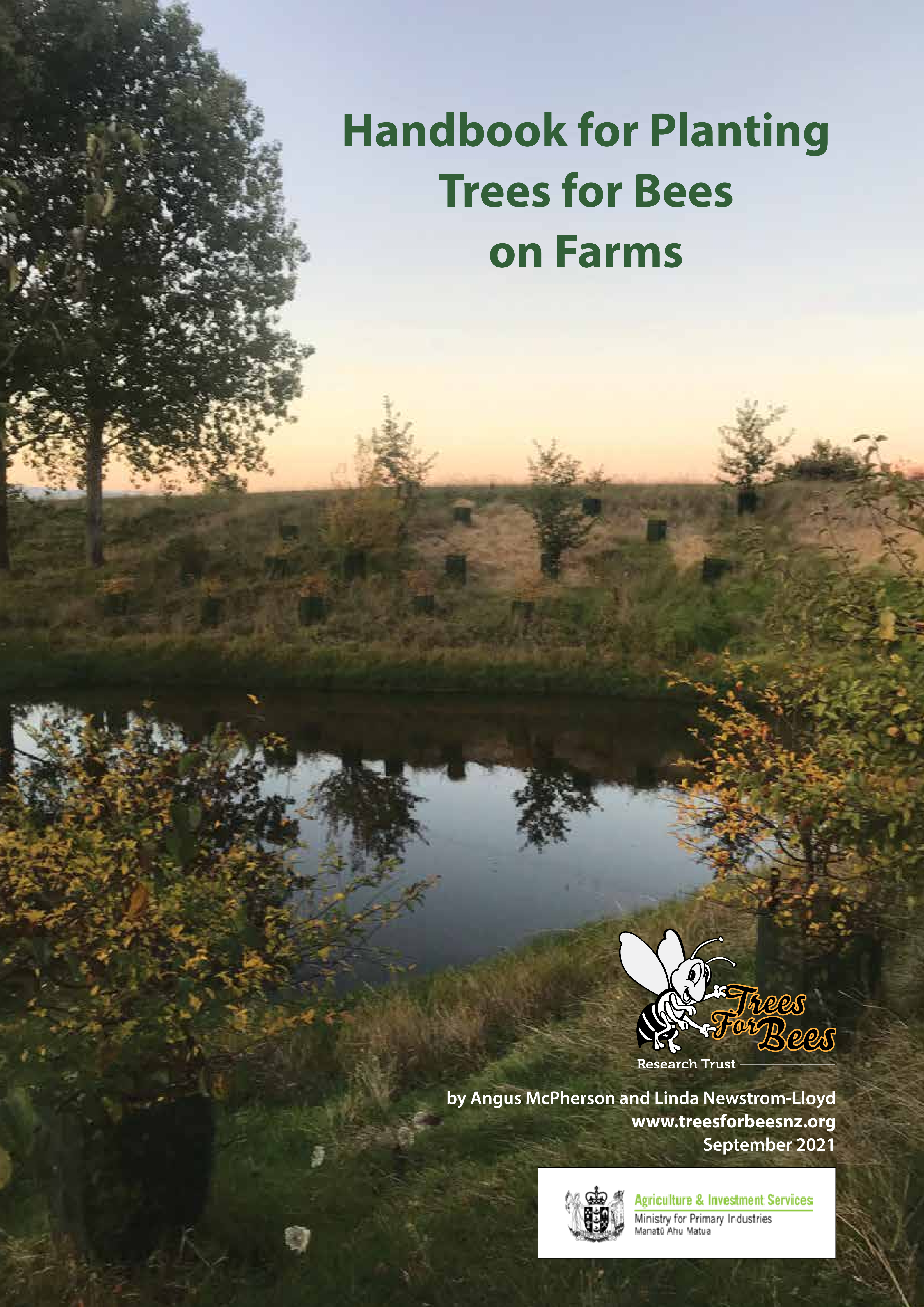

Handbook for Planting Trees for Bees on Farms

Trees For Bees Research Trust

by Angus McPherson and Linda Newstrom-Lloyd

www.treesforbeesnz.org
September 2021

Agriculture & Investment Services
Ministry for Primary Industries
Manatū Ahu Matua

Dedication to New Zealand beekeepers

The Trees for Bees NZ research programme would not exist today without the ongoing support of New Zealand's brilliant and hardworking beekeepers. Our work would not have been possible without their guidance, financial investment, and practical assistance over the last ten years, and for this we are profoundly thankful. This Handbook is dedicated to all New Zealand beekeepers.

