Second stage ecological restoration

near Te Roto o Wairewa/Lake Forsyth

and Little River, Horomaka (Banks Peninsula)

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Abstract

Most revegetation and ecological restoration projects throughout New Zealand are planted with a limited selection of native plant species. Funding restrictions often do not allow additional time for forward planning of longer term plant community diversity outcomes. Little consideration is made for the emergence of beneficial seedlings, or for the planting of later stage species. The aim of this research was to investigate whether expanding the plant species list proposed for a selected planting area would enhance and extend local biodiversity, if understorey plants are included in longer-term planning. One objective was to enhance an existing ecological restoration project by doubling the number of native species with a selection of regionally rare, less common plants, and common plants with limited sale in nurseries. Twenty-one plant species were selected for the study. This research study was carried out in conjunction with the Wairewa Rūnanga. The hau kāinga hapū (the local people belonging to the Wairewa Marae, are Ngāti Irakehu and Ngāti Makō, (sub-tribes of Ngāi Tahu), are based at Little River and Te Roto o Wairewa / Lake Forsyth, Horomaka (Banks Peninsula), in Canterbury. With the support of a Vision Mātauranga award, the project was based near the Wairewa Marae, and at a nearby partially re-vegetated stream terrace.

A preliminary study of archival oral and written histories provided a database of regionally rare or less common plants that were once present in this Banks Peninsula landscape. These included plant species of more particular or significant interest to the Wairewa tangata whenua, (the local people belonging to this area), particularly plants used in Rongoā Māori, (traditional Māori healing). A desk study provided an historical background upon which to base a proposed planting list and site location.

Sixteen native plant species were already present in wider adjacent areas of the existing project on the stream banks or in the low terrace areas on the eastern side of the Ōkana Stream, but only 14 species were present in the immediate designated study areas. The additional 21 species planted included 17 taller growing plants, (trees, shrubs, one sedge and climbers) and 4 ground cover species. Of the 21 species, 16 new plant species were introduced into the existing project area. All the plants were monitored over a period of 15 months. The experimental area was a strip of revegetated land approximately 3.5ha (500m long and 70 m wide). Six individual plots (10m x 7m) were located along 70m length of terrace. Each plot measured 70m^2 and began at the top of the terrace, with a gentle slope of 0.3m to 1.5 m, down to a low point by the old stream bed. The total width of the study area was 7m for plots on one side, and 7 m wide for plots on the other side of the old stream bed, with a total overall width of the study area of no more than 20m. The experimental plots covered 0.14 ha. A

seventh plot was situated at the nearby Wairewa Marae, also measuring 70 m^2. A total of 697 plants were included in the field study.

Initial strategic planning was found to be important to ensure successful establishment of plants: location and species-suitability issues, as well as known geological, geographical, climatic and biological risks were taken into account at the early stages. Planting techniques, and careful individual plant selection and placement were considered to be important issues.

Rare, less common and uncommon plants performed equally as well as the common species. The shade or shelter provided by foliage of the existing plants allowed healthier growth of all species, whereas fringe frost-tender species such as *Fuchsia excorticata* did not perform as well in the open spaces. One rare species, *Pittosporum obcordatum*, performed consistently well at all locations. The rate of survival in each species category, was observed in terms of successful establishment, (health and growth), failure, or recovery. Height and health recordings showed that given placement in favourable locations or conditions, such as partial shade or shelter, then the rare, uncommon and culturally useful species could grow equally robustly as the common species. *Pseudopanax arboreus* had the second highest number of deaths, but was among the tallest growing plants. Three species showed signs of set-backs due to frost damage or summer dryness, followed by new growth and recovery. All *Melicytus ramiflorus* survived and followed this pattern. When placed in sheltered positions, *Pseudopanax arboreus* and *Fuchsia excorticata*, had some success in set-back and recovery.

The project resulted in an 87.9% survival rate of the taller plants, and an 82.9% survival rate overall, which included ground cover species. Given the limited period of study and evidence of plant recoveries and set-backs after two winter periods, it was thought that the survival rate maybe improved with further summer data observations. The benefits of a well prepared area in which to allow emergent seedlings to flourish was apparent. Only three emerging seedlings were identified in the unmanaged area compared with several hundred in the managed plots. Many emerging seedlings favoured the protection of the ground-cover species, where these had been placed in cluster groups together.

Knowledge gained through this field study has increased biodiversity and Rongoā Māori species in the Te Roto o Wairewa/ Lake Forsyth and Little River areas, informed and raised awareness of the range and opportunities of ecological restoration amongst the Wairewa Rūnanga and local community, and has also advanced restoration practice towards considering how to establish rarer and less common species.

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Te Tirohanga and Te Ngaru, Kaitiaki (guardians, caretakers) of Te Roto o Wairewa.

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Chapter 1
Introduction

1.1 General Introduction

The research reported in this thesis was focussed around the establishment of regionally rare and uncommon plants that were once present in the Banks Peninsula landscape, particularly in areas of significant interest to the Ngāi Tahu people, and the Wairewa Rūnanga, whose Marae and home areas are within the Little River basin and surrounding coastal bays.

After photographing local plant species and logging them into the New Zealand iNaturalist database for identification I surmised that from over 120 easily visible locally growing native plants, some of these plant species could be introduced into a local restoration site. Observations and knowledge of the survival and establishment of these additional species could form a useful planning base for future revegetation projects within the local community.

During less formal non-academic work as a restoration practitioner by the present author, it was observed that a number of Canterbury native plant revegetation projects may not have reached reach their full potential, with initial high plant losses during establishment, low species richness within the site, and slow long-term progress. Based on my experience, I considered that greater potential could well be reached with more attention to detail in both the initial planning stages, and planting methodology. The hypothesis was that: by paying attention to detail in the selection process, the plant placement process, and the physical planting techniques and protection, there would be a comparable survival rate of all the additional species chosen. This provided a rational for the research project.

This research project investigated the performance of a selection of native plant species within the Te Roto o Wairewa/ Lake Forsyth water catchment area. These species included rare, less common, common but not commonly planted and common species, as well as traditional Māori medicinal plant species. (Described as "Rongoā" species throughout this thesis). The research was conducted over 15 months from June 2016 to September 2017, which included two winter periods.

This research project was carried out in conjunction with Ngāi Tahu and the Wairewa Rūnanga, and was supported by the Ministry of Business, Innovation and Employment, (MBIE) with a Vision Mātauranga grant. The Wairewa Rūnanga have deep concerns for the health of Te Roto o Wairewa/ Lake Forsyth, (Ngāi Tahu 2013), and approach wider conservation issues and their custodianship (kaitiakitanga), (Wairewa Rūnanga 2013), of this area with strong values. In the exact spirit of the expectation expressed in the Vision Mātauranga grant, it is hoped that this study will advance restoration practices with some innovative thinking, raise awareness in the community and offer some practical and sustainable solutions. The Mission Statement of the Vision Mātauranga program, (MBIE 2018), is: “To unlock the innovation potential of Māori knowledge, resources and people to assist New Zealanders to create a better future”. Sir Paul Reeves, founder in 2005, (MBIE 2018), stated that Vision Mātauranga was “geared toward innovative and revolutionary thinking, and practical and sustainable solutions”.

Because of the values intrinsic in the research grant, the study area assumes importance for future community revegetation planning with respect to the health of the Lake. Te Roto o Wairewa/ Lake Forsyth is currently recognised as a lake under environmental threat and one of the most polluted water bodies in New Zealand, (ECAN 2016, Ngāi Tahu 2013), largely due to the deforestation of the large catchment area around the lake. The lake itself is over 6 km long. The catchment extends over 19 km into the upper valleys, and is approximately 9 km wide at its widest point (Plate 1.1).

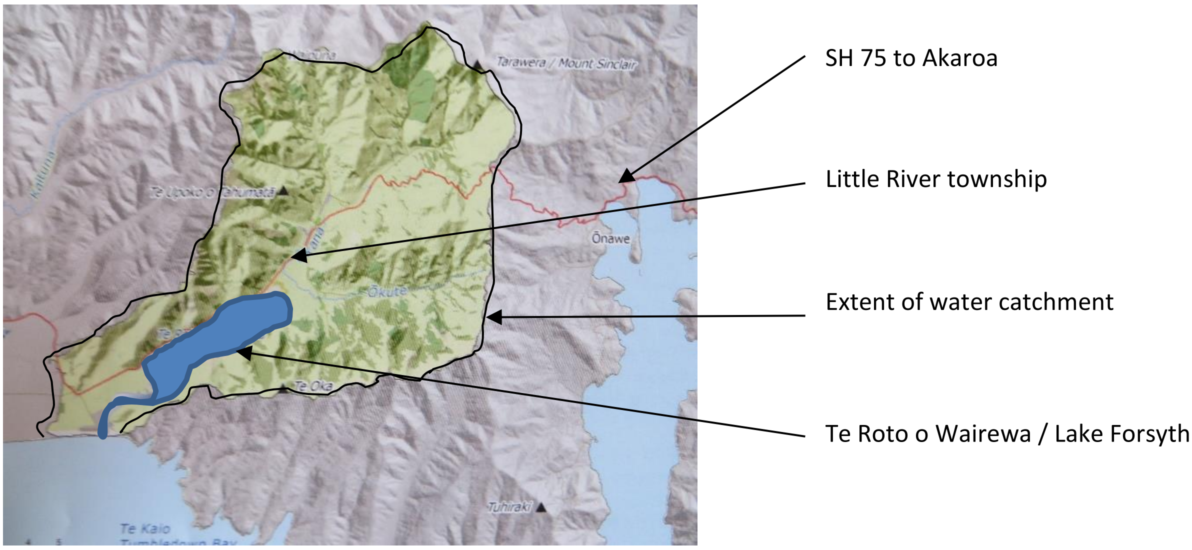


Plate 1.1. Te Roto o Wairewa/Lake Forsyth is shown bottom left hand side of picture. The large area surrounding it is the extent of the catchment associated with it. From left to right, State Highway 75 runs from Christchurch to Akaroa. At the head of the lake is the small township o Little River. The catchment is approximately 19 km long and 9 km wide at its widest point.

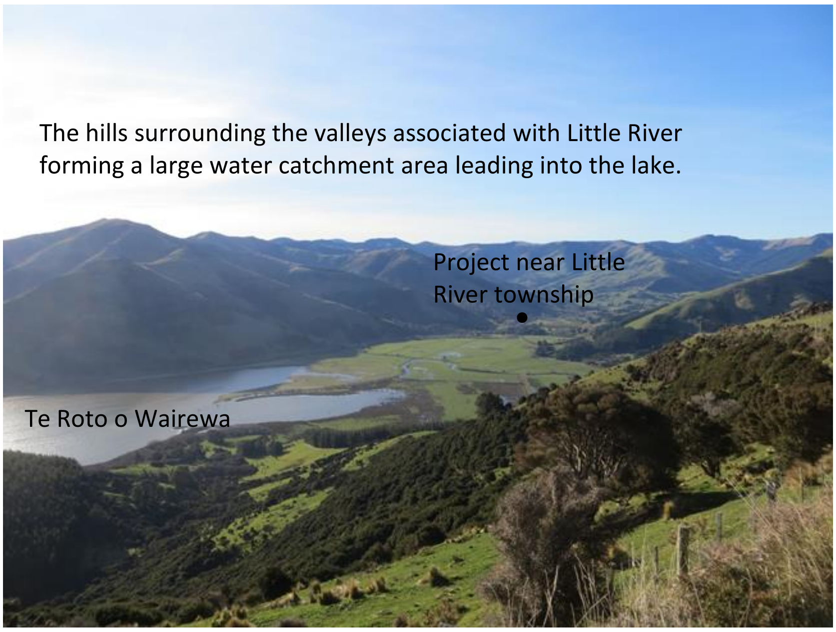
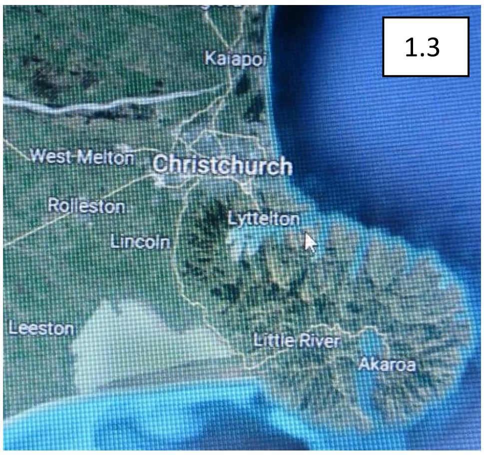


Plate 1.2 Picture taken from the Bossu Road saddle looking down at the head of Te Roto o Wairewa/Lake Forsyth, Little River township, and the surrounding water catchment area.

To put the study site into a wider perspective in relation to Bank's Peninsula (Horomaka) and the Canterbury Plains, Little River is situated 53 Km southeast from Christchurch, the major city on the seaward eastern side of the mostly flat, Canterbury Plains. Bank's Peninsula itself is a hilly landmass of volcanic origin southeast of Christchurch. The Little River township is located at the head of Te Roto o Wairewa/ Lake Forsyth, with the popular tourist resort town of Akaroa further to the east. (Plate 1.3 & 1.4).



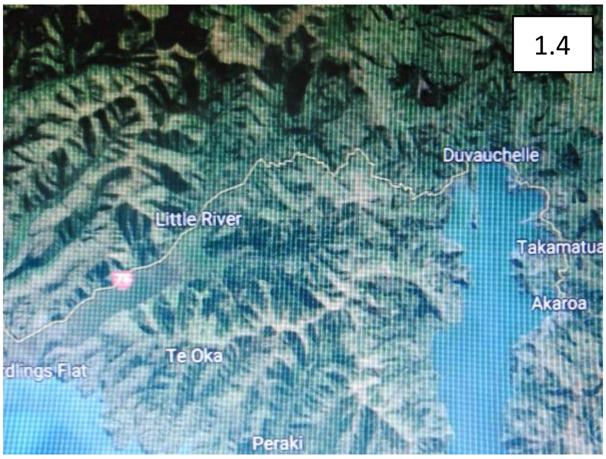


Plate 1.3. The City of Christchurch is 53 Km from Little River. The landmass to the south east of Christchurch is known as Bank's Peninsula (Horomaka). Akaroa is a well-known tourist destination 28 Km further along route 75 past Little River. (Google map 2018)

Plate 1.4. Little River is at the head of the lake, Te Roto o Wairewa / Lake Forsyth.

1.2 Research Aims and Objectives:

The aim of this work was to understand and design a successful second stage restoration project, by successfully planting and establishing an increased diversity of native plant species within an existing revegetation project. Increased diversity was planned to include rare, uncommon, common, and Rongoā Māori plant species, and to further explore methods that can be used to extend and enhance planning and implementation processes towards a successful restoration outcome, including appropriate conditions for the natural regeneration of seedlings.

The project had the following objectives:

Objective 1:

To engage in a desk study to provide the background for site selection, plant species selection, and plant husbandry techniques, to evaluate:

i) The historical background of native vegetation communities once present in the landscape, developing a database of local flora.

ii) The risks and likely survival and establishment issues of the plants at the proposed study sites.

iii) Planting strategies that may reduce the risk of plant failure, the possibility of using translocated material for plant species hard to obtain in nurseries, and the requirements for creating conditions that encourage the natural emergence of seedlings, (chapter 3.3)

Objective 2:

To underplant an existing native revegetation site with a wider selection of plant species to increase local biodiversity, with a target of:

i) Doubling the existing plant species in the project site,

ii) Including Rongoā- medicinal plants in the selection (chapter 3.2)

Objective 3:

To investigate specific conditions that would enhance the existing semi-mature revegetation project through:

i) Allowing natural seedling regeneration to occur

ii) Allowing a selection of more uncommon species to be successfully planted in the understorey

1.3 Thesis structure

The chapters within the thesis broadly follow the objectives, as set out above.

The literature review highlights the importance of the research and planning process in order to have satisfactory plant survival rates and good forward progress in a revegetation planting project.

Traditional knowledge and historical background was important in order to make inputs for both site and plant species selections, which in turn resulted in the restoration study.

Chapter 2 provides a detailed background, including descriptions of the preparatory research with relevance to the Ngāi Tahu *Rūnanga* and the Wairewa *Rūnanga*. Chapter 3 is the results of the desk study, and includes rationale for site and plant choices. Planting techniques, strategies and risks management are also covered in this chapter.

Chapter 4 describes the set-up of the field experiments and data collection. The following chapters 5-7 cover results, discussion and conclusions. Chapter 8 refers to recommendations for practical application of the resulting research in relation to the biodiversity and ecological goals of the Wairewa Rūnanga, for application within their district of care. The Appendices provide additional information, particularly related to the plant species chosen for this study. Appendix A also provides a glossary of terms used throughout the thesis, and Appendix B has photographic examples.

1.4 Literature Review

1.4.1 Introduction

The purpose of this literature review is to evaluate existing knowledge of plant establishment in revegetation projects, focussing particularly on smaller-scale ecological restoration in New Zealand.

Increasing diversity in plant communities

The year 2010 was declared International Year of Biodiversity, by the General Assembly of the United Nations, (Convention on Biological Diversity (CBD) 2018). Concern over biodiversity losses and safeguarding irreplaceable natural wealth were two of the main issues raised and discussed by the 193 nations. Dalrymple et al. (2012) were also concerned about the global threat of high numbers of plant species facing extinction. Karl and Trenberth (2003) had earlier elucidated that increasing rates of habitat destruction, spreading invasive species, and effects of climate change were factors contributing to species extinction. Managers and planners have sought ways to mitigate, solve and address these issues in large-scale projects. For example, Bakker et al. (2017), evaluated planning tools, and compared two management styles, i) of adaptive management (AM) and ii) staged-scale restoration, (SSR). Two of their conclusions are particularly relevant to smaller projects in the planning stages: Firstly, the importance of determining the specific causes of decline in wild populations and, secondly, identifying the conditions supporting population growth at the proposed project sites. Ehrenfield (2000) suggested that diverse site conditions would require a more flexible goal-setting approach to restoration ecology. Ehrenfield (2000) also suggested that acknowledging the true scope and limitations of what is possible in a given project would lead to more favourable outcomes. Albrecht et al. (2011) focusing on rare plant re-introduction, and Bakker et al. (2009) in general terms, both encouraged sustained, long-term monitoring and reporting of reintroduced populations.

Limited funding and community involvement

Limited funding for many small revegetation and restoration projects in New Zealand, necessitates volunteer participants and projects driven by community desires. A starting point is a desire to "save" something specific, such as improving declining numbers, assisting colonisation, the reintroduction of a threatened species, or enhancing a defined area such as a waterway system, or a degraded land area.

<u>Example One</u>; the Open Sanctuary at Tiritiri Matangi Island (Tiritiri Matangi 2018) where a 1600 strong non-profit conservation volunteer group works in partnership with the Department of Conservation to co-manage, monitor, and assists in relocation (and reintroduction) of the tīeke/saddlleback (*Notiomystis cincta*) and hihi/stitchback (*Philesturnus rufusater),* (Graham et al. 2010, Chauvenet et al. 2013).

<u>Example Two</u> is located at Waihora/Lake Ellesmere, a degraded South Island lake where the community formed a Trust (Waihora Ellesmere Trust, WET 2018), dedicated to the improvement of the health and biodiversity of Te Waihora/Lake Ellesmere and its catchment.

Linking biodiversity to conservation outcomes

Biodiversity and conservation outcomes are often linked. With the tīeke / saddleback (*Philesturnus rufusater*) (Conservation status: "at risk and in recovery", (DOC 2016)) and the hihi / stitchback (*Notiomystis cincta*), (Conservation status: "nationally vulnerable", (DOC 2016)) on Tiritiri Matangi Island, both assessment of vegetation and habitat was required, (Forbes and Craig, 2013), in order to achieve the conservation goals of increased bird numbers. With the North Canterbury Greening of Waipara Project, (Wratten and Meurk, 2006), 50 pockets of land within the Waipara V alley were each planted with between 250 and 500 native plants. Wider community benefits were derived throughout the valley over time, from the general reduction in the use of pesticide sprays as the plants provided habitat for predatory insects which in turn provided an ecological service to the local vineyards.

Another outcome linking biodiversity and conservation outcomes, as well as involving a wider management and planning with government, corporate and community involvement, is the example of the Punakaiki Coastal Restoration Project on the West Coast of New Zealand. In 2014 partners in future management and planning included Lincoln University, Conservation Volunteers of New Zealand and the Department of Conservation. Corporate sponsorship included legacy management from Rio Tinto Services Ltd. (PCRP 2018). One goal on this restoration project was to address the issue of biodiversity losses by increasing the numbers of plant species over time. The project began with a limited proportion of species, but by planning the project in stages, as the plants matured, additional species such as understorey plants, complimentary species, and even rare or threatened species were planned to be introduced. The Punakaiki Coastal Restoration Project began with a plan (Smith et al. 2016), for 31 plant species, but for later stages the target plan is for over 200 species to be reintroduced.

1.4.2 Cost effectiveness.

There are a number of tools in planning that contribute to cost effectiveness. Cost effectiveness in restoration projects is an issue common throughout the world. Plant losses or failure during establishment can be costly, not only in the physical plant material cost, but also loss in terms of balance of survived species within a project. Initial planning choices may have direct bearing on the short, medium and long-term health of a project. Examples of larger scale projects with large budgets requiring validation of money spent include: restoring rivers in the United States, (Bergstrom and Loomis, 2017), marine coastal systems in Australia, (Bayraktarov et al. 2016), environmentally sensitive areas in Scotland, (Hanley et al. 2008), and dryland forest restoration in Latin America, (Birch et al. 2010). Cost effectiveness may also include intrinsic values, such as economic services and the economic values that can be derived from ecological restoration projects (Barbier et al. 2011, and De Groot et al. 2013). In decision making, the costs of restoration projects may be difficult to predict because of the many variables involved, (Bayraktarov et al. 2016). While Bayraktarov et al. (2016) were focussing on marine coastal ecosystems, their conclusions remain relevant in wider fields: that success or outcomes in restoration work are linked not only to the ecosystem, but also to site selection and techniques applied rather than on money spent.

In New Zealand, Cullen et al. (2005) noted that, when economic tools were not applied to conservation decision making, errors may result in project selection, and a non-optimum use of scarce resources. Although that paper was aimed at evaluating larger projects such as New Zealand mainland habitat islands, offshore islands and river recoveries, targeting both fauna and flora, the underlying principles are the same. Evaluating cost effectiveness and intrinsic values of a project, as well as optimum use of available resources, could assist decision makers to reap a fuller potential within projects.

Evaluating site history:

The importance of understanding the site history is to improve the cost effectiveness of the project. Mathews et al. (2017) highlighted the importance of studying antecedent site conditions for more successful project outcomes, and stated that landscape context and site history, including antecedent site conditions, may constrain restoration potential despite the efforts of restoration practitioners. Brudvig and Holl (2011) acknowledge that relatively little attention has been paid to how landscape or historical factors interplay with restoration, and look to a future where more attention is focussed on a wider space and time continuum in restoration ecology. Even though comments by Lachlan et al. (2018) refer more to seedling establishment in the forestry industry, the underlying process and reasoning is the same. In that paper Lachlan et al. (2018) refer to Martinez-Garza et al. (2013), who also indicate that the performance in later years of restoration planting is affected by the seedling establishment in the early stages, and this in turn can affect the overall plan of the revegetation project. (In practical terms in New Zealand this could mean where seedlings fail there are gaps, or an imbalance of native plant species reproduced). Martinez-Garza et al. (2013) were investigating beneficial traits in seedlings which may then be useful in future planning and plant choices to enhance overall performances of restoration plantings.

Funding and Performance accountability

With limited financial resources, a plan for a target performance and accountability is generally a requirement before funding allocation. A number of restoration projects are undertaken in New Zealand each year with Government or community funding. For example, during 2017, $4,221,127 was given to successful projects throughout the country in the DOC Community Fund 2017/18 funding round. (Department of Conservation, (DOC), 2018-3). For each of these applications, a plan would have been produced, which would have acknowledged potential risks, and clearly stated the goals and benefits to the targeted eco-system. Research would have included: observations of local fauna and flora, characteristics of existing local projects, and legislation relevant to the area. Planning would have included; targets for the introduction of beneficial species enhancing local biodiversity long-term, and planning for optimum practical applications during planting. Typically in New Zealand, management plans for projects must be included with the application forms prior to funding being allocated. This type of accountability on paper can serve to clarify the goals and aims for a project, and lay out desired strategies in an attempt to achieve optimum results to match the allocated funds. Environment Canterbury Immediate Steps Program, ECAN (2017) allocate funds of over a million dollars annually for protection and restoration of biodiversity on private and public land, and give practical encouragement for projects to reach their on-paper performance targets.

Enthusiasm and stakeholder investment

Engendering enthusiasm in project stakeholders has on-going economic benefits. Revegetation projects are an investment, often costing thousands of dollars, so that when Stakeholders take “ownership” of their projects, they are financially motivated to see success in plant survival, rather than failure. Burbidge et al. (2011) suggested that through research and management followed by interaction with key stakeholders, communication, and collaboration, then the research would be translated into better practice on the ground. Wyburn et al. (2012) also proposed that social and contextual influences shaped restoration practices and highlighted the importance of dialogue between researchers, practitioners and landholders around the goals and expectations of restoration and management interventions.

Locally, especially where funding is a challenge, community environmental groups form to undertake local projects, partnerships between community and government departments plan together and the idea of “citizen science” is promoted though education outlets such as school and internet, Landcare Trust (2018), Te Ara Kākāriki (2017). Examples of citizen science and community involvement are where school children and local people who participate in on-line data recording such as for iNaturalist (2018-3) and undertake bird, local fauna and flora surveys. Landcare Trust NZ has a mission statement: ‘Sustainable land management through community involvement', (Landcare Trust 2018) and since 1996 have been working with many community groups and landowners on enhancing biodiversity related projects to improve landscapes and waterways within New Zealand. The citizen science involves degrees of monitoring by local people to measure the success of outcomes of projects. The launch of a citizen science inventory is another guide in this field (Naturespace 2017). Nature Space is a website for groups, individuals and landowners undertaking ecological restoration in New Zealand. A Lincoln University unpublished internal report (Greer, Bowie and Doscher 2017) proposed collating restoration projects nationwide and particularly locally in the Selwyn area, by means of mapping, and that by sharing knowledge of biodiversity corridors, plants used in projects this had the potential to lead to more beneficial conservation outcomes, such as creating wildlife or ecology corridors. Dobson et al. (2006) further explain the benefits of ecological corridors, and practical guidelines for connectivity, with not only benefits for the ecosystems, but the human element of benefits for people and communities.

Recording outcomes including failures

Recording outcomes is one of many tools which can assist planners to better mitigate or remove likely threats or risks to potential restoration projects, and to better increase cost-effectiveness of future projects. Bayraktarov et al. (2016) pointed out that success rates reported in the scientific literature could be biased towards publishing successes rather than failures, and that looking at failures, or reasons for failures was an area of investigation not often published. Bayraktarov et al. (2016) refer to Hobbs (2009) and Knight (2009) who indicated that causes of restoration failure could mainly be linked to inadequate site selection, unpredictable events (such as unexpected floods), or human disturbance. Knight (2009) encourages contributions to journal articles that document failures, so that these can be an opportunity to learn from a wider forum of experience. Redford and Taber (2000) also call for conservation professionals to document failures to promote a “safe-fail” learning culture in conservation. Linking these ideas of that both successes and failures are part of the restoration process, then in the planning stage, when both of these ideas are taken into consideration, planners can suggest longer-term targets for the establishment of plant species. Conditions for favourable growth of planted material and naturally emerging species can be created, and allowance made for maximum long-term biodiversity benefits to the targeted site or eco-system.

Clarifying success and failure

Zedler (2009) raises a whole new area of appraisal category by noting that there is a vast difference between being successful and being effective, and that with reference to “success”, a value judgement, that clarity of definition is the key. “Successes” could more accurately be replaced with more specific terms, (for example, project completion, achieving dense plant cover, supporting high species richness, or colonization by target species). Similarly with “failures” to be specific what the failure is or how it occurred. A “failure” may have resulted from a threat, or risk, and the outcome of the failure could be for example, physical plant losses, uneven vegetation coverage, or an imbalance in the desired plant species and diversity. Threats and risks can be can be reduced or removed for optimum performance at the planning stage.

In many countries around the world, State administrative bodies produce guidelines for restoration projects to manage risks and hazards in the planning stage. For example, in Australia, the Department of Environment and Natural Resources (2018) and in the USA, the National Service Center for Environmental Publications (NSCEP) (1997). Then once the potential risks and threats have been covered in the planning stage, this may only leave “failures” such as incomplete information during planning, an unexpected environmental threat not provided for, or plants not reaching an unexplained health and progress target after a specified time.

1.4.3 Linkage of Planning, Outcomes and Benefits

Benefits linked to outcomes

Planning of outcomes and benefits are linked in a number of different ways. Benefits are generally linked to outcomes. If the outcome or results are favourable, then benefit is likely to have occurred. Stanturf et al. (2001) when considering hardwood bottomland forests, proposed that the focus for ecological restoration should be to restore functions, and that one criterion for success should be the establishment of forested conditions, i.e., canopy closure. The outcome here was that the function of the canopy closure of the forest was reached. The planning in this instance would have focused on canopy closure as the desired result, and the benefit was that a full coverage of an economic unit of forestry was reached. Peh et al. (2014) when looking at the benefits and costs of ecological restoration and the changing eco-systems in the world today, concluded that there were gains to society as a whole from land-use conversion, (the outcome), and that farmers, villagers, townspeople and global communities had benefitted from ecological restoration changes.

A recent study in New Zealand, Daigneault et al. (2017), indicated that when planting riparian strips, the benefits to climate and freshwater are significantly greater than the implementation costs of riparian restoration. To plan a revegetation project around a riparian strip that will in some way cleanse the waterways it is adjacent to, is a desired outcome. The successful outcome of the project may be that the plants have grown well, with good root structure, and when soil samples are taken it is observed that there has been much improvement in the health of the soil, and when water samples are taken downstream, the water shows greater health as well. Consequently, the benefits reach the wider community downstream of the original riparian planting.

Community education benefits, raised conservation awareness outcomes

Community education is a beneficial tool in conservation. Bennet et al. (2016) considered that a better understanding of human or social dimensions of environmental issues improves conservation. There is a wealth of revegetation projects occurring in Canterbury and many media invitations to the Canterbury population to engage in enjoyment of conservation areas, or hands-on support with "planting days". (Christchurch City Council, 2018). The Christchurch City Council (2008), highlighted the importance and variety of remnant habitats around Christchurch: significant systems and habitats that support indigenous biodiversity in Christchurch are the Kahikatea forest at Putaringamotu/Riccarton Bush; freshwater estuaries and wetlands in the north and west; silver tussock landscapes and remnant forests on the Port Hills; riverbed communities of the Waimakariri River; dunelands and dune slacks along the coast; and regenerating indigenous wetland communities under the willows in the north. Local Canterbury revegetation projects or Trusts which also demonstrate the range of the habitat diversity include: Te Ara Kākāriki, the Christchurch Perimeter Walkway, Travis Wetland Natural Heritage Park, and Ellesmere Wetland Trust. On the Port Hills there are two projects underway encouraging the resurgence of both Kererū and Tui bird numbers, with community enthusiasts participating in summer Kererū bird counts, iNaturalist (2013).

Planning to include local history, outcome based on variables

Research into local history for site relevance or plant species suitability is likely to produce many variables for a proposed project site. The size of projects differ greatly, the habitats even just around Christchurch, rivers, wetland, dunes, streamsides, remnant bush, differ greatly. The site conditions are variable: bare open ground, under willows, alongside remnant bush. The plant species suitability for the proposed area may be extensive or otherwise, the length of time a project is going to be maintained, the particular goals of each project, and the funding, how much is there to spend, and for how long. All of these considerations ultimately have to be answered, and based on the determination of each section, the outcome will be accordingly. The desired outcome may be, that by engaging in the research planning, there will be a higher expectation of plant survival rates during establishment.

