Ecology and management of invasive weeds

CONSERVATION SCIENCES PUBLICATION NO. 7

Department of Conservation
Te Papa Atawhai

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Peter A. Williams

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Department of Conservation
PO Box 10-420
Wellington, New Zealand

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Cover photograph: Volunteers in a Department of Conservation weed control programme at Whitiau Scientific Reserve pull out and discard pink ragwort plants (*Senecio glastifolius*) before they can set seed. Reproduced by kind permission of the *Wanganui Chronicle*.

ISSN 0113-3691
ISBN 0-478-01956-4

This publication originated from work done under Department of Conservation contract 1971, carried out by Peter A. Williams, Manaaki Whenua-Landcare Research, Private Bag 6, Nelson. It was approved for publication by the Director, Science and Research Division, Department of Conservation, Wellington.

Cataloguing-in-Publication data

Williams, P. A. (Peter Arthur), 1945-
Ecology and management of invasive weeds / Peter A. Williams. Wellington, N.Z. : Dept. of Conservation, 1997.
1 v. ; 30 cm. (Conservation sciences publication, 0113-3691 ; 7.)
Includes bibliographical references.
ISBN 0478019564
1. Weeds–Ecology. 2. Weeds–Management. 3. Weeds–Control–New Zealand. I. Title. II. Series: Conservation sciences publication ; 7.
581.6520993 20
zbn97-100716

CONTENTS

Abstract

The report provides an understanding of the overall nature of weeds, their relationship with the native vegetation, and the importance of weed biology when considering control measures. The life modes of weeds, e.g. perennial herbs, iris-like herbs, trees, and vines, are described, together with their dispersal modes, including vegetative reproduction systems, their ecology, and impacts. Weed invasion patterns through time and space are related to six post-migration phases. These in turn are related to the changing opportunities for control, and their relative costs. The relationship between weeds and several broad vegetation structural classes are discussed to emphasise the invadability by different weed life modes of these classes. This leads on to a discussion of the opportunities and limitations of using vegetation succession as an approach to weed control. Weed control is discussed in terms of a species-led strategy, where the emphasis is placed on controlling individual weed species, and a site-led strategy, where the values of the area being protected are paramount. The required change in emphasis between these two strategies, as weeds progress through their invasion phases, is discussed. Weed control tactics are outlined for the different weed life modes, and the need to consider weed biology and ecology is emphasised. Finally, two composite examples of priority setting of site-led weed control strategies, in two different reserves, are given. An appendix summarising the biology, distribution, ecology, and impacts of 160 weeds is included.

1. Introduction

There are about 240 naturalised plant species recognised by the Department of Conservation primarily for their potential as ecological weeds. In some places, several dozen invasive weeds grow on the same site, resulting in complex interactions of weeds and their environment, and difficulties in prioritising weed control. There are two complementary and interrelated approaches to prioritising the control of environmental weeds. The top down approach begins with the strategic plan for the management of plant pests prepared by individual conservancies, while the bottom up approach uses an understanding of an individual weed species. There is comprehensive information on preparing plans (Owen 1996), and many good regional plans already exist. There are also individual summaries of the biology, ecology, and control of 60 weed species (Timmins & Mackenzie 1995). The following account contributes towards an understanding of the overall nature of weeds, their relationship with the native vegetation, in successional processes for example, and the importance of weed biology when considering control measures.

Weediness is a concept which emerges only where plants, the environment, and human interests meet.

In this account, the term weed refers only to introduced plants, i.e., non-native plants that diminish the natural values of the area being invaded. Weeds interact with native ecosystems in many ways, some of which are barely understood, and there can be an expectation that these impacts may change with time. Weeds influence the species composition and structure of vegetation, the flow of energy and nutrients between the vegetation and the soil, and the susceptibility of the vegetation to disturbances such as fire and grazing. In doing so, they influence the way native and introduced animals use the vegetation for food, shelter, and for breeding.

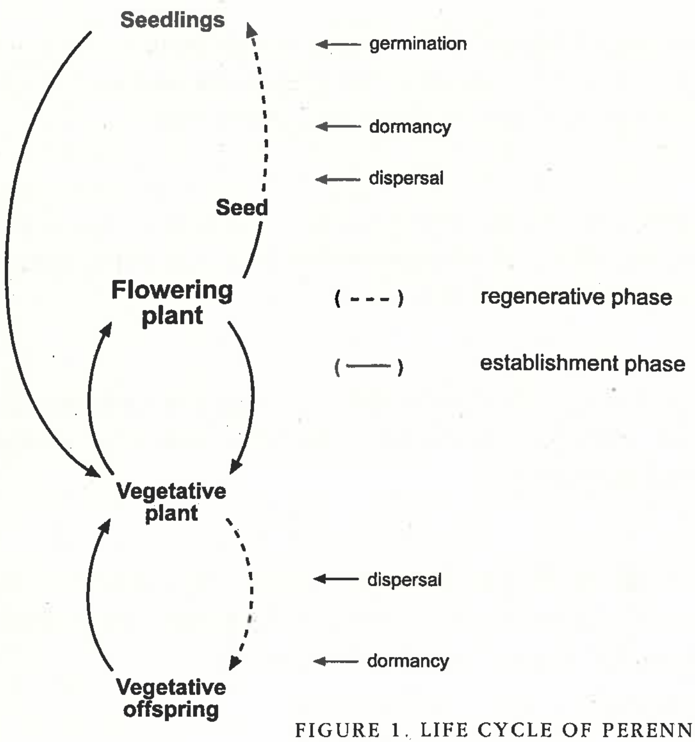
On the conservation estate, weeds need to be controlled for other reasons, such as keeping tracks clear, or improving the health of humans or domestic stock, but in these circumstances, management imperatives are generally immediate and straightforward. Certain plants which have their weed status defined in law may have to be controlled to comply with the legislation. None of these situations are considered here, when discussing priorities for weed control by the Department of Conservation, although their importance is acknowledged. The emphasis in this account is on terrestrial weeds, because the management of water weeds is a topic in its own right.

Both the plant and the vegetation features must be considered when assessing degree of weediness, because weeds are only such in specific vegetation contexts. Of particular relevance are the weeds' life mode, and the structure and successional status of the vegetation being invaded. This information needs to be assembled for all the weeds of a particular area prior to the development of an overall strategy and the deployment of specific tactics for individual weeds.

This account is based on a large amount of written material and information from many people. In the interests of readability, references to individual scources are seldom made, but some general references are included in Section 9, Bibliography. Formal names to weeds are given in Section 10.1.

2. Life modes

The concept of life modes was developed by Esler (1988) to describe the many forms of plant life, taking into consideration their growth habit, their manner of reproduction and spread, and their interaction with other plants and the environment. The concept of life modes embraces many familiar terms such as **trees**, which have sufficient woody tissue to form trunks, and **herbs** which lack woody tissue. Some life modes present in the weed flora are absent or uncommon amongst the native flora, e.g. large nitrogen-fixing herbs, and conifers with wind-blown seed. Their absence makes native communities vulnerable to invasion from such life modes. The life mode of a weed also has implications as to its likely effects on natural values and the possibilities of it being controlled.



The life cycle of a plant is the most important factor determining its life mode. Plants have distinctive periods when they are either established or actively regenerating, and periods where they are dormant and or being dispersed. Plants which complete their life cycle in one or two years are annuals or biennials whereas those that persist for longer are perennials. Figure 1 shows these phases for a perennial plant such as climbing dock, which has well developed vegetative parts underground and also produces prolific seeds. An understanding of these aspects of a plant's life cycle, and their relative contribution to its dispersal, establishment, and persistence at a site, are critical for successful weed control.

FIGURE 1. LIFE CYCLE OF PERENNIAL PLANTS PRODUCING BOTH SEEDS AND VEGETATIVE OFFSPRING, e.g. CLIMBING DOCK.

2.1 ANNUAL AND BIENNIAL HERBS

Annual herbs are among the most abundant weeds in the world, e.g. garden chickweed (*Stellaria media*), but they are insignificant in the list of the problem weeds of conservation lands. They germinate in spring or autumn and are gone by the following spring when the next generation may establish. If the ground is not disturbed they are usually followed by herbaceous perennials.

2.2 PERENNIAL HERBS

These are plants living for at least two years which do not develop aerial woody tissue to any great extent, while at the ground surface or just below, there may be massive volumes of plant material (e.g. pampas grass, wild ginger). Some perennials develop extended vertical stems, but these are short-lived, usually only for one year (e.g. hemlock). Individual plants can develop from seeds, or from new pieces of the parent plant, termed clones. As the buds of perennials usually lie close to the ground surface, at least in the spring, they are protected from stress (e.g. drought), or disturbance (e.g. fire, grazing) and other damage. Most are summer-green, but a few die back in late summer (e.g. three-cornered garlic).

The perennial herbaceous weeds can be grouped into the following six life mode classes, and also herbaceous vines, which are mentioned in the next section.

Erect or tufted herbs

These are self-supporting branching herbs forming woody tissue up to 2 m tall (e.g. Russell lupin, mist flower). They all resprout from the base after the first year, but they have a range of vegetative forms of reproduction.

Mat-forming herbs

These are multi-stemmed herbs that sprawl laterally, sometimes rooting at the tips (e.g. wandering Jew, lotus). Their main form of vegetative reproduction is via creeping above-ground stems (see below).

Iris-like herbs

These have strap-like leaves. Most are leafless for a period each year (e.g. watsonia, montbretia). Most have rhizomes, either with corms (e.g. watsonia, montbretia) or without (stinking iris).

Lily-like herbs

Fleshy leaved, often large herbs with spikes of berries (e.g. arum lily). Most have very fleshy roots (e.g. arum lily), rhizomes (e.g. agapanthus) or bulbs (e.g. wild onion), which can develop to a considerable biomass.

Grasses and grass-like herbs

These have thin, mostly narrow, leaves and basal sheaths, and most are evergreen. They range from tall tufted grasses (e.g. pampas grass) to creeping short grasses (e.g. browntop), and include the leafy rushes (e.g. *Juncus tenuis*). Most produce prolific seed, but vegetative reproduction is frequently by rhizomes (e.g. kikuyu grass) or creeping stems (e.g. browntop).

Rushes and rush-like herbs

A broad group of upright plants with tightly packed, stiff, upright cylindrical leaves, arising from underground rhizomes. Most produce prolific seed. Spread is also via clumps that become independent through decay of the connecting tissue.

Reproduction

The diversity of above-ground parts in perennial herbs is matched by an equal diversity in the combinations of below-ground organs and sexual reproduction methods. These greatly influence the resistance to control and persistence of the species.

Creeping above-ground stems

These are stems, often called stolons, which advance above or at the ground surface, and root at intervals. They often spread laterally to form a dense mat (e.g. kikuyu grass, wandering Jew). Most plants with this attribute also reproduce by seed, with wandering Jew a notable exception.

Rhizomes

These swollen underground stems produce new shoots and roots by extending horizontally, sometimes very rapidly. Rhizomes can be a massive proportion of the whole plant and provide food reserves if the tops are damaged. They do not necessarily contribute to the spread of the plants unless they are broken up and dispersed. Most plants with rhizomes also produce seeds, with exceptions such as yellow ginger.

Corms and bulbs

These are swollen stems (corms) or leaf bases (bulbs) formed mostly underground, but occasionally above ground (e.g. watsonia). New propagules, which are produced each year, detach from the parent organ and are readily dispersed, especially those produced above ground. Most plants with corms and bulbs also produce seeds.

Tubers

These swollen rhizomes or roots are often deeper in the soil than other vegetative organs. They are less readily dispersed than some other vegetative organs, which contributes to their persistence (e.g. climbing asparagus and climbing dock). Most tuberous plants also reproduce by seed, as does the familiar potato. Sometimes tubers are produced on stems, as swollen stem portions which break off and disperse by gravity. They are highly resistant to herbicides (e.g. Madeira vine).

Tillers

These are shoots produced on non-creeping above-ground stems at the bases of grasses and rushes. They form their own roots and may sometimes eventually break off to develop into new individuals. Most tillering plants also produce abundant seed (e.g. browntop, pampas). Two of the three species of spartina (the hybrid *Spartina* x *townsendii* and the American *S. alterniflora*) are notable exceptions.

Ecology and impact

Herbaceous perennials affect conservation values mainly by preventing the regeneration of native plants in habitats such as grasslands, openlands, forests, and the margins of water bodies. They are favoured greatly by disturbances that reduce competition from woody plants and, in many cases, distribute the propagules, e.g. flooding. Herbaceous perennials are often only temporary as they are replaced over time by more substantial growth forms. This process may take a considerable time, for example where herbaceous perennials invade short vegetation such as native grassland (e.g. hawkweed), or forest floors (e.g. wandering Jew).

The largest perennial herbs (e.g. pampas, wild ginger) are often major weeds of scrub and forest margins, where they can dominate the vegetation for long undefined periods of time, possibly decades.

As herbaceous perennials often form a dense cover to the exclusion of all other species, their removal creates large areas of bare ground. In these high-light environments, the site becomes vulnerable to re-invasion, either from buried seed or newly arrived seed of these or other weed species.

2.3 FERNS AND FERN-LIKE PLANTS

There are three terrestrial weedy ferns. The upright royal fern and tuber sword fern both grow from vigorous above-ground or underground rhizomes to form dense stands up to 1 m high. These are very difficult to remove. The prostrate creeping selaginella and horsetail are fern allies which grow from underground rhizomes. These plants reproduce by wind-blown spores.

2.4 VINES

Weedy vines include soft perennial herbs (e.g. convolvulus), perennial woody herbs (e.g. German ivy), or long-lived woody plants (e.g. old man's beard). They have a wide variety of branching patterns and climbing mechanisms, i.e. stem tendrils (passionfruit species), root suckers (ivy), twining stems (smilax), twining petioles (old man's beard) and hooked thorns (blackberry), and this influences the kind of support they use and their efficiency at finding it.

Reproduction

Most vines produce seed, dispersed either by wind or animals, including birds. Most also reproduce vegetatively, particularly by stem fragments or more specialised organs such as tubers. There are important differences between species in their reproductive vigour, and this influences their degree of threat. Wonga wonga vine, for example, reproduces primarily vegetatively and spreads very slowly. At the other extreme, the fruit of banana passionfruit is sometimes thrown from the windows of vehicles on to roadsides, where young plants readily establish.

Ecology and impact

Vines are mostly forest margin or scrub plants with high light requirements, particularly at the seedling stage. However, they vary in this respect, and those with perhaps relatively lower light requirements are able to penetrate into damaged forest, particularly where the understorey is very sparse (e.g. climbing asparagus, old man's beard).

Vines are the *bête noire* of shrubby vegetation because they rely on other plants for support, and ultimately suppress them. Some do this by strangulation (e.g. climbing asparagus), but most simply cover the canopy of their hosts by various means of attachment and deny them light. In some cases they may produce such a weight of foliage that they break branches off their hosts and eventually crush them (e.g. old man's beard and banana passionfruit). Apart from these initial smothering actions, vines also prevent the establishment of woody seedlings beneath their very dense canopies, especially once the original vegetation has collapsed.

Many vines are newly invasive in New Zealand and their long-term impacts cannot readily be determined.

2.5 TREES AND SHRUBS

The critical aspects of these life forms are their maximum size, growth rate, and longevity.

Small shrubs

Esler (1988) described several forms of low shrubs, but here they are combined. These are mostly less than 3 m in height, with a few individuals or stands reaching a maximum of 5 m. They often have shoots arising from their bases or below ground (e.g. Spanish heath, sweet brier); most have the capacity to resprout from the base (e.g. gorse). They branch low on the main stem, producing weak interlacing branches (e.g. Himalayan honeysuckle, tree lupin, lantana) or rigid and spreading branches (e.g. heather, Spanish heath). Some shrubs are relatively open (e.g. brier) but most produce a crowded mass of branches limiting light levels at ground level. Most small shrubs live for up to 20 years.

Tall shrubs

Tall shrubs are usually 3-5 m in height and up to 20 cm stem diameter at c. 1 m above ground level. They often form impenetrable thickets in their early years with effects similar to small shrubs. In later stages one can almost walk beneath their canopies, and sub-canopy light levels increase (e.g. gorse, needle-leaved hakea).

They live for as little as 15 to 20 years (e.g., broom, buddleia) to as long as 30 years (e.g. evergreen buckthorn, cotoneaster).

Small trees

In contrast to shrubs, small trees become single-leadered at an early stage, to produce stems up to 6 m tall and often greater than 20 cm diameter at c. 1 m. Because the lower stems become clear of branches, there is a chance of greater light reaching the ground, and it is often possible to walk beneath the canopy. This space frequently becomes occupied by a sparse sub-canopy layer of shrubs and/or ferns during the later stages of the canopy tree's life (e.g. willow-leaved hakea).

The fastest growing small trees (e.g. brush wattle, woolly nightshade) may live for only 20 years, while many small trees live for 30 to 50 years.

Medium trees

These are trees up to 10 m tall which are capable of forming a distinct forest (e.g. wattle species, grey willow). Their greater height often allows a substantial sub-canopy shrub layer to develop, which may remain until the collapse of the canopy.

Some medium trees live for as little as 30 years (e.g. Sydney golden wattle, silver wattle) and some as long as 100 years in certain circumstances (e.g. hawthorn, elderberry). The longevity of many medium trees has not yet been determined in New Zealand.

Tall trees

Trees more than 10 m tall are not common as weeds, but there are several spectacularly successful examples, such as crack willow, sycamore, tree privet and radiata pine. Once established, tall trees can initially exclude all native plants, especially where they invade in herbaceous vegetation such as tussockland. As with medium trees, once a sub-canopy space has developed beneath such species as radiata pine and gums, woody weeds (e.g. Himalayan honeysuckle) or native plants, including ferns, often establish. However, the future outcome of such vegetation, or its effects on the soil, are unknown, because the canopy weeds live for more than 100 years.

Reproduction

Most shrubs and trees reproduce from seed. Seed output and dispersal efficiency varies greatly between species; seeds are mostly dispersed either by wind (e.g. pines, sycamore) or animals (e.g. hawthorn, monkey apple). A few species reproduce only vegetatively, by suckers or stem fragments (e.g. crack willow), and some spread by both seed and vegetative means (e.g. poplars, Khasia berry).

Many shrubs and trees resprout from the base as both root suckers (e.g. sweet brier) and stem suckers (e.g. hawthorn, contorta pine), or from fallen branches (e.g. crack willow), which increases their persistence at the site. Coral tree, a northern adventive not yet recognised as a problem weed on conservation land, has a remarkable ability to regenerate from cut branches, even in mangrove (*Avicennia resinifera*) swamps.

