

Persistence and detection of weed locations in some northern New Zealand island weed programmes

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Summary As part of island weed eradication and control programmes managed by the New Zealand Department of Conservation, many weed locations have been monitored for over 15 years. Some species have been surprisingly persistent within the original detection site, and have remained intermittently active for many years, while others have died out within a few years.

Regular grid searching and lucky finds have been the main method of finding new weed locations, but aerial surveillance and adaptive sampling have also resulted in new weed finds.

Some weed locations were unexpected due to their remoteness from potential weed sources, and were probably spread by weed teams or wide ranging pests such as goats that have now been eradicated. Others were a surprise because they were within known survey sites or were near general work areas and well travelled roads.

New weed species have been detected; these have either been dispersed from adjacent mainland sites by birds or wind, left by visitors, or were the relics of experimental pastoral farming and missed by earlier botanists.

Improved GPS technology, mapping and database management have assisted in the management of island weed programmes by enabling teams to focus on search areas, to undertake self-checking of their search patterns and to understand the local environment.

We are in the process of developing data loggers and aerial surveillance techniques to target eradication targets such as *Psidium guajava* L. and *Olea europaea* subsp. *cuspidata* (Wall ex G.Don) Cif.

Keywords Island weed programmes, island weed infestations, persistence.

INTRODUCTION

The New Zealand Department of Conservation manages several island weed programmes off the north east coast of New Zealand and on Raoul Island. Many of these islands have relic fauna populations, endemics and priority ecosystems. The weed problems and the programmes on New Zealand islands are described by Atkinson (1997).

Long running weed programmes are present on Cuvier Island, Rangitoto Island, Taranga, Hauturu O Toi, (Little Barrier Island) Poor Knights, and Raoul Island. The Raoul Island weed programme has been described by: Holloran (2006), West (1996) and West and Thompson (2013); Curvier Island by Timmins and Braithwaite (2003); Rangitoto Island by Wotherspoon and Wotherspoon (2002); and Poor Knights Islands by West (1999) and Couston (2002).

Raoul Island is a remote oceanic island over 900 km from New Zealand and Tonga. The invasive flora is largely derived from historic horticultural and agricultural introductions, but at least three introductions have occurred since the island was gazetted as a nature reserve. Curvier and Hauturu O Toi and the Poor Knights Islands are approximately 23 kilometres from mainland sites but within wind and bird mediated pest dispersal distances. Rangitoto is within four kilometres of the mainland sites and is subject to ongoing natural plant pest dispersal from the mainland and tourism-mediated pest dispersal.

Mammalian pests have been eradicated from the islands and all islands have biosecurity programmes.

The objective of this review is to determine if a study of infestation histories could improve weed strategy and invasive plant management.

MATERIALS AND METHODS

Weed infestation data was gathered by grid searching along transects or by repeat visits to known infestations. At each infestation, the number of adults as defined by the presence of fruit, flowers, evidence of fruiting, adolescents/juveniles (greater than 30 cm), and seedlings (equal to and less than 30 cm high) were counted. On Raoul Island, a weed patch must have evidence of an adult plant such as fruiting plants or a seed bank to be classified as an infestation, otherwise it is classified as a random occurrence. Infestation sites were marked by tape and GPS to enable repeat visits. At some weed sites, patches within 30m of each other were considered to be within the same infestation, but in other cases, discreet patches less than 30 m apart were considered to be a separate infestation.

On Raoul and Hauturu O Toi, when a new infestation is detected the area around the infestation is searched up 300 m from the new infestation, unless the infestation occurs within an area that is regularly grid searched. Initially circular searches were used but as most new infestations were within transect search areas and teams found circular searches difficult, transect searches were used to search new areas. The maximum distance searched out from new infestations was determined by distances between known infestations. Depending on the species and number of weed individuals found at a site, most infestations are checked at least annually, or six-monthly; rapidly maturing species such as *Ehrharta erecta* Lam. and *Selaginella kraussiana* (Kunze) A. Braun are checked six-weekly. Sites of localised high priority weeds are checked by special visits in addition to grid searches. Grid searches are mapped using Garmin GPS and GIS software. Weed teams are either departmental staff or contractors. Aerial surveillance (and surveillance from boats) is undertaken when helicopters and Air Force aircraft are available, and finds are followed up by ground visits.

