The Problem of Weed Control in Newly Established Native Plantings

GEOG309
12th October 2020

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Executive Summary

- With Earth's warming climate, landscape revegetation is key to reducing CO_2 emissions, increasing biodiversity, and preserving cultural importance. Effective weed control is key to the success of these revegetation efforts.
- This report aims to evaluate the most effective weed control options when planting native species into exotic grass within Canterbury. Five methods were explored: mechanical, chemical, natural processes, mulches and matting, and site preparation. Effectiveness, cost, and labour were considered.
- This report reviews existing literature and the results from interviews with experts. We used a semi-structured interview as a fast way to learn from experts' experience which allows elaboration of ideas and topics not expected. Site visits checked these findings against field observations.
- The main findings from the research showed chemicals to be the most effective and cheapest weed control option. However, hand-weeding and matting and mulches can be more viable options on some sites. Financing control is critical but costs vary greatly. Good site preparation and ecological techniques can reduce future weeding efforts.
- Due to time constraints, field experiments could not be conducted. This would have allowed a quantitative comparison of the different techniques and their costs. Some topics (such as matting and mulches) had little information specific to New Zealand native plantings, so the findings in the literature review may be less relevant.
- Further research should conduct field experiments to compare weed control techniques. Other knowledge gaps, such as the best site preparation, safety of biological control in New Zealand, and how to minimise environmental impacts from chemical control, should be researched.

1: Introduction

Earth's climate has warmed an average of 1°C since the industrial revolution but reaching net zero CO_2 emissions and reducing other emissions would be sufficient to slow, and eventually stop, anthropogenic warming (IPCC, 2018). Carbon sequestration by landscape revegetation is key to the achievement of net-zero CO_2 (IPCC, 2019).

Planting trees removes atmospheric carbon and increases local biodiversity. This increases resilience by offsetting carbon emissions and increasing ecosystem functional redundancy (IPCC, 2019). Planting native trees is especially beneficial since they release 2.5 times less carbon dioxide from the soil into the atmosphere than similar exotic species due to slower microbial decomposition (Waller et al., 2020). Vegetation also reduces erosion and helps trap sediment, nitrogen, phosphorus and pathogens before they enter waterways, improving waterway health (Burrell et al., 2014; Prosser et al., 2016; Wright, 2012). Plants directly cool the surrounding area through increasing shading and evapotranspiration (Kong et al., 2016). Indigenous forests also have significant cultural importance (Forbes et al., 2020). The importance of planting more native species has been recognised in New Zealand through numerous national and local revegetation programs.

These plantings need three to five years of regular weed control to minimise mortality and achieve successful establishment (Landscape architect, personal communication, September 17, 2020). Although many weed control guides exist, there are no comprehensive guidelines for Canterbury that combine conventional weed control techniques with ecological processes, site preparation and cost comparisons. Creating region-specific weed control guidelines is key as Canterbury's most problematic weed species differ from national lists (Meurk et al., unpublished research). Additionally, a common cause of invasive weed control failure is an inadequate evaluation of the costs and benefits of different control options (Kettenring & Adams, 2011). As weed control requires a lot of resources such as time, labour and money, it is important to create comprehensive guidelines to effectively manage weed control in native plantings.

This report aims to evaluate what effective weed control options exist when planting native species into exotic grass in Canterbury. The research is focused on five methods: site preparation, chemical sprays, matting and mulches, mechanical controls, and use of natural processes, and considers financial costs. This report summarises key points from literature, outlines applied methodology, reviews key findings from the interviews and makes recommendations for future research.

2: Methods

The methods used to gather data for this report comprised of assessment of existing literature, interviews with experts and site visits.

A review of peer-reviewed literature and existing weed control guidelines provided a basis of information which identified existing knowledge gaps and structured interview questions. The literature review is provided in Section 2.

