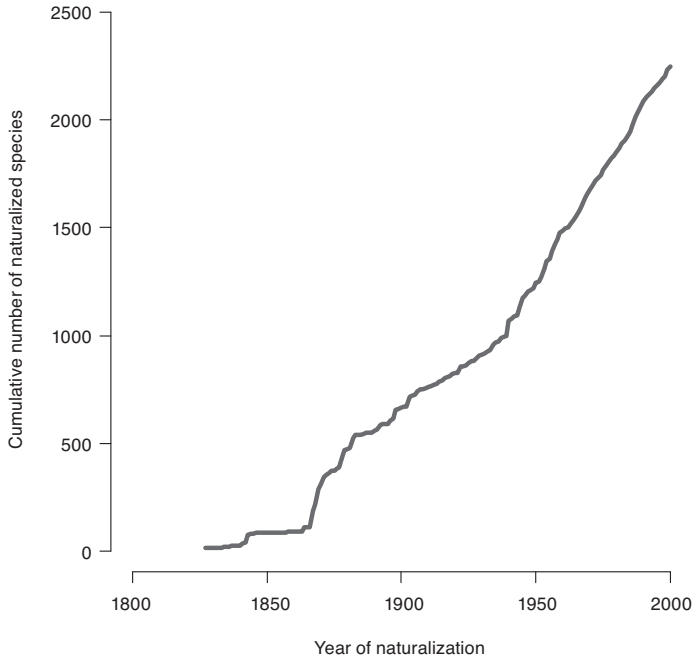

Figure 1. Cumulative number over time of all naturalized plants in New Zealand.

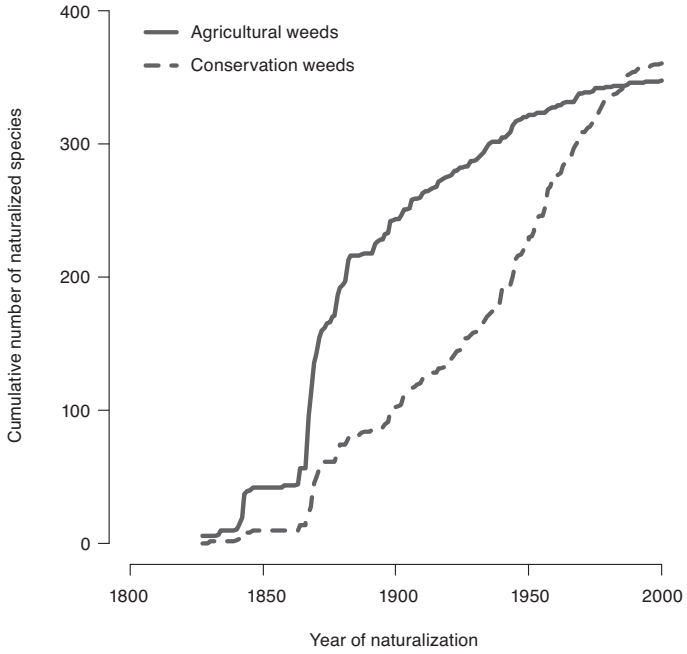

Figure 2. Cumulative number over time of all agricultural weeds (upper) and conservation weeds (lower) in New Zealand.

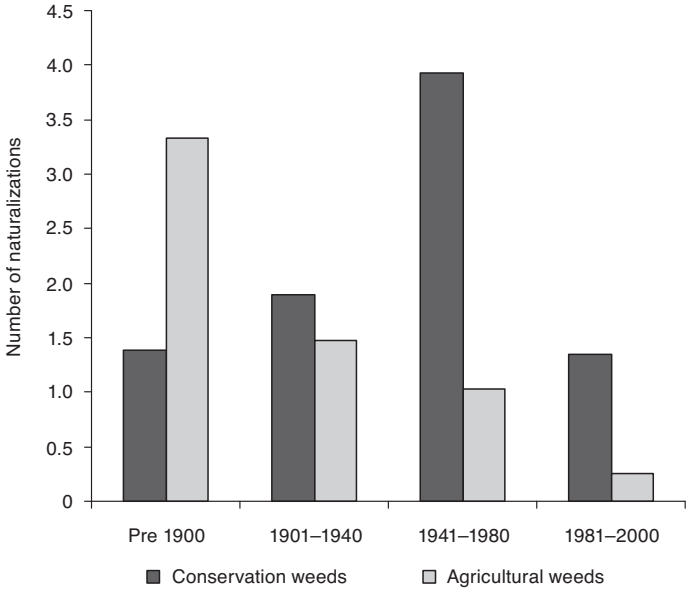

Figure 3. Mean number of conservation weeds (left) and agricultural weeds (right) naturalizing per year for four periods.

