A resource for collection development at the University of Washington Botanic Garden's Ecogeographic New Zealand Forest

Kyra Matin
August 2019

A project in partial fulfillment of the requirements for the degree of
Master of Environmental Horticulture
University of Washington School of Environmental and Forest Sciences
Committee: Dr. Soo-Hyung Kim, Dr. James Fridley,
Raymond J. Larson M.S., and Dr. Caren Crandell

Executive Summary

I traveled to New Zealand in February 2019 to do a horticultural internship with the Dunedin Botanic Garden and to collect wild New Zealand native seed to be imported to the US to grow and add to the University of Washington Botanic Garden's New Zealand living plant collection. This paper is intended to serve as a reference for understanding and a resource for developing the Pacific Connections New Zealand Forest at the University of Washington Botanic Gardens (UWBG).

Part one of this document provides background about the role of botanical gardens in general and specific information about the Pacific Connections New Zealand Forest. I then summarize and compare the current collection themes of the New Zealand Forest to literature about vegetation patterns and plant communities of the South Island as a way to understand the intentions of the New Zealand Forest. I contribute my recommendations for ways to enhance the ecogeographic plant collection. Part two provides background about the process of seed collecting in New Zealand, and documents my specific methods and experiences collecting and cleaning seed. Part three seeks to provide the groundwork for incorporating more cultural elements into the New Zealand Forest. It presents background information about the Māori of the South Island and their relationship to plants and conservation in New Zealand. My aim is to synthesize information from the literature as well as my experiences in New Zealand to create a useful document for the continued enhancement of the New Zealand Forest at the UWBG.

Table of Contents

List of Tables

List of Figures

Part 1: An exploration of the UWBG New Zealand Forest

1.1 Introduction

1.1.1 Background about the Pacific Connections Garden New Zealand Forest

The University of Washington Botanic Gardens (UWBG) has been developing the Pacific Connections Garden at the Washington Park Arboretum location over the past 10 years. Groundwork has been laid to continue the expansion of this project for the next several decades. The garden features eco-geographic plant collections from five regions around the world with climates similar to the Pacific Northwest. There are gardens representing plant communities of Chile, China, Australia, Cascadia, and New Zealand.

While the infrastructure and some wild-collected plantings for the Cascadia Forest were installed in 2010, the New Zealand Forest was the first garden to be fully completed as part of the larger Pacific Connections project. The garden opened in 2013. It is a well-developed 2.5 acre area with as many as 10,000 plants representing over 90 taxa native to New Zealand. Prior to the conception of the Pacific Connections Garden project, the UWBG featured a smaller collection of plants native to the subalpine forest of Arthur's Pass, an area in the northeast region of the South Island of New Zealand. That smaller display garden was installed in partnership with the Seattle-Christchurch Sister City Association. This part of the collection has been moved and incorporated into the larger New Zealand garden. In 2010 several UWBG staff members undertook an analysis of the climate in both the South and North Islands of New Zealand in order to identify a region of New Zealand with plant communities that could thrive in the climatic realities of Seattle, WA. Through this work, the Lakes region and Central Otago (see Figure 1) were identified as the best match to Seattle's climate (Dunne 2013). The southern part of the Canterbury region also has plants that can survive in Seattle and are included in the New Zealand Forest.

A limiting factor in ecoregion selection was identifying parts of New Zealand with adequately low temperatures. Seattle is at a latitude of 47.6062° N, 122.3321° W and Central Otago and the Lakes region are centered around 45.2828° S, 169.6568° E. New Zealand is an island with a mostly oceanic climate. The most continental climate occurs in the widest part of the country, only 160 km from the coast, in the Central Otago region. The Lakes region (also called Queenstown-Lakes) is in the western part of Otago, extending to the edge of New Zealand's Fiordland National Park on the west coast of the South Island. The Lakes region is mountainous with freezing temperatures in winter. In addition to concerns about cold hardiness, another major determining factor was finding a region with plant communities that could handle the drought stress of the dry summers that occur in Seattle. Both Seattle and Central Otago exist in a rain shadow. However, Central Otago receives significantly less rainfall with some areas receiving as little as 501 mm of rain per year compared to the average of 965 mm in Seattle. While these climates are not a perfect fit, the initial and subsequent installations of the New Zealand Forest have been successful. The New Zealand Forest is the largest collection of New Zealand native plants outside of New Zealand. It is undoubtedly a highlight of the UWBG.

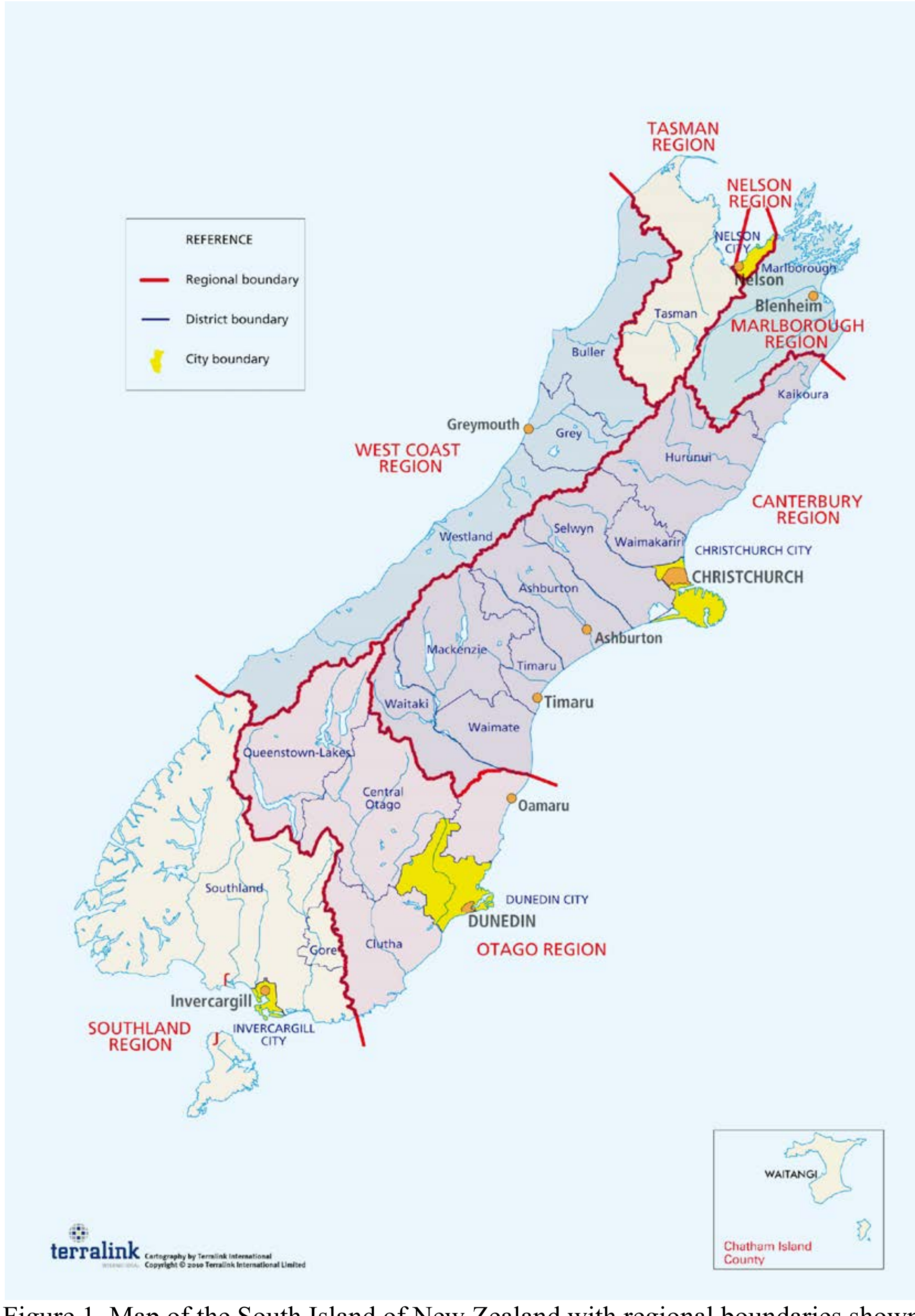


Figure 1. Map of the South Island of New Zealand with regional boundaries shown in red. The target areas of Central Otago and the Lakes region (demarcated Queenstown-Lakes on map) are shown.
Source:Local Government New Zealand (LGNZ) (2017). https://www.lgnz.co.nz/
https://www.lgnz.co.nz/nzs-local-government/new-zealands-councils/

1.1.2 The role of botanical gardens in community, education, and conservation

Now that we have a taste of the theme and purpose for the New Zealand Forest, let's zoom out and look broadly at the intent of botanical gardens in general. For centuries, botanical gardens have been hubs of horticulture, plant science, and public engagement. The global plant conservation network Botanic Gardens Conservation International (BGCI 2012) defines botanical gardens as "...institutions holding documented collections of living plants for the purposes of scientific research, conservation, display and education." Throughout history the role of botanical gardens in academia and society has shifted significantly. The interpretation and methods for pursuing scientific research, conservation, display and education have evolved. Botanical gardens around the world vary substantially in their missions and how they achieve these essential garden-defining characteristics.

The earliest botanical gardens date back to the mid 16th century. Gardens in this era were established by universities and focused on facilitating the study and cultivation of medicinal plants (Oldfield 2007). During the Age of Exploration, when Europeans began sailing and colonizing faraway lands, the focus of European botanical gardens shifted to studying and growing exotic plants. In this era, botanical gardens played a critical role in the introduction and trade of foreign plants with newfound economic importance, like tulips, coffee and rubber. (Borsch and Lohne 2014). The desire to study, explore, and collect the entirety of the floral biodiversity on earth was kindled during this time.

Today, botanical gardens are less focused on studying exotic plants that could be economically significant, and more focused on connecting a disconnected public to the natural world. Botanical gardens play a major role in actively conserving biodiversity, in addition to educating the public about sustainability and threats to the environment. By hosting different programming and research in an immersive botanical environment, gardens provide an invaluable informal education. (Krishnan 2016). Globally, botanical gardens see as many as 200 million visitors each year. While there is progress to be made in inclusivity and serving a more diverse audience, botanical gardens have the opportunity to enlighten a broad swath of the public about the crucial role plants play in our world (Borsch and Lohne 2014).

One of the core principles identified in the BGCI's *International Agenda for Botanic Gardens in Conservation* is that plant collections at botanical gardens should have an underlying scientific basis (Wyse and Sutherland 2000). The way gardens interpret the scientific basis of their plant collections is variable. Traditionally, there has been more of an emphasis on arranging living collections in taxonomic or systematic groups. The foundation and rapid expansion of Royal Botanic Gardens, Kew and other historic European gardens in the 18th century occurred concurrently with the publication of Darwin's *On the Origin of Species* and the subsequent explosion of taxonomy and classification study in the scientific world (Judd 2007). Displaying living collections by phylogeny was logical and useful for the scientific pursuits undertaken in that era. Fundamentally, gardens reflect the culture and values of the time (Krishnan 2016). Present day gardens use a diverse array of methods to uphold their commitment to the scientific underpinnings of their collections, corresponding to their themes and goals. Many gardens have a combination of traditional taxonomic displays coupled with thematic gardens. Thematic gardens can retain their scientific nature by being phytogeographic or representing a specific ecosystem with emphasis on how plant communities are adapted to certain environments. Some gardens incorporate more ethnobotanical elements to their displays. For example, The Eden Project in Cornwall, UK has Mediterranean and rainforest indoor geodesic dome biomes. Their collection is meant to tell stories of plants used by people from many different cultures (Prance 2002). Another trend in contemporary botanical gardens is developing in situ conservation programs. Conducting monitoring and restoration outside the walls of the physical botanical garden is increasingly important in the current age of rampant biodiversity loss and degradation of ecosystems (Aronson 2014). In the 21st century, botanical gardens are uniquely positioned to connect the public to plants and the environment, as well as to play a key role in plant conservation and ecosystem restoration. Botanical gardens can help bridge the gap between in situ and ex situ plant conservation by focusing on both restoration *and* collection. By working in and accessing in situ sites, gardens can enhance their ex situ conservation goals through seed collection, conserving germplasm, and building robust living plant collections. Furthermore, research, horticulture, and education are fundamental to the missions of many gardens and are vital components in successful integrated plant conservation (BGCI 2012). Botanical gardens are based on science and are meant to serve the purposes of education and conservation. Assessing the path forward for any garden is about understanding and balancing these goals.

1.1.3 Pacific Connections Garden and The New Zealand Forest

The Washington Park Arboretum (WPA) at the UWBG is a large and diverse garden. The UWBG 2018 collections policy nicely summarizes the three types of collections maintained in the garden. There are nationally accredited plant collections arranged by phylogeny with known wild or garden origin. These displays, in addition to other robust collections of genera and families, are used in research and education at the University of Washington. There are also Horticultural and Functional Plant Collection displays that are useful in demonstrating landscape management techniques (UWBG Collections Policy 2018). The living collections are interwoven within a native plant matrix that occupies a large portion of the grounds at the WPA. There are several sites where urban ecological restoration is actively taking place. In addition to native plants, functional, and taxonomic themed gardens, the UWBG has Ecological and Geographic (also called ecogeographic or phytogeographic) Collections. The Pacific Connections Garden has an ecogeographic theme; there are focal forests representing Cascadia, China, Chile, Australia, and of course New Zealand. The 2018 collections policy suggests that plants in ecogeographic collections should have:

· Ability to grow in the Puget Sound basin. Most commonly, these plants originate from temperate regions with similar rainfall and temperature
· Potential and actual landscape value
· Origin from native and/or local habitats of significance
· Research and educational interest

The 14-acre Pacific Connections garden was the first major addition to UWBG's Washington Park Arboretum's collections since the installation of the Conifer Meadow expansion of the Pinetum in the early 1980s (Washington Park Arboretum Historic Review 2003). This project was undertaken with great enthusiasm because of its alignment with the UWBG mission statement of "Sustaining managed to natural ecosystems and the human spirit through plant research, display and education."

Indeed, presenting immersive ecogeographic displays which educate about plants, culture, and conservation simultaneously, is a vital and worthwhile feature of the WPA. As the first of the PCG's focal forests to be fully completed, the New Zealand Forest has long excelled at presenting such opportunities to learn. However, several strengths make the New Zealand Forest particularly well suited to do so in a compelling and dynamic fashion.

New Zealand has a visually interesting and biologically rich native flora with a fairly high degree of endemism; 80% of plant species found in New Zealand are only native to New Zealand (Dawson 1988). New Zealand has been geographically isolated for 60 million] years, when it separated from the Gondwanan supercontinent (Thorsen 2009). It provides a unique opportunity to study evolution because although it has been isolated for so long, it has a longer evolutionary history compared to other remote islands like Hawaii and the Galapagos (Winkworth 2005). Plants in New Zealand have some noteworthy traits. Unlike North American native plants, many species exhibit heteroblasty, distinct juvenile and adult forms. Many plants have small leaves with divaricating branches. This is hypothesized to be a defense against browsing by Moa, the now extinct large flightless birds that used to inhabit New Zealand (Dawson 1988). Many New Zealand natives have non-distinctive white flowers because the primary pollination methods are wind and moths. Wind is the most common seed dispersal method, followed by endozoochory, seed dispersal via ingestion by a vertebrate animal (Thorsen 2009). While New Zealand species often have white flowers, many have brightly colored fruits that attract birds who disperse seed. It is no surprise that many New Zealand natives have been bred into cultivation and can be seen growing in gardens throughout the world.

Another strength of the garden is the rocks that are incorporated into the design. The rock placement mimics the natural ecosystem found in Central Otago and the Lakes region (Wood 2013). Particularly, the landscape of inland Otago features rocky outcrops known as schist tors, which are formed by different weathering-rates of rocks (Mckinnon 2015). In the New Zealand Forest, the rockwork serves the dual purpose of processing water and helping amend the heavy clay soil at the site. Nuanced horticultural systems that mimic natural ecosystems are on the rise in botanical gardens (Krishnan 2016). The success and sophistication of the New Zealand Forest and Pacific Connections Garden indicate that the UWBG could be a leader in the field in ecogeographic displays and a helpful resource to a larger network of botanical gardens.

Seattle is privileged to have a sister city relationship with Christchurch, New Zealand. The sister city association allows citizens and local governments to collaborate and promote international goodwill and friendship. The New Zealand Forest is a physical representation of this relationship and honors the friendship. It is a great space for people of all cultures to connect while appreciating the flora of another part of the world.

1.1.4 Dunedin Botanic Garden internship

As part of my studies I travelled to New Zealand to do a horticultural internship with the Dunedin Botanic Garden on the South Island of New Zealand. The Dunedin Botanic Garden (DBG) is the closest botanical institution to Central Otago and the Lakes region, the target ecogeographic areas for the New Zealand Forest. I lived at the Dunedin Botanic Garden and worked alongside curators, gardeners, and apprentices there from February to May of 2019. As

New Zealand is in the southern hemisphere, I was there during the late summer and autumn, an ideal time to both learn about plants and collect seed. I worked mostly in the New Zealand Native and Geographic Plant collections, alongside curators Kate Caldwell and Dylan Norfield, as well as with the staff Botanist Tom Myers.