The benefits of research into local plant species available for the project plant list are important. By choosing plant species that grow naturally, or are considered endemic to the area, the likelihood that they will thrive is higher. There are many helpful publications to support a choice. For example, the Department of Conservation, Motukarara Conservation Nursery, publishes plant lists for regional areas in Canterbury such as the Port Hills, DOC. 2015). iNaturalist (2015), the public forum of locally observed flora and fauna is a helpful tool in finding out from other people's observations what plant species are already present in a proposed restoration site locality. On the other hand, too much plant material from the same close source could result in a lack of genetic diversity, and limit adaption to climate change, Breed et al. (2012), Johnson et al. (2010). However on a practical level, observing which local species are flourishing and those that are not, is important information, and assists in making a plant list based on the likelihood of flourishing plants. Local species present in remnants add to the overall picture. Threlfall and Kendall (2018) highlight the benefits of better understanding the complimentary roles that urban greenspaces and remnants play in the complexity of urban eco-systems which benefit both people and nature.

A comprehensive plant list to maximise diversity in the chosen project can reap benefits in the long-term, but a challenge may arise in finding all the plant species on the chosen plant list, which may be unavailable in local nurseries. This may be because of the rarity of the material, the species is uneconomic to grow in a nursery situation, is currently unfashionable in the nursery industry, or so popular in agricultural (e.g. riparian margins on dairy farms) industry planting there are none left in the nursery. Because a plant is unavailable, this does not necessarily mean that it would fail if it were to be included in the project. It means for example, in the experience of the present author from plant sourcing for restoration projects, that if *Pseudopanax arboreus* (five finger) a plant commonly found in the local habitat, is not readily available to buy, it should not be discounted in the plant list choice, because if it were to be included, the likelihood of its successful growth is very high. (ECAN. 2017-1)

Planning linked to outcomes: three examples

Unique site conditions can create an opportunity for a particular species to flourish, especially if the species is considered regionally rare, or a nationally threatened species, (Head et al. 2001), or in some way difficult to grow. Planners can then use these observations for practical application in future restoration or revegetation projects.

Example One: In a study of pollen in three New Zealand native saprophytic orchids, *Gastrodia cunninghamii, Gastrodia minor,* and *Gastrodia* "long column", MacDonald et al. (2015), observed that *Gastrodia cunninghamii* and *Gastrodia minor* were autonomous self-pollinating species. In contrast, *Gastrodia* "long column" had almost no fruit set when pollinators were excluded, and was visited by the endemic New Zealand bee *Lasioglossum sordidum*, which acted as a pollen vector in order to produce fruit. Visitation rate by *Lasioglossum sordidum* varied among four sites around Christchurch, and natural fruit set in *Gastrodia* "long column" ranged from 76% where *Lasioglossum sordidum* were abundant to 10% where bees were not observed." *Gastrodia* "long column" plants were observed at an Ohoka site in summer 2013, where in previous years this species thrived. The following summer, 2014, there were no visible plants, giving rise to the supposition there may have been no native bees present. As *Lasioglossum sordidum* is a regular visitor to plants such as the *Hoheria angustifolia*, and all nearby *Hoheria polpunea*, a North Island species invasive in the swamp which had been recently removed, the future management plan was to plant more *Hoheria angustifolia* in the hope that the *Gastrodia* "long column" would once again thrive.

Example Two. In a willow dominated wetland site near Tai Tapu, Stella (2007), observed that *Dacrycarpus dacrydioides* (kahikatea) regenerated naturally under willow on root islands or raised mounds within wetlands. As *Dacrycarpus dacrydioides* was once present in the Canterbury forests, it is an important plant choice for many revegetation projects. *Dacrycarpus dacrydioides* is a slow growing plant and not cheap to replace, and the example of natural regeneration locally, can influence the site conditions and plant placement for a greater chance of survival and success in future projects.

Example Three. The third example of a more practical nature, learning from one project to benefit future plant choices in another is the case for *Astelia grandis*. A 500 strong plant community of *Astelia grandis* was discovered in Ohoka in 2010, (ECAN 2017-1) with both male and female plants. In an adjoining property there were two single female plants. With the benefit of an Environment Canterbury Biodiversity Grant, several plants of *Astelia grandis* were divided and translocated to the adjacent property. By 2015 over 100 mixed male and female *Astelia grandis* were flourishing in additional nearby locations. In the summer season of 2016 and 2017 over thirty natural seedlings of *Astelia grandis* emerged. (ECAN 2017-1). In 2014 both Motukarara and Waiora nurseries collected and propagated seed from the original plant community and produced plants for Canterbury wetland revegetation projects such as for the Travis Wetland Natural Heritage Park, and other private or public projects for which the growing conditions were suitable. Based on the outcome of *Astelia grandis* being seen to be successfully reintroduced into Canterbury wetland areas over the last few years, planners can now have the benefit of augmenting proposed planting lists with this species. (Note: Thirty five of the seedlings which were propagated at Motukarara Nursery from the Ohoka *Astelia grandis* seeds, form part of the study species for this thesis).

1.4.4 Planning to avoid pitfalls.

Planning to avoid pitfalls is better than fixing issues later. Picket and Parker (1994) noted that one pitfall to take into account is that ecological systems are continually being changed by the impact of humans, and that humans are forever introducing new processes or interactions into these systems. They suggest that scientists monitor their data and adjust accordingly to move with the changes. They further propose that in restoration the goal is to provide a working ecological system, and that the system is not likely to be static, but changing. Consequently, on a practical level, when planning for healthy plants, and progress, a planner might take into account optimum human controlled conditions to allow for i) the best plant choice, ii) site and plant placement, iii) techniques for planting, iv) aftercare, and education, and non-human conditions such as v) wild animal interference or vi) environmental stress.

1.4.5 Practical considerations.

In choosing the optimum plant species for a project, certain types of conditions or species could be selected. In the forestry sector, Grossnickel & MacDonald (2012) state that successful forest restoration requires planting quality seedlings with optimal growth potential, which is as true for choosing plant seedling material for afforestation projects as it is for any kind of revegetation or restoration project.

The Department of Conservation publishes useful practical guides DOC, (2018-1), (2018-4) for help with selecting relevant species for the site and then choosing quality seedling material for the planting. A quality seedling with optimum growth potential includes plant species that are: not susceptible to frost, do not require shelter from high winds, are robust in open spaces, can be commonly found emerging in understorey if they belong in that environment, and may be available for a second- stage planting at a later date, (e.g. that could be planted after year three of a project rather than in the initial stages), plants that belong in the local landscape naturally, (e.g. North Island *Sophora tetraptera* , not introduced into a South Island location when the South Island *Sophora microphylla* would be far more appropriate), and plants that have been locally sourced, and have not been grown or sourced from a warmer northern location.

The selection of the plant itself is important: not appearing sickly, root bound, should have a sturdy stem, not having a double leader unless the plant is supposed to be of a bushy nature, not old stock, bent, "lollipop" style, not spindly, or weak, and trimmed if required to promote growth. An example of failure are the lollipop shaped *Veronica* species often seen laying down horizontally on motorway planting, having succumbed to high winds. Tables on nursery plant grades and their characteristics (Davis & Meurk 2001), give advantages and disadvantages of container size which is also a point to consider when selecting plant material. The volume of the growing container is often linked to cost, the size of plant required at purchase, and the proposed spacing on site, Washington State University (2018). This is also true in New Zealand, where the funding allocation may be a factor in the chosen size of seedling container at purchase, which may not be the optimum choice for the given site conditions.

Sometimes an aim of a project is to introduce flora that once may have flourished in an area but is currently no longer in evidence. In the case of threatened species, or rare material there is the risk of poor survivorship, which impacts on the actual numbers of each plant species chosen for the project. In cases like this a reduced number of plants could be added, but with the financial risk of failure understood by the stakeholders. Genetic diversity is another practical consideration in the plant selection process. Recently, Wright et al. (2017) suggested that if areas had only a few remnants or samples of genetic material, with respect to *Pittosporum obcordatum*, there could be unfavourable long-term reductions in genetic diversity, because of inbreeding and genetic drift. *Pittosporum obcordatum*, was found in only small sample areas or remnant plantings on Bank's Peninsula, and the current conservation status for *Pittosporum obcordatum* in New Zealand is: Threatened, Nationally Vulnerable, (NZPCN 2012). Long-term reductions in genetic diversity could also be the case for other species derived from small samples or a restricted genetic range. (Note: *Pittosporum obcordatum* is also included in this thesis study. Seeds were collected from Bank's Peninsula plant material and propagated at the Motukarara Nursery Canterbury. These seedlings are now being included in new revegetation projects around Canterbury.)

1.4.6 Clarity of Goal

A long-term specific goal is important. Being specific about choosing plant numbers, plant spacing and plant placement has long-term ramifications, directly linked to the goal. For example, if there is no maintenance budget, a quick covering or shading of the ground may be required in order to supress weeds, and consequently fast-growing robust species may be chosen and planted at closer spacing distances.

Zedler (2009) encourages clarity and specification around tasks leading to desired outcomes. With more meticulous identification of tasks leading to the desired goals of the projects, the easier it will become to more accurately state what level and type of "success" or "failure". Zedler (2009) stated that failure was not all bad, but had the benefit of improving learning, enhancing innovation, and creating a better sharing of knowledge platform amongst conservation practitioners, professionals, participants and stakeholders. He further notes that through the better understanding of failures this would promote more adaptive management and ultimately greater effectiveness in conservation. (One example of an adaptive plan change could be that the overall project size may be reduced in order to fit a successful plan and budget, rather than have a larger project with plant failures.) Ehrenfield (2000) suggests that it is important to understand the limitations within a project, set goals accordingly, and be realistic about the outcomes the restoration ecology can accomplish within the given setting.

Since Zedler (2009) prompted greater clarity and specification when referring to success or failure, attention could be paid to detail so that a "quality" plant can be minutely specified. Grossnickle & MacDonald (2012) refer to planting "quality" seedlings. Not only could the qualities of proposed plant material be specified, but also the range of plant numbers of each species in the overall mix, more precise plant spacing instructions, and the placement of each species within a project.

Examples of specifications for quality placement may include the placement of plants that: are not overcrowded, are not too open-spaced or isolated, prefer being planted in groups, prefer a wet or dry environment, prefer a rich or stony environment, require shelter from prevailing winds, or prefer shade or light conditions. Davis & Meurk (2001) give guidance and practical recommendations on these points for both protection and restoration work, particularly in selection, planning and after-care management. Other external factors that may influence plant layout specifications could include placement which: allow for neighbour's views, allow community safety, allow safety and access during maintenance, or allow for sunny or shady cultural aspects during the initial growth period of the selected plants.

Successful outcomes for reintroduction

In paying attention to detail, Godefroid et al. (2011) highlighted the importance of the reintroduction of native species to conservation globally, and analysed data of 249 plant species reintroductions worldwide. They identified a number of issues contributing to the successful outcomes of reintroduction. Two of the contributing issues they identified were: lack of understanding of the underlying reasons for decline in existing plant populations, and poorly defined success criteria for reintroduction projects. By quantifying the criteria for accurate plant placement and understanding the specific cultural requirements of each species to be planted, a reduction in the risk of failure might be achieved. For example, in the author's own experience from observing *Podocarpus totara* (tōtara), and *Cordyline australis* (tī kōuka), these two species do not grow side by side in the wild. Project placements may be set at on average one plant per 1.0m, or one plant per 1.5m. When larger growing trees are chosen these will need to be spaced at practical intervals. Planting five *Podocarpus totara* saplings within a space of five square meters is not practical, and allows no room for the trees to grow long-term. Planting *Podocarpus totara* under groves of *Cordyline australis* is also not practical, as the *Cordyline australis* creates a dry condition on the ground which results in *Podocarpus totara* failure, although *Podocarpus totara* is associated with similar soil types. (Simpson 2000). Simpson (2000) also notes that *Cordyline australis* occurs in a wide range of plant communities, and that in certain fertile alluvial soils, *Dacrycarpus dacrydioides* (Kahikatea) seedlings can be seen surrounded by a band of *Cordyline australis*. For successful reintroduction of plants into the landscape it is important to consider the details of plant placement.

There are many variables contributing to the two points made by Godefroid et al. (2011), understanding decline or failure, and poorly defined success criteria for reintroduction projects. There are many variables for success criteria, and in the changing world, goals also are adapted to keep up with progress or change, (Picket & Parker 1994), but a few examples of variable criteria could include: strategies for natural pollination, seed dispersal, spatial placement, and plant community designs, all of which relate back to clarity of goal.

1.4.7 Protection

Putting in place protection measures is very much part of the planning process and many studies have been undertaken to understand which protection works well in different environments. In a pilot study by Alexander et al. (2016), undertaken in South Texas and northeastern Mexico in notably arid conditions, the growth and survival response of thornscrub seedlings were evaluated after various pre-planting treatments. The study aimed to look at ways to alleviate expected stressors that included invasive grass cover and herbivore browsing. Those seedlings protected by tubes had higher survival rates and were effective against browsing animals in the early stages. Tuley (1985) also found that, in both their own and other studies, shelter tubes tended to modify the microclimate by reducing air temperature, shading the soil, increasing humidity, and funnelling dew to a narrow region around the seedling stem, thereby minimizing water stress in semi-arid regions and increasing seedling survival. (Bellot et al., 2002; Del Campo et al., 2006; Jiménez et al., 2005)." Other findings by Alexander were: seedlings were tallest in plots with pre-planting fire, no herbicide application, and shelter tubes. Experiments looking at the effectiveness of protective shelters have been conducted around the world, including research by Puértolas et (2010) who studied whether the positive effects of tube shelters was due to enhanced growth during the wet season or to reduced light stress during the dry season. In the spirit of detailed planning reaping benefits, the lesson learnt from Puértolas et al. (2010) was that in the future, tube designers should consider the light tolerance of the species to be protected, using lighter tubes for shade intolerant species.

The costs of protection measures initially may be high, but when considered over the length of the targeted project run, the protection measures may allow many seedlings to flourish and achieve target goals such as desired canopy cover, biodiversity mix within an area, a pleasing aesthetic result, or an effective system for cleaner waterways, and be cost effective in the long run. Protective plant growing tubes are one such protection measure.

In some New Zealand revegetation or restoration projects, a protective tubes with or without a wool mat base, such as Combiguards or Tri-guards, (Advance Landscape Systems, 2018), are often used: not only to create a mini microclimate shelter, and be a visible beacon for maintenance workers, but also effective as a deterrents to small browsing animals such as rabbits or birds such as pukeko (NZ swamp hen). (Advance landscape systems, 2018). In a study which included protection of *Kunzea serotina* with combiguards, Dollery (2017), found, there was higher mortality for those plants without tree guards and damage by herbivore was lower where the plants had been protected.

1.4.8 Versatility

In targeting the desired outcome (the goal) for the restoration or revegetation project, it could be that taking notice of innovation and versatility also plays a part in the planning stage. Picket and Parker (1994) advocated that ecological systems are in a state of continual evolution, and change can occur particularly from human intervention and impacts. It would make sense then that our ideas should be updated at times, and we can learn from both our own and other projects, Knight et al. (2009) or Matzek et al. (2017) who ask the question “Given that we have defined our goals, can we find better ways to reach them?”

In the New Zealand dairy industry, particularly in North Canterbury, rapid growth has resulted in huge numbers of native plants being introduced into the local landscapes in the form of property border and riparian planting. (DairyNZ, 2018). Studies have been undertaken to evaluate nutrient uptake by native and exotic species to see if there are any benefits that can be measured, (Hahner et al. 2014). In the planning process of a revegetation project, these ideas can be used to promote the inclusion of certain species in the hope that some benefit to the underlying aquifers may be ultimately derived by this choice.

Another versatile use of plants is, considering the planting of deep-rooted plant species to assist in flood prone bank stabilisation, such as *Coriaria aborea*, (tutu),(Marden et al. 2005) and *Fuchsia excorticata,* planted alongside commonly available species such as *Phormium tenax* and *Cordyline australis*, Czernin & Philips, (2005). *Coriaria aborea* is considered a weed by many especially as it may affect the health of stock, and contamination of honey (Marden et al. 2005) but this species could still be potentially used in selected areas, to assist with stabilisation and later removed.

Again by exploring research in the wider community, our plant choices may be swayed by potential benefits in the riparian zone. When choosing plants for sites in water catchments that may feed into known pollution challenges such as Lake Forsyth and Lake Ellesmere in Canterbury, we may consider the ‘Hyporheic Zone’, (Hester and Gooseff, (2010), the area directly below a river bed or water body where water exchanges carrying nutrients, heat and organisms may affect the whole water ecosystem and this “zone” should not be overlooked in the wider planning process. The benefits that plants can give to the hyporheic zone in riparian planting, may not have yet been proved, but we can open our minds to the understanding of hyporheic zones and begin to choose some plant species that may have future benefit, such as those that have much deeper tap roots, or can serve to stabilise other species.

1.4.9 Planning towards desired outcomes.

This literature review has provided evidence that the planning process at the beginning is the most important undertaking in order to have satisfactory plant survival rates and good forward progress in a revegetation planting project.

The success at a restoration project may be measured in many ways, (Zedler, 2009), (Smith et al. 2015), with a multitude of specified or targeted outcomes: aiming for high plant survival rates, the increased biodiversity in the site, or district, canopy closure, the spontaneous emergence of natural seedlings, a greater community awareness, enthusiasm and level of education, the potential of beneficial growth by embracing new ideas, and resulting from having a broad view in the initial planning process. Careful consideration in the initial planning stages is the key to success and the best strategy towards planning for successful outcomes in revegetation and restoration projects.

Chapter 2
Desk Study, Research and Methodology

2.1 General Background

Background historical research provided preparation for the field studies in this project. This included research into archival oral history and written historic accounts of birds, place names, and location descriptions relating to the surrounding district. The specific location for the research plots and the final chosen plants were determined from this pre-study.

This research project was part of a Vision Mātauranga program, and as such carried with it an expectation of identifying knowledge and sharing it in such a way as it would generate future benefit to Ngāi Tahu and the Wairewa tangata whenua (local people) at Little River. The first chapter covers the concept of "takiwā', people and place, the determination of the specific location, the specific plants chosen for the study, planning strategies, careful site management and specialised plant husbandry.

In an effort to ensure as high a plant survival rate as possible, a number of technicalities were addressed: i) plant choice, ii) site choice, iii) plant placement, iv) planting techniques, and v) risks from natural hazards. Having clarity on goals, aims and benefits of a project, having a long-term plan that acknowledges biodiversity progress not only within a specific site but also as a contribution to a wider region, the achievement of higher species diversity is likely to be increased. Therefore, each of these points had relevance in the preparatory research with respect to choices made in this research study.

2.1.1 Connections: "Takiwā" - People and Place

Throughout this project it has been important to understand the concept of "takiwā' and the significant connections between people and place. By reading early accounts of habitation in this area (Beattie & Tikao 1939) and reading oral accounts of the early discovery of Te Roto o Wairewa / Lake Forsyth, we have insight into what plants were here once, and how the early people impacted on the environment. Today, Te Roto o Wairewa/ Lake Forsyth is considered one of the more polluted lakes in NZ with regular toxic algae bloom warnings issued, ECAN. (2017-2). Iwi, Government and Canterbury Administrative bodies are working to change the management of the catchment towards a cleaner future (ECAN. 2016). The local community in particular wish to work together to make a difference in improving the health of the streams and lake. Questions that arise are: if we do something today, can we re-introduce the plant material that was once here, make traditional places special again, improve the health of the lake, and can we have a sustainable environment physically, socially and spiritually? "Kaitiakitanga" is the value that purports that through action as a custodian and caretaker of the land or water bodies, and with forward planning, can we improve and leave such places in a better condition for a future generation?

Therefore, bearing both the concept of "takiwā" (place) in mind, and "kaitiaki" (the custodial people) we set the background for this study. By going beyond common practice in revegetation projects, we are pushing the boundaries in this second stage restoration by using a wider range of plant species. We acknowledge the benefits of both Māori medicinal (Rongoā), and cultural species and plant species that may be currently threatened, in decline, or not commonly available for revegetation projects. The future expectation is that the biodiversity mix in the area will be increased, that more revegetation projects will follow around the stream edges and lake edges and any other catchment area within the Lake Forsyth catchment, and that the Wairewa Rūnanga and local community will be encouraged by an example of an informative research experiment.

2.2 Historical Relevance

2.2.1 Historical References: Location

The significance of choosing one site for the study, and the choice of plants used in the study, has significant impact on future planting and projects planned within the Wairewa Rūnanga *areas of custodianship.* Therefore, it was important to delve deeper into the local historical background with respect to location.

The Wairewa Marae is situated in the Ōkana valley at the head of Te Roto o Wairewa /Lake Forsyth. The whare tūpuna (the ancestral meeting house) is named Te Makō and the wharekai (dining hall) is Te Rōpūake. The story of how Makō and his descendants came to settle in the areas around Te Roto o Wairewa/ Lake Forsyth is recounted on the Wairewa Rūnanga website, (Wairewa Rūnanga Inc. Soc., 2018.) Many generations ago, "At a hui south of Kaikōura, descriptions of the land southward and the resources it held were reported; in his turn, Makō claimed Southern Horomaka (Bank's Peninsula) as his new home. Eventually, Makō and his people went to Horomaka and settled Waikākahi the enormous Ngāti Mamoe pā between Te Roto o Wairewa and Te Waihora. Later, he built his pā named Otawiri at the head of the lake and settled peacefully. Ngāti Makō had lived in abundance and flourished for seven generations at Wairewa (Little River). Their relations, Ngāti Irakehu of Wainui were also prosperous and ūpoko ariki Te Maiharanui would build a pā for the purpose of trade across the harbour from Wainui, at Takapuneke."

Early European maps (Christchurch City Library Heritage Maps, 1894, Anderson 1927) indicated a number of settlements around the Birdling's Flat, Te Roto o Wairewa/ Lake Forsyth and Little River areas, as well as at other nearby locations on Bank's Peninsula. Early place name records are very variable. One place name "Oashore" has been loosely named in 29 various ways over time with different spellings, oral and dialect nuances. A local river at the head of the lake is currently known by the name "Takiritawai", but in the 1894 heritage map it shows as "Kakerikawai". Throughout this research a number of naming anomalies were found. However, whatever the spelling style, it is apparent that in 1894 there is naming of seven older Pā at the outlet end of the lake being: Otungakau, Te Mata Hāpuka, Te Marokura, Ōruaka pā, Poutaiki, and Te Puia, as well as current at that time, the celebrated Waikākahi Pā. All water bodies had separate names, each branch of stream even if short had a specific name and description. The point of noticing the wealth of habitation, dwellings, pā, urupa, springs, streams and look out points is to relate this to likely vegetation. Waihora/ Lake Ellesmere was known as Te Kete o Rakaihautū, (the food basket of Rakaihautū) and the wider area of Horomaka (Bank's Peninsula), which included Te Roto o Wairewa/ Lake Forsyth and Waihora, were traditionally referred to as Te Pātaka o Rakaihautū, (the great food storage house of Rakaihautū), (Ngai Tahu 2018), as this area was notably abundant with many kinds of food (kai), which lead to great food exchanges among the peoples of Banks Peninsula of their particular local food, (Beattie & Tikao 1939). Special feasts, (kaihaukai), and staged food displays, (whata or tirewa), were erected on frames or platforms, (kaho). There are a number of accounts mentioning a great abundance of food exchanges taking place on the pass between Little River and Port Levy. (Cowan 1923, and Taylor 1952), mention shark from Koukourararta (Port Levy) being bartered for eel from Wairewa (Little River), and Meredith (2018) refers to "tons" of food being carried each way., in keeping with the huge quantities of food that were prepared for exchanges or formal feasts. The population required to catch, preserve, store, display and move this must have been of some size. These fragments of the past add up to a huge fibre trail, and plant resource even up to 200 years ago. Once there must have been huge tracts of fibre bearing plants such as *Cordyline australis* (tī kōuka), and *Phormium tenax* (harakeke). *Astelia grandis*, is mentioned by Armstrong (1879) as being present on the Canterbury plains, as a "dense growth along with *Phormium tenax"* as well as "numerous species of *Cyperaceæ*, and *Junceæ*." This collection of fibre-useful plants would have supported the everyday requirements of the population: clothes, dwellings, fishing lines, storage, and so on, as well as the hardwood and softwood plants all of which were required for many medicinal and cultural uses. For example, the ropes used for the rafters of any building were made of *Cordyline australis* (Makarete Papakura 1939) as this was considered the strongest rope fibre. There are many accounts of the flax and timber trades in and around the lakes and the Little River valleys. The flax and timber trading, along with fires and European habitation ultimately resulted in decimation of these resources. Therefore, looking back at early accounts of food resources and cultural uses of floral resources I conclude that not only were the valleys around Little River and Lake Forsyth known for its birds and fish, but also for its forest and wetland, and that any restoration project should take this into account and seek to restore forest and wetland plants and fibre producing plants.

2.2.2 Historical References: Plants

The historical research in respect to plants is often linked to historical site research, particularly with place names originating from oral locality descriptions of local plant and bird life. Within our area of study interest, there is not only public and private land, but also rivers, waterways, lake edges and sea. There are also a number of reserves which also may have gone by several names or just number references. The significance of attempting to identify such reserves was to try and locate any past records of threatened or uncommon plant species in them. I was unsuccessful in this attempt, and consequently drove on all possible roadways within the Little River catchment area to identify and photograph plant material. However late in 2017 the online, digital Ngāi Tahu Atlas was launched, Kā Huru Manu, (Ngāi Tahu Cultural Mapping Project 2017) which uses the latest Geographical Information System (GIS) technology to record and map Ngāi Tahu stories and place names onto a virtual landscape for future generations. In this digital Cultural Mapping Project, Māori place names have been referenced from whānau manuscripts, published books, 19th century maps, newspaper articles, and a vast array of unpublished material. The atlas also includes information about Ara Tawhito (traditional travel routes), Native Reserves and other original Māori land allocations.

Many Māori place names have a botanical reference, and are a clue to plant species that grew abundantly in those places. Anderson (1927) refers to a number of local and Banks Peninsula place names with a plant background as was understood at that time., and the following is a selection. Te Kaio, (Ngāi Tahu dialect for Ngāio), now Tumbledown Bay after the *Myoporum laetum* which grew there, Te Kai-waitau, from the food of a young *Cordyline australis*, Kawa-kawa, *Piper excelsum,* later called O-tama-hua and then Quail Island, Motu-kauati-iti, acknowledging the firemaking trees, Kaikōmako, *Pennantia corymbosa* in that location, O-te rako, or Palm tree gully, which according to Cowan was named for the density of palms and shrubs. Anderson quotes Canon Stack, 1894, who refers to the name Peraki, being originally “Pireka’ a shortened form of pipi-reka which referred to a fragrant or sweet rooted fern which grew abundantly there. The place name Pireka is found on early maps. (Anderson 1927, p 152), and is present in the Ngāi Tahu Cultural map. Lastly, Titoki Bay after the tree *Alectryon excelsus.* There are many more, with references to local plants such as for māhoe, (Ngāi Tahu name hinahina) *Melicytus ramiflorus*, Rōhutu, *Myrtus obcordata*, tauhinu, *Ozothamnus leptophyllus* and korokio, *Corokia cotoneaster*. All these plants were once present in the local landscape.

There is an oral tradition pertaining to Te Roto o Wairewa/ Lake Forsyth which refers to four bird species and one fish: weka, kākā, kererū, pūtakitaki and tuna. These lines are often quoted in formal evidence hearings on mahinga (mahika) kai and custodial matters. (*Mahika kai* refers to Ngāi Tahu interests in traditional food and other natural resources and the places where those resources are obtained) From evidence hearings given by Cranwell (2014), and oral history recounted to Anderson, (Anderson 1927) there is a particular reference given to the traditional first observation at Te Roto o Wairewa. Cranwell states: "The two escapes were outlining the mahika kai they had seen on the way back. When it came to Wairewa, Makō asked the pair what food is available there. They replied, "There are many kinds‟ weka (a ground bird), kākā (native parrots), kererū (native pigeons), pūtakitaki (paradise shelduck) and tuna (eels)". When Makō heard this he said, "Ki uta he uruka mō tōku ūpoko, Ki tai he tūraka mō ōku waewae". Inland a pillow for my head and on the shores a rest for my feet. This was a direct reference to the abundance of kai (food) in the forests, lake and sea and by stating this Makō effectively placed a tapatapa (claim) on the takiwā for himself, his family and their descendants."

The weka was a ground bird and would have lived between the lake and in the forests enjoying the dense cover. The kākā (native parrot) was a forest dweller, obtaining all its food such as berries, nectar, sap and foliage from the trees as well as insects in the fallen logs. The kererū (N.Z. native wood pigeon) was also a forest dweller in podocarp-broadleaf forest and beech forest. The pūtakitaki (paradise shelduck) was a waterfowl, prized for its good eating. It inhabited the more open spaces of the lake headwaters swampy areas and the lake itself, probably near those places with high fibre bearing plants such as *Phormium tenax*. Large fields of *Phormium tenax*, "flax" were documented at Wairewa in October 1830", when Te Rauparaha, his chiefs and war party (taua) were on the ship *Elizabeth* which anchored in Takapuneke Bay, Akaroa Harbour. "To prevent discovery of the real purpose of the ship's visit, Te Rauparaha's party remained below decks, and, as Tamaiharanui was absent at the flax grounds at Wairewa, messages were sent to him that the captain wished to trade muskets for flax," (Wikipedia 2018). One mystery still unsolved is the nature of the early fibre for the eel nets and traps used on Te Roto o Wairewa. Kiekie and mangemange were two fibres common in the making of eel traps (Buck 1982). *Freycinetia banksii* (kiekie) would have been present in the local forests but *Lygodium articulatum* (mangemange, makomako) is currently found as far south as the Bay of Plenty in the North Island. It is possible that other local vines were used such as *Ripogonum scandens* (supplejack), but this has not been confirmed. All that is known for sure is that since Makō was first informed about the presence of plentiful eels, and up until the present day, Te Roto o Wairewa/ Lake Forsyth is renowned for its eeling, and that the fibre and timber plants for constructing the nets, traps and weirs must once have been readily available nearby. Teone TaareTikao (Beattie & Tikao 1939) does reflect however, that the knowledge of the "kupeka" nets, which were “ten to fifteen chains long” (200-300m) had been brought to Waihora and Wairewa by *Ngāi Tahu* from the East Coast of the North Island. (Where mangemange grew).

The National Heritage Collection has an article on flora and fauna once present on Bank’s Peninsula: “Banks Peninsula was once 98% covered in forest and only 1% remained by 1920. After European settlement most bays had a saw mill in action to harvest the wood, enable more stock to be grazed and to enhance the value of land. The forests were generally of tōtara, kahikatea, mataī and red beech.” In early European days the timber from the Little River area was renowned for its quality. In 1873 New Zealand's longest bridge over the Rakaia River, used timber from the mill at Little River. (Arnold 2016). The timber from the forests around Little River was rafted or punted across the lake to Birdling’s Flat, where a tramway took it over the flat to Lake Ellesmere, and dispersed from there by wagon according to market demand in Christchurch. Eventually the hills became denuded.

One more reference to plants of old. At the summit of the Little River valley, lay the Waipuna saddle, on the old route to Port Levy (Koukourārata). On the saddle stood a mighty tōtara between Waipuna and Mount Fitzgerald with a diameter over 14.4 m and canopy spread of 71 m^2 (Anderson 1927). Another noted tōtara in the area was visited by Bishop Selwyn in 1844, and was thought to have been over 17m in circumference, but this tree was later destroyed by fire (Anderson 1927).

2.3 Determination of Location and Plants

2.3.1 Determination of Location

The choice of location was driven by a number of factors: Intrinsic values included historical significance, ownership and caretaking responsibilities, public profile and educational opportunities, as well as the physical characteristics such as risks of plant failure due to, for example, climatic stress, floods, stock, and soil characteristics, moisture, light and shelter.

Sites offered for study

Seven study sites were offered up for consideration, guided by representatives from the Wairewa Rūnanga. These sites all held potential for the increase of local biodiversity, and were in harmony with the long-term conservation values and goals of the Wairewa Rūnanga and the Ngāi Tahu Iwi.