Infestation data, (search date, weeds found, team members, location and work carried out) is either stored in an Excel spreadsheet or Access database. Databases are backed up on DVD or saved to the Departmental of Conservation document storage system (DOCDM). Infestations are retired from targeted searching after several years of inactivity. On Rangitoto, infestations undergo a gradual reduction in search frequency as the period of no finds increases.

Weed species are prioritised for control and eradication on the basis of impact on biological values, weed distribution and control difficulty. Weed prioritisations generally follow the methodology of West (1996) and Owen (1998), but in the last review of the Raoul programme the methodology of Downey et al (2010) was used to prioritise weed control. Because of the size of the search areas, areas are prioritised for search on the basis of time since last search and the time for species within the search area to produce propagules.

The activity of infestations and number of infestations per species was determined by reviewing weed databases.

RESULTS

Eradications Of the 13 plant species thought to have been eradicated or died out on Raoul, nine existed as one infestation, and none existed at more than seven sites. None persisted at a site for more than four years following control.

Infestation persistence Infestation persistence from 1995 to 2014 is listed in Table 1. Control of *Caesalpinia decapetala* (Roth) Alston was initiated in 1975. Persistence is variable, for example 95% of infestations of *Olea europaea* subsp *cuspidata*, on Raoul persisted for less than three years, but 1% persisted for over six years. An infestation of *Olea europaea* subsp *cuspidata* persisted on Rangitoto for nine years. *Vitis vinifera* L. infestations have persisted for at least 18 years on Raoul, with over 30% of the infestations persisting for more than five years.

Patterns of activity Many infestations have a common pattern of activity: the infestation initially has high numbers of matures, adolescents and seedlings present. Within two to six years of management the numbers of pests found within the infestation declines to the extent that only a few seedlings are found on annual searches. However the number of years to achieve no further finds may be many more. Gaps of several years of infestation activity are common, for example in one grape infestation, shoots were found in 1998, 2003, 2006 and 2011. Gaps in *Ricinus communis* infestation activity were up to nine years. The longest gap in infestation activity for all species was 16 years. Three species (*Psidium guajava*, *Psidium cattleianum* and *Vitis vinifera*) had small peaks in activity five to six years after control; some of these infestations consisted of large patches or shrubs.

Table 1. Maximum infestation persistence.

Species	Persistence (years)
<i>Anredera cordifolia</i> (Ten.) Steenis	18
<i>Araujia sericifera</i> Brot.	16
<i>Brachiaria mutica</i> (Forssk.) Stapf	11
<i>Caesalpinia decapetala</i>	27
<i>Cortaderia</i> Stapf	11
<i>Ehrharta erecta</i>	7
<i>Ligustrum sinense</i> Lour.	2
<i>Olea europaea</i> subsp <i>cuspidata</i>	6
<i>Passiflora edulis</i> Sims	10
<i>Prunus persica</i> (L.) Batsch	16
<i>Psidium cattleianum</i> Sabine	12
<i>Psidium guajava</i> L.	12
<i>Ricinus communis</i> L.	16
<i>Vitis vinifera</i>	16

Weed detection New locations of mature plants continue to be found within regularly searched areas and surprise finds of invasive plants have been made on roadside edges and within 30m of roads. Significant finds have been made when more emphasis was placed on grid searching rather than rechecking old sites, when the search area around new infestations was extended from 30 m to 300 m, and when low priority zones were checked. Aerial surveillance, and recreational exploring have also resulted in new finds.