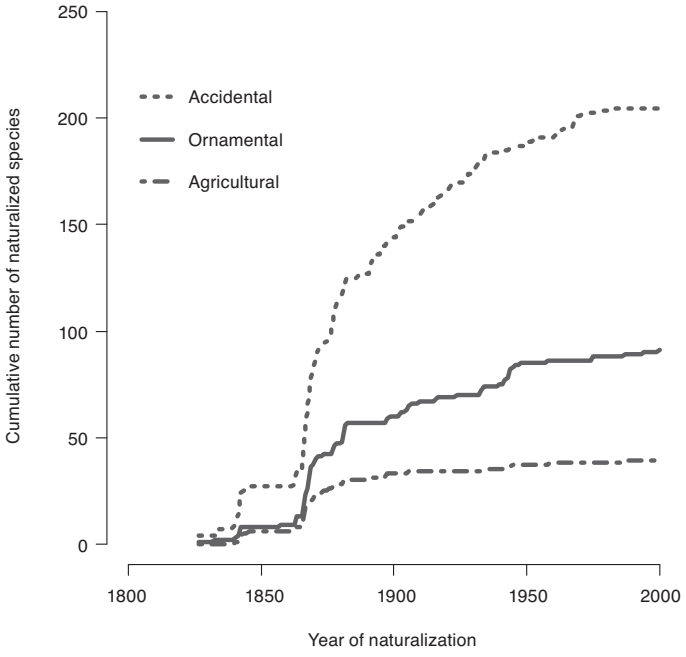

Figure 4. The accumulated number over time of agricultural weeds derived from three modes of introduction: accidental (upper), ornamental (middle), and agricultural (lower).

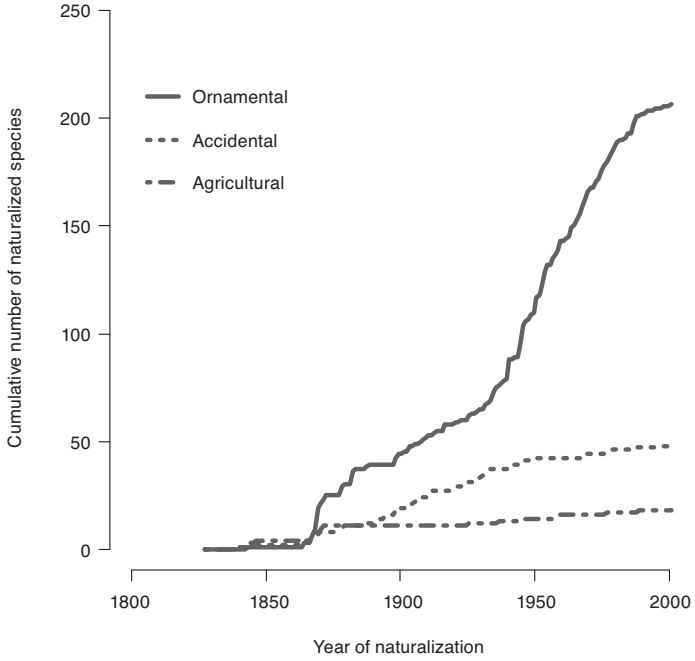

Figure 5. The accumulated number over time of conservation weeds derived from three modes of introduction: ornamental (upper), accidental (middle), and agricultural (lower).

Legislation

The Control of Thistles Act 1854 was enacted only 14 years after Britain was given authority to govern the country by the indigenous Maori. This legislation, and much that followed soon after, was targeted at individual species and aimed at stopping the spread of weeds to neighbours. Thistles were obviously recognized as serious, or potentially serious, problems from a very early stage.

The first comprehensive legislation, the Noxious Weeds Act 1900, dealt with a wider range of species. Three weeds – Canadian or Californian thistle (then *Cnicus arvensis*, now *Cirsium arvense*), blackberry (*Rubus fruticosus*), and sweet-briar (*Rosa rubiginosa*) – had to be controlled everywhere. Territorial authorities were given powers to declare up to a further 12 species, or groups of species (thistles),

as noxious in defined areas. Further species were subsequently added in gazette notices and other Acts. All these enactments were brought together in the Noxious Weeds Act 1950, which, critically, gave Government subsidies that made it attractive enough for most landowners to become involved. While all this early legislation was not aimed specifically at preventing the introduction of potential new naturalizations, it laid the foundation for what much later became more broadly expressed as 'biosecurity' and the operation of tight border controls. These were to some extent in operation nevertheless, because seed testing at the border began as early as 1895, and a specialist laboratory was established in 1910. By 1950 this was dealing with 33 000 samples annually. These tests were primarily for germinability, but the facilities were utilized for screening for impurities both in exports and imports and this was supported by strong legislation. Arthur Healy, in the position of Assistant Director of the Botany Division of the Department of Scientific and Industrial Research from 1949 to his retirement in 1977, warned of the dangers of importing plants likely to become weedy. He was required to comment on lists of requested plant imports sent to the Department of Agriculture, and also investigated the methods by which seeds and fruit of weeds entered New Zealand by accident – on clothing or footwear, in agricultural produce and in military equipment imported from the Pacific war theatre.