A particular place of significance was the outlet at Birdling’s Flat where a canal had been constructed to better manage the out flow of Te Roto o Wairewa/ Lake Forsyth. Te Roto o Wairewa/ Lake Forsyth is one of two customary lakes in New Zealand and is important because of the lake’s association with traditional food sources and food gathering traditions (mahinga kai). Because Te Roto o Wairewa/ Lake Forsyth is currently recognised as a lake under environmental threat any future work using plants as an aid to stream or water catchment cleanliness may have immense benefit (ECAN. 2016). The collective Ngāi Tahu environmental management document (Mahaanui Iwi Management Plan, 2013) also states some clear goals concerning the custodianship and environmental responsibility for Lake Forsyth, Little River and the Wairewa Rūnanga areas of concern.

Therefore, after first seeing the Birdling's Flat canal, and understanding the relationship of the Wairewa Rūnanga custodianship of the lake and in particular the eels (tuna), we were then shown the other potential sites for study.

The seven sites were:

- Sites 1 and 2 - The canal area at Birdling's Flat, and the low stony terraces at the lake edge nearby the New Brighton Boat club.
- Site 3 - The spring and ditch area opposite the Little River Hotel was a section of the Christchurch to Little River Railtrail (Little River Railtrail 2009) which had been planted with native vegetation by the Department of Conservation some years previously.
- Site 4 - The stream edge of the Takeritawai River, also known as the Kakerikawai River.
- Site 5 - This was an alluvial terrace site, bounded by the Ōkana stream and the main road to Akaroa SH75, between the Wairewa Rūnanga Marae and the Little River Township.
- Site 6 - The coastal streamside at Tumbledown Bay leading into the dune area.
- Site 7 - A potential location at Peraki, a working organic farm based near Magnet Bay.

Site 7 was shown to us so we could keep in mind, knowledge, strategies and benefits that may arise from our study that could be useful in this *Ngāi Tahu* farm enterprise. Two other sites are acknowledged that could benefit in the future from preparatory research. Site 1, the canal area, and site 4, the flat land adjacent to the Takeritawai River. Both these sites have extreme conditions, but long-term, are available for restoration with natural plant species.

2.3.2 Determination of Plants

The choice of which plants to promote at the terrace site was driven by many factors, including the understanding of: how to overcome any likelihood of failure, risks, aspect, shelter, individual plant requirements, how native plant communities exist in the wild and the relationship with the Wairewa cultural values, particularly "whanaungatanga" or family community groups.

Further understanding of what level of rarity or common availability was attached to each plant species, both traditional and current status of medicinal or cultural use of the plant, and whether by introducing a particular plant species into this existing revegetation project it would have a benefit in the future, particularly the relationship between today's planting expectations and future revegetation project planning.

Lists were constructed to evaluate the potential plants available for selection.

Traditional plant uses, and study of oral history referring to fauna and fauna once present in the landscape gave an insight into how past populations were driven by available resources, such as dependency on fibre products for everyday living. It was important to acknowledge a historical connection to allow for plants to be chosen in this category.

The planning considerations also included: were the right cultural conditions present for our selection to survive in, would our particular selection of uncommon plants survive over time, would there be a follow up management plan, and would provision be made for other naturally occurring plant material to emerge and would all these be compatible?

Eco sourcing, availability of the chosen plant species for purchase were also important factors in the choosing of a potential plant list, as well as likely plant health during the establishment phase. Some species on the proposed list would be hard to source locally, but these were not necessarily discounted as there was sufficient time to propagate in advance from local material, or potentially, if practical, translocate seedlings locally. (This could only be done at certain times of the year and usually within the same property).

In this research project time was restricted to planting in late April 2016, measuring growth and health from the first winter cycle, and through until after the second winter cycle. If more time had allowed, it would have been constructive to measure growth and health after the second spring/summer period, as some species could be frost tender, such as *Fuchsia excorticata* and *Melicytus ramiflorus* and could suffer set-backs and later recovery. Frost tender plants were not discounted in the final choice.

At the start of the project many local plant species were photographed and put on the "iNaturalist" database for formal identification. (iNaturalist 2015-3). This database served as a guide to the final plant list.

Some plant species were not selected. As part of an overall planning process this was an important consideration, as when looking at an overall balance of expected biodiversity benefits within a project, some species should be included: it may be these species could be added at a later date, in which case allowances could be made for them in the plant list for later placement. Five of the additional species which were considered were: *Horagis erecta, Griselinia littoralis* and *Rorippa palustris, Penantia corymbosa,* and *Muehlenbeckia ephedroides*. There were insufficient numbers of *Haloragis erecta* propagated in time for the study, *Griselinia littoralis* was considered too easy a species to grow, and *Rorippa palustris* would have been a useful plant to include for the Little River catchment area being cultrually beneficial as a Rongoa Māori herb and natural remedy used for livelstock in organic agriculture. The given site had unsuitable conditions to trial *Rorippa palustris*. *Penantia corymbosa*, (kaikomako), while having a strong cultural link and being a softwood species tradtionally used in firemaking, (Best, 1924), was not obtainable in sufficient numbers to be in the study, nor could sufficient material be propagated in time. *Melicytus ramiflorus*, (māhoe), a softwood also used in traditional firemaking, was included in the project selection. *Muehlenbeckia ephedroides* would have been a useful species to trial if an exposed site was chosen, but site 5, the vegetated river terrace, was not suitable for this species.

2.4 Local and Regional Databases and Lists

Making an informed decision on which plants to select for the project was helped by referring to plant databases. The final plant choices were made from these databases and information lists.

There were two kinds of plant databases to refer to: locally relevant, both existing and non- existing and regionally relevant which is in current (existing) use.

Regionally relevant databases included:

i) Motukarara Nursery plant locality plant lists E.g. *Native Plants Natural to Banks Peninsula* (DOC. 2015).

ii) Landcare Research Native Plant databases and comprehensive tools: *Ngā Tipu Whakaoranga - Māori Plant Use Database* (Landcare Research 2017-2)

Information from Burrows (1993) collection of plant and seed types from the Ahuriri Summit Bush, in western Banks Peninsula.

iii) Plants listed as present or likely to be beneficial in a report by Johnson (2015) for *Ngāi Tahu* at the organic farm enterprise at Peraki.

Local plant databases, existing and constructed.

Comprehensive Banks Peninsula relevant plant lists were included in "*Plant Life on Banks Peninsula*" (Wilson 2013). In particular this source provided the classification for local native vascular plants of current abundance, and was a very useful guide. However, on the practical matter of choosing a physical plant to put in the ground, we had to consider ways to obtain the material, and once planted, how to retain it and promote the success of its growth.

Consequently five more plant lists were firstly collated and then compared:

i) A list of existing plants in the proposed study area, on the stream terrace site See: Table 3.2

ii) A list of as many as possible plants found in the local landscape. A photographic record was undertaken to record as many local native plant species as possible. (iNaturalist 2015-3)

iii) A list of local plants potentially available in local Canterbury Nurseries (Potentially able to be sourced plants included in Appendices 6 (Legend) 7 and 8)

iv) A list of plants available in specialist nurseries to add to the project.

v) A list of additional plants a) common, and b) uncommon that were not available in nurseries, but having answered the future planning questions above, that we could propose for the research plant list. (Appendix A.5 explaining "uncommon")

vi) Medicinal plants used in Māori, and plants of cultural significance list. (Appendix A.6, and Appendix A.8)

vii) A list of plant species that S. McGaw (author) has had experience handling: propagating, sourcing planting and husbandry. (Appendix A.6, A.8)

Of the resulting list of proposed plants, some were readily available from local nurseries, a few species were harder to source, and others had to be propagated or translocated. Each species carried risks of progress, but by detailing a management plan, these risks would be greatly reduced.

2.5 Identifying Potential or Risks

2.5.1 Site Potential

Site choice favouring future potential included:

i) Educational value, and public profile.
ii) Closeness to Little River community, school and Marae.
iii) Potential for site to be developed at a later stage.
iv) Favourable conditions on site with respect to soil, moisture, light, and shelter.

2.5.2 Site risks

A number of risks in respect to site and location were acknowledged. They included:

- i) Land ownership; Ngāi Tahu, Crown owned or other. Site required to be Ngāi Tahu owned.
- ii) Grazing risks: Lack of existing fencing, breached fencing, unlikelihood of imminent fencing, during the study period. Plant losses from grazing stock.
- iii) Flood risks: Historical information indicated that the Ōkana stream was prone to flooding in some years. (ECAN 2016)
- iv) Theft or vandalism: This was a low risk, but needed to be considered.
- v) Stressful environmental conditions such as exposure to high winds, dry or frosty conditions.
- vi) Animal interference: Deprivation by herbivores, rodents and insects.
- vii) Exotic grasses and weeds: many areas had been fallow for some years and the abundance of exotic weeds and grasses were a draw-back in some cases, considered too difficult to control within the time frame.

2.5.3 Species potential

Each plant species with a potential for the study was given a rarity category. The categories, A, (common) B, (less common) C, (locally rare) were based on "current abundance", (Hugh Wilson 2013) on Banks Peninsula of native vascular plants. An additional category, A*, (commonly found in the landscape but not readily available in nurseries or commonly planted in local revegetation projects) was assigned which reflected potential inclusion in project planning.

- i) Any species from the “C” or “B’ (Wilson 2013), or A* categories were considered useful plants to trial.
- ii) All species considered for the study could be included in future revegetation or restoration projects within the Wairewa catchment area.
- iii) Species used in Māori (tradition al healing) or plants with cultural significance, could have a place in education, particularly for the Wairewa Rūnanga.
- iv) Ground cover species could have wider application in revegetation or restoration projects in Canterbury.

2.5.4 Species risks

When selecting the plant species for study, there were establishment risks associated with each species. These included such risks as:

i) Frost tender species, or species potentially requiring shelter during establishment: E.g. *Fuchsia excorticata*

ii) Species in open ground which require shade and vica versa.

iii) Species with no previous history in projects, establishment performance unknown e.g. *Pittosporum obcordatum* and *Astelia grandis.*

iv) Sourcing challenges. Some species may not be as stable or strong as desired due to difficulty in procuring material, e.g. small basal diameter, or non-optimum growing container size.

v) Plant functional traits, such as large leaves, deciduous foliage, could introduce other risks in growth and establishment.

2.6 Ground conditions

Ground conditions were considered suitable at sites where existing plant species were observed to have made good progress over the previous 5-8 years. These types of sites were considered suitable for study.

Favourable conditions for the natural emergence of seedlings are covered in 3.3, planning strategies.

Chapter 3

Outcomes of the Desk Study: Site and Species Selection Protocols

3.1 Site Selection - Result

The importance of investigating the seven sites had relevance as a whole. The primary site chosen potentially carried the least risk and highest likelihood of plant survival. Based on results of this study we expect to make a recommendation for progress for each of the other six sites, in keeping with the intention of sharing knowledge, Vision Mātauranga. A full description of each site comparison can be found in Appendix A.3.

Site 5 became the primary site chosen for the study. As the aims for this project included exploring a second stage revegetation site, where more tender plants or more uncommon species could be introduced under an existing layer of planting, site 5 was considered suitable. The area is fertile, situated on river terraces, bounded by the Ōkana stream and the main road to Akaroa SH75. The study area is situated between the Wairewa Rūnanga Marae and the Little River township. The existing revegetation planting was approximately eight years old, and while it appeared that the plants may have been originally set at 1.5 m spacing (an observation based on current plant existence), there appeared to be many gaps, but overall an estimation of 50-65% plant survival in the original project was estimated. The existing vegetation had not been maintained in recent years, with an exotic grass growth up to 1 m high, which had smothered a number of plants. This site was chosen for its high public profile, being close to the Little River township and the Wairewa Rūnanga Marae, and has future learning and teaching possibilities. It was nearby the local school. It was also fenced, is *Ngāi Tahu* owned land and did not have a great deal of public access so that it posed a lesser risk from plant thefts or vandalism. Although the grass was high, there was not too great an invasive weed issue, although some *Convolvulus arvensis* was present in isolated patches.

The greatest risks were likely to be from browsing animals breaching the fence, and from occasional flooding. Historically floods had taken out some of the plants, but more damage had been done by the cattle that breached the fences after the flooding. Previous observation by the author of projects with combiguards performing well during flood situations in Canterbury, Coes Ford, and Marlborough, Kākāpo Bay, indicated well-applied combiguards could protect plants and withstand limited occasional flooding. With a limited flood risk and not under threat from wandering stock this site posed the least risks overall, with the benefits of easy access, the greatest likelihood of plant success and a high public profile.

3.2 Plant Species Selection – Results

3.2.1 Species Selection

There were sixteen native plant species already present in the wider study area at Little River, and only fourteen species present in the immediate area of the proposed study plots (Table 3.1). Twenty-one plant species were ultimately chosen for the study, of which seventeen species were not already in the area, although they did belong in the Little River catchment area.

The twenty-one species were made up of seventeen trees, shrubs and climbers, and four ground cover species.

Table 3.1 Fourteen plant species were present in the existing revegetation area, with two additional species nearby, (list on the left). The list on the right comprises of the twenty-one plant species chosen for the study. Those plants marked with an asterix* represent the sixteen new species that were introduced into the area.

Existing Species Already in Project Area	**All Plants 2016/17 Project**
Austroderia richardii	*Astelia grandis* *
Carex secta	*Carex secta*
Coprosma propinqua	*Carmichaelia australis**
Coprosma robusta	*Clematis paniculata**
Cordyline australis	*Coprosma propinqua* var *latiuscula Allan**
Hoheria angustifolia	*Coprosma robusta*
Kunzea ericoides	*Copsosma rotundifolia**
Leptospermum scoparium	*Dacrycarpus dacrydioides**
Olearia paniculata	*Fuchsia excorticata**
Plagianthus regius	*Hoheria angustifolia*
Podocarpus totara	*Melicytus ramiflorus**
Pittosporum tenuifolium	*Muehlenbeckia astonii**
Veronica salicifolia	*Parsonsia heterophylla**
Veronica strictissima	*Pittosporum obcordatum**
	Podocarpus totara
	*Pseudopanax arboreus**
	Sophora microphylla
Additional nearby	**Ground Covers**
Phormium tenax	*Leptinella dioica**
Sophora microphylla	*Luzula rufa**
	*Poa imbecilla**
	*Ranunculus reflexus**

Footnote: *Coprosma propinqua* var. *latiuscula Allen* has also been commonly referred to locally as *Coprosma propinqua* 'Birdlings Flat', as this is where source material was collected from.

Twenty-one plant species were chosen for the 2016/17 field study, comprising of 17 above ground or taller growing plants, and four ground level, or ground cover plant species as shown in Table 3.1. Fourteen plant species were in the immediate area of the study, and two additional species nearby making a total of sixteen existing species. Another sixteen species were newly introduced into the area, thereby doubling the existing plant species on the project site (Table 3.2).

Table 3.2 Location of plant species in the vicinity of the research plots, illustrating the addition of 16 project species doubled the existing species list

Existing species	**Totals**
nearby areas	16
in project area	**14**
Species in 16/17 project	
trees/shrubs/climbers	17
ground covers	4
TOTAL	**21**
Additional new species	
trees/shrubs/climbers	12
ground covers	4
TOTAL	**16**

The species choices were based on the objectives, which were to double the number of plant species within the existing revegetation project, to include and trial some less common species, and to include plant species used in Rongoā Māori, or cultural use plant species, within the plant choice mix (Table 3.3).

Out of the 21 selected plant species for study, 17 of these species were chosen as having Rongoā Māori qualities, or of cultural significance.

In group one there were four category (C), three category (B) and four category (A*) making up eleven rare, not common, less common species and uncommonly planted species, against ten common local species (Table 3.4). The total numbers out of a total of 697 plants of rare versus common plants were: 345 rare, less common, and uncommonly planted versus 352 commonly seen and nursery available plants.

Table 3.3 The final choice plant list. The scientific name shows the plant species grouping and relationship to ground slope, for example, *Carex secta* and *Astelia grandis* were planted in the low area, while *Sophora microphylla* and *Coprosma propinqua var. latiuscula* were planted on the top of the slope or the terrace area. Against each species name is the rarity category of A, (common) B, (less common) C, (locally rare) and A*, (commonly found in the landscape but not readily available in nurseries or commonly planted in local revegetation projects). Note: This table is based on "current abundance" on Banks Peninsula of native vascular plants with respect to categories of A, B, C (Hugh Wilson 2013). Seventeen plant species (R) have Rongoā Māori qualities, used in traditional healing. (Appendix A.4 explains A, B, C, and A* in detail, and Appendix A.6 has a full list of local plants with Rongoā Māori qualities.)

Position	Rarity	Plant Species
Climbers	A	*Parsonsia heterophylla* (R)
	A	*Clematis paniculata* (R)
Top or upper slope	C	*Muehlenbeckia astonii* (R)
	A	*Carmichaelia australis* (R)
	A	*Sophora microphylla* (R)
	A	*Coprosma propinqua var. latiuscula* Allan (R)
Ground cover	A-C	*Luzula rufa* (R)
	B	*Poa imbecilla* not R
	A	*Ranunculus reflexus* (R)
	A	*Leptinella dioica* (R unknown)
Mid slope	A	*Hoheria angustifolia* (R)
	C	*Pittosporum obcordatum* (R unknown)
	A*	*Melicytus ramiflorus* (R)
	B	*Podocarpus totara* (R)
	A*	*Coprosma rotundifolia* (R)
Lower slope	A*	*Pseudopanax arboreus* (R)
	B	*Dacrycarpus dacrydioides* (R)
	A	*Coprosma robusta* (R)
	A*	*Fuchsia excorticata* (R)
Low area	C	*Carex secta* (not R)
	C	*Astelia grandis* (R)

Table 3.4 The plant numbers in each category of A, B, C, and A*are based on "current abundance" on Banks Peninsula of native vascular plants. (Hugh Wilson 2013). A total of 697 plants includes all plant types including ground cover species. Group one comprising of rare, less common, and common but not readily available or not commonly planted in local revegetation projects, makes up a total of 11 species, while group two, common plants, are represented by 10 species. Group one has 344 plants, and group two has 353 plants represented.

	Rarity Status	Species Represented	Numbers of Plants
Group One			
Rare plants	C	4	140
Less common	B	3	100
Common but not readily available	A*	4	104
Total group one		11	344
Group Two			
Common	A	10	353
Total species type		21	697

As part of the selection process, thought was given to plant placement and pairing of species for planting in layers in the existing revegetation site. More detailed description of planting layers is given in Chapter 4.1.2. Two plant species were chosen per line, or layer. (Table 3.5). Beginning with Line 1, the two species chosen were *Carex secta* and A*stelia grandis.* Two of each species was laid out in each line. *Parsonsia heterophylla* and *Clematis paniculata* were placed in line 8 and generally placed next to a fence, shrub or tree as terrain and adjacent foliage allowed. *Coprosma rotundifolia* and the ground level, (GL's), or ground cover species were placed in the middle area, or mid slope.

Table 3.5 Plant selection per line or layer. Beginning with Line 1, the two species chosen were *Carex secta* and *Astelia grandis*. Two of each species was chosen for each line, ending with *Parsonsia heterophylla* and *Clematis paniculata* which were placed in line 8. *Coprosma rotundifolia* and the ground cover species (GL's) were placed in the middle area, or mid slope. (Table 3.3).

Line Number	Scientific Name
Line 1	*Carex secta*
	Astelia grandis
Line 2	*Coprosma robusta*
	Dacrycarpus dacrydioides
Line 3	*Pseudopanax arboreus*
	Fuchsia excorticata
Line 4	*Melicytus ramiflorus*
	Podocarpus totara
Line 5	*Hoheria angustifolia*
	Pittosporum obcordatum
Line 6	*Coprosma propinqua var. latiuscula*
	Sophora microphylla
Line 7	*Carmichaelia australis*
	Muehlenbeckia astonii
Line 8	*Parsonsia heterophylla*
	Clematis paniculata
GL's 1-6	*Poa imbecilla*
Middle	*Luzula rufa*
	Ranunculus reflexus
	Leptinella dioica
Middle	*Coprosma rotundifolia*

The following is a brief description of each of the twenty-one plant species chosen and why.

Astelia grandis (C) and (R), was chosen as the opportunity arose to trial this plant. In early European times it was recorded as present in large numbers in the swamps across the Canterbury plain. (Armstrong 1879). The only reference to use which has been found was to its employment as a decorative fibre in weaving. In line 1 this plant was teamed with *Carex secta.*

Carex secta (C) (not R), while present in the Canterbury Plains was not seen as abundant in this part of the Banks Peninsula. It was considered a useful plant to trial as there are a number of future locations in revegetation projects where it could be used. *Carex secta* and *Astelia grandis* together represented wet area edging plants.

Coprosma robusta, Dacrycarpus dacrydioides, Fuchsia excorticata, and *Pseudopanax arboreus* were the next grouping of plants selected as fringe layers to the wet area and at the bottom of the slope, lines 2 and 3

Coprosma robusta (A) and (R), (karamū) protects and shelters its neighbouring plants, grows quickly, throws seeds and generally can be relied upon to grow well.

Dacrycarpus dacrydioides (A) and (R), (kahikatea) is a plant that was part of the heritage of Little River and its environs. Only a handful of mature kahikatea remain in the Wairewa catchment area.

Fuchsia excorticata (A*) and (R), (kōtukutuku) is a plant seen plentifully all throughout the Wairewa catchment. It is seen even on the windy roadsides, which indicates that potentially it could be hardy. It is not however readily available in nurseries. If time had permitted, we would have propagated *Fuchsia excorticata* from cuttings with a robust stem.

Pseudopanax arboreus (A*) and (R), (whauwhaupaku) is the most abundant plant seen growing around the roadsides in the upper valleys. *Melicytus ramiflorus* (māhoe) is also very abundant. The only exceptions visually in the valley are where *Kunzea ericoides* (kānuka) is dominant as a plant community, or where *Sophora microphylla* alongside *Hoheria angustifolia* form a plant community. One of the many uses for whauwhaupaku is for its dye properties in weaving and decoration (Landcare Research, 2017, Cranwell et al. 1943), which could be of interest to local craftspeople.

The next groupings formed layers mid slope, placed in lines 4 and 5. This grouping was: *Melicytus ramiflorus, Podocarpus totara, Hoheria angustifolia* and *Pittosporum obcordatum.*

Melicytus ramiflorus (A*) and (R), (māhoe, hinahina) is the softwood used in fire-making along with *Pennantia corymbosa* (kaikōmako) and has many medicinal qualities (Plate 3.1). (Stark, 1979). In nearly every location visited in the valley māhoe was present. Also of note was that every *Prumnopitys taxifolia* (mataī) seedling was growing alongside or underneath a *Melicytus ramiflorus* (māhoe) which was sheltering it. *Melicytus ramiflorus* was one of the few seedlings seen naturally occurring at the seven sites shown to us at the beginning and was considered an important cultural plant to include in the study. *Melicytus ramiflorus* is not particularly commonly planted in Canterbury revegetation sites in the early stages. There was root-trainer seedling material available at Motukarara nurseries. However, if time had permitted, potentially this was a plant that could have been propagated into a larger container size before planting, as a wider root ball option has been successful in Ohoka Projects. *Melicytus ramiflorus* was therefore an unknown category of expectation, but was included because of cultural significance. Although seen in only a few places in the valley, as both mature trees and seedlings, *Pennantia corymbosa* (Kaikōmako) was not included in the study as there was a limit to the number of plants that could be chosen. Future studies could usefully include this plant species alongside of *Melicytus ramiflorus.*

Podocarpus totara (B) and (R). In Māori lore there were many everyday uses for *Podocarpus totara* (tōtara). As a culturally important plant tōtara was included.

Hoheria angustifolia (A) and (R), (houhere) also has many medicinal uses. In the valley *Hoheria angustifolia* was plentiful and grew alongside *Sophora microphylla* in many places. Where one plant was present the other would be present.

Pittosporum obcordatum (C) and (R unknown), *is sometimes r*eferred to as "heart-leaved kōhūhū". (NZPCN 2012). For the Rongoā Māori status which is unknown to me, other New Zealand *Pittosporum* species, particularly *Pittosporum tenuifolium*, also known as kōhūhū, potentially have antibiotic properties (Earl et al. 2010). *Pittosporum obcordatum* was included as it was a plant species recently rediscovered in the Bank's Peninsula area, and propagated by Motukarara nursery. There was enough plant material for it to be included in the study. The conservation status is "Threatened and Nationally Vulnerable". (NZPCN. 2018). In order that *Pittosporum obcordatum* could be used in future revegetation projects it was thought a useful species to include in the study.

Coprosma rotundifolia (A*) and (R). This plant species was growing visibly and robustly along all the forest edges in the Little River valley roads. It was not available in nurseries. It was also considered a useful plant to trial and include in later revegetation projects. It was placed within the centre slopes in the middle layer of the project.

Sophora microphylla and *Coprosma propinqua* var*. latiuscula* Allan (were placed at the top of the slope along with *Muehlenbeckia astonii* and *Carmichaelia australis* being the top layers, 6 and 7. Generally the overhead vegetation was in the middle of the slope so the top layers were more open in the flatter terrace area.

Sophora microphylla (A) and (R), (South Island kōwhai) was sparsely represented in the existing revegetation project area. *Sophora microphylla and Hoheria angustifolia* are well represented in the valley. Therefore it was considered helpful to add this species for study, particularly as it was likely that the gaps in the existing project may have included the *Sophora* species and failed over time.

Coprosma propinqua* var. *latiuscula Allan. (A) and (R), (mingimingi). This variety of *Coprosma* was collected from seed in the Birdling's flat area and propagated. It was previously loosely described in local nurseries as "*Coprosma propinqua* Birdling's Flat.

Muehlenbeckia astonii (C) and (R), (tororaro) is Nationally Threatened and considered Vulnerable. (NZPCN 20102). However this plant is gaining popularity, and is readily available from local nurseries and had a high likelihood of survival success.

Carmichaelia australis (A) and R, (mākākā, maukoro) is a hardy plant in the wild, but not often offered for sale in large numbers in nurseries. It is commonly observed in the dry hillsides around Te Roto o Wairewa/ Lake Forsyth.

Clematis paniculata (A) and (R) and *Parsonsia heterophylla* (A) and (R) were placed in line 8, mostly on the top terrace, next to a fence or tree.

Clematis paniculata *(*puawhananga) and ***Parsonsia heterophylla*** (kaihua, akakiore, akākāikiore as well as kaikū (Landcare Research 2017-2), kaiwhiria, poapoa tautau, tawhiwhi, tūtae-kererū (Williams 1971). The common European name is New Zealand jasmine. These two species were two climbing plants chosen. Both were plants common to Banks Peninsula and both have Rongoā Māori qualities. *Parsonsia heterophylla* is seen in abundance throughout the valley, and *Clematis paniculata* less so.

Leptinella dioica (A) and (R unknown), ***Luzula rufa*** (A-C) and (R), ***Poa imbecilla*** (B) and (not R), and ***Ranunculus reflexus*** (A) and (R) (maru, maruru, kopukapuka, pirikau) were ground cover species and placed in the mid layers.

These last four ground cover plant species were planted in clumps together, i.e. one of each species per clump. They were included as unknown performers, and it was possible that if they performed well they could be of benefit in future planting projects.

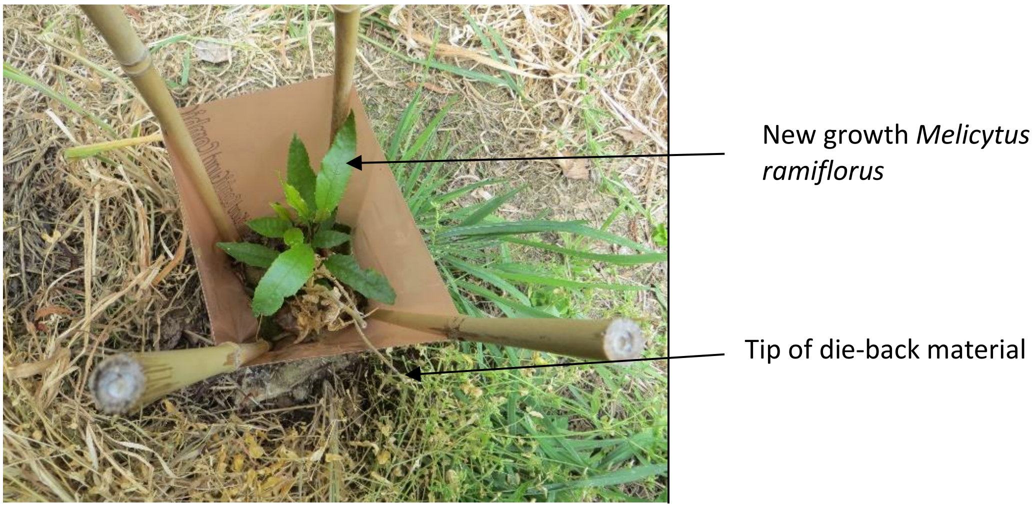


Plate 3.1. *Melicytus ramiflorus* (Ma) showing new shoots and bushy appearance in summer after initial dieback during winter.

Plate 3.2. *Coprosma robusta* (Cr) seedlings (top right) growing in *Leptinella dioica* (Lp) which has spread along the ground from the original source.

3.3 Management and Planning Strategies

The planning strategy to ensure a reasonable likelihood of success, i.e. plant establishment over the short time period of twelve to fifteen months of the research time limit, covered three main points. These were careful plant selection and specialised husbandry, careful site selection and management and careful planting techniques. Plant selection has been covered in the previous chapter. Specialised husbandry, planting techniques and protection are covered in the following sections.

3.3.1 Site Management

Since the primary site was chosen, some site preparation was required prior to planting to reduce the exotic grass which had reached a height in most places of over 1m. The bases around all the existing vegetation was also choked with exotic grass. A regime of spraying and weed-eating was undertaken in the proposed study site areas. This was achieved by three knock-down sprays with Glyphosate 360, two passes with a weed-eater, and control of a wasps nest. No pest control was undertaken although there was evidence of rat activity. The site preparation work was undertaken in November 2015 and January, February and March 1916.

3.3.2 Plant Management

All plants except for the four ground cover species and *Coprosma rotundifolia* were eco-sourced from Motukarara Nurseries, Canterbury. The ground cover species and *Coprosma rotundifolia* were propagated at Lincoln University, and material came from local sources.

As far as was possible each plant was chosen as a healthy specimen of its kind available in the nursery. If time had allowed, *Fuchsia excorticata*, *Pseudopanax arboreus* and *Melicytus ramiflorus* would have been sourced further afield, or allowed into the project as a larger root container size, or greater stem sized plant for better survival potential. However, constraints that all plant material be sourced from one location as far as possible did not allow for dissimilarity in root container sizes. (Note: *Fuchsia excorticata* was observed in 2013 (pers. com 2013) to be growing successfully at Orokonui Ecosanctuary near Dunedin and was understood to be planted as a healthy and fair sized plant specimen grown in a PB5 planter bag. A PB5 bag is a 2.8 litre black plastic planter bag measuring 23.5 cm long x 12.5 cm wide measured flat with drainage holes at the base (Easy grow 2018). It was important to note this as future plans for inclusion of *Fuchsia excorticata* in new projects may benefit from similar practice).

All plants were planted at the end of March 2016 on the same day.

3.3.3 Risk Management

Planting techniques, specialised husbandry, as well as protection for the plants during establishment were issues that required attention to reduce the risk of unnecessary plant failures (Plate 3.3).
In order to reduce this potential risk, the planting techniques were directed as follows: Firstly a clear ground free of weeds and top turf would be established at the site of each hole. A hole a bit deeper than the root ball of each plant would be dug, which would then be half filled with water. The water would drain, leaving a fine moist tilth at the bottom of the hole in which to place the healthy root ball, which would have no constricted roots. The selected healthy plant would be firmly surrounded by soil, allowing no oscillation of the roots from wind. A wool mat and protective Combiguard sleeve, (Advance Landscape Systems 2018), would be placed around each plant. The orange Combiguard sleeves would be anchored by 600 mm high robust stakes. This stake size and specification would allow for firm combiguard construction in the event of possible floods. The choice of an orange sleeve would aid in identification of plants during spray events. The sleeve itself would offer partial protection from the plants being eaten by rabbits or hares. The wool mat would afford some protection against emerging weeds at the base of the plant as well as retention of moisture.