1.1.5 Aims and intentions of this paper

This document serves to contribute research and information for the continued development of the New Zealand Forest. Through existing connections and new relationships formed with and through the DBG, I was able to collect wild growing seed from the regions the New Zealand Forest garden at the UWBG is meant to represent. The seed I collected and sent back to Seattle is being grown to be added to the collection at the UWBG. The appendices of this paper document provenance data and other useful information about the seed lots. Through my internship in New Zealand, and connection to the UWBG as a student and employee, I hope to forge stronger connection and encourage collaboration between the Dunedin and University of Washington Botanic Gardens.

This paper is intended to be used as a resource for present and future staff at the UWBG. It will review and synthesize personal communications and input shared regarding New Zealand native plants from skilled gardeners and botanists from New Zealand. It will document my process and methods for obtaining seed in order to create a record and to be a resource for future seed collecting endeavors for the Pacific Connections Garden and potentially for other projects at the UWBG. I will also remark on my experience and make suggestions about how to most effectively source seed from New Zealand and continue to add to the collection.

This paper contains three sections.

1. **An evaluation of the current collections of the New Zealand Forest and suggested plant additions**. I will discuss the ecoregions represented in the garden and how they could be adjusted and added to. This section contains reference photos of Central Otago and the Lakes regions. I will end with a list of plants that would be well suited to grow in the New Zealand Forest.
2. **Seed collection process and data.** I will present my intentions and provide an explanation of my seed collection process. This section will outline the importance of growing wild-collected plants in botanical gardens. It will contain an explanation of the requirements for seed collecting in New Zealand that should be helpful for procuring more New Zealand native seed in the future. I will discuss how I was able to collect seeds and my specific methods of collection, cleaning, and storing for each species. To conclude, I will make recommendations for the best methods for sourcing seed from New Zealand and provide a list of useful contacts and resources. This section will be accompanied by a seed inventory list with provenance data for the seed I have successfully mailed to the US to be grown by Far Reaches Farm on behalf of UWBG.
3. **Cultural considerations and contributing research.** In this section I will provide background about indigenous cultures and plants in New Zealand. I will discuss the value of incorporating cultural information and traditional uses of plants in botanical garden displays and learning opportunities. I will compile information about the cultural stories and uses for plants growing in the New Zealand Forest.

1.2 An evaluation of the ecoregions represented in the New Zealand Forest

1.2.1 Vegetation Patterns of Central Otago and the Lakes Region

The vegetation patterns in the South Island of New Zealand can be classified at various scales and through different lenses. Habitat qualifications are useful for organizing and understanding how to capture a complete-as-possible version of the focal region for the New Zealand Forest. While these classifications serve as a great framework for guiding the development of the collection, giving them too much consideration can be restrictive. Of course, it is impossible to distil 12,000 square miles into 2.5 acres. However, loose zones of distinct yet fluid plant communities help to break up the space and create a more sophisticated experience for garden visitors. Accordingly, the New Zealand Forest is composed of seven fairly distinct habitat types based on the focal region. These are: Silver Beech, Mountain Beech, Griselinia Bush, Snow Tussock, Mountain Tussock, Hebe Heath, and Phormium Fen. The zones create visual and topographical diversity in the garden.

Before we delve into each featured habitat type, it is worthwhile to discuss the general climatic trends of Central Otago and the Lakes region. The prevailing wind on the South Island comes from the west and is intercepted by the Southern Alps, creating a drastic gradient in rainfall from west to east across the country. (Mark 1969). Central Otago is in the rain shadow and therefore is New Zealand's driest region. 160km from the coast, Central Otago has one of the only climates in New Zealand that is not directly affected by proximity to the ocean. Central Otago has the largest seasonal variation, with hot dry summers and cold frosty winters (McGlone 2007). The Lakes region is located to the west of Central Otago and has a wetter climate with more forest. The Southern Alps run more directly through the Lakes region and moisture from the west coast penetrates the area. This part of the country was highly glaciated and has many valleys and large, deep lakes.

The two main resources I consulted to better situate the UWBG's featured ecoregion classifications within the broader discussion of the ecology in New Zealand were *Forest Vines to Snow Tussock* by John Dawson and *A Classification of New Zealand's Terrestrial Ecosystems* published by the New Zealand Department of Conservation.

Dawson identifies the predominant vegetation types in New Zealand prior to European settlement as:

- Conifer-broadleaf forest
- Beech forest
- Lowland shrub and fernland
- Short Tussock grassland
- Alpine shrubland and herbfield
- Alpine fellfield and barrens

Of these vegetation types, Central Otago and the Lakes region are comprised mostly of tussock grasslands, beech forest, montane, subalpine and alpine shrublands and herb fields, and small amounts of conifer-broadleaf forest.

Figure 2. Vegetation map for Central Otago and Queenstown Lake ecoregions.
Souce: Malcom Mckinnon, “Otago region- climate, plants, and animals.” Te Ara- the Encyclopedia of New Zealand, https://teara.govt.nz/en/interactive/22165/vegetation-map.

The New Zealand Department of Conservation (DOC) published *A Classification of New Zealand’s Terrestrial Ecosystems* (CNZTE) in 2014. This document breaks down the ecosystems found in New Zealand into zonal and azonal types. For the purposes of this paper I will focus on the zonal classification that are determined by macroclimatic factors, opposed to azonal types, that are determined by edaphic conditions. Figure 3, taken from the DOC report shows the macroclimatic patterns of the South Island.

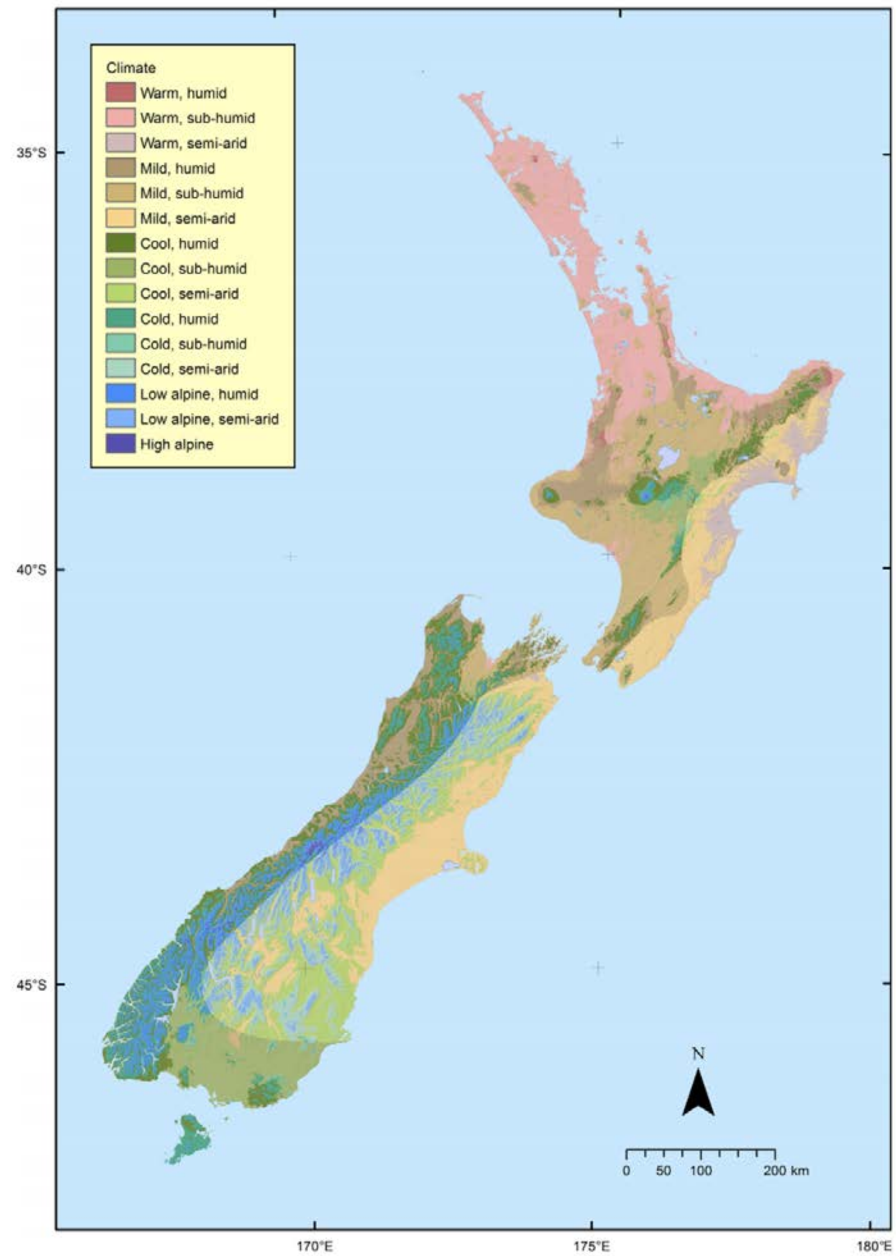


Figure 3. Macroclimatic zones of New Zealand (from *A classification of New Zealand's Terrestrial Ecosystems* by Nicholas J.D. Singers and Geoffrey M. Rogers.)

Macroclimates in Central Otago and Lakes region are predominantly:

Mild (mean summer temperature >15 °C to < 17.5°C, **semi-arid** (Penman annual water deficit is greater than 270mm per)

Cool (>12/5°C to <15°C, **semi-arid**

Cold (>10°C to <12.5°C), **semi-arid**

Low alpine (5°C to <10°C, **humid**(Areas where rainfall is at least four times greater than evapotranspiration, predominantly mesophytic plants.)

Low alpine, **semi-arid**

The ecosystems identified in the CNZTE are more specific and numerous than the 7 habitat types found in the New Zealand Forest, but there is overlap between the two habitat classification systems. Based on rainfall and temperature, 21 ecosystem units identified in the DOC document spatially overlap with geographic target region for the New Zealand Forest. These ecosystem units are described in more detail in tables 1 through 6.

Table 1. Semi-arid mild forests

Ecosystem unit code	Plant community
MF3	Mataī (*Prumnopitys taxifolia*), tōtara (*Podocarpus totara*), kahikatea (*Dacrycarpus dacrydioides*), broadleaf (*Griselinia littoralis*) forest. This forest type has a similar mean summer temperature to Seattle.

Table 2. Semi arid to sub humid cool temperate forest and scrub

Ecosystem unit code	Plant community
CLF1	Hall's tōtara (*Podocarpus cunninghamii* syn. *P. hallii*), mountain celery pine (*Phyllocladus alpinus*), broadleaf (*Griselinia littoralis*) forest.
CLF3	Podocarp, ribbonwood (*Plagianthus regius*), kowhai (*Sophora* spp.) forest.
CLF4	Kahikatea (*Dacrycarpus dacrydioides*), tōtara (*Podocarpus totara*), mataī (*Prumnopitys taxifolia*) forest.
CLF9	Red beech (*Fuscospora fusca*), podocarp forest.
CLF10	Red beech (*Fuscospora fusca*), silver beech (*Lophozonia menziesii*) forest.
CLF11	Silver beech (*Lophozonia menziesii*) forest.
CLF12	Silver beech (*Lophozonia menziesii*, mountain beech (*Fuscospora cliffortioides*) forest

Table 3. Semi-arid cold forests and scrub

Ecosystem unit code	Plant community
CDF1	Pāhautea (*Libocedrus bidwillii*), Hall's tōtara (*Podocarpus cunninghamii* syn. *P. hallii*), mountain celery pine (*Phyllocladus alpinus*), broadleaf (*Griselinia littoralis*) forest.
CDF2	*Dracophyllum*, mountain celery pine (*Phyllocladus alpinus*), *Olearia*, *Hebe*, subalpine scrub.
CDF3	Mountain beech (*Fuscospora cliffortioides*) forest.
CDF7	Mountain beech (*Fuscospora cliffortioides*), silver beech (*Lophozonia menziesii*), montane podocarp forest.

Table 4. Sub-humid, semi-arid to humid low alpine

Ecosystem unit code	Plant community
AL1	Narrow-leaved (*Chionochloa rigida*) and slim snow tussock (*Chionochloa macra*) tussockland/shrubland.
AL3	Red tussock (*Chionochloa rubra*)tussockland/shrubland.
AL4	Mid-ribbed (*Chionochloa pallens*) and broad-leaved snow tussock (*Chionochloa flavescens*) tussockland/shrubland.
AL5	Mid ribbed (*Chionochloa pallens*), broad leaved, red (*Chionochloa rubra*) and carpet grass (*Chionochloa australis*) tussockland/shrubland.
AL6	Mid ribbed (*Chionochloa pallens*) and narrow-leaved snow tussock (*Chionochloa rigida*) tussockland/shrubland.
AL7	Pungent snow tussock (*Chionochloa crassiuscula* subps. *crassiuscula*) tussockland/shrubland.

Table 5. Semi-arid to sub-humid cold air inversion topography

Ecosystem unit code	Plant community
TI1	Bog pine (*Halocarpus bidwillii*), mountain celery pine (*Phyllocladus alpinus*) scrub, forest.
TI4	*Coprosma*, *Olearia*, matagouri (*Discaria toumatou*) scrub [Grey scrub].

Table 6. High Alpine sub-humid

Ecosystem unit code	Plant community
AH2	*Dracophyllum muscoides* cushionfield

Additional species lists and habitat details for each of these ecosystem classifications can be found in *Classification of New Zealand's Terrestrial Ecosystems*.

Mountain and silver beech, as well as tussock grasslands, are clearly recognized in the literature. Hebe Heath, Griselinia Bush, and Phormium Fen are looser terms that are less defined with regard to how and where they occur in Central Otago and the Lakes region. I have been able to understand these three themes by reviewing the species lists for each habitat type in the New Zealand Forest and comparing them to plant communities I saw in New Zealand that had the same or similar species composition. Furthermore, I have read about and observed ecosystems in Central Otago that were not well represented in the seven habitat themes of the New Zealand Forest. For instance, grey scrub is a habitat type that thrives in dry regions of New Zealand and is present in less modified areas of Central Otago. Two shrubs, matagouri (*Discaria toumatou*) and *Coprosma propinqua* are characteristic plants of this community, along with other small-leaved divaricating shrubs. While grey scrub typically occurs in areas of Central Otago that are significantly drier than Seattle, it is a rich and significant ecosystem in the target region for the New Zealand Forest. An ecological report done in response to proposed development in the Wakatipu basin cites grey shrubland as the key remaining indigenous flora in the area (Davis 2018). If possible, it is in line with the mission of the New Zealand Forest to represent this plant community. There is no existing ecozone in the New Zealand Forest that grey scrub could be logically absorbed into, but it could be blended in among existing themes. I observed and collected seed from grey scrub growing adjacent to communities of mountain beech forest and below snow tussock grasslands near Wanaka, in the Lakes region.

This section will provide background information about each of the seven highlighted habitat types in the New Zealand Forest. I will compare the species composition of the New Zealand garden to the vegetation types and ecology noted by ecologists and botanists in the literature.

When available I'll share photos of plant communities occurring naturally in New Zealand that mirror one or a combination of the habitat types in the New Zealand Forest. This section will conclude with a list of plants currently not in the UWBG collection that would be a good fit for the New Zealand Forest.

1.2.2 Silver and Mountain Beech Forests

While they are distinct, I have combined the Silver and Mountain Beech vegetation types for simplicity. Silver beech (*Lophozonia menziesii*) and mountain beech (*Fuscospora cliffortioides*) are not true beeches, but are known as southern beech. Both species, along with the other New Zealand natives red beech, hard beech, and black beech had all been classified in the larger genus *Nothofagus* before new molecular evidence suggested that New Zealand beeches are phylogenetically distinct from the rest of the genus. Beech forest is one of New Zealand's two main types of native forest, with beech trees occurring in 80-90% of forests in the South Island (Orwin 2007). Both silver and mountain beech occur in montane and subalpine forests. Highlighting silver and mountain beech as focal species to represent their respective habitats is a solid strategy because in many situations one species dominates the landscape. However, beech forests in the South Island are dynamic. While beech forests tend to be relatively simple plant communities with low species richness and open understories, many beech forests blend and contain a mosaic of beeches and other associated species.

There are many variations of silver beech habitat on the South Island of New Zealand. The silver beech tree, *Lophozonia menziesii* (*Nothofagus menziesii*) is New Zealand's most cold- hardy beech. Seedlings can withstand temperatures as low as 12.4°C (Sun 1996). Although they can tolerate the cold , Central Otago is mostly devoid of silver beech forest because there is not enough rainfall to support tree growth. Silver beech grows from sea level to tree line in the southwestern part of the South Island. The trees can grow to 25 meters high with a 0.6 to 1.5m trunk that is sometimes buttressed (Orwin 2007). It prefers more fertile soils than mountain beech (NZ Department of Conservation).

I observed silver beech habitat in a recreational area northeast of Wanaka. Silver beech dominated, growing among red and mountain beech from 374m to 700m at the base of Rob Roy Glacier. Silver beech forests appeared to have greater species richness compared to the mountain beech habitats I visited. I saw *Lobelia angulata*, *Raukaua simplex*, *Astelia nervosa, Gaultheria crassa*, *Coprosma rigida, C. pseudocuneata*, *C. rugosa*, *C. cuneata*, *Olearia moschata*, *Chionochloa conspicua*, among many others. I also observed silver beech forest in the Catlins, a coastal area southeast of the target region for the New Zealand Forest. Figures 4 through 6 show silver beech habitat I observed.


