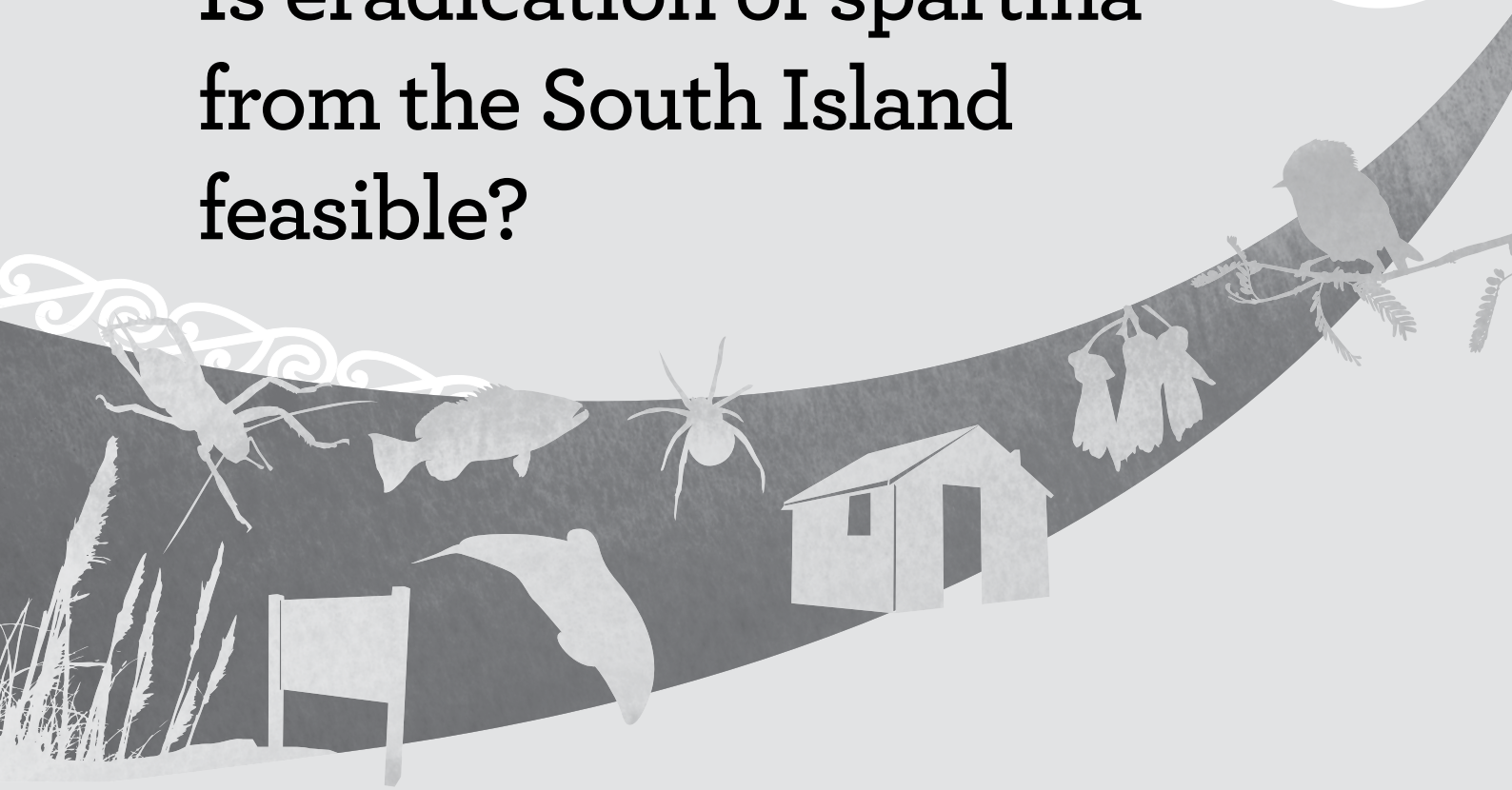
Is eradication of spartina from the South Island feasible?



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CONTENTS

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Abstract

Spartina (*Spartina* spp.) is an introduced maritime grass that is widespread in the South Island, New Zealand, but at very low density in almost all of the 29 areas where operations to control it are being carried out. The only exception is the Waikouaiti-Karitane River Estuary in Otago, where spartina is mostly present at low density, apart from an approximately 2 ha area of medium to high density. This report summarises the results of recent reviews of spartina eradication programmes in the South Island. These programmes are jointly carried out by the Department of Conservation and territorial local authorities. This study assesses the feasibility of eradicating spartina from the South Island. It concludes that eradication is feasible, but only if certain conditions are met.