As recommended by Frances et al. (2009), semi-structured discovery interviews were chosen as a fast way to learn from experts' experience. This interview structure means interviewees could diverge from the prepared questions to elaborate on certain details, tell stories and provide new information (Frances et al., 2009). The questions for interviewees are provided in Appendix A. The interview contacts were primarily sourced from the research community partner, Di Lucas, and were emailed a participation invite. In some cases, the contact passed our request to someone else who we interviewed instead. We contacted fourteen people whose experience encompassed ecology, botany, landscape architecture, nursery work and council work requesting interviews, and were able to conduct five. The interviews were a mixture of in-person and online and consisted of questions about the participant's experience using weed control and opinions on various techniques' effectiveness and costs.

Native planting visits were used to cross-check the secondary interview data against personal observations. These sites included a restoration site in Templeton on the Canterbury Plains, the foothills of the Port Hills and surrounding area, and the Heathcote and Christchurch Adventure Park Planting sites. Observations were made about utilised weed control techniques and how effectively weeds were suppressed.

Data analysis consisted of extracting key points from the interview notes and compiling them into themes on another document, which was used to identify important findings and common points for this report. The literature review section was summarised by the group member who conducted the review on that topic, and the key findings were checked against site visit observations to confirm real-life applicability before entry into this report.

2.1: Mana Whenua Engagement

The significance of this research to mana whenua was identified in a mana whenua engagement report. Native restoration is closely linked with kaitiakitanga, an important Māori philosophy (Walker et al., 2019). There are obligations under the RMA (Sections 6-8) to consider Māori values and the Treaty of Waitangi when altering the environment. The Ngāi Tahu Iwi Management Plan outlines that native restoration is a form of cultural wellbeing restoration (Ngā Papatipu Rūnanga Working Group, Dyanna Jolly Consulting, 2013). Therefore, weed control in native plantings has significance to mana whenua as it has a role in kaitiakitanga, obligations under the law and significance to the iwi of the research focus area. The mana whenua engagement report was analysed by Dr Abby Suszko, the College of Science Kaiārahi at the University of Canterbury. Dr Suszko advised the research team that further engagement with mana whenua would be beneficial to the research through the Māori consultation process at the University of Canterbury.

The Ngāi Tahu Consultation and Engagement Group (NTCEG) Māori consultation process was then undertaken. This involved providing a research proposal and a brief report considering how various aspects of the research could have an impact on Māori. The NTCEG responded with the advice that further engagement with Māori was not needed.

To answer the research question effectively, the cultural impacts of weed control methods need to be considered. An attempt was made to organise interviews with two mana whenua contacts to establish the cultural impacts of different weed control methods, despite being advised by NTCEG that further consultation with Māori was not needed. However, no reply was received from either contact, no literature on the topic was found and there was no specific further information in Ngāi Tahu's Iwi Management Plan. Therefore, the cultural impacts of the weed control methods could not be established.

3: Literature Review

This section summarises the literature review on the topic of weed control in native plantings.

3.1: Planting Planning and Site Preparation

Rapid achievement of a dense canopy is vital as it reduces sunlight for weed growth (Davis & Meurk, 2001; Sullivan et al., 2009), and increases native plant growth rates by providing wind shelter and a good microclimate (Pratt, 1996; Sullivan et al., 2009). Planting densely was the key method that allowed a canopy to form quickly (Davis & Meurk, 2001; Sullivan et al., 2009).

The only soil characteristic addressed in the literature was soil compaction. Studies focussed on specific species and showed that there is variation amongst native plants in their tolerance to soil compaction (Anton et al., 2015; Bassett et al., 2005; Sullivan et al., 2009). Despite this, Sullivan et al. (2009) and Davis & Meurk (2001) both concluded that planting in ripped soils was, in general, a good method for site preparation for native plants. The loose soil encourages root development and can increase growth rates which allows for a quicker canopy creation.

There was clear consensus in the literature that vegetation around the site should be cleared prior to planting (Anton et al., 2015; Davis & Meurk, 2001; Sullivan et al., 2009). Clearing of grass and other weeds around plants reduces the competition for water and light, decreasing the mortality rates of new native plants (Anton et al., 2015; Davis & Meurk, 2001).