Angus McPherson and Linda Newstrom-Lloyd
June 2021

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Handbook for Planting Trees for Bees on Farms

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Cover photo: A mix of spring flowering bee forage, which also provides shade and feed for ducks, is planted around a farm pond. The smaller blossom plants (Japanese bush crabapple *(Malus sieboldii)* and Chinese ornamental pear *(Pyrus calleryana)*) are on the pond margin, with the taller Portuguese oak *(Quercus faginea)* and Hungarian oak *(Q. frainetto)* located higher on the pond's upper bank.

Smart farming for healthy bees in New Zealand does not mean that a farmer must set aside productive land to allow space for planting bee forage. Instead, farmers can take advantage of their current planting programmes designed for other farm goals that increase production and improve the land.

CONTENTS

TABLES

FIGURES

PREFACE

This *Handbook for Planting Trees for Bees on Farms* provides information and practical advice on how to incorporate premium bee forage into farm planting. The aim of this work is to increase and improve the supply of pollen and nectar to our most important pollinator, the honey bee, while also supporting other pollinators and farm biodiversity in general. By delivering good nutrition for bees, the health and sustainability of pollinators and farms are both safeguarded.

This Handbook is the culmination of ten years of research conducted by Trees for Bees NZ on farms. The goal of our research is to determine how to plant high-quality pollen and nectar sources without asking farmers to set aside productive land or engage in long-term extra inputs or labour. In other words, how a farmer can integrate low-maintenance bee forage into on-farm planting that they are already establishing to meet the needs of their other farm operations.

Our focus is primarily on domesticated honey bees because they are the premier industrial strength pollinator, and honey bees are undergoing threats from the consequences of loss of habitat for bee forage, overstocking in many regions, and increasing pest, disease, and pesticide issues. Farms provide the most excellent and abundant opportunities for planting bee forage to protect bee health.

The principles and advice in this Handbook are based on our field, lab and literature research as well as our experience in establishing bee forage on demonstration farms. We have worked with farmers, landowners, beekeepers, and nurseries to optimise best-practice establishment of bee forage on farms. We recommend bee forage plants based on our field observations of bees visiting flowers, lab data on pollen nutrition and scientific literature searches. We have developed planting strategies based on extensive work implementing our research results on demonstration farms. Since 2011, we have planted over 75,000 bee forage plants in 32 demonstration farms throughout New Zealand.

Based on our work, we have determined the best multi-functional bee plants to cover the critical flowering times for bees–in spring and autumn when bees are most at risk for pollen and nectar shortages. We prioritised a selection of high-performance bee plants and developed effective designs and templates for many different types of farm plantations. Our plantations have proven to reduce deficits in pollen and nectar and increase the carrying capacity of land to support bees.

Our research has broad applications for all pollinators and all land uses. Our demonstration farms currently range from sheep and beef farms, to arable farms, vineyards, horticultural and lifestyle blocks as well as public land. Some of the demonstration farms include home bee yards where queen bees and nucleus colonies are raised. Many include dedicated apiary sites for spring build-up or overwintering operations used by commercial beekeepers. Our demonstration farms show the great diversity of opportunities for establishing multi-purpose trees and shrubs that function well for bee forage while also improving farm operations and production.

We acknowledge and thank the Ministry for Primary Industries for four consecutive three-year Sustainable Farming Fund grants since 2010 and all our sponsors and donors in the apicultural and agricultural industries, as well as regional councils and nurseries. The Trees for Bees NZ research programme is a charitable trust, the *New Zealand Trees for Bees Research Trust*, with website at www.treesforbeesnz.org.

Happy planting.