Keywords: Spartina, *Spartina alterniflora*, *S. anglica*, *S. gracilis*, *S. maritime*, *S.* × *townsendii*, eradication, feasibility, review, best practice

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1. Introduction

Spartina is a maritime grass that forms dense swards in estuaries and other intertidal habitats. It was introduced to New Zealand in the early 1900s to assist with land reclamation through its ability to aid accumulation of sediments. The growth of spartina leads to large-scale physical modification of estuaries and the loss of saltmarsh and mudflat habitat for a wide range of marine life, including shellfish, fish and wading birds (Brown 2002).

Five species of spartina were introduced to New Zealand: *Spartina alterniflora*, *S. anglica* and *S.* × *townsendii* (Partridge 1987), and *S. maritime* and *S. gracilis* (Clayson Howell, Department of Conservation (DOC), unpubl. data). *Spartina maritima* and *S. gracilis* are potentially extinct in New Zealand. *Spartina alterniflora* is easy to identify and occurs only in the North Island. *Spartina anglica* and *S.* × *townsendii* also occur in the North Island, as well as in the South Island, where they are the only two species present (Clayson Howell, DOC, pers. comm. 2012).

Spartina × *townsendii* is a hybrid between the American species *S. alterniflora* and the European species *S. maritima. Spartina anglica* is a double chromosome derivative that has developed from *S.* × *townsendii*. However, it is not easy to distinguish between *S. anglica* and *S.* × *townsendii*, and recent evidence suggests that intermediate forms exist (Clayson Howell, DOC, pers. comm. 2012). For management purposes, South Island populations of spartina should be treated as if they contain *S. anglica*, which can set viable seed, even if historical records indicate that only *S.* × *townsendii* is present.

Spartina control in the South Island began in the 1970s and is ongoing. The extent of spartina infestations has been reduced dramatically through ground-based and aerial herbicide applications. Glyphosate was used initially. Subsequently, use of the grass-selective herbicide Haloxyfop has enabled large beds of spartina to be destroyed without putting indigenous plant and animal communities at risk (Shaw & Gosling 1996, 1997; Shaw 1999; Swales & Morrisey 1998; Brown 2002). Knapsack spraying of individual plants with Haloxyfop is now the most commonly used method of control.

The Department of Conservation's Southland Conservancy received international recognition for its knockdown of spartina over 1000 ha of estuary. Similar success has been achieved at Havelock Estuary in a joint DOC and Marlborough District Council programme. Programmes in the South Island (in Southland, Otago, Canterbury and Nelson/Marlborough) are in the mop-up phases of control. Spartina is controlled at all known sites in the lower North Island and is thought to occur only at very low abundances. There is a strong commitment to spartina eradication by various agencies internationally in North America, China and Australia, as well as in New Zealand.

2. Methods

Spartina eradication workers throughout the South Island were interviewed in July–September 2012. These interviews were used to compile a table of all active management sites (operational areas) in the South Island in the 2011/12 operational season (including operational areas from which spartina has been eradicated within the last 5 years) and to review the eradication programmes.

An operational area is a geographically distinct area (e.g. a harbour) of undefined size. Operational areas can be thought of as management units. A site is defined as an individual spartina tiller or patch at least 10 m from another individual tiller or patch (Appendix 1).

Interviews were carried out using DOC's Weed Led Project Review Template (Appendix 2), which is linked to DOC's Strategic Plan for Managing Invasive Weeds (Owen 1998). The review template contains questions about eradication feasibility, practicality, monitoring, control methods, non-target effects, costs and other issues, and allows for recommendations to be made (Appendix 2). The responses to key questions were compiled.

The collated data were then used to assess the potential eradication of spartina from the South Island against six eradication feasibility criteria developed by Bomford & O'Brien (1995). The criteria are:

- The rate of removal exceeds the rate of increase at all population densities
- Immigration is zero
- All reproductive pests must be at risk
- The target pest can be detected at low densities
- The cost-benefit analysis must favour eradication
- A suitable socio-political environment is required

3. Results

3.1 Spartina operational areas and sites in 2011/12

Table 1 sets out the agencies, budgets and number of active sites for South Island spartina operational areas in the 2011/12 operational season. The DOC Sounds Area Office has the largest amount of money budgeted for control, but it also has the largest expanses of difficult habitat (reed beds) to search. Our assessment indicated that budgets are currently adequate for DOC operations in the Sounds, Golden Bay, Motueka and Southland areas, although Southland staff intended to reassess their budget at the end of the 2012/13 season because of changes to the programme. However, budgets appear to be insufficient for Canterbury (with a likely shortfall of $28,000; Trevor Partridge, Christchurch City Council (CCC) and Craig Alexander, DOC, pers. comm. 2012) and Otago (with a likely shortfall of $27,000; Richard Lord and John Pearce, Otago Regional Council (ORC), pers. comm. 2012).

3.2 Spartina eradication evaluated against six eradication criteria

Results from the review are presented below within the eradication feasibility framework provided by Bomford & O'Brien (1995).

