How often to search for new weeds

Susan Timmins[1], Simon Harris[2] and Jennifer Brown[3]
[1] Science and Research, Department of Conservation, PO Box 10-420, Wellington, New Zealand
stimmins@doc.govt.nz
[2] Harris Consulting, PO Box 70, Lyttelton, New Zealand
[3] Mathematics Department, Canterbury University, Christchurch, New Zealand

Summary Early detection of weeds minimises both control costs and ecological impact. But how often and where to search for maximum benefit? We developed a model to recommend appropriate search frequencies for five broad habitat types: forest, shrubland, short vegetation, wetland, and open habitat for the weed growth forms most likely to be of concern in a habitat. The model considers several factors: ability to find a new weed, rate of spread of different weeds, cost of their control, and the biodiversity value of a site. The model allows for two control-cost thresholds at a site: \$500 and \$5000. A simple cost analysis of early versus late control showed weed surveillance at the right frequency is a worthwhile investment.
Keywords Weed surveillance, search frequency, weed control, environmental weeds.

INTRODUCTION

Early detection and control of new incursions of environmental weeds is considered desirable because it minimises both the control costs and ecological impacts of invasive weeds. To facilitate this, the New Zealand Department of Conservation (DOC) developed a weed surveillance system (Braithwaite 2000, Braithwaite and Timmins 1999). This involves both systematic searching and fortuitous surveillance – the latter a byproduct of other activities; it involves checking both valuable and vulnerable sites. But how often and where to search? Can we ensure that new weeds are found while they can still be eradicated for modest cost, and before they have wrought irreparable damage? When does the cost of searching exceed the savings of finding the weed early?

ESTIMATING SURVEILLANCE FREQUENCIES

To address the first two questions we developed a model to determine appropriate surveillance intervals for different vegetation types and weed growth forms (Harris *et al*. 2001). Having assumed that weeds will arrive, the model determines what surveillance interval is needed to find a weed before it reaches a specified threshold cost of control at a site. The model is simple and assumes that as the weed occupies more of a site the infestation becomes more expensive to control (see e.g. Stephens *et al.* 2002).

Factors included in the model Several factors determine site weediness and urgency of detection: rate of spread of the weed, ability to find the new weed, cost of its control, and the biodiversity value of the site. The rate of arrival of weeds at a site varies with the proximity of the site to roads, towns and adjoining land use (Timmins and Williams 1991). Once a weed has arrived, its rate of spread depends on the habitat, the weed's growth form, and its inherent biological capacity for spread. Five broad habitat types were used: forest, shrubland, short vegetation, wetland and open habitat, and different weed growth forms (Table 1).

The visibility of a weed, and hence our probability of finding it, varies with its growth stage, growth form and the location of the infestation. The range of growth forms used covered this range in visibility. Our ability to find a weed is also a function of our search effort.

The cost of controlling a particular weed incursion also influences how often we should search. Some weeds are cheap and easy to control; others are expensive. The model recommends surveillance intervals that enable weeds to be located when the cost of control can still be readily accommodated; either a) by being absorbed (up to \$500), or b) by reprioritising other work (up to \$5000). The first threshold of \$500 roughly matches control of a weed as it emerges from its lag phase and the second cost threshold of \$5000 occurs as the weed starts to expand rapidly.

For each of the factors included in the model, standards were assumed based on DOC field practices and experience in New Zealand. For example, the model assumes a standard search intensity of two hours per 10 ha and the distances at which different types of weeds are visible in the habitat types. The model also assumes that a conservancy can easily absorb \$500 but must reprioritise to find \$5000. Similarly, estimates of weed growth and spread rates in the different habitat types were based on field observations (Harris *et al*. 2001).

RESULTS

The model suggests search frequency for the weed growth forms most likely to be of concern in each of the five habitat types (Table 1). It gives search intervals with the probabilities (80% or 95% certainty) of finding a new weed if it is present before either the \$500 or \$5000 cost threshold is reached. Weed workers select the level of certainty of finding an infestation on the basis of the conservation value of the site – 95% for sites with a high biodiversity, 80% certainty for most sites.

The model was supported by assumptions about how many years a newly established weed takes to spread so that its control would cost more than \$500 or \$5000. The recommended surveillance interval is always less than the predicted number of years for the weed to spread to nuisance levels. The recommended surveillance intervals err on the side of caution. They allow for the possibility that a new weed incursion may not be detected at the first or later surveillance visits after its establishment or that a weed might arrive and establish immediately after a site has been searched.

Having been developed in New Zealand, the search frequencies may be applicable in other countries, perhaps those with cool temperate climates. Different surveillance frequencies would probably apply in regions with different climates, or different weed management practices.

DISCUSSION

The recommended search frequency differs between habitat types and growth forms. The surveillance interval required in forest is 1–2 years but in wetland or short vegetation return visit time can be as long as 5–10 years. Surveillance intervals for shrubland weeds fall somewhere in between. This reflects differences in visibility, infestation rates and control costs of weeds in different habitats.

Wetland habitats generally have longer surveillance intervals (10 years) because wetland weeds usually have slower growth rates but detecting short weeds there is hard and the interval for them reduces to three years. In open habitats greater surveillance intensities are required to detect short weeds (<1 m) compared with more conspicuous taller weeds like shrubs or trees.