3.2: Natural Processes

The role of nurse plants and classical biological control was examined. Fires are used overseas (Fuhlendorf & Engle, 2004) but in some New Zealand ecosystems, fire and grazing can be as detrimental as weeds (Holdaway et al., 2014). Although grazing can be used to successfully control some weeds (Bellingham & Coomes, 2003; Popay & Field, 1996), it is likely not viable for native plantings because of high palatability.

Nurse plants are species which provide shelter for young seedlings, and Scotch broom and gorse have been successfully used for this in New Zealand (Burrows et al., 2015; Wilson et al., 2017). Hinewai Reserve on Banks Peninsula is an example of successfully using nurse plants for weed suppression and native seeding shelter (Wilson et al., 2017). However, gorse and scotch broom are some of Canterbury's worst invasive weeds; they replace pasture, displace native species and increase nitrogen leaching (Isern, 2007; Magesan et al., 2012).

Classical biological control involves the introduction of a species' natural enemy. The success of biological control on weeds is dependent on the weed's traits; the introduction of seven biological control agents has had little effect on gorse (Isern, 2007) but two weevils would be sufficient to reduce nodding thistle populations in Canterbury by 20% per year (Shea & Kelly, 2004). There are also New Zealand examples where biological control has targeted eight non-target species (see Barratt et al., 2007). However, overall, biological control is unlikely to have non-target effects and these are most likely to occur on cacti and thistles (Suckling & Sforza, 2014). New Zealand has no native and few commercially valuable species (Cripps et al., 2013), so detrimental host-shifts may be less likely. This meta-analysis was not New Zealand specific and New Zealand has many unusual flora and flora so the applicability of this report is limited. Additionally, because of the risk of host shifts, intensive screening of control agents is required which can take 16 to 25 years (Ogden, 2020). Biological control of species which also have economic value can also be controversial (Isern, 2007) and might not be recommended for species such as gorse, broom and pasture grasses.

3.3: Mechanical Control

The literature regarding mechanical control primarily focussed on mowing and hand pulling, which was found to be efficient but labour-intensive and costly. MacDonald et al. (2013) reported that four years of hand pulling reduced the cover of spotted knapweed in a local area to only 1%. Three years of hand pulling caused large reductions in the biomass and density of adult knapweed in combination with mowing. Hand pulling alone reduced the cover of knapweed from 10% to 2% after one year, but increased cover returned with the absence of control. Hand pulling needs to be carried out regularly on a long-term basis or be combined with mechanical mowing to see proper results. Hand pulling is effective, but labour costs are still an issue for long term control.

MacDonald (2013) found that the only combinations of treatments that reduced the knapweed seed bank was hand pulling following mowing. Without the continuing suppression of the seed production, the seed bank densities will possibly return to the $400m^2$ that were found on untreated areas within the study (MacDonald, 2013), emphasizing the need for long-term management.

3.4: Mulching and Matting

Plastic matting is cheap but has costly labour and therefore no net savings (Schonbeck, 1999), but it did reduce weeds between 24-68% in uncovered vs. covered plots (Cirujeda et al., 2012). Plastic was found to be more resilient than paper mulch because it would not tear from pegs as easily in high winds (Harrington & Bedford, 2004). Water run-off is a significant issue with plastic options (Schonbeck, 1999). Klett (2014) deemed paper mulch (newspaper) to be a readily available option, but it only had a lifespan of about 6 months, was let down by poor wind resilience and is somewhat unattractive (Harrington & Bedford, 2004). Carpet was a relatively popular option in small native plantings, but was more labour intensive to apply than mulch, and some carpets can leach chemicals (Smaill et al., 2011). Bark, woodchips, and other wood options were somewhat popular in the literature and are relatively accessible, as well as not being easily blown away. These options can cause nitrogen deficiencies if incorporated into soil, and are somewhat flammable (Klett, 2014). Light mulch options such as grass and straw were not found to be useful because of rapid breakdown and easy weed permeation, but they can be useful for shorter period weed control when layered and require minimal manual labour (Schonbeck, 1999).