3.2.1 The rate of removal exceeds the rate of increase at all population densities

The distribution of spartina is limited and all known populations are being treated (Table 1.). All programmes (with the possible exception of that of CCC) have resulted in reduced spartina abundance in the last 5 years, as indicated by mark and map data, photographs and informal observations.

Haloxyfop is a very effective herbicide for killing spartina. While all DOC staff use Haloxyfop mixed with mineral or vegetable oil (as a penetrant), there is variation in the mixes used. A recommended mix has been identified and presented in a draft best practice document (Appendix 1). Meanwhile, CCC and ORC have been using glyphosate, which is considerably more variable in its effectiveness (Hammond & Cooper 2002). Both CCC and ORC have shown interest in trialling the use of Haloxyfop.

Spartina 'became more obvious' in McCormacks Bay following the 2009 Christchurch earthquake. It is most likely that it grew from deep-rooted rhizomes that were raised by the quake, based on the observed growth form (Keith Briden, DOC, pers comm. 2012). Christchurch City Council's use of glyphosate may have increased the risk of rhizome re-growth, as it is not always effective against the rhizomes. This 'deep-rooted rhizome' hypothesis is consistent with the Southland experience, where large controlled patches that were in deep mud re-sprouted, most likely from deep-rooted rhizomes (Graeme Miller, DOC, pers comm. 2012).

3.2.2 Immigration is zero

Spartina has not been detected outside any of the South Island operational areas in the last decade, despite the presence of suitable habitat. However, it has spread from seed within these areas. For example, spartina seedlings reappeared in locations 500 m to 1 km from Crossies Point, Mapua, until the adult seeding plant was detected and destroyed (Ian Cox, DOC, pers comm. 2012).

3.2.3 All reproductive pests must be at risk

All eradication programmes had carried out delimiting surveys. While it cannot be guaranteed that spartina does not exist outside current operational areas, the likelihood of this is low. Surveillance within and beyond operational areas is being carried out and is encouraged (Appendix 1).

Table 1. South Island spartina operational areas and sites in 2011/12.

AGENCY AND LOCATION	TOTAL 2011/12 BUDGET ($)	OPERATIONAL AREAS	NUMBER OF ACTIVE SITES
DOC Golden Bay, Nelson/Marlborough	6500	1. Golden Bay	0
		2. West Haven	5
		3. Farewell Spit	0
		4. Wairoa River	1
		5. Muddy Creek	1
DOC Motueka, Nelson/Marlborough	6000	6. Waimea Inlet	56
		7. Mariri Inlet	1
		8. Abel Tasman National Park coastline	0
DOC Sounds, Nelson/Marlborough	66000	9. Kaituna	7
		10. Pelorus	7
		11. Mahau Sound	10
		12. Outer Pelorus Sound	29
		13. Mahakipawa estuaries	11
		14. Queen Charlotte Sound	1
DOC Mahaanui, Canterbury	1000	15. Lyttelton Harbour	2
Christchurch City Council	<1000	16. Avon/Heathcote	4
		17. McCormacks Bay	5
		18. Brooklands Lagoon	4
DOC Coastal Otago	3000	19. Catlins Lake	2
		20. Merton (Waikouaiti)*	>100
		21. Taieri mouth*	4
		20. Hawksbury (Waikouaiti)*	2
Otago Regional Council (ORC)	10000	22. Blueskin Bay	1
		20. Waikouaiti-Karitani River Estuary*	>50 + 2
		21. Taieri River mouth*	4
		23. Pleasant River Estuary	> 50
		24. Otago Harbour	0
DOC Murihiku, Southland	12500	25. New River Estuary	147
		26. Bluff Harbour-Awarua Bay	6
		27. Haldane Estuary	3
		28. Jacobs River Estuary	46
		29. Waimatuku River mouth	2

* In Otago, DOC and Otago Regional Council have overlapping operational areas

Most spartina sites occur on land managed by government agencies. Where they occur on private land, access to every site has been granted to control agencies. Spartina is listed as a total control plant in the Tasman, Nelson, Marlborough, Otago and Southland Regional Pest Management Strategies. The objective of all spartina programmes is eradication, and relevant agencies have a legal right to control spartina on private land under the Biosecurity Act 1993. Canterbury is the only region in which spartina is not included in its pest management strategy. In one case in Otago, several small patches of spartina occur on the private land of an organic grower. The grower has requested that no chemical is used and physical removal at these sites will be carried out (Kevin Allan, ORC, pers. comm. 2012).

3.2.4 The target pest can be detected at low densities

Spartina can be difficult to locate when the high tide line is covered with driftwood and other debris. It can occur beyond the line of driftwood as the result of high tide surges, and has been found up to 2 km inland up tidal creeks and drains. Sometimes spartina plants growing among

reeds can be difficult to detect until they start seeding. In Southland, three searches are carried out each year (in January, February and March) to maximise the chances of any remaining plants being detected.