Plate 3.3. The study site looking south. Plot 4 is on the right hand side, and plot 3 is on the left. Note the long grass on the left. In the low area centre of picture, orange combiguard sleeves are visible. The height of the more mature trees and overhead vegetation is approximately 4-6 m.

Chapter 4

Field Study

4.1 Experimental Design

4.1.1 Site Design

The experimental design was set up with for 5 treatments (Plots 1-5) x 5 replicates of each of the basic species within the project site, plus two open space treatments (Plots 6-7, Figure 4.1).

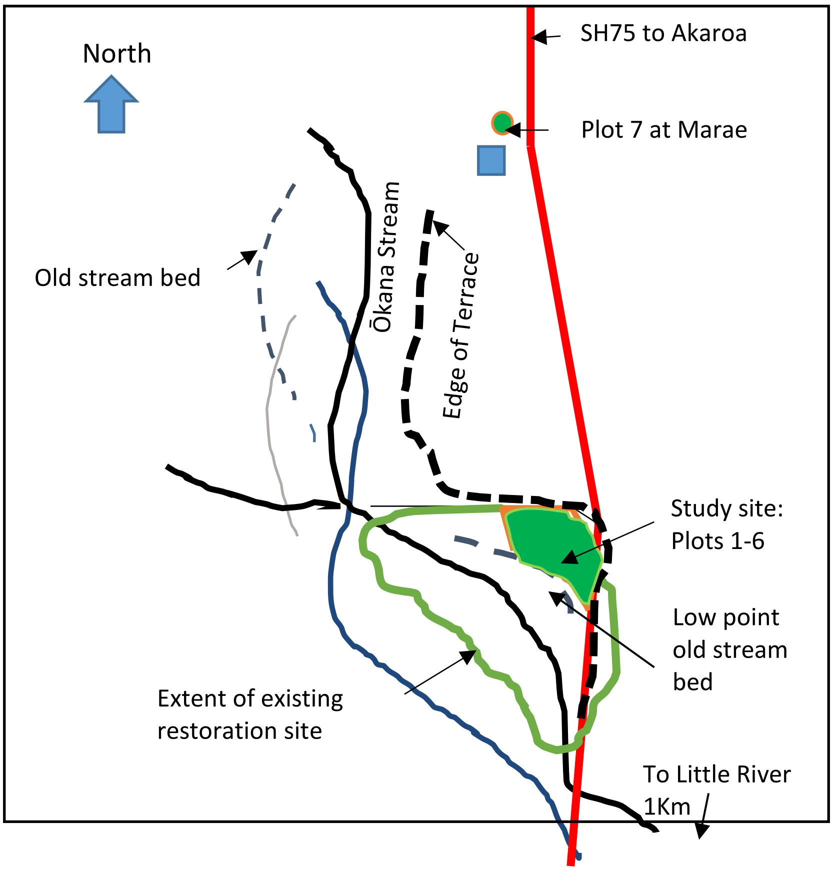


Figure 4.1 Diagram of the location of the study site, within an existing restoration project, between an old stream terrace and an old stream bed, adjacent to the Ōkana Stream. (Not to Scale)

Each plot measured approximately 10m x 7m. All the study plots 1-5 were situated under partial native plant cover, and are described as "Plot 1, Plot 2, Plot 3, Plot 4, and Plot 5". The remaining two plots were in open space with marginal or no cover, and were more exposed to weather. The 6th plot was divided into two parts, 6A and 6B as the terrain did not allow for a continuous area of open space (Figure 4.2). The 7th plot was situated at the edge of the Wairewa Marae carpark. Except for

Plot 7, all plots had a slope varying between 0.6m and 1.3 m from top to bottom, and had minimal fall along the bottom row (0.1m- 0.3m).

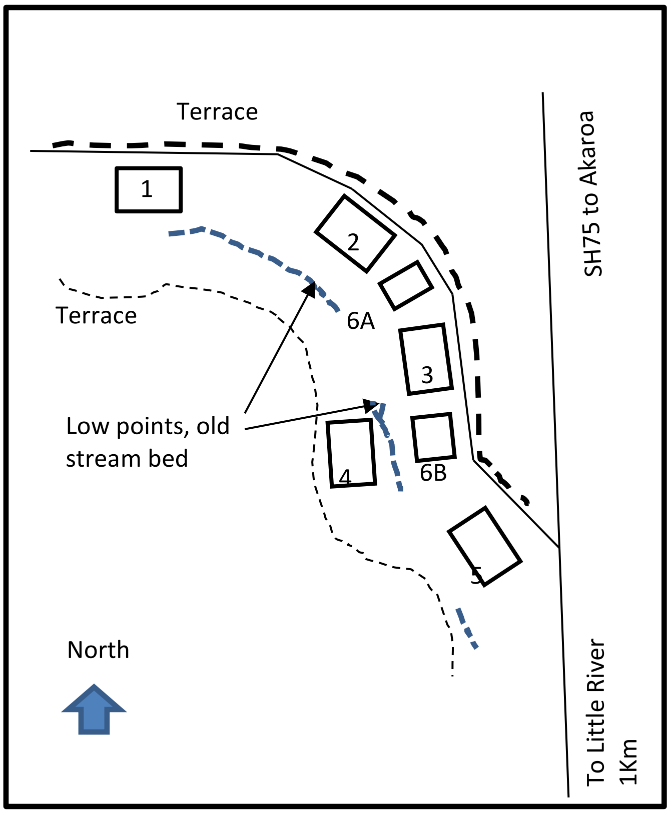


Figure 4.2 Site plan showing North orientation, the positioning and naming of Plots 1-6 and sketch showing position of low points in old stream bed. Plot 6 was divided into 6A and 6B, in order to take the best advantage of an open location on the existing study site.

Plant numbers: There were eight basic lines or layers of planting per plot. (Table 3.5). In each layer two plant species were represented, with five of each species per layer. These were placed alternately to each other. With 7 plots, 5 of each species per plot, this resulted in 35 plants of each species type for the basic study.

In addition to the 8 basic layers, *Coprosma rotundifolia* was included in the study, even though there were a fewer number of plants due to low numbers available after propagation during summer, a total of 18 plants. This species was included as it is very prevalent within the Little River catchment area. *Coprosma rotundifolia* were placed in the mid layers of each plot.

The ground cover species were planted in cluster groups (touching) of four plants per group, with 5 groups per plot in plots 1-6. There were no ground cover species trialled in the Marae Plot 7 as the grass and dry ground conditions were unsuitable for their survival. There was a total of 120 ground-cover plants.

A total 697 plants were planted.

The numbers of plants in each plot are tabulated in Table 4.1.

Table 4.1 Plant numbers per plot. Plots 1-7 had 8 rows of ten plants in each row, (80 plants per plot) except for plot 4 where one plant went missing at an early stage (79) plants. *Coprosma rotundifolia* (Rts) was represented by only 18 plants. 20 ground level plants (GL's) i.e. ground cover plants, were planted in plots 1-6, 20 plants per plot. Each plot had 5 clusters of ground cover species planted in a cluster. The main body of study of above ground plants, (shrubs, trees, climbers, one monocot and one sedge) totalled 577 plants. The total number of plants including ground cover plants was 697.

Plot Number	Plants in layers	Rts	Totals	GL's in clusters	Total Plants
Plot 1	80	3	**83**	20	103
Plot 2	80	3	**83**	20	103
Plot 3	80	3	**83**	20	103
Plot 4	79	3	**82**	20	102
Plot 5	80	2	**82**	20	102
Open-1	80	2	**82**	20	102
Open-2	80	2	**82**	0	82
Totals	559	18	**577**	120	**697**

Site identification: i) The perimeter of each plot site 1-7 was pegged. ii) An additional five sites at the terrace location were pegged adjacent to plots 1-6. These sites were of the same size and aspect, but received no treatment, weed control or management of any kind. The undergrowth in these plots were observed over the fifteen months for any sign of emerging seedlings.

4.1.2 Planting layers

The 16 basic study species were planted in layers, two species per layer, and five plants of each species. Planting within the existing revegetation, the bottom layer was in the lower part of the ground, e.g. *Astelia grandis* and *Carex secta*. (Table 4.2). The next two layers represented fringe planting at the edge of a stream, or the lower edge of the slope. The four species represented here were: *Fuchsia excorticata*, *Coprosma robusta*, *Dacrycarpus dacrydioides*, and *Pseudopanax arboreus.* The mid slope layers included: *Podocarpus totara*, *Melicytus ramiflorus*, *Hoheria angustifolia, and Pittosporum obcordatum.* The upper slope and terrace layers were*: Sophora microphylla* and *Coprosma propinqua* var. *latiuscula*, along with *Muehlenbeckia astonii* and *Carmichaelia australis. Clematis paniculata* and *Parsonsia heterophylla* were generally placed near the top layer close to a tree or shrub or fence up which they could climb.

The secondary study plants were: *Coprosma rotundifolia* arranged in the mid slope layer, as well as the four ground cover cluster groups, *Leptinella dioica, Luzula rufa*, *Poa imbecilla, Ranunculus reflexus*.

(Appendix 10 describes in fuller detail the cultural requirements of each species, in respect to slope).

Table 4.2 Planting layout and ground features.

Position	Species	
Terrace	*Parsonsia heterophylla* *Clematis paniculata*	
Top	*Carmichaelia australis* *Muehlenbeckia astonii* *Sophora microphylla* *Coprosma propinqua var latiuscula Allen*	
Mid **Slope**	*Hoheria angustifolia* *Pittosporum obcordatum* *Coprosma rotundifolia* *Podocarpus totara* *Melicytus ramiflorus*	**Ground Covers** *Luzula rufa* *Poa imbecilla* *Ranunculus reflexus* *Leptinella dioica*
Fringe	*Fuchsia excorticata* *Coprosma robusta* *Dacrycarpus dacrydioides* *Pseudopanax arboreus*	
Low	*Astelia grandis* *Carex secta*	

4.1.3 Overhead and Sheltering Vegetation

As per table 4.3, there were 14 native plant species making up the existing vegetation species where the study plots were situated. *Austroderia richardii, Carex secta, Coprosma propinqua, Coprosma* *robusta, Cordyline australis, Hoheria angustifolia, Kunzea ericoides, Leptospermum scoparium, Olearia paniculata, Plagianthus regius, Podocarpus totara, Pittosporum tenuifolium, Veronica salicifolia,* and *Veronica strictissima.* These were generally semi-mature plants of around 8-10 years old. There were no mature *Sophora microphylla* plants nearby, or seen within 120m of the study site. However two *Sophora microphylla* seedlings later emerged in Plot 2, probably due to seeds having come downstream in previous floods. Plots 1-5 had partial cover with 4-6 plants species represented adjacent or overhead, offering shade or shelter. Plots 6 and 7 were more open and exposed, with most of any vegetation or fence only near or 2-3 m away from the perimeter. As the sites for the project were dictated by the existing terrain on offer, it was not possible to have a perfectly open or exposed plot for trial.

Table 4.3 Existing Species overhead per plot. Y = existing species overhead, Edge = species present near perimeter of site, and 2m away = species at designated distance away from edge of plot.

Existing Species Overhead	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7
	Partial cover					Open	
Austroderia richardii	Y	Y					
Carex secta				Y	Y		3m away
Coprosma propinqua		Y					
Coprosma robusta				Y			
Cordyline australis		2m away	Y	Y	Y		
Hoheria angustifolia	Y	Y	Y	Y	Y	Edge	
Kunzea ericoides	Y	Y	Y				
Leptospermum scoparium							
Olearia paniculata	Y		Y		Y		
Plagianthus regius				Y			
Podocarpus totara	Y						
Pittosporum tenuifolium			Y			Edge	Edge
Veronica salicifolia	Y			Y			
Veronica strictissima			Y		Y		

4.2 Data Collection

4.2.1 General data information

The data collected for the field study fell into two general categories: the physical plant measurements, and the geophysical measurements. Data included: recording date, plot location, unique identifier, plant type, growth height (in mm) over time, health status, new growth observed, position relative to slope, description of open or shade, general observations and comments, aspect, (N) and overhead vegetation species. Data loggers recorded temperatures within the site, basic soil samples were analysed, and photographs were taken at regular intervals. Seedling emergence was noted, and a survey of the physical site was undertaken.

Dates: Establishment success rates and growth were measured at intervals after planting in April 2016 up until September 2017.

4.3 Plant Measurements

The physical plant measurements comprised of:

i) The unique identifier, (UI), which individually described each plant with the plot location, the plant species, and the plant number in the row (line). There were 697 plants in the study. Each plant had a unique identification. For the purposes of data collection, each plot had a number 1-7. This is the first number in the IU. The second part was the plant description which was abbreviated according to the key "Ca" for *Carex secta*, "Ka" for Kahikatea (*Dacrycarpus dacrydioides*) (Table 4.4, a full abbreviation key can also be found in Appendix A.1, for ease of reference during the reading of this thesis). The last number refers to the position of a particular plant species in the layer. Therefore the first three *Carex secta* in plot 1, would read 1Ca1, I Ca2, I Ca3, and in plot 2 would read, 2Ca1, 2Ca2, and 2Ca3. Similarly, 5Ma4, would be situated in Plot 5, (5th plot), Māhoe, (*Melicytus ramiflorus*), 4th plant along the row.

ii) The height of the plant as it grew. This was measured in mm. Note: During the recording process, some plant species had two height measurements. This occurred when a plant such as *Melicytus ramiflorus*, *Fuchsia excorticata* or *Dacrycarpus dacrydioides* had a dieback event such as from frost or drought, and then displayed regrowth. The overall height difference was taken from the second regrowth figure in final growth calculations. (Chapter 5.4.2 Plant Recoveries, for sample regrowth events).

iii) The general health observation of the plant (Table 4.5) particularly with respect to growth height. This ranged from dead (1), less than average growth, (2) average (3), showing growth (above average), very healthy and robust (5) and extra-ordinary growth (6). (An example of extra-ordinary growth would be *Parsonsia heterophylla* growing to over 2m high in 15 months).

iv) At the same time as the general health and growth height observations, an additional observation was made in all plants for signs of new growth in the stems or foliage. The "new growth" observations included swelling buds on the stems, and fresh leaf tips. In some plants species, at the end of the second winter, while no growth upwards in height was observed, there were fresh buds appearing.

Table 4.4 Key to plant abbreviations for data collection.

Scientific Name	Abbreviation
Astelia grandis	As
Carex secta	Ca
Carmichaelia australis	Ch
Clematis paniculata	Cl
Coprosma propinqua var latiuscula	Cp
Coprosma robusta	Cr
Coprosma rotundifolia	Rt
Fuchsia excorticata	Fu
Hoheria angustifolia	Ho
Dacrycarpus dacrydioides (Kahikatea)	Ka
*Leptinella dioica**	Lp
*Luzula rufa**	Lu
Melicytus ramiflorus (Māhoe)	Ma
Muehlenbeckia australis	Mu
Parsonsia heterophylla	Pa
Pittosporum obcordatum	Pi
*Poa imbecilla**	Po
Pseudopanax arboreus	Ps
*Ranunculus reflexus**	Ra
Sophora microphylla	So
Podocarpus totara (Tōtara)	To

Table 4.5 Health Observation Key, a subjective observation grade given to the health of the plant. (3) was average, where no appreciable change in growth height was observed over time since the time of planting. Where a plant was observed to have died back, or was less than average growth, it was deemed to be (2), and if dead then (1). These were the "no-growth" category plants. Growth category plants included: (4) where there were signs of growth and above the average, (5) very healthy and robust plants, being a better than average growth, and (6) being an exceptional growth spurt in the given time.

Health Observation	Description pertaining to growth height
6	Extra-ordinary growth
5	Very healthy and robust
4	Above average, some signs of growth
3	Average (no growth)
2	Less than average growth
1	Dead

General observations included conditions that may have affected the plant during the growth period and resulted in a singular appearance for a particular plant (Table 4.6). An example would be a die-back (db) event followed by new growth (ng) becoming visible. Other observations included events that may have occurred adjacent to the plant, such as adjacent seedling emergence. Below is a sample of observations. This more detailed subjective observation was useful particularly with respect to the establishment history of weaker plants, which later showed signs of recovery. Plant recoveries are covered in the results chapter 5.4.3. Records and observations of the visible history during establishment, may also be useful in future planning work, where inclusion of more diverse species may be a challenge. By understanding their individual history, plants that may be slow to establish could well make worthwhile contributions to a project as a whole, and should not be discounted as a species choice. A total of 94 different types of comments were made in the field to build up the establishment picture. These additional local observations will form part of a knowledge sharing with the Little River community and the Wairewa Rūnanga community at a later date.

Table 4.6 A sample of comments made in the field when observing the growth and health of plants, with an abbreviation and associated description. Not only detrimental health effects were noted, but also cases where sudden growth spurts had occurred, where dormancy seemed likely, where robust flowering occurred in some species, and where seedlings emerged adjacent to different species. A collection of 94 field comments, some used more than once, built up a local establishment plant history which can aid in future local project planning.

Comments Field	Description	Additional explanation
fr	frosted off	
fr, db	frosted, and die back	frosted (browned leaves) and die back, tips of branches looking dead
fr, ng	frosted, but with new growth appearing	
fr,sick	frosted and looking sick	
br	browned off	browned off but still alive
br, ?dead	browned off, possibly dead	
br,ng	browned off, but has new growth	
eaten	eaten	
healthy	healthy	
sick	sick	
recovery	plant was knoocked back but recovered with new growth.	plant has second set of growth measurements from recovery time
db	die back	
db, ng	dieback, new growth	
db excess weeds	die back due to excess weeds	due to excess weeds and shading/choking rather than say climatic reason
db, recovery	die back, followed by recovery	
db, eaten at root	db, eaten at root	die back at top, but root area appeared eaten (probably by insects) not climatic cause of death
fl	flowering	
fl, eaten	flowering, but being eaten	
spray	spray damage	

A visual description was assigned to each plant, of where it was in relation to degrees of open ground, shaded ground, a fringe shaded plant, or in sheltered ground, (Table 4.7). Starting with a plant being in full, deep shade (5), a number was then given to medium shade (2). The fringe numbers, described a plant placed exactly on the fringe of adjacent foliage. By giving a top, bottom, left and right fringe, we are later able to link this fringe aspect with site orientation. This more detailed analysis is not covered in this thesis. Numbers (2, 3, 4, 5, 6, and 7) are considered shaded locations for the purpose of this thesis. Number (1) is full open location and also considered “exposed”. Plot 6 was mostly in this category. Number (8) is an open location, but within 1m of shelter, Number (9) is an open location within 2m of shelter, (e.g. *Carex secta* sheltering *Dacrycarpus dacrydioides*, within 1m was (8), or a fence sheltering a plant species such as *Clematis paniculata* but otherwise an open or unshaded area, (8).

Table 4.7 Key to position of each recorded plant in relation to an open, shaded or sheltered position. This key also noted the positions to the right or left (fringe) of a study plant relative to an existing tree or shrub, and aided in the orientation data for every plant.

Field Number	Description
1	Open
2	Medium shade
3	Fringe bottom
4	Fringe left
5	Full shade
6	Fringe right
7	Fringe top
8	Open but sheltered + 1m
9	Open but sheltered +2m

Cultural descriptions are given in appendix A.11, which include: The scientific name, the species abbreviation, description of each species’ habit, (e.g. shrub, climber, ground cover), the likely location of where found in nature, the deciduous status, and the position or placement of the species in relation to the slope in the study

4.3.1 Geophysical data

The geophysical data included:

i) Aspect (Table 4.8). This was ascertained on site. A GPS logger was trialled, but when the data was entered into the computer the margin for error was too variable particularly in respect to height above sea level. Consequently a compass, tape measure and level were used to construct a more accurate site map to understand the slope of each site and the true relationship of contours for each site in respect to each other.

Table 4.8 Key to aspect of each plot.

Plot Number	Aspect	Survival rate %
Plot 1	N	96.4
Plot 2	NE	90.4
Plot 3	E	83.1
Plot 4	W	91.5
Plot 5	NE	84.1
Plot 6	E	80.5
Plot 7	N	89.0

ii) Light levels. A Fisheye lens was initially used to photograph the light/shade level above each plant. However as two attempts were unsuccessful to achieve consistent data results and objective scale was used instead. (Table 4.7). This measurement was related to the plant itself, and how close it was to shelter or shade, or situated in more open ground. At the same time this measurement took aspect into account as we measured a shade fringe location left/right, top or bottom, which then gave a reading as to which direction the plant was shaded or sheltered from.

4.3.2 Emerging seedlings

Naturally emerging seedlings were noted and in some cases photographed as they were observed during the height measurement recording rounds. Appendix B, Plates 8-15 show some examples of seedling emergence.

4.3.3 Photography

Photographic records were taken at intervals throughout the year. Subjects of note were: plants that were frosted off, had a browned off appearance, new growth, dieback but otherwise healthy, evidence of insect, rabbit or rat damage, phenomenal growth, evidence of recovery following unhealthy appearance, the tallest plants in the study and overall timeline pictures. (A selection of some of these photos are shown in Appendix B. The photographic study will form part of an educational opportunity for the Wairewa Rūnanga in their later planning of further projects, as part of the Vision Mātauranga knowledge sharing process.

4.4 Data Analysis

For Table 5.3, and Figures 5.5 and 5.8: Means of plant survivorship and growth were graphed using Excel and differences in plant health and growth between plots, species and shade were investigated using one-way analysis of variance (ANOVA) followed by post-hoc Tukey test (Minitab). A two-way ANOVA was used to determine the differences and interactions in plant survivorship between plots and species.

All other statistical analysis and graphical representation was carried out using Minitab® (V 17.2.1) and Sigma Plot (V 12.3). A chi-square test for independence was used to test whether growth form of the plant and herbivory affected plant mortality. Soil and plant health data were analysed using one-way Analysis of Variance (ANOVA) with post-hoc Tukey HSD tests. No data transformation could be found for soil ammonium therefore a Kruskal-Wallis test was used to assess differences between plots.

Chapter 5

Results

5.1 Introduction

The following results include:

i) A comparison of the numbers of plant species introduced into the project, how many of these were Rongoā Māori species, and how many of the species were in each common or uncommon category,

ii) The performance of the plants, in terms of health, growth, height, and consistency,

iii) The plant establishment, survival rates, failures and recoveries,

iv) How geophysical influences such as light, and shade, shelter, aspect, overhead vegetation, soil, slope placement affected either the plants themselves or the species type,

v) Results relevant to ground cover species and naturally emerging seedlings.

5.2 Comparison of Numbers

5.2.1 Additional Species

The number of plant species new to the area was doubled. Fourteen plant species were present overhead, two more species were nearby. Twenty-one plant species were in the trial, and sixteen of these species were new to the study area. (The selection of plant species type was covered in Chapter 3, and Table 3.1)

5.2.2 Species used in Rongoā Māori

Rongoā Māori plant species were included and survived successfully. Seventeen out of twenty-one plant species had medicinal healing properties: these species being used in Rongoā Māori. In the main group of plants for study, this was made up of fifteen known medicinal plants, one not recorded as medicinal (*Carex secta*) and one unknown but likely (*Pittosporum obcordatum*) medicinal plant. Of the ground cover species, two species had known medicinal properties, one not recorded as such, and *Leptinella dioica* was an unknown although other *Leptinella* species may have medicinal uses. When looking at the sum of the health status of all the plant species together, in (Figure 5.5) it can be seen that representatives of all species used in Rongoā Māori medicine had survived. Although some species had more health status than others, there were no Rongoā Māori species that did not survive at all. The performance of each plant species appeared to be influenced by other factors such as light or shade, rather than Rongoā, medicinal status.

5.2.3 Common/ Uncommon Species

There were 697 plants in total including ground cover species which were made up of: 140 plants, Rare, Uncommon (C), 101 plants Less common (B), 104 plants, uncommonly planted (A*), Together these categories made up 345 Plants. There were a total of 353 Common plants (A, Table 3.2 and 3.3).

Looking at two groups of plant species and categories of rarity status, (Table 5.1), the ratio of group 1 (Rare Plants, (C) Less Common, (B) Common Plants but not commonly available in nurseries, (A*) in relation to group 2 (Common plants (A)), was 49.6:51.4, which was almost equal. There was an equal survival of Group One, (82.8%) in relation to Group Two, (82.7%. Plants that were in the "Common but not available' Category A*, had greater losses. The majority of the losses were attributed to the ground cover species, covered in chapter 5.6 (Ground cover). Contributions to failure included: position on the slope, open ground, frost stress, lack of light from weed smother, and inadvertent weed spray. (Plant failures are covered in chapter 5.4.2). Rare plants in the (C) category had a 96% survival rate. Note: There were no ground cover species in the (C) category.

Table 5.1 A comparison of the survival of two groups of plants. Group 1 (Uncommon Plants) includes the categories of Rare Plants (C), Less Common Plants, (B), and Common Plants but not available in nurseries, (A*). Group 2 is Common Plants (A). This table includes the numbers of all the plant species, including ground cover species. The % Survival of Group One is 82.8 %, and Group Two, 82.7 %. The greatest plant losses occurred with those plants in the (A*) category, (Common but not available in nurseries), the majority of which were ground cover species.

Uncommon, Common Comparison Survival				
	Category	**% Survived**	**% Dead**	**Total Plants**
Group One				
Rare Plants	C	96.4	3.6	140
Less Common Plants	B	85.0	15.0	100
Common Plants, but not available	A*	62.5	37.5	104
Group one results		**82.8**	**17.2**	**344**
Group Two				
Common Plants	A	**82.7**	**17.3**	**353**
Results groups 1 & 2		82.8	17.2	**697**

5.3 Performance

Section 5.2 looked at the groups of plants and categories and how the chosen rare, or less common plants, and culturally useful plants might contribute to an increase in diversity, especially where it could be shown they could establish as well as common plants might, given favourable circumstances. This section looks more closely at the species type themselves, and plant performance comparisons have been made in several categories:

- Survival rates
- Health status
- Growth
- Failures and recoveries
- Geophysical influences, e.g. light, shade and shelter

Results were variable when considering the tallest, healthiest and most consistently performing plants. The plants themselves, and the plant species types that grew the most over the 15 months of measurement, were not the same as the healthiest species type, or the individual plant that had the highest health status. Later in Chapter 5, Table 5.8 demonstrates consistency: the tallest, the greatest growth difference in 15 months, the healthiest and weakest, the least growth and deaths and the most consistent (consistently healthy with no deaths, and in both sun and shade). For example, the tallest growing individuals of a species represented in the trees and shrubs category (Table 5.9), were *Hoheria angustifolia, Coprosma robusta,* and *Pseudopanax arboreus.* The species that had the highest number of health status 6 category was *Hoheria angustifolia*. Where *Pseudopanax arboreus* was in a sheltered position, this species type achieved a high health status, tall growth, but it failed in open positions. *Pittosporum obcordatum* performed consistently well in all shade or open conditions, with no plant failures and consistent growth.

Note: Some of the following tables divide separate ground cover results from the trees and shrubs results. From a practical point of view, comparing likely plant choices for future field projects would concentrate on shrubs and trees, whereas the ground covers may serve a purpose for hosting emerging seedlings.

5.3.1 Survival Rates

Out of 577 plants in the main body of study, 507 survived leading to an 87.9% survival rate after 15 months of study (70 died, Table 5.2). This figure dropped with the inclusion of the ground cover species to 82.9 % survival, for a total of 697 plants.

Table 5.2 Survival rates per plot for trees and shrubs (17 species), 577 plants. GLs refers to ground level plants (ground cover species)

Plot No.	Plant No's per Plot	Deaths	Survival	% Rate Survival
Plot 1	83	3	80	96.4
Plot 2	83	8	75	90.4
Plot 3	83	14	69	83.1
Plot 4	82	7	75	91.5
Plot 5	82	13	69	84.1
Plot 6	82	16	66	80.5
Plot 7	82	9	73	89.0
Average % Survival Rate (Trees,shrubs, etc, no GL's				87.9

Plant survivorship was influenced significantly by plot and species and the interaction of both (P<0.001, Table 5.3). Plot 3 had less over-head cover and was more open in the mid layers, and Plot 6 was an open, (fully exposed to sunlight) location, with no over-head cover. While Plot 7 was in an open location, also with no over-head cover, there were no ground cover species in this plot, as with rampant exotic grass species present it was considered the risk of loss during establishment was too great. In plots 1-6, the ground-cover species were included and contributed to the higher loss figure in these plots. Plant failures are covered in the following chapter 5.4.1.

Table 5.3 Results of a two-way ANOVA assessing differences in plant survivorship when influenced by plot, species and interactions of both.

	DF	F-Value	*P*-Value
Plot	6	7.66	<0.001
Species	16	17.24	<0.001
Plot*Species	96	2.56	<0.001

When considering the survival rates per plot, plant placement appeared to make a difference amongst some species. *Fuchsia excorticata,* and *Pseudopanax arboreus* did better in more sheltered areas. Light, shade or shelter also made a difference between some species, but not overall per plot, and aspect appeared to have no appreciable effect on the survival rate per plot.

Plot 1 had the best overall performance based on growth rates, health observations, and overall survival rates per plot (Figure 5.1). Note excluding ground covers

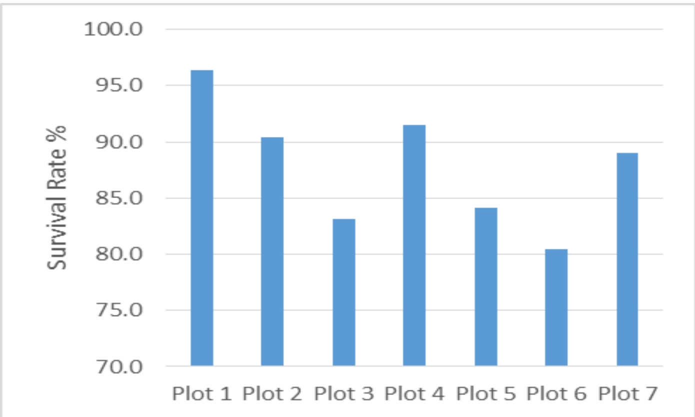


Figure 5.1 Survival rates per plot for all above ground plants in each plot, exclusive of ground cover plants.

5.3.2 Plot Soil Data and Plant Mortality

Soil nitrate was not statistically different in any of the plots (Figure 1). Plot 7 had the lowest soil available ammonium ($F_{(6, 31)}$=3.50, p<0.01, Figure 1) and soil moisture ($F_{(6, 31)}$=5.82, p<0.001, Figure 1).

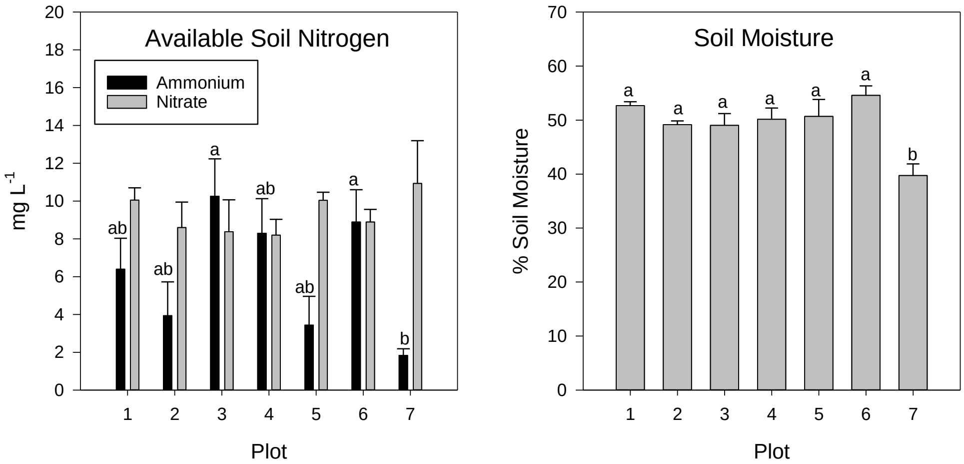


Figure 5.2 Soil available nitrogen and soil moisture in each plot. There is a statistical difference where means do not share a letter ($p<0.05$). No letters denote no difference.