Ecology and impact

Shrubs and trees of every size and shape occupy a very wide range of habitats. They colonise bare ground and also occupy the understorey of damaged native forest. Some species are encouraged by soil disturbance, because it activates the germination of buried seed (e.g. gorse, broom) or creates a more favourable environment for seedlings (e.g. wattles). Others are able to occupy ground that has only a minimal amount of disturbance (e.g. hawthorn, Darwin's barberry, Khasia berry, and many other bird-dispersed species).

Shrubs and trees completely alter the composition and structure of the vegetation by preventing native species from occupying the sites or else by replacing them. This has a wide range of effects on the native biota. For example, recent work in Nelson has shown that some adventive species (e.g. hawthorn, barberry) produce fruit that is avoided by native birds (bellbirds, tuis) but favoured by adventive birds, particularly blackbirds and thrushes. These birds then spread these weeds further and so make even more habitat less suited to certain native birds.

The actual impact of weedy trees and shrubs is very dependent on the nature of the vegetation being invaded, and this is discussed in the section on vegetation structure and succession.

3. Dispersal

3.1 DISPERSAL MECHANISMS

Most environmental weeds originally derive from horticulture, including urban gardening, and forestry. Their primary dispersal mechanism within New Zealand has been to be purposefully transported about by humans for whatever use they were intended. Once established in a new situation, these plants are dispersed by a wider range of mechanisms.

Propagules may be dispersed by: wind; internally or externally by birds and mammals; by water either as floating seeds or carried within the water body; by humans via rubbish dumping; or by no obvious means (unspecialised). Clones generally have no obvious means of dispersal (Table 1) and are commonly dispersed by the last two methods listed above.

The dispersal mechanism of propagules is very important in determining the rate and direction of weed spread, and thus the extent of the area vulnerable to invasion in any defined time period. The seed shadow is the zone receiving seed input around a parent plant. This may extend to many kilometres in the case of

TABLE 1. WEED DISPERSAL MECHANISMS AND THEIR MANAGEMENT IMPLICATIONS.

MECHANISM	**WIND**	**BIRDS/ANIMALS**	**UNSPECIALISED PROPAGULES**	**VEGETATIVE**
CHARACTERISTICS				
Frequency/regularity	Yearly to irregular	Generally yearly	Generally yearly	Irregular to yearly
Spatial determinants	Wind direction	Animal/bird behaviour	Gravity, water, etc.	Gravity, water, people
Distance	Local, to many km	Up to a few km	Local, to many km	Local to many km
Receiving area	Large, predictable	Small, unpredictable	Predictable and unpredictable	Predictable to less so
ASSISTING FACTORS				
Disperser diversity	One only	More carriers > chance	More carriers > chance	More carriers > chance
People	Not involved	Minor role	Major role	Major role
Parent size	Tall plant > chance	Plant size unimportant	Plant size unimportant	Plant size unimportant
Fruit size	Unimportant	Small fruit > chance	Unimportant	n.a.
Seed size	Small seeds advantaged	Small seeds advantaged	Large seeds disadvantaged	n.a.
Fire	Often assists (cones)	Destroys fruit	Generally destroys fruit	Generally little influence
Propagule fate post parent death	Often dispersed	Not dispersed	Often dispersed	Often dispersed
STRATEGY IMPLICATIONS				
Possible human influence	None	Minor	Minor to major	Minor to major
Border control	Impossible	Impossible	Difficult	Difficult
Detection strategy	Wide ranging	Local	Wide ranging to local	Usually local
Education	Important	Important	Very important	Very important
TACTICAL IMPLICATIONS				
Ideal control period	Prior to seeding	Prior to seeding	Prior to seeding	Prior to propagule formation
Destroy propagules	Vital	Not important	Often vital	Vital

wind-dispersed seeds or those carried by animals. The efficacy of weed dispersal by explosive means (e.g. gorse, broom) is often exceeded by unpredictable dispersal via such means as carriage on animal hooves, and, in the case of Russel lupin, by intentional human dispersal.

The regularity and frequency of dispersal is a second factor in determining weed spread, and it is influenced by factors other than simply the timing and frequency of propagule production. For example, wind-dispersed seed may be carried long distances only by extreme wind events (e.g. pines), and non-specialised propagules may be dispersed only after floods. In both cases the need to search for new infestations is periodic.

Wind dispersal is usually highly directional, and is governed by the prevailing wind or that of storm events. Small wind-blown seeds tend to be dispersed further than large seeds and this can be expected to lead to more rapid weed invasion in the presence of suitable sites. Effective regeneration of contorta pine, for example, can occur over distances of greater than 40 km in New Zealand.

Viable seed of wind-dispersed fruit (and some non-specialised seed) often disperses after the adult has been cut down or killed by fire (e.g. pines, hakeas). In contrast, the seeds of fleshy fruits are seldom dispersed at this point because they spoil rapidly and are not eaten by potential dispersers.

Animal-dispersed fruit and seeds may have several vectors which behave in different ways, e.g. possums and wax-eyes, and hence may deposit seeds of the same species along different pathways and in different habitats. A few weeds have fruit which is dispersed by only a few dispersers, or in some cases perhaps by only one, e.g. monkey apple dispersed by New Zealand pigeons. If they are eaten primarily by fruit-eating birds, seeds are dispersed via gut passage or by regurgitation. Finches and quail, which eat seeds such as those of gorse and broom, grind them up in their crops.

The external and internal carriage of seeds by animals, such as sheep and wild pigs, has not been investigated, but it is likely to be an important weed dispersal mechanism, especially for gorse and broom. These two, and other weeds, are also widely dispersed unconsciously by humans in roading operations.

Both fresh water and salt water are important media for seed dispersal in New Zealand. Spartina and marram grass seeds are dispersed along the coasts, and although gorse seeds sink, they too are effectively dispersed along the coast when still in their pods or attached to branches.

Clonal material is dispersed particularly erratically, and this is especially so for species dependent on being carried consciously by humans, as in dumped rubbish. However, once the vector(s) are identified, the direction away from the source infestations and the size and shape of the area potentially infested are often more predictable than for wind- or animal-dispersed weeds. A single waterway or roadway may be the route by which a particular species is spread from a known location. Weeds that inhabit waterways (several water weeds) or their margins (e.g. wandering Jew) are examples.

Fire is not actually a dispersal mechanism, but it aids dispersal by opening seed pods (hakeas) and cones (pines), by stimulating the germination of buried seed (e.g. gorse), and by creating open ground for seed germiattion and seedling establishment.

The nature of propagule dispersal influences the strategic and tactical aspects of weed control, particularly distance-related factors such as the width of buffer zones around weed-free areas, and the area required to be searched for new infestations. As a general rule, only where the weeds are carried by humans or their agents does an opportunity exist for actually preventing seed dispersal or propagule dispersal. Education plays a vital role here.

Propagules which can survive after the death of the parent should ideally be destroyed. This applies to all clonal material. Where this is not possible, greater attention needs to be given to follow-up operations at a frequency less than the time to reproductive maturity, and for a sufficient length of time to eradicate the plant derived from the last viable propagule, be it a vegetative fragment or a seed. Conspicuousness of the young plants may also be a factor in the seasonal timing of these operations.

3.2 INVASION PHASES

Invasion patterns through time and space are the result of many interacting forces, which can be simplified and illustrated graphically as the proportion of all potential habitat occupied by the organism at any point in time. Many pests and diseases tend to follow a well defined, very simplified "S" shaped pattern (Fig. 2, solid line). This applies particularly where there are numerous establishment sites at an early stage. The essential features are a long tail at the beginning of a species invasion, a steep rise as it finds suitable habitats, and then a flattening off as these habitats are saturated. The precise shape of the curve, and the time involved for each phase, differs for each species, depending on such factors as its means of dispersal, life cycle, and so on. As the invasion proceeds, the proportion of uninfested habitat declines at a rate defined by a "reverse S" (Fig. 2, dotted line).

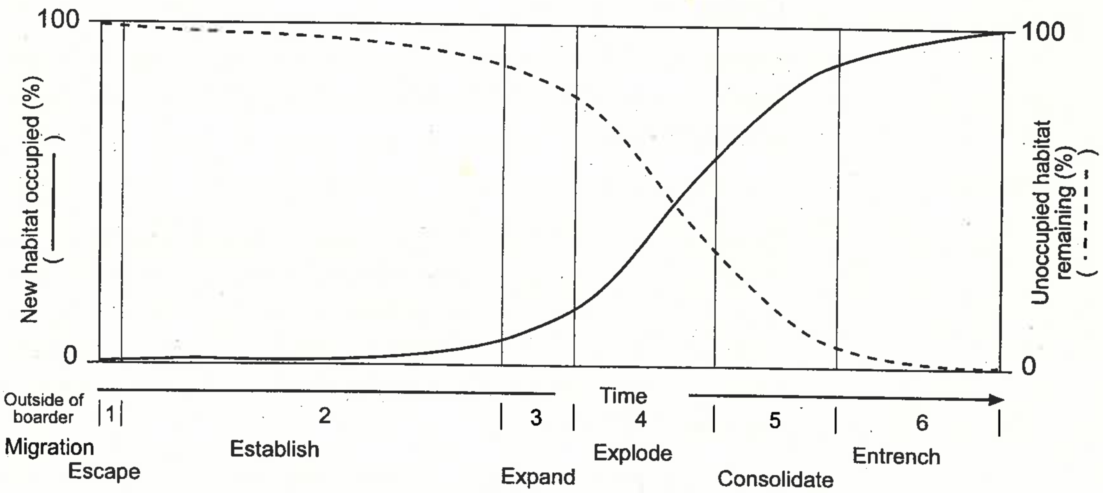


FIGURE 2. CONCEPTUAL PHASES IN THE INVASION OF A WEED THROUGH TIME, AND THE WAY THESE RELATE TO THE PERCENTAGE OF OCCUPIED AND UNOCCUPIED HABITAT.

The invasion process is continuous, although the point at which an individual species begins to spread rapidly has often been described mathematically, in hindsight, for some weeds. Despite this, several points are still recognisable where the rate of change **alters markedly** from the preceeding period. The "S" shape can thus be divided into conceptual stages based on the extent of the invasion and the rate at which it is occurring.

This process can be observed at any geographic scale, from a paddock to a continent. For the purposes of this exercise one could consider a whole DoC conservancy as the unit area, while in Section 7 the concept is applied to single small reserves.

Migration phase

The plant must first reach the area under consideration, that is, a paddock, a region, or a country. Once it has arrived, it may or may not enter, depending on a variety of factors. In the situation where a defined border exists, these will mostly depend on the efficiency or otherwise of border control in assessing the potential weediness of the plant. As DoC conservancies do not operate border controls (except on islands) the most likely event is that the weed will enter and be initially unnoticed.

Some plants have narrow habitat preferences and these limit entry points. For example, water weeds may enter only on boats, and the effort made to ensure these plants do not enter specific lakes is an example of border control.

Escape phase

Once inside the conservancy, the plant must complete its life cycle, which often involves several migration attempts before success is achieved. Once new propagules are produced, the plant may escape beyond the initial establishment point, e.g. a garden. The locations of these new establishment points will be unpredictable for wind- and animal-dispersed fruits, but for many terrestrial environmental weeds they will be in land adjacent to gardens and along transport routes. Many environmental weeds were originally purposeful introductions to New Zealand, if not to land actually managed by DoC.

Establishment phase

During this phase, the plant is able to reproduce in the new environment, and population numbers slowly begin to build up. Virtually all potential habitat is still uninfested.

Expansion phase

Eventually, the number of sites occupied begins to expand beyond the initial localities. The causes of this expansion are not well documented, but they include the arrival of new pollinators or dispersers, the species becoming adapted to its new environment by the formation of new genotypes, and the creation of new and suitable habitats. This process will be faster where there are multiple localities.

Some local areas of habitat are noticeably infested, but most potential habitat is uninfested. It is often at this stage that the plant begins to be perceived as a weed by management agencies.

Explosion phase

This is the period where the plant expands rapidly and where it begins to attract a lot of concern. Most potential habitats are infested during this phase.

Consolidation phase

In this phase the plant slowly occupies the last remaining habitats.

Entrenchment phase

The plant now occupies its full range. Once the invasion is complete, all potential habitat has been occupied. This does not mean that the weed occurs on all DoC land, but only that the weed occurs in the general area, and has a high chance of occurring in all suitable habitats. Further expansion can occur only if more suitable habitat is created, e.g. by fire. Importantly, the plant may be present only in a dormant stage of its life cycle, as shown in Fig. 1. Gorse would be a good example of such a weed, for it is present over most of New Zealand, but in some areas it is present only as seed.

None of these early phases is easily predicted for new weeds in New Zealand, and for most species, their potential for spread in new habitats is unknown. As the invasion continues, and more information is gathered about the behaviour of the weed in its new environment, the vulnerable habitats become increasingly predictable.

4. Vegetation structure

Vegetation structure describes the vertical arrangement and density of vegetation. These features determine the light intensity in the upper layers, termed the vegetation canopy, and in layers beneath the canopy, including the ground layer. The canopy density also has a great effect on the moisture condition of the litter and upper soil layers. Leaf structure and composition also influence the nutrient availability and decomposition rates, e.g. the deep litter layer beneath gorse compared with that beneath manuka.

The shade tolerance of plants is a critical factor in determining their ability to establish, grow, and reproduce in a particular canopy, sub-canopy, or open position. Many species can grow as adults in deeper shade than they are able to either establish in as seedlings or later produce seed. This means the degree of threat they present to natural values varies depending on the kind of vegetation they are growing in. This may influence the need to control a particular species at particular sites, unless they are the subject of a species-led control programme (Section 6.1).

For the purposes of describing the relationship between weeds and vegetation structure, four broad classes of vegetation can be recognised. Details of which species invade these structural classes are given in Section 10.4.

4.1 INTACT FOREST

No pristine forest remains in mainland New Zealand, although much forest still has the basic structure of canopy and sub-canopy layers over a dense ground layer. In the outer forest canopy there are high light levels. This environment is accessible to only a few trees and vines which have relatively shade-tolerant seedlings, because they must first establish beneath the forest canopy where the light levels are lower. Epiphytic plants are an exception, but no weeds appear to exploit this position other than on a very casual basis.

Forest margins and light pools, such as occur on open gully sides, are more akin to damaged forest and are mentioned in the next section.

4.2 DAMAGED FOREST AND FOREST MARGINS

This encompasses forest with a history of disturbance, from milling, grazing, tracking, recreational use, and natural events such as storm damage. Light levels are high in the outer canopy, in open patches, and on the margins, and decrease to low levels under the denser patches. Such forests often have areas of disturbed ground and patches of higher soil fertility, such as along stream sides. These situations act as entry points for weeds.

This variability offers a wide range of habitats suitable to many weed life modes and species, even within the same forest patch. Damaged forest with margins armoured by dense scrub of fivefinger (*Pseudopanax arboreus*), for example, is less susceptible to weed invasion than forest with open margins.

4.3 SCRUB AND FERNLAND

This vegetation is characterised by woody plants, ferns (and rushes) of less than c. 6 m tall. Sites with low soil fertility or extremes of soil drainage and moisture status, such as sand dunes and peat bogs, often support scrub. Otherwise, in forest environments, the presence of scrub and fernland rather than forest is likely to reflect time since the last disturbance at the site. This is usually in the order of less than 50 years.

Grazing and fire are the most widespread causes of disturbance in shrublands. Frequent fires increase the existence of the invading shrubs, e.g. gorse and dally pine, which weakens the native vegetation, mainly by reducing seed sources, and makes it even more susceptible to burning and open to invasion by these species. Slope instability and flooding are also important factors in creating localised weed habitats.

Dense scrub has extremely low light levels beneath the canopy, and this limits establishment of other life modes to openings or the margins. More open-canopy scrub and shrublands are vulnerable to a wider range of life forms and weed species than any other kind of vegetation structure, primarily because of their limited height, and the shelter or support offered to invading weeds. Many trees and vines can establish in scrub openings, from where they grow through and overtop the scrub, in one way or another. Vines are readily able to establish on the margins of scrub or in canopy gaps, and spread to cover the whole canopy. Revegetation projects are particularly vulnerable to this mode of invasion, partly because they often involve vegetation clearance and ground disturbance in the early stages.

4.4 TUSSOCKLAND, GRASSLAND AND HERBFIELD

Tussockland and grassland vary widely in their openness and susceptibility to invasion because their structure ranges from dense vegetation, similar to scrub, to openland. Because most tussockland is in the cool montane zone, there are relatively few problem weeds, and they are scattered through a narrow range of life modes (e.g. hawkweeds, heather, and pines). These invaders are nonetheless very damaging, particularly if they are woody species. The few remaining lowland tussocklands and herbaceous peat bogs are invaded by the same species, as well as a wide spectrum of lowland weeds (e.g. willows, Japanese honeysuckle).

Short grassland and turf grow over a wide range of climatic conditions, from sea level to the alpine zone. Creeping herbs and grasses tolerant of exposure and competition are important invading life modes of short grassland. Resistance to, or tolerance of, grazing is an important attribute of woody weeds in this community, and may be expressed by the possession of spines (e.g. gorse) and/ or the ability to regenerate following damage (e.g. some pines).

As grasslands are often grazed, resistance to grazing, especially at the seedling stage, can be an important attribute of invading species occupying openings in the turf, e.g. gorse, barberry.

4.5 OPENLAND (BARE)

This general term covers habitats such as riverbeds, bluffs, and sand dunes, as well as induced habitats such as gravel pits and roadsides, with very low vegetative cover. Disturbance is usually a feature of openlands, resulting from a very wide range of causative factors such as fire, erosion, flooding, and grazing. Climate and soil moisture conditions are often extreme, frequently because of the free-draining substrate, e.g sand. In contrast, exposed subsoil such as occurs on moist slip faces may be more hospitable.

Plants with most life modes, and indeed a high proportion of all weed species, can invade openland. The exceptions are those intolerant of exposure. Plants established in openland often provide the seed source for adjacent, less open vegetation, such as damaged forest.

4.6 WETLAND

True water weeds are beyond the scope of this account, but semi-aquatic vegetation, and that growing on wetland margins, is invaded by a wide range of predominantly terrestrial growth forms, from trees (e.g. willows) to grasses (e.g.

tall fescue). Wetland margins are also invaded by rushes and rush-like plants and even vines.

Saline wetland habitats also form a special category that is invaded mainly by grasses in the form of spartina species, tall fescue, and, less frequently, pampas grass.

5. Vegetation succession

Vegetation succession refers to the process whereby one set of plants at a site is gradually replaced over time by another. This may be primary succession, where plants have not previously occupied the site, such as riverbeds, or secondary succession, where the plants are re-occupying a site after a one-off disturbance (e.g. wind throw) or after an ongoing disturbance ceases (e.g. grazing and fire). Most of lowland New Zealand once supported forest, apart from areas such as wetlands, swamps, and perpetually disturbed habitats like cliffs. This means that most other kinds of vegetation eventually become forest, provided that the substrate is suitable and the site is not disturbed. In most places this takes from 50 to 100 years.