Figure 4. Silver beech forest at Rob Roy Glacier Track. Photo taken by Kyra Matin near Wanaka, New Zealand. May 2019.

Figure 5. Silver beech understory at Rob Roy Glacier Track. Photo taken by Kyra Matin near Wanaka, New Zealand. May 2019.

Figure 6. Silver beech forest in The Catlins. Photo taken by Kyra Matin near Papatowai, New Zealand. March 2019.

Mountain beech trees grow predominantly in dry montane and subalpine forests and shrublands. They can grow to 20 meters tall, but can be severely stunted when growing at high elevations (T.E.R:R.A.I.N). The mountain beech forests I encountered in Central Otago and the Lakes region were far simpler than forests with silver, red or a mixture of beeches. I collected seed from remnant patches of almost pure stands of mountain beech at Mahu Whenua, a privately owned land covenant near the Crown Range in the Lakes region. Figures 7 through 11 show how the forest floor devoid of understory plants. The landscape there consisted of patches of dense mountain beech surrounded by grey scrub with manuka (*Leptospermum scoparium*), matagouri (*Discaria toumatou*), mingimingi (*Coprosma propinqua*), and snow tussock grasslands above the treeline.

Figure 7. *Gaultheria antipoda* growing in association with mountain beech at Mahu Whenua. Photo taken by Kyra Matin near Glendhu Bay, New Zealand. March 17 2019.

Figure 8. Mature mountain beech at Mahu Whenua; see sparse understory. Photo taken by Kyra Matin near Glendhu Bay, New Zealand.March 17 2019.

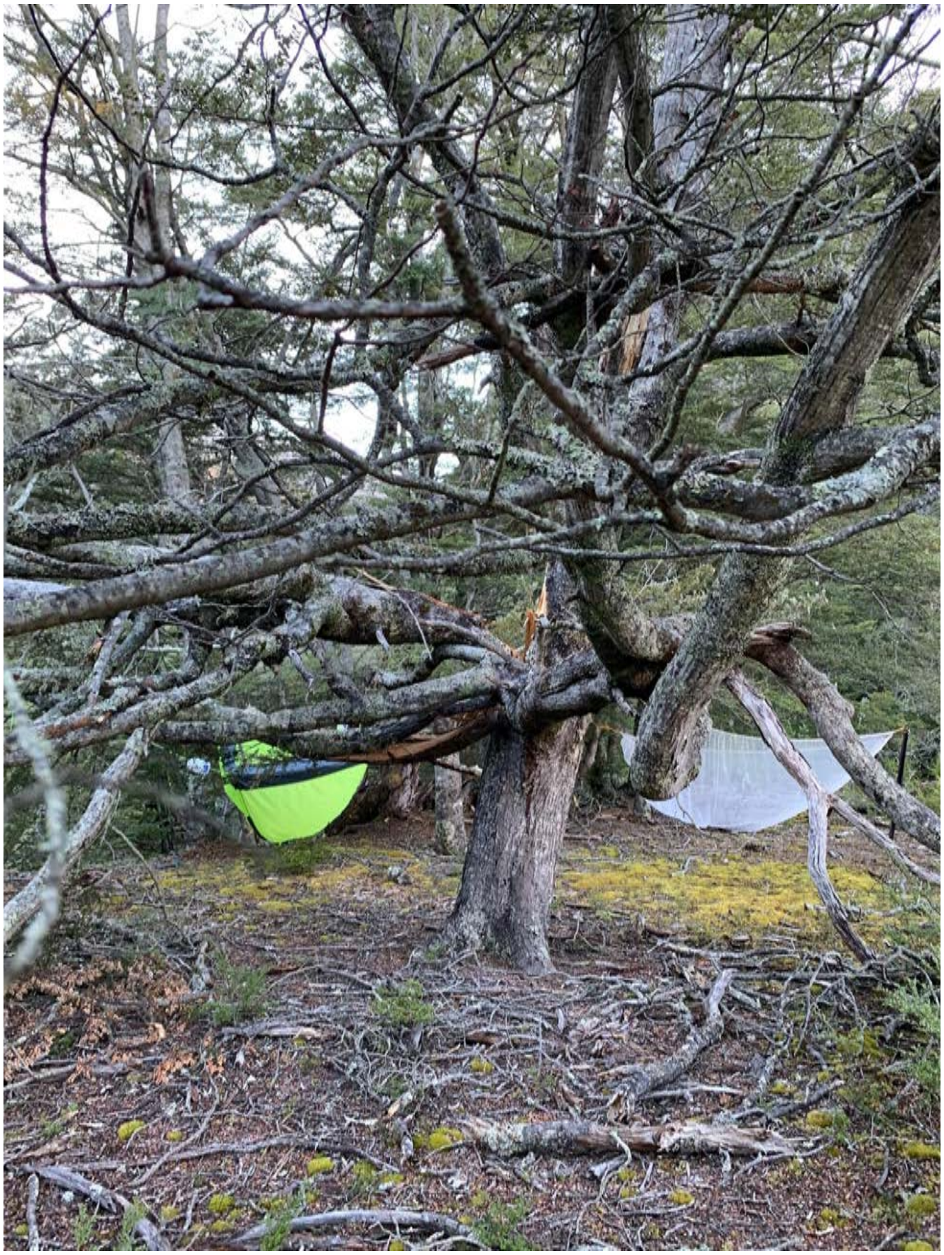


Figure 9. Mature mountain beech with seed traps at Mahu Whenua. Photo taken by Kyra Matin near Glendhu Bay, New Zealand. March 17 2019.

Figure 10. Forest floor in patch of mountain beech at Mahu Whenua. Note the large amount of woody debris on the ground. Photo taken by Kyra Matin near Glendhu Bay, New Zealand. March 17, 2019.

Figure 11. University of Otago students and professor walking through mountain beech patch in Mahu Whenua. Photo taken by Kyra Matin near Glendhu Bay, New Zealand. March 17 2019.

There are several well-developed southern beech specimens, including a *Nothofagus* species from Chile, in the New Zealand Forest. However, far more beech trees will need to be planted in order to accurately mimic the beech forests of New Zealand. Procuring and planting southern beech is a high priority. I have successfully imported wild-sourced mountain beech seeds but unfortunately did not successfully import silver beech. If the mountain beech seed has high germination success, those trees that have developed in the nursery will be incorporated into the New Zealand Forest. In the meantime, if understory plants become available they could be planted near existing specimens or in temporary shady locations to be moved or propagated as the beech canopy develops. If limbs fall from the existing mountain beech specimens it would be interesting to try to keep that wood onsite, because woody debris was a particularly striking feature of the mountain beech forests I observed at Mahu Whenua.

1.2.3 Griselinia Bush

Griselinia is an interesting genus with only seven species, five that are endemic to South America and two endemic to New Zealand. New Zealand's native *Griselinia* are *G. littoralis* and *G. lucida*. *G. lucida* grows mainly in Coastal regions of the North Island and is often epiphytic. *G. littoralis*, also known as kapuka or broadleaf, grows throughout the North and South islands. It is common in cultivation and often planted as a hedge or windbreak. A garden designer from the firm O2 Landscapes in Auckland writes about *Griselinia*:

> Our native members of this genus have become so ubiquitous that it could be easy to be dismissive of them as a sort of horticultural panacea that is trundled out in the absence of other ideas. However, a good plant shouldn't be dismissed just because it has become a standard.

G. littoralis can grow to ten meters but smaller specimens are common. They grow well in sandy or well-drained loamy soils. In the wild, kapuka is commonly seen growing in a variety of settings among broadleaf shrubs, trees, and conifers (Terrain 2018).

There are two forest types from the DOC's *A Classification of New Zealand's Terrestrial Ecosystems* for Otago that feature *Griselinia*. The first, CDF1, is a forest system composed of *Griselinia* growing alongside *Podocarpus cunninghamii,* celery pine, and the threatened conifer *Libocedrus bidwillii*. The other, MF3, is a forest system featuring *Griselinia*, Mataī (*Prumnopitys taxifolia*), tōtara (*Podocarpus totara*), kahikatea (*Dacrycarpus dacrydioides*).

I collected seed from a landscape that could be characterized as 'Griselinia Bush' in the hilly North East Valley suburb of Dunedin. This area is coastal and more temperate than Seattle, but there are microclimates with colder temperatures at higher elevations, specifically on Mount Cargill. There, *Griselinia* is found growing to only 2 meters tall. It is present at varying densities from the foothills to the top of Mount Cargill. At lower elevations I saw it growing alongside *Fuchsia excorticata*, *Clematis paniculata*, and *Weinmannia racemosa*.

At higher elevations it grew alongside *Dracophyllum longifolium*, *Phyllocladus alpinus*, *Libocedrus bidwillii*, *Coprosma* spp., *Gaultheria antipoda*, *Schefflera digitata*, *Neomyrtus pedunculata, Raukaua simplex*, and other species. There are many species of moss, lichen, ferns, and herbs growing alongside the shrubs mentioned above. Currently, Griselinia Bush in the New Zealand Forest features other shrub species like *Pittosporum*, *Olearia*, *Hebe*, *Melicytus*, *Leptospermum* and *Pseudopanax*. More shrubs and trees like *Coprosma*, *Brachyglottis*, and *Fuchsia excorticata* could be added to the area. New Zealand native conifers like mataī (*Prumnopitys taxifolia*) and kahikatea (*Dacrycarpus dacrydioides*) could also be tried. Ground covers like *Fuchsia perscandens* and *Nertera* spp. could be planted with ferns alongside the trees and shrubs.

Figure 12. Mature *Griselinia littoralis* growing at Dunedin Botanic Garden on South Island of New Zealand. Photo taken by Kyra Matin. February 2019.

Figure 13. *Griselinia* growing with *Phormium*, *Hebe salicifolia*, and *Pseudopanax* on Mount Cargill. Photo taken by Kyra Matin in Dunedin, New Zealand. February 2019.

1.2.4 Snow and Mountain Tussock

Tussock grasslands are an emblematic vegetation type of New Zealand. They deliver a wide range of vital ecosystem services, particularly for water storage and soil conservation. In New Zealand, they are under threat from grazing, invasive species, and climate change (Mark 2013). It is important that tussock grasslands are protected and managed in New Zealand. The miniature tussock grassland at the New Zealand Forest is a snapshot of this awe-inspiring ecosystem. In managed landscapes, tussocks help hold banks and stop erosion. Continued development of the tussock grasslands at the New Zealand Garden will strengthen the benefits of this plant community in the garden.

I have combined the Snow and Mountain Tussock habitats in this paper because when I was in New Zealand I received feedback from local botanists and ecologists that they do not distinguish between snow and mountain tussock (Kate Caldwell, personal communication). Grasslands in the mountains are called snow tussock (sometimes mountain-snow tussock) grasslands. Snow tussock or snow grass, with various qualifiers, is the common name for many species of *Chionochloa* that grow in alpine and subalpine grasslands. Snow tussock grassland is also referred to as tall tussock, as these species can reach 2 m in height. In addition to tall tussock communities, short tussock grasslands are present in the South Island from sea level to the subalpine zone (800m). Unfortunately, short tussock grasslands have been heavily modified by land use changes and invasive species pressure, so unaltered short tussock is extremely rare. Short tussock grassland is dominated by *Festuca novae-zelandiae*, *Poa colensoi*, and *Poa cita*.(Environment Guide 2018).

Tall tussock grasslands are dominated by 6 species of *Chionochloa*, four of which grow well in cold situations. *Chionochloa rubra* or red tussock grows in subalpine to alpine habitats and thrives in wet, poorly-draining soil (Mark 1969). It performs well in the New Zealand Forest. *Chionochloa rigida,* also called narrow leaf tussock, is common on the South Island from sea level to the high alpine zone. *Chionochloa flavescens* is large and can reach almost 2m in height. t grows within 200m of the tree line and tolerates wet soils. *Chionochloa crassiuscula*, curly tussock, thrives in the subalpine to alpine in poor-draining soils. I saw *Chionochloa conspicua* in the Lakes region growing in forest margins in both hard clay and rockier well-draining soil. *Celmisia*, *Ranunculus*, *Gentiana*, *Aciphylla, Anisotome*, *Astelia*, *Hebe*, and *Dracophyllum, Carex breviculmis,* and *Poa maniototo* are observed growing in tussock lands of western Otago (Mark 2013). More herbs that grow in subalpine tussock include:

Atriplex brevicephalus	*Carmichaelia petriei*	*Colobanthus brevicephalus*
Convolvulus verecundus	*Craspedia* 'Clutha'	*Epilobium hectori*
Lepidium solandri	*Leptinella conjuncta*	*Muehlenbeckia axillaris*
Muehlenbeckia ephedroides	*Myosotis uniflora*	*Raoulia australis*
Raoulia beauverdii	*Raoulia monroi*	*Scleranthus uniflorus*

One way to clarify the current distinction between Mountain and Snow tussock in the New Zealand Forest would be to create an elevation gradient. More grasses, herbs, and shrubs that grow in tussock grassland at lower elevations and in montane and subalpine zones could be added to the Mountain Tussock area, while subalpine and alpine tussocks and herbs could be the focus of the Snow Tussock area. This distinction may be too fine-grained given the relatively small space, but could be considered if an opportunity to plant in these garden sections arises. The sloped nature of the New Zealand Forest may make it possible to create an experience where visitors either enter the from Arboretum Drive E. and walk down in elevation from Snow Tussock into Mountain Tussock, or enter via the lower trail and wind their way up the path from Mountain Tussock to Silver Tussock.

A feature of tussock grassland I found especially attention-grabbing was the tall and spikey *Aciphylla* spp., commonly called Spaniards, growing among the grasses. According to collections records the diversity of *Aciphylla* that grow in Central Otago and the Lakes region is fairly well represented in the New Zealand Forest. However, planting more among the tall tussock would enhance the interest of the area.

Figure 14. Snow tussock and *Aciphylla* growing at Pisa flats, located between Wanaka and Queenstown, New Zealand. Photo taken by Kyra Matin. May 2019.


Figure 15. Snow tussock flowering in the distance at Mahu Whenua. Photo taken by Kyra Matin near Glendhu Bay, New Zealand. March 16 2019

Figure 16. Snow tussock and mountain beech forest in the distance (center left) at Mahu Whenua. Photo taken by Kyra Matin near Glendhu Bay, New Zealand. March 16 2019.

Figure 17. Snow tussock in flower, intermixed with herbs at Mahu Whenua. Photo taken by Kyra Matin near Glendhu Bay, New Zealand. March 16 2019.

1.2.5 Hebe Heath

According to systematic authorities, the genus *Hebe*, along with the closely related genera *Chionohebe*, *Parahebe*, *Leonohebe*, and *Heliohebe* have been reclassified to the newly expanded *Veronica* genus. Before this reclassification *Hebe* contained the most species of any genus in New Zealand; now, the newly restructured *Veronica* genus contains 124 New Zealand natives. *Hebe* is a recognized synonym and for the sake of consistency I will refer to this group of plants as Hebes.

Hebes grow throughout New Zealand from sea level to high alpine habitats. There is significant morphological variation among species growing at different elevations and moisture levels. Like *Griselinia* and *Phormium*, they do well in cultivation and are a popular landscaping plant. However, there are hundreds of distinct species, varieties, and cultivars of *Hebe* available, compared to the only two New Zealand native *Griselinia* species. Realistically, the most heath-like situation where hebes grow in Central Otago would be in subalpine to alpine herbfield and tussock grasslands, intermixed with grasses and other ericaceous herbs (Dawson 1988).
While hebes are present in forested, scrub, and subalpine heath-scrub systems, they dominate the landscape in the higher shrubland zone (Dawson 1988). The Department of Conservation's

Classification of Terrestrial Ecosystems describes one ecosystem type that features hebes and overlaps with the general focal region for the UWBG New Zealand Forest (Table 3). This is CDF2, a short forest scrub community, characterized by *Hebe* spp., *Dracophyllum* spp., *Phyllocladus alpinus*, *Olearia* spp., *Ozothamnus* spp., *Carmichaelia* spp., *Coprosma* spp., and *Podocarpus nivalis*. This shrubland community has many local variants and occurs in subalpine areas and in the beech gap; areas of the South Island where southern beech is absent despite the climate and soils being suitable for beech forest growth (Orwin 2007). Walker et al. (2004) also note an association between *Hebe odara* and *Phyllocladus alpinus*. *Hebe odora, H. propinqua*, and *H. pauciramosa* can form dense stands, commonly growing with *Phyllocladus alpinus, Ozothamnus leptophyllus*, *Halocarpus bidwillii*, *Olearia nummularifolia*, and *Leptospermum scoparium*. The current 'Hebe Heath' collection in the New Zealand Forest has nice overlap with both habitat types described above, and they could serve as a loose structural outline for the continued development of that part of the collection. In line with the heath theme, more ericaceous heath-type species, like *Androstoma empetrifolia*, *Pentachondra pumila*, *Acrothamnus colensoi*, and *Gaultheria depressa* may be suited to this area.

'Hebe Heath' in particular presents questions in how to best represent these plants. Again, the New Zealand Forest has an ecogeographic theme and aims to represent plant communities of the South Island as they exist in nature. However, there is a huge amount of diversity in hebes from New Zealand. 'Hebe Heath' could focus solely on hebes, showcasing all the varieties of wild hebe species that grow throughout both islands. Alternatively, 'Hebe Heath' could be focused on representing shrub communities with hebes as a key focal plant. More hebe species from the South Island could be planted in appropriate spots throughout the New Zealand Forest. Currently there are hebes in the 'hebe heath' zone as well as in other areas, so there is flexibility in future decision making.