3.5: Chemical Control

Herbicide use can mean the difference between survival and failure of native plantings (Porteous, 1993), as the small stature of a native species may predispose them to being outcompeted by weeds (Champion, 1998). Chemical sprays are the most used weed control due to its time- and cost-effectiveness, with glyphosate being the most common chemical applied; however, glyphosate cannot control all weeds (Porteous, 1993; Rolando et al., 2013). Haloxyfop is good for targeted control of grassy weeds (Champion, 1998). Broom, gorse, Pinus radiata and various grass species were found to be the most problematic weeds to control with sprays in New Zealand (Rolando et al., 2013). Other difficulties stem from pastures containing a mixture of different weed species which will react differently to the herbicide used (Bourdôt et al., 2007), which highlights the need for species-targeted spray control.

3.6: Literature Knowledge Gaps

Significant knowledge gaps were found during the literature review. Much of the literature on site preparation focused on individual species. There was no literature on soil characteristics other than compaction and its effects on native plants. The literature was unclear on how safe classical biological control is to use in New Zealand. Most of the literature on mulches and matting was limited in detail and primarily related to usage for vegetable crops and foreign plants, making it difficult to apply to native plants. Mechanical control literature largely focused on specific sites with unique physical characteristics and weeds, meaning that limited information could be drawn out and applied to this research. The most significant literature gap was how herbicides' environmental effects can be mitigated or prevented and the cultural implications of weed control.

4: Interview Results and Discussion

Overall, the findings were similar to our literature review. Novel findings will be discussed in their relevant sections. One new and previously unconsidered finding was the debate around the role of community engagement in weed control. Some interviewees believed hand-weeding was too labour-intensive and time consuming compared to sprays and mulches, while others considered it a valuable way to involve the community which could be low-cost if volunteers were involved. This disagreement may be due to personal values and experiences, whether the project requires high efficiency and weed control success, and the amount of community involvement already in the area.

4.1: Planting Planning and Site Preparation

Establishing early canopy cover to reduce weeds was, as in the literature, important (Council Employee, personal communication, September 20, 2020). The effectiveness of canopy shade is shown in figure 1. However, early canopy creation is a trade off as planting densely requires more plants and early maintenance, increasing costs (Nursery Employee, personal communication, September 18, 2020). Planting design and timing can help reduce expenses. For example, white clover was used in Karamea to create ground cover, reduce erosion and fix nitrogen to increase the success of subsequent native plantings (Environmental Agency, personal communication, September 21, 2020). Planting workhorse species first and enrichment species two to three years afterward can increase shading, therefore reducing the weeding effort required from other techniques (Landscape

Figure 1: The canopy shade is very effective in reducing the grassy weeds at this field site in Templeton. Source: Burgin, 2020

architect, personal communication, September 17, 2020). Examples of successional planting species is provided in Appendix B.

Clearing of immediate vegetation is standard practice for planting native plants (Figure 2) (Ecologist, personal communication, September 24, 2020; Council Employee, personal communication, September 20, 2020; Environmental Agency, personal communication, September 21, 2020). The use of chemical sprays was the main method used by interviewees to clear immediate vegetation and is covered in the chemical control section 4.5.

The relationship between planting method and the plant's ability to combat weeds did not appear in the literature but was discussed as being significant in the interviews. Planting quality determines a plant's health and growth rate, and therefore its ability to out-grow competitors. Direct seeding was used for steep slopes (Environmental Agency, personal communication, September 21, 2020). In some cases, direct seeding outpaced nursery grown and transplanted plants at the same site. Further information on this was not able to be gathered but could be a point for future research.