Succession can be used as a passive weed management tool, whereby the manager simply waits for the weeds to be taken over by native plants. The usefulness of succession in this way depends on several factors:

- the conservation values and management goal of the area being invaded;
- the structure and composition of the vegetation being invaded;
- the maximum height of the invading weed;
- the longevity of the weed, including the life of the soil seed bank;
- the time interval between the disturbance events which allow weed invasion;
- the time the manager is prepared to wait for succession to occur.

Succession is generally not a practicable management tool in the following situations:

- where the disturbance factor continues, e.g. grazing;
- where there is insufficient seed of native species to re-colonise the site after the first generation of weeds, e.g. areas of broom in eastern South Island where beech is very sparse;
- where the height, and/or longevity of the weeds are greater than any desired species likely to occupy the site, e.g. pines invading tussockland and willows invading wetlands;
- where weeds are replacing native species of similar stature and life mode, e.g. tall fescue invading wetland margins;
- where weeds inhibit germination and establishment of taller species, and where indications are that this situation will continue beyond the time

period the manager is prepared to wait, e.g. mats of wandering Jew or wild ginger in forest remnants;

- where the weeds are invading animal habitat, e.g. sea bird nesting sites;
- where two or more of the above conditions apply at the same site — this may occur through the actions of a single weed (e.g. old man's beard) or by two or more weeds in combination;
- where the weeds are the seed source for adjacent areas where establishment is undesirable, even if their present establishment sites are of limited conservation value — that is, the weed may be the subject of a weed-led weed control programme (see Section 6.1).

One measure of the effect of weeds could be seen as the time taken for the site to return to native vegetation once they have occupied it. Weed-dominated vegetation ranging from dense grass swards (e.g. cocksfoot), through short scrub (e.g. short gorse), tall scrub (e.g. willow-leaved hakea) to forest (e.g. privet) can be envisaged as a time sequence approximating to the age of the vegetation. At the initial stages, weeds may have a strong inhibitory effect on native species, and the time taken for the site to return to native woody vegetation is likely to be in the order of 25–40 years. At intermediate stages, where the scrub consists of woody weeds with life spans of about 40–75 years, the inhibitory effect of weeds will be low because many native species are able to establish beneath the weed canopy and many live longer than the weeds. Once a forest of weeds, such as tree privet and sycamore, has developed, the inhibitory effect of weeds probably increases again, because the weeds are long-lived and it would probably take a long time for them to be replaced. However, many weeds have not been present on the New Zealand landscape for sufficient time for their ultimate interactions with native vegetation to be adequately predicted. Such vegetation can develop an understorey of native species, but also invasive, shade-tolerant herbs (e.g. wild ginger, wandering Jew).

These limitations mean that succession will generally be a useful weed management strategy only in equable environments where the disturbance factors are removed, there is an adequate seed source of native species, the ultimate native vegetation is taller than the particular weeds of concern, and the conservation values threatened are such that the manager is prepared to wait.

6. Weed control

Weed control programmes are required to consciously use resources in the most effective way, e.g. to curb the temptation to rush out and attack the infestation in the most dense spot. A two-phase approach to the problem must be developed: the overall strategy and the specific field tactics to apply.

For whatever reason a particular weed is being controlled, the overall strategy must be appropriate to its biology and ecology, the values being threatened, the extent to which weeds have invaded the area concerned, and the technologies and resources available for control.

6.1 CONTROL STRATEGIES

There are many ways, both in space and time, in which plants invade. Section 3.1 described the idealised spatial spread of a species into a new area as begining slowly at first, going through a phase of rapid range expansion, and then slowing as the available habitat was occupied (Fig. 2).

At the earliest stages of invasion it may be possible to keep the species from establishing in an area by preventing entry or by eliminating founder individuals. Once a weed has begun to expand rapidly, the effort required to eliminate it will increase dramatically (Fig. 3). Resources required will be greater, even from the outset of the invasion, for species with persistent seed or other regenerative life features that require repeated visits to the site (Fig. 3).

The history of successful control programmes, economic analyses, and scientific studies, shows that the greatest return for expenditure of money and effort comes from controlling weeds at the early phases of invasion.

This principle can be applied at any scale, from a single infestation to the whole country. For example, the area covered by a single broom plant and its seeds expands to 13 times the area occupied by the original broom bush within the first few years of seeding, even when the seeds are dispersed simply by explosive dehiscence.

A further point for controlling weeds at the earliest phase is the relationship between the amount of funds for successful control and the ease with which they can be obtained (Fig. 3). During the earliest phases of invasion, when the required funds are minimal, these can be effectively obtained as an adjunct to other weed control programmes, or even other kinds of activity, such as track clearing. Once the weed has reached the explosion and consolidation phases, the funds required may be orders of magnitude greater. These will then need to be specifically budgeted and applied for, and they may be difficult to obtain. To rephrase this, at one extreme, only the person with the spray gun (or spade or slasher) needs to be persuaded, while at the other, it may require the approval of Cabinet.

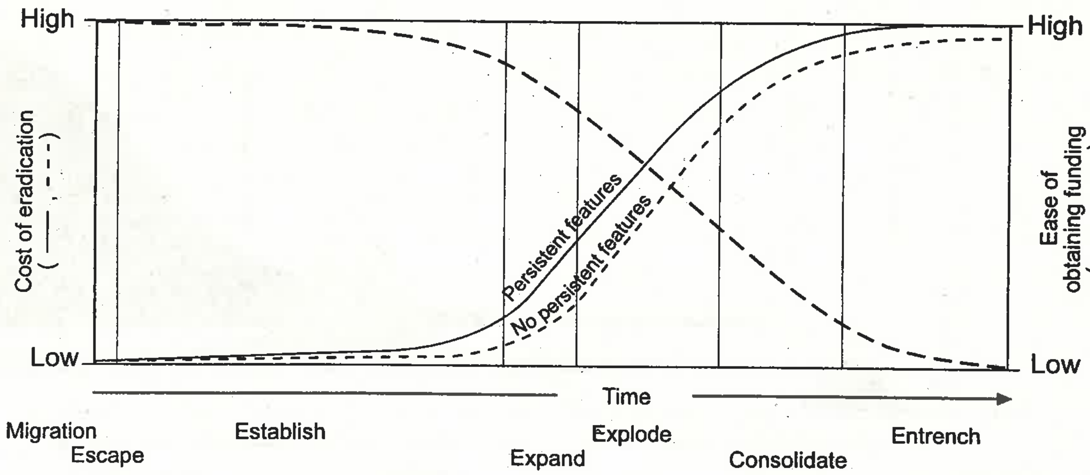


FIGURE 3. RELATIONSHIP BETWEEN THE INVASION PHASES OF A WEED WITH AND WITHOUT PERSISTENT FEATURES SUCH AS A SEED BANK, THE RELATIVE MONETARY COST OF ERADICATION, AND THE EASE WITH WHICH FUNDS CAN BE OBTAINED FOR CONTROL.

While it is true that there are difficulties in obtaining funding to control poorly known plants that are not commonly perceived as weeds (e.g. Mexican daisy) as opposed to those that are (e.g. old man's beard), the chances of successful control at a regional scale are much greater for the former.

The total accumulative costs over time can be expressed as the effort required to obtain the funds, the money spent on actual control, plus the impacts on the environment. These accumulated costs become progressively greater with time if control attempts are delayed, as illustrated by the differences in the areas under the three curves in Fig. 4.

For DoC, the scale at which these relationships are viewed will vary. Large scale might be considered to be each conservancy, or sets of ecological regions as defined by McEwen (1987). The critical conservation values being threatened by weeds need to be considered, and these will differ depending on the vegetation type, habitat modification, and other factors. As a weed increases in distribution within a defined area, towards a stage where eradication is impossible, the conservation values directly threatened need to be of greater value to warrant undertaking control measures.

As each DoC conservancy has weeds at all stages of invasion, and conservation areas of widely different value, the weed control strategies should include both **targeting individual species** relatively new to the region and **protecting areas of high conservation** value from all problem weeds. These approaches have different requirements for success. The issue of scale is always present. The target area for a species-led approach will usually be small, such as a single reserve or series of reserves along a river valley, for a weed of potentially great impact such as old man's beard.

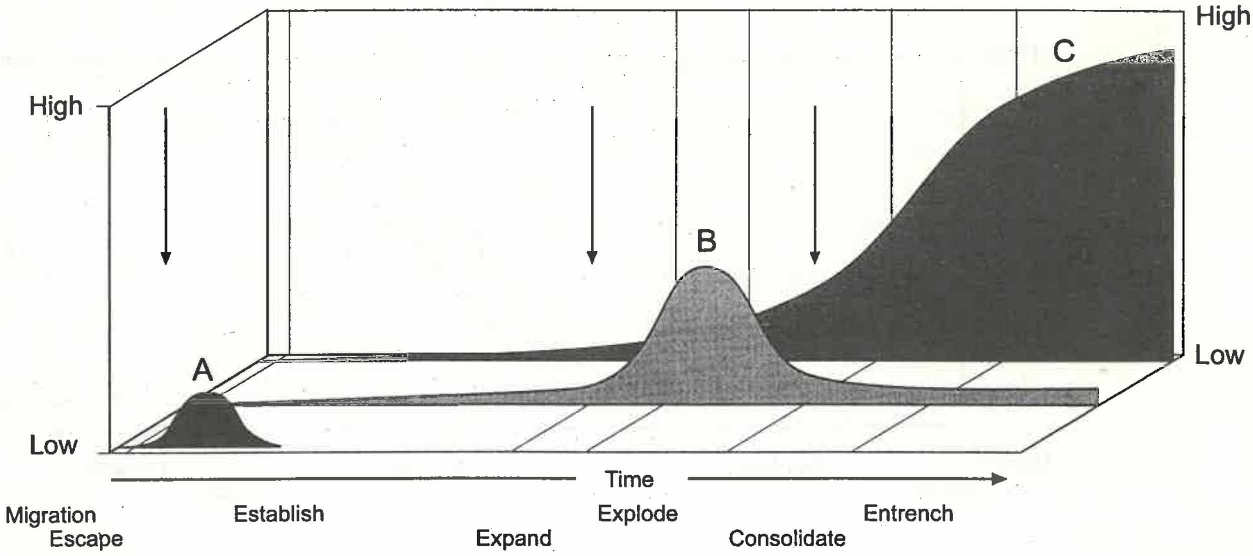


FIGURE 4. RELATIVE COMBINED MONETARY AND ENVIRONMENTAL COSTS OF UNDERTAKING AN ERADICATION PROGRAMME (A), TOGETHER WITH THOSE OF INITIATING ONGOING CONTROL PROGRAMMES AT AN EARLY (B) AND LATE STAGE (C) OF THE INVASION. ARROWS INDICATE PROGRAMME STARTING POINTS. THE DIFFERENCES IN AREA BENEATH THE CURVES (B-A, C-A, C-B) REPRESENT THE BENEFIT OF CONTROL ACTION AT THE EARLIER STAGE.

Species-led strategy

The aim is to eradicate a species from a defined area or to restrict it until eradication is possible. If the strategy is to succeed, this must be irrespective of the ownership and conservation value of the land on which it grows. The most important conditions necessary for success are:

- all individuals of the particular weed species can be located;
- practicable control measures are available;
- all individuals can be targeted within a defined time period dictated by the plant's life cycle;
- the plant's response to control is known, e.g. new seedlings emerge annually;
- resources are available to undertake follow-up work which can treat new plants as fast as they appear.

Less intensive species-led control strategies can also be applied at any stage of their invasion, from simply monitoring their initial spread while their potential impact is being assessed, to controlling them at the margins of their spread to prevent their entry into defined buffer zones round areas of high conservation value.

The co-operation of local authorities, other landowners, and plant nurseries are necessary for a successful species-led control strategy. The wider the area under consideration, the more organisations will be involved.

Overall, most species invasions proceed inexorably at large geographical scales once the invasion has passed beyond the exploration phase; many serious weeds already occupy much of New Zealand. For most species, **eradication** attempts at a conservancy level will therefore be very difficult, if not impossible, because of reinfestation and the high cost of finding the last individual. The alternative objective of maintaining a particular problem weed at a level where it does not unduly affect conservation values may still be achieved however. We are thus forced in most situations to switch the strategy to protecting specific areas from invasion (Fig. 5).

The importance of biological control, where one living organism is managed to reduce another, does not necessarily follow the same trend. It may be only a little more expensive to control a large area of weed than a small area, if a successful organism has a high dispersal ability, e.g. gorse spider mite (*Tetranychus lintearius*), which blows in the wind.

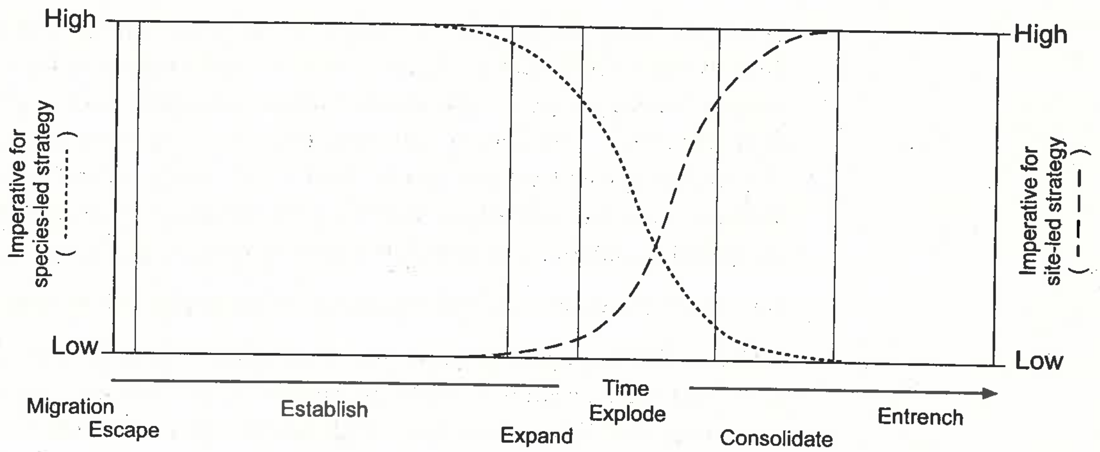


FIGURE 5. RELATIONSHIP BETWEEN THE INVASION PHASE OF A WEED (FIG. 2) AND THE IMPERATIVE FOR A SPECIES-LED STRATEGY AND A SITE-LED STRATEGY FOR CONTROL.

Site-led strategy

The aim is to minimise the impacts on conservation values of all target weed species in a defined area. The conditions necessary for success are:

- the area must be of sufficient conservation value to attract the initial and ongoing resources;
- the species' responses to control measures are known, e.g. whether or not seedlings will emerge in future;
- practicable control measures are available for all targeted species;
- the factors which initially led to weed invasion can be addressed (e.g. rubbish dumping).

While the co-operation of local authorities and adjacent land owners is obviously desirable to minimise re-invasion, it need not be a prerequisite for areas of the highest conservation value.

The steps that need to be taken prior to determining which approach is appropriate for any situation are outlined in several DoC Weed Management Strategies. These are concerned with:

- ranking the areas being threatened in terms of their conservation value;
- knowing about the distribution, biology, and ecology of the weeds of a region to be able to rank them in order of threat to these values;
- knowing how the indigenous vegetation will respond to whatever tactics and level of control are employed;
- relating the conservation values of an area to the relative ease and efficacy of weed control.

6.2 WEED CONTROL TACTICS

There are many aspects of successful weed control programmes that are not directly concerned with eradicating plants, such as preventing a weed entering an area, obtaining the co-operation of neighbours, publicity to gain support and to advertise successes, and controlling or preventing some of the factors which may enhance weed establishment, such as flooding, animal grazing, and wind damage. Coupled with these are the tasks concerned directly with managing identified populations of problem weeds in specific places.

Once a species or an area to be managed has been selected, several questions arise:

- What changes could be expected to the total vegetation in 5, 10, or 30 years, if nothing was done? [This question may not be relevant for species-led control strategies where the weeds are targeted wherever they occur.]
- Does the impact of the weed on the conservation values of the area differ in each of these time frames?
- If weed control is conducted and is successful, will the cleared area be reclothed in native vegetation, or will the weeds re-invade the area either vegetatively or from dormant seed banks?

Once these questions are answered, there are several points that need to be considered.

If the target weeds or others are likely to regenerate, the control tactics should aim to make the minimum disturbance to the site. When large areas are disturbed, the resulting bare ground becomes vulnerable to reinvasion, in effect a localised revegetation problem for which resources will be required. Methods of revegetating forest are given in Porteous (1993).

Weed control should begin with the outlying infestations or individuals, move in towards the margins of the main stands, and only then attack the bulk of the infestation. This is true within single reserves, conservancies, or the country as a whole, depending on resources and the scale of the operation.

Exceptions to this rule occur when resources are available to eliminate both the seeding adults and the juveniles before they too begin seeding.

Control tactics include passively waiting for natural processes, and using hand tools, mechanical equipment, chemicals, or biological control. They are best thought of as interrelated possibilities rather than discrete methods.

Selection of a method or combination of methods is constrained by the life form of the plant, its response to treatment, and the size of the infestation. Other considerations of varying importance to the different methods are the biology and sensitivity of the weed compared with surrounding non-target species, the time of year, and soil moisture and weather conditions at the time. Local politics also have a bearing.

The response of the weed to the treatment, and the properties of the dead material (e.g. will it be a fire hazard) and its possible disposal, must be considered prior to control operations. The primary factor will be whether the plant parts regenerate once cut or damaged. If above-ground parts are known to regenerate, they must be removed either from the site, or in the case of small amounts of material such as cut vines, they can be draped in the surrounding vegetation. Otherwise they can be composted. Underground parts or surface vegetative organs should be disposed of with special care; some will burn once they have dried out, but others virtually never do, and must be disposed of in a controlled tip or otherwise deeply buried, e.g. wild ginger roots. Cuttings and bulbs that can regenerate should never be dumped. Some species bearing fruit will continue to disperse seeds after they have been cut, e.g. pine cones will open when they eventually dry.

Annuals and biennials

Control of annuals and biennials is seldom necessary on conservation land, other than for management objectives such as maintaining camping grounds, protecting new plantings, and for ensuring good relationships with neighbours. Numerous hand or mechanical methods, and several chemical sprays, are widely known and readily available. Many weeds have persistent seed banks and control needs to be maintained for several years, e.g. ragwort.

Control of these plants, and herbaceous perennials discussed in the next section, will become more important with the development of recovery plans for individual species of native herbs, some of which may be threatened by herbaceous weeds.

Herbaceous perennials

The wide range of life modes and habitats occupied by this broad group of plants presents a myriad of weed control problems requiring careful consideration.

Erect herbs and mat-forming herbs

These two life modes are grouped together because they tend to invade similar vegetation, although individual species may require quite different tactics.