1.2.6 Phormium Fen

Figure 18. *Phormium tenax* growing in moist conditions at the top of Swampy Summit in Dunedin, New Zealand. Associated with *Olearia*. Photo taken by Kyra Matin. April 7 2019.

A fen is a wetland with peaty substrate that exists on a slope or edge of a raised bog. Fens receive groundwater from neighboring soils and therefore have higher nutrient status than bogs. *Gleichenia dicarpa*, tussock, *Leptospermum scoparium*, *Machaerina tenax*, and other tall herbs can be found in fens throughout New Zealand (National Wetland Trust of New Zealand).

The 'Phormium Fen' habitat type in the New Zealand Forest does not necessarily have the edaphic characteristics to qualify as a true fen. However, fens, like many other types of wetlands, are under threat from land use change and habitat loss. Wetlands are not easily accessible to many people, so exhibiting this unique habitat system has value. Furthermore, the 'Phormium Fen' habitat is at the bottom of a hill where soils are generally saturated, so planting water-loving plants capitalizes on the conditions of the site.

There are two species of *Phormium* (flax) on the South Island, *Phormium tenax* and *Phormium cookianum* (syn. *P. colensoi*). *Phormium tenax*, harakeke or swamp flax thrives at lower elevations and can survive in wet, infertile soils. It is often observed growing in ditches along the side of the road (Wehi 2007). *Phormium cookianum*, wharariki or mountain flax grows at higher elevations and also thrives in riparian areas (New Zealand Plant Conservation Network 2014). At

Mirror Lake, north of Te Anau in Fiordland National Park there are small subalpine and alpine lakes surrounded by borders of flax with tussock grassland with beech forest and mountain tops in the background (Figure 19).

Figure 19. Mirror Lake in Fiordland National Park, New Zealand. Note flax growing along the lakeside with beech forest in the background.
Soure: https://scribblesnz.files.wordpress.com/2012/03/img_5690.jpg

Figure 20. High alpine wetland at Mahu Whenua. Photo taken by Cara-Lisa Schloots near Glendhu Bay, New Zealand. 2019.

Figure 21. High alpine wetland at Mahu Whenua. Photo taken by Cara-Lisa Schloots near Glendhu Bay, New Zealand. 2019.

1.3 Plants to consider adding to the collection

1.3.1 Background

The current New Zealand native plant collection at the UWBG is robust and contains a wide array of exemplary species from each of the habitat types represented in the garden. The initial plantings have established nicely. There has been especially good development in the tussock, as well as shrubs and smaller tree species. The species listed below are plants not currently in the UWBG's collection that I encountered either through my research or in person while seed collecting and exploring natural areas on the South Island. They are good candidates to add to the collection because most are found growing in association with Central Otago and Lakes region plants that currently grow in the New Zealand Forest. I have included many herbs, because I think the current shrub layer in the New Zealand Forest could serve to shelter and create more favorable conditions for herbs to establish. Some of these plants may have borderline cold hardiness in Seattle, but I have attempted to restrict the list to species that I saw growing at some elevation or in areas with hard frosts. I have noted in the plant description if a species has specific soil requirements. The table lists which habitat type garden section of the New Zealand Forest I think each plant would be best suited to, but these are loose recommendations; many of these plants would be suitable throughout the New Zealand Forest. I see this list serving as a first step resource and reference for when an opportunity to procure more New Zealand plant material arises. Obviously a thorough evaluation of current space availability and site conditions should be done if any of these species are to be procured.

1.3.2 Table 7. List of suggested plants for the New Zealand Forest

Plant	Garden Section of NZ Forest	Description
Androstoma empetrifolia	Hebe Heath	Commonly called bog mingimingi. This is a creeping ericaceous shrub that grows in shrubland and short forest. It has 0.5cm red berries (Dawson and Lucas 2000). It thrives in poor or peaty soils.
Anisotome cauticola	Hebe Heath Mountain Tussock Snow Tussock	Carrot herb that grows in exposed rocky places (New Zealand Plant Conservation Network 2014).
Apodasmia similis	Phormium Fen Mountain Tussock	Commonly called jointed oi oi, or wire rush. This rush grows in estuaries and along lake margins. It is occasionally found inland in shrubland (New Zealand Plant Conservation Network 2014).
Carex secta	Phormium Fen	This sedge is endemic to New Zealand. It grows in moist sites, often along stream banks (New

		Zealand Plant Conservation Network 2015). It may require too much consistent moisture to thrive in the New Zealand Forest.
Carmichaelia compacta	Mountain Beech	This species has a narrow range centered around Cromwell and Alexandra, near Mt. Pisa. Exporting seed to America may be difficult because the species has an at-risk-declining conservation status. It has purple flowers and grows in rocky scree slopes and steep tussock grassland (New Zealand Plant Conservation Newtok 2014).
Carmichaelia petriei	Snow Tussock	Shorter leafless broom that grows up to 2 m, has small purple flowers. Found growing in rocky grasslands of east of the Southern Alps from the McKenzie country to Central Otago and central Southland. (T.E.R:R.A.I.N)
Celmisia haastii	Hebe Heath Mountain Tussock Snow Tussock	An endemic patch-forming mountain daisy that grows in subalpine to alpine habitats in the South Island. This species likes moist rocky places (New Zealand Plant Conservation Network 2014).
Celmisia prorepens	Hebe Heath Mountain Tussock Snow Tussock	Creeping mountain daisy that is endemic to Central Otago (New Zealand Plant Conservation Network 2011).
Dianella haematica	Griselinia Bush Mountain Tussock Silver Beech	Recently reclassified from all-encompassing *Dianella nigra* to be a group of three species, now including *D. haematica* and *D. latissima* in addition to *nigra.* Both are larger than *nigra*. Named derived from Roman goddess Diana of hunting and the moon. This species thrives in wet habitats (Heenan and De Lange 2007).
Dracophyllum kirkii	Hebe Heath Griselinia Bush	This relatively small species of *Dracophyllum* is endemic to the Eastern South Island from Canterbury to Central Otago. It can be found growing in grasslands and scrub and in rocky habitats. This species thrives in places with consistent rainfall (I saw it growing near north of

		Wanaka, which receives 682 mm of precipitation annually) but can handle dry periods. It thrives in exposed sunny conditions but can grow in some shade (O2 Landscapes 2019). It grows in stony and shingle river beds. It has glaucous leaves with pale yellow flowers in late spring (New Zealand Plant Conservation Network 2014).
Dracophyllum muscoides	Hebe Heath	*Dracophyllum muscoides* herb field (AH2) is an ecosystem type suggested in the DOC ecosystem classification document (Table 6). The prostrate *Dracophyllum* is associated with other cushion/mat forming sub-shrubs. It grows on the South Island in subalpine cushion herb fields and in areas dominated by *Celmisia haastii* (New Zealand Plant Conservation Network 2014, Dawson 1988). Growing alpine plants in garden conditions is challenging and requires trial and error and soil amendment would likely be necessary. However, creating a small subalpine/alpine cushion herbfield display would add a unique and charismatic plant community of Central Otago and the Lakes region to the New Zealand Forest.
Epacris pauciflora	Hebe Heath	Ericaceous shrub with acicular leaves and white flowers that grows in infertile soils on the west coast (New Zealand Plant Conservation Network 2014).
Gunnera monoica	Hebe Heath Griselinia Bush Phormium Fen Silver Beech Mountain Beech	This species is endemic to New Zealand and one of the smallest species of Gunnera, especially compared to its South American counterparts. It likes wet soil and often grows in roadside ditches. Fruits are white with black dots (T.E.R:R.A.I.N). The curator of the UW Botanic Gardens has recently procured several examples of this species to incorporate into the garden in the autumn of 2019.
Hydrocotyle elongata	Hebe Heath Griselinia Bush	This species was recently introduced to cultivation by Oratia Native Plant Nursery in Auckland. It is more common in the warmer parts of New Zealand, but is present on the South Island. It is a creeping ground cover that grows from damp forest floors to grassland edges and thrives in dry shade. (O2 Landscapes, Inaturalist). At the

		Dunedin Botanic Garden this species grows aggressively in wet sections of some beds in the Native plant collection, but has not escaped into other collection or bush areas of the garden. There are aggressive members of the *Hydrocotyle* genus, but it is possible that the colder temperatures in Seattle compared to the species' native range may reduce the plant's vigor if planted in the New Zealand Forest. Regardless, if planted special attention should be paid to the spread of the plant. If substantial patches could establish, this species could serve as a good competitor to buttercup.
Jovellana sinclairii	Snow Tussock Hebe Heath	Herb with white flowers similar to Calceolaria. Grows at sea level to montane region, in wet areas particularly cliff seepages (New Zealand Plant Conservation Network 2015). May be borderline hardy in Seattle.
Kelleria dieffenbachii	Snow Tussock	I saw this diminutive creeping bright green plant with scale leaves growing in tussock grasslands in the Lakes region.
Lobelia angulata	Silver Beech	I observed this creeping lobelia with magenta berries growing in silver beech forest at Rob Roy Glacier track near Wanaka, New Zealand.
Olearia cymbifolia	Silver Beech Griselinia	Tree daisy with rounded form and almost succulent linear leaves. Grows only on the South Island, in shrubland east of the main divide (T.E.R:R.A.I.N).
Pentachondra pumila	Hebe Heath Silver Beech Snow Tussock	This plant is commonly called carpet heath. It is a prostrate evergreen shrub that grows to about 4 inches in height and has attractive red berries. It thrives in acidic and moist soils in sun. It grows in subalpine and alpine areas. (Plants for a Future, T.E.R:R.A.I.N).
Pimelea aridula subsp. aridula	Hebe Heath Silver Beech	This is an emblematic dryland Central Otago plant that thrives in rocky sites and requires full sun and rocky soil. This would need to be planted in an area with amended soil, potentially near some of the rock work in the New Zealand Forest (New Zealand Plant Conservation Newtok 2014). This species would be complimented by growing alongside *Veronica pimeleoides* and *Carmichaelia petriei* or

		Carmichaelia compacta (Clyde Railroad Community Eco-Nursery).
Ranunculus lyallii	Hebe Heath	This is the largest of the mountain buttercups endemic to New Zealand and thrives in herbfield and streamsides in the subalpine and mountain areas of the South Island (New Zealand Plant Conservation Network 2010)
Tmesipteris tannensis	Silver Beech Griselinia Bush	A typically epiphytic fern ally. It may be hard to procure and cultivate but would be interesting to add.

1.4 Ferns

1.4.1 Background

New Zealand is home to many incredible lower order plants. There are 200 fern species, plus an abundance of endemic club moss and moss species native to New Zealand. The silver fern is depicted on the flag, as well as on the uniform of the national rugby team the All Blacks. Ferns are a key feature of the landscape in both the Pacific Northwest and New Zealand; highlighting them creates an opportunity to compare and contrast those landscapes. Moreover, it is worthwhile to showcase ferns found in each of the five Pacific Connections regions as a means to observe the variation of geographically distant yet evolutionarily closely related species. There are ferns in the genus *Polystichum* native to New Zealand and Washington. The family *Blechnaceae* is well represented in Chile and New Zealand.

There are more fern species growing on the North Island, which is more temperate with areas in the subtropical zone. While New Zealand's native tree ferns are visually striking and could be the focal point of a garden, they are borderline hardy in Seattle. On the South Island, tree fern species like *Cyathea dealbata* occur in coastal areas slightly outside the target region for the New Zealand Forest. However, tree ferns are present in many beech forests, and planted in the right location with protection may survive in the Pacific Connections New Zealand Forest.

Each of the habitat types represented in the New Zealand Forest, with the potential exception of Phormium Fen, would be well suited to incorporating more ferns. Ferns were present in almost all the preserved forest, shrubland, and tussock land plant communities I visited during my time on the South Island. They are particularly prevalent in Silver beech forest understory and in wetter shrublands with *Griselinia* and *Hebes*. I have compiled the list below from species I personally observed growing on the South Island. I have also included species from lists for various conservation lands in Central Otago and the Lakes region, compiled by plantsman and retired University of Otago lecturer John Steel and with the help of Otago Botanical Society members. Many of these species have never been grown outside of New Zealand. I have tried to include species that are not only common in the wild but are also available horticulturally in New Zealand. The plant communities I observed on the South Island featured many more ferns, club mosses, and liverworts, but importing and growing those plants may be outside the scope of the

New Zealand Forest and the goals for ecogeographic collections at the UWBG (UWBG Collections Policy 2018). The Royal Botanic Garden at Kew has a strong collection of filmy ferns (*Hymenophyllum* spp.) from New Zealand but they grow under controlled conditions in a glasshouse.

Successfully growing imported fern spores can be difficult because spores are short lived and shipping time and the United States Department of Agriculture Animal and Plant Health Inspection Service quarantine process can be lengthy. However, there are avenues to source ferns--the low spreading *Blechnum penna-marina* thrives throughout the New Zealand Forest and is fairly common in cultivation in the US (Plant lust). The list below is by no means complete but could be useful to cross reference if an opportunity to import ferns to the US arises. It is my opinion that if any wild sourced New Zealand native fern species can be procured they should be installed in abundance wherever possible throughout the New Zealand Forest as a means to represent the general prevalence of ferns in New Zealand.

Table 8. Potential fern species for the New Zealand Forest

Asplenium flaccidum	*Asplenium bulbiferum*	*Asplenium gracillimum*
Austroblechnum lanceolatum	*Cranfilla fluviatilis*	*Gleichenia dicarpa*
Histiopteris incisa	*Leptopteris hymenophylloides*	*Lomaria discolor*
Notogrammitis heterophyllus	*Parablechnum novae-zelandiae*	*Polystichum neozelandicum*
Polystichum vestitum	*Pyrrosia eleagnifolia*	*Sticherus cunninghamii*
Dicksonia squarrosa		


Figure 22. Lomaria discolor. Photo taken by Kyra Matin at Trotters Gorge near Palmerston, New Zealand. April 2019.

Part 2: Process of collecting seeds in New Zealand

I was very lucky, despite several constraints, to have a successful and fulfilling experience collecting wild seed. I collected over 10,000 seeds from 30 different species. It would not have been possible for me to achieve what I did without the help and support of the Dunedin Botanic Garden staff and their connections within the larger plant community of New Zealand. Although technology has made open communication between scientists and gardens possible, this seed collection process has highlighted the advantage of being physically present in a place to network and take advantage of opportunities to collaborate.

To uphold the standards of UWBG geographic collections it was important I found seed from wild plants with known provenance. The intention of the New Zealand Forest is to accurately represent the plant communities found in Central Otago and the Lakes region, so I wanted to collect from ecosystems with emblematic plant communities that had not been heavily disturbed.

There are strict laws about harvesting material from the land in New Zealand. The New Zealand Department of Conservation *Te Papa Atawhai* (DOC) oversees, monitors, and protects a large portion of public lands. It is possible to apply for a Research and Collection permit to collect samples and undertake research on plants found on public conservation land. This is an involved and lengthy process that requires a pre-application meeting and application fee, and can take months to complete. While seeds collected for the UWBG would not be used for commercial purposes, there are complicating factors with the non-commercial use of New Zealand plant material outside of New Zealand. Furthermore, there are cultural considerations. The Treaty of Waitangi, signed in 1840, exerted the rule of Great Britain in New Zealand. The treaty was signed by over 500 Māori rangatira, or chiefs, and specified that Māori would keep rangatiratanga, or chieftainship, over their resources (Orme). Claims for breaches to the Treaty of Waitangi are currently being presented and settled by various Iwi (tribes) (New Zealand Government). The Waitangi Tribunal Report of flora & fauna claim (WAI 262) outlines how flora and fauna are considered cultural treasures by the indigenous people of New Zealand, and that Iwi have discretion on how they are used and distributed (Waitangi Tribunal Report).

With the impressive measures in place to protect public conservation land it was not realistic to apply for permits when they likely would have been too time consuming and too narrow in scope for my purposes. Instead I collected from privately owned land. I was fortunate to connect with a PhD student at the University of Otago doing a restoration ecology study on mycorrhizal associations with several Southern beech species. She had access to Mahu Whenua, a large land covenant of high country grasslands near Glendhu Bay in the Lakes region. With introduction, I was able to get permission from the land manager to collect seed, and to go with the research team to Mahu Whenua. This was an amazing opportunity to collect Southern beech. I did more seed collecting on other privately-owned farms and residences. I also collected with Dunedin Botanic Garden staff at a site they had a permit for. The seed we collected together was to be distributed in the DBG seed exchange, so I was able to take it to be planted in another botanical garden.

I hope the connections I have made will be useful for future pursuits to obtain species from New Zealand. The DBG is a member of the Index Seminum, a collaborative of botanical gardens sharing seeds exclusively for research, education, and conservation. This is an excellent resource to the UWBG for procuring New Zealand seeds. The DBG is in the process of applying for a 5-year collection and research permit from DOC for the highland Central Otago region. It would be worthwhile to stay in communication with relevant parties. Reaching out to botany departments at New Zealand Universities, (University of Otago, Otago Polytechnic, etc.) is another useful strategy for sourcing information and plant material. I found the botanical community in New Zealand to be very helpful and enthusiastic about my project and the New Zealand Forest at the UWBG. Seed collection provenance and habitat data can be found in Appendix 2.