Figure 2: Immediate vegetation has been cleared around new native plants at this field site on the Heathcote River. Source: Hopper, 2020

4.2: Natural Processes

Gorse was identified as a suitable nurse plant provided that the site had adequate rainfall, a nearby seed source, and that fire and browsing animals (including seed predators) were kept out of it (Ecologist, personal communication, September 24, 2020). The same interviewee discussed using mānuka and kānuka as native nurse plants but said these species are not very competitive and best establish in bare soils or grazed grass. Importantly, they said most nurse plants are shade intolerant. However, the Environmental agency (personal communication, September 21, 2020) discussed planting mānuka and kānuka into gorse which they then outcompeted. The ecologist also discussed successful biological control, such as using the ragwort flea beetle to control ragwort.

4.3: Mechanical Control

Overall, the interviewees said mechanical control is non-feasible and labour intensive, leading to it being a less-preferred control technique. However, mechanical control is highly desired in some areas despite its high cost. Environmental Agency (personal communication, September 21) discussed how mechanical control methods such as brush cutters and hand pulling are more feasible for native plants on the steep slopes of the port hills, because of the difficulty to manage them any other way.

The Christchurch City Council (CCC) has started to use steam as a control technique (personal communication, September 20, 2020). The boiler system is expensive and the steam does not break down the whole plant, allowing regrowth of weeds. Therefore, this technique needs to be carried out regularly.

An Environmental Agency (personal communication, September 21, 2020) controls noxious weeds such as perennials with a cut and paste method. The root is cut at its base and a paste is applied on top to stop regrowth. This is important for perennials, as they are capable of vegetative reproduction. Therefore, regular cutting techniques will not influence perennials due to their ability to regrow their shoots.

Site specifications determine weed control techniques used; sensitive sites such as at the Port Hills use primarily mechanical control due to the environmental effects of chemical control. Mechanical control options are very intensive, but the literature shows that it is still possible to carry it out effectively. Innovation is key to take the hard work out of mechanical control, such as by creating automated robots. Mechanical control is also more viable around waterways to minimise the use of chemical control (Botanist, personal communication, September 17, 2020).

4.4: Mulches and Matting:

Figure 3: Plantings along the Heathcote River illustrating the use of matting squares for weed control. Source: Hopper, 2020

The CCC uses single use mat squares to protect the base of plants from weeds (Figure 3) (Council employee, personal communication, September 17, 2020). Coconut fibre is now a popular choice for this, but DOC is moving towards wool. Mulches are good for moisture and weed suppression (Nursery employee, personal communication, September 18, 2020), whereas mat options can be detrimental to plants because of a lack of moisture if placed on dry ground. Hemp fibre is proving to be a useful option, but due to its cost it is not a good large-scale option (Nursery employee, personal communication, September 18, 2020). The environmental agency is producing compost blankets from green waste and mulch which simulate forest floor conditions for transplanted natives (Environmental agency, personal communication, September 21, 2020). The environmental agency discussed wool option but found apple trays to be useful and easy to apply, despite it not lasting as long. It is, however, crucial that matting is not so thick as to impede water permeability and that the matting is applied on moist soil (Environmental agency, personal communication, September 21, 2020). Wood mulch is the most effective option for steeper terrain as it binds together, but it is best to use semi-decomposed mulch so as not to remove nitrogen from soils (Landscape architect, personal communication, September 17, 2020). The consensus in all the interviews was that plastic mat options should be avoided since they break down relatively rapidly, leaving behind plastic fibres in the soil. Some of the interviewees' companies had adaptable guidelines, but a general standard of the best options did not exist.

There were a range of good options discussed in the interviews, but generally mulch options were thought to hit the best balance of cost and labour requirements, with coconut-fibre and wool matting options becoming increasingly popular.

4.5: Chemical Control

For most interviewees, chemical control is preferred over mechanical control on large sites due to time and labour costs, but careful and targeted application is crucial to avoid killing native plants (Nursery employee, personal communication, September 18, 2020). A number of measures can be taken to reduce this risk such as only spraying at low wind velocities, placing cones over the plants, checking for branches underneath matting, weeding around the plants first or cutting and pasting chemicals into the weed's trunk (Council Employee, personal communication, September 20, 2020; Environmental Agency, personal communication, September 21, 2020; Ecologist, personal communication, September 24, 2020). Galant can be used to control exotic grasses when native plants are present (Ecologist, personal communication, September 24, 2020). Organic herbicides exist, but sometimes do not kill the weed's roots and can be dangerous to work with (Council employee, personal communication, September 20, 2020).