Wandering Jew is the most shade tolerant of all weedy herbs and can penetrate deep into forest. Because it is suppressed, yet simultaneously dispersed, by grazing animals as they roam about, wandering Jew can rapidly reach high densities from numerous scattered small patches following the end of grazing, e.g. after fencing. The window of opportunity to control the plant is often very narrow under these circumstances. Control of small patches can be achieved by very careful hand pulling, and at the invasion front even small fragments should be lifted or treated with herbicide. Where dense mats have formed, they can be raked back and rolled up, then carried into heaps to compost. However, the exposed bare area will be re-invaded from inconspicuous fragments within 12 months unless there is follow up treatment. The alternative is to apply heavy quantities of appropriate herbicide at sufficient frequency to prevent reinvasion. The associated woody seedlings are often damaged by this treatment and large patches of wandering Jew require a revegetation programme following the removal of the herbaceous mat if they are to be eliminated.

Periwinkle is more resistant to both physical and chemical treatments than wandering Jew but it is less shade tolerant and does not resprout as rapidly. Physical removal involves removing the above-ground stems and all the associated roots.

The two gingers are among the largest of the herbaceous weeds and they both have the ability to spread rapidly. Removing the seed heads of Kahili ginger slows the formation of new colonies. Small plants less than half a metre tall and with weakly developed rhizomes can be pulled out. Larger isolated plants can be dug out, taking care to remove all the rhizome. Dense infestations need to be poisoned. This usually involves cutting and injecting the stumps. The rhizomes have the capacity to regenerate for at least a year after having been pulled out. Any material removed must therefore be disposed of in a controlled rubbish dump, because it will not rot or burn.

Mist flower and Mexican devil spread so prolifically by wind, and grow so rapidly, that overall control is very difficult. The former is under consideration for biological control. Both can be dug out by the roots, if the infestations are identifiable individual plants, but they recover from root fragments and seed. Control should be conducted in late winter and early summer prior to flowering to avoid spreading seed. Disposal by either composting or burning is recommended. Where the infestations are large and there are abundant native species, heavy cutting by hand or machine at regular intervals may be sufficient to reduce the weed's vigour and allow native plants to shade or re-occupy the site.

The other herbs considered below are weeds primarily of grassland and open land. Russell lupin and lotus are two legumes with persistent seed banks. As the seeds of lupin are dispersed via water, re-infestation from upstream is a common occurrence, so that control measures need to be directed initially to infestations in the upper parts of catchments. Russell lupin forms dense clumps with vigorous root systems that will resprout following physical damage or frosting. These need to be dug out if control is confined to physical methods. Several herbicide sprays are effective. The other erect herb included here is coltsfoot, which can be controlled in a similar way to lupin.

Lotus is a mat herb, and like several others, e.g. Mexican daisy and mouse-ear hawkweed, controllable by close hand weeding or sprays, but as there are seldom native species to take their place, care must be taken not to simply create more open ground for these weeds, or others, to reoccupy. These species are all strongly influenced by grazing, but studies of grazing as a management tool of native herbaceous communities are in their infancy in New Zealand.

Iris-like herbs

The three main iris-like plants are montbretia, stinking iris, and watsonia. In many forest situations they can be ignored, because their low stature means they tend to be shaded out eventually. In contrast, on intensively managed forest margins they may need to be controlled to assist natural regeneration and maintain an appearance of naturalness.

A common feature relating to their control is the need to consider the underground organs. Small infestations can be dug by hand and all the organs removed. This should be done before flowering when the number of new underground organs is at a minimum, and in the case of watsonia, before the above-ground bulbils are formed.

Sprays are effective and should be applied after flowering when translocation is active, and in the case of watsonia, before the tops begin to die back.

Lily-like herbs

Arum lily, Italian arum, and elephant's ear are ranked in increasing order of shade tolerance. Arum lily spreads the most rapidly, particularly in areas marginal to wetlands. Control of these species may be warranted in these situations or where dense stands prevent regeneration. Otherwise Italian arum and elephant's ear tend to be shaded out eventually in forest situations.

All are difficult to control because of their preference for deep moist soils and their heavy underground systems. Underground parts need to be dug out and disposed of. Protective clothing must be worn to avoid the possibility of skin irritation from the calcium oxalate crystals in all parts of these plants.

Sprays are effective when applied after flowering, but careful consideration needs to be given to the species likely to occupy the newly exposed ground.

Grasses and grass-like plants

Grasses have their growing point near ground level, enabling them to recover rapidly after damage to the upper leaves. Physical control involving slashing and chopping is therefore rarely effective in killing grasses.

Most grasses are intolerant of shade and where they occur in woody vegetation they can often be left to be shaded out. Grasses are a persistent problem in very open forest or scrub, and openland generally. Pyp grass may be an exception, as it appears able to tolerate shade under quite dense pine forest. Particularly vigorous grasses such as kikuyu grass and pampas also have some capacity to invade scrub and forest margins, where they may need to be controlled to allow regeneration of native species to proceed.

Physical removal of grasses is usually effective if the whole plant can be uprooted. Particular care must be taken to remove the underground portion in those with resprouting rhizomes (e.g. kikuyu grass, African feather grass) or strongly resilient tufted top-growth (e.g. nassella tussock, pampas grass). Seedlings of these species and other grasses can be grubbed out, but large pampas grasses may require cutting (with chain saws) and the subsequent application of chemical sprays, or even heavy machinery to pull them out.

Grasses produce abundant seed, which are wind-dispersed in some species (nassella, pampas), and these enable new plants to establish even after the parent plant has been killed. Weeding should therefore be done in spring prior to seeding. At other times of the year, the seeding grasses will need to be disposed of without spreading the seed. There is a particular problem with veld grass because it seeds nearly all year round. While the vegetative tops of grasses compost readily, the seeds may remain viable for several years.

Most grasses can be controlled by heavy grazing but this has limited application in conservation areas. There are many herbicides selective for grasses.

Rushes and rush-like plants

These are plants primarily of poorly drained areas and wetlands proper and they are seldom controlled for conservation reasons. The correct identification is important in all weed control and this is difficult when dealing with rushes (but see Johnson & Brooke 1989). This is partly because native rushes and weed rushes are very similar in form and ecological character, they are difficult to distinguish at a distance, and they often grow closely intermingled.

Rushes have strong underground rhizomes and root systems, enabling them to resist physical damage and resprout when these parts are fragmented. Rushes also have very long-lived seed banks. Physical removal of them is difficult once they are well established, and most control needs to be carried out using herbicides.

Vines

Weedy vines can be devastating to all successional stages of native vegetation. Where the aim is to maintain or restore vegetation to a natural state within say a 5-10 year time frame, then vines need to be removed as one of the first priorities.

All species are not of equal threat and there are also strong regional differences in species vigour. Those most in need of control are a small group of shade-tolerant species capable of establishing well inside forest margins, from where they can dominate the understorey and/or reach the canopy (e.g. smilax, old man's beard, jasmine). Plants of another large group require more light to establish, but they have great smothering ability once they reach the canopy from open patches or forest margins (e.g. Japanese honeysuckle, potato vine, several passionfruit species, cathedral bells, moth plant, blue morning glory, ivy, and hops). Those of a third group have limited height growth but a high impact in shrubby vegetation (e.g. convolvulus, smilax, blackberry, climbing dock). Elaeagnus has some ability to climb, and is rather like blackberry, in that its main impact appears to be as a gap filler.

Vines are vulnerable to hand control methods where they form localised small infestations arising from a single plant, and the main stem(s) can be easily cut. The remaining stump will often regenerate and must be treated immediately with herbicide while it is still moist.

Damage to surrounding vegetation and subsequent weed re-invasions will be minimised if the cut vines are left in place. Most vines can re-root or resprout from cut pieces, and so these must be raised off the ground (e.g. ivy, German ivy, jasmine, old man's beard). Ivy climbs by producing roots on its stems which can support the plant even after the basal stems have been cut, which necessitates removing all the stems from whatever they are climbing on. However, removing vines by hand can be extremely difficult where they are dispersed through the vegetation (e.g. climbing asparagus, Japanese honeysuckle). Some vines are particularly brittle and small pieces are easily left behind after cutting and removing (e.g. Cape ivy, German ivy, climbing dock, convolvulus).

Where the stems have vegetative organs that can fall and grow (e.g. Madeira vine) or where wind-dispersed seeds are produced from drying fruit (e.g. German ivy, hops, climbing dock, moth plant, old man's beard, cathedral bells), the vines should be removed outside the fruiting season. Otherwise, the propagules may be spread during the control operation itself. If control must be done during this season, the seed heads need to be removed and disposed of before the bulk of the plant material is carried from the site.

Vines have many underground forms which demand different treatment. The roots of some species have no great potential to form underground runners. This includes species which have large rootstocks (e.g. passion vine species, Japanese honeysuckle, blue morning glory, elaeagnus, hops, moth plant, old man's beard) or root tubers (e.g. climbing dock, climbing asparagus, smilax). For these species, the whole rootstock can often be dug out, bagged, and removed. If this is not possible, the stems should be cut just above ground level, and the stump treated with herbicide immediately. For species that are particularly difficult to kill, and where the stump cannot be removed, an alternative approach is to dig out round the stump, apply herbicide, and cover the stump and roots with heavy plastic before replacing the soil (e.g. elaeagnus, Cape ivy).

Vines that form extensive underground or surface runners are very difficult to kill by hand methods because of the difficulty of extracting all the runners (e.g. convolvulus, jasmine). They should always be worked at with a fork, rather than a spade or grubber, because this reduces the chance of cutting the runners. The maximum amount can be removed by simultaneously digging and lifting along the direction of the runners.

Where there has not been a successful kill by stump treatment at the first attempt, the resulting regrowth should be about 0.5 m tall before re-applying herbicides.

Several herbicides are suitable as foliar sprays for vines, and these can be used on small infestations, particularly for susceptible species with a high leaf area (e.g. blue morning glory, cathedral bells, blackberry, Japanese honeysuckle, German ivy, old man's beard, and possibly others). When vines are well established and cover a large area, spray damage to associated vegetation is often disproportionately high. This applies particularly to species that require high rates of herbicide (e.g. elaeagnus, Madeira vine, moth plant, and probably others). Large infestations of some canopy vines (e.g. jasmine) or sub-canopy vines (e.g. climbing asparagus) would seldom justify the use of herbicides unless there was an ongoing revegetation programme for the gap created. However, where the area concerned is of no conservation value itself, but is functioning as a seed source infesting more valuable vegetation, drastic measures may be justified.

Trees and shrubs

The impact of these life forms, and hence the necessity to control them, varies greatly with the ecology of the individual species, and the stature and successional status of the vegetation they are invading.

Tall trees

No tall trees are able to invade completely intact forest. Such forest, if it exists at all on the mainland of New Zealand, occurs only in stands of more than several hundred hectares, and far removed from sources of weeds. Most small forest remnants are vulnerable to invasion by a few species capable of establishing under low light conditions (e.g. sycamore, tree privet, and possibly monkey apple). Rowan needs more light than these species and requires larger light gaps. Control of these shade-tolerant tall trees is generally a high priority, wherever they grow, because of their size, longevity, and potential impact.

Poplars and pines require high light to establish and therefore threaten only very damaged forest as well as shorter vegetation types such as tussockland and openland, including bluff systems and other open areas within forested landscapes. Emergent pines that have survived from previous successional stages in regenerating forest are of lower priority for control, as a second generation will not re-establish unless the area is burnt.

Control of tall trees should start with pulling seedlings, to prevent further spread, and progress to more intensive work. Big trees that are cut down usually need to be stump-treated with herbicide, because many resprout from the base, especially in high light situations. One option is to poison trees and leave them standing, a technique that has the advantage of minimising disturbance to the surrounding vegetation.

Most trees mentioned here, with the possible exception of tree privet, do not have a significant soil seed bank to re-establish from. Small seedlings may act in this capacity, however, by growing rapidly to occupy the light gaps resulting from canopy disturbance, e.g. sycamore. Often these become apparent some time after the death or removal of the parent, and need to be removed. In a similar manner, the cones of many pines open over several years after the adults have been killed, and surveillance timetables need to be drawn up that are appropriate for the species and environments involved.

Medium and small trees

With the possible exception of Darwin's barberry, and the two spindle berries, these life forms do not establish from seedlings in forest that is even moderately intact. Medium and small trees, therefore, threaten mainly damaged forest and secondary vegetation. Some of the more shade-tolerant bird-dispersed species (e.g. barberry, hawthorn, Japanese spindle berry, spindle berry, *Prunus* spp., Chinese privet, African olive) have some ability to establish in relatively small canopy openings and gaps, and persist there for a surprisingly long time. Their relatively low stature prohibits their reaching the canopy, however, and they are low priority for control work in forest situations. Many others, such as woolly nightshade and all the wattles and hakeas, have little shade tolerance as seedlings or adults, and can establish only in large clearings such as those created by fire or wind throw. Here they may be be suppressed by native vegetation on forest sites in less than 30 years, given an adjacent seed source.

Woolly nightshade may have an allelopathic effect on seedling establishment. Little control work would be required in these situations if waiting was a management option.

Many small and medium trees may form mixed or almost pure stands, where they establish on open ground or in conjunction with native or weedy shrubs. On sites that are stressed by aridity and infertility, where there is periodic ground disturbance, grazing, or fire, or where a source of native trees is lacking, all these species can be expected to persist in excess of 30 years. Examples include hakea and oxylobium on coastal headlands and pakihi; hawthorn and rowan in inland South Island; and wattles and boxthorn on steep slopes. Control measures may be required in all these situations to maintain the native vegetation.

Methods for the control of medium and small trees are similar to those described for tall trees, but many of the former have a greater propensity to resprout from the base or rootstocks, e.g. barberry, boxthorn, Chinese privet, hawthorn.

High water tables enable willow invasion, a further example of weed trees ocupying extreme sites. In scattered localities from the Waikato to Canterbury, there is preliminary evidence of willows acting as precursors to native forest, but this situation has not been widely reported. Willows are therefore candidates for control in all wetlands of high value because their effects on wetland systems are so pervasive.

A moderate soil seed bank occurs for some wattle species, and this can be activated by disturbance or fire. The hakea species have canopy-stored seed banks in the form of capsules, which open gradually over time, or following a fire. In all these situations, seedling control would be needed at appropriate intervals after disturbance.

Tall and short shrubs

The species composition and successional status of the vegetation being invaded is more important as a factor in deciding to control weedy shrubs than is the case for any other single plant life form. This is partly because shrubs cover a very wide range of habitats over extensive areas of New Zealand.

Shrubs are precursors to taller vegetation in most places below tree line, and even tall shrub weeds are shaded out by the growth of native species, or prevented from further establishment, under conditions favourable for native forest. This process is most rapid for a small group of fast growing multi-stemmed or twiggy-form shrubs, some bird-dispersed (e.g. tutsan, inkweed, apple of Sodom, orange cestrum, Himalayan honeysuckle) and others wind-dispersed (e.g. Spanish heath, heather, Cape honey flower) or explosively dispersed (e.g. tree lupin, dally pine). Several tall shrubs can be expected to disappear in similar fashion, although the process will take up to 30 years in cool or dry climates (e.g. buddleia, gorse, broom). Control would not be required for any of these species under many circumstances apart from preventing their spread into adjacent more sensitive areas.

Some tall shrubs in forest climates appear to be behaving more similarly to native species, such as coprosmas, and it may be more than 30 years before they are suppressed by the next generation of native broadleaved species. These are all bird-dispersed and relatively slow-growing (e.g. Khasia berry, firethorn, evergreen buckthorn, cotoneaster). Patience might be required if succession was to be the operative factor in returning vegetation dominated by these weeds to purely native species.

The role of many shrubs is quite different in herbaceous or open communities, such as coastal cliffs, riverbeds, and sand dunes. Several species are largely confined to northern New Zealand (e.g. sweet pea bush, oxylobium), while many other species are more widespread and dominant, e.g. gorse and bone-seed on sand dunes, broom and buddleia in riverbeds. The effort required to control them needs to be carefully weighed against the conservation values to be protected, because there is frequently little chance of returning the site to native vegetation. Where the habitat of nesting birds or specific threatened plants is at stake, the value of the effort to control species such as bone-seed, boxthorn, and broom may be readily apparent.

Short shrubland/fernland/rushland on peat soils is also severely affected by shrub weeds, and vegetation succession is not an option for weed control. As the native species are slow to recover from disturbances on the infertile soils, including those caused by weed control operations, the maxim of preventing the invasion by eliminating the early invaders is especially important.

Unlike that of tree life forms, the density of seedlings produced by shrubs generally precludes simply pulling them by hand as a viable method of control, other than around very isolated plants. This applies particularly with species that have persistent seed banks and where abundant seedlings can emerge over a period of several years (e.g. gorse, broom, bone-seed, Spanish heath, sweet pea bush) or where (perhaps) short lived seeds are stimulated by fire (e.g. sweet pea bush, dally pine). These plant characteristics strengthen the need to remove shrubs prior to seeding wherever possible, while at the same time undertaking an ongoing programme to remove second generation plants.

A defining characteristic of shrubs is their multiple shoots and the readiness with which they resprout at any point of the plant in response to damage. Most shrubs, therefore, respond to physical cutting, even at ground level, by producing new shoots on the cut stump. In some cases these arise also from root suckers, creating dense multi-stemmed thickets. Gorse, buddleia, Himalayan honeysuckle, Spanish heath, Cape honey flower, and heather exhibit this response particularly strongly. When cut, these species must be simultaneously poisoned; alternatively they must be cut so frequently that the plant is eventually killed. Grazing can effectively do this, but at the cost of most other plants as well. Another alternative is to dig them out.

For the few small shrubs which can grow from stem portions (e.g. Italian jasmine, red cestrum, lantana), the cut material must be disposed of in an appropriate manner.

There are several very effective herbicides available for shrubs, because these species have agricultural significance. Species vary in their susceptibility to different chemical application rates. Formulations to enhance the effectiveness of herbicides also increase the vulnerability of surrounding vegetation, even where only the woody stems of native plants are exposed.

7. Model control sites

The following composite examples illustrate how information on weed ecolgy might be used in the management of weeds in specific conservation areas, termed site-led control, in conjunction with the guidelines for weed control strategies (Owen 1996). For species-led control, widely applicable examples cannot readily be given because their phase of invasion varies between regions of New Zealand.

7.1 EXAMPLE 1: LOWLAND FOREST

This hypothetical area consists of a 50 ha patch of broadleaved forest in close proximity to a town north of latitude 38 (Fig. 6).