5.3.3 Plant Health

During field data collection, a subjective health status was given to each of the 697 plants. Plant health was objectively measured where 1= dead, 2 = less than average growth, 3 = average (no discernible growth over the study period), 4 = above average, and showing some signs of growth, 5 = very healthy and robust, 6= exceptional or extra-ordinary growth. In all categories there was little difference between uncommon or common plant species.

Observed growth, (above average 4, very good, 5, and exceptional growth, 6), returned excellent results with 170 plants in Group One, and 181 plants in Group Two, a total of 351 plants being in robust health after 15 months in the ground. (Table 5.4). The ratios between each groups one and two were similar, both for observed health above average categories, health average and below average, and the number of deaths, Survival and plant losses are covered in Chapter 5.4.

Table 5.4 Comparison of health observation for all 697 plants, including ground cover species. Health above average includes observation 4, 5 & 6. Health below average include 3 & 2. Dead plants were in category 1. (See Table 4.5 for health observation categories). The two groups were: Group One, (Uncommon Plants) includes the categories of Rare Plants (C), Less Common Plants, (B), and Common Plants which may not be available in nurseries, (A*). Group 2 is Common Plants (A).

Health Observation: Numbers per category. (All Plants, including ground cover species)						
		Health above average	**Health average & below**	**Survival Total**	**Dead Totals**	**Total Plants**
Group One						
Rare plants	C	86	49	135	5	140
Less common	B	55	30	85	15	100
Common but not available	A*	29	36	65	39	104
		170	**115**	285	**59**	**344**
Group Two						
Common	A	**181**	**111**	292	**61**	**353**
Total Plants		**351**	**226**	577	**120**	**697**

Hoheria angustifolia (Ho), *Clematis paniculata*, (Cl), and *Parsonsia heterophylla* (Pa), were the top three out of eleven species observed to have had extra-ordinary growth. (Table 5.5). Sixteen species, including one individual *Fuchsia excorticata*, were included in health observations (4, 5, and 6) showing growth over time, a total of 351 plants.

Table 5.5 Plant species and numbers of plant within each species type, with a health observation of (6), being an extra-ordinary growth observation over 15 months.

Species Description	Abbreviation	Plant numbers
Hoheria angustifolia	Ho	7
Clematis paniculata	Cl	6
Parsonsia heterophylla	Pa	6
Carex secta	Ca	2
Pseudopanax arboreus	Ps	2
Podocarpus totara	To	2
Carmichaelia australis	Ch	1
Coprosma propinqua var *latiuscula*	Cp	1
Coprosma robusta	Cr	1
Muehlenbeckia astonii	Mu	1
Coprosma rotundifolia	Rt	1

Rarity categories: The rarer, less commonly planted plants did as well as the common plants. When the plants were divided into rarity status, A, common, and B, C and A*, less common, there was a non-linear statistical difference between plants rarity and health classification. Common and locally rare plants had the highest mean health rating above average whilst those which were not readily available in nurseries (A*) showed lower average health ratings ($F_{(3, 693)}$=9.78, *p*<0.001.) (Figure 5.3).

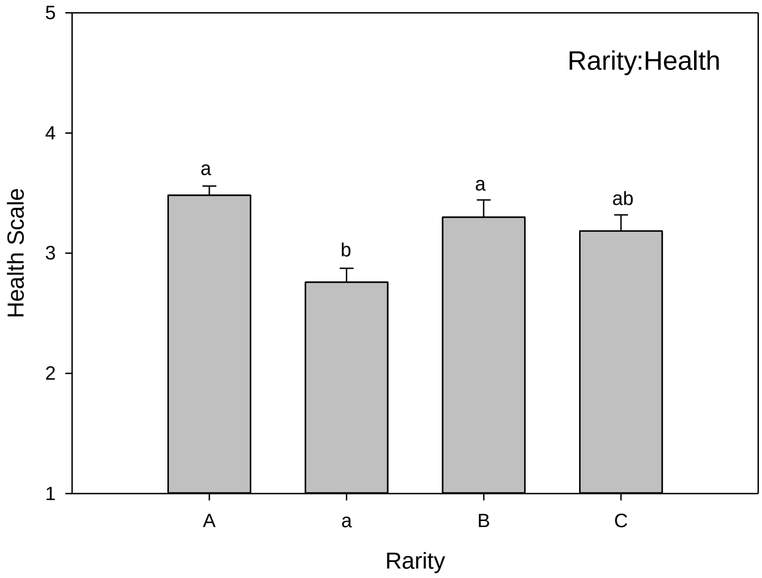


Figure 5.3 The health of plants was assigned a score with 1=dead, 2= less than average, 3=average/no growth, 4=some signs of growth, 5= very healthy and robust, 6=extraordinary growth. The graphs show the mean (±SEM) health rating in the different rarity categories. (A = common, "a" above (elsewhere A*) = common, but not readily found in nurseries, B = less common, C = locally rare. Means that do not share a letter are statistically different (p<0.05).

The average health rating does not reflect the survivorship nature of the four species in this category A* (Shown as "a" in Figure 5.3). Table 5.6 gives an example of the variable nature of the category A* species trialled. *Melicytus ramiflorus* was knocked back during the establishment period, made full recovery and had 100% survival. *Coprosma rotundifolia* had two deaths, but new growth on all remaining plants. *Fuchsia excorticata* had 17, deaths, *Pseudopanax arboreus* 21, with most of their health rating falling into the 1, 2, 3 categories ranging from dead to less than average growth. In all cases there were individuals represented in the 4, 5 and 6 category. *Fuchsia excorticata* is a deciduous plant and *Pseudopanax arboreus* has larger leaves than most other plants in the study. The individuals of these species that survived displayed good growth. (Table 5.6). This research was looking at the practical outcome of including the selected range of species in local community planting in the future, and the result of survival, rather than survivorship traits.

Table 5.6 The four category A* plant demonstrating the variable traits of each species. *Melicytus ramiflorus* had 100% survival. *Coprosma rotundifolia* had few losses and one individual reached a height of 900 mm. For *Pseudopanax arboreus* and *Fuchsia excorticata* most losses occurred in the open and exposed locations, but both these species had an individual that reached an above average height: *Pseudopanax arboreus* to 1450 mm and *Fuchsia excorticata* to 450 mm.

Species Name	Number of test species	No. survival	N.o deaths	Survival %	Tallest individual mm	No. of recovery	Rarity	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	TOTAL deeaths/plot	Open	Fringe	Shaaade	TOTAL deaths / shade category
Melicytus ramiflorus	35	35	0	100.0	700	35	A*								0				0
Coprosma rotundifolia	18	16	2	88.9	900		A*		1	1					2		1	1	2
Pseudopanax arboreus	35	18	17	51.4	1450		A*		2	4		3	4	4	17	15	2		17
Fuchsia excorticata	35	14	21	40.0	550	14	A*		2	3	4	4	5	3	21	19	1	1	21
								0	5	8	4	7	9	7	40	34	4	2	40

5.3.4 Plant Mortality and Herbivory

Total survival rate of all plants was 82.9%. When separated into growth form, survival rate was above 78% for all growth forms apart from the ground forbs which experienced a 36% loss (X^2_4=46.741, p<0.001, Table 5.7). Survival rates were lowest in the two ground forb species (*Leptinella dioica* and *Ranunculus reflexus*), the low stature monocot species *Poa imbecilla* and *Luzula rufa*, the tree species *Fuchsia excorticata* and *Pseudopanax arboreus* and the shrub *Coprosma robusta* (X^2_{20}=210.332, p<0.001, Table 1).

There was no statistical difference in herbivory levels within each plot. Herbivory was highest amongst the climbers and lowest for the monocots (X^2_4=46.36, p<0.001, Table 1). Both climbers received herbivory on >25% of the plants in the investigation. There was no association between herbivory and mortality (X^2_1=2.806, *p=0.094*)

Note: This section looks at comparison between growth forms. In other parts of this thesis, the ground level, (GL's) plants were grouped and planted together as a cluster (*Leptinella dioica*, *Ranunculus reflexus, Poa imbecilla* and *Luzula rufa*.)

Table 5.7 Percentage mortality and the number of dead plants at the end of the experiment in each species and each growth form type. Growth form was based on mean potential height at five years.

Species	Max. Growth Height (m)	% Mortality	% Herbi-vory	Species	Max. Growth Height (m)	% Mortality	% Herbi-vory
Monocots		***14***	***0.8***	***Shrubs***		***9***	***10***
A. grandis	2	6	0	*C. australis*	3	9	26
C. secta	1.5	0	0	*C. propinqua*	4	6	6
L. rufa	0.3	20	3	*C. robusta*	4	31	17
P. imbecilla	0.5	33	0	*M. ramiflorus*	8	0	0
				M. astonii	2	6	0
Trees		***21***	***6***	*P. obcordatum*	8	0	10
F. excorticata	6	60	11	*C. rotundifolia*	5	11	11
H. angustifolia	6	6	3	***Ground Forbs***		***53***	***5***
D. dacrydioides	6	9	0	*L. dioica*	0.3	27	0
P. arboreus	6	43	9	*R. reflexus*	0.3	80	10
S. microphylla	8	6	9	***Climbers***		***3***	***30***
P. totara	15	0	6	*P. heterophylla*	>5	3	26
				C. paniculata	>5	3	34

5.3.5 Plant Health: Growth Form

Plant health rating followed a similar pattern to mortality with climbers having the highest health rating and ground forbs having the lowest ($F_{(4, 692)}$=26.19, p<0.001, Figure 5.4). Most trees and shrubs had a health rating of average or above with the exception of *Fuchsia excorticata, Pseudopanax arboreus* and *Carmichaelia australis*. The ground forbs and two low growing monocots (*Poa imbecilla* and *Luzula rufa*) were also below average.

The two climbers showed good growth even after some initial set-backs due to herbivory.

In Figure 5.4, the hatched and cross hatched bars representing less common and locally rare plants indicated performances equally as good the solid hatched bars for common plants. The exception was the performance of the two species *Pseudopanax arboreus* (Ps) and *Fuchsia excorticata* (Fu), both being common plant species seen readily throughout the Little River catchment area, but had lower than average health scores in this study.

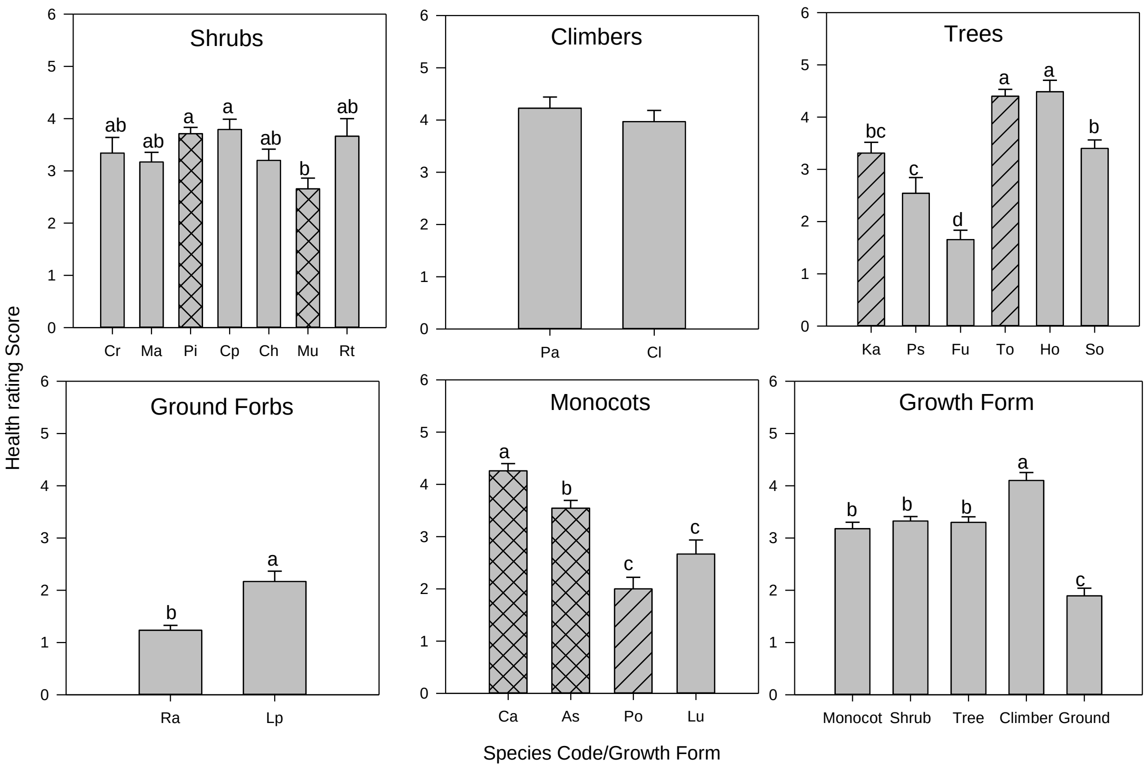


Figure 5.4 Mean plant health rating (±SEM) for each species and growth form. Means that not share same letters are significantly different and no letter denotes no significance (p<0.05). Solid bars represent common species, hatched bars are those which are less common and cross hatched are those which are locally rare.

Another way of looking at plant species with overall higher health observations than others, is to look at the sum of their health observations, (Figure 5.5). However it should be noted that *Coprosma rotundifolia* (Rt) was only represented by 18 species and the other plants by 35 of each, except for *Coprosma propinqua* var. *latiuscula* (Cp) which had 34. Two tree species: *Hoheria angustifolia*, (Ho) and *Podocarpus totara* (To) had the highest health scores (75% and 73% respectively) and *Fuchsia excorticata* had the lowest with 28% ($F_{16,560}$=12.90; P<0.001). *Pittosporum obcordatum* (Pi), the third tallest tree species, was a consistent performer. (Reasonable growth and all plants survived). The two low ground species, *Carex secta* (Ca), and *Astelia grandis* (As), both scored highly, and the climbers *Parsonsia heterophylla*, (Pa), and *Clematis paniculata*, (Cl). Figure 5.5 does not portray situations where some species had both good and bad performance (e.g. *Fuchsia excorticata*, (Fu) and *Pseudopanax arboreus,* (Ps). All species had some plants which were represented in good growth, and these included Rongoā Māori species (5.2.2) and species in both the uncommon and common categories. (5.2.3)

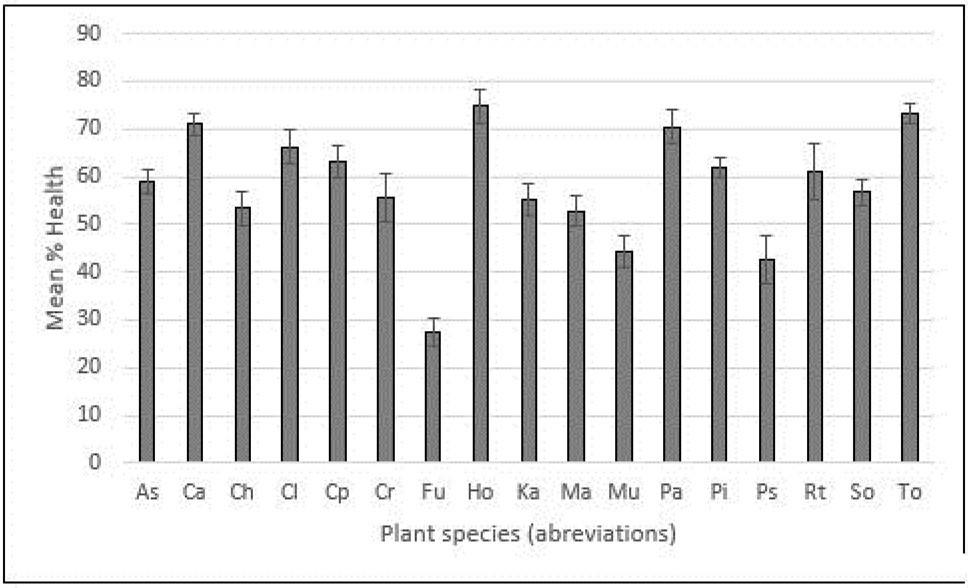


Figure 5.5 A health observation comparison of 17 study species (trees shrubs and climbers, not including ground cover species), based on percentage of best possible health per species. The best scoring tree species were: *Hoheria angustifolia*, (Ho) and *Podocarpus totara* (To). The shrub *Coprosma rotundifolia* (Rt) also scored highly. The two low ground species, *Carex secta* (Ca), and *Astelia grandis* (As), both scored highly, as well as the climbers *Parsonsia heterophylla*, (Pa), and *Clematis paniculata*, (Cl).

5.4 Plant Growth

5.4.1 Plant Growth

The plants were put in the ground at the end of April 2016. The height differences of all the plants were observed in June 2017 (beginning of winter) and September 2017 (end of spring beginning go of summer). Each plant was also observed for signs of developing buds or new leaf growth. Figure 5.6 shows the average growth in height during the previous twelve months to either June 2017, or to September 2017 in each plot. This was helpful to observe losses during winter or recovery during spring. The highest growth in June 2017 was recorded in both plots 1 and 7 with the lowest in plot 6 ($F_{16, 560}=2.69$; $P<0.014$). However, the lowest growth in September 2017 was recorded in plot 7 which was statistically different to the growth in plot 1 which remained high ($F_{16, 560}=2.56$; $P<0.018$). Plant failure and recoveries are discussed in chapter 5.5. Plot 1 was sheltered during winter and there were few losses due to frost. Plot 7 was exposed during winter and frost sensitive plants suffered setbacks and later either loss or recovery. Plot 6 was open and mostly exposed.

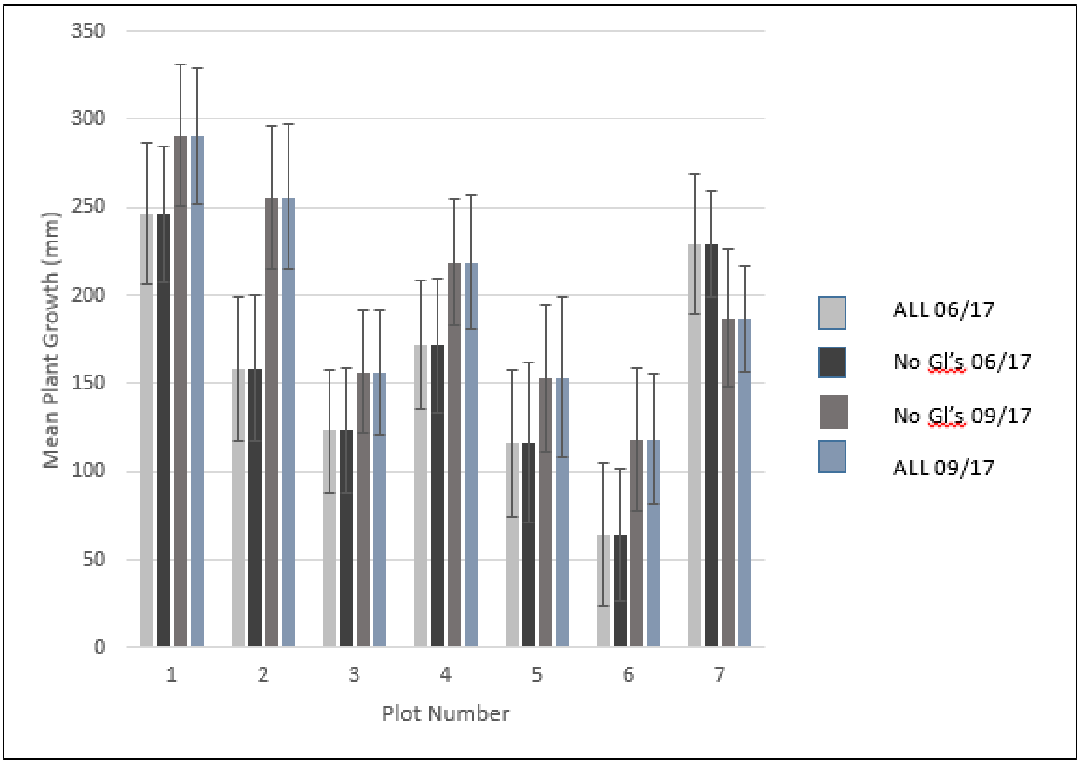


Figure 5.6 Average growth per plot, plots 1-7. Example, Plot 1. Bars from the left: i) all plants measured June 2017, ii) plants except GL's measured June 2017, iii) all plants measured September 2017, iv) plants except GL's measured Sept 2017.

Comparing plots 1-7 in Figure 5.6, the average growth height per species excluding deaths, for the species in the main body of study shows a range of growth during the establishment period. Figures 5.6 and 5.7 do not include ground-cover species. In Figure 5.7 the top six species showing the greatest difference in height in September 2018 were: *Carex secta,* (Ca), *Parsonsia heterophylla,* (Pa), *Hoheria angustifolia,* (Ho), *Coprosma robusta*, (Cr), *Clematis paniculata,* (Cl), and *Coprosma propinqua* var. *latiuscula* (Cp). Of the plants that survived in the study species, *Fuchsia excorticata, Pseudopanax arboreus, Melicytus ramiflorus* and *Coprosma rotundifolia,* some good growth in height was observed. *Sophora microphylla* and *Carmichaelia australis* were observed to have had a mixed result in growth height in the field, being subject to browsing and a slow growth habit.

It is worth noting that average differences in height do not take into account good height differences where the conditions were favourable for growth, against deaths where the conditions were unfavourable. *Fuchsia excorticata* and *Pseudopanax arboreus* both had good growth, especially where they were in sheltered positions, but in Figure 5.4, mean health rating, these species indicated a poor performance overall. (Both these two species are not commonly sold in Canterbury Nurseries for local revegetation projects.)

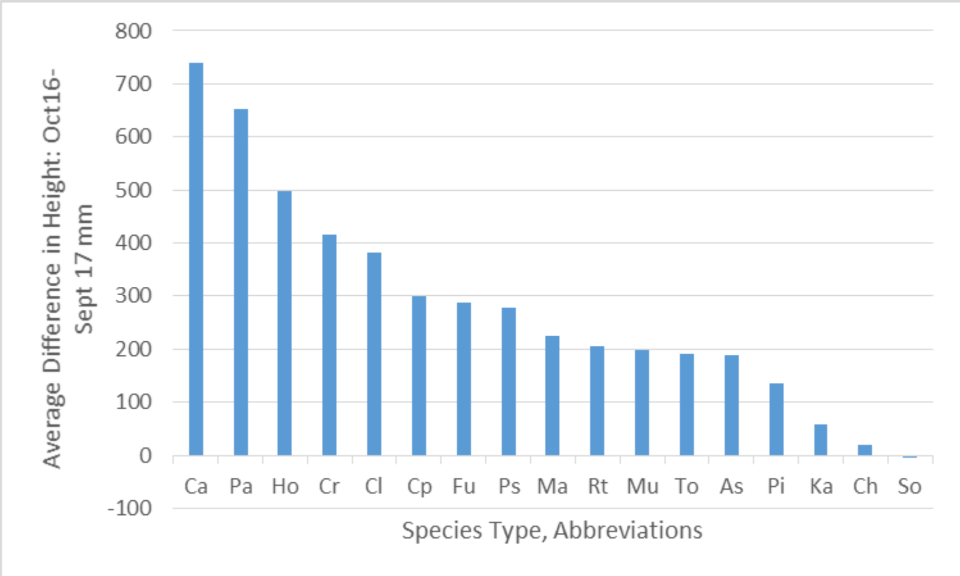


Figure 5.7 Average growth height per species excluding deaths, for the species in the main body of study. (Excludes ground-cover species).

Most plants were observed to have new growth. The following table (Table 5.8) demonstrates that while some species may have suffered set-backs, death or slow upward height growth, at the beginning of the second spring after two winters, there was a consistent show of emerging buds or new leaf tips. *Podocarpus totara, Carex secta* and *Pittosporum obcordatum* all had new growth, and 100% survival. Surviving individuals in the lower scoring species *Pseudopanax arboreus* and *Fuchsia excorticata* had a high percentage of new growth, (Table 8.5) while only 9 out of 32 surviving *Dacrycarpus dacrydioides* showed new growth, and while this species had a high survival rate, the overall health ratings and new growth rating, was low.

Table 5.8 When combining % survival, and % possible new growth, the order in which the different species can be evaluated is changed. Within each species represented in the study, new growth, (e.g. leaf tips or buds) has been observed. Of note is the rare category (C) *Pittosporum obcordatum* showing overall consistency in establishment with 100% survival, and 97% new growth observed.

Species Name	Number of test species	No. survival	N.o deaths	Survival %	No. of recovery	Newgrowth oct17	% poss new growth (exd. dead plants)	Combined percent survival & possible newgrowth	Rarity
Podocarpus totara	35	35	0	100.00		**35**	**100.00**	**100.00**	B
Clematis paniculata	35	34	1	97.14		**34**	**100.00**	**98.57**	A
Carex secta	35	35	0	100.00		**34**	**97.14**	**98.57**	C
Pittosporum obcordatum	35	35	0	100.00		**34**	**97.14**	**98.57**	C
Hoheria angustifolia	35	33	2	94.29		**33**	**100.00**	**97.14**	A
Parsonsia heterophylla	35	34	1	97.14		**33**	**97.06**	**97.10**	A
Melicytus ramiflorus	35	35	0	100.00	35	**32**	**91.43**	**95.71**	A*
Coprosma propinqua var latiuscula Allen	34	32	2	94.12		**31**	**96.88**	**95.50**	A
Coprosma rotundifolia	18	16	2	88.89		**16**	**100.00**	**94.44**	A*
Astelia grandis	35	33	2	94.29		**31**	**93.94**	**94.11**	C
Sophora microphylla	35	33	2	94.29		**31**	**93.94**	**94.11**	A
Carmichaelia australis	35	32	3	91.43		**25**	**78.13**	**84.78**	A
Muehlenbeckia astonii	35	33	2	94.29		**22**	**66.67**	**80.48**	C
Coprosma robusta	35	24	11	68.57		**22**	**91.67**	**80.12**	A
Pseudopanax arboreus	35	18	17	51.43		**17**	**94.44**	**72.94**	A*
Dacrycarpus dacrydioides	35	32	3	91.43		**9**	**28.13**	**59.78**	B
Fuchsia excorticata	35	13	21	37.14	14	**10**	**76.92**	**57.03**	A*

Table 5.9 List of plant species in the main body of study, (exclusive of ground cover plants) with the tallest height measured in September 2017. Note *Coprosma robusta, Pseudopanax arboreus*, and *Fuchsia excorticata* show good growth where conditions have been favourable.

Scientific Name	Height (mm) - Tallest individual Sept-17
Parsonsia heterophylla	1800
Clematis paniculata	1700
Carex secta	1600
Hoheria angustifolia	1600
Coprosma robusta	1460
Pseudopanax arboreus	1450
Podocarpus totara	1100
Sophora microphylla	1000
Coprosma rotundifolia	900
Coprosma propinqua var latiuscula A	850
Carmichaelia australis	850
Muehlenbeckia astonii	840
Pittosporum obcordatum	810
Melicytus ramiflorus	700
Astelia grandis	690
Dacrycarpus dacrydioides	650
Fuchsia excorticata	550

When looked at together, the results show variation in "performance": Plant species that showed capability of good growth measurement, Table 5.9, and species that were subject to losses, Table 5.10.

For example, *Coprosma robusta* (Cr) had 11 deaths, but also was amongst the tallest plants measured. In Plot 1, *Pseudopanax arboreus* (Ps) recorded a height of 890mm. *Pseudopanax arboreus* deaths occurred in open locations. The tallest growing *Pseudopanax arboreus* in Plot 1 occurred where the plant was sheltered between an existing *Podocarpus totara* to the west and a *Kunzea ericoides* to the east. In plot 2, two *Pseudopanax arboreus* were measured at 900mm and 1000mm respectively, all *Pseudopanax arboreus* in plot two had been subject to knock back: three individuals lived and two died.

Although *Parsonsia heterophylla* had 1 death, and was regularly eaten throughout the study, it still accounted for 11 out of 35 plants being in the top twenty greatest growth difference plants.

The following chapter looks more closely at plant losses.

5.5 Plant Failures and Recoveries

5.5.1 Plant Failures

The species with the most deaths were: *Fuchsia excorticata* (22), *Pseudopanax arboreus* (17) *Coprosma robusta* (11), a (Table 5.10). Thereafter the numbers dropped to: *Carmichaelia australis* and *Dacrycarpus dacrydioides*, (3), *Coprosma propinqua* var. *latiuscula*, *Hoheria angustifolia*, *Muehlenbeckia astonii, Coprosma rotundifolia*, *Sophora microphylla* and *Astelia grandis* (all 2), and lastly only one death (1) for *Clematis paniculata* and *Parsonsia heterophylla*. All other plant species types survived. (Ground cover figures are not included in this statement as they are treated separately.)

Table 5.10 Plant species losses, numbers of losses in descending order (exclusive of ground cover species). *Fuchsia excorticata* had the most losses. *Coprosma robusta* had 11 losses, but this species was also amongst the top twenty best growth species. Four species had no losses.

Scientific Name	Abbrev.	Number
Deaths		
Fuchsia excorticata	Fu	22
Pseudopanax arboreus	Ps	17
Coprosma robusta	Cr	11
Dacrycarpus dacrydioides	Ka	3
Carmichaelia australis	Ch	3
Coprosma propinqua var *latiuscula* Allen	Cp	2
Hoheria angustifolia	Ho	2
Muehlenbeckia australis	Mu	2
Astelia grandis	As	2
Coprosma rotundifolia	Rt	2
Sophora microphylla	So	2
Clematis paniculata	Cl	1
Parsonsia heterophylla	Pa	1
		70
No Deaths		
Carex secta	Ca	0
Melicytus ramiflorus	Ma	0
Pittosporum obcordatum	Pi	0
Podocarpus totara	To	0

During data collection in the field, subjective comments on which plants were failing, or had failed, were added to the collected information. These descriptive observations helped to give an overall picture of how the failures occurred over the establishment time. For example the information included whether: the plant had failed early on, had begun to fail, recovered and died later, had been affected by summer dryness (browned off) or winter frosts, (frosted off), had been damaged by rodents, rabbits, or insects, had flowered but later died, or in cases where new growth had been observed, the plant either recovered or later died. If there was no apparent reason for failure this was also noted, as well as if the plant was subject to lack of light due to long grass, was ring-barked, or lost due to accidental spray damage. The month when the most plant failures were recorded occurred was January 2017 with 40 failures, followed by June 2017 with 7 failures. September, October, and December 2017 had only 2 or 3 failures per month. Examples of plant failure observations in the field during data collection, can be found in Appendix A.12

5.5.2 Plant Recoveries

Over 70 plants showed signs of failure followed by signs of new growth and recovery in the early stages of establishment. The months when the most recovery occurred was October 2016, followed by November 2016. The species with the most dieback and recovery were*: Fuchsia excorticata,* (Fu)*,* *Melicytus ramiflorus,* (Ma), and *Pseudopanax arboreus* (Ps).

Examples of the recoveries of two species *Fuchsia excorticata* (Fu) and *Melicytus ramiflorus* (Ma) are shown in Table 5.11. The first *Fuchsia excorticata* in the row, in Plot 3, (Unique ID = 3Fu1) shows an initial reading of 170mm in June 2016, but by November 2016 the original single stalk had no foliage, but did show signs of new growth to a height of 20 mm. This particular plant (3Fu1) later did not survive. Also in Plot 3, the third *Fuchsia excorticata* in the row, (3Fu3) showed similar recovery and signs of new growth, and went on to grow to a height of 600mm before winter in June 2017, and was measured at 500mm after winter in September 2017. Looking at Table 5.11, we can observe the story for this particular *Fuchsia excorticata* (3Fu3), where in the first comment column the observation was recorded "fr" frosted off, later showed signs of having been "eaten" then "shaded", "eaten" again, and then evidence of "n.g. - new growth" in the spring.