Many plant species in New Zealand have mast flowering and seeding events, where plants produce huge amounts of seed in one season. These mast years can be followed by multiple seasons with poor or no seed set. Unrelated genera like beeches, tussock, and flax often have simultaneous high-seed-production years. It is up for debate if there is an evolutionary advantage to mast seed production. Masting can be dependent on seasonal conditions of the previous summer (Dylan Norfield, personal communication). It could be a strategy to avoid predation and optimize reproductive efficiency (Allen and Platt 1990). Regardless, I was extremely lucky to find a huge mast season occurring when I arrived in February of 2019.

2.1 Collection Methods

2.1.1 Southern Beech: Fuscospora cliffortioides and Lophozonia menziesii

There are a few impressive Mountain beech (*F. cliffortioides*) and Silver beech (*L. menziesii*) specimens in their respective focal forests, but many more individuals are needed to grow the canopy and start to mimic a true southern beech forest experience at the New Zealand Garden. Southern beech was a top-priority species throughout my collection process. I was very successful in procuring Mountain beech, and less so with Silver Beech. In the wild Southern beech species hybridize, so in order to get seed that is true to species I needed to find isolated stands of all Mountain or all Silver beech. Mahu Whenua, the land covenant where I did a majority of my Southern Beech seed collecting, is dominated by Mountain beech with small stands of Silver and Red intermixed. Many trees I collected from were on a forest patch edge. I attempted to collect only from trees in stands of all the same species. As this species is wind dispersed and pollinated, there is still some chance of hybridization. I travelled to Department of Conservation Land that had abundant amounts of Silver beech growing on it, but without the proper permitting I could not take that plant material from the land.

I sent over 1600 Mountain beech seeds, 150 Silver beech seeds, and 100 Red beech seeds to the UWBG. I have excellent provenance data for the Mountain beech seed I collected. I procured Silver beech seeds from a wholesale grower in Te Anau who grows plants from wild-collected seed to be used in habitat restoration. This seed had been in storage and has less specific provenance data. I was given Red beech seed by a PhD student at the University of Otago who had seed traps set up in various beech forests throughout the South Island as part of her field work.

Southern beech trees have mast seeding events. It is not unusual to have multiple seasons with low to no seed set, followed by a mast year with extremely heavy seed production. Mountain beech has mast years with a frequency of 3 to 7 years. Silver beech has a masting frequency of 6-10 years, with more partial seeding events between mast years. (Ogden 1996). I heard anecdotally from various people that the 2019 season was the most prolific seeding year for Southern beech in recent memory. (Dylan Norfield; Kate Caldwell; Matt Larcombe, personal communication). A study by Wardle in 1984 found *F. cliffortioides* produced 16 grams of viable seeds per square meter, *L. menziesii* produced 10 grams of viable seeds per square meter, and Red beech (*Fuscscspora fusca*) produced 23 grams of viable seeds per square meter. These data suggest at least some of the seeds I collected should be viable and we will hopefully see some germination success, especially in *F. cliffortioides*.

I experimented with a few different collection techniques for southern beech. Southern beech seeds are wind dispersed and timing is critical (Thorsen, 2009). It is desirable to collect when the seed is readily falling off the tree, or to gather seed from the ground soon after a wind event (Matt Larcombe, personal communication). Southern beech seed can be collected by setting up seed traps. These are mesh nets that hang within the tree and catch seed as it falls from higher branches. This method works well, but results in a large amount of non-seed material landing in the traps. It is most useful for projects that require huge amounts of seed at sites that can be visited multiple times throughout the seeding period.

I found the most successful and efficient collection method for my purposes was to do it manually. I put a tarp or sheet under the tree in question and vigorously shook a branch, resulting in seeds raining down onto the tarp. Then I transferred seed that fell on the tarp into labeled paper bags. Depending on branch height and ripeness of the seed, this method was not always possible. However, it is likely that if seeds do not easily fall off the tree with agitation, they are not fully ripe and would be less likely to germinate.

The branch-shaking method resulted in an abundance of seed, as well as a fair amount of chaff and other unwanted material accompanying the seed. A huge lesson I learned throughout this process is that the best seed-cleaning method will depend on how much and how dirty the seed lot you are cleaning is. I was unsure if I would have access to my mountain beech collection site again, or if seed would be present on a return trip, so I collected as much seed from as many trees as I could.

The seed cleaning process was involved. I started by using the 'muesli method.' Seed and chaff of different densities will separate from top to bottom, just like oats and nuts in a box of muesli. I dumped portions of what I collected into the turquoise bowl pictured below. The seed mostly fell to the bottom of the bowl, and I was able to use a tea spoon to scoop out bigger twigs and leaves at the top. I repeatedly flipped and shook the seed and chaff mixture and sifted what I could off the top. Then, I used 5mm and 2mm sieves to filter out material larger and smaller than the beech seeds. Southern beech seed morphology is similar to true beech seeds in that seeds are borne in a cupule. Southern beech species have three seeds, two flattened and one triangular that fall out of the cupule as it opens. To free seed that was still contained in its outer shell, I put the seed between too sieves and applied pressure as I moved the sieves in a circular motion. Through repeated sieving and pressing I was able to get very clean seed, picture below. Before shipment I stored the seed at room temperature in a closet with low relative humidity at the DBG propagation facilities.

Figure 23. Beech seed cleaning station at the Dunedin Botanic Garden. See sieves of different widths, plastic bowl, tea spoon. Photo taken by Kyra Matin in Dunedin, New Zealand. March 2019.

Figure 24. Clean *Fuscospora cliffortioides* seeds. Photo taken by Kyra Matin. March 2019.

2.1.2 Seeds with a fleshy coat

Gaultheria spp.	*Coprosma* spp.	*Pseudowintera colorata*
Aristotelia fruticosa	*Myrsine divaricata*	*Astelia* spp.
Leptecophylla juniperina	*Melicytus alpinus*	*Prumnopitys ferruginea*
Pseudopanax colensoi var. *ternatus*	*Fuchsia* spp.	*Raukaua simplex*

Coriaria sarmentosa

Figure 25. *Copsroma* drupes from Mount Cargill in Dunedin, New Zealand. Photo taken by Kyra Matin. May 2019.

I picked seed into a large plastic bowl and then transferred it into labeled ziplock bags. If I could not immediately clean the seed, I stored it in a refrigerator at 4 °C. I used a ribbed flexible plastic friction mat to separate the seed from the fleshy fruit. I placed the fruits on the mat, folded the mat in half, and applied pressure to the fruits as I rubbed back and forth. Once the fleshy material was sufficiently separated from seeds Figure 26, I rinsed pulp and seeds into a large bowl. I carefully poured water and pulp out of the bowl, leaving seeds to sink to the bottom. I drained as much water as possible, sometimes using a sieve. Then I moved seeds from the bowl onto a clean piece of notebook paper to dry. The seeds dried in the seed cleaning room at the DBG. Some seed required soaking and multiple rinses to totally clean it of pulp. After seeds were clean and dry, I put them back in the refrigerator.

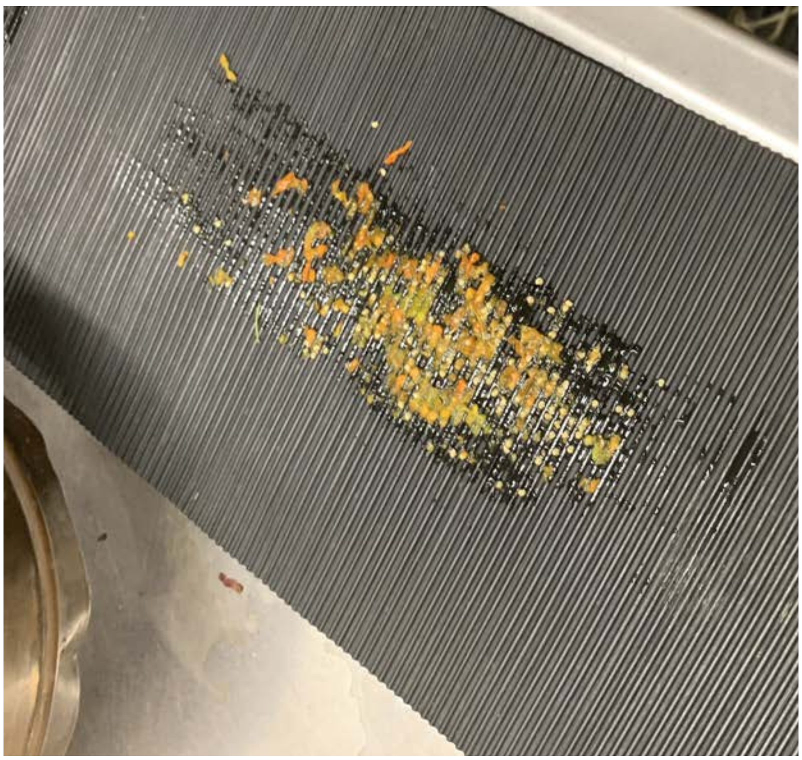


Figure 26. Friction mat with *Neomyrtus pedunculata* seed at Dunedin Botanic Garden. Photo taken by Kyra Matin. February 2019.

2.1.3 Asters

Raoulia spp. *Brachyglottis rotundifolia* *Olearia* spp.

All of these species had seeds attached to white fluff. I collected whole flower heads and stored them in paper bags at room temperature. To clean the seeds, I simply pulled the white fluff and seed from the receptacle and spread it on white paper to dry if needed. Asters have notoriously unreliable seed germination. When packing seeds, I used a microscope and made an effort to select seed with plump ovaries to be shipped.

2.1.4 *Dacrycarpus dacrydioides*

D. dacrydioides had an incredible seeding year. Multiple horticulturalists and botanists I encountered said they had not seen such prolific seeding by *D. dacrydioides* in their lifetime. I collected a small amount of *D. dacrydioides* from the ground nearby the large parent tree. The seed is attached to a fleshy red aril, which I removed by hand before packaging and mailing the seeds.

Figure 27. *Dacrycarpus dacrydioides* seed cones on the ground under tree. Photo taken by Kyra Matin near Gore, New Zealand. April 2019.

2.1.5 *Phyllocladus alpinus*

I collected *P. alpinus* from diverse sites. I was able to get permission under permits held by the Dunedin Botanic Garden to collect on Mount Cargill, a natural area managed by the Dunedin

City Council. I also collected from Dale Farm, a working farm located on the western edge of Otago. I picked seed cones from the areas on the tree I could reach up to 3m high on the tree. This species has an unusual seed morphology and was a challenge to clean. After trying multiple methods, I ended up manually removing individual black seeds from the seed cones. Before and after cleaning the seed were stored at 4 °C in the DBG propagation building.

Figure 28. *Phyllocladus alpinus* seed at Mount Cargill in Dunedin, New Zealand. Photo taken by Kyra Matin. May 2019.

Part 3: Enhancing elements of Māori Culture in the New Zealand Forest

3.1 Background Information

The UWBG's mission statement: 'Sustaining managed to natural ecosystems and the human spirit through plant research, display and education' is intentional in its inclusion of 'the human spirit'. It is increasingly recognized that biological and cultural conservation are interdependent; people are part of the environments in which they live and many ecosystems we are trying to preserve have been long influenced by humans (Salick et al. 2014). Botanical gardens have the opportunity, and perhaps responsibility, to conserve biocultural as well as biological diversity. In addition to conserving and presenting the plants of a region we must consider and honor the indigenous knowledge and traditions that go along with these plants. As such, there is a great opportunity to highlight the rich relationship between the indigenous Māori people and the native plants of New Zealand growing at the UWBG. It is vitally important when researching and developing materials about indigenous culture that representatives of the culture are involved have influence throughout the process. This section is a very first step in compiling basic research about Māori culture and plants. For the purposes of my research I did briefly consult with a Dunedin City Council representative from the South Island Iwi Ngāi Tahu.

There is interpretative signage that provides basic information and highlights cultural stories about plants and animals in New Zealand (See Appendix IV). I propose potentially adding to the current signs and developing an accompanying brochure or other programming to further enrich visitor experience. It could be beneficial to provide information about each habitat type in the garden, and to share with the public some of the considerations that have gone into the garden's design. Of course, too many signs can be overwhelming, and it would be best to develop new innovative ways for people to learn in the New Zealand Forest. Through connecting plants to myth and cultural use stories, the New Zealand collection presents an opportunity to teach visitors and students about the history and culture, as well as the plants and habitats of New Zealand.

For example, *Phormium* (flax), traditionally called harakeke and wharariki, is a vitally important and sacred plant in Māori culture. Like *Hebe*, *Phormium* are not only common in New Zealand's natural systems but have been introduced to horticulture and are popular landscape plants worldwide. Harakeke is the Māori name for *Phormium tenax*, and wharariki is the name for *Phormium cookianum*. Both species are Taonga, or treasured plants to the Māori. Flax is cultivated and used in weaving. A pā harakeke is a planting of harakeke grown to be harvested for weaving. There are many traditions and cultural practices that accompany harakeke, including rituals done when pruning. In winter, each fan can be trimmed back to three leaves with a sharp knife. The middle youngest leaf in the fan is called the rito (the baby), surrounded by the awhi rito (the parents) and then the tūpuna (the grandparents). Fans represent families and the arrangement of fans in the larger bush represent a hapū or community. In a pā harakeke, all the individual bushes together symbolically represent an Iwi or tribe. After a harakeke fan flowers it dies, so removing fans that have bloomed is an ideal way to keep air circulation at the base of the plant (Tawiri 2019). I think this information is interesting, and as *Phormium* grow well and are fairly common in Seattle they are a great plant teach the public about.

In Māori mythology Tāne Mahuta is the spirit or god of the forest and birds and plays a key role in the story of creation. Tāne is the son of Ranginui 'Sky Father' and Papatuanuku 'Earth Mother'. He and his siblings were trapped in the darkness between the loving embrace of their parents, who refused to be separated. Eventually the children tried to break free of the embrace to enter the world of the light. It was Tāne Mahuta who had the strength to push his parents apart, sending Ranginui to the sky and Papatuanuku to the earth. Rain are the tears of Ranginui 'Sky Father' pining for his wife. The legend of Tāne is embodied in a 2000-year-old 51 m 13.8 diameter Kauri tree in Waipoua forest on the west coast of the North island. Although it is too cold to grow Kauri trees in Seattle, we can share the rich culture and legends surrounding other plants in the New Zealand Collection.

There are several botanists' names, Cheeseman, Colenso, Petrie, Banks, Cook, Bidwill, Cunningham, Solander, to name a few, that come up again and again in the names of New Zealand plants. While these explorer-botanists first officially described many of these plants for western science, indigenous people had been tending to, using, and living with these plant communities for hundreds of years before western botanists "discovered" and named them. Some of the largest losses of habitat are a direct result of colonization and industrialization. Botanical names are useful for sharing phylogenetic relationships. They tell one valuable story and incorporating traditional names will tell another. During my time at the DBG I found both the public and garden staff often referred to New Zealand native plants by their Māori names. If there is success in using Māori names in New Zealand, why not try to encourage the use of traditional names when discussing New Zealand native plants in America.

There are many Iwi throughout New Zealand and traditional names vary regionally, with different dialects spoken by North and South Island Māori. Today, the principal Iwi of the South Island, Te Wai Pounamu, is Ngāi Tahu. Ngāi Tahu has a takiwā, or a tribal area, that occupies a majority of the South Island. There are 18 rūnanga (governance areas) in the takiwā that correspond to traditional settlements (Beattie 2009). The New Zealand Forest is meant to represent South Island plant communities, so it is logical South Island traditional names should be represented when possible.

In 2019 the Science Communicator Clare Fraser and Native Plant Curator Kate Caldwell at the DBG worked in collaboration with author Rob Tipa to develop a traditional-use-focused native plant walk in the New Zealand native plant garden there. Rob Tipa is the author of "Treasures of Tāne, Plants of the Ngāi Tahu." Treasures of Tāne outlines the traditional uses and mythology of Taonga, culturally significant treasured plants of the South Island Māori. There is not a huge amount of literature documenting the culture and history of South Island Iwi. Oral histories were written down in *Life ways of the Southern Māori* and other primary source historical texts. Treasures of Tāne synthesizes this information with a focus exclusively on traditional uses of South Island native plants. The book describes each of the plants listed as Taonga in Schedule 97 of the Ngāi Tahu Claims Settlement Act 1998.

Below I have compiled a list of plants that are in, or I think should be in, the collection at the UWBG with significant cultural histories and traditional uses. This table directly pulls from and builds on research done at the Dunedin Botanic Garden and Rob Tipa and the development of the native plant walk and brochure there.

3.2 Table 9. Cultural history and traditional use information for a selection of plants found in the New Zealand Forest. For pronunciation, consult the website: maoridictionary.co.nz or other Māori-English dictionaries.