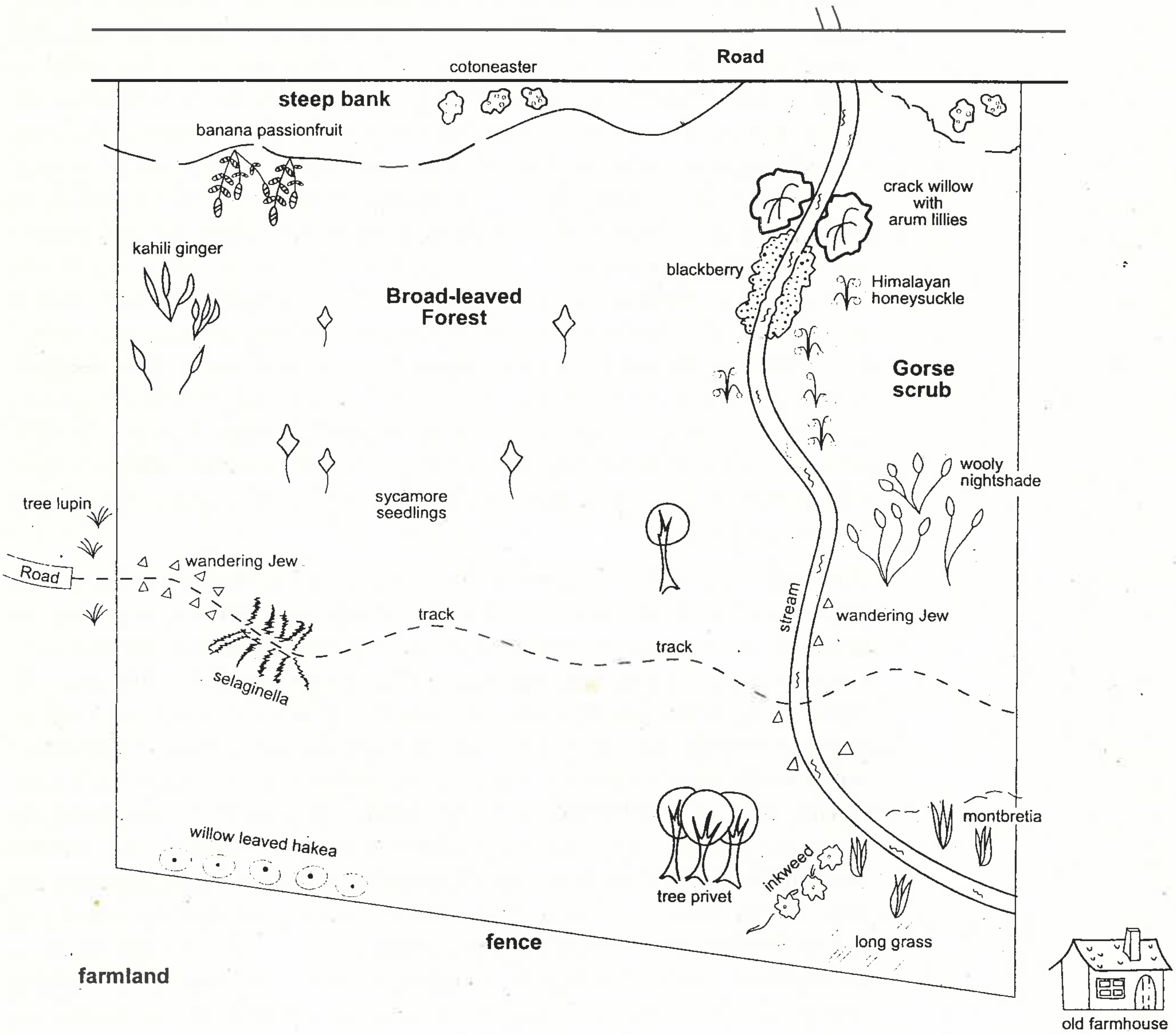


FIGURE 6. HYPOTHETICAL RESERVE OF LOWLAND FOREST WITH WEEDS.

The northern boundary is formed by a steep bank leading down to a highway, while the western and southern sides are bounded by farmland. There are the remains of an old homestead near the south-east corner of the reserve. A small side road on the western boundary leads right up to the edge of the reserve. The eastern side of the reserve is gorse scrub, and this runs up into the hill on that side. A small stream flows through the reserve and down to the sea 1 km away. The forest has been logged, and it has open areas on the margins and scattered clearings throughout, but otherwise it is in quite good condition. The reserve was created five years ago, when it was fenced off from the surrounding farmland.

The reserve is considered a fine example of its type and is often used for educational purposes; a track runs from the road end on the western side. The reserve has a wide range of weeds because of its fertile soils, history of use, the stream flowing from farmland, and its close proximity to a town and highway. However, there are no boundary issues and weed control is not required to appease neighbouring property owners.

The approximate distribution of weeds within the reserve is shown in Fig. 6. Their effects on the system (EOS), biological success rating (BSR), and total scores (see Section 10.4) are summarised under their respective life modes in Table 2. These data give a useful first approximation of the rank order of the detrimental impact of these weeds on the reserve. Their actual priority for control can only be determined if combined with a finer analysis of their biology, stage of invasion, impact, and interaction with other weeds and native species. The practicality of their control is also a factor and this will also depend on the availability of resources. To demonstrate how the priorities might vary with different levels of resources, the weeds are ranked into four "action groups" (Table 2). If minimal resources were available, species in group 1 would be attended to; with an increase in resources, those in action group 2 would be dealt with, and so on. Even then, the level of control differs between species because the availability of effective control methods varies between species. Generally, the highest-priority species are those with minimal infestations but with a big potential impact, and those which would be difficult to control if they became consolidated.

The group receiving the highest priority for control includes two trees and two herbs; these have the potential either to occupy most of the canopy gaps or openings, or smother the forest floor with dense vegetation, with the long-term consequences of preventing regeneration. Sycamore is present only as a few saplings, the escape phase within the context of this reserve, and these can all be removed with little effort. Likewise, all seedlings and saplings of tree privet can be easily removed but the adult trees would need to be cut down and their stumps painted with herbicide. Kahili ginger, present in its establishment phase, can also be eradicated. Young plants could be removed in wide sweeps through the forest at the same time as searches are made for young trees and other weeds. Because the reserve was lightly grazed until recently, wandering Jew is spreading from its invasion fronts along the track and down the stream — the explosive phase. The highest priority is to locate and control the outlying patches of wandering Jew before the mats at the centre of the infestation are controlled.

TABLE 2. WEEDS IN A THEORETICAL FOREST RESERVE: THEIR WEEDINESS SCORES, PRIORITY FOR CONTROL, AND PRACTICABLE LEVEL OF CONTROL.

LIFE FORM	EOS	BSR	TOTAL SCORE	RANK	ACTION GROUP	CONTROL LEVEL
Trees						
Grey willow	4	16	20	6=	3	eradication
Sycamore	9	15	24	3	1	eradication
Tree privet	10	17	27	1	1	eradication
Willow-leaved hakea	8	12	20	6=	4	eradication
Woolly nightshade	3	15	18	8=	4	no control
Shrubs						
Cotoneaster	5	15	20	6=	3	sustained control
Gorse	10	15	25	2=	4	no control
Himalayan honeysuckle	7	11	18	8=	4	no control
Tree lupin	6	11	17	9	4	sustained control
Vines						
Climbing asparagus	9	16	25	2=	2	sustained control
Banana passionfruit	6	15	21	5=	2	eradication
Ferns						
Selaginella	4	16	20	6=	4	no control
Grasses						
Cocksfoot	7	14	21	5=	3	no control
Iris-like herbs						
Montbretia	2	12	14	11	4	no control
Lily-like herbs						
Arum lily	5	14	19	7	4	no control
Erect herbs						
Inkweed	4	12	16	10	4	no control
Kahili ginger	9	16	25	2=	1	eradication
Mat-forming herbs						
Wandering Jew	8	15	23	4	1	sustained control

Notes: EOS (Effects on the system) and BSR (Biological success rating) are derived from Section 10.4. Total score is the sum of EOS and BSR. Rank is the placing within Total score. Action group is the relative priority for control, taking into consideration factors other than Rank. Control level is the recommended practicable level of control for the given level of resources.

These weeds of action group 1 are of high priority because, although eradication is possible now, this would require much greater expense if they were allowed to expand.

Group 2 consists of only two vines, which are ranked here for two quite different reasons. Climbing asparagus has the potential to spread through the more open areas of understorey and it is very difficult to control without damaging the native vegetation once this has happened. As the weed has become well established at one end of the reserve, the initial weed control effort has been directed towards more tractable problems represented by Group 1 weeds. Banana passionfruit looks dramatic, as it climbs from its establishment site on the road cuttings up into the overhead trees, but it has limited potential to spread from this margin because of its relatively high light requirements — the entrenchment phase within this reserve. Were there further extensive open banks and bluffs along the stream course it would receive a higher ranking for control.

Group 3 comprises a group of plants which are not having a major impact, and which are unlikely to spread to any great extent within the reserve: cotoneaster, grey willow, and willow-leaved hakea. The last species will eventually die and be replaced by native species. However, as they are only ten years old, this process is likely to take at least another 20 years. In the meantime, they are all conspicuous and detract from the naturalness of the reserve. They can all be readily located and, with easy access, they can be controlled by cutting and stump painting with herbicide.

Group 4 consists of a large group of weeds which need not be controlled, for a variety of reasons, unless there were extra resources available. Cocksfoot and inkweed are relics from when the area was grazed and will soon be overtaken by shrubs. The gorse, Himalayan honeysuckle, and woolly nightshade, while conspicuous at this point, will give way to native species in about 10 years. The arum lily and montbretia could be sprayed or dug out, but this would require a lot of work. The arum lily will not spread within the reserve. Likewise, the selaginella will probably not spread far beyond the high light environment of the track margin, where it can be expected to be shaded out by shrubs eventually.

7.2 EXAMPLE 2: COASTAL COMMUNITIES

This is an ecologically diverse reserve north of latitude 39°, consisting of 25 ha of coastal broadleaved forest and associated scrub communities, with coastal cliffs and foreshore communities (Fig. 7). The northern boundary is formed by the sea, the western boundary by well-managed farmland, and the eastern and southern boundaries by a road. The reserve is relatively intact forest, but the headland and western side were burnt about 20 years ago. Here there are weeds that have spread from adjacent farmland before it was cleared (hakeas, pines). The foreshore appears natural, as the manuka comes right down to the dunes. However, these are completely modified by marram grass, and adventive shrubs (bone-seed, evergreen buckthorn) have just started to move into the area. Kikuyu grass dominates one end of the beach near the road end. Pampas grass is well established at one end of the coastal cliffs and is spreading north. The north-eastern corner of the reserve is the site of an old homestead, which was the source of the wandering Jew and the mist flower that is spreading along the bush track from an infestation near a small creek. This corner of the reserve consists of paddocks which are presently used for camping. A new revegetation project is under way on part of this area.

The reserve is considered one of the better patches of coastal forest in the area, and although very modified, the coastal communities are some of the most natural within their particular ecological district.

The approximate distribution of weeds within the reserve is shown in Fig. 7, while their effects on the system (EOS), biological success rating (BSR), and total scores (see Section 10.4) are summarised under their respective life modes in Table 3. As with the first example, these data give a first approximation of the rank order of the impact these weeds are likely to have on this particular reserve. However, there is much less spread amongst the total scores, with only two weeds (apple of Sodom and oxylobium) having scores less than 20. An

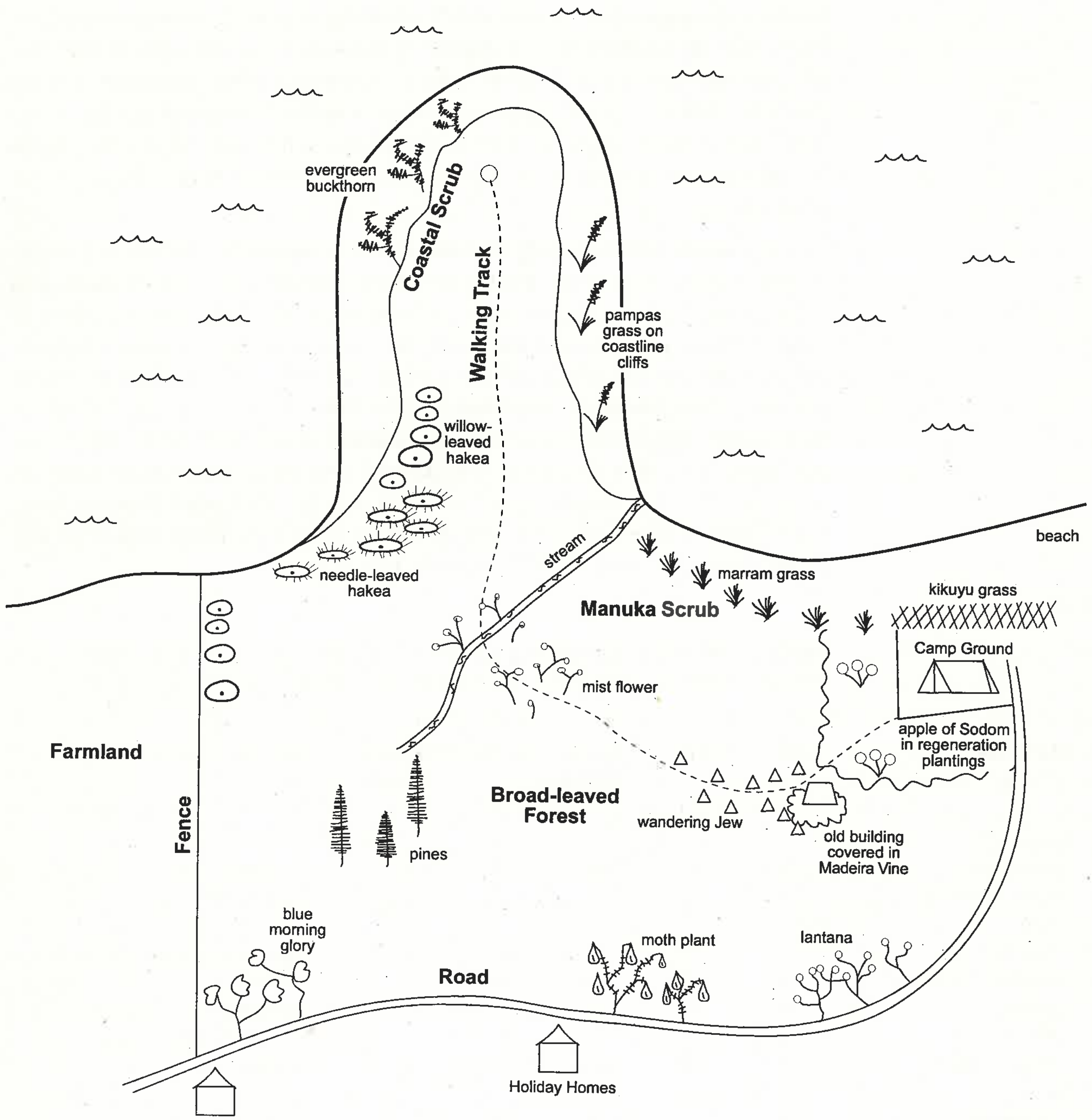


FIGURE 7. HYPOTHETICAL COASTAL RESERVE OF VARIOUS COMMUNITIES WITH WEEDS.

additional complication is introduced here, too, in that marram and kikuyu grasses are useful in their role of erosion prevention in this modified system. In these circumstances, the priority for control of any particular weed will be even more heavily dependent on a finer analysis of its biology, stage of invasion, impact and interaction with the native species and other weeds, the practicality of its control, and other land users' desires. As a result, the total scores bear little relationship to the rankings within the four levels for control, as determined by the author, within this reserve.

Group 1 includes those weeds, establishing in this reserve, which could spread and for which there are practicable, albeit labour-intensive, control measures.

These are two shrubs (evergreen buckthorn and lantana) and two vines (blue morning glory and moth plant), which are all fairly new to the area and can be eradicated or placed under a regime of sustained control. The group also includes wandering Jew, which must be prevented from spreading if at all possible. The last species, apple of Sodom, is unlikely to spread and has a low score, but is included in this first group because of its ease of control, which would make the management of the revegetation project easier (the plant has prickles).

Group 2 are no less damaging than the above, as shown by their scores (Table 3), but they are more firmly established in this reserve — the consolidation and entrenchment phases — and would require much more effort to eradicate or control. These are bone-seed and mist flower, which are hard to control because of the difficulty of killing the adult plants and the vigorous post-treatment response from seeds or resprouts. In the case of bone-seed, it would be strategically appropriate to reduce its numbers as far as possible, before any reduction of the marram grass was attempted. Otherwise, some of the openings in the marram community would probably provide ideal seed beds for bone-seed. Madeira vine is placed in this second group, purely on the basis of its low score and the fact that control can easily be achieved.

TABLE 3. WEEDS IN A THEORETICAL COASTAL RESERVE: THEIR WEEDINESS SCORES, PRIORITY FOR CONTROL AND PRACTICABLE LEVEL OF CONTROL.

LIFE FORM	EOS	BSR	TOTAL SCORE	RANK	ACTION GROUP	CONTROL LEVEL
Trees						
Radiata pine	11	13	24	3=	4	no control
Willow-leaved hakea	8	12	20	7=	4	no control
Shrubs						
Bone-seed	10	14	24	3=	2	sustained control
Evergreen buckthorn	5	18	23	4=	1	eradication
Lantana	4	17	21	6	1	eradication
Oxylobium	4	7	11	8	3	sustained control
Prickly hakea	8	12	20	7=	4	no control
Vines						
Madeira vine	6	14	20	7=	2	eradication
Morning glory	10	15	25	2=	1	sustained control
Moth plant	8	14	22	5=	1	sustained control
Grasses						
Kikuyu grass	5	17	22	5=	4	containment
Marram grass	12	18	30	1	3	no control yet
Pampas	8	14	22	5=	3	sustained control
Erect herbs						
Apple of Sodom	2	6	8	9	1	eradication
Mist flower	8	18	26	2=	2	sustained control
Mat-forming herbs						
Wandering Jew	8	15	23	4=	1	sustained control

Notes: EOS (Effects on the system) and BSR (Biological success rating) are derived from Section 10.4. Total score is the sum of EOS and BSR. Rank is the placing within Total score. Action group is the relative priority for control, taking into consideration factors other than Rank. Control level is the recommended practicable level of control for the given level of resources.

Group 3 weeds would be tackled only after a decision was made for ongoing restoration of the coastal vegetation. The removal of pampas grass from the cliffs would be difficult and expensive despite the existence of effective sprays. Likewise, marram grass could only be removed if there was something available from outside the reserve to replace it, probably pingao (*Desmoschoenus spiralis*).

Group 4 weeds are the hakeas and pines, which can be left, as they will be overwhelmed by native vegetation through successional processes. The latter could perhaps be ring-barked and poisoned, however, purely on the grounds of adding to the naturalness of the reserve. Were there adjacent vulnerable communities such as heathlands, or had they shown any tendency to invade the sand dunes, they would receive a higher priority. Kikuyu grass will have to be tolerated in the area of high human use, but its spread along the beach should be constantly checked and new colonies prevented from becoming established.