Melicytus ramiflorus (Ma) behaved similarly. In Plot 2, the *Melicytus ramiflorus*, first in the row, Unique ID. (2Ma1) was observed in November 2016 to have a bare original stalk but new growth was present. For 2Ma1 the height of the original single stalk was 520mm, the new growth measurement was 40mm. and 2Ma1 established successfully over the winter and reached a height of 500mm in September 2017. The appearance of the *Melicytus ramiflorus* plants that grew in this manner with new growth were bushy with several stalks per plant. 2Ma4 has a comment "*Coprosma robusta*" which indicated the presence of naturally emerging *Coprosma robusta* seedlings adjacent to it.

Table 5.11 Recovery examples *Fuchsia excorticata* (Fu) Plot 3, and *Melicytus ramiflorus* (Ma). By following the progress of 3Fu3 (third row down) we can see it was frosted and died back, had new shoots that were measured, was eaten, shaded, eaten some more, had new growth, but still managed to reach a height of 500mm at the end of the measuring period.

Species Type	I.D.	Height 06-16	Comment 06-16	Height 07-16	Height 10-16	Recovery 10-16	Comment 10- 16	Height 11-16	Recovery 11-16	Comment 11-16	Height 01-17	Comment 01-17	Height 06-17	Comment 06-17	Height 09/17	Comment 09-17	Health Status 6-17	New Growth	Open / shade
Fuchsia excorticata	3Fu1	170		150	0	**20**	ng	0		eaten	0		0	dead	0		1	0	1
Fuchsia excorticata	3Fu2	190		183	30	**10**		0		pic	0		0	dead	0		1	0	1
Fuchsia excorticata	**3Fu3**	**220**	**fr**	**151**	**110**	**40**		**110**	**90**	**eaten**	**340**	**shaded**	**600**	**eaten**	**500**	**ng**	5	1	3
Fuchsia excorticata	3Fu4	200	fr	145	115	**40**		110	**30**	fr	100		300		300		2	0	1
Fuchsia excorticata	3Fu5	200	fr	175	115	**15**		110	**10**	ng	0		0		0		1	0	1
Melicytus ramiflorus	**2Ma1**	**520**		**500**	**440**	**40**	**fr, ng**	**500**	**140**		**350**		**450**		**500**		**5**	1	3
Melicytus ramiflorus	2Ma2	500		510	447	**40**	fr, ng	500	**120**		420		350		400		4	1	5
Melicytus ramiflorus	2Ma3	430		430	440		fr	400	**40**		300		350		300		3	1	8
Melicytus ramiflorus	2Ma4	460		460	460	**90**	fr, ng	480	**230**		400		500		600	Cop. rob	5	1	2
Melicytus ramiflorus	2Ma5	460		440	447		fr	460	**110**		240		300		400	ng	3	1	2

5.5.3 Open, Shade/Shelter

The plant species for this study did not do as well in open and exposed locations as those in shaded or fringe locations. Plants that were in open locations, but subject to shelter by neighbouring trees, shrubs or fences, survived better than those plants solely in open or exposed locations (Figure 5.8).

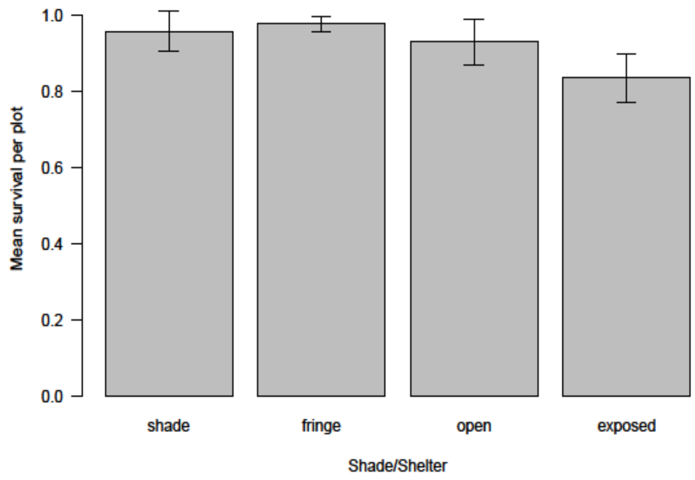


Figure 5.8 Mean survival of plants in each plot relative to the amount of shade and shelter.

This figure mirrors results shown in Figure 5.3 where plot 7 was an exposed site where many plants suffered mortality or reduced growth during winter. Other sites, even open plots were under the shelter of nearby vegetation.

Table 4.7 described the visual location of each plant placed in respect to shade, fringe shade and shelter, or open location with either a fully exposed open location, or an open location which was within 1m, or 2m of a shelter influence.

Overall, fringe locations were the preferred plant placement location for growth, and open exposed locations, resulted in the most plant losses, particularly for frost tender species in winter, or species unable to compete with exotic grass weed competition in summer.

Pittosporum obcordatum grew consistently in all locations, regardless of shade conditions. *Hoheria angustifolia* had good growth in all locations except where it was in full shade, where one plant died. As previously outlined, *Pseudopanax arboreus*, *Fuchsia excorticata, Dacrycarpus dacrydioides* and *Coprosma robusta* all had failures in open areas, but grew well in fringe locations.

5.5.4 Aspect

From the base line of planting (Line 1) in the low area, a compass bearing gave an orientation of each plot as follows.

Plots 1 and 7	faced North,
Plot 2 and Plot 5	faced North East.
Plot 3 and 6	faced NNE, close to East,
Plot 4	faced West.

There appeared to be no relationship between plant losses and aspect with respect to plot position Figure 5.9 shows survival rate /plot, with an associated compass heading. As the site had semi-mature existing vegetation, the study plants came under the influence of the existing overhead or adjacent foliage, or the open nature of the ground area, rather than which way the 70m x 10m plot was facing with respect to North.

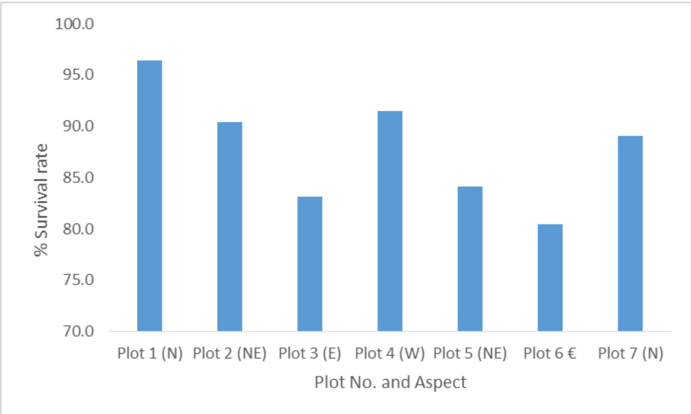


Figure 5.9 Survival rate per plot, exclusive of ground cover plants). Plot 1 had the highest survival rate, 96.4% while the open plot 6 had the least at 89%

5.5.5 Canopy Differences / Overhead Vegetation

While data was recorded of the precise nature of the overhead vegetation for each plot, no analyses was made of the individual performance of each plant under each overhead species type. The overhead vegetation and canopy was treated as a general cover, and a general influence over the plants as a group per plot. The vegetation type formed part of the desk study research, and was one of the influences in the selection process of plant species to be introduced.

The overhead canopy had some influence on seedling emergence, in that some plots were easier to keep weed free under and close to the existing canopy. Natural seedlings tended to emerge in these locations.

5.6 Ground Cover Results:

The conditions in Plot 1 were the most conducive for survival of the ground cover species.

Plots 3 and 6 were subject to high growing exotic grass during the study period and experienced the most losses. *Ranunculus reflexus* had the highest number of failures. All the ground cover species were initially planted from a Tikau pot size (100mm x100mm) with a plant spread width/height of minimum 100mm. After 15 months of establishment the greatest spread for *Leptinella dioica* was 1m wide in understorey situations and very little or no spread in long grass.

In all cases in plots 1-5 naturally emerging seedlings were observed amongst some of the ground cover clusters. In particular three species seemed to like the cluster ground cover conditions. They were *Hoheria angustifolia, Coprosma robusta* and *Veronica strictissima.*

The ground cover species were planted at the beginning of winter in May 2016 at the same time as the other plant species. They were recorded throughout the following spring summer and autumn, and the final recording was taken at the end of the winter, beginning of spring. During observations and plant data recordings, two species, *Poa imbecilla* and *Ranunculus reflexus* i) had not survived over the study period or ii) had not shown fresh seed emergence after winter even if they had shown seedling emergence during the previous summer.

Appendix B, Plates 8-15 have examples of both numerous and cluster group naturally emerging seedlings.

In Table 5.12 below, it can be seen that *Luzula rufa* had the highest survivorship, and *Ranunculus reflexus* the most deaths. The deaths of the ground cover species mostly occurred in 6, which was the most open location. During summer, it was difficult to control the exotic grasses in the open spaces during that time, and consequently the ground cover clusters became shaded by the long grass, and died. Other group deaths were caused by accidental spray damage. The ground cover species had good growth under or at the fringe of the existing vegetation, and harboured natural seedlings in a number of cases.

During the study period *Ranunculus reflexus* and *Poa imbecilla* seedlings were observed.

Leptinella dioica had the greatest spread measurement of 790 mm in Plot 2.

Table 5.12 Ground cover species percentage survival per ground cover species.

Scientific Name	Deaths	Survival	Total Plants	% Survival
Leptinella dioica	8	22	30	73.3
Luzula	6	24	30	80.0
Poa imbecilla	11	19	30	63.3
Ranunculus	24	6	30	20.0

Ranunculus reflexus recorded the most deaths, *Luzula rufa* had the least deaths. *Leptinella dioica* measured the greatest spread. Plot 1 &5 had the best survival. Plot 6 had the most deaths (Table 5.13).

Table 5.13 Number of deaths per plot for the ground cover species.

Scientific Name	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Total deaths
Leptinella dioica	0	1	2	1	0	4	8
Luzula rufa	0	1	1	0	0	4	6
Poa imbecilla	2	2	1	2	0	4	11
Ranunculus hirta	3	3	4	4	5	5	24
Deaths/Plot	**5**	**7**	**8**	**7**	**5**	**17**	**49**

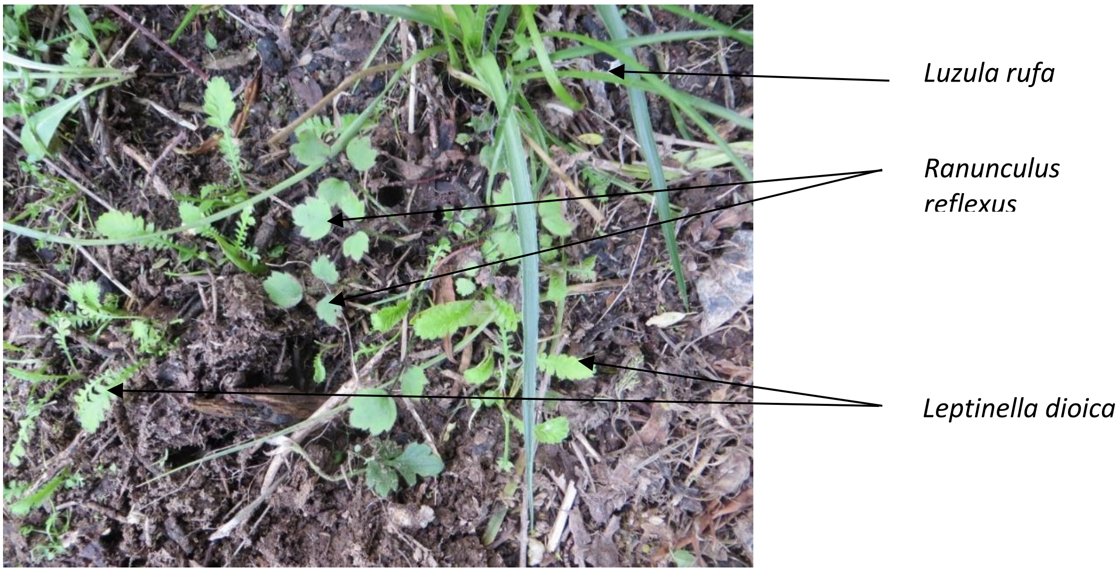


Plate 4.1 Groundcover cluster showing *Luzula rufa* (top right), *Leptinella dioica* (centre) and four *Ranunculus reflexus* seedlings (centre).

5.7 Emerging Seedlings

Natural seedlings did appear within the test study plot sites. The seedlings were numerous and favoured the cleared areas under foliage, and in the protection of the ground cover clusters. By comparison only two seedlings were seen to emerge on the non-managed areas over the whole 15 months' study.

The seedling species observed throughout the study period within the plots sites were as follows:

Hoheria angustifolia and *Plagianthus regius* seedlings in mixed groupings, more than 250 and less than 300.
Coprosma robusta, between 30 and 40
Veronica strictissima, less than 5
Veronica salicifolia, one seedling observed and survived.
Coprosma propinqua, 5 seedlings were observed emerging at stages throughout the study, but none survived and were likely eaten.
Sophora microphylla, 2 seedlings observed but also did not survive.
Kunzea ericoides, 1 seedling observed but did not survive
Poa imbecilla and *Ranunculus reflexus*, (Appendix B, Plate 13) numbers not recorded.

In the 5 pegged sites which were unmanaged in any way, only three naturally emerging *Coprosma robusta* seedlings were seen throughout the 15 month period. These seedlings were situated in an area opposite Plot I, and underneath *Veronica salicifolia* and *Hoheria angustifolia*.

5.8 Photographic Record

A large number of photographs were taken throughout the year, and it is hoped that they will contribute in education and knowledge sharing with the Wairewa tangata whenua (local people) and the local community. The photographs included pictures of insect activity around the study plants, which could be linked to future research with second-stage restoration in observing increased biodiversity and additional plant species.

The photographs in appendix B cover four main topics: i) plant recoveries and successes, ii) numerous seedling observed, iii) seedlings in smaller numbers and groups, iv) low ground and *Astelia grandis* failure, and v) and miscellaneous observations of plant species with potential for inclusion in future projects.

Of special note are the pictures of *Melicytus ramiflorus* and *Fuchsia excorticata* and *Pseudopanax arboreus* and *Coprosma robusta*. All the study plants of *Melicytus ramiflorus* survived, many after a die back and recovery period. The next three species had the highest number of deaths (21, 17 and 11 respectively). *Fuchsia excorticata* and *Pseudopanax arboreus* both had die back events and new growth events, but all of these species are represented in healthy, robust and well grown specimens in locations where conditions were favourable for these species, i.e. with a little shelter, semi shade and no grass competition.

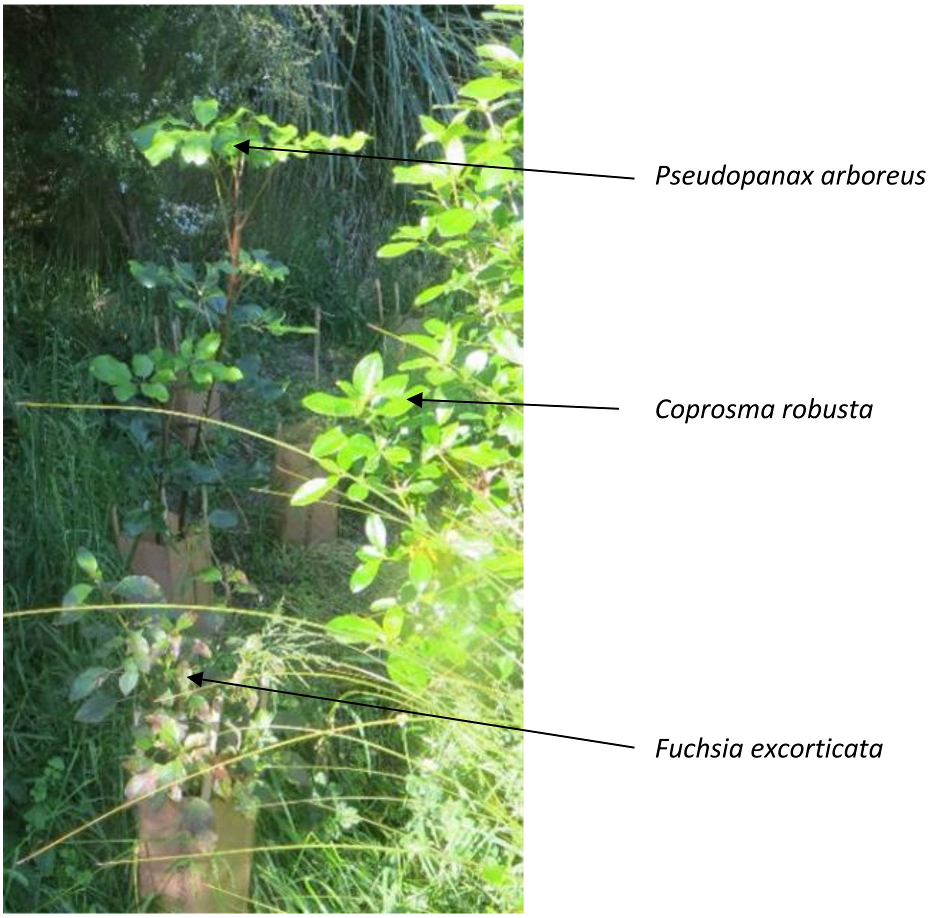


Plate 5.1. This group of two category A* and one category A plants shows good growth in all three species in this favourable sheltered and semi-shaded location. The three species are: *Fuchsia excorticata* bottom left, and *Pseudopanax arboreus* top left, in category A*, (plants that were considered not readily available in local nurseries and not commonly planted in projects) and *Coprosma robusta*, right, category A, (plants commonly found to be present on Bank's peninsula. (Wilson 2013).

5.9 Survival Precis

Table 5.11 is a precis of all the plant species, and is arranged according to survival, with the top four species showing full survival (no deaths). These four species include *Melicytus ramiflorus*, which was subject to die-back and recovery events, *Pittosporum obcordatum*, a threatened species category plant, and *Podocarpus totara* and *Coprosma rotundifolia*. Note: None of these species were in the common category (A).

Table 5.14 Plant Species Precis: Rarity, Survival & Comment

Scientific name	Number	Rarity	Survived	Deaths	Re-coveries	
Melicytus ramiflorus	35	A*	35	0	Yes	All survived, after knock backs, recoveries, and then good growth
Pittosporum obcordatum	35	C	35	0		Overall top consistent performer. Survived in all locations, open shade and consistent growth
Podocarpus totara	35	B	35	0		Consistent growth. All plants survived. Fringe location preferred
Coprosma rotundifolia	17	A*	17	0		All plants survived.Surprising: survived in the open.
Astelia grandis	35	C	34	1		All survived except one, probably due to flood/wet lying area. Note all were in open ground at bottom of slope. This plant would prefer shade but it was not possible in this study due to the design layout. It did however get the benefit of the shelter from the existing vegetation from 1-5 m distant from the actual plants.
Clematis paniculata	35	A	34	1		Some diebacks, but also among the top twenty highest growing plants
Parsonsia heterophylla	35	A	34	1	Yes	Robust growth, in spite of being eaten by rabbits at times
Sophora microphylla	35	A	34	1		Slow steady growth. One death,often eaten by rabbits
Carex secta	35	C	33	2		*Carex secta* had excellent growth. Sick plant in the flood spot, tallest in the damp spots
Coprosma propinqua var.latiuscula	35	A	33	2		Slow to start. Growth occurred towards end of measurement period
Hoheria angustifolia	35	A	33	2		Overall good growth, one died in the shade, one in long grass
Muehlenbeckia astonii	35	C	33	2		Deaths occurred from long grass and shade. Slow to establish
Carmichaelia australis	35	A	32	3		Flowered during summer. Deaths from long grass comepetition
Dacrycarpus dacrydioides	35	B	29	6		Some knock backs in open areas especially susceptible to frost. Surprisingly the *Carex secta* in the open space sheltered the young *Dacrycarpus dacrydioides* enough to allow healthy plants nestled in behind them to flourish. Good learning for plant placement in the future
Luzula rufa	30	A	24	6		*Luzula rufa* had the least deaths. Contributed to seedling emergence in ground-cover clusters
Leptinella dioica	30	A	22	8		Measured the greatest spread. Contributed to seedling emergence in ground-cover clusters
Coprosma robusta	35	A	24	11		High number of deaths in open locations. One of the tallest plants measured, and all robust growth in favourable locations.
Poa imbecilla	30	B	19	11		Contributed to seedling emergence in ground-cover clusters. Preferred drier location and no weed competition
Pseudopanax arboreus	35	A*	18	17	Yes	Knock backs, recovery, deaths and the among tallest recorded heights, s grew robustly in favourable conditions
Fuchsia excorticata	35	A*	14	21	Yes	All plants flourished in favourable locations. Deaths occurred in open locations
Ranunculus reflexus	30	A	6	24		Most deaths, mostly in long grass. Seedlings were observed. Preferred shady open location

Chapter 6

Synopsis and Overall Conclusions

6.1 Synopsis

In this study, research and planning were important in the selection of native plant species that would increase diversity within the existing revegetation project. Having constructed a database of local flora (on iNaturalist 2015) and prepared lists of suitable plants for selection, 21 species were selected for planting. These included species used in Rongoā Māori healing, plants of cultural significance, and some species that are locally rare or are rarely planted in local revegetation or restoration projects. The 21 plant species doubled the species present in the existing study site.

<u>Objective One</u> *was to engage in a desk study which included research into the background not only of the catchment of Te Roto o Wairewa /Lake Forsyth, but also the floral history, as well as to understand risks, establishment and survival issues, and strategies for reducing those risks*.

Over 100 native plant species were found to be present in the catchment area, from which the 21 species were selected for study. Species were selected from categories that included differing rarity status, i.e. common, less common, locally rare, and plants not commonly planted in local revegetation projects or readily available for sale at local nurseries. (Appendix A.3 has a full description of the common, uncommon categories

In order to promote the successful establishment of the chosen species, it was important to understand and mitigate the likely risks during the establishment period. Risks included understanding the cultural requirements of the plants, preferred site conditions, appropriate method of planting, protection, after-care, and environmental stressors likely to occur. The selected study site was situated on a river terrace adjacent to the Ōkana stream and considered to pose the least risk to plant establishment of all the sites offered for study by the Wairewa tangata whenua. The principal risks at this site were considered to be damage by flood, and competition from exotic grasses within the study area.

During the sourcing process of plant selection, some species were not offered for sale in local nurseries. Consequently, *Coprosma rotundifolia* and all the ground cover species (*Leptinella dioica*, *Poa imbecilla*, *Ranunculus reflexus*, and *Luzula rufa*) were propagated by the author at the Lincoln University Nursery,

The requirements for creating conditions that encouraged the natural emergence of seedlings necessitated a program pre-planting of knock-down of the exotic grasses. This was achieved through weed-spraying and using a weed-eater during the 5 months before planting. Also high grass at bases of trees and shrubs were hand weeded. For example, exposing clear ground for seedlings to emerge without weed competition, resulted in *Coprosma propinqua* seedlings to appear underneath the existing *Coprosma propinqua*, whereas previously with exotic grasses rising to over 1m there was no sign of seedling activity.

The strategies involved to reduce risks, was the sum of small parts, each step contributing to the whole. Risks were reduced by: choosing the site with the most likelihood of plant survival, selecting plant species suitable for the terrain, and complimentary to the existing overhead cover. Plants were selected where the author had previous experience in handling some of the rarer or uncommon species except for *Pittosporum obcordatum*, which was an unknown, and not previously planted in a study or in large numbers in a restoration project in Canterbury. The study site was pre- prepared over 5 months with the knock-down of exotic weeds. The 697plants selected for planting were individually inspected prior to planting, and each chosen to have as high a quality as possible. There were constraints in some cases, notably *Fuchsia excorticata* and *Melicytus ramiflorus*, where a smaller grade than optimum preference was planted, but the planted grade was uniform with the other plants in the study. The choice of healthy plants, with single leader where required or bushy nature if required was an example of a small step taken to reduce risk of failure during plant establishment. Other risk reduction included planting techniques on site, water in the bottom of the hole to provide moist tilth, and the construction of a protective sleeve, Combiguard, with a wool mat at the base of the plant with designated stout and 600mm stakes to anchor the protective sleeve in the case of flood. The protective sleeve also gave partial protection against rabbits, and the colour orange aided in identification during weed maintenance occasions.

<u>Objective Two</u> *was to underplant the existing vegetation with a wider selection of plant species to enhance the local biodiversity. This was achieved by doubling the existing plant species and by including Rongoa Māori plant species*.

In objective one above, the research into the plant selection resulted in a site selection and a plant species selection. As 14 native species were identified as already being on site, with another 2 species nearby, the total existing species either overhead or adjacent to our field study, were 16 species. Of the 21 species selected for the study, 16 of these species would be newly introduced into the area, thereby doubling the species diversity as a future plant community. The plant types of the 21 study species included: above ground and taller growing plants being trees, shrubs, climbers, one monocot and one sedge, (577 plants in total), as well as four ground cover species, (120 plants in total). Seventeen out of the twenty-one species had acknowledged Rongoa Māori status.

Objective Three *was to investigate specific conditions that would enhance and progress the existing semi-mature vegetation was achieved through i) creating conditions and spaces that allowed natural seedlings to occur, and ii) and allowing the selected species of both uncommon, rare and Rongoa Māori species to be successfully planted in the understorey*.

Even though the study period was short, the establishment phase is well known to be most critical phase of ecological restoration. I was able to study these species during their early establishment period to better understand the cultural conditions each species best favoured in our given second-stage restoration study area. By comparing our prepared and managed study sites against the unmanaged areas it was apparent that seedling emergence occurred in the managed areas and not in the unmanaged areas.

6.2 Overall Conclusions

Understanding and designing a successful second stage restoration project was greatly enhanced through the desk study. Three points stand out from the literature review:

i) that increasing species diversity is a global issue, in response to a worldwide decline in biodiversity and eco-system services. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2018) is currently addressing issues such as threats and opportunities for biodiversity and strategies for attaining a sustainable future.

ii) the importance of identifying the reasons for decline in wild populations, identifying the conditions supporting population growth at the chosen recipient sites followed by longer-term monitoring and reporting of reintroduced populations. By understanding failure, decline and risks, monitoring and records become tools to aid in planning for targeted outcomes, particularly in re-introductions, or increase in species range.

iii) being as specific as possible about the desired outcome and meaning of “success”, and that an outcome could include acknowledgement of “failures” in order that risks may be understood in the planning process.

In order to achieve successful establishment, it was important to understand the likely risks during the establishment period. Risks included understanding the cultural requirements of the plants themselves, the site conditions preferred, the method of planting, protection and after-care, and environmental stressors likely to occur. The selection of more uncommon species were successfully planted in the understorey, and natural seedlings emerged in the plots where early site preparation had left clear ground spaces.

There were a total of 697 plants in the study. 577 were made up of shrubs, trees and climbers, and 120 were made up of ground cover species. Choosing rare or uncommon plants species, or Rongoā Māori plant species appeared to have little effect on overall performance. The statistical analyses of rarity status shown in Figures 5.3 and 5.4 indicated that the rarer plant groups chosen compared favourably with the more common plants, and could be considered for inclusion in second stage restoration planting.

Plant health varied, with the highest deaths being *Fuchsia excorticata* (21), *Pseudopanax arboreus* (17), *Coprosma robusta*, (11) and *Dacrycarpus dacrydioides,* (6). However all of these species showed healthy robust growth in locations which were sheltered and with partial light afforded by the existing vegetation. One *Coprosma robusta* plant grew to a height of almost 1.5m over the 15 month study period. Both *Melicytus ramiflorus* and *Fuchsia excorticata* had die-back and new growth events, and *Melicytus ramiflorus* recorded a full 100% survival after 15 months. The tallest *Fuchsia excorticata* reached 600mm, even after a die back event, and showing evidence at times of being eaten (probably by rabbits). This gives rise to the supposition that given favourable conditions in which to establish, all the species chosen for the study, including those with lesser survival rates, have the potential to be useful contributors to second stage restoration.

Comparing the consistency of performance of the 21 species returned an unexpected result. The most consistent species, in terms of regular growth, no deaths, number of specimens in the "5" health category (robust growth, better than above average) or "4' category, (above average growth), was *Pittosporum obcordatum*. *Pittosporum obcordatum* is a plant species in the rarity status "C" category (Wilson 2013) being considered "rare" on Bank's Peninsula and is characterised as a Nationally Threatened status (NZPCN 2012) and in this study all plants of this species survived. Apart from one plant which showed signs of being "eaten" during summer, and only regained a height of 400mm at the end of the recording period, all other heights recorded were between 550mm and 810mm, giving an average height at the end of 15 months of 640mm. *Podocarpus totara* also performed well overall, with no deaths. *Pittosporum obcordatum* measured from 400-820 mm, with only 6 plants under 600mm in September 2017, whereas *Podocarpus totara* measured 300-1100mm, with 11 plants measuring under 600mm, hence *Pittosporum obcordatum*, was given the highest overall rating for consistency. *Podocarpus totara* (B category) was a close second, followed by *Hoheria angustifolia* (A), (good growth but two deaths), *Coprosma rotundifolia*, an A* category plant had full survival, with the highest plant growing to 900mm, and the rest of the *Coprosma rotundifol*ia species had an average height in September 2017 of 408mm. The top 4 performing plant species were represented in all rarity status categories, and as such all could be beneficial inclusions in adding to plant diversity in second stage projects.

In terms of plant survival rates, out of 577 plants in the main body of study, 507 survived leading to an 87.9% survival rate after 15 months of study (70 died). This figure dropped with the inclusion of the ground cover species to 82.9 % survival, for a total of 697 plants. In the more open plots, with less shelter, the survival rate was lower. Plants that were frost-tender, or are naturally found in shady conditions did less well in the open areas. It was not possible to control the long grass at all times during the study. Consequently in the open areas, the ground cover plant species tended to fail due to the grass competition, especially in Plot 6 (the open and exposed plot) and the open spaces in Plot 3.

The photographic record included pictures of *Melicytus ramiflorus, Fuchsia excorticata* and *Pseudopanax arboreus,* which were in all in the category A* group, (plants that are not readily available in local nurseries and not commonly planted in local projects), and also pictures of *Coprosma robusta* which was in category A, (plants commonly found to be present on Bank's Peninsula, (Wilson 2013). I think the photographic record shows, that if category A* species were to be placed in suitable locations within a second-stage restoration, they could enhance the biodiversity of the project, and in my opinion, should not be discounted as a plant species choice in the planning process.

The overhead canopy had some influence on seedling emergence, in that some plots were easier to keep weed free under and close to the existing canopy. Natural seedlings tended to emerge in these locations. The two most prevalent locations for natural seedling emergence were: i) the most numerous clusters of seedling occurred at the Plot 4 location, under *Hoheria angustifolia*, *Plagianthus regius,* (Appendix B, Plates 8-10) and in the lee side of *Coprosma robusta* (prevailing wind was Norwest), and ii) on all plots 1-6 where the ground cover clusters were influenced by shelter or overhead vegetation. (Appendix B, Plates 11-15) (Note nearly all ground cover species did not survive in competition with the exotic long grass in the open area.) The numerous seedling patches tended to being solely *Hoheria angustifolia* and *Plagianthus regius*. The ground cover clusters fostered mainly *Coprosma robusta, Coprosma propinqua, Veronica strictissima, Veronica* *salicifolia, Poa imbecilla,* and *Ranunculus reflexus*. The benefits of a well prepared area in which to allow emergent seedlings to flourish, compared to fallow areas, was apparent. Only three emerging seedlings were identified in the unmanaged area against several hundred in the managed plots.

By progressing the establishment of plant species to increase local plant diversity it was hoped that results from this study would contribute to an outcome of raising awareness in future revegetation and restoration planning, both in the local community and in particular for the Wairewa tangata whenua at Little River and in the catchment areas of Te Roto o Wairewa / Lake Forsyth. This future expectation relates directly back to the concept of “Takiwā”, the significant connection between people and place, acknowledged before the commencement of this research. Each of the other six sites proffered by the Wairewa Rūnanga representatives for study, (Appendix, A.4) has significant potential for future development, particularly including plant species used in Rongoā Māori and of particular cultural significance.