The ethos to protect the natural lands was accentuated by the Reserves Act 1977 which formally extended the pre-eminent role of native biota over about 34% of New Zealand held by the Crown as conservation land. In this Act, 'Exotic flora and fauna shall as far as possible be exterminated.' This has been the mandate for strong weed control strategies on public lands which was further extended by other conservation orientated legislation. This legislation also does not aim specifically at naturalization, but it illustrates the country's priorities and has made it possible for biological conservation interests to be directly involved in screening potential new imports.

While much of the earlier noxious plants legislation was confined to empowering local authorities, the Noxious Plants Act 1978 established a National Noxious Plants Council. This was technically well supported and responsible for deciding whether plants nominated by local committees were to be declared noxious. The council developed innovative classification and mapping schemes, distributed central Government subsidies for weed control (exclusively agricultural weeds, although some, like blackberry, caused problems on conservation land) and established training programmes for noxious plants officers. In 1982, still well before the current world wide concern in science circles for 'invasive species' (Richardson and Pyšek 2008), an amendment made it illegal to sell or distribute noxious plants. Again, the plants dealt with were mostly already in the country, but it was also possible to prevent the importation of new species which were similar to existing weeds and extremely likely to be invasive, such as *Cirsium* species for the cut flower trade. It also helped reduce the spread of aquatic weeds which affected agriculture (and power generation) by impeding water flows in lakes, dams, irrigation ditches and farm drains.

In October 1993 the Biosecurity Act restated and reformed the law relating to the exclusion, eradication and effective management of all 'pests' and 'unwanted organisms'. It replaced some 28 enactments including the Noxious Plants Act and the Agricultural Pests Destruction Act. Under this new legislation each regional council was required to develop a five-year strategy for 'pest plants' through a public consultative process. New horticultural plants could still be imported, provided they were free of disease and not obviously potential agricultural weeds.

This door was finally closed by the Hazardous Substances and New Organisms Act 1996 (HSNO Act 1996) that made it illegal to import any new organism or hazardous substance without authority. Applications for plant imports under this process are very time consuming and expensive for would-be importers which acts a disincentive to making an application. Consequently, we have little idea as to what would have been brought in had the legislation not been in place. The only formal application to be declined was for 11 species of *Agathis* (http://www.ermanz.govt.nz). Successful applications for importation and release in the last decade all have only a remote chance of naturalizing, i.e. 25 species in the genera *Clivia*, *Dictyocaryum*, *Encephalartos*, *Xanthorrhoea*, and a (sterile) *Miscanthus* × *giganteus* species.

Finally, in 2001, a voluntary agreement between the Nursery and Garden Industry Association, regional councils and government departments with biosecurity responsibilities established the National Pest Plant Accord. This has now classified some 200 existing horticultural species as 'unwanted organisms' under the Biosecurity Act 1993. These plants cannot be legally sold, propagated, or distributed in New Zealand. Most of these are in addition to the lists of 'pest plants', controlled by regional councils under their Regional Pest Management strategies, and many are controlled by the Department of Conservation on land it looks after for the nation. This NPPA agreement too, is aimed primarily at existing species but it has the potential to slow the transition of some species from being simply naturalized, to problematic status. The agreement is reviewed and updated regularly, with new species added after approval by both a technical committee and a steering committee of the interested parties.

Discussion and conclusions

Three main factors have contributed to the particularly unique New Zealand approach to weed invasions. Firstly, it was the last major landmass to be colonized by humans, about 1000 years ago by Polynesians. These Pacific peoples brought no plants that are now considered weeds (Williams and Cameron 2005). Europeans arrived only about 250 years ago to a land virtually untouched by plants from the Old World or anywhere else. The distinction between native species and exotic species, which became weeds, was very obvious from the outset. As a consequence, New Zealand was half a century ahead of every other country in the world in compiling 'the facts regarding the first introduction of every species into the country' (Thomson 1922). Moreover, pride in the distinctiveness of native flora and fauna, in contrast to the introduced, was a powerful force in preserving indigenous nature. Secondly, from the outset the country was, and still is, dependant on agriculture exports (ironically, based almost entirely on introduced species of plants and animals). These products are far from international markets, but the systems that produce them are also very distant from weed sources. The farming community is well educated by international standards and highly politicized. Right up until the end of the 20th century, the national politic was dominated by farmers and their interests. Thirdly, many farmers were aware from the outset of the importance of biosecurity, although it wasn't called that until recently. This resulted in legislation aimed primarily at the weeds of agriculture. Legislation concerning potential or actual weeds of conservation land built on this foundation.