8. Acknowledgements

I would like to express my special thanks to Alan Esler for his insights into weediness and for his encouragement and hospitality at the early stages of this project. Likewise, Jack Craw for introducing me to the weeds of Northland and to Susan Timmins and Claire Williams for their company on weeding expeditions. Susan Timmins and Carol West originally suggested this project. Many people provided me with unpublished information and ideas: Maire Fromont, John Greenwood, Colin Ogle, S-J Owen, Nigel Mountford, Dane Panetta, Sue Scobie, Geoff Walls. Drafts of the script were improved by Ralph Allen, Bill Lee, Carol West and especially Susan Timmins. The graphs were drawn by Ivan Morgan, and Merle Rae converted my draft into a presentable format.

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10. Appendices

10.1 COMMON AND SCIENTIFIC NAMES OF WEEDS

Common name	Botanical name	Common name	Botanical name
African feather grass	*Pennisetum macrourum*	egeria	*Egeria densa*
African fountain grass	*Pennisetum setaceum*	elaeagnus	*Elaeagnus* x *reflexa*
agapanthus	*Agapanthus orientalis*	elder	*Sambucus nigra*
alder	*Alnus glutinosa*	elephant's ear	*Alocasia macrorrhiza*
alligator weed	*Alternanthera philoxeroides*	evergreen buckthorn	*Rhamnus alaternus*
American spartina	*Spartina alterniflora*	fennel	*Foeniculum vulgare*
apple of Sodom	*Solanum linnaeanum*	firethorn	*Pyracantha angustifolia*
aristea	*Aristea ecklonii*	floating sweetgrass	*Glyceria fluitans*
arum lily	*Zantedeschia aethiopica*	German ivy	*Senecio mikanioides*
asparagus fern	*Asparagus scandens*	giant knotweed	*Reynoutria sachalinensis*
Australian sedge	*Carex longebrachiata*	giant reed	*Arundo donax*
banana passionfruit	*Passiflora mollissima*	gorse	*Ulex europaeus*
barberry	*Berberis glaucocarpa*	grey willow	*Salix cinerea*
black passionfruit	*Passiflora edulis*	hakea, downy	*Hakea gibbosa*
blackberry	*Rubus fruticosus* agg.	hakea, prickly	*Hakea sericea*
blue morning glory	*Ipomoea indica*	hakea, willow-leaved	*Hakea saticifolia*
blueberry	*Vaccinium corymbosa*	hawkweed	*Hieracium* spp.
bone-seed	*Chrysanthemoides monilifera*	hawthorn	*Crataegus monogyna*
boxthorn	*Lycium ferocissimum*	heath rush	*Juncus squarrosus*
broom	*Cytisus scoparius*	heather	*Calluna vulgaris*
browntop	*Agrostis capillaris*	hemlock	*Conium maculatum*
brush cherry	*Syzygium australe*	Himalayan honeysuckle	*Leycesteria formosa*
brush wattle	*Paraserianthes lophantha*	hops	*Humulus lupulus*
buddleia	*Buddleia davidii*	horsetail	*Equisetum arvense*
bulbous rush	*Juncus bulbosus*	hydrilia	*Hydrilia verticillata*
buttercup bush	*Senna septemtrionalis*	inkweed	*Phytolacca octandra*
Cape honey flower	*Melianthus major*	Italian jasmine	*Jasminum humile*
Cape ivy	*Senecio angulatus*	Italian arum	*Arum italicum*
cathedral bells	*Cobaea scandens*	ivy	*Hedera helix*
cheatgrass	*Bromus tectorum*	Japanese honeysuckle	*Lonicera japonica*
Chilean flame creeper	*Tropaeolum speciosum*	Japanese knotweed	*Reynoutria japonica*
Chilean needlegrass	*Stipa neesiana*	Japanese spindle tree	*Euonymus japonicus*
Chinese privet	*Ligustrum sinense*	Japanese walnut	*Juglans ailantifolia*
climbing asparagus	*Asparagus scandens*	jasmine	*Jasminum polyanthum*
climbing dock	*Rumex sagittatus*	Jerusalem cherry	*Solanum pseudocapsicum*
climbing spindle berry	*Celastrus orbiculatus*	jointed rush	*Juncus articulatus*
cocksfoot	*Dactylis glomerata*	kahili ginger	*Hedychium gardnerianum*
coltsfoot	*Tussilago farfara*	kangaroo acacia	*Racosperma paradoxa*
contorta pine	*Pinus contorta*	Khasia berry	*Cotoneaster simonsii*
convolvulus	*Convolvulus arvense*	Kikuyu grass	*Pennisetum clandestinum*
coral tree	*Erythrinum* x *sykesii*	lagarosiphon	*Lagarosiphon major*
cotoneaster	*Cotoneaster glaucophyllus*	lantana	*Lantana camara* var. *aculeata*
crack willow	*Salix fragilis*	lodgepole pine	*Pinus contorta*
dally pine	*Psoralea pinnata*	loquat	*Eriobotrya japonica*
Darwin's barberry	*Berberis darwinii*	lotus	*Lotus pedunculatus*
Douglas fir	*Pseudotsuga menziesii*	Madeira vine	*Anredera cordifolia*

Common name	Botanical name	Common name	Botanical name
Manchurian rice grass	*Zizania latifolia*	Senegal tea	*Gymnocoronis spilanthoides*
marram grass	*Ammophila arenaria*	sharp rush	*Juncus acutus*
maritime pine	*Pinus pinaster*	silver wattle	*Racosperma dealbata*
Mercer grass	*Paspalum distichum*	smilax	*Asparagus asparagoides*
Mexican daisy	*Erigeron karvinskianus*	spanish heath	*Erica lusitanica*
Mexican devil	*Ageratina adenophora*	spartina	*Spartina anglica*
mile-a-minute	*Dipogon lignosus*	spartina hybrid	*Spartina* x *townsendii*
mist flower	*Ageratina riparia*	spindle tree	*Euonymus europaeus*
monkey apple	*Acmena smithii*	St John's wort	*Hypericum perforatum*
monkey musk	*Mimulus guttatus*	stinking iris	*Iris foetidissima*
montbretia	*Crocosmia* x *crocosmiiflora*	stone crop	*Sedum acre*
Montpellier broom	*Teline monspessulana*	sweet brier	*Rosa rubiginosa*
moth plant	*Araujia sericifera*	sweet cherry	*Prunus avium*
Mysore thorn	*Caesalpinia decapetala*	sweet pea bush	*Polygala myrtifolia*
nassella tussock	*Nassella trichotoma*	sycamore	*Acer pseudoplatanus*
nasturtium	*Tropaeolum malus*	Sydney golden wattle	*Racosperma longifolia*
nodding thistle	*Carduus nutans*	tall fescue	*Festuca arundinacea*
northern banana passionfruit	*Passiflora mixta*	tall oatgrass	*Arrhenatherum elatius*
old man's beard	*Clematis vitalba*	thistle	*Cirsium* spp.
olive	*Olea europaea*	three-cornered garlic	*Allium triquetrum*
onion weed	*Allium triquetum*	tree lupin	*Lupinus arboreus*
orange cestrum	*Cestrum aurantiacum*	tree privet	*Ligustrum lucidum*
oxylobium	*Oxylobium lanceolatum*	tuber sword fern	*Nephrolepis cordifolia*
palm grass	*Setaria palmifolia*	tutsan	*Hypericum androsaemum*
pampas grass	*Cortaderia selloana*	veld grass	*Ehrharta erecta*
parrot's feather	*Myriophyllum aquaticum*	viper's bugloss	*Echium vulgare*
perennial ryegrass	*Lolium perenne*	wandering Jew	*Tradescantia fluminensis*
periwinkle	*Vinca major*	water net	*Hydrodictyon reticulatum*
potato vine	*Solanum jasminoides*	wattle	*Racosperma* spp.
purple pampas	*Cortaderia jubata*	watsonia	*Watsonia bulbillifera*
pyp grass	*Ehrharta villosa*	white poplar	*Populus alba*
radiata pine	*Pinus radiata*	wild ginger	*Hedychium* spp.
ragwort	*Senecio jacobaea*	wild onion	*Allium vineale*
red cestrum	*Cestrum elegans*	wilding pine	*Pinus* spp.
rowan	*Sorbus aucuparia*	willow	*Salix* spp.
royal fern	*Osmunda regalis*	wonga wonga vine	*Pandorea pandorana*
rush	*Juncus* spp.	woolly nightshade	*Solanum mauritianum*
Russell lupin	*Lupinus polyphyllus*	yellow ginger	*Hedychium flavescens*
salvinia	*Salvinia molesta*	yellow jasmine	*Jasminium humile*
selaginella	*Selaginella kraussiana*	yellow water iris	*Iris pseudacorus*

10.2 GLOSSARY OF SOME TERMS USED IN THE TEXT

Adventive	Not native to New Zealand.
Allelopathic	The effect of one plant on another, usually reserved for chemical effects in the soil.
Annuals	Plants that complete their life cycle in one year.
Biennials	Plants completing their life cycle in two years. Some are optionally annual or biennial.
Biota	All living things.
Bulbs	Specialised underground organs with thick fleshy leaves.
Canopy	The outer layer of vegetation.
Capsules	Dry plant parts containing seeds.
Clones	Plants derived from fragments of a parent plant.
Corms	Enlarged below ground stem.
Creeping stems	Generally thin stems, on or immediately beneath the soil surface.
Dispersal	The process of carrying propagules from the parent plant, to a new location.
Forest	Vegetation dominated by woody plants with stems grater than 10 cm diameter.
Herbs	Plants with no secondary thickening in the woody tissue.
Life mode	The way a plant earns a living, based mainly on its form.
Perrenial	Plants that live for more than two years.
Propagules	Any part of a plant that may develop into another, i.e., piece of stem or seed.
Rhizomes	Thick horizontal stem, partly above ground, sending out roots below and shoots above.
Scrub	Vegetation dominated by shrubs with stems less than 10 cm diameter.
Seed bank	Seeds that are capable of germinating; usually refers to those in the soil.
Shrubs	Plants with a main stem less than 10 cm diameter.
Site-led strategy	Emphasis is placed on managing a particular site for all weeds (cf. species-led strategy).
Species-led strategy	Emphasis is placed on the weed species, wherever it grows (cf. site-led strategy).
Strategy	The art of deploying resources, in this case, to control weeds.
Subcanopy	Layer of vegetation beneath the canopy.
Suckers	Shoots developing from the roots or basal stem portions of woody plants.
Sward	A mass of interlacing shoots, usually of grasses.
Tactics	The particular methods used, in this case, to control weeds.
Terrestrial weeds	Weeds that grow primarily on land.
Tillers	Shoots produced at the base of grasses and some rushes.
Tubers	Thickened fleshy underground stem or root, with surface buds.
Vegetation structure	Spacial arrangement of the vegetation on a site.
Vines	Plants with thin stems that climb and need the support of other plants or objects to do so.

10.3 EXPLANATION OF SOME TERMS USED, AND REFERENCES, IN SECTION 10.4

The tables which form the body of Section 10.4 are abridged from Owen (1996) and were compiled with the assistance of the author (PAW) as part of the present project.

Owen (1996) used the term growth form, which is very similar to life mode. The following terms were also used:

Text	Section 10.4
Annual and biennial herbs	Bi/annual
Perennial herbs	
Erect or tufted herb	Erect or tufted
Mat-forming herb	Mat forming
Iris-like herb, Lily-like herb	Bulb herb
Grasses and grass-like herbs	Grass
Rushes and rush-like herbs	Rush
Ferns and fern-like plants	Fern
Vines	Vine
Trees and shrubs	
Small shrubs	Shrubs <3 m
Tall shrubs	Shrubs 3-5 m
Small trees	Trees <6 m
Medium trees	Trees 6-10 m
Tall trees	Trees >10 m tall

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10.4 ECOLOGICAL WEEDS ON LANDS ADMINISTERED

Modified from Owen (1996).

Key to community type affected

3 = Community very easily invaded by this species
2 = Community often invaded by this species
1 = Community sometimes invaded by this species
No score = Community only very rarely or never invaded by this species

Key to country codes

(N/S/E/W/C = north,etc., central;
Afr = Africa; Am = America;
Arg = Argentina
Aust = Australia; Eur = Europe;
Haw = Hawaii
Ind = India; Jap = Japan; trop
trop = tropical
Aust* = species which is both
and a weed in Australia
a weed in Australia

Botanical name	Common name	Lit. Ref	Nox stat	Growth form	Date of natlstn in NZ	Country / area of origin
Acer pseudoplatanus	sycamore	8, 12		Tree (>10m)	1880	C & S Europe
Acmena smithii	monkey apple			Tree (>10m)	1982	E.Australia
Agapanthus orientalis	agapanthus	11		Bulb herb	1952	S.Africa
Ageratina adenophora	Mexican devil	1,3		Erect herb	1931	Mexico
Ageratina riparia	mist flower	1		Erect herb	1931	Mexico, W. Indies
Agrostis capillaris	browntop			Grass	1871	Eurasia
Allium triquetum	onion weed	11		Bulb herb	1928	S.Europe,N.Africa
Alnus glutinosa	alder			Tree (>10m)	1914	Eurasia, N Africa
Alocasia macrorrhizos	elephant's ear	12		Bulb herbs		trop Asia
Alternanthera philoxeroides	alligator weed	2,11,1	B	Aquatic	1906	Brazil
Ammophila arenaria	marram grass	2, 12		Grass	1873	Europe
Anredera cordifolia	Madeira vine	2,11,12		Vine	1940	trop S America
Araujia sericifera	moth plant			Vine	1888	S Brazil, Argentina
Aristea ecklonii	aristea			Bulb herbs	1975	trop & S Africa
Arrhenatherum elatius	tall oatgrass			Grass	1883	Eurasia,N.Africa
Arum italicum	Italian lily			Bulb herbs	1945	Europe, N Africa
Arundo donax	giant reed	3		Rush	1979	Europe, N Africa
Asparagus asparagoides	smilax	2		Vine	1905	trop & S Africa
Asparagus scandens	climbing asparagus	2		Vine	1970	trop & S Africa
Berberis darwinii	Darwin's barberry	11		Tree (<6m)	1946	S. Chile
Berberis glaucocarpa	barberry		B	Tree (6-10m)	1916	W Himalaya
Bromus tectorum	cheatgrass	1, 12		Grass		Europe, N Asia
Buddleja davidii	buddleia	8		Shrub (3-5m)	1946	China
Caesalpinia decapetala	Mysore thorn	1,3,12		Vine	1965	India
Calluna vulgaris	heather			Shrub (<3m)	1910	Eurasia, N Africa
Carduus nutans	nodding thistle		B	Bi/Annual	1889	Eurasia, N Africa
Carex longebrachiata	Australian sedge		B	Rush	1906	Australia
Celastrus orbiculatus	climbing spindleberry			Vine	1981	NE temp Asia
Cestrum aurantiacum	orange cestrum			Shrub (<3m)	1958	Guatemala
Cestrum elegans	red cestrum	2	B	Shrub (3-5m)	1958	Mexico
Chrysanthemoides monilifera	boneseed	2		Shrub (3-5m)	1870	S Africa
Cirsium spp.	thistles	2		Bi/Annual	1870	Eurasia
Clematis flammula				Vine	1968	Eurasia, N Africa
Clematis vitalba	old man's beard	2	B	Vine	1940	Europe, SW Asia
Cobaea scandens	cathedral bells			Vine	1946	C & S America
Convolvulus arvense	convolvulus	10		Vine	1880	N temperate
Cortaderia jubata	purple pampas	4, 5	B	Grass	1965	C &S America
Cortaderia selloana	pampas	2,5		Grass	1925	C & S America

Key to "National Distribution Status"

B = Naturalised, but only just starting to spread
I = Isolated/confined distribution nationally
L = Limited distribution nationally, but spreading within or between regions
S = Widely distributed nationally & spreading into new habitats or regions
W = Widespread - has reached almost all suitable habitat

Key to Bioclimatic zones

W = Warm Temperate (31 - 42 S)
C = Cool Temperate (42 - 50 S)
WM = Warm Maritime (<600m, 17.5 - 22.4 C)
WUM = Warm Upper Montane (>600m, 12.5 - 17.4 C)
CM = Cool Maritime (<700m, 12.5 - 17.4 C)
CSA = Cool Sub-alpine (>700m, 10 - 12.4 C)
CLA = Cool Low alpine (>1200m, 5 - 9.9 C)
Ranges include intervening zones; eg :
WM - CSA includes WUM & CM
WM - CM includes WUM

Community type potentially affected												Natnl Distrib status	Bioclimatic zone(s) in which is a major pest
Terrestrial Communities								Aquatic/wetlnd/riparian					
Forest		Shrub-land	Tussockland		Fern-land	Herb-field	Bare	Lake pond	River, riparia	Wetland			
Intact	Distb		Tall	Shor						FW	saline		
	1	3		3	3		1					L	WM - CM
	1	2		2								L	WM
							1					L	WM
1	3	3			3		3		2	3		L	WM
1	3	3			3		3		2	3		L	WM
			2	2		2	2		2			W	CSA
	1					2	1					W	WM - CM
							1		1			S	WM - CSA
	1	2				1	1			1		L	WM
								3		3		L	WM
				3			3					W	WM - CM
	2	1										L	WM
	3	3			3							L	WM
		2				2	2					L	WM
				3		1	2					L	CSA
	1	1				1	1			2		S	WM
	2	2		3	3					1		L	WM
1	1	3		1								L	WM
1	3	3										L	WM
	3	3		3		1	1					S	WM - CM
	1	3		3			1					S	WM - CM
				2			2					W	CM
	2	3		3			2		2			S	WM - CM
	3	3			3							I	WM
		3		3		3	2			1		L	WM - CSA
						2	2					W	WM - CM
		1		3								L	WM
	1	1										L	WM
		2										L	WM
		2										B	WM
		2		2	1		3					L	WM - CM
				1		3	3					W	WM - CM
		2										B	WM
2	3	3		1	1		1					S	WM - CM
	1	1		1								L	WM
		1		1	1							L	WM - CM
	1	2		3		2	3					S	WM
	1	2		3		2	3					S	WM