6.3 Recommendations for future research:

Three areas of potential research relate to overcoming challenges of plant failures in Canterbury locations in practice:

i) Taking the idea of using cluster planting in ground cover plants a) dry ground species and b) damp ground species and using these as natural nursery areas to either encourage natural seedlings to occur among the cluster, or use the cluster species to shelter smaller growing species. This could be a practical way of adding diversity to a project when considering including threatened or more difficult to grow species in the plant community plan. An example could be: to plant a ground cover mix of *Leptinella* species, *Geranium sessiflforum*, *Poa imbecilla*, *Dichelacne crinita*, in order to foster *Muelenbeckia axillaris*, *Muehlenbeckia ephedroides* (at risk and declining, conservation status, NZPCN 2012-1) and other dryland divaricating plants or herbs.

ii) The second potential research area is the concept of whanaungatanga, (family, community, Appendix A.1) and giving credence to replicating plant associations and community groups that are seen in nature. A study could include: Planting specific plants in tandem, two plants together, close to each other. One example is *Prumnopitys taxifolia* (mataī) and *Melicytus ramiflorus* (māhoe). (Appendix B, Plate 17, two seedlings often seen growing together in nature. A second example, learning from this thesis study, by planting *Carex secta* and

Dacrycarpus dacrydioides (kahikatea) together at the same time, even though it the location was open with no overhead cover, the *Carex secta* grew at a faster rate which was sufficient to protect the *Dacrycarpus dacrydioides* whereas away from the shelter of the *Carex secta*, in open ground only 1m away, the *Dacrycarpus dacrydioides* failed. Planting the specific plant species in tandem could have useful practical application, not only in dryland areas such as Eyrewell (Canterbury Plains) but also in the damper situations such as riparian planning.

iii) Increasing planning potential towards plant establishment survival outcomes, by researching a selection of say thirty existing restoration projects in Canterbury, and assessing plant failures, as well as investigating contributors to plant failures. In order to plan against failure towards success, more information is required. By addressing plant losses, seen over a group of projects, it may be possible to discern a failure trend that could be arrested and improved, or a success trend that could be applied more generally in future planning.

6.4 Limitations of the study

My own critical evaluation of this study is based on the limitations of the species and of the site. For the species selection, a limited number of 21 species were chosen, resulting in a total of 697 plants, most of which were represented by 35 individuals. Cost and space were issues: a greater number of plants was not an option. A number of additional species were considered, with reference to the researched constructed lists of available plants, and included *Haloragis erecta, Griselinia littoralis* and *Rorippa palustris*. In the case of *Haloragis erecta,* insufficient plant material was propagated in time for the study. *Griselinia littoralis* was a plant species readily available in nurseries and was unlikely to provide a challenge. *Rorippa palustris* would have been a useful plant to include for the Little River catchment area being cultrually beneficial as a Rongoa Māori herb and natural remedy used for livelstock in organic agriculture, but the chosen site had unsuitable conditions to trial *Rorippa palustris.*

For the site location I had to take the best of seven sites on offer, evaluate the risks of plant survival, and undertake the study under an existing vegetation area. As second-stage restoration is a practical undertaking in-situ, it was not possible to create a perfect experimental design with true replicate sites.

Additional labour, and proximity to Lincoln University may also have aided in more practical site management during the 15 month establishment period. While pre-planting site management occurred to good effect, it was not always practically possible to attend a distant site in order to spray, weed control of long grass growth, and manicure the site on a regular basis especially during the summer months.

In retrospect it may have been better practice to put a wire cage around the ground cover species clusters, and mark the areas with a flagged stake, for easy identification. A few ground cover patches were lost due to weed control spray damage in the long grass conditions. Wire cages in pre-selected seedling-likely locations on other projects I engage in, result in naturally emerging seedlings within the cage area, which are then later useful for propagation (e.g. *Coprosma virescens*, Ohoka) or seed dispersal (e.g. *Gastrodia minor*, NZ native orchid, Ohoka). Wire cages for the ground cover clusters may have resulted in a higher survival rate of these species in the study.

In second-stage restoration, the practical application is sometimes to repair in order to progress. In critique of this study, the plant choice was not primarily aimed at repairing or complementing the existing vegetation, and as a result the overall river terrace diversity of species may be incomplete as a plant community. Rather in this , the aim was to introduce plants that were previously unlikely to be included in the project plan: species that included rare, nationally threatened, uncommon, uncommonly planted, as well as culturally significant species useful in Rongoa Māori, medicinal healing, and available for community education.

Overall, results from this research indicate that it would be worthwhile to include in proposed planting lists, species that have previously been considered harder to grow, and to increase the richness of the plant community on site for greater future benefits in biodiversity. With careful research, planning, and favourable placement, the uncommon plants were found to be just as likely to survive as the common plants in this study. For the Te Roto o Wairewa / Lake Forsyth catchment area and future Little River Community plantings, these findings could be practically applied, and are in keeping with the Vision Mātauranga goal: to envision knowledge, think about new ways of doing things, find answers, to solve problems, as well as to share knowledge gained.

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Appendix A

A.1 Plant list and Abbreviations

A full list of plant species with the scientific name and the associated abbreviation used during the data collection process.

Scientific Name	Abbreviation
Astelia grandis	As
Carex secta	Ca
Carmichaelia australis	Ch
Clematis paniculata	Cl
Coprosma propinqua var latiuscula	Cp
Coprosma robusta	Cr
Coprosma rotundifolia	Rt
Fuchsia excorticata	Fu
Hoheria angustifolia	Ho
Dacrycarpus dacrydioides (Kahikatea)	Ka
*Leptinella dioica**	Lp
*Luzula rufa**	Lu
Melicytus ramiflorus (Māhoe)	Ma
Muehlenbeckia australis	Mu
Parsonsia heterophylla	Pa
Pittosporum obcordatum	Pi
*Poa imbecilla**	Po
Pseudopanax arboreus	Ps
*Ranunculus reflexus**	Ra
Sophora microphylla	So
Podocarpus totara (Tōtara)	To

A.2 Māori English Definitions

Hau kāinga: Home, true home, local people of a *marae*, home people.[1]

Hapū: Kinship group, clan, tribe, subtribe - section of a large kinship group and the primary political unit in traditional Māori society. It consisted of a number of *whānau* sharing descent from a common ancestor, usually being named after the ancestor, but sometimes from an important event in the group's history. A number of related hapū usually shared adjacent territories forming a looser tribal federation (iwi). [1]

Hau kāinga hapū, referred to in this thesis are Ngāti Irakehu and Ngāti Makō, (sub-tribes of Ngāi Tahu), who are based at Little River and Te Roto o Wairewa / Lake Forsyth, [2]

Iwi: Extended kinship group, tribe, nation, people, nationality, race - often refers to a large group of people descended from a common ancestor and associated with a distinct territory.[1]

Kaitiakitanga: guardianship, stewardship, trusteeship, trustee. [1]

Mahinga (mahika) kai: In this thesis mahinga kai refers to Ngāi Tahu interests in traditional food and other natural resources and the places where those resources are obtained.[2, 3].

Marae: Courtyard - the open area in front of the wharenui, where formal greetings and discussions take place. Often also used to include the complex of buildings around the marae.[1]

Rongoā Māori: natural remedy, traditional treatment, Māori medicine.[1].

Rūnanga: A traditional Māori assembly or gathering.[1]

Tangata whenua: Local people, hosts, indigenous people - people born of the whenua, i.e. of the placenta and of the land where the people's ancestors have lived and where their placenta are buried.1

Whānau: Extended family, family group, a familiar term of address to a number of people -the primary economic unit of traditional Māori society. In the modern context the term is sometimes used to include friends who may not have any kinship ties to othermembers.[1]

[1] Māori English on-line dictionary. (2018). Retrieved from http://Māoridictionary.co.nz/

[2] http://ngaitahu.iwi.nz/ngai-tahu/the-settlement/settlement-offer/cultural-redress/ownership-and-control/mahinga-kai/

[3] Ngāi Tahu (1998), *Ngāi Tahu Claims Settlement Act* New Zealand Government, Wellington, New Zealand

A.3 Glossary of Terms Used

GL's: Ground level or ground cover plants. E.g. *Leptinella dioica*

A, B, C. Wilson (2012) categorises Banks Peninsula native vascular plants into three main types. These are "A", abundant to common, "B", more or less common, and "C", uncommon to rare, or very local. One more category "A* was added to allow for plants often common in the local landscape but which may not be readily available in local nurseries.

R Rongoā Māori, plants used in Māori traditional healing

New Zealand Conservation Status of Plants and Animals. An explanation of categories to better explain where the species *Notiomystis cincta* (stitchback) and *Philesturnus rufusater* (North Island saddleback), fit in to the NZ Conservation Status of Plants and Animals. (DOC 2016).

"Threatened Species"

Nationally Critical: most severely threatened, facing an immediate high risk of extinction

Nationally Endangered: facing high risk of extinction in the short term

Nationally Vulnerable: facing a risk of extinction in the medium term, e.g. *Notiomystis cincta,* (stitchback).

"At risk species"

Declining, population declining but still common
Relict, small population stabilised after declining

Naturally Uncommon, population is naturally small and, therefore, susceptible to harmful influences

Recovering, population is small but increasing after previously declining, e.g. *Philesturnus rufusater* (North Island saddleback))

A.4 Description of Sites 1-7

A full description of sites 1-7, including geographical locations, species of note nearby, historical relevance, potential risks as a study project, and comment on future interest.

Sites 1 and 2. The canal area at Birdling's Flat, and the low stony terraces at the lake edge nearby the New Brighton Boat club. The canal area had few local plant species, although the lake edge site had rushes, sedges, grasses ground cover species and shrubby divaricating plants, mostly *Muehlenbeckia complexa* and *Coprosma propinqua* var*. latiuscula* Allan. It is interesting to note however, that observations by the Canterbury Botanic Society, logged on the public website iNaturalist (iNaturalist: Project Lake Forsyth Wairewa 2015), showed that a number of rare lake edge species were present on the opposite shoreline. A potential goal of planting included the preservation and collection of rare species, with a view to husbandry and later replanting back into the existing landscape along the lake edge. *Muehlenbeckia ephedroides*, a regionally threatened plant species (Head & Given, 2001), is one such species found nearby on the stony terraces. A small test site with a mix of plant species, both locally successful and threatened, carefully managed could lead to increased seed sources which long term could colonise the lake edges and stony terraces. Documentation of management practice could aid in success or failure of the long term spread of these lost or dwindling species. However, both these sites were in exposed locations with unlimited public access. The lake edge was grazed and at the time there were no suitable areas to be fenced off to protect planting. These sites were discounted for immediate study.

Site 3. The spring and ditch area opposite the Little River Hotel was a section of the Christchurch to Little River Railtrail (Little River Railtrail 2009) which had been planted with native vegetation by the Department of Conservation some years previously. The survival of the existing plants had been patchy with about 60 % of the original material observed to be remaining. In a 500 m2 area only four naturally emerging seedlings were observed. This area was basically level, with productive soil, and with a small ditch running along one side to an overgrown spring. Potentially, naturally occurring low-growing streamside plants could be planted to aid water clarity around the spring There was also potential for plant species such as Rorippa palustris and other marsh/ditch plants or herbs, to be planted along the ditches to increase and become the fore-runners of medicinal planting either for local Rongoā (Māori cultural and medicinal plants) or for natural animal husbandry such as described in a report by Johnson & Perley (2015) for the Ngāi Tahu organic farm at Peraki. This site was discounted due to its high public access and risks of plant thefts. It was also discounted as this was Christchurch City Council land, not Ngāi Tahu Land, and further because of the existing level of plant losses. However, this site carried potential as a nursery area for Rongoā herbs.

Site 4. The stream edge of the Takeritawai River, also known as the Kakerikawai River. This site was subject to browsing by stock, with no plans for fencing during the study period. It was also heavily covered with exotic grasses and fallen willows. The plant loss risk was too high.

Site 5 This area became the primary site chosen for the study.

The aims of this project were to explore second stage revegetation sites, where more tender plants or more uncommon species that were once present in the landscape, could be introduced under the existing layer of planting, and also to include plant species known to be helpful in traditional medicinal or cultural uses. The area is fertile, situated on river terraces, bounded by the Okana stream and the main road to Akaroa SH75. The study area is situated between the Wairewa Rūnanga Marae and the Little River Township. The existing revegetation planting was approximately eight years old, and while it appeared that the plants may have been originally set at 1.5 m spacing (an observation based on current plant existence), there appeared to be many gaps, but overall an estimation of 50-65% plant survival in the original project was estimated. The existing vegetation had not been maintained in recent years, with an exotic grass growth up to 1 m high, which had smothered a number of plants. This site was chosen for its high public profile, being close to the Little River Township and the Wairewa Rūnanga Marae, and has future learning and teaching possibilities. It was nearby the local school. It was also fenced, is Ngāi Tahu owned land and did not have a great deal of public access so that it posed a lesser risk from plant thefts or vandalism. Although the grass was high, there was not too great an invasive weed issue although some *Convolvulus arvensis* was present in isolated patches.

The greatest risks were likely to be from browsing animals breaching the fence, and from occasional flooding. Historically floods had taken out some of the plants, but more damage had been done by the cattle that breached the fences after the flooding. Previous observation of and projects with combiguards performing well during flood situations (e.g. Coes Ford, Canterbury and Kakapo Bay, Marlborough) indicated well applied combiguards could protect plants and withstand limited occasional flooding. With a limited flood risk and not under threat from wandering stock this site posed the least risks overall, with the benefits of easy access, the greatest likelihood of plant success and a high public profile.

Site 6. The coastal streamside at Tumbledown Bay leading into the dune area. This site had previously been subject to intensive coastal planting with *Ficinia spiralis* (Pingao) (Christchurch City Council District Plan Tumbledown Bay) with about ten thousand plants being planted. There was a lot of possibility with this site potentially adding a selection of uncommon plants that would once have been naturally present. It also would have been possible to study a small streamside plot planted with Carex spp. and other sedges with a view to observation of regeneration and accelerated regeneration. The valley leading up from the dunes and into natural forest area, then to the summit of the Bossu Road had potential for many kinds of further study highlighting the plant community differences along the way. However this location was at a greater distance from Little River, access was by gravel road, and the main drawback was that cattle and livestock had free access to the area. It was also a public area and could pose vandalism or theft threats. Those plants which were existing apart from the Pingao, were very sparse, giving rise to concern on plant survival in the windy and dry summer conditions.

Site 7. The Magnet Bay farm area was a working organic farm but had a few natural revegetated areas that could provide the more uncommon plant material to be used in other study areas.

This special area was shown to us so we could keep in mind, knowledge, strategies and benefits that may arise from our study that could be useful in this Ngāi Tahu farm enterprise.

Two other sites are acknowledged that could benefit in the future from some preparatory research. Site i) the canal area. Site ii) Takeritawai outlet. Both these sites have extreme conditions, but long term, are available for restoration with natural plant species.

A.5 Explaining "Uncommon"

At the beginning of this research it was necessary to define or propose some clarity around the plant categories in the potential plant list. Accordingly a more in depth look at the colloquial description "uncommon!" was necessary. In the initial planning stages of a planting project, the plant stock and plant lists from plant providers, such as plant nurseries, are compared for available plants. Historically if we look at local planting projects we find that the range of plant species chosen and subsequently actually planted is very limited. This is usually attributed to nurseries being businesses and as such only grow plants that are economic, attractive to sale and are part of a plant fashion culture. (Stewart et al. 2011).

For a planting project planner, there are degrees of choices of "common", and "uncommon" plants in relation to nursery and available plant sources, quite separate from a taxonomic formal description of plants ranging in varying degrees of "uncommon." Taxonomic classification of rarity (Head and Given 2001), include a range of threatened plant categories: "recovering, naturally uncommon, sparse, vagrant, range restricted, vulnerable, declining, threatened, critically endangered, insufficiently known, and presumed extinct." This taxonomic list of degrees in turn was based on a document prepared for the Department of Conservation New Zealand "Canterbury Conservancy Nationally Threatened and Uncommon Plants" (de Lange et al. 1999). For the purposes of our research this category range was too wide, and we sought to reduce it to a more practical range.

Wilson, (2012) proposes a practical classification for native plants in this area. Wilson categorises Banks Peninsula native vascular plants into three main types. These are "A", abundant to common, "B", more or less common, and "C", uncommon to rare, or very local. One more category "A* was added to allow for plants often common in the local landscape but which may not be readily available in nurseries.

On the practical matter of choosing a physical plant to put in the ground, consideration had to be given to how these different categories of plants could be obtained for the study, and once planted, how best to promote the success of its growth. The following lists break down plant availability in more practical terms.

Common Plants, Commonly Available in Nurseries (A)

Common local plants. These are plants that are commonly seen in the local landscape. They are easily identified and are commonly available in nurseries. Common local plants are easily found in local revegetation projects, but the range of species is limited potentially leading to an imbalance in plant diversity. Wilson (2013) described these types of plants as “abundant to common to widespread” on Bank’s Peninsula. These plants were given a category (A) in our research.

Common Plants Uncommon in Nurseries (A*)

Common plants uncommon in nurseries refers to plants that are common in the landscape, but only a selection of these plants are commonly available in nurseries. While they are “common’ in the landscape, they become “uncommonly planted” in local revegetation projects. In Canterbury, practical examples would be *Pseudopanax arboreus*, *Fuchsia excorticata* and *Melicytus ramiflorus*. This could be due to a number of reasons including low demand for product choice at nursery, frost damage risks in the early stages, or lack of education as to the role of these plants within a revegetation community to allow for their inclusion in the plant list plan. For the purpose of our research this plant category was given an (A)*, common but not commonly planted, and in the chapters of preparation, methodology and results the uncommon availability of these plants was recognised.

More or Less Common (B)

Wilson (2013) described plants such as *Podocarpus totara* as “B” category plants. They were not abundant, but are still seen in the landscape, but not in large groups or numbers.

Uncommon Plants, Uncommon in Nurseries and Projects (C)

i) Uncommon in the surrounding landscape. These plants fall into the formally recognised taxonomic degrees of “uncommon,” as explained in the introduction. They range from threatened, endangered to extinct species. These plants were given the description (C) in the research project, and the category of “uncommon to rare or very local” on Banks Peninsula (Wilson, 2013).

ii) Uncommon in the local landscapes but are available in nurseries and grown because plants are becoming fashionable and useful, or are part of a drive for public awareness e.g. *Astelia grandis* chosen rare plant of the year 2011 in the Nelson region, Marlborough, or *Muehlenbeckia astonii*, a regionally rare plant which is very hardy in Canterbury conditions, often included in revegetation projects, is fashionable as a loose hedge and is a popular eco-planting species plant choice in Canterbury. In the case of the above two plant species, they are considered “rare” in Canterbury and consequently have the category (C).

iii) Uncommon to find in nurseries at all. The usual practice if these plants are required in a proposed plant list is to grow these plants on especially for the project, to create conditions on site to allow them to emerge naturally, or translocate plant material at certain limited times of the growing season. Three species that species that fell into this category during this research were: *Parsonsia heterophylla*, *Coprosma rotundifolia* and *Haloragis erecta*. All these species were commonly found in the local landscape. They were given the category (A). *Parsonsia heterophylla*, was propagated in sufficient numbers and was included in the research. *Coprosma rotundifolia* was propagated in limited numbers and included in the research. *Haloragis erecta* propagation failed to produce sufficient numbers for the research and was not included.

Note: Plants that may be not present in the local landscape, but given the right conditions to grow would naturally emerge, can include both common and uncommon plant possibilities. E.g. *Coprosma robusta, Aristotelia serrata*, *Fuchsia excorticata*, and NZ native orchids such as *Microtis unifolia* (common) or *Gastrodia minor* (rare/not so common in Canterbury).

A.6 Rongoā Māori Plant Species on Bank's Peninsula

100 plant species known to be present on Banks Peninsula which have Rongoā Māori (medicinal properties), or significance. This list contributed to the final selection.

Rongoa Plants	Māori name	Rongoa Plants	Māori name
Aceana anserinifolia	Piripiri	*Melicytus ramiflorus*	Māhoe
Aciphylla squarrosa	Taramea	*Mentha cunninghamii*	Hīoi
Anaphaloides	Puatea	*Muehlembeckia ephedroides*	Pōhuehue
Apium prostratum	Tūtae kōau	*Muehlenbeckia astonii*	Tororaro
Apodismia similis	Oioi	*Muehlenbeckia axillaris*	Pōhuehue
Aristotelia serrata	Makomako	*Muehlenbeckia complexa*	Tororaro
Arthropodium cirratum	Rengarenga	*Myoporum laetum*	Ngaio
Astelia solandri	Wharawhara	*Myrsine australis*	māpou
Astelia spp.		*Olearia spp very likely*	
Austroderia spp	Toetoe	*Oxalis exilis likely*	(Tūtae kāhu, uncertain of name and spp match)
Austrofestuca littoralis	Pouaka	*Parsonsia heterophylla*	Tautaua, akakiore
Baumea articulata	Wāwā	*Passiflora tetrandra*	Kōhia
Calystegia soldanella	Pōhue	*Pennantia corymbosa*	Kaikōmako
Cardomine debilis	Panapana	*Phormium cookianum*	Wharariki
Carmichaelia spp		*Phormium tenax*	Harakeke
Celmissia		*Pimelea prostrata*	Pinātoro, wharengārara
Chionochloa spp + Poa spp	Wī	*Piper excelsum*	Kawakawa
Clematis		*Pittosporum engenioides*	Tarata
Clematis paniculata	Puawānanga	*Pittosporum tenuifolium*	Kōhūhū
Coprosma acerosa	Tātaraheke, Tarakupenga	*Plagianthus divaricatus*	Mākaka
Coprosma grandiflora	Manono + Kanono	*Plantago novae zelandiae*	Kopakopa
Coprosma propinqua	Mikimiki	*Poa Cita*	Wī; pātītī
Coprosma robusta	Karamū	*Podocarpus totara*	Tōtara
Cordyline australis	Tī kōuka	*Polygonum plebeium*	Tutunawai
Cyperus ustulatus	Toetoe whatu mana	*Pomaderris kumarahou*	Kumarahou
Dacrycarpus dacrydioides	Kahikatea	*Pomaderris phylicifolia*	Tauhinu
Dacrydium cupressinum	Rimu	*Porphyra columbina*	Karengo
Discarla toumatou	Tūmatakuru	*Prumnopitys ferruginea*	Miro
Disphyma australe	Horokaka	*Prumnopitys taxifolia*	Mataī
Dodonaea viscosa	Akeake	*Pseudopanax arboreus*	Whauwhaupaku
Einadia triandra	Poipapa	*Pseudopanax crassifolium*	Horoeka
Elaeocarpus hookerianus	Pokaka	*Pseudowinter colorata*	Horopito
Elymus solandri	Pātītī taranui	*Pteridium esculentum*	Aruhe
Euphorbia glauca	Waiū atua	*Ranunculus amphitrichus*	Raoriki
Ficinia spiralis	Pīngao	*Ranunculus hirtus*	Mārūrū
Fuchsia exorticata	Kōtukutuku	*Ranunculus reflexus*	Mārūrū
Galium propinquum	Mawe	*Ripogonum scandens*	Kareao
Gastrodia cunninghamii	Perei. Hūperei. Para.	*Rorippa palustris*	Hānea
Grisilinia littoralis	Kāpuka	*Rumex flexuosus*	Runa
Haloragis erecta	Toatoa	*Scandia rosefelia*	Koheriki, Kohepiro
Hebe salicifolia	Koromiko	*Schoenoplectus tabernaemontani*	Kāpūngāwhā
Hedycarya arborea	Porokaiwhiri	*Shefflera digitata*	Patē
Hoheria angustifolia	Houhere	*Sophora tetraptera*	Kōwhai
Ileostylus micranthus	Pirita	*Sophora microphylla*	Kōwhai
Ipomoea batatas	Kumara	*Stellaria decipiens + S. gracilenta*	Kohukohu
Juncus maritimus	Wīwī	*Taraxacum magellanicum*	Tohetaka
Kunzea ericoides	Kānuka	*Tetragonia tetragonioides*	Kokihi
Lepidium oleraceum	Heketara, naunau	*Ulva lactuca*	Karenga
Leptospermum scoparium	Mānuka	*Urtica ferox*	Ongaonga
Leucopogon fasciculatus	Mingimingi	*Zostera spp*	Karepō

References: DOC. (2015) Landcare Research, (2017-2, Wilson, (2013)

A.7 Plant Choice List legend

This legend is associated with appendices A-8 and A-9 and is related to site preference description, e.g. coastal, wet areas, and list references such as Rongoā Māori species, species known to be present on Bank's Peninsula, and whether S. McGaw had previous experience with the husbandry of the plant species.

	Rarity Status of Plant Choice
C	Rare Plants Bank's Peninsula
B	Less Common Plants Bank's peninsula
A*	Common Plants bur not readily available in nurserie
A	Common Plants Bank's Peninsula
	Site Preference Description
N	New, emerging species usually for second stage
W	Wet, damp conditions
C	Coastal planting
D	Prefers drier conditions
H	Found on higher ground, higher altitudes
G	Groundcover species
E	Existence sparse
T	Terrace conditions
X	Unknown, or not well known site preferences
	Other Descriptions in Plant Choice
Y	Yes, found on Bank's Peninsula
S	S. McGaw Experience with handling
R	Plants used in Rongoā Māori (tradtional healing) or of other cultrual significance

A.8 Plant Choice List

This list includes: species scientific name, Rongoā Māori status, Māori name, common name, S. McGaw handling experience, whether the plant was present on Bank's Peninsula and the likelihood of the plant being easily sourced.

Scientific Name: Possible Plant Species	Found Banks Peninsula	Wilson (2013) A,B,C categories	Potentially able to source	Likely species	S McGaw experience	Rongoa	Māori name	Common Name
Acaena anserinifolia	Y	A	1		S	1	Piripiri	Biddybid
Aceana spp								
Aciphylla aurea	Y	C	1					
Aciphylla squarrosa						1	Taramea	Spear Grass
Aciphylla subflabellata	Y	A	1		S			
Anaphaloides							puatea	pigweed
Apium prostratum						1	Tūtae kōau	Native Wild Celery
Apodasmia similis	Y	C	1		S	1	Oioi	Oioi
Aristotelia serrata	Y	A	1			1	Makomako	Wineberry
Aristotelia spp other	Y	C						
Arthropodium candidum	Y	A	1		S			
Arthropodium cirratum						1	Rengarenga	NZ Rock Lily
Astelia fragrans	Y	A	1	1	S			
Astelia grandis	Y	C	1		S			
Astelia solandri						1	Wharawhara	Perching Lily
Austroderia richardii	Y	B	1	1	S	1	Toetoe	some spp medicinal
Austrofestuca littoralis	Y	B	1			1	Pouaka	Sand Tussock
Blechnum penna-marina	Y	A	1		S			
Calystegia soldanella	Y	C	1		S	1	Pōhue	Shore Convolvulus
Cardomine debilis						1	Panapana	NZ Bittercress
Cardomine debilis						1	Panapana	
Carex breviculmus	Y	A	1					
Carex flagellifera	Y	C	1					
Carex inopinata	Y	C	1		S			
Carex secta	Y	B	1	1	S			
Carex spp	Y				S			
Carex triffida	Y	C	1		S			
Carex virgata	Y	B	1	1	S			
Carmichaelia australis	Y	A	1	1	S		Mākaka	
Carmichaelia spp	Y		1	`	S	1		some spp medicinal
Carpodetus serratus	Y	A	1	1	S			
Celmisia mackauii	Y	C				1		? Some spp medicinal
Chionocloa conspicua	Y	C						
Clematis afoliata	Y	B	1		S	1		some medicinal
Clematis paniculata	Y	A	1		S	1	Puawānanga	White Clematis
Coprosma acerosa	Y	C	1		S	1	Tātaraheke, Taraku	Sand coprosma
Coprosma crassifolia ?	Y	A	1		S			
Coprosma lucida	Y	A	1		S			
Coprosma lucida	Y	A						
Coprosma propinqua	Y	A	1	1	S	1	Mikimiki	Mingimingi
Coprosma robusta	Y	A	1	1	S	1	Karamū	
Coprosma rotundifolia	Y	A	1			1	Manono + Kanono	Large Leaved Coprosma
Coprosma rugosa	Y	C		1	S			
Coprosma virescens	Y	A	1	1	S			
Coprosma wallii	Y	B	1					
Cordyline australis	Y	B	1	1	S	1	Tī kōuka	Cabbage Tree
Coriaria arborea								
Corokia cotoneaster	Y	A	1	1	S			
Cyperus ustulatus	Y	C				1	Toetoe whatu mana	Umbrella Sedge
Dacrycarpus dacrydioides	Y	B		1	S	1	Kahikatea	white pine
Dacrydium cupressinum	Y	C				1	Rimu	Red Pine
Dianella nigra	Y	C	1		S			
Dichelacne crinita	Y	A	1		S			
Dichondra repens	Y	A	1		S			
Discaria toumatou	Y	A			S	1	Tūmatakuru	Wild Irishman
Dodonaea viscosa	Y	B	1	1	S	1	Akeake	
Dysphyma australe	Y	A	1		S	1	Horokaka	NZ Ice Plant
Einidia triandra	y	A					Poipapa	Pigweed
Elaeocarpus dentatus	Y	C				1	Hinau	
Eleaocarpus hookerianus ?	Y	C	1		S		Pōkākā	

Scientific Name: Possible Plant Species	Found Banks Peninsula	Wilson (2013) A,B,C categories	Potentially able to source	Likely species	S McGaw experience	Rongoa	Māori name	Common Name
Elymus solandri	Y	B					Pātītī taranui	Blue Wheat Grass
Elymus solandri						1	Patiti	Blue Wheat Grass
Elymus spp	Y	A_C						
Epilobium spp	Y		1					
Euphorbia glauca	Y	Declined	1		S	1	Waiū atua	Shore Splurge
Festuca actae	Y	A	1		S			
Ficinia nodosa	Y	A	1					
Ficinia spirilis	Y	C	1		S	1	Pīngao	Pingao
Fuchsia excorticata	Y	A	1		S	1	Kōtukutuku	Tree Fushia
Fuchsia perscandens	Y	B	1					
Fuchsia procumbens					S			
Galium propinquum						1	Mawe	NZ Bedstraw
Gastrodia cunninghamii	Y	C				1	Perei. Hūperei. Para	Orchid
Gastrodia 'long column'	Y	C			S			
Gaultheria antipoda	Y	B				1	Tāwiniwini, koropul	snowberry
Gaultheria depressa								
Geranium retrorsum	Y	C	1		S			
Geranium spp	Y		1		S			
Griselinia littoralis	Y	A	1	1	S	1	Kāpuka	
Griselinia lucida	Y	C						
Gunnera monoica	A							
Haloragis erecta	Y	A	1		S	1	Toatoa	
Hebe odora	Y	C	1		S			
Hebe salicifolia	Y	A	1		S	1	Koromiko	check spp
Hedycarya arborea	Y	A	1			1	Porokaiwhiri	Pigeon Wood
Hoheria angustifolia	Y	A	1		S	1	Houhere	
Hydrocotle moschata	Y	A						
Hydrocotle spp	Y	A-C						
Ileostylus micranthus	Y	B				1	Pirita	NZ Mistletoe
Ipomoea batatas						1	Kumara	Sweet potato
Isolepis nodosa			1					
Juncus edgarii(gregiflorus)	Y	A	1		S			
Juncus maritimus						1	Wīwī	
Juncus pallidus	Y	C	1		S			
Juncus sarophorus	Y	C	1					
Kunzea ericoides	Y	A	1	1	S	1	Kānuka	
Lachnagrostis spp	Y	C	1		S			
Lepidium oleraceum	Y	C	1			1	Heketara, naunau	cooks scurvy grass
Leptinallea dioica	Y	B	1		S			
Leptinella spp	Y		1		S			
Leptospermum scoparium	Y	B	1	1	S	1	Mānuka	
Leucopogon fasciculatus						1	Mingimingi	Prickly Heath
Leucopogon fraseri	Y	A	1		S		Pātōtara	
Libertia ixioides	Y	B	1		S			
Libocedrus bidwillii	Y	B	1					
Linum monogynum	Y	B	1		S		Rauhuia	
Lobelia angulata	Y	C	1		S			
Lophomyrtus obcordata	Y	A						
Luzula banksiana var orina								
Luzula spp	Y	A-C	1		S			
Machaerina rubiginosa	Y	C	1		S	1	Wāwā	NZ Club Rush
Macropiper excelsum	Y	A			S	1	Kawakawa	Peppertree
Macropiper excelsum						1	Kawakawa	Peppertree
Melicytus alpinus	Y	A	1	1	S			
Melicytus micranthus?	Y	C						
Melicytus ramiflorus	Y	A	1		S	1	Māhoe	Whiteywood
Mentha cunninghamii	Y	B	1			1	Hīoi	
Microtis unifolia	Y	A	1		S			
Mimulus repens	Y	C	1		S			
Muehlembeckia ephedroides	Y	C	1		S		Tororaro	
Muehlenbeckia astonii	Y	C	1		S	1	Tororaro	