Spartina is mainly detected by labour-intensive systematic searching, with searchers spaced from shoulder-to-shoulder to 1 m apart in thick reed beds, and wider apart where substrate and vegetation allow. Helicopters are useful surveillance tools for detecting spartina in open mud flats, but their use is limited when spartina patches are small and located amongst other vegetation. However, a method DOC Southland recommends involves the use of a Jet Ranger helicopter flown sideways at very low altitude, slowly, carrying four observers, including the pilot (Appendix 1).

Monitoring enables measurement of the efficacy of spartina detection at low densities. Most programmes use GPS to mark and map sites. All eradication staff have been encouraged to use the 'Total Count' method when spartina is of low enough abundance to have clearly distinct sites (Appendix 1). Use of the Total Count method enables staff to track the progress of eradication within the operational areas and throughout the South Island. Data (track log and point data) have been used to confirm kills and direct future effort, but not all programmes are collecting data of the same quality. Again, it is recommended that the standards presented in the draft best practice document (Appendix 1) be adopted.

3.2.5 The cost-benefit analysis must favour eradication

The current expenditure on spartina control programmes is $106,000 per year (Table 1). An additional $55,000 was identified as necessary to increase the level of control in Canterbury and Otago so that eradication could be achieved within 10 years. A further 5 years of surveillance was suggested as being prudent.

3.2.6 A suitable socio-political environment is required

The review clearly indicated that all stakeholders are supportive of eradication. Although DOC is leading most programmes, Marlborough District Council, Tasman District Council, CCC, Environment Canterbury, ORC and Environment Southland have all contributed financially, are currently engaged operationally or are, at least, supportive. Environment Canterbury is the only local authority that does not include spartina as a total control pest in its Regional Pest Management Strategy, but it is now proposed that it be included. The rate of removal in Canterbury and Otago is limited by the level of effort and resources being applied. An additional $55,000 is required to enable eradication to be acheived, as identified above.

4. Discussion

4.1 The rate of removal exceeds the rate of increase at all population densities

Bomford and O'Brien (1995: p. 249) point out that 'If the removal rate is less than the rate of replacement at any population density, eradication cannot be achieved.' As reported above, Haloxyfop is effective at killing spartina. Digging has also been effective at removing relatively small patches of the plant (Franko et al. 1985). Heavy-grade black plastic sheets pinned down with chicken wire have also been used successfully to kill small spartina infestations (Bishop 2000).

Removal rates can be significantly greater than replacement rates at the knockdown stage of spartina control. For example, in January 2004 and February 2005, Haloxyfop was aerially applied by helicopter to the Havelock estuary (43 ha and 47 ha, respectively). It was estimated that a kill of over 99% was achieved (Phil Clerke, DOC, pers. comm. 2012). At low densities, it takes progressively more time and expense to locate individual plants. Spartina replacement rate (reproduction) is not particularly rapid compared with the rates of many other weed species. Spread rates are probably only in the order of 1–2 m per year of clonal growth without management (Clayson Howell, DOC, pers. comm. 2012; Lee & Partridge 1983). Rates of plant establishment from seed dispersal are unknown but thought to be low when spartina abundance is low.

Again, as Bomford & O'Brien (1995: p. 250) point out: 'There must be motive and resources to continue removing [target pests] at low densities, when numbers [killed] and damage inflicted are extremely low.' For removal rates to be greater than replacement rates at low densities, there must be the political will and resources to maintain the appropriate effort (discussed under criterion 6 below) and the ability to find the last individuals (discussed under criterion 4 below). The effectiveness of knockdown and the successful eradication of spartina at some sites show that it is possible to kill it more quickly than it spreads at all population densities.

4.2 Immigration is zero

Spartina is known to disperse from seed and vegetatively, and its seed disperses further (e.g. 30 km) than its root fragments (e.g. 200 m) (Daehler 1998; Ayres et. al. 2004). Spartina has spread from seed within South Island operational areas (e.g. Crossies Point at Mapua). It is known to float and survive in salt water for several months (Marks & Truscott 1985; Huiskes et al. 1995), so long-distance dispersal is possible.

Though long-distance spread (immigration) of spartina is possible, we suggest that the actual risk of this occurring is very low. The D'Urville Current could transport seed from the west coast of the North Island to the top of the South Island, but there is no evidence that this has occurred. Spartina is controlled at all known sites in the lower North Island and is thought to occur only at very low abundance south of the Manawatu River on the west coast (Clint Purchase and Colin Giddy, DOC, and Darryl Kee, Greater Wellington Regional Council; pers. comm. 2012). Spartina is not known to occur south of Gisborne on the east coast of the North Island (Partridge 1987; Clayson Howell, DOC, pers. comm. 2012).