Botanical name	Common name	Lit. Ref	Nox stat	Growth form	Date of natlstn in NZ	Country / area of origin
Cotoneaster glaucophyllus	cotoneaster	2		Shrub (3-5m)	1982	China
Cotoneaster simonsii	Khasia berry			Shrub (3-5m)	1958	Burma
Crataegus monogyna	hawthorn	2,10	B	Tree (6-10m)	1899	Europe
Crocosmia x crocosmiiflora	montbretia	2		Bulb herbs	1935	trop S America
Cytisus scoparius	broom	2	B	Shrub (<3m)	1872	Eurasia
Dactylis glomerata	cocksfoot	12		Grass		Eurasia
Dipogon lignosus	mile-a-minute	2		Vine	1871	S Africa
Echium vulgare	viper's bugloss	10,11		Bi/Annual	1870	Eurasia
Egeria densa	egeria		B	Aquatic	1946	sub-trop America
Ehrharta erecta	veld grass	2		Grass	1944	Sth.Africa
Ehrharta villosa	pyp grass	2		Grass	1990	Sth Africa
Elaeagnus x reflexa	elaeagnus			Vine	1940	?Japan
Equisetum arvense	horsetail			Fern	1922	N temperate
Erica lusitanica	spanish heath	2, 12	B	Shrub (<3m)	1926	SW Europe
Erigeron karvinskianus	Mexican daisy			Mat forming	1940	Mexico
Eriobotrya japonica	loquat	1		Tree (<6m)	1982	China, Japan
Euonymus europaeus	spindleberry			Tree (<6m)	1958	Europe
Euonymus japonicus	Japanese spindleberry	2		Tree (6-10m)	1980	Jap, China, Korea
Festuca arundinacea	tall fescue			Grass	1871	Eurasia
Glyceria fluitans	floating sweetgrass			Grass	1872	Eurasia
Gymnocoronis spilanthoides	Senegal tea		B			
Hakea gibbosa	hakea, downy			Tree (<6m)	1937	NSW
Hakea salicifolia	hakea, willow-leaved	2		Tree (<10m)	1908	E Australia
Hakea sericea	hakea, prickly	2,3,12		Tree (<6m)	1883	Tas., E Australia
Hedera helix	ivy	1,2		Vine	1873	temp. Europe, Asia
Hedychium flavescens	yellow ginger	1, 12	B	Erect herb	1898	Himalayas
Hedychium gardnerianum	kahili ginger	1, 12	B	Erect herb	1940	India
Hieracium spp.	hawkweed			Mat forming	1878	Europe
Humulus lupulus	hops	11		Vine	1872	Europe, C&W Asia
Hydrilla verticillata	hydrilla	1, 12	B	Aquatic	1963	Eurasia
Hydrodictyon reticulatum	water net			Aquatic	pre 1986	?
Hypericum androsaemum	tutsan	2		Shrub (<3m)	1870	S & W Europe
Hypericum perforatum	St John's wort	2, 5		Erect herb	1869	Eurasia, N.Africa
Ipomoea indica	blue morning glory	1, 11		Vine	1950	pantropical
Iris foetidissima	stinking iris			Bulb herbs	1958	Europe, N.Africa
Iris pseudacorus	yellow water iris	11		Bulb herbs	1878	Eurasia, N.Africa
Jasminium humile	yellow jasmine			Shrub (<3m)	1958	temp Himalaya, SW China
Jasminum polyanthum	jasmine			Vine	1980	W China
Juglans ailantifolia	Japanese walnut			Tree (>10m)	1983	Japan
Juncus acutus	sharp rush	2, 11		Rush	1923	Europe, Africa, N Am
Juncus articulatus	jointed rush	11		Rush	1864	Eurasia, N Am, N Africa
Juncus bulbosus	bulbous rush	11		Rush	1896	Eurasia, N Africa
Juncus effusus	rush	2		Rush	1874	Europe, N.Africa
Juncus squarrosus	heath rush			Rush	1910	Europe, N.Africa
Lagarosiphon major	lagarosiphon	12	B	Aquatic	1950	trop & S Africa
Lantana camara var. aculeata	lantana	1,6		Shrub (<3m)	1912	trop America
Leycesteria formosa	Himalayan honeysuckle	2		Shrub (<3m)	1878	temp Himalaya
Ligustrum lucidum	tree privet	2,12		Tree (>10m)	1958	China, Korea
Ligustrum sinense	Chinese privet	2		Tree (<6m)	1950	China
Lolium perenne	perennial ryegrass			Grass	1855	
Lonicera japonica	Japanese honeysuckle	1,2,12		Vine	1926	E Asia
Lotus pedunculatus	lotus			Mat forming	1867	Europe, Asia, N Afri
Lupinus arboreus	tree lupin	1,2		Shrub (<3m)	1899	California
Lupinus polyphyllus	Russell lupin	1,11		Erect herb	1958	N America
Lycium ferocissimum	boxthorn	2	B	Shrub (<3m)	1897	S Africa
Melianthus màjor	Cape honey flower			Shrub (<3m)	1878	S Africa
Mimulus guttatus	monkey musk	8		Shrub (<3m)	1878	N America
Myriophyllum aquaticum	parrot's feather	12	B	Aquatic		S. America

Community type potentially affected												Natnl Distrib status	Bioclimatic zone(s) in which is a major pest
Terrestrial Communities								Aquatic/wetlnd/riparian					
Forest		Shrub-land	Tussockland		Fern-land	Herb-field	Bare	Lake pond	River, riparia	Wetland			
Intact	Distb		Tall	Shor						FW	saline		
	1	3		2	3		1					S	WM - CM
	1	3		2	2							L	WM - WU
	1	3		2	3							S	WM - CM
	2	2		3	2		1			2		S	WM - CM
		3	3	3	3		3		3	1		W	WM - CSA
				2		1	3			1		W	WM - CSA
	2	3			3							L	WM
				2		1	2					L	CM - CSA
								3				L	WM
				2		1	2					L	WM
	1	1		1		1	1			1		I	WM
	2	2	1				1					L	WM - CM
				2			2		2	2		S	WM - CM
		3	3	3	3	3	2					S	WM - CM
		2				1	3					L	WM
	2	2										L	WM
	3	3										L	WM - CM
	3	3										L	WM
				3			3			3	2	S	WM - CM
									2	2		L	WM - CM
										1		B	WM
		3		1			2					L	WM
	1	2		2	2		1					L	WM
		3		1			2					L	WM
1	2	2					1					L	WM - CM
1	3	3			1	1	2					S	WM
1	3	3			1	1	2					S	WM
		2	3	3	2	3	3					S	WUM - CS
	1	1			1							L	WM
								3		2		I	WM
								3				L	WM
		1		2			2					S	WM - CM
				2		1	1					S	CM
	3	3			1							L	WM
	1	1					2					S	WM - CM
										2		L	WM - CM
		2										L	WM - CM
	3	3										L	WM
	1	1										L	WM
							1		2	3		S	WM
						1				3		S	WM - CM
							2			3		S	WM - CM
								2				S	WM - CM
		1	1	1			1			2		L	WM - CM
								3				S	WM - CM
	2	3		2								L	WM
	2	3			3		1					S	WM - CM
	2	3		3								S	WM
	2	3										S	WM
				3		3	2			1		W	WM - CM
	3	3			1							S	WM - CM
		2	3	3	3	1	2			3		W	WM - CSA
				3			3		3			W	WM - CM
		1		2			3		3	2		L	WM - CM
		3		1	3	2	1					S	WM - CM
	1	2		1	2		2					L	WM
									2	2		L	WM - CM
										3		I	WM

Botanical name	Common name	Lit. Ref	Nox stat	Growth form	Date of natlstn in NZ	Country / area of origin
Nassella trichotoma	nassella tussock	1,3,12	B	Grass	1931	S. America
Nephrolepis cordifolia	tuber sword fern			Fern	1974	pantropic
Olea europaea	olive			Tree (<6m)	1977	Africa
Osmunda regalis	royal fern			Fern	1890	Eur, W&S America
Oxylobium lanceolatum	oxylobium	2		Tree (<6m)	1931	W Australia
Pandorea pandorana	wonga wonga vine			Vine	1981	N Guinea, E Australia
Paraserianthes lophantha	brush wattle	1,2,3		Tree (<6m)	1870	W Australia
Paspalum distichum	Mercer grass		B	Grass	1906	Cosmopolitan
Passiflora edulis	black passionfruit	1,3		Vine	1950	trop America
Passiflora mixta	nthn banana passionfruit	1		Vine	1970	N Andes
Passiflora mollissima	banana passionfruit	1,12		Vine	1958	trop S America
Pennisetum clandestinum	Kikuyu grass	1,2		Grass	1970	trop & S Africa
Pennisetum macrourum	African feather grass		B	Grass	1940	S.Africa
Pennisetum setaceum	African fountain grass	1,12		Grass		W Asia - N Africa
Phytolacca octandra	inkweed	11	B	Shrub (<3m)	1867	trop C&S America
Pinus contorta	lodgepole pine		B	Tree (>10m)	1957	NW America
Pinus pinaster	cluster pine	1,2,3,12		Tree (>10m)	1830	Mediterranean
Pinus spp.	wilding pine	1		Tree (>10m)	various	N.Hemisphere
Polygala myrtifolia	sweet pea bush	1,2		Shrub (<3m)	1870	S Africa
Populus alba	white poplar	11		Tree (>10m)	1904	Eurasia. Africa
Prunus avium	sweet cherry			Tree (6-10m)	1872	Europe
Pseudotsuga menziesii	Douglas fir			Tree (>10m)	1925	N America
Psoralea pinnata	dally pine	2		Shrub (3-5m)	1870	S Africa
Pyracantha angustifolia	orange firethorn	11		Shrub (3-5m)	1958	China
Racosperma dealbata	silver wattle	2,3,10		Tree (6-10m)	1870	E Australia
Racosperma longifolia	Sydney golden wattle	2,12		Tree (6-10m)	1897	E Australia
Racosperma paradoxa	kangaroo acacia	2		Tree (<6m)	1911	W & E Australia
Reynoutria japonica	Japanese knotweed	7		Erect herb	1935	Jap, Korea, N China
Reynoutria sachalinensis	giant knotweed	7		Erect herb	1935	E Asia, N Japan
Rhamnus alaternus	evergreen buckthorn	2		Shrub (3-5m)	1940	Mediterranean
Rosa rubiginosa	sweet brier	10,12	B	Shrub (<3m)	1867	Europe
Rubus fruticosus agg.	blackberry	1,2	B	Vine	1867	N temperate
Rumex sagittatus	climbing dock			Vine	1935	S Africa
Salix cinerea	grey willow	2		Tree (6-10m)	1925	Eur, W Asia, N Africa
Salix fragilis	crack willow	2		Tree (6-10m)	1880	Europe, W Asia
Salvinia molesta	salvinia, water fern	12	A	Aquatic	1964	Brazil
Sambucus nigra	elder / elderberry			Tree (>10m)	1867	Eur, W Asia, N Africa
Sedum acre	stone crop			Mat forming	1904	Eur, W Asia, N Africa
Selaginella kraussiana	selaginella	11		Fern	1919	C&S Africa
Senecio angulatus	Cape ivy	11		Vine	1940	S Africa
Senecio jacobaea	ragwort	2	B	Bi/Annual	1894	Europe, W Asia
Senecio mikanioides	German ivy	1,10		Vine	1870	S Africa
Senna septemtrionalis	buttercup bush			Shrub (3-5m)	1965	Mexico, C America
Setaria palmifolia	palmgrass	1		Grass		India
Solanum jasminoides	potato vine			Vine	1958	S Brazil
Solanum linnaeanum	apple of Sodom	11		Shrub (<3m)	1883	N Africa
Solanum mauritianum	woolly nightshade	3, 12	B	Tree (<6m)	1883	S Brazil, Uruguay
Solanum pseudocapsicum	Jerusalem cherry	1		Shrub (<3m)	1935	S.America
Sorbus aucuparia	rowan	11		Tree (>10m)	1904	Eurasia
Spartina alterniflora	American spartina			Grass	1965	N,S.America
Spartina anglica	spartina hybrid	2,12	B	Grass	1981	Europe
Spartina x townsendii	spartina	2	B	Grass	1924	Europe

Community type potentially affected												Natnl Distrib status	Bioclimatic zone(s) in which is a major pest
Terrestrial Communities								Aquatic/wetlnd/riparian					
Forest		Shrub-land	Tussockland		Fern-land	Herb-field	Bare	Lake pond	River, riparia	Wetland			
Intact	Distb		Tall	Shor						FW	saline		
		2	2	2			3					L	WM - CM
	2	2		1	1							L	WM
	1	2					1					I	WM
							2			2		L	WM
		3		1	3	3						L	WM
	2	2										L	WM
	1	3		1	1		2					S	WM - CM
		1		3			3			2		L	WM
	2	3										L	WM
	2	3										L	WM
	2	3										S	WM - CM
	1	2		3	2		3					W	WM
		1		2	1		2					L	WM
							1					B	WM
	1	2		2			1					L	WM - CM
	2	3	3	3	3	3	3					S	WM - CLA
		2					2					L	WM - CM
		3	3	3	3	3	3					S	WM
		2		1			1					L	WM
	1	1		1			1		2			S	WM - CM
	1	2										L	WM - CM
	1	3	3	3								L	CM
		2		2		1	1					L	WM
	1	2		2			1					L	WM - WU
	1	3		1			1		1			S	WM - CM
		3		2			1					S	WM
		2		2			1					L	WM
		2							2			S	WM - CM
		2					1					L	WM
	2	2		2	2	1	1					L	WM
		2	3	3			2		1			S	WM - CM
	1	3		3	3		3			2		W	WM - CM
		2		2	2		1					L	WM
									2	2		S	WM - CM
							3		3	2		W	WM - CM
										3		L	WM
	2	3			3							L	WM - CM
			1	1			3		3			L	WM
	2	2										L	WM
	1	2										S	WM - CM
				3		3	2					W	WM - CSA
	2	3										S	WM - CM
	3	3					1					L	WM
												B	WM
	1	2										L	WM
		1		3			3					L	WM
	1	3		2	1		1			1		S	WM
	2	2										S	WM - CM
	1	2										L	WM - CM
				3			3				3		WM - CM
				3			3				3	W	WM - CM
				3			3				3	W	WM - CM

Botanical name	Common name	Lit. Ref	Nox stat	Growth form	Date of natlstn in NZ	Country / area of origin
Stipa neesiana	Chilean needlegrass	2	B	Grass	1930	S.America
Syzygium australe	brush cherry			Tree (6-10m)	1982	Qld, NSW
Teline monspessulana	Montpellier broom	2, 10	B	Shrub (<3m)	1872	Eurasia, Medit.
Tradescantia fluminensis	wandering Jew	12		Mat forming	1916	Brazil
Tropaeolum majus	nasturtium	1		Vine	1883	S.America
Tropaeolum speciouum	Chilean flame creeper			Vine	1958	Chile
Tussilago farfara	coltsfoot		B	Erect herb	1975	Eur, N Afr, N&W Asia
Ulex europaeus	gorse	1,2,12	B	Shrub (3-5m)	1867	W Europe
Vaccinium corymbosa	blueberry			Shrub (<3m)	1988	N America
Vinca major	periwinkle	2		Erect herb	1870	E&C mediterranean
Watsonia bulbillifera	watsonia	2		Bulb herbs	1895	S Africa
Zantedeschia aethiopica	arum lily	2		Bulb herbs	1870	S.Africa
Zizania latifolia	Manchurian rice grass		B	Grass	1906	

Key to scores for Effect on Natural systems (max score = 9)

Significant change 3 = major change in composition of dominant species; and/or major or complete change to structure of community (eg collapse of forest)

Aquatic = covers surface; restricts water flow; suppresses natives

Suppresses regen. 3 = Major suppression of many natives

Persists over time (Lifespan) 3>50 yrs; 2 = 5-50 yrs; 1< 5 yrs

Incr. fire hazard 3 = readily ignites & burns intensely ;

1 = burns only in very dry periods

Botanical name	Effect on natural systems						
	Significant change to struct/comp	Suppress regen of native spp	Persist over time	Incr Fire hazard	Serious other effect	EoS Total excl fir	EoS Total (incl fire)
Acer pseudoplatanus	3	2	3	1		8	9
Acmena smithii	2	1	2	2		5	7
Agapanthus orientalis	0	1	2	0		3	3
Ageratina adenophora	2	3	3	1		8	9
Ageratina riparia	2	3	3	1		8	9
Agrostis capillaris	2	2	2	2		6	8
Allium triquetum	2	1	1	0		4	4
Alnus glutinosa	3	2	2	1		7	8
Alocasia macrorrhizos	2	2	2	0		6	6
Alternanthera philoxeroides	3	3	3	0		9	9
Ammophila arenaria	3	3	3	3		9	12
Anredera cordifolia	2	3	3	0		8	8
Araujia sericifera	3	3	2	0		8	8
Aristea ecklonii	2	2	3	2		7	9
Arrhenatherum elatius	2	3	1	2		6	8
Arum italicum	2	2	2	0		6	6
Arundo donax	3	3	2	2		8	10
Asparagus asparagoides	3	3	3	1		9	10
Asparagus scandens	2	3	3	1		8	9
Berberis darwinii	2	3	2	1		7	8
Berberis glaucocarpa	2	3	2	2		7	9
Bromus tectorum	0	1	1	1		2	3
Buddleja davidii	3	2	2	1		7	8
Caesalpinia decapetala	3	3	3	1		9	10

Community type potentially affected												Natnl Distrib status	Bioclimatic zone(s) in which is a major pest
Terrestrial Communities								Aquatic/wetlnd/riparian					
Forest		Shrub-land	Tussockland		Fern-land	Herb-field	Bare	Lake pond	River, riparia	Wetland			
Intact	Distb		Tall	Shor						FW	saline		
						2	1					B	WM
	1	1										L	WM
	1	3		2	3		2		2			S	WM - CM
2	3	2								1		S	WM - CM
		1				2				2		S	WM
	3	3										L	WM - CM
				1			2			2		L	CM
		3	1	3	2	2	3		3			W	WM - CM
		1		3			3			3		I	WM
1	3	3					1					S	WM - CM
		1		1			2					L	WM
		1			1				2	2		S	WM
										3		L	WM

Key to scores for Biological Success Rating (max score = 21)

Maturation 3 = seeds within one year, very rapid growth ; seeds > 3 years, slow growth
Seeding 3 = more than 1000 seeds/plant ; 0 = no seeds
Dispersal 3 = variety of efficient dispersal mechanisms; 1, unspecialised
Establisment/growth 3 = good,fast; 1 = poor,slow
Veg. reproduction 3 = spread freely; 1;|; 1 = minor importance; 0 = none
Competative ability 3 = competative, wide tolerance; 1 = non-competative
Resistance to manage. 3 = no known controls or expensive; 1 = easily controllable
Details of recovery The manner in which weeds re-occupy the site after damage. Note, this is not veg. reproduction max = 33