Angus McPherson and Linda Newstrom-Lloyd

Section 1

INTRODUCTION

Honey bee collecting pollen from oak catkins *(Quercus sp.)*

1 INTRODUCTION

This *Handbook for Planting Trees for Bees on Farms* presents essential principles and advice on how to incorporate bee forage plants into a variety of ongoing farm planting programmes. Farmers and other landowners have an important role to play in promoting and protecting pollinators, especially bees. Smart farming for healthy bees in New Zealand does not mean that a farmer must set aside productive land to allow space for planting bee forage. Instead, farmers can take advantage of their current planting programmes designed for other farm goals that increase production and improve the land. To include bee forage plants in these programmes, the farmer simply chooses to use plant species that are multi-purpose so the plants will function for the farmer's primary goals, as well as feeding the bees.

In the past, farm biodiversity encompassed a great diversity and abundance of bee forage plants, but due to changes in agriculture, many farms now have less diversity and much less abundance. Bees need a dependable source of fresh natural pollen and nectar throughout most of the year. It is vital to ensure that floral resources are available at critical times to prevent deficits. Nutritional stress results in weak or dying bee colonies. By establishing low-maintenance trees and shrubs with good floral resources, the bees will have a steady supply.

Weak bee colonies produce poor pollinators, which leads to reduced productivity on pastoral, arable and dairy farms as well as in horticultural and lifestyle blocks. A steady supply of bee forage increases the number and size of bee colonies and produces robust bees with resistance to pests and diseases. Strong bees make strong bee colonies that are less costly to maintain.

1.1 The benefits of planting on farms

Farmers who plant trees and shrubs on farms contribute to a wide range of economic, environmental, and social outcomes that support and enhance farm production. Many benefits can be obtained by including bee forage plants that are multi-purpose for the primary and other goals on the farm.

In terms of economics, planting for bees creates more resilient farms and improves sustainability so that farmers can manage their land more profitably with increased production and income diversification. For example, supporting bees results in better pollination on-farm or extra honey extraction. The creation of overwintering sites for bees can utilise unproductive land or add shade and shelter for livestock.

Environmentally, different types of bee plantations can directly contribute to various farm goals such as water and soil quality management (sediment and run-off), stream habitat (riparian) protection, land stabilisation, paddock shade and shelter, improved biodiversity with habitat enhancement of native bush, or farm amenity and beautification.

Socially, supplying bee forage directly provides alternative avenues for engagement and employment for local communities through planting and beekeeping, and indirectly supports local communities and their enterprises through increased employment and commercial opportunities.

These economic, environmental, and social benefits contribute to the health of the local landscape and the farms and rural communities that rely on them.

1.2 Why do bees need help?

Pollinators are facing multiple threats in New Zealand and worldwide. The most important pollinators for agriculture are bees, including honey bees, bumble bees and solitary bees. Honey bees are the most highly domesticated. They are the premier industrial-scale pollinator for all temperate agricultural economies in the world—including New Zealand. For this reason, our Trees for Bees NZ plantations have been mainly focused on the health of honey bees because they drive production in the primary sector (Newstrom-Lloyd, 2013).

Domesticated honey bee colonies have the remarkable ability to live in movable, man-made beehives and they can adapt readily to new locations. Upon arrival at a new site, the scout bees search for available pollen and nectar sources and communicate the location and quality of resources back to the group of forager bees waiting in the hive. The ability to freely move bees in hives for pollination services or honey collection means that keeping bees can be economical for beekeepers. Compared to other bees, the significant advantage of honey bees is that they produce revenue from surplus honey production and they can rapidly communicate the location of floral resources back to their colony.

However, other pollinators also contribute to pollination services and they also benefit from bee forage plantations. In general, honey bees share the same types of flowers that other pollinating insects visit. This includes all insect pollinators seeking pollen or nectar, such as bumble bees, exotic and native solitary bees, flies, moths, and butterflies. The larger pollinators such as birds, bats and lizards require more sturdy flowers and strong branches for landing platforms, but they also share flowers with honey bees and other insect pollinators (e.g., large rātā flowers). Because some flowers have restricted or closed access to their pollen or nectar rewards, not all pollinators have access to all types of flowers (Newstrom & Robertson, 1985).