Plant	Brief description
Taramea *Aciphylla* spp. Spear or Spaniard grass	Taramea is extremely sharp and prickly. It produces a sticky resin that can be mixed with oils and used to make an aromatic bundle to be hung around the neck (Tipa 2018).
Tarata *Pittosporum eugenioides* Lemonwood	As the name lemonwood implies its scented leaves are aromatic and used in perfumes and other concoctions. The tarata gum worked well as a glue (Tipa 2018).
Kapuka *Griselinia littoralis* Broadleaf	Inner bark was used as medicine for venereal disease and other types of infections. The timber was known for its durability (T.E.R:R.A.I.N).
Wī; Pātītī Tussock *Chionochloa* spp.	Used to make marowai, leggings that protect the shin from sharp Spaniard grass and matagouri spikes. Used to make thatch, in bedding, pillows, mats and seats (Tipa 2018).
Wīwī *Juncus* spp. Rushes	Used to waterproof roofs and walls (Tipa 2018).

Horopito *Pseudowintera axillaris & colorata* Pepper tree	Horopito leaves are chewed on to treat tooth and headaches (Tipa 2018).
Harakeke *Phormium tenax* Swamp flax	Hugely important plant. Used for weaving clothes, baskets, rope (Tipa 2018).
Wharariki *Phormium cookianum* Mountain flax	Hugely important plant. Used for weaving clothes, baskets, rope (Tipa 2018).
Tawhai *Lophozonia menziesii* Silver beech	The bark used to make dyes and for weaving (Tipa 2018). Puku tawai, a fungoid growth on trunk can be used as a fire starter. (Best 1908).
Rātā *Metrosideros umbellata* Southern rata	Strong dark timber used for carving weapons, constructing beams, and smaller delicate items like flutes (Tipa 2018).

Tī Kōuka *Cordyline australis* Cabbage tree	Significant food source and useful weaving plant. Tap root harvested and pounded to release sugars, mixed with fish or bird fat (Tipa 2018). Used to make threads, cords, ropes, deep sea fishing lines. (Colenso 1982).
Toi *Cordyline indivisa* Mountain Cabbage tree	Root is cooked into sugary dish called *kauru* (Taylor 1855). Used to make threads, cords, ropes, deep sea fishing lines. (Colenso 1982).
Koromiko *Hebe salicifolia*	Cure for stomach aches. During the second world war dried leaves were sent to New Zealand soldiers as a cure for dysentery (Tipa 2018).
Tutu *Coriaria* spp.	Most toxic plant found in New Zealand but can be processed to make sweetener and edible jelly. Pigment from berries was used for ink for tattooing Tipa 2018).
Horoeka *Pseudopanax* Lancewood	Leaves used to make paint brushes (Tipa 2018).
Tikumu *Celmisia* spp. Mountain daisy	Woven to make waterproof cloaks and hats (Tipa 2018).

Ponga *Cyathea dealbata* Silver tree fern	Fronds used for bedding. White undersides of fronds placed facing the sky to illuminate paths at night (Tipa 2018).
Tōtara *Podocarpus totara* Totara	Lumber used to build long canoes. Outer bark is used to wrap and protect kelp bags used to preserve mutton birds (Tipa 2018).
Kōwhai *Sophora prostrata & tetraptera* Sophora	Flower, seedpods, bark and twigs used to make various colors of dye (Tipa 2018).
Kōtukutuku *Fuchsia excorticata* Tree fuschia	Berries can be eaten straight from the tree. Blue pollen used to decorate lips and faces (Tipa 2018).
Kopoti, Pinakitere *Anisotome* Aromatic aniseed	Root is harvested and may have been cultivated (Taylor 1855).
Kōhūhū *Pittosporum tenuifolium* Black matipo	Key ingredient to many Māori perfumes. Leaves and gum exude scent. Was mixed with extract of Taramea, Miro, and Kōhia (New Zealand passion fruit) to make scented concoction. Gum was obtained by bruising the bark or making small vertical cuts into the trunk and could be used for bad breath and sore gums (Tipa, 2018).

3.3 Thoughts on incorporation of cultural information into the New Zealand Forest

There are many ways to incorporate more cultural information into the New Zealand Forest collection. First, it is necessary to contact and consult a representative of the Māori, specifically a representative off the Ngāi Tahu, to get their permission, opinion, and input on how to approach this project. The Christchurch Seattle sister city relationship contacts will be a good resource for getting in contact with an indigenous representative. While I was in New Zealand, a DBG staff member put me in touch with Donna Matahaere-Atariki who is a representative on the Dunedin City Council for a Southland regional segment of the South Island Iwi Ngāi Tahu. We discussed my research and intentions and she said to feel free to contact her with further questions.

The work done to highlight Māori culture and plants at the DBG could serve as a model for the UWBG. There, a brochure with cultural stories and traditional use information was assembled and paired with a native plant walk. To celebrate the new brochure there was an afternoon event in the garden where visitors were guided through the plant walk and enjoyed traditional Māori music. Regardless of the exact way more cultural material is incorporated into the collection at the UWBG, devoting energy to enhancing this aspect of the garden is worthwhile. Furthermore, having an event to celebrate the culture of New Zealand will introduce visitors to new information and a different framework for understanding the New Zealand collection. As I write this in the summer of 2019 the ten-year anniversary of the initial opening of the New Zealand Forest approaches. The anniversary in 2023 could be an opportunity to celebrate both the garden and Seattle's sister city relationship with Christchurch, as well as to showcase any new developments to the collection.

References

"Anisotome Cauticola." *New Zealand Plant Conservation Network*, 10 May 2014, www.nzpcn.org.nz/flora_details.aspx?ID=1500.

Allen, Robert B., and K. H. Platt. "Annual Seedfall Variation in Nothofagus Solandri (Fagaceae), Canterbury, New Zealand." *Oikos*, vol. 57, no. 2, 1990, pp. 199–206.

"Apodasmia Similis." *New Zealand Plant Conservation Network*, 4 Dec. 2014, www.nzpcn.org.nz/flora_details.aspx?ID=2052.

Aronson, James. "The Ecological Restoration Alliance of Botanic Gardens: A New Initiative Takes Root." Restoration Ecology, vol. 22, no. 6, 2014, pp. 713–715.

Beattie, James Herries., and Atholl Anderson. *Traditional Lifeways of the Southern Maori: the Otago University Museum Ethnological Project, 1920*. Otago University Press, 2009.

Best, Elsdon. "Maori forest lore : being some account of native forest lore and woodcraft, as also of many myths, rites, customs, and superstitions connected with the flora and fauna of the Tuhoe or Ure-wera District - Part 1." Transactions of the New Zealand Institute, vol. 40, 1908, pp. 185-254.

"Beech Forest." Native Plants, www.doc.govt.nz/nature/native-plants/beech-forest/.

BGCI. "International Agenda for Botanic Gardens in Conservation: 2nd edition." Botanic Gardens Conservation International, Richmond, UK, 2012.

BOLA Architecture + Planning & Karen Kiest Landscape Architects. *Washington Park Arboretum Historic Review*. Washington Park Arboretum, 2003.

Borsch. T, Lohne C. "Botanic gardens for the future: integrating research, conservation, environmental education and public recreation." Ethiopian Journal of Biological Science vol. 13, 2014, pp.115–33.

"Carex secta." *New Zealand Plant Conservation Network*, 18 June 2015, http://www.nzpcn.org.nz/flora_details.aspx?ID=1418.

"Carmichaelia Compacta." *New Zealand Plant Conservation Network*, 31 May 2014, www.nzpcn.org.nz/flora_details.aspx?ID=409.

"Celmisia haastii." *New Zealand Plant Conservation Network*, 15 Aug. 2014, http://www.nzpcn.org.nz/flora_details.aspx?ID=1622.

“Celmisia prorepens.” *New Zealand Plant Conservation Network*, 5 May 2011, http://www.nzpcn.org.nz/plant_distribution_results.aspx?Species_Name=Celmisia+prorepens.

Colenso, William. “Vestiges: Reminiscences, memorabilia of works, deeds and sayings of the ancient Māoris.” *Transactions of the New Zealand Institute* vol. 24, 1892, pp. 445 -467.

“Collections Policy.” University of Washington Botanic Gardens. Revised February 6, 2018.

“Cyathea dealbata (Silver Fern).” *T.E.R:R.A.I.N - Taranaki Educational Resource: Research, Analysis and Information Network*, 8 June 2018, http://www.terrain.net.nz/friends-of-te-henui-group/nz-ferns/silver-fern.html

Davis, Glen. *Before the hearings panel for the proposed Queenstown lakes district plan in the matter of the Resource and Management Act 1991 and in the matter of Hearing Stream 14:Wakatipu Basic hearing and transferred Stage 1 submissions related to Arrowtown and Lake Hayes*. 2018.

Dawson, John. *Forest Vines to Snow Tussocks: The Story of New Zealand Plants*. Victoria University Press, 1988.

Dawson, J. W. “Vegetative Features of Griselinia Lucida— A New Zealand Shrub Epiphyte.” *Tuatara*, vol. 14, no. 3, Dec. 1966, pp. 121–129.

“Dracophyllum kirkii .” *New Zealand Plant Conservation Network*, 14 Aug. 2014, nzpcn.org.nz/flora_details.aspx?ID=1802.

“Dracophyllum Muscoides.” *New Zealand Plant Conservation Network*, Aug 14 2014, nzpcn.org.nz/flora_details.aspx?ID=1806.

Dunne, Niall. “Planting the New Zealand Forest .” *Washington Park Arboretum Bulletin*, 2013, pp. 10–17.

Eadie, Fiona M. *100 Best New Zealand Native Plants for Gardens*. Godwit, 2001.

“Epacris pauciflora.” *New Zealand Plant Conservation Network*, Sep 14 2014, http://www.nzpcn.org.nz/flora_details.aspx?ID=1834.

“Fuscospora Cliffortioides (Mountain Beech).” *T.E.R:R.A.I.N - Taranaki Educational Resource:*

Research, Analysis and Information Network, www.terrain.net.nz/friends-of-te-henui-group/table-1/nothofagus-solandri-var-cliffortioides-mountain-beech.html.

“Gardens in Conservation.” Botanic Gardens Conservation International, U.K, 2000.

“Grasslands.” *Environment Guide*, 11 Apr. 2018, www.environmentguide.org.nz/issues/biodiversity/new-zealands-biodiversity/grasslands/.

“Griselinia Littoralis (Broadleaf, Kapuka).” *T.E.R:R.A.I.N - Taranaki Educational Resource: Research, Analysis and Information Network* , 8 Feb. 2018, www.terrain.net.nz/friends-of-te-henui-group/trees-native-botanical-names-g-to-l/broadleaf.html.

“Griselinia Littoralis (Broadleaf, Kapuka).” *T.E.R:R.A.I.N - Taranaki Educational Resource: Research, Analysis and Information Network*, www.terrain.net.nz/friends-of-te-henui-group/trees-native-botanical-names-g-to-l/broadleaf.html.

“Gunnera Monoica.” T.E.R:R.A.I.N - *Taranaki Educational Resource: Research, Analysis and Information Network*, www.terrain.net.nz/friends-of-te-henui-group/plants-native-botanical-names-g-to-l/gunnera-monoica.html.

Heenan, P. B., and P. J. De Lange. “Two New Species Of *Dianella*(Hemerocallidaceae) from New Zealand.” *New Zealand Journal of Botany,* vol. 45, no. 1, 2007, pp. 269–285.

Hubbard, John C. E., and J. Bastow Wilson. “A Survey of the Lowland Vegetation of the Upper Clutha District of Otago, New Zealand.” *New Zealand Journal of Botany*, vol. 26, no. 1, 1988, pp. 21–35.

“Hydrocotyle Elongata.” *INaturalist*, 2019, www.inaturalist.org/taxa/402569-Hydrocotyle-elongata.

“Jovellana sinclairii.” *New Zealand Plant Conservation Network*, 30 May 2015, http://nzpcn.org.nz/flora_details.aspx?ID=174.

Judd, Water S., et al. *Plant Systematics A Phylogenetic Approach.* Sinauer Associates Inc., 2007.

Krishnan, S. “The Role of Botanic Gardens in the Twenty-First Century.” *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources,* vol. 11, no. 023, 2016, pp. 1-10.

Lindsay, William Lauder. *Contributions to New Zealand Botany*. William & Norgate, 1868.

"Māori and Biodiversity." *Environment Guide*, 11 April 2018, www.environmentguide.org.nz/issues/biodiversity/maori-and-biodiversity/.

"Māori and Biodiversity." *Environment Guide*, 11 Apr. 2018, www.environmentguide.org.nz/issues/biodiversity/maori-and-biodiversity/.

Mark, A. F. "Ecology of Snow Tussocks in the Mountain Grasslands of New Zealand." Vegetatil*,*vol. 18, no. 1-6, 1969, pp. 289–306.

Mark, A. F., Barratt B. P., Weeks E. "Ecosystem services in New Zealand's indigenous tussock grasslands: conditions and trends." Manaaki Whenua Press, Lincoln, New Zealand, 2013.

McGlone, Matt. 'Ecoregions - Central Otago', *Te Ara - the Encyclopedia of New Zealand*, 2007, http://www.TeAra.govt.nz/en/photograph/13549/drought-central-otago/.

McKinnon, Malcolm. 'Otago region - Climate, plants and animals', *Te Ara - the Encyclopedia of New Zealand*, 2015, http://www.TeAra.govt.nz/en/interactive/22165/vegetation-map/.

Nicholas, J. D. Singers and Geoffrey M. Rogers. *A classification of New Zealand's terrestrial ecosystems***.** New Zealand Department of Conservation,Science for Conservation 325, 2014.

Ogden, John, et al., "Ecology of New Zealand Nothofagus Forests." The Ecology and Biogeography of Nothofagus Forests, Yale University Press, 1996, pp. 25–74.

Oldfield, S. *Great Botanic Gardens of the World*. London, New Holland, 2007.

"Olearia Cymbifolia (Hard Leaved Tree Daisy)." *T.E.R:R.A.I.N - Taranaki Educational Resource: Research, Analysis and Information Network*, www.terrain.net.nz/friends-of-te-henui-group/trees-native-botanical-names-m-to-q/oleari-nummularifolia-hard-leaved-tree-daisy.html.

Orme, Sarah. "Waitangi Treaty Grounds, Northland & Bay of Islands." New Zealand Tourism , www.newzealand.com/us/feature/treaty-of-waitangi/.

"Pacific Connections: An Overview." *The Arboretum Foundation*, 2019, www.arboretumfoundation.org/support/support-our-capital-campaign/pacific-connections/project-and-campaign-overview/.

"Pentachondra Pumila." *Plants for a Future*, pfaf.org/user/Plant.aspx?LatinName=Pentachondra pumila.

“Pentachondra Pumila.” *T.E.R:R.A.I.N - Taranaki Educational Resource: Research, Analysis and Information Network*, http://www.terrain.net.nz/friends-of-te-henui-group/trees-native-botanical-names-m-to-q/pentachondra-pumila-little-mountain-heath.html.

“Phormium cookianum.” *New Zealand Plant Conservation Network*, 14 Jan 2014, http://www.nzpcn.org.nz/flora_details.aspx?ID=1110.

“Pimelea Aridula Subsp. Aridula.” *New Zealand Plant Conservation Network*, 4 Jan. 2014, www.nzpcn.org.nz/flora_details.aspx?ID=1119.

“Blechnum Penna-Marina: Plant Lust.” *Plant Lust - Seriously Simple Search for Plants*, plantlust.com/plants/4473/blechnum-penna-marina/.

“Plant Profiles - Hydrocotyle.” *O2 Landscapes*, 2017, www.o2landscapes.com/pages/pp-hydrocotyle.php.

“Plant Profiles- Dracophyllum.” *O2 Landscapes*, 2019, http://www.o2landscapes.com/pages/pp-dracophyllum.php

“Plants for Insects.” *Clyde Railroad Community Eco-Nursery*, crcen.weebly.com/plants-for-insects.html.

Powledge, Fred. “The Evolving Role of Botanical Gardens.” BioScience, vol. 61, no. 10, 2011, pp. 743–749.

Prance, Ghillean T. “A Paradise for Economic Botanists: The Eden Project.” Economic Botany, vol. 56, no. 3, 2002, pp. 226–230.

“Ranunculus lyallii.” *New Zealand Plant Conservation Network*, 28 Jan 2010, http://www.nzpcn.org.nz/flora_details.aspx?ID=1232.

Report of The Waitangi Tribunal on The Te Reo Maori Claim. Waitangi Tribunal Department of Justice Wellington, New Zealand, 2013.

Salick, Jan, et al. *Curating Biocultural Collections: a Handbook*. Kew Publishing in Association with Missouri Botanical Garden, 2014.

“Settling Historical Treaty of Waitangi Claims.” *New Zealand Government Te Wānanga o*

Aotearoa, www.govt.nz/browse/history-culture-and-heritage/treaty-of-waitangi-claims/settling-historical-treaty-of-waitangi-claims/.

Stupples, Polly. "Fields of Gold." New Zealand Geographic, 2013, www.nzgeo.com/stories/fields-of-gold/.

Sun, Osbert J., and Geoffrey B. Sweet. "Comparison of Frost Tolerance Of *Nothofagus Solandri* var.*cliffortioides*(Hook.f.) Poole And *Nothofagus Menziesii*(Hook.f.) Oerst." New Zealand Journal of Botany, vol. 34, no. 2, 1996, pp. 273–278.

"Swamps: National Wetland Trust of New Zealand: Types Of Wetlands." *National Wetland Trust of New Zealand*, www.wetlandtrust.org.nz/what-we-do/resources/types-of-wetlands/.