Biological success ratings (BSR)								Total score (EoS + BSR)	Details of plants recovery after management
Matur. rate	Seed ability	Effect. of disp.	Estab./ grwth rate	Veg. repro.	Comp. ability	Resst to manmt	BSR total score		
1	2	3	2	1	3	1	13	22	Suckers; seedling bank
1	2	3	3	0	2	1	12	19	Weakly from suckers; seedling bank
2	1	3	2	2	2	2	14	17	Rhizomes resprout
3	3	2	3	2	3	2	18	27	Masses of surface stems; seedlings
3	3	2	3	2	3	2	18	27	Masses of surface stems; seedlings
3	2	1	2	3	3	2	16	24	Resprouts
2	1	2	2	3	2	1	13	17	Resprouts from bulbils
1	3	2	3	1	3	2	15	23	Suckers, resprouts
2	2	2	2	2	2	3	15	21	Rhizomes resprout
3	0	1	3	3	3	3	16	25	
2	2	2	3	3	3	3	18	30	Rhizomes resprout
2	0	2	2	3	3	3	15	23	Resprout from stems and fallen tubercules
2	2	2	3	0	3	2	14	22	Stems resprouts
2	2	2	3	2	1	1	13	22	Rhizomes resprout
3	2	1	3	0	2	2	13	21	Very weak
2	2	2	2	2	2	2	14	20	Tubers resprout
2	1	2	3	3	3	2	16	26	Rhizomes resprout
2	2	3	3	0	3	3	16	28	Tubers resprout
2	2	3	3	0	3	3	16	25	Tubers resprout
1	2	3	3	1	3	2	15	23	Stems resprout
1	2	3	3	1	3	2	15	24	Stems resprout
3	1	2	2	0	1	2	11	14	Seedbank
2	3	2	2	1	2	2	14	22	Stems resprout
3	3	3	3	1	3	2	18	28	Stems/roots resprout

Botanical name	Effect on natural systems						
	Significant change to struct/comp	Suppress regen of native spp	Persist over time	Incr Fire hazard	Serious other effect	EoS Total excl fir	EoS Total (incl fire)
Calluna vulgaris	2	3	2	3		7	10
Carduus nutans	1	2	1	1		4	5
Carex longebrachiata	1	3	1	2		5	7
Celastrus orbiculatus	2	2	2	1		6	7
Cestrum aurantiacum	2	2	2	1		6	7
Cestrum elegans	2	2	2	1		6	7
Chrysanthemoides monilifera	2	3	3	2		8	10
Cirsium spp.	2	1	1	1		4	5
Clematis flammula	1	1	2	1		4	5
Clematis vitalba	3	3	3	1		9	10
Cobaea scandens	3	3	3	1		9	10
Convolvulus arvense	2	3	1	1		6	7
Cortaderia jubata	2	3	2	3		7	10
Cortaderia selloana	2	3	2	3		7	10
Cotoneaster glaucophyllus	2	2	2	1		6	7
Cotoneaster simonsii	3	2	2	1		7	8
Crataegus monogyna	3	3	3	1		9	10
Crocosmia x crocosmiiflora	1	2	2	1		5	6
Cytisus scoparius	2	2	2	2		6	8
Dactylis glomerata	1	2	2	2		5	7
Dipogon lignosus	1	3	2	2		6	8
Echium vulgare	1	3	1	1		5	6
Egeria densa	3	3	1	0		7	7
Ehrharta erecta	2	3	3	2		8	10
Ehrharta villosa	3	3	3	1		9	10
Elaeagnus x reflexa	3	3	3	2		9	11
Equisetum arvense	2	2	2	0		6	6
Erica lusitanica	2	2	2	3		6	9
Erigeron karvinskianus	2	3	2	1		7	8
Eriobotrya japonica	2	1	2	1		5	6
Euonymus europaeus	1	1	2	1		4	5
Euonymus japonicus	1	1	2	1		4	5
Festuca arundinacea	3	3	1	2		7	9
Glyceria fluitans	2	3	1	0		6	6
Gymnocoronis spilanthoides	3	3	2	0		8	8
Hakea gibbosa	2	2	2	3		6	9
Hakea salicifolia	2	1	3	3		6	9
Hakea sericea	2	2	2	3		6	9
Hedera helix	2	3	2	1		7	8
Hedychium flavescens	2	3	3	1		8	9
Hedychium gardnerianum	2	3	3	1		8	9
Hieracium spp.	2	3	2	1		7	8
Humulus lupulus	2	2	1	1		5	6
Hydrilla verticillata	3	3	2	0		8	8
Hydrodictyon reticulatum	3	2	3	0		8	8
Hypericum androsaemum	2	3	2	1		7	8
Hypericum perforatum	1	1	1	1		3	4
Ipomoea indica	3	3	3	1		9	10
Iris foetidissima	2	2	2	1		6	7
Iris pseudacorus	1	2	1	1		4	5
Jasminium humile	2	3	2	1		7	8
Jasminum polyanthum	2	3	3	1		8	9
Juglans ailantifolia		2		1		2	3

Biological success ratings (BSR)									
Matur. rate	Seed ability	Effect. of disp.	Estab./ grwth rate	Veg. repro.	Comp. ability	Resst to manmt	BSR total score	Total score (EoS + BSR)	Details of plants recovery after management
2	3	2	2	2	3	3	17	27	Suckers
2	3	2	3	0	2	2	14	19	Root stock resprouts
2	3	2	2	0	3	3	15	22	Tillers resprout
2	2	3		0	1	2	10	17	No information
2	3	3	2	1	2	2	15	22	Stems resprout
2	3	3	3	3	2	2	18	25	Stems resprout
2	3	2	2	0	3	2	14	24	Seedlings
1	2	2	3	3	2	2	15	20	Root stock resprouts
2	2	3	2				9	14	No information
2	3	2	3	2	3	3	18	28	Stems resprout, seedlings
2	2	2	2	2	3	3	16	26	No information
2	2	1	2	3	3	2	15	22	Rhizomes resprout
3	3	3	3	0	3	2	17	27	Tillers resprout; seedlings
3	3	3	3	0	3	2	17	27	Tillers resprout; seedlings
2	3	3	2	1	2	2	15	22	Stems resprout
2	2	3	2	1	2	2	14	22	Stems resprout
2	3	3	3	0	2	2	15	25	Stems/roots resprout
2	2	1	2	3	2	2	14	20	Resprouts from underground
2	3	2	3	0	2	2	14	22	Stumps resprout; seedlings
3	2	2	2	1	2	2	14	21	Tillers resprout
2	2	1	2	1	2	2	12	20	No info
3	2	2	2	0	3	2	14	20	Root stock resprouts
3	0	1	3	3	3	3	16	23	
3	3	3	3	3	3	2	20	30	No info
3	3	3	3	3	3	2	20	30	Stems resprout
2	1	3	3	2	3	2	16	27	Suckers on stumps and roots
2	0	2	2	3	2	3	14	20	Resprouts from underground
1	3	3	2	0	2	3	14	23	Stems resprout; seedlings
2	3	2	2	2	2	3	16	24	Creeping stems resprout
1	2	3	1	0	1	1	9	15	Weak recovery from stumps
2	2	3	2	0	1	2	12	17	Weak recovery from stumps
2	2	3	2	0	1	2	12	17	Weak recovery from stumps
3	2	2	3	3	2	2	17	26	Tillers resprout
3	3	2	3	2	3	3	19	26	Tillers resprout
3	2	2	2	2	1	2	14	22	Stems resprout
2	3	2	2	0	2	2	13	22	No resprouts; seedlings after fire
1	3	2	2	0	2	2	12	21	No resprouts; seedlings after fire
2	2	2	2	0	2	2	12	21	No resprouts; seedlings after fire
1	1	3	1	3	3	3	15	23	Stem fragments resprouts
2	0	1	2	3	3	3	14	23	Rhizomes resprout; tops annual
2	2	3	2	3	3	3	18	27	Rhizomes resprout; tops annual
3	3	2	2	3	3	3	19	27	Rootstock resprouts
2	2	1	2	2	2	2	13	19	Rootstock resprouts
3	0	1	3	3	3	3	16	24	Stem fragments, tubers resprout
3	0	3	3	3	3	3	18	26	Fragments divide
2	3	3	2	0	2	2	14	22	Weak resprout
3	2	1	2	1	2	2	13	17	
3	0	2	2	2	3	3	15	25	Roots resprout
2	2	3	2	2	2	2	15	22	Rhizomes resprout
2	2	2	2	3	2	2	15	20	Rhizomes resprout
1	2	3	2	3	3	3	17	25	Stems resprout
2	2	3	2	3	3	3	18	27	Stems resprouts
1	2			0	2	1	6	9	No info

Botanical name	Effect on natural systems						
	Significant change to struct/comp	Suppress regen of native spp	Persist over time	Incr Fire hazard	Serious other effect	EoS Total excl fir	EoS Total (incl fire)
Juncus acutus	0	2	2	3		4	7
Juncus articulatus	2	3	1	3		6	9
Juncus bulbosus	2	3	1	3		6	9
Juncus effusus	2	1	2	3		5	8
Juncus squarrosus	2	2	3	3		7	10
Lagarosiphon major	3	3	2	0		8	8
Lantana camara var. aculeata	2	3	2	1		7	8
Leycesteria formosa	1	2	2	2		5	7
Ligustrum lucidum	3	3	3	1		9	10
Ligustrum sinense	2	2	2	2		6	8
Lolium perenne	2	3	2	1		7	8
Lonicera japonica	3	3	3	1		9	10
Lotus pedunculatus	2	2	1	1		5	6
Lupinus arboreus	3	2	2	1		7	8
Lupinus polyphyllus	3	3	1	1		7	8
Lycium ferocissimum	3	2	2	2		7	9
Melianthus major	2	3	2	1		7	8
Mimulus guttatus	1	2	1	0		4	4
Myriophyllum aquaticum	3	2	3	0		8	8
Nassella trichotoma	2	2	3	3		7	10
Nephrolepis cordifolia	1	2	2	1		5	6
Olea europaea	2	1	3	1		6	7
Osmunda regalis		3				3	3
Oxylobium lanceolatum	2	2	2	1		6	7
Pandorea pandorana		3		1		3	4
Paraserianthes lophantha	2	2	2	1		6	7
Paspalum distichum	2	1	2	1		5	6
Passiflora edulis	2	2	2	1		6	7
Passiflora mixta	3	2	2	1		7	8
Passiflora mollissima	3	2	2	1		7	8
Pennisetum clandestinum	3	3	2	2		8	10
Pennisetum macrourum	2	3	2	2		7	9
Pennisetum setaceum	2	3	3	2		8	10
Phytolacca octandra	1	1	1	1		3	4
Pinus contorta	3	2	3	3		8	11
Pinus pinaster	3	2	3	3		8	11
Pinus spp.	3	2	3	3		8	11
Polygala myrtifolia	1	2	2	1		5	6
Populus alba	2	2	3	1		7	8
Prunus avium	1	1	2	1		4	5
Pseudotsuga menziesii	2	2	3	3		7	10
Psoralea pinnata	2	3	2	2		7	9
Pyracantha angustifolia	2	1	2	1		5	6
Racosperma dealbata	3	2	2	2		7	9
Racosperma longifolia	3	2	2	2		7	9
Racosperma paradoxa	3	2	2	2		7	9
Reynoutria japonica		3				3	3
Reynoutria sachalinensis						0	0
Rhamnus alaternus	2	3	2	2		7	9
Rosa rubiginosa	3	2	2	1		7	8
Rubus fruticosus agg.	2	3	3	2		8	10
Rumex sagittatus	1	3	1	2		5	7
Salix cinerea	3	3	3	1		9	10
Salix fragilis	3	3	3	1		9	0
Salvinia molesta	3	3	2			8	8

Biological success ratings (BSR)								Total score (EoS + BSR)	Details of plants recovery after management
Matur. rate	Seed ability	Effect. of disp.	Estab./ grwth rate	Veg. repro.	Comp. ability	Resst to manmt	BSR total score		
3	2	2	2	2	3	3	17	24	Rhizomes resprout
3	2	2	3	2	3	3	18	27	Rhizomes resprout
3	2	2	2	3	3	3	18	27	Rhizomes resprout
2	2	1	2	3	2	2	14	22	Rhizomes resprout
2	2	2	2	2	3	3	16	26	Rhizomes resprout
3	0	2	3	3	3	3	17	25	Stems resprout
3	2	3	2	2	3	3	18	26	Stems resprout
2	1	3	3	1	2	2	14	21	Stems resprout
2	3	3	3	1	3	2	17	27	Stems resprout; seedlings
2	3	3	2	1	2	2	15	23	Stems resprout; seedlings
2	2	3	2	1	3	2	15	23	Stems resprout
2	2	3	2	2	3	3	17	27	Stems resprouts
2	2	2	3	2	3	2	16	22	Stems resprouts
3	2	2	3	0	2	2	14	22	Weak root stock resprout
3	2	2	3	0	3	2	15	23	Root stock resprouts
2	3	3	2	0	2	2	14	23	Stems resprout
1	2	1	2	2	3	2	13	21	Root resprout
2	2	2	3	2	3	2	16	20	Weak root stock resprout
3	0	2	2	3	3	2	15	23	Stems resprout
1	3	2	3	2	3	3	17	27	Tillers resprouts; seedlings
2	3	1	1	2	2	3	14	20	Rhizomes resprout
2	3	3	2	1	2	2	15	22	No info
2				2	3	3	10	13	Incomplete info.
1	2	1	2	0	1	2	9	16	No info
2	1			3			6	10	No info
2	2	1	3	1	2	2	13	20	Minimal resprout; seedlings
2	2	2	3	2	2	2	15	21	No info
2	2	3	2	0	2	2	13	20	Stem fragments and root stock resprout
3	1	3	3	1	2	2	15	23	Stem fragments and root stock resprout
3	1	3	3	1	2	2	15	23	Stem fragments and root stock resprout
2	1	2	3	3	3	3	17	27	Stolons resprout
3	3	3	3	3	3	3	21	30	Rhizomes resprout
3	3	2	3	3	3	3	20	30	Resprouts from rhizomes
3	3	3	3	0	1	2	15	19	Weak resprout
2	3	2	3	0	2	2	14	25	Stems resprout
1	3	2	3	0	2	2	13	24	Weak recovery from stumps
1	3	2	3	0	2	2	13	24	Stems resprout
2	2	1	2	0	2	2	11	17	Weak resprout; seedlings after fire
1	2	0	2	2	2	2	11	19	Suckers strongly
1	2	3	2	1	2	1	12	17	Stems resprout
1	2	2	3	0	2	2	12	22	Stems resprout
2	2	1	2	0	2	2	11	20	Weak resprout; seedlings after fire
2	2	3	2	0	2	2	13	19	Stems resprout
2	3	1	3	1	2	2	14	23	Minimal - weak resprout; seedlings
2	2	1	3	1	2	2	13	22	Seedlings
2	2	1	3	1	2	2	13	22	Seedlings
		2		3	3	3	11	14	Stem fragments sprout
	0						0	0	Stem fragments sprout
2	3	3	3	2	2	3	18	27	Stems resprout
1	3	3	2	2	2	3	16	24	Stems and roots resprout
1	3	3	3	3	2	3	18	28	Stems and root stock resprout
3	2	2	2	3	2	3	17	24	Stems and tubers resprout
2	3	2	3	3	3	2	18	28	Stems resprout
2	0	2	3	3	3	2	15	15	Stems resprout
3	0	1	3	3	3	3	16	24	Grows from fragments

Botanical name	Effect on natural systems						
	Significant change to struct/comp	Suppress regen of native spp	Persist over time	Incr Fire hazard	Serious other effect	EoS Total excl fir	EoS Total (incl fire)
Sambucus nigra	3	2	2	1		7	8
Sedum acre	3	3	2	0		8	8
Selaginella kraussiana	1	3	1	0		5	5
Senecio angulatus	2	3	2	0		7	7
Senecio jacobaea	2	2	1	1		5	6
Senecio mikanioides	2	3	2	1		7	8
Senna septemtrionalis	2	2	2	1		6	7
Setaria palmifolia						0	0
Solanum jasminoides	3	3	3	1		9	10
Solanum linnaeanum	1	1	1	1		3	4
Solanum mauritianum	1	2	2	1		5	6
Solanum pseudocapsicum	1	1	2	1		4	5
Sorbus aucuparia	2	2	3	1		7	8
Spartina alterniflora	3	1	3	0		7	7
Spartina anglica	3	1	3	0		7	7
Spartina x townsendii	3	1	3	0		7	7
Stipa neesiana	1	1	2	2		4	6
Syzygium australe		2		1		2	3
Teline monspessulana	2	2	2	1		6	7
Tradescantia fluminensis	2	3	3	0		8	8
Tropaeolum majus	2	1	1	o		4	4
Tropaeolum speciouum	2	1	2	1		5	6
Tussilago farfara	2	1	2	2		5	7
Ulex europaeus	2	3	2	3		7	10
Vaccinium corymbosa		2		2		2	4
Vinca major	1	2	2	1		5	6
Watsonia bulbillifera	1	2	1	2		4	6
Zantedeschia aethiopica	2	1	2	0		5	5
Zizania latifolia	3	3				6	6

Biological success ratings (BSR)								Total score (EoS + BSR)	Details of plants recovery after management
Matur. rate	Seed ability	Effect. of disp.	Estab./ grwth rate	Veg. repro.	Comp. ability	Resst to manmt	BSR total score		
1	2	3	2	0	2	2	12	20	Weak resprout
3	3	2	1	3	2	2	16	24	Minimal recovery
2	3	2	2	3	3	3	18	23	Fragments sprout
2	3	2	3	3	3	2	18	25	Stems resprout
2	3	2	3	1	2	2	15	21	Root stock resprout
2	3	2	2	1	3	1	14	22	Stem fragments sprout
3	3	2	2	0	2	2	14	21	Seedlings
							0	0	
2	2	3	3	2	2	2	16	26	No info
2	2	3	3	0	2	2	14	18	Root stock resprouts
3	3	3	3	0	1	2	15	21	Stems resprout
2	2	3	2	0	2	2	13	18	Weak stem resprout
1	2	3	3	0	3	1	13	21	Weak resprout
2	0	1	2	3	2	2	12	19	Rhizomes resprout
1	1	1	3	3	3	3	15	22	Rhizomes resprout
1	1	1	3	3	3	3	15	22	Rhizomes resprout
2	2	2	2	0	1	2	11	17	
1	2	3		0	2	2	10	13	No info
2	3	2	3	0	2	1	13	20	Seeds
2	0	1	3	3	3	3	15	23	Stems fragments resprout
3	2	1	2	1	2	1	12	18	Seeds
2	2	3	2	2	1	2	14	20	Weak stem resprout
3	3	3	2	3	1	3	18	25	Root stock resprouts
3	3	2	3	0	3	1	15	25	Stems resprout; seedlings
2	2	3		1	2	1	11	15	
2	1	2	2	3	3	3	16	22	Stem fragments
3	0	1	2	3	2	2	13	19	Corms resprout
2	1	3	2	2	2	2	14	19	Restock resprouts
3	2	2		3	3	3	16	22	

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