There are several possible explanations (though with only limited direct evidence) for small spartina infestations that have appeared at isolated sites historically. For example, it is assumed that it was deliberately planted in the Oparara Estuary, Karamea, prior to 1996 because of the population's isolation (approximately 90 km from the nearest source) and location (on the inland side of a causeway) (Tom Belton, DOC, pers. comm. 2012). It is likely that spartina arrived accidentally at Mill Creek, Stewart Island in 1994/95 on heavy machinery that was barged from Invercargill to build sewage ponds (Graeme Miller, DOC, pers. comm. 2012).

Given that spartina has not appeared outside operational areas in the last decade, despite the presence of suitable habitat, we concur with Clayson Howell, DOC, who stated that, historically, 'unrecorded deliberate translocations are the most likely mechanism for colonisation of new harbours by *S. anglica* in New Zealand' (pers. comm. 2012). We suggest that the low abundance of spartina within the operational areas probably reduces the risk of immigration and that the risk further diminishes as each population is eradicated.

4.3 All reproductive pests must be at risk

All spartina plants need to be found and killed—preferably before they set seed—for eradication to be achieved. To find all plants, we need to know where all populations occur (i.e. we need to delimit the species) and we need to be able to find all individuals within operational areas (i.e. detection is necessary; see below). As previously stated, all South Island populations have been delimited, although further surveillance beyond current known population boundaries is advisable. Spartina is relatively easy to kill once detected.

The behavioural characteristics of spartina make it easier to place at risk compared with many other weeds. Spartina's habitat range is narrow (the intertidal zone) and is relatively easily accessible. The plant's dispersal ability is also relatively low (while dispersal has been human-assisted historically, dispersal is not currently believed to be a significant issue).

Spartina has been eradicated from operational areas (mainly smaller infestations) in the North (e.g. Ohiwa Harbour—Sarah Crump, DOC, pers. comm. 2012) and South Islands. In the South Island, it was eradicated from the Wairau Lagoons, Marlborough in 1999 (Malcolm Brennan, DOC, pers. comm. 2012); Oparara Estuary, West Coast in 2006 (Tom Belton, DOC, pers. comm. 2012); Stewart Island/Rakiura in the early 1990s (Graeme Miller, DOC, pers. comm. 2012); and Golden Bay, Farewell Spit, Abel Tasman National Park and Otago Harbour (this report). Because spartina has been eradicated from some sites, we know that it is possible to put all individual plants at risk. The key question is: are we able to detect all individuals?

4.4 The target pest can be detected at low densities

Labour-intensive, systematic ground searching and aerial searching by helicopter are the two methods currently used to detect spartina at low densities. Helicopter surveillance was important in finding spartina within the Motueka Area (Ian Cox, DOC, pers. comm. 2012) but was of limited use for locating it in reed beds within the Sounds Area (Phil Clerke, DOC, pers. comm. 2012) and parts of Golden Bay Area (Hans Stoffregen, DOC, pers. comm. 2012). In Southland, helicopter surveillance was useful when the helicopter was flown low and sideways with multiple observers aboard (Graeme Miller, DOC, pers. comm. 2012). Intensive ground searching with people spaced shoulder-to-shoulder has proved very effective in the Sounds Area. The number of sites at which spartina is found has decreased from 507 in 2008/09 to 417 in 2009/10, 114 in 2010/11 and 66 in 2011/12, for similar annual search effort.

Another potential tool is spartina-detection dogs. Dogs have been used to detect a wide range of animals including rats (Gsell et al. 2010), snakes (Savidge et al. 2011), tortoises (Cablak & Heaton 2006), bears, fishers and bobcats (Long et al. 2007) and bed bugs (Pfiester et al. 2008) and to detect weeds (Goodwin et al. 2010). Preliminary trials in New Zealand showed that dogs could be trained to detect spartina and that it is more detectable than some other weed species (Peter Crocker, Detector Dog Systems, pers comm. 2011). Unfortunately, this early work was not continued, but another attempt to train a dog is underway (Graeme Miller, DOC, pers. comm. 2012). Once a dog has been trained, it is proposed that its effectiveness be compared experimentally with that of ground searchers.

A key issue with all eradication attempts is determining when success has been achieved (when the last individual has been found and killed). New tools that model search effort and results have been developed to quantify the likelihood that all individuals have been detected and killed and therefore eradication has been achieved (Ramsey et al. 2008; Choquenot & Parkes 2011; Jarrad et al. 2011; Ramsey et al. 2011). Regan et al. (2006) have also developed an economic model to direct the duration of search effort. These tools could be applied to improve the confidence of managers that the eradication of spartina from the South Island has been achieved. It may be possible to detect all spartina with current tools. However, it is also possible that a spartina-detection dog would increase confidence that eradication has been achieved and possibly enable it to be completed sooner.