4.6: Finances and Key Findings

It was difficult to establish costs for the weed control techniques as prices vary hugely between sites and the weeds which need controlling. Estimated costs ranged between $40,000 and $70,000 per hectare of native plantings (Nursery employee, personal communication, September 18, 2020; Environmental Agency, personal communication, September 21, 2020). This is a great deal more than the $4,000 per hectare the government supplies through One Billion Trees. Given the variability in prices, most of this section shall discuss approximate relative costs instead of hard figures.

Designing your planting sequence to increase shading is a cheap and easy way to reduce the amount of money spent on other weed control techniques, although it requires a higher density of plants. Nurse plants are a cheap and low-intensity form of weed control (Burrows et al., 2015). Biological control is cheap and low-effort once it is established (Paynter et al., 2012) but there is potential for it to have unwanted effects (Barratt et al., 2007). Biological control is also slow to introduce (Ogden, 2020).

Chemical control is the cheapest weed control option but should be applied carefully to avoid killing native plants, either by accidental direct application or via spray drift. Mulches and matting are the second-cheapest option, but sleeves around plants are expensive. It costs $3 per plant to attach a sleeve and add a fertiliser tablet (Council employee, personal communication, September 20, 2020). However, other interviewees felt mulches and matting were the cheapest weed control option.

Mechanical control is labour intensive, but hand-weeding may be more appropriate than chemical control in urban areas and instances where the community wants to be involved. Provided the community can access the site, using volunteer weeding is a low-cost way to manage weeds that also engages the community in local restoration and reduces the use of chemical control.

5: Summary and Concluding Comments

Planting densely in ripped soils where vegetation has been cleared appears to be the best method for site preparation. Planting healthy plants increases growth rates, allowing for quicker canopy creation and shading of weeds. Growth rates could potentially be improved by direct seeding. Nurse plants and classical biological control have limited useability but can be effective when used correctly. Planting workhorse species first is a free way to reduce the number of weeds to control later.

Chemical control is often the cheapest, fastest and most-effective control technique but it can have unwanted environmental effects and kill native plants. Matting and mulches are the most popular alternative and can also be cost-effective.

There was considerable disagreement among the interviewees on the role of community hand-weeding to suppress weeds. If the project is accessible to the public, involving the community can foster a sense of public engagement with restoration projects. It may also be beneficial in sites where chemical sprays may have unwanted environmental and human health impacts.

It is hoped that these findings can help increase the success of weed control in native plantings in Canterbury. They suggest chemical control is best for large-scale programs, but that matting, mulches and mechanical control are more appropriate for small-scale approaches. Site preparation and mimicking successional planting can be used to reduce the later weed burden. Biological control and nurse plants have limited usefulness but can be effective when applicable.

There are some technical knowledge gaps that are important to fill with more research. These have been identified in Section 3.6. Additionally, a scientific field experiment would provide quantitative data to statistically determine weed control effectiveness and compare their costs in a controlled environment. This research has important cultural implications for mana whenua which we were unable to adequately address in this report and should be developed further.

Finally, our research emphasises the importance of having locally tailored and easily accessible weed control guidelines. DOC provides ecosystem-specific guidance (DOC, n.d.) and websites such as Weedbusters have a wealth of information on individual weeds. However, commentary on how to control weeds using typical techniques alongside site preparation and natural processes, and their relative costs and time-effectiveness, is lacking. As local soils and climates vary, which may alter weed control effectiveness, it is crucial these region-specific guidelines are created. In turn, this should increase the success of revegetation attempts in New Zealand to mitigate carbon emissions and improve environmental wellbeing.