Tawiri, Katarina. "Establishing a Pā Harakeke." Manaaki Whenua - Landcare Research, 2019, www.landcareresearch.co.nz/resources/collections/harakeke/establishing-a-pa-harakeke.

Taylor, Rev. Richard. *Te Ika a Maui. New Zealand and its inhabitants*. Wertherim and Macintock, London, 1855.

Thorsen, Michael J., et al., "Seed Dispersal Systems in the New Zealand Flora." Perspectives in Plant Ecology, Evolution and Systematics, vol. 11, no. 4, 2009, pp. 285–309.

Tipa, Rob. *Treasures of Tāne: Plants of Ngāi Tahu*. Huia Publishers, 2018.

"Waitangi Tribunal Report on Flora & Fauna Claim WAI 262." *Howard Hughes Intellectual Property*, www.henryhughes.com/site/news/waitangi-tribunal-report-on-flora-and-fauna-wai-262.aspx.

Walker, Susan, et al. "The Woody Vegetation of Central Otago, New Zealand." *New Zealand Journal of Botany*, vol. 42, no. 4, 2004, pp. 589–612.

Wassilieff, Maggy. "Shrublands- Shrublands of dry country", *Te Ara- the Encyclopedia of New Zealand*, https://teara.govt.nz/en/photograph/14541/grey-scrub-central-otago.

Wehi, Priscilla M., and Clarkson, Bruce. "Biological Flora of New Zealand 10.Phormium Tenax, Harakeke, New Zealand Flax." *New Zealand Journal of Botany*, vol. 45, no. 4, 2007, pp. 521–544.

Wilson, Hugh D. *Stewart Island Plants: Field Guide*. Manuka Press, 2009.

Winkworth, R. “Evolution of the New Zealand Mountain Flora: Origins, Diversification and Dispersal.” *Organisms Diversity & Evolution*, vol. 5, no. 3, 2005, pp. 237–247.

Wood, Phil. “Creating a Rock Framework for the New Zealand Forest.” *Washington Park Arboretum Bulletin*, 2013, pp. 7-9.

Wyse Jackson, P.S.and Sutherland, L.A. (2000) “International Agenda for Botanic Gardens in Conservation.” Botanic Gardens Conservation International, U.K, 2000

Appendix I: Reference photos of Dunedin Botanic display gardens

‘Old scree’ at Dunedin Botanic Garden, featuring *Bulbinella*, *Lobelia*, *Aciphylla*, *Hebe*, with divaricate shrubs and a flax in the background. Photo taken by Kyra Matin in Dunedin, New Zealand. May 2019.

Raoulia and *Meulenbeckia axillaris* growing directly in rock in the 'Old Scree' garden in the native section at the Dunedin Botanic Garden. Photo taken by Kyra Matin in Dunedin, New Zealand. May 2019.

Marlborough daisies(*Pachystegia*) with *Scleranthus*, *Astelia*, *Pittosporum patulum*, and *Cordyline indivisa* growing in the native section at the Dunedin Botanic Garden. This bed was recently planted by Kate Caldwell and is heavily composted and receives supplemental water in the summer. Photo taken by Kyra Matin in Dunedin, New Zealand. May 2019.


Rabbit protection in a parking lot near Queenstown in Central Otago on the South Island of New Zealand. Photo taken by Kyra Matin. May 2019.

Appendix II Wild collected seed provenance data and habitat information

Collector	Genus	Species	Code	Waypoint/ pin	Location	northing/easting or lat/long	Elevation(m)	Vegetation/ community type	Notes	Collection date
Kyra Matin	Fuscospora	cliffortioides	KSM-1a	49	Mahu Whenua	e1275272n5035 167	596	patch of beech forest, lots of dead wood on the ground		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-1b	49	Mahu Whenua	e1275272n5035 167	596	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-1c	49	Mahu Whenua	e1275272n5035 167	596	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-1d	49	Mahu Whenua	e1275272n5035 167	596	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-2a	51	Mahu Whenua	e1275146n5035 165	580	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-2b	51	Mahu Whenua	e1275146n5035 165	580	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-3a	53	Mahu Whenua	e1274731n5034 741	580	"		17-Mar

Kyra Matin	Fuscospora	cliffortioides	KSM-3b	53	Mahu Whenua	e1274731n5034 741	580	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-4a	56	Mahu Whenua	E1274214N503 3610	617	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-4b	56	Mahu Whenua	E1274214N503 3610	617	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-4c	56	Mahu Whenua	E1274214N503 3610	617	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-5a	58	Mahu Whenua	E1277882N503 6419	590	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-5b	58	Mahu Whenua	E1277882N503 6419	590	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-5c	58	Mahu Whenua	E1277882N503 6419	590	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-5d	58	Mahu Whenua	E1277882N503 6419	590	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-5e	58	Mahu Whenua	E1277882N503 6419	590	"		17-Mar

Kyra Matin	Fuscospora	cliffortioides	KSM-5f	58	Mahu Whenua	E1277882N503 6419	590	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-5g	58	Mahu Whenua	E1277882N503 6419	590	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-6a	59	Mahu Whenua	e1278819n5040 104	328	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-6b	59	Mahu Whenua	e1278819n5040 104	328	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-6c	59	Mahu Whenua	e1278819n5040 104	328	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-7a	60	Mahu Whenua	e1279023n5040 253	398	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-7b	60	Mahu Whenua	e1279023n5040 253	398	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-7c	60	Mahu Whenua	e1279023n5040 253	398	"		17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-8a	61	Mahu Whenua	e1278814n5040 718	520	"	largest tree, loaded with seed	17-Mar

Kyra Matin	Fuscospora	cliffortioides	KSM-8b	61	Mahu Whenua	e1278814n5040 718	520	"	Large=est tree, loaded with seed	17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-8c	61	Mahu Whenua	e1278814n5040 718	520	"	largest tree, loaded with seed	17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-8d	61	Mahu Whenua	e1278814n5040 718	520	"	largest tree, loaded with seed	17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-8e	61	Mahu Whenua	e1278814n5040 718	520	"	largest tree, loaded with seed	17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-8f	61	Mahu Whenua	e1278814n5040 718	520	"	largest tree, loaded with seed	17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-8g	61	Mahu Whenua	e1278814n5040 718	520	"	largest tree, loaded with seed	17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-8h	61	Mahu Whenua	e1278814n5040 718	520	"	largest tree, loaded with seed	17-Mar

Kyra Matin	Gaultheria	antipoda	KSM-12a	R16	Mahu Whenua	-45.754731, 168.933745		patch of beech forest, scattered canopy	rough location	
Kyra Matin	Gaultheria	antipoda	KSM-12b	R16	Mahu Whenua	-45.754731, 168.933745		patch of beech forest, scattered canopy	rough location	
Kyra Matin	Gaultheria	antipoda	KSM-12c	R16	Mahu Whenua	-45.754731, 168.933745		patch of beech forest, scattered canopy		
Kyra Matin	Gaultheria	antipoda	KSM-13a	R18	Mahu Whenua	-44.754526, 168.934197		patch of beech forest, scattered canopy		
Kyra Matin	Gaultheria	antipoda	KSM-13b	R18	Mahu Whenua	-44.754526, 168.934197		patch of beech forest, scattered canopy		
Kyra Matin	Gaultheria	antipoda	KSM-13c	R18	Mahu Whenua	-44.754526, 168.934197		patch of beech forest, scattered canopy		

Kyra Matin	Gaultheria	antipoda	KSM-14a	R20	Mahu Whenua	-44.720523, 168.944622		edge of beech forest, on steep slope		
Kyra Matin	Gaultheria	antipoda	KSM-14b	R20	Mahu Whenua	-44.720523, 168.944622		edge of beech forest, on steep slope		
Kyra Matin	Gaultheria	antipoda	KSM-14c	R20	Mahu Whenua	-44.720523, 168.944622		edge of beech forest, on steep slope		
Kyra Matin	Myrsine	divaricata	KSM-9a	H	Haast	-44.049885, 168.500759				18-Mar
2nd shipment										
Kyra Matin	Fuscospora	cliffortioides	KSM-8i	61	Mahu Whenua	e1278814n5040718	520	"	largest tree, loaded with seed	17-Mar
Kyra Matin	Fuscospora	cliffortioides	KSM-8j	61	Mahu Whenua	e1278814n5040718	520	"	North facing slope largest tree, loaded with seed	17-Mar

Kyra Matin	Aciphylla	aurea	KSM-15a	L2	Mahu Whenua					17-Mar
Kyra Matin	Aciphylla	aurea	KSM-15b	L2	Mahu Whenua					17-Mar
Kyra Matin	Aciphylla	aurea	KSM-15c	L2	Mahu Whenua					17-Mar
Kyra Matin	Aciphylla	aurea	KSM-15d	L2	Mahu Whenua					17-Mar
Kyra Matin	Aciphylla	aurea	KSM-15e	L2	Mahu Whenua					17-Mar
Kyra Matin	Aciphylla	aurea	KSM-15f	L2	Mahu Whenua					17-Mar
Kyra Matin	Aciphylla	aurea	KSM-15g	L2	Mahu Whenua					17-Mar
Kyra Matin	Cordyline	indivisa	KSM-16a		DBG					
Kyra Matin	Cordyline	indivisa	KSM-16		DBG					
Kyra Matin	Pseudowint era	colorata	KSM-17a	moss walk 4/6						6-Apr

Kyra Matin	Pseudowintera	colorata	KSM-17b	moss walk 4/6						6-Apr
Kyra Matin	Dacrycarpus	dacrydioides	KSM-18a	moss walk 4/6						6-Apr
Kyra Matin	Prumnopitys	ferruginea	KSM-19a	catlins walk 3/31						31-Mar
Kyra Matin	Phyllocladus	alpinus	KSM-20a	69	Mount Cargill		587			16-Apr
Kyra Matin	Phyllocladus	alpinus	KSM-20b	69	Mount Cargill		587			16-Apr
Kyra Matin	Phyllocladus	alpinus	KSM-20c	69	Mount Cargill		587			16-Apr
Kyra Matin	Phyllocladus	alpinus	KSM-20d	69	Mount Cargill		587			16-Apr
Kyra Matin	Phyllocladus	alpinus	KSM-20e	69	Mount Cargill		587			16-Apr
Kyra Matin	Phyllocladus	alpinus	KSM-20f	69	Mount Cargill		587			16-Apr
Kyra Matin	Fuscospora	fusca	KSM-21a	no waypoint	Dale Farm, Manapouri					23-Apr

Kyra Matin	Fuscospora	fusca	KSM-21b	no waypoint	Dale Farm, Manapouri					23-Apr
Kyra Matin	Astelia	fragrans	KSM-22a	66	Mount Cargill	-45.8124198 170.5560836	628			16-Apr
Kyra Matin	Astelia	fragrans	KSM-22b	66	Mount Cargill	-45.8124198 170.5560836	628			16-Apr
Kyra Matin	Leptecophylla	juniperina	KSM-23a		TG		top			13-Apr
Kyra Matin	Leptecophylla	juniperina	KSM-23b		TG		top			13-Apr
Kyra Matin	Leptecophylla	juniperina	KSM-23c		TG		top			13-Apr
Kyra Matin	Pseudopanax	colensoi var. ternatus	KSM-24a	68	Mount Cargill	-45.8124478 170.5573953	599	collected from a few plants all in this general area		16-Apr

Kyra Matin	Pseudopanax	colensoi var. ternatus	KSM-24b	68	Mount Cargill	-45.8124478 170.5573953	599			16-Apr
Kyra Matin	Pseudopanax	colensoi var. ternatus	KSM-24c	68	Mount Cargill	-45.8124478 170.5573953	599			16-Apr
Kyra Matin	Pseudopanax	colensoi var. ternatus	KSM-24d	68	Mount Cargill	-45.8124478 170.5573953	599			16-Apr
Kyra Matin	Pseudopanax	colensoi var. ternatus	KSM-24e	68	Mount Cargill	-45.8124478 170.5573953	599			16-Apr
Kyra Matin	Pseudopanax	colensoi var. ternatus	KSM-24f	68	Mount Cargill	-45.8124478 170.5573953	599			16-Apr
Kyra Matin	Phormium	cookianum	KSM-25a		Mount Cargill	-45.8121358 170.5621713	591			16-Apr

Kyra Matin	Phormium	cookianum	KSM-25b		Mount Cargill	-45.8121358 170.5621713	591			16-Apr
Kyra Matin	Phormium	cookianum	KSM-25c		Mount Cargill	-45.8121358 170.5621713	591			16-Apr
Kyra Matin	Aristotelia	fruticosa	KSM-27a	74	Dale Farm, Manapouri	E1201538 N4962272	391			23-Apr
Kyra Matin	Pseudowintera	colorata	KSM-28a	67	Mount Cargill	-45.8124102 170.5560583	618			16-Apr
Kyra Matin	Pseudowintera	colorata	KSM-28b	67	Mount Cargill	-45.8124102 170.5560583	618			16-Apr
Kyra Matin	Pseudowintera	colorata	KSM-28c	67	Mount Cargill	-45.8124102 170.5560583	618			16-Apr

Kyra Matin	Coprosma	dumosa	KSM-29a	65	Mount Cargill	-45.8126705 170.5542108	657			16-Apr
Kyra Matin	Coprosma	dumosa	KSM-29b	65	Mount Cargill	-45.8126705 170.5542108	657			16-Apr
Kyra Matin	Coprosma	dumosa	KSM-29c	65	Mount Cargill	-45.8126705 170.5542108	657			16-Apr
Kyra Matin	Melicytus	alpinus	KSM-30a	76	Dale Farm, Manapou ri	E1201589 N4962353	387			16-Apr
Kyra Matin	Melicytus	alpinus	KSM-30b	76	Dale Farm, Manapou ri	E1201589 N4962353	387			16-Apr
Kyra Matin	Melicytus	alpinus	KSM-30c	76	Dale Farm, Manapou ri	E1201589 N4962353	387			16-Apr

Kyra Matin	Melicytus	alpinus	KSM-30d	76	Dale Farm, Manapouri	E1201589 N4962353	387			16-Apr
Kyra Matin	Carmichaelia	spp.	KSM-46a		Homecreek			not wild, horticultural interesting.		23-Apr
3rd Shipment										
Kyra Matin	Myrsine	divaricata	KSM-31a	70	Mount Cargill	-45.8120472 170.5618148	586.00			16-Apr
Kyra Matin	Myrsine	divaricata	KSM-31b	70	Mount Cargill	-45.8120472 170.5618148	586.00			16-Apr
Kyra Matin	Myrsine	divaricata	KSM-31c	70	Mount Cargill	-45.8120472 170.5618148	586.00			16-Apr
Kyra Matin	Myrsine	divaricata	KSM-31d	70	Mount Cargill	-45.8120472 170.5618148	586.00			16-Apr

Kyra Matin	Myrsine	divaricata	KSM-31e	70	Mount Cargill	-45.8120472 170.5618148	586.00			16-Apr
Kyra Matin	Olearia	linneata	KSM-32a		Queensto wn.			wild collected by Homecreek nursery on private land in queenstown		?
Kyra Matin	Olearia	linneata	KSM-32b		Queensto wn.			"		?
Kyra Matin	Olearia	linneata	KSM-32c		Queensto wn.			"		?
Kyra Matin	Olearia	linneata	KSM-32d		Queensto wn.			"		?
Kyra Matin	Olearia	linneata	KSM-32e		Queensto wn.			"		?
Kyra Matin	Olearia	linneata	KSM-32f		Queensto wn.			"		?
Kyra Matin	Olearia	linneata	KSM-32g		Queensto wn.			"		?
Kyra Matin	Olearia	linneata	KSM-32h		Queensto wn.			"		?