The early legislation ensured the flow of contaminants into and within the country, for example, was greatly reduced, and the importation of obvious agricultural weeds prohibited. As a result, the naturalization of new agricultural weeds all but ceased. Just recently, Bourdot *et al.* (2007), in a summary of pastoral weeds in New Zealand, used the gross annual naturalization rate of exotic plants in New Zealand to raise the issue of potential pastoral weeds. However, they mention no species naturalized within the last 20 years that are likely to become weeds of pastoral farming. They do give examples of 'sleeper weeds' (Groves 1999) that might yet become problems (we do not deny

this) but some of these (mostly *Centaurea* species) arrived over 100 years ago (Webb *et al.* 1988). Some long naturalized tropical and sub-tropical grasses, e.g. *Pennisetum clandistinum*, that are also in this category, have started spreading more rapidly only in the last 50 years, suggesting perhaps a climate more amenable to invasion by warm-zone plants (Field and Forde 1990).

Aside from pastoral land, there are many weeds of arable land that might not have been included in the discussion of Bourdot *et al.* (2007). This land was included within the land cover category of 'grasslands and herbfields' by Williams and Cameron (2005). It contributed only 8% of the 267 new naturalizations between 1989 and 2000. Even using the 'tens rule' (Williamson 1996) as an indication, only two of these are likely to become weeds of economic importance; less than one a decade.

Legislation aimed at conserving indigenous biodiversity and landscapes has essentially ridden on the coat-tails of the foundation laid by agricultural and human health interests. But plant import legislation aimed directly at this was enacted much later, as we have explained. Consequently the inflow of horticultural plants continued right up until the HSNO Act 1996; imported plants had only to be free of diseases. It is from this large pool of already present species that new weeds of conservation are naturalizing. Although the size of the pool is often quoted as being in the order of 25 000, the number of species with even a remote chance of naturalizing is very much smaller. For example, none of the 1800 species of orchids and 800 bromeliads have naturalized in New Zealand (Duncan and Williams 2002). Because of the HSNO act, only similarly benign species, or those with an extremely low probability of becoming weeds, are likely to be legally imported.

Neither the decline in naturalization rates shown here, nor the difference in agricultural and conservation weed naturalizations, can be attributed to a single cause. The cumulative effect of New Zealand's biosecurity legislation is one reason, and we would not expect to relate changes in naturalization rates to specific pieces of legislation, in part because of the long time lags involved. Declining naturalization rates in recent decades, especially of agricultural weeds, may also be attributed to the fact that the majority of temperate weeds suitable to New Zealand climates had already been imported by the middle of last century. For example, the mean introduction time for *Trifolium* spp. for commercial sowing was 1881 ±11 and for experimental planting, 1964 ±3 (Graveur *et al*. 2008). Potential weeds of tropical origin that were introduced into New Zealand were less likely to naturalize than in Australia (Diez *et al*. 2009). Nevertheless, introduction pressure from tropical Asia is increasing, as indicated by the seizures at the border of such things as culinary herbs (Williams *et al*. 2001).

Another contributing factor is that agricultural systems are now much more intensively managed than they were before the advent of modern farming technologies. Such intensive management has not been applied to the large areas of roadsides, forest edges, cliffs and 'waste places', where conservation weeds have naturalized. This contrast tends to increase the likelihood of a species becoming a conservation weed. Furthermore, conservationists are more likely to consider a 'new' exotic plant a weed than are agriculturalists (Pheloung *et al*. 1999). We also believe that conservation interests are more likely to report new naturalizations to the authorities simply because native plants are their focus: agricultural interests are focused on production from the land and are concerned about a new weed only when it seems to be interfering with that production.

Whatever the precise apportionment between the many factors involved, there has been a dramatic decline in the naturalization rate of agricultural weeds in New Zealand and possibly a slight decline in that of conservation weeds. This can only be good news, and we believe it is largely because of our biosecurity legislation and the good efforts of many people putting it into practice. The longer the existing regulations governing the entry of new species continue to operate, the more pronounced the flattening of the naturalization curve is likely to be.

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