Scientific Name: Possible Plant Species	Found Banks Peninsula	Wilson (2013) A,B,C categories	Potentially able to source	Likely species	S McGaw experience	Rongoa	Māori name	Common Name
Muehlenbeckia axillaris	Y	C	1		S	1	pōhuehue	
Muehlenbeckia complexa	Y	A	1		S	1		
Myoporum laetum	Y	A	1	1	S	R	Ngaio	Ngaio
Myrsine australis	Y	A	1		S	R	Māpou	Red Matipo
Myrsine divaricata	Y	A	1		S			
Olearia avicennifolia	Y	C	1		S			
Olearia linariifolia ? (dartonii)					S			
Olearia nummularifolia	Y	C	1		S			
Olearia paniculata	Y	B	1	1	S			
Olearia spp	Y				S	R		
Oxalis exilis	Y	A	1		S	R	(Tutae kahu, uncertain of name	
Ozothamus leptophylla	Y	C	1		S			
Parsonsia heterophylla	Y	A	1			R	Tautaua, akakiore	NZ Jasmine
Passiflora tetrandra						R	kōhia	NZ Passionfruit
Passiflora tetrandra						R	Kohia	NZ Passionfruit
Pennantia corymbosa	Y	A	1		S			
Phormium cookianum	Y	B	1		S	R	Wharariki	Mountain Flax
Phormium tenax	Y	B	1		S	R	Harakeke	
Pimelea prostrata			1		S	R	Pinātoro, wharengā	NZ Daphne
Piper excelsum	Y	A	1		S			
Pittosporum eugenioides	Y	A	1	1	S	R	Tarata	Lemon wood
Pittosporum obcordatum (very limited)*	Y	C	1					
Pittosporum tenuifolium	Y	A	1	1		R1	Kōhūhū	Kohuhu
Plagianthus divaricatus	Y	B	1	1	S	R	Mākaka	Marsh Ribbonwood
Plagianthus regius	Y	A	1	1	S			
Plantago novae zelandiae							Kopakopa	NZ Plantain
Poa cita	Y	A	1	1	S	R	Wī; pātītī	Silver Tussock
Poa imbecilla ?	Y	B	1		S			
Podocarpus halli	Y	A						
Podocarpus totara	Y	B	1	1	S	R1	Tōtara	Totara
Polygonum plebeium							Tutunawai	NZ Williow Weed
Pomaderris kumarahou							Kumarahou	Gumdiggers Soap
Pomaderris phylicifolia					S	R	Tauhinu	Cottonwood
Porphyra columbina							Karengo	Sea Lettuce
Potentilla anserinoides	Y	C	1		S			
Prumnopitys ferrunginea	Y	C	1		S	R	Miro	Brown Pine
Prumnopitys taxifolia	Y	B				R	Mataī	Black Pine
Pseudopanax arboreus	Y	A	1	1	S	R	Whauwhaupaku	Five Finger
Pseudopanax colensoi	Y	A						
Pseudopanax crassifolius	Y	A	1	1	S	R	Horoeka	Lancewood
Pseudopanax ferox	Y	B	1	1	S			
Pseudowinter colorata	Y	A	1		S	R	Horopito	
Pteridium esculentum							aruhe	fern
Ranunculus amphitrichus							Raoriki	Water Buttercup
Ranunculus hirtus							mārūrū	Hairy Buttercup
Ranunculus macropus	Y	C	1		S			
Ranunculus reflexus	Y	A	1		S	R	Mārūrū	
Raukaua anomalus ?	Y	B	1					
Raukawa edgerleyi	Y	C						
Rhytidosperma spp	Y	A-C	1		S			
Ripogonum scandens							Kareao	Supple Jack
Rorippa palustris	Y	C	1		S	R	Hānea	marsh cress
Rubus squarrosus	Y	B	1		S			
Rumex flexuosus							Runa	Native dock
Scandia geniculata	Y	A				R	Koheriki + Kohepiro	NZ Anise chec
Schefflera digitata	Y	A	1			1R	Patē	Seven Finger
Schoenoplectus pungens	Y	B			S			
Schoenoplectus tabernaemontan	Y	C				R	Kapungawha	Lake Clubrush
Selliera radicans	Y	C	1					
Sophora microphylla	Y	A	1	1	S	R	kōwhai	
Sophora prostrata	Y	B	1		S	R	kōwhai	
Stellaria decipiens + S. gracilenta		z					Kohukohu	NZ Chickweed
Streblus hetrophyllus	Y	B						
Taraxacum magellanicum						R	Tohetaka	Native Dandelion
Tetragonia tetragonioides						R	Kokihi	NZ Spinach
Teucridium parviflolium	Y	C	1		S			
Ulva lactuca						R	karenga	Sea Lettuce
Urtica ferox						R	Ongaonga	Stinging Nettle Tree
Wahlenbergia gracilis?	Y	A						
Zoisya minima					S			
Zostera spp							karepō	Eel Grass, Sea Grass

A.9 List of available species with site preference.

To be read in conjunction with legend A-7

Scientific name	Location preference	Scientific name	Location preference	Scientific name	Location preference
Acaena anserinifolia	W	*Elymus solandri*	H	*Myoporum laetum*	TC
Aceana spp	G	*Elymus spp*	T	*Myrsine australis*	T
Aciphylla aurea	H	*Epilobium spp*	G	*Myrsine divaricata*	C
Aciphylla subflabellata	H	*Euphorbia glauca*	C	*Olearia avicennifolia*	TC
Anamanthele lessoniana	T	*Festuca actae*	H	*Olearia linariifolia (dartonii)*	X
Apium prostratum	W	*Ficinia nodosa*	W	*Olearia nummularifolia*	T
Apodasmia similis	W	*Ficinia spirilis*	W	*Olearia paniculata*	TC
Aristotelia serrata	NE	*Fuchsia excorticata*	W	*Olearia spp*	C
Aristotelia spp other	NE	*Fuchsia perscandens*	W	*Oxalis exilis*	G
Arthropodium candidum	G	*Fuchsia procumbens*	W	*Ozothamus leptophylla*	TC
Astelia fragrans	W	*Gastrodia cunninghamii*	T	*Parsonsia heterophylla*	T
*Astelia grandis * (limited)*	X	*Gastrodia 'long column'*	T	*Passiflora tetrandra*	T
Astelia nervosa	X	*Gaultheria depressa*	H	*Pennantia corymbosa*	T
Austroderia richardii	W	*Geranium retrorsum*	C	*Phormium cookianum*	C
Austrofestuca littoralis	C	*Geranium spp*	T	*Phormium tenax*	W
Blechnum penna-marina	G	*Griselinia littoralis*	T	*Pimelea prostrata*	X
Calystegia soldanella	C	*Griselinia lucida*	C	*Piper excelsum*	T
Carex breviculmus	C	*Gunnera monoica*	G	*Piper excelsum*	T
Carex flagellifera	W	*Haloragis erecta*	T	*Pittosporum eugenioides*	T
Carex inopinata	T	*Hebe odora*	H	*Pittosporum obcordatum* (very limited)*	T
Carex secta	W	*Hebe salicifolia*	T	*Pittosporum tenuifolium*	T
Carex spp	W	*Hedycarya arborea*	T	*Plagianthus divaricatus*	C
Carex triffida	W	*Hoheria angustifolia*	T	*Plagianthus regius*	W
Carex virgata	W	*Hydrocotle moschata*	G	*Poa cita*	T
Carmichaelia australis	T	*Hydrocotle spp*	G	*Poa imbecilla ?*	G
Carmichaelia spp	T	*Ileostylus micranthus*	H	*Podocarpus halli*	T
Carpodetus serratus	T	*Isolepis nodosa*	W	*Podocarpus totara*	T
Celmissia	H	*Juncus edgarii(gregiflorus)*	W	*Potentilla anserinoides*	G
Chionochloa spp		*Juncus pallidus*	W	*Prumnopitys ferrunginea*	W
Chionocloa conspicua	H	*Juncus sarophorus*	W	*Prumnopitys taxifolia*	W
Clematis afoliata	T	*Kunzea ericoides*	T	*Pseudopanax arboreus*	T
Clematis paniculata	T	*Lachnagrostis spp*	G	*Pseudopanax colensoi*	X
Clematis spp		*Lepidium oleraceum*	C	*Pseudopanax crassifolius*	T
Coprosma acerosa	C	*Leptinallea dioica*	C	*Pseudopanax ferox*	H
Coprosma crassifolia ?	T	*Leptinella spp*	T	*Pseudowinter colorata*	T
Coprosma lucida	C	*Leptospermum scoparium*	C	*Ranunculus macropus*	G
Coprosma propinqua	T	*Leucopogon fasciculatus*	x	*Ranunculus reflexus*	G
Coprosma robusta	T	*Leucopogon fraseri*	G	*Raukaua anomalus*	X
Coprosma rotundifolia	T	*Libertia ixioides*	G	*Raukawa edgerleyi*	X
Coprosma rugosa	T	*Libocedrus bidwillii*	X	*Rhytidosperma spp*	G
Coprosma virescens	T	*Linum monogynum*	TC	*Rorippa palustris*	G
Coprosma wallii	T	*Lobelia angulata*	G	*Rubus squarrosus*	T
Cordyline australis	W	*Lophomyrtus obcordata*	T	*Scandia geniculata*	C
Coriaria arborea	X	*Luzula banksiana var orina*	G	*Schefflera digitata*	T
Corokia cotoneaster	T	*Luzula spp*	G	*Schoenoplectus pungens*	W
Cyperus ustulatus	W	*Machaerina rubiginosa*	W	*Schonoplectus tabernaemon*	X
Dacrycarpus dacrydioides	W	*Melicytus alpinus*	H	*Selliera radicans*	C
Dacrydium cupressinum	W	*Melicytus micranthus*	T	*Sophora microphylla*	T
Dianella nigra	T	*Melicytus ramiflorus*	T	*Sophora prostrata*	T
Dichelacne crinita	T	*Mentha cunninghamii*	G	*Streblus hetrophyllus*	X
Dichondra repens	G	*Microtis unifolia*	G	*Teucridium parviflolium*	X
Discaria toumatou	T	*Mimulus repens*	G	*Wahlenbergia gracilis*	X
Dodonaea viscosa	C	*Muehlembeckia ephedroides*	TC	*Zoisya minima*	X
Dysphyma australe	C	*Muehlenbeckia astonii*	T		
Einidia triandra	C	*Muehlenbeckia axillaris*	C		
Eleaocarpus hookerianus	T	*Muehlenbeckia complexa*	TC		

A.10 Full Plant Explanation

Astelia grandis (C) and (R), was chosen as the opportunity arose to trial this plant. In early European times, Armstrong (1879) recorded *Astelia grandis* as being present in large numbers in the swamps across the Canterbury plain. The only reference to use which has been found was to its employment as a decorative fibre in weaving. In the first layer this plant was teamed with *Carex secta.*

Carex secta (C) (not R), while present in the Canterbury Plains was not seen as abundant in this part of the Banks Peninsula. It was considered a useful plant to trial as there are a number of future locations in revegetation projects where it could be used. *Carex secta* and *Astelia grandis* together represented wet area edging plants.

Coprosma robusta, Dacrycarpus dacrydioides, Fuchsia excorticata, Pseudopanax arboreus were the next grouping of plants chosen as fringe layers to the wet area and at the bottom of the slope.

Coprosma robusta (A) and (R). *Coprosma robusta* (karamu) is a great work horse. It protects and shelters its neighbouring plants, grows quickly, throws seeds and generally can be relied upon to grow well.

Dacrycarpus dacrydioides (A) and (R). *Dacrycarpus dacrydioides* (kahikatea) is a plant that was part of the heritage of Little River and its environs. Only a handful of mature kahikatea remain in the Wairewa catchment area.

Fuchsia excorticata (A*) and (R). *Fuchsia excorticata* (kotukutuku) is a plant seen plentifully all throughout the Wairewa catchment. It is seen even on the windy roadsides, which indicates that potentially it could be hardy. It is not however readily available in nurseries. If time had permitted, we would have propagated *Fuchsia excorticata* from cuttings with a robust stem.

Pseudopanax arboreus (A*) and (R). *Pseudopanax arboreus* (whauwhaupaku) is the most abundant plant seen growing around the roadsides in the upper valleys. *Melicytus ramiflorus* (mahoe) is also very abundant. The only exceptions visually in the valley are where *Kunzea ericoides* (kanuka) is dominant as a plant community, or where *Sophora microphylla* alongside *Hoheria angustifolia* form a plant community. One of the many uses for whauwhaupaku is for its dye properties in weaving and decoration (Landcare Research, 2017, Cranwell et al. 1943), which could be of interest to local craftspeople.

The next groupings formed layers mid slope. This grouping was: *Melicytus ramiflorus Podocarpus totara, Hoheria angustifolia* and *Pittosporum obcordatum.*

Melicytus ramiflorus (A*) and (R). *Melicytus ramiflorus* (mahoe, hinahina) is the softwood used in fire-making along with *Pennantia corymbosa* (kaikomako) and has many medicinal qualities. (Stark, 1979). In nearly every location visited in the valley mahoe was present. Also of note was that every *Prumnopitys taxifolia* (mataī) seedling was growing alongside or underneath a *Melicytus ramiflorus* (mahoe) which was sheltering it. *Melicytus ramiflorus* was one of the few seedlings seen naturally occurring at the seven sites shown to us at the beginning and was considered an important cultural plant to include in the study. *Melicytus ramiflorus* is not particularly commonly planted in Canterbury revegetation sites in the early stages. There was root-trainer seedling material available at Motukarara nurseries. However, if time had permitted, potentially this was a plant that could have been propagated into a larger container size before planting, as a wider root ball option has been successful in Ohoka Projects. *Melicytus ramiflorus* was therefore an unknown category of expectation, but was included because of cultural significance. Although seen in only a few places in the valley, as both mature trees and seedlings, *Pennantia corymbosa* (Kaikomako) was not included in the study as there was a limit to the number of plants that could be chosen. Future studies could usefully include this plant species alongside of *Melicytus ramiflorus.*

Podocarpus totara (B) and (R). In Māori lore there were many everyday uses for *Podocarpus totara* (Totara). As a culturally important plant Totara was included.

Hoheria angustifolia (A) and (R). *Hoheria angustifolia* (Hoheria) also has many medicinal uses. In the valley *Hoheria angustifolia* was plentiful and grew alongside *Sophora microphylla* in many places. Where one plant was present the other would be present.

Pittosporum obcordatum (C) and (R unknown). *Pittosporum obcordatum* (The Māori name is unknown to me) was included as it was a plant species recently rediscovered in the Bank's Peninsula area, and propagated by Motukarara nursery. There was enough plant material for it to be included in the study. The conservation status is "threatened and nationally vulnerable". (NZPCN. 2018). In order that *Pittosporum obcordatum* could be used in future revegetation projects it was thought a useful species to include in the study.

Coprosma rotundifolia (A*) and (R). This plant species was growing visibly and robustly along all the forest edges in the Little River valley roads. It was not available in nurseries. It was also considered a useful plant to trial and include in later revegetation projects. It was placed within the centre slopes in the middle layer of the project.

Sophora microphylla and *Coprosma propinqua* var*. latiuscula* Allan (were placed at the top of the slope along with *Muehlenbeckia astonii* and *Carmichaelia australis* being the top layer. Generally the overhead vegetation was in the middle of the slope so the top layers were more open.

Sophora microphylla (A) and (R). *Sophora microphylla* (South Island kowhai) was sparsely represented in the existing revegetation project area. *Sophora microphylla and Hoheria angustifolia* are well represented in the valley. Therefore it was considered helpful to add this species for study, particularly as it was likely that the gaps in the existing project may have included the *Sophora* species and failed over time.

***Coprosma propinqua* var*. latiuscula* Allan**. (A) and (R), (mingimingi). This variety of *Coprosma* was collected from seed in the Birdling's flat area and propagated. It was previously loosely described in local nurseries as "*Coprosma propinqua* Birdling's Flat.

Muehlenbeckia astonii (C) and (R). *Muehlenbeckia astonii* (tororaro) is nationally threatened and considered vulnerable. However this plant is gaining popularity, and is readily available from local nurseries and had a high likelihood of survival success.

Carmichaelia australis (A) and R. *Carmichaelia australis* (mākaka, maukoro) is a hardy plant in the wild, but not often offered for sale in large numbers in nurseries. It is commonly observed in the dry hillsides around Te Roto o Wairewa/ Lake Forsyth.

Clematis paniculata* (A)** and **(R) and *Parsonsia heterophylla (A) and (R). *Clematis paniculata (*puawhananga) and *Parsonsia heterophylla* (kaihua, akakiore, akakaikiore as well as kaikū (Landcare Research 2017-2), kaiwhiria, poapoa tautau, tawhiwhi, tūtae-kererū (Williams 1971). The common European name is New Zealand jasmine. These two species were two climbing plants chosen. Both were plants common to Banks Peninsula and both have Rongoā qualities. *Parsonsia heterophylla* is seen in abundance throughout the valley, and *Clematis paniculata* less so. These plants were generally placed near trees, shrubs or fences or in the top layer of planting layout.

Leptinella dioica (A) and (R unknown) ***Luzula rufa*** (A-C) and (R) ***Poa imbecilla*** (B) and (not R) ***Ranunculus reflexus*** (A) and (R) (maru, maruru, kopukapuka, pirikau). These last four ground cover plant species were planted in clumps together, i.e. one of each species per clump. They were included as unknown performers, and it was possible that if they performed well they could be of benefit in future planting projects

A.11 The Physical Description and Cultural Note of Each Plant Species

Cultural descriptions. Details are given which include: The scientific name, the species abbreviation, description of each species' habit, (e.g. shrub, climber, ground cover), the likely location of where found in nature, the deciduous status, and the position or placement of the species in relation to the slope in the study.

Position	**Scientific name**	**Species Type**	**Description**	**Likely to be found**	**Deciduous/ evergreen**
Terrace	*Parsonsia heterophylla*	Pa	Climber	forest edges	Evergreen
Terrace	*Clematis paniculata*	Cl	Climber	forest edges	Evergreen
Upper slope	*Carmichaelia australis*	Ch	Shrub	forest edges	Evergreen
Upper slope	*Muehlenbeckia astonii*	Mu	Shrub	open ground	Semi deciduous
Upper slope	*Sophora microphylla*	So	Tree	light forest	Evergreen
Upper slope	*Coprosma propinqua var latiuscula*	Cp	Shrub	light forest	Evergreen
Mid slope	*Hoheria angustifolia*	Ho	Tree	light forest	Evergreen
Mid slope	*Pittosporum obcordatum*	Pi	Tree	not known	Evergreen
Mid slope	*Coprosma rotundifolia*	Rt	Shrub	light forest	Evergreen
Mid slope	*Podocarpus totara*	To	Tree	general forest	Evergreen
Mid slope	*Melicytus ramiflorus*	Ma	Tree	general forest	Evergreen
Mid slope	*Luzula rufa*	Lu	Ground cover	ground cover	Evergreen
Mid slope	*Poa imbecilla*	Po	Ground cover	ground cover	Tufted perennial
Mid slope	*Ranunculus reflexus*	Ra	Ground cover	ground cover	Tufted perennial
Mid slope	*Leptinella dioica*	Lp	Ground cover	health status 6	Evergreen
Bottom of slope	*Fuchsia excorticata*	Fu	Tree	stream or seepage fringe plants	Deciduous
Bottom of slope	*Coprosma robusta*	Cr	Shrub	general forest and wetland fringe	Evergreen
Bottom of slope	*Dacrycarpus dacrydioides*	Ka	Tree	water fringe and general forest	Evergreen
Bottom of slope	*Pseudopanax arboreus*	Ps	Tree	forest edge and general forest	Evergreen
Low point	*Astelia grandis*	As	Flax-like	wetlands, swamp area	Tufted perennial
Low point	*Carex secta*	Ca	Sedge	wetlands, swamp area	Tufted perennial

A.12 Observations of Failure.

The following descriptions are observations made in the field during data collection. The observations included examples of potential reasons for failure as well observations in cases where the reason for failure was not immediately apparent or was not known.

Descriptive Examples of Observation of Failure
Browned off Dead from an early time Died early Eaten by rat Eaten early Eaten, lost in longrass, later recoverd, weak and died Eaten, new growth and then died Flowered summer, suddely died after winter Frosted and died back Frosted early, never recovered Frosted, browned off, weakened, died Just died, reason not apparent Not found Long grass in summer Not known why, maybe long grass in summer Ringbarked Small recovery, then died Small recovery, weak plant died Spray damage Very shady, insifficient light

Appendix B

Photographic Section

B.1 Recoveries and Success

Plate 1, October 2016, Close-up of *Melicytus ramiflorus*, Marae Plot 7. (7Ma2). All *Melicytus ramiflorus* survived the initial 15 month establishment period, but many died back and lost their first leaves during the first winter, followed by new growth. The new growth can be seen at the bottom of the protective combiguard, centre, and the old stalk is still visible top middle. (7Ma 2) is the Unique Identifier (IU) given to this particular plant.

Plate 2, October 2016, Close-up of *Fuchsia excorticata*, Plot 1. (1.Fu1). The species *Fuchsia excorticata* generally suffered the most losses during the initial establishment period. However many died back and lost their first leaves during the first winter, followed by new growth. The new growth can be seen at the bottom of the protective combiguard, centre, and the old stalk is still to the left of the top right-hand Combiguard stick. (1Fu1) is the Unique Identifier (IU) given to this particular plant.

Plate 3. By December 2016, all *Melicytus ramiflorus* plants have shown new growth reaching the top of the Combiguard sleeves (300mm high) or higher. This particular plant is in Plot 1, and the Unique Identifier (IU) for it is (1Ma3). This *Melicytus ramiflorus* was later measured in September 2017 with a height of 700mm.

Plate 4 By December 2016, The *Fuchsia excorticata* plants which have shown new growth have also reached the top of the Combiguard sleeve (300mm high) or higher. This particular plant is in Plot 1, and the Unique Identifier (IU) for it is (1Fu4). It was later measured in September 2017 with a height of 450 mm. *Fuchsia excorticata* was in the category A*, (not readily available in local nurseries and commonly planted in projects). Where *Fuchsia excorticata* was placed in open and unsheltered locations, this species failed but where it was placed in favourable conditions, the remaining 14 *Fuchsia excorticata* thrived

Plate 5. December 2016. This *Pseudopanax arboreus* plant, (1Ps2), Unique Identifier (IU), was measured at a height of 570 mm in November 2016, and 970 mm in January 2017. It was later measured in September 2017 at 1450 mm high. *Pseudopanax arboreus* was in the category A*, (not readily available in local nurseries and not commonly planted in local projects) and while 17 out of 35 plants failed, given the right conditions, the remaining 18 *Pseudopanax arboreus* similarly thrived, as can be seen in this picture.

Plate 6. January 2017 *Pseudopanax arboreus* measures 970mm in height.

Plate 7. This group of two category A* and one Category A plants shows good growth in all three species in this favourable sheltered and semi-shaded location. The three species are: *Fuchsia excorticata* bottom left, and *Pseudopanax arboreus* top left, in category A*, (plants that were considered not readily available in local nurseries and not commonly planted in projects) and *Coprosma robusta*, right, category A, (plants commonly found to be present on Bank's peninsula. (Wilson 2013). Were category A* species to be placed in suitable locations within a second-stage restoration, they could enhance the biodiversity of the project, and in my view, should not be discounted as a plant species choice in the planning process.

B.2 Numerous Seedlings

Plate 8. November 2016. Plot 5, with overhead vegetation including *Hoheria angustifolia, Plagianthus regius*, *Cordyline australis, Coprosma robusta* (and *Veronica salicifolia* not seen in picture). In the foreground the combiguards can be seen laid out in rows along a gentle slope. The following picture is a close up of the emerging seedlings which are generally in the centre picture location, and were too numerous to count.

Plate 9. The area centre of Plate 10, where numerous *Plagianthus regius* and *Hoheria angustifolia* seedlings emerged.

Plate 10. ***Plagianthus regius*** **and** ***Hoheria angustifolia*** **seedlings in a 300mm x 300mm square area in Plot 5. By September 2017 some of these seedlings had reached a recorded height of 450 mm.**

B.3 Ground Cover Clusters

Plate 11. ***Coprosma robusta*** **seedlings emerging among the ground cover species clusters. (*Luzula rufa, Leptinella dioica, Poa imbecilla, and Ranunculus reflexus). Luzula rufa*** **can be seen at the top of the picture**

Plate 12. ***Coprosma robusta*** **seedlings to the right of** ***Leptinella dioica,*** **one of the ground cover cluster plants.**

Plate 13. The ground cover cluster groups consisted of ***Luzula rufa, Leptinella dioica, Poa imbecilla, and Ranunculus reflexus.*** **Here in the centre of the picture, fresh** ***Ranunculus reflexus*** **seedlings can be seen, (September 2017) amongst sparse** ***Leptinella dioica*****.** ***Luzula rufa*** **leaves can be identified top right.**

Plate 14 Unidentified seedling emerging in *Leptinella dioica*, and protected by combiguard sleeve. Possibly *Coprosma robusta/propinqua* hybrid

Plate 15. November 2016. *Kunzea ericoides* seedling (centre against Combiguard sleeve) emerging amongst *Leptinella dioica*, which has spread over 500mm along the ground from its original location. *Coprosma robusta* seedlings are also present (top right).

B.4 Low Ground

Plate 16. Photo is taken looking North, with Plot 3 on the right –hand side, and looking toward Plot 6A (hidden, and also on the right hand side in a more open location) and Plot 2 (top left under existing vegetation, *Hoheria angustifolia* is the larger tree visible. Note the first layer of planting in the lower ground, is made up of two species, *Carex secta* and *Astelia grandis,* and in the second row, *Coprosma robusta* is visible above the Combiguard sleeve. To the left of the *Carex secta*, the lower ground of the old water course is apparent.

Plate 17. *Astelia grandis* had two deaths out of the 35 plants in the study. This was likely due to being at the lowest point of the old water course which did fill with water after prolonged rain. *Astelia grandis* was in the C category plants. (Considered rare on Bank's Peninsula, Wilson 2013).

B.5 Recommendations

Plate 18 *Prumnopitys taxifolia* (mataī) seedling, protected by *Melicytus ramiflorus* (māhoe). This close relationship of protective plants was consistently observed by the author in the Little River catchment area, during the exercise of taking as many photographs as possible of different species to put on iNaturalist website for formal identification and collation into a project site collection. (iNaturalist 2015). In the Ōkuti Valley in particular, photographs were taken of mataī seedlings in all cases growing under the *Melicytus ramiflorus*, the stems being within 200 mm of each other.

Plate 19. *Coprosma rotundifolia*, a plant species commonly seen within the Little River catchment, not only in forest fringes, but also on roadside edges, some of which in exposed and windy locations. *Coprosma rotundifolia* was included in the study as a category A* plant, (not readily available in local nurseries and commonly planted in projects) and all 18 species in the study survived. This typical example shows healthy growth, and in my opinion, *Coprosma rotundifolia* would make a useful contribution for species diversity were it to be included in local second-stage restoration projects.

Plate 20. Plot 5. Seedlings emerge under *Coprosma robusta*, *Plagianthus regius* and *Hoheria angustifolia*. There is clear ground available without too much weed competition, light and shelter. This is the type of location that could be identified for future seedling catchment. Small wire cages could be placed at chosen sites in a second stage restoration projects with the specific target to allow natural seedlings to emerge within a protected area. These could later be either, potted-up and introduced again later, or if conditions allow, direct translocation within the site at a favourable time of the year.

Plate 21. Cage placed by path for seedling emergence, collection, potting up and later reintroduction back into project site. This wire cage (Ohoka 2018) is approximately 450 mm diameter. Seedling species emerging are: *Coprosma virescens, Coprosma robusta, Cordyline australis, and Muehlenbeckia australis.*

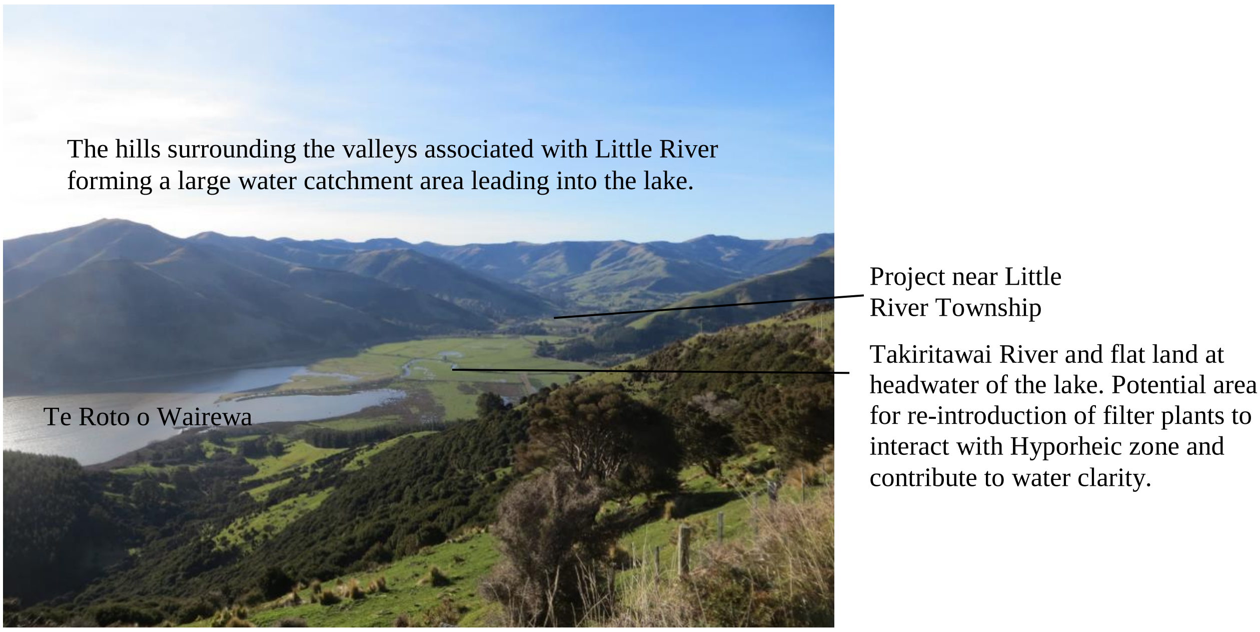

Plate 22. Picture taken from the Bossu Road saddle looking down at the head of Te Roto o Wairewa/Lake Forsyth, Little River Township, and the surrounding water catchment area. The flat lying land between the Little River township and te Roto o Wairewa/ lake Forsyth, where the Takiritawai River (also known as Kakerikawai River) enters the lake, is an area of potential planting with species that could be beneficial in filtering or improving the water quality entering the lake.