DISCUSSION

All of the plant pests eradicated on Raoul, Rangitoto and Hauturu O Toi have been species with limited distribution which did not have a persistent or widespread propagule bank. Low numbers of infestations or the small size of individual infestations is not necessarily a determinant of successful eradications, for example *Selaginella krausiana* has not been eradicated at any infestation on Hauturu O Toi (one patch), Raoul (two patches) or Motutapu (three patches), despite the relatively small areas of the patches and weed coverage within the patches. The eradication of *Anredera cordifolia* has yet to be achieved on Raoul (two sites) despite over 20 years of work. The persistence of some infestations which have short lived seeds or do not produce seed can be explained by sucker development from buried roots and tubers. In some infestations, the terrain and vegetation are such that detection of pests is difficult. Infestations of *Cortaderia* species and *Araujia sericifera* infestations have persisted for over ten years on several islands; and it is likely that a combination of ongoing long distance dispersal, difficulty in detecting pests within the infestation, and inadequate herbicide treatments are an issue. Alternatively propagules may be more persistent than expected.

Since the botanical surveys of 1990s, new exotic species have been found on Rangitoto, Hauturu O Toi, and Raoul. At least three species have probably arrived from biosecurity breaches. *Ehrharta erecta* was found under the hostel deck on Hauturu O Toi, *Soliva sessilis* Ruiz & Pav., which is a common prickly lawn weed in New Zealand was found in the hostel lawn, and *Persea americana*, Mill. was detected near tourist paths on Rangitoto.

Some species have been presumably dispersed by birds. *Passiflora caerulea* L. was found on Rangitoto and *Ehrharta erecta* was found in gull colonies.

In 2011, dense patches of *Setaria sphacelata* (Schumach.) Stapf & C.E.Hubb. were detected in tall grassland adjacent to the airfield on Raoul island. This species was probably a relic of earlier farming, as it only occurs on two research stations in New Zealand

which have no current connections with the Raoul programme and is unlikely to have spread to Raoul via conservation management programmes or air drops. The find of *Setaria sphacelata* demonstrates that even with a relatively distinctive grass, it can be easy to miss invasive species which blend in with the surrounding vegetation. This is also the case for *Brachiaria mutica* which blends in with *Paspalum dilatatum* Poir. and *Imperata cheesemanii* Hack.

Infestations of several invasive species on Raoul and Hauturu O Toi are known to be over one kilometre from their closest neighbors, with many infestations up to 300 m from neighboring infestations. There is evidence from species distributions within the Hauraki Gulf that species such as *Homalanthus populifolius* Graham, *Asparagus scandens* Thunb., *Cortaderia*, *Araujia sericifera* and *Eriobotrya japonica* (Thunb.) Lindl. disperse over 20 km. As a consequence most of the northern offshore islands, some over 2000 ha in size, are at risk from invasive plants, but often less than a third of the potential habitat of invasive species is surveyed.

Aerial surveillance has been successful in detecting new weed infestations on Rangitoto, Hauturu O Toi, Curvier and Raoul. However follow up ground surveys detected additional infestations on Raoul and Rangitoto which were obscured by surrounding vegetation, indicating follow up ground surveys are often necessary. Infestations of *Cortaderia* spp. persisted for several years when aerial spraying was used, presumably due to ongoing seedling dispersal and the protection of seedlings and tillers from herbicide by surrounding vegetation.

Because of difficulties in obtaining regular aerial surveillance we are exploring the use of a small quadricopter with a GPS unit and camera. which can be operated by island weed teams. Early work indicates that quadricopters can be used to produce high quality aerial photographs and detect invasive plants.

Given the difficulty in detecting some weeds we are now training dogs to detect plant infestations. The dogs need to work with relatively inexperienced dog handlers. The list of target plant species was derived by considering species close to eradication which are proving persistent and hard to detect.

Improvements in herbicide application such as basal spraying, and wand application of herbicide from helicopters are likely to reduce infestation persistence especially for cliff infestations of *Cortaderia* species on Hauturu O Toi and Motutapu.

In conclusion the eradication of invasive plant from islands is difficult, the easy to eradicate species have largely been removed. Though some invasive plants have been reduced to low levels, several

invasive species such as *Cortaderia* spp. and *Araujia sericifera* remain at high levels. Many highly invasive species have proved to be very persistent even within small areas and at a relatively few number of locations. Long lived propagules, detection issues, biosecurity breaches, ongoing long distance dispersal from sites outside control zones, and inadequate control methods have to be overcome if we are to achieve more extensive eradications and eradicate a greater number of invasive plant species.

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