4.5 The cost-benefit analysis must favour eradication

Eradication of weeds is a very seductive concept, but is rarely achieved (Mack & Lonsdale 2002; Panetta & Timmins 2004; Panetta 2007). Successful eradication is more cost effective than sustained control because, once achieved, the ongoing costs (of surveillance) are relatively low. In comparison, sustained control involves ongoing costs, in perpetuity. In addition, it is more cost effective to spend a little more initially and achieve eradication sooner rather than prolonging eradication programmes. Panetta (2009) pointed out that total costs are a combination of surveillance and control costs.

We explored the time it would take to 'break even' using different discount rates for eradication and control costs. There is considerable debate in the literature over the appropriate discount rate (e.g. Mendelsohn 2006). The Stern Review on the Economics of Climate Change (Stern 2007) suggests that a discount rate of 0% is appropriate, or an interest rate of 3.5% could be used or, alternatively, New Zealand Treasury's default rate of 8% (Anon 2008) could also be appropriate.

When control is estimated at the 2011/12 cost of $106,000 per year, eradication was estimated to cost $161,000 ($106,000 plus $55,000 see section 3.2.5) per year for 10 years, and surveillance to confirm eradication was estimated at $100,000 (a guesstimate) in years 11, 13 and 15. At a discount rate of 8%, it took 30 years (an additional 15 years to the 10 years to achieve eradication and 5 years surveillance) to break even; at 3.5%, it took 21 years (an additional 6 years); and at 0%, it took 19 years (an additional 4 years). We conclude that attempting eradication makes sound economic sense.

4.6 A suitable socio-political environment is required

Bomford and O'Brien (1995: p. 251) point out that 'even when technical and economic criteria can be met, social and political factors can play an overriding role in determining the prospects for successful eradication'. Eradication is seldom guaranteed, and while practitioners can be optimistic about achieving it, decision makers are often very cautious. When the feasibility of eradication is being debated, there is often a tension between in-depth investigation to fill knowledge gaps and taking action (Parkes 2006).

The reviews described here clearly indicate that all stakeholders are supportive of eradication. Extra resources will need to be found for Otago and Canterbury to ensure that the rate of removal exceeds the rate of increase at all population densities.

4.6.1 Who should lead eradication?

The Department of Conservation was responsible for administering the foreshore and seabed for the Crown under the Foreshore and Seabed Act 2004. That meant that DOC was responsible for controlling spartina in all estuarine areas up to the high water spring tide mark. However, the Marine and Coastal Area Act 2011 repealed the Foreshore and Seabed Act, with the consequence that the land is effectively unowned, so the responsibility for functions such as spartina control has probably shifted from DOC to the territorial local authorities.

The Ministry of Primary Industries (MPI) is responsible for biosecurity responses nationally. MPI currently leads eleven National Interest Pest Responses that aim to eradicate selected established pests from New Zealand. These pests (10 plants and one bird) were chosen because of their potential to have a significant impact on our economic, environmental, social and cultural values. While, theoretically, MPI could lead spartina eradication, it is more likely to direct its limited resources at incursion responses, particularly those with economic pay-offs.

We suggest that it is appropriate for one agency to take responsibility for coordinating the eradication of spartina from the South Island. The Department of Conservation is informally taking the lead and the current partnerships between territorial local authorities and DOC are working well, although better coordination in Canterbury and Otago is desirable. We suggest that a potential way forward is for DOC to take a more formal role in the eradication of spartina from the South Island, through the gate-keeper approach as proposed in the Pest Management National Plan of Action (MAF 2011). Assuming that extra resources can be found and that the coordination of programmes in the South Island can be improved, we are not aware of any socio-political constraints to eradication.

5. Is eradication of spartina from the South Island feasible?

This study concludes that eradication of spartina from the South Island is feasible, but only if the following conditions are met:

- Eradication is the aim of all agencies responsible for spartina operational programmes in the South Island
- One agency coordinates and/or project manages all the spartina eradication programmes being conducted in the South Island.
- Management in each agency supports the eradication objective for the duration of the eradication programme
- All eradication programmes are adequately resourced for the duration of the eradication programme
- Dedicated staff who understand the difference between eradication and control are employed
- Spartina is made a total control plant in all South Island regional pest management strategies
- Best practice spartina control is used at all operational sites, including control techniques, surveillance, monitoring
- All programmes are monitored and the monitoring data are collated and analysed centrally
- Spartina can be detected at very low densities down to the last individual plant at a site
- The number of active sites continues to trend down over time
- All spartina sites in the southern North Island are intensively managed to reduce the risk of sea-dispersed seed reaching the South Island
- Once eradication is presumed to have been achieved, intensive and extensive surveillance is carried out to ascertain success.

If these conditions are not met, then eradication of spartina from the South Island is unlikely to be achieved.