Acknowledgements

We would like to thank Boyden Evans, Colin Meurk, Fern Factor, Red Tree and one anonymous interviewee for participating in our interview process, and Abby Suszko for giving her time and guidance through the Māori engagement process. We would like to give a special thank you to Di Lucas, our community partner, for her help refining the research aim and providing interview contacts. We would like to give another special thank you to Ed Challies, our supervisor, for his encouragement and advice throughout the research process.

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Appendix A: Interview Questions

The following are guiding questions interviewers used to undertake an interview with. They are open-ended, allowing for interviewees to expand and discuss topics we may not have had specific questions on.

What weed control options do you have experience using? (And how long for?) How much planting have you done in exotic grasses? - Both lawn and pasture

Do you have a set of guidelines that you follow for native plantings? Do you know of any guidelines that people use? What is your experience of the effectiveness of different guidelines?

What was the entire process of planting? How did you prepare the site? Early weed control methods? Weed control methods once established?

What did it cost to use each weed control option? And how easy/fast was it to apply each weed control option? How long did it take for the weed control to be effective?

What are some weeds that are common or hard to control? (Or useful!) And what's the best way to control them?

Are there any restrictions when using any control methods, like not using it at certain locations/under certain conditions or staff protective equipment/health and safety?

Did any have unexpected side-benefits (or problems)?

What mechanical weed control methods do you use, and how effective are each of the controls?

Which common weeds are useful for protecting and providing nutrients to young native seedlings while they are being established?

Any tips or recommendations for someone who's new to using weed control?

What matting or mulch options would you consider to be most effective in grass type native plantings?

What is the cost of each of these options?

Do you have any unusual matting or mulch options which are not well known which could be effective (jute, wool, wood, plastic, steam)?

What do you consider to be the realistic cost of weed maintenance for two years after planting per hectare?

How can native plantings be designed in such a way to make weed control as easy and viable as possible?

How can we use 'cues to care' to make native plantings more appreciated by the public? "Aesthetics"

Site factors (e.g. slope, aspect, soil type etc) that make weed control more or less successful?

Appendix B: Species List

An example of a species list at a site which used successional planting to suppress weeds (Landscape Architect, personal communication, September 17, 2020). Enrichment species are indicated with a 'y' in the far-right column, while the priority column indicates how soon species should be planted.

Botanical name	Common name	Priority	Enrichm
Gymnosperm trees			
Dacrycarpus cupressium	Rimu	2	y
Dacrycarpus dacrydioides	Kahikatea	1	y
Podocarpus totara	Totara	1	y
Prumnopitys ferruginea	Miro	3	y
Prumnopitys taxifolia	Matai	3	y
Monocot trees			
Cordyline australis	Ti kouka	1	
Rhopalostylis sapida	Nikau	3	y
Dicot trees and shrubs			
Alectryon excelsus	Titoki	2	y
Aristotelia serrata	Makomako	1	
Beilschmiedia tawa	Tawa	1	y
Carpodetus serratus	Putaputaweta	2	
Coprosma acerosa	Sand Coprosma	1 edges	
Coprosma areolata	Thin leaved Coprosma	2	
Coprosma crassifolia			
Coprosma grandifolia	Kanono	1	
Coprosma lucida	Shining karamu	1	
Coprosma propinqua	Mingimingi	2	