Growth form makes a dramatic difference to surveillance intervals in forest. A vine is the most difficult growth form to spot early. Seedlings and young plants are often hard to find but grow rapidly. Vines that have reached the canopy are easier to spot but may seed and spread beyond the search zone. By contrast, a three to seven year interval is acceptable for ground creepers with their slower rate of invasion and lower cost of control. Surveillance for shade-tolerant shrub and tree weeds in forest can stretch out to every six or 10 years respectively.

While the table gives an interval of less than one year for a climbing vine in forest, surveillance at greater than annual frequency is unlikely to improve the chances of detection. Spending more time at a site during the annual visit would be preferable.

Surveillance for short weeds in short vegetation is problematic because weeds like herbs or grasses are hard to see. Thus they are only likely to be found when they have formed a large patch. The return on this surveillance is therefore commonly low, and the

Table 1. Recommended frequency of weed surveillance given in years between searches (interval) by broad habitat type for different weed growth forms with two different probabilities (80% or 95% certainty) of finding a new weed incursion before a cost threshold of \$500 or \$5000 is reached.

Habitat type	Weed growth form	Surveillance interval (years)			
		80% certainty of detection		95% certainty of detection	
		\$500 cost threshold	\$5000 threshold	\$500 cost threshold	\$5000 threshold
Forest	Climbing vine	1	3	<1	1
	Ground creeper	3	7	1	4
	Shade-tolerant shrub or tree	6	10	3	6
Shrubland	Vine	1	9	1	5
	Tree or tall shrub	2	9	1	5
Short vegetation	Short weed	2	5	1	3
	Shrub or tree	5	10	3	6
Wetland	Short weed	3	7	1	4
	Shrub	10	10	6	10
	Tree	10	10	10	10
Open habitat	Short weed	1	6	1	3
	Taller weed	4	9	2	5

surveillance interval selected will be influenced by the importance of the habitat.

The search interval is also affected by the control cost threshold selected. For example, surveillance in open habitat would need to be annual to find a short weed before a threshold of $500 is reached, but the interval extends out to six years if a $5000 threshold is acceptable. Surveillance for vine weeds in shrubland must be annual if they are to be found below the $500 threshold, but only every nine years if the $5000 threshold is acceptable.

Financial benefit of weed surveillance DOC's weed surveillance plan is based on the premise that early detection of weeds delivers a net benefit to conservation – that the cost of the surveillance activity itself is more than compensated for by cheaper control costs. To test this assumption, and answer the third question in our introduction, we did a simple cost/benefit analysis of early versus late control. We used the net present value approach to compare the financial attractiveness of the two options, expressing cost in today's terms and allowing for the differing value of money over time. We found that for weeds with very low growth rates, early detection and control offer little cost advantage. However, for weeds of moderate or faster growth rate (characteristic of all the weeds DOC currently controls), there is a considerable saving in controlling the weed early (Figure 1). In other words, environmental weeds spread faster than the change in the value of money over time. Early control minimises control costs and ecological damage.

CONCLUSION

The model described is based on a set of assumptions about weed behaviour, visibility and cost of control. It makes recommendations on surveillance frequency for different habitat types and weed growth forms – useful guidelines to be used in conjunction with local experience of weeds and habitats. The cost analysis of early versus late control lent great support to surveillance. It showed it is always cheaper to control environmental weeds early rather than later, that weed surveillance at the right frequency is definitely a sound investment.

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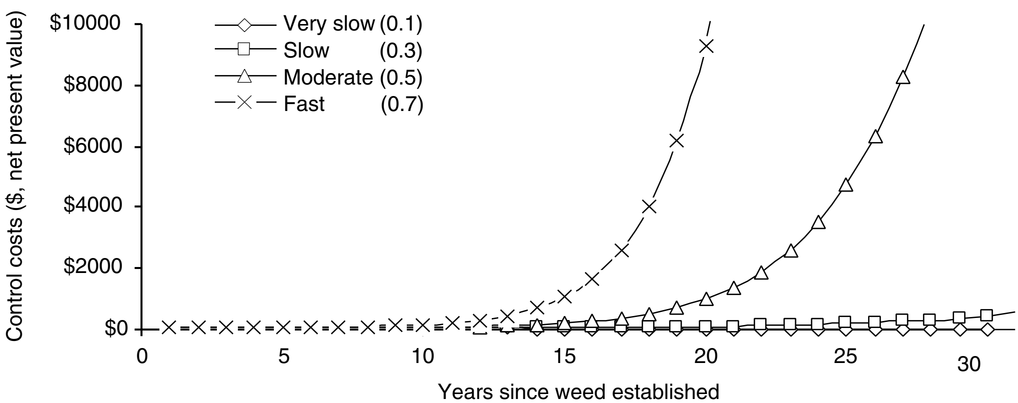

Figure 1. Changes in control costs ($, net present value) with expansion of a shrub infestation in short vegetation from establishment at year 0, projected at four different rates of weed growth and spread (Source: Harris *et al*. 2001, p. 7.). Note: costs are standardised to the present day using a discount rate of 10%.