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Appendix 1

Spartina control, monitoring and surveillance best practice

A1.1 Introduction

The purpose of this document is to provide current best practice to assist with the eradication of spartina from the South Island. Practice currently varies between locations. The intention is that by standardising control, monitoring and surveillance of spartina, control effectiveness will improve and progress can be tracked.

A1.2 Control

- Apply the herbicide mixture Gallant Ultra at a rate of 29 mL/10 L (0.29% volume/volume) (equivalent to 15 g/L Haloxyfop ester active ingredient) plus Kwickin (canola-based oil penetrant) at 200 mL/10 L (2.0% volume/volume) and ammonium sulphate at 100 g/10 L (1% wt/volume) from a knapsack to the entire spartina plant until it is saturated.
- A water-based dye can be added to the herbicide mixture at label rates.
- If practical, the plants should be sprayed with clean water to remove salt and mud residues before the herbicide is applied.
- People with the right understanding of eradication (focused on ensuring that the last plant is found and killed) should be used to do the control work.
- Apply herbicide at least 2 hours before spartina is reached by an incoming tide.
- The number of seed heads per site should be recorded (see spartina site record sheet below), and the seed heads removed and bagged to prevent weed spread.
- In some instances, it may be necessary to rake debris to expose spartina plants for treatment.
- Black polythene can also be used to cover spartina in the event that herbicide application is not possible. This would need to be securely fixed in place with pegs, wire and/or rocks to prevent it being washed away at high tide.

A1.3 Monitoring

The 'Total Count' monitoring method is incorporated into control. Each site is revisited annually to determine if controlled spartina is dead or requires further treatment. The method involves collecting and analysing presence/absence data from each site visit. It provides a clear visual means of tracking the progress of the eradication programme.

- This method should be used when spartina sites are relatively few (e.g. <100).
- An 'operational site' is defined as where a spartina plant or patch occurs at least 10 m away from another spartina plant or patch.
- Sites should be clearly delineated using a numbered white wooden stake (25 mm × 25 mm) and their location recorded using a GPS device and photographs.
- Photographs could be used (when appropriate) to show the size of the spartina 'patch' and to help locate the site should the numbered white stake disappear.
- Numbered white stakes should be placed 0.5 m to the north of individual plants and in the centre of patches at all sites. Additional posts should be used to delineate the boundaries of patches.
- Sites should remain constant (not changed through time), even when new infestations are found within a 10 m radius of the numbered peg.
- New infestations greater than 10 m away from a numbered peg become new sites.

- Sites are visited annually and the spartina (if present) treated.
- Field practitioners should be given a map, datasheet, waypoint and photographs of each site to be treated prior to each visit.
- In addition, two types of information should be collected annually for each site:
  - The numbers of plants (e.g. 2 tillers) or patch size (e.g. 2 m × 3 m)
  - The status of spartina at each site, scored annually (active, surveillance, historic or unreported). Scoring is as follows:
    - Active: population size is greater than 0
    - Surveillance: population size is 0 for 3 years
    - Historic: population size is 0 for more than 3 years
    - Unreported: site not visited that year.

A stacked bar chart (e.g. Fig. 1) provides a clear visual representation of the results:

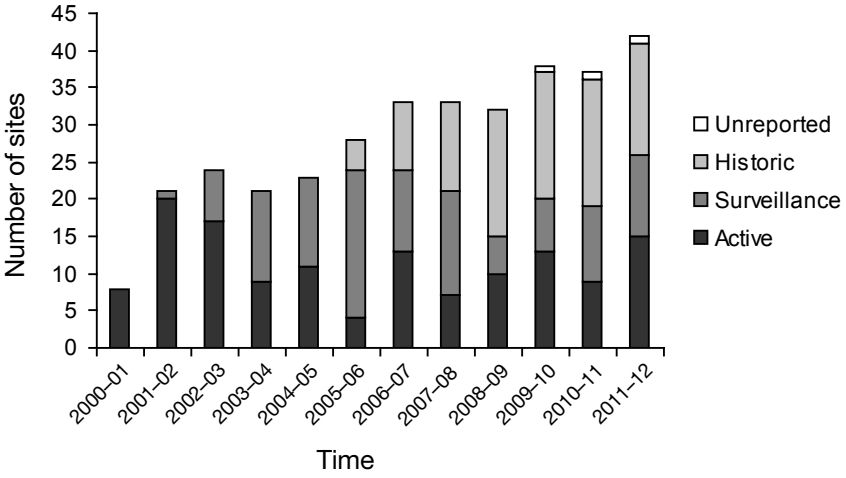

Figure 1. Theoretical annual Total Count results for spartina.