Coprosma repens	Taupata	3	
Coprosma rhamnoides			
Coprosma robusta	Karamu	1	
Coprosma tenuicaulis	Hukihuki, swamp Coprosma	2	
Dysoxylum spectabile	Kohekohe	1	y
Elaeocarpus dentatus	Hinau	3	y
Fuchsia excorticata	Kotukutuku, Tree fuchsia	2	
Geniostoma ligustrifolium	Hangehange	2	
Griselinia littoralis	Kapuka, Broadleaf	2	
Griselinia lucida	Puka, Broadleaf	1	both
Hebe stricta	Koromiko	2	
Hedycarya arborea	Porokawhiri, Pigeonwood	3	y
Hoheria sexstylosa	Lacebark	1	
Knightia excelsa	Rewarewa	3	y
Kunzea ericoides	Kanuka	1	
Leptospermum scoparium	Manuka	1	
Laurelia novae-zealandiae	Pukatea	2	y
Macropiper excelsum	Kawakawa	1	
Melicope simplex	Poataniwha		
Melicope ternata	Wharangi	2	both
Melicytus ramiflorus	Mahoe	1	
Myoporum laetum	Ngaio	2	
Myrsine australis	Mapou, Matipo	1	
Olearia solandri	Coastal tree daisy	1	
Pennatia corymbosa	kaikamako	3	y
Pittosporum eugenioides	Tarata, lemonwood	1	both
Pittosporum tenuifolium	Kohuhu	1	
Plagianthus divaricatus	Makaka, saltmarsh ribbonwood	delete	
Plagianthus regius	Ribbonwood	1	
Pseudopanax anomalous			
Pseudopanax arboreus	Whauwhaupaku, Fivefinger	1	
Pseudopanax crassifolius	Horoeka, Lancewood	3	
Solanum aviculare	Poroporo	2	
Sophora microphylla	Kowhai	2	

Streblus banksii	Turepo, large leaved milk tree			
Streblus heterophyllus	Turepo, small leaved milk tree	3		
Syzygium maire	Maire, tawake, Swamp maire	3	y	
Dicot lianes				
Clematis paniculata	puawhangana	3		
Muehlenbeckia complexa	Pohuehue, wire vine	1		
Parsonsia heterophylla	Akakiore, NZ Jasmine	2		
Rubus australis	bush laywer	3		
Tetragonia implexicoma	NZ spinach	3		
Acaena pallida				
Ferns (to be added naturally)				
Loads found				
Grasses				
Austroderia fulvida	syn Cortaderia, toetoe	1		
Austroderia toetoe	syn Cortaderia, toetoe	local?		
Sedges				
Bolboschoenus fluviatilis	Kukuraho, Marsh club rush	3		
Carex dipsacea	Teasel sedge	3		
Carex geminata	Cutty grass, rautahi	2		
Carex lessoniana	Cutty grass	2		
Carex secta	Pukio, Purei	1		
Carex solandri	Forest sedge, Solander's sedge	3		
Carex virgata	Swamp sedge	1		
Cyperus ustulatus	Toetoe upokotangata, Giant umbrella sed	2		
Eleocharis acuta	Sharp spiked sedge	2		
Eleocharis gracilis	Slender spiked sedge	2		
Eleocharis sphacelata	Kuta, Bamboo spike sedge	2		
Ficinia nodosa	Wiwi, Knobby club rush	2		
Machaerina articulata (syn Baumea)	Jointed baumea or twig rush	1		
Machaerina rubiginosa (syn Baumea)		1		
Machaerina tenax (syn Baumea)	formerly Baumea tenax	1		
Machaerina teretifolia (syn Baumea)	Common twig rush, pakihi sedge	1		
Schoenus validus	Kuta	delete		
Schoenoplectus tabernaemontani (syn S. validus)	Lake club rush	FED?		
Typha orientalis	Raupo	limited use		
Eleocharis sphacelata		TP10 not local		
Isolepis prolifer		TP10 invades naturally		
Myriophyllum propinquum		TP10		
Potamogeton cheesmanii		TP10		
Rushes and allies				

Apodasmia similis	Oioi	1		
Juncus pallidus	Giant rush	1		
Juncus edgariae (syn J gregifolius)	Wiwi	1		
Juncus sarophorus		1		
Moncot herbs				
Astelia fragrans	Kakaha, Bush flax, bush lilly	3		
Dianella nigra	Turutu, NZ Blueberry	2		
Libertia ixiodes	Mikoikoi, NZ Iris	3		
Libertia peregrinans	Mikoikoi, NZ Iris	3		
Phormium cookianum	Wharariki, Mountain flax	amenity, not local		
Phormium tenax	Harakeke, Flax	1		

Ficinia spiralis	Pingao
Pomaderris kumeraho	Kumarahou
Pomaderris apetalus subsp maritima	Tainui