Kyra Matin	Olearia	linneata	KSM-32i		Queensto wn.			"		?
Kyra Matin	Olearia	linneata	KSM-32j		Queensto wn.			"		?
Kyra Matin	Olearia	linneata	KSM-32k		Queensto wn.			"		?
Kyra Matin	Brachyglotti s	rotundifolia	KSM-33a		Mount Cargill	E1410034 N4923796	672			16-Apr
Kyra Matin	Brachyglotti s	rotundifolia	KSM-33b		Mount Cargill	E1410034 N4923796	672			16-Apr
Kyra Matin	Brachyglotti s	rotundifolia	KSM-33c		Mount Cargill	E1410034 N4923796	672			16-Apr
Kyra Matin	Brachyglotti s	rotundifolia	KSM-33d		Mount Cargill	E1410034 N4923796	672			16-Apr
Kyra Matin	Brachyglotti s	rotundifolia	KSM-33e		Mount Cargill	E1410034 N4923796	672			16-Apr
Kyra Matin	Brachyglotti s	rotundifolia	KSM-33f		Mount Cargill	E1410034 N4923796	672			
Kyra Matin	Brachyglotti s	rotundifolia	KSM-33g		Mount Cargill	E1410034 N4923796	672			

Kyra Matin	Chionochloa	rubra	KSM-34a		Te Anau			wild collected by home creek nursery in Te Anau basin		?
Kyra Matin	Chionochloa	rubra	KSM-34b		Te Anau					?
Kyra Matin	Chionochloa	rubra	KSM-34c		Te Anau					?
Kyra Matin	Chionochloa	rubra	KSM-34d		Te Anau					?
Kyra Matin	Coprosma	lucida	KSM-35a		Queenstown			wild collected by home creek nursery in Wakatipu basin		?
Kyra Matin	Coprosma	propinqua	KSM-36a	71	Dale Farm, Manapouri	E1201500N4962156	405			23-Apr
Kyra Matin	Phyllocladus	alpinus	KSM-37a	75	Dale Farm, Manapouri	E1201538 N4962288	393			23-Apr

Kyra Matin	Coprosma	dumosa	KSM-38a	73	Dale Farm, Manapou ri	E1201530 N 4962250	393			23-Apr
Kyra Matin	Coprosma	decurva	KSM-39a	70	Mount Cargill	-45.8120472 170.5618148	586.00			16-Apr
Kyra Matin	Coprosma	decurva	KSM-39b	70	Mount Cargill	-45.8120472 170.5618148	586.00			16-Apr
Kyra Matin	Coprosma	foetidissima	KSM-40a	66	Mount Cargill	-45.8124198 170.5560836	628			16-Apr
Kyra Matin	Coprosma	foetidissima	KSM-40b	66	Mount Cargill	-45.8124198 170.5560836	628			16-Apr
Kyra Matin	Coprosma	foetidissima	KSM-40c	66	Mount Cargill	-45.8124198 170.5560836	618			16-Apr

Kyra Matin	Coprosma	rigida	KSM-41a	75	Dale Farm, Manapouri	E1201538 N4962288				23-Apr
Kyra Matin	Coprosma	orange berry	KSM-42a		Mount Cargill L1					16-Apr
Kyra Matin	Lophozonia	menziesii	KSM-43a		Homecreek			Milford Road		23-Apr
Kyra Matin	Lophozonia	menziesii	KSM-43b		Homecreek			Milford Road		23-Apr
Kyra Matin	Lophozonia	menziesii	KSM-43c		Homecreek			Milford Road		23-Apr
Kyra Matin	Coprosma	rugosa	KSM-44a	63	Mount Cargill	-45.8131208 170.5556153				16-Apr
Kyra Matin	Coprosma	rugosa	KSM-44b	63	Mount Cargill	-45.8131208 170.5556153				16-Apr
Kyra Matin	Coprosma	rugosa	KSM-44c	63	Mount Cargill	-45.8131208 170.5556153				16-Apr

Kyra Matin	Coprosma	rugosa	KSM-44d	63	Mount Cargill	-45.8131208 170.5556153				16-Apr
Kyra Matin	Gaultheria	macrostigma	KSM-45a	70	dale Farm, Manapouri	E1201486 N4962117	301			23-Apr
Kyra Matin	Gaultheria	macrostigma	KSM-45b	70	dale Farm, Manapouri	E1201486 N4962117	301			23-Apr
Kyra Matin	Gaultheria	macrostigma	KSM-45c	70	dale Farm, Manapouri	E1201486 N4962117	301			23-Apr
Kyra Matin	Gaultheria	macrostigma	KSM-45d	70	dale Farm, Manapouri	E1201486 N4962117	301			23-Apr
Kyra Matin	Carmichaelia	spp.	KSM-46b		Homecreek			not wild, horticultural interesting.		23-Apr
4th Shipment										

Kyra Matin	Raukaua	simplex	KSM-26a	68	Mount Cargill	-45.8124478 170.5573953	~600			16-Apr
Kyra Matin	Raukaua	simplex	KSM-26b	68	Mount Cargill	-45.8124478 170.5573953	~600	collected from a few plants all in this general area; not on import permit!!!		16-Apr
Kyra Matin	Raukaua	simplex	KSM-26c	68	Mount Cargill	-45.8124478 170.5573953	~600			16-Apr
Kyra Matin	Raukaua	simplex	KSM-26d	68	Mount Cargill	-45.8124478 170.5573953	~600			16-Apr
Kyra Matin	Raukaua	simplex	KSM-26e	68	Mount Cargill	-45.8124478 170.5573953	~600			16-Apr

Kyra Matin	Raukaua	simplex	KSM-26f	68	Mount Cargill	-45.8124478 170.5573953	~600			16-Apr
Kyra Matin	Raukaua	simplex	KSM-26g	68	Mount Cargill	-45.8124478 170.5573953	~600			16-Apr
Kyra Matin	Gaultheria	antipoda	KSM-47a		Mount Cargill	-45.811243 170.555363	~600			16-Apr
Kyra Matin	Gaultheria	antipoda	KSM-47b		Mount Cargill	-45.811243 170.555363	~600			16-Apr
Kyra Matin	Gaultheria	antipoda	KSM-47c		Mount Cargill	-45.811243 170.555363	~600			16-Apr
Kyra Matin	Gaultheria	antipoda	KSM-47d		Mount Cargill	-45.811243 170.555363	~600			16-Apr
Kyra Matin	Aciphylla	aurea	KSM-15h	L2	Mahu Whenua					17-Mar
Kyra Matin	Aciphylla	aurea	KSM-15i	L2	Mahu Whenua					17-Mar

Kyra Matin	Coprosma	rugosa	KSM-44e	63	Mount Cargill	-45.8131208 170.5556153				16-Apr
Kyra Matin	Coprosma	rugosa	KSM-44f	63	Mount Cargill	-45.8131208 170.5556153				16-Apr
Kyra Matin	Chionochlo a	rubra	KSM-34e		Te Anau				wild collected by home creek nursery in Te Anau basin	?
Kyra Matin	Fuchsia	procumbens	KSM-48a		DBG					7-May
Kyra Matin	Pseudowint era	axillaris	KSM-49a		DBG					26-Apr
Kyra Matin	Pseudowint era	axillaris	KSM-49b		DBG					26-Apr
Kyra Matin	Fuchsia	excorticata	KSM-50a		DBG					
Kyra Matin	Fuchsia	excorticata	KSM-50b		DBG					

Kyra Matin	Celmisia	monroi	KSM-51a		DBG					
Kyra Matin	Anistome	lyallii	KSM-52a		DBG					
Kyra Matin	Anistome	lyallii	KSM-52b		DBG					
Kyra Matin	Anistome	lyallii	KSm-52c		DBG					
Kyra Matin	Bulbinella	angustifolia	KSM-53a		DBG					
Kyra Matin	Bulbinella	angustifolia	KSM-53b		DBG					
Kyra Matin	Astelia	spp.	KSM-53c		near glendhu bay	nervosa I think				
Kyra Matin	Astelia	spp.	KSM-54a		near glendhu bay	nervosa I think				
Kyra Matin	Astelia	spp.	KM-54b		near glendhu bay	nervosa I think				
Kyra Matin	Astelia	spp.	KSM-54c		near glendhu bay					
Kyra Matin	Pseudowintera	colorata	KSM-55a		near glendhu bay					

Kyra Matin	Pseudowint era	colorata	KSM-55b		between wanaka and cromwell					
Kyra Matin	Raoulia	subsericea	KSM-56a		between wanaka and cromwell					
Kyra Matin	Raoulia	subsericea	KSM-56b		between wanaka and cromwell					
Kyra Matin	Raoulia	subsericea	KSM-56c		between wanaka and cromwell					
Kyra Matin	Raoulia	subsericea	KSM-56d		between wanaka and cromwell					
Kyra Matin	Raoulia	subsericea	KSM-56e		between wanaka and cromwell					

Kyra Matin	Raoulia	subsericea	KSM-56f		near glendhu bay					
Kyra Matin	Gaultheria	spp.	KSM-57a		near glendhu bay					
Kyra Matin	Gaultheria	spp.	KSM-57b		near glendhu bay					
Kyra Matin	Coprosma	rugosa	KSM-58a		near glendhu bay					
Kyra Matin	Lophozonia	menziesii	KSM-59a		near glendhu bay					
Kyra Matin	Phyllocladu s	alpinus	KSM-60a		near glendhu bay					
Kyra Matin	Coprosma	pseudo cuneata	KSM-61a	70	Dale Farm, Manapou ri					23-Apr
Kyra Matin	Coriaria	sarmentosa	KSM-62a	70	Dale Farm, Manapou ri					23-Apr

Appendix III Reference photos of South Island plant communities

Silver beech fern understory on Rob Roy Glacier track near Wanaka, New Zealand. Photo taken by Kyra Matin. May 2019.

.


Olearia with silver beech in the background, Rob Roy Glacier track in Mount Aspiring National Park, New Zealand. Photo taken by Kyra Matin. May 2019.


Dracophyllum in silver beech forest on Rob Roy Glacier track in Mount Aspiring National Park, New Zealand. Photo taken by Kyra Matin. May 2019.

Pittosporum with *Polystichum vestitum* and *pseudowintera colorata* at lower part of Mount Cargill in Dunedin, New Zealand. Photo taken by Kyra Matin. February 2019.

Aciphylla in tussock grassland near Queenstown, New Zealand. Photo taken by Kyra Matin. May 2019.


Tussock grassland between Queenstown and Wanaka, New Zealand. Photo taken by Kyra Matin. May 2019.

Dracophyllum, Lycopodium, and *Androstoma empetrifolia* at Swampy Summit in Dunedin, New Zealand. Photo taken by Kyra Matin. May 2019.

Heath plants at Swampy Summit in Dunedin, New Zealand. Photo taken by Kyra Matin. April 2019.


Heath-type scene near Manapouri, New Zealand. Photo taken by Kyra Matin. April 2019.


Celmisia growing at Trotter's Gorge, New Zealand. Photo taken by Kyra Matin. April 2019.

Pimelea pseudolylallii with *Leptecophylla juniperina* at Trotter's Gorge, New Zealand. Photo taken by Kyra Matin. April 2019.

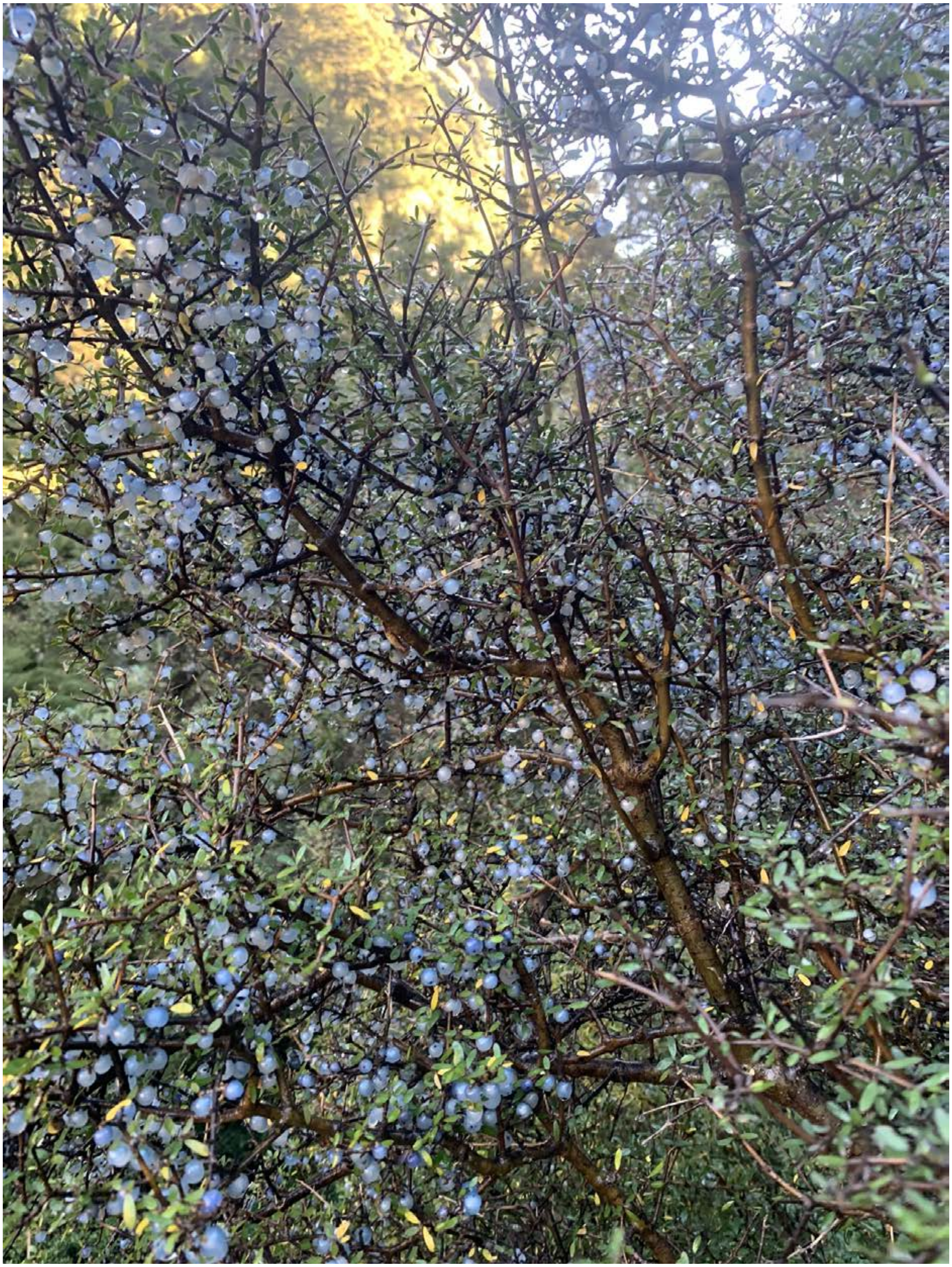
Griselinia growing under Manuka at Mahu Whenua near Glendhu Bay, New Zealand. Photo taken by Kyra Matin. March 2019.

Coprosma spp. Near Mossburn, New Zealand. Photo taken by Kyra Matin. April 2019.

Coprosma propinqua at Dale Farm in Manapouri, New Zealand. Photo taken by Kyra Matin. April 2019.

Coprosma foetidissima in the Catlins near Papatowai, New Zealand. Photo taken by Kyra Matin. March 2019.


Coprosma rugosa Dale Farm in Manapouri, New Zealand. Photo taken by Kyra Matin. April 2019.

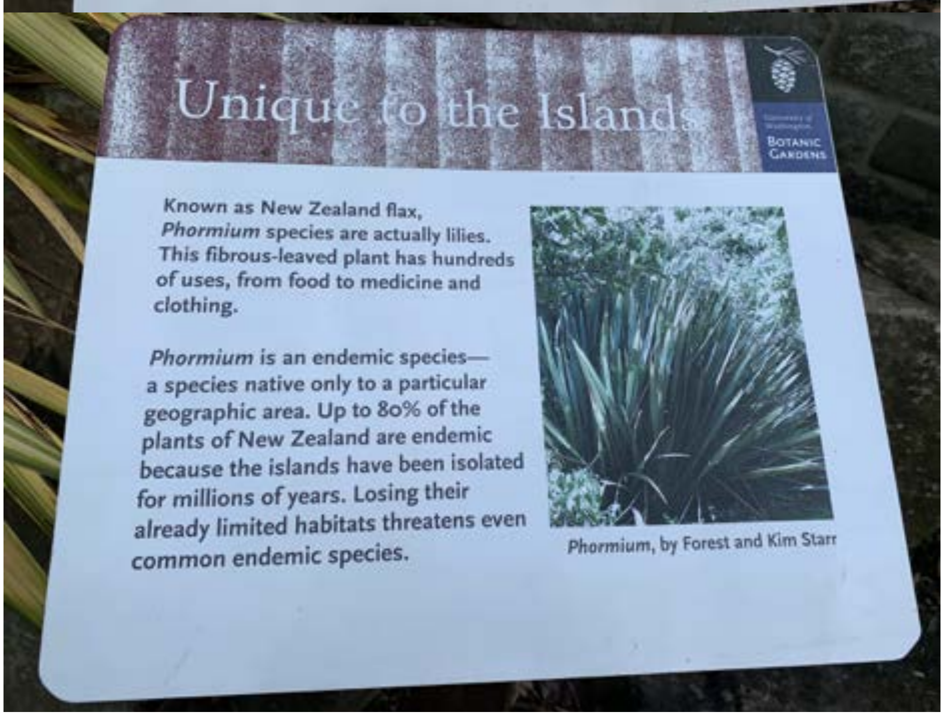


Coprosma spp. at Rob Roy Glacier Track in Mount Aspiring National Park, New Zealand. Photo taken by Kyra Matin. May 2019.


Coprosma dumosa with *Parablechnum* spp. on Mount Cargill in Dunedin, New Zealand. Photo taken by Kyra Matin. March 2019.

Appendix IV Current informational signage in New Zealand Garden


Rites and Rights
Botanic Gardens
Traditional Maori healing techniques which use plants are known as Rongoā rākau. Plants used for Rongoā are treasured as natural resources, called taonga. Many of the plants around you are used in traditional healing, including New Zealand flax, tea tree, cabbage tree, and many others.
Collecting these plants requires special rites, called tikanga. Although some species are endangered, New Zealand law recognizes the right of Maori tribes to use these precious plants, and the Maori in turn help conserve these irreplaceable species.
Cabbage tree in flower


Unique to the Islands
Botanic Gardens
Known as New Zealand flax, Phormium species are actually lilies. This fibrous-leaved plant has hundreds of uses, from food to medicine and clothing.
Phormium is an endemic species—a species native only to a particular geographic area. Up to 80% of the plants of New Zealand are endemic because the islands have been isolated for millions of years. Losing their already limited habitats threatens even common endemic species.
Phormium, by Forest and Kim Starr