- Data should be stored on an Excel spreadsheet, and a copy of this should be printed off and stored on the relevant DOC area office file.
- Column headings on the spreadsheet should read: Operational Area, Site number, Easting, Northing, Date discovered, Number of tillers when found or Patch size when found, and Active, Surveillance, Historic or Unreported by year. Use a separate column for each year (e.g. see DOCDM-330098[1]).

An example of a spartina site record sheet is shown on the next page.

A1.4 Surveillance

'Active surveillance is the systematic checking of an area for new incursions, as part of a planned programme of work' (Braithwaite 2000).

- Searches should be carried out between November and March. Some DOC area offices choose to carry out surveillance after Christmas, because plants are generally larger and therefore easier to find, and likely to take up more herbicide. Field practitioners should consider multiple searches each season if resources allow.
- Searches should be carried out before seed is shed in March.
- Searches should be carried out by staff walking close enough together to ensure all spartina plants are detected (e.g. shoulder to shoulder).

[1] Department of Conservation internal file.

Spartina site record sheet		Site number
Site name		Area office
Ecological region	Easting	Northing

Number of tillers (if individual tillers are obvious)

OR

Patch length and width: (rough estimate—e.g. 2 m × 3 m)

Length: Width:

Actions taken

Comments (provide an opinion on whether plants found are re-growth or new plants; whether plants are seeding etc.)

Site description

Map of area

- Hip chains can be used to partition search effort.
- GPS track logs should be used to record areas searched.
- These track logs can be placed over aerial images to identify areas not searched.
- GPS waypoints should be recorded for all spartina plants or patches detected.
- Surveillance should also be carried out at treatment sites visited. Intensive searching should be carried out to a distance of at least 10 m from the centre of a site because this is where other Spartina plants are most likely to occur. Common sense should be used to direct the shape and extent of the search area.
- Person hours spent searching should be recorded.
- Using a helicopter to search for large patches of spartina is effective. However, it is not known if the method is also effective for individual plants.
- Helicopter surveillance has had mixed results but, based on the Southland experience, we recommend the following method: a Jet Ranger helicopter flown sideways at very low altitude, and slowly, with four observers (including the pilot).
- Kayaks may be an effective way to get into in difficult-to-access areas.
- Delimiting surveys (beyond known distribution) should also be carried out periodically to ensure that the full extent of infestations is known.

A1.5 Training

Training of new staff is essential and should, whenever possible, include the use of live plant material.

Appendix 2

DOC weed–led project review template

GENERAL INFORMATION	
Project title:	
Conservancy and Area:	
Area(s) being treated:	
Habitat type:	
Contact person:	
Target weed:	
Programme start and completion dates:	
Control year/s being reviewed:	
Review date:	
Review team:	
Date of next review:	
DOCDM1 and File refs:	Golden Bay Area (DOCDM-1044807), Motueka Area (DOCDM-1044399), Sounds Area (DOCDM-1044011), Mahaanui Area & Christchurch City Council (DOCDM-1087543), Coastal Otago Area & Otago Regional Council (DOCDM-1088049) & Murihiku Area (DOCDM-1088344).

Step 1: Review FEASIBILITY		
Is the species likely to have significant impacts on native species and communities?	Original: Revised:	Explanation:
Are acceptable effective control methods available (even at low densities)?	Original: Revised:	Explanation:
Is there low possibility of re-invasion:	Original: Revised:	Explanation:
Do you know full extent of infestation/s—is another delimiting survey required?	Original: Revised:	Explanation:
Is distribution of the species limited enough for the programme to be feasible?	Original: Revised:	Explanation:
Are all affected land-owners expected to agree to the control?	Original: Revised:	Explanation:

Step 2: Review PRACTICALITY		
Practicality score	Original: Revised:	Explanation:
Aim of programme:		
Expected timescale of programme:		
Geographic level:		

Step 3: Review MONITORING	
Are the monitoring methods appropriate to achieve the monitoring objectives?	
Have monitoring results been successfully incorporated into weed control operations?	
Do monitoring results indicate that the control programme is achieving what it set out to do?	

Step 4: Review CONTROL METHODS	
Has planned work been achieved?	
Has the weed population been reduced or contained?	
Are there alternative control methods to consider?	

Step 5: Review NON-TARGET EFFECTS	
Has non-target species impact been as expected?	
Have the appropriate steps been taken to minimise risk?	
What changes should be made?	

Step 6: Review COSTING
Are funds adequate, insufficient or excessive to meet operational costs?

Step 7: Review OTHER ISSUES

Step 8: Provide RECOMMENDATIONS	
Overall recommendation:	

Checklist: remember to...	Done	N/A
Make appropriate changes to the Tech Specs:		
Add new information to the BioWeb / the Weeds Database:		
Provide a copy of this review to your TSO:		
Release review to interested parties:		
Update the Monitoring spreadsheet:		
Add this review to the: Review spreadsheet.		

Authorisation Signatory:

Area Manager Date

Conservator Date