If a farmer or landowner wishes to focus on other biodiversity goals such as supporting different pollinator groups like bumble bees, native bees, or birds, then adjustments are easy to make in the plant lists. The main adjustment is the timing of flowering because different types of bees have different times of peak demand for food. For the honey bee, forage is most needed in early spring and autumn when deficits are most likely. Native bees have an active season from late spring through summer, which matches the peak native flowering diversity in New Zealand. Bumble bees have a critical demand in midwinter to early spring when the solitary queen is establishing her new nest and starting to raise a new colony. For each type of pollinator, the flower type and the timing of flowering can be adjusted to suit.

These differences in the timing of peak demand for floral resources show that introduced honey bees and bumble bees are at a disadvantage in New Zealand compared to native bees. Honey bees and bumble bees have critical supply demands in late winter, early spring and autumn when there is a dearth of flowering compared to summertime. This dearth can be remedied by planting more native and exotic plants that do flower at these critical times, such as the native five finger in very early spring and native *Hoheria* in autumn.

Honey bees and bumble bees are the backbone of pollination services in pastoral, arable and horticultural production, which is why they were introduced to New Zealand in the mid- to late 1800s (Newstrom-Lloyd, 2013). To ensure an abundant supply of these two key commercial pollinators, farmers can establish bee forage as a cost-effective means to provide pollen and nectar, especially in spring and autumn. Once the plantations are established and flowering, they will automatically provide many years of low-maintenance bee forage. The supply of flowers will increase as the plants mature and grow larger, and many flowering tree species are long-lived, such as oak trees.

For honey bees, planting critical bee forage reduces the beekeeper's labour and cost of having to regularly visit apiaries to provide supplementary feed in times of pollen dearth. While many beekeepers now provide supplements (e.g., pollen patties, sugar solution) for extra honey bee food, a diversity and abundance of fresh natural pollen and nectar has been shown to be central to bee health, bee immune response, and bee colony growth (Di Pasquale et al., 2013). Providing a steady supply of fresh natural pollen is a compelling reason to plant bee forage because it boosts bee health significantly and ensures colony survival, thereby safeguarding a sustainable and profitable apiculture industry over the long term.

Supplements have a use as emergency rations during sustained poor weather conditions that restrict bee flight for foraging trips, but they are costly to supply for extended periods. A bee diet primarily based on artificial supplementary feed does not measure up to fresh natural pollen, just as a farmer would not feed livestock on silage, hay and supplements year-round, and humans cannot thrive on a predominantly fast-food diet with artificially high fat and sugar.

Furthermore, some supplement formulas have excessive amounts of certain nutrients that can become toxic to bees when fed in excess. In New Zealand, increased use of bee feed supplements has been linked to an increase in nutrition-related diseases such as *Nosema* (caused by a *microsporidian)* and American foulbrood (caused by a bacteria), as well as susceptibility to pests such as the varroa mite.

The problem of decreasing floral resources due to loss of habitat and elimination of certain weeds (e.g., willow, gorse and broom) has been greatly amplified since 2013 because of the tripling of hive numbers as a result of the expansion of the mānuka industry. This tripling of the demand for pollen and nectar has not been matched with a sufficient increase in floral resources especially spring and autumn forage. The current situation of overcrowding bees beyond the carrying capacity of the available floral resources has led to an increased use of supplement feed and consequent increase in the spread and intensity of diseases and pests that harm bees.

Honey bees in New Zealand, and the world, are facing an increasing complexity of threats that can compound each other; for example, even slightly malnourished bees can be more susceptible to the varroa mite, while good nutrition has been shown to be effective in helping resist varroa infestations. It is more important than ever to protect bee health now because bees are developing more resistance to current varroa treatments and showing sensitivity to alternative varroa treatments.

Planting essential bee forage as part of farm management will ensure a viable and sustainable future for bees, beekeepers, and farmers. Honey bee health is crucial because honey bees are at the foundation of agricultural production in the New Zealand economy.

1.3 Planning for bee forage on farms

This *Handbook for Planting Trees for Bees on Farms* is a handy reference manual with comprehensive coverage of practical explanations and advice on why, where, and how to plant bee forage in many types of ongoing farm planting programmes. The format and content of the Handbook provides farmers, landowners, and others with ready access to relevant sections as needed.

Section 2. Ten Types of Bee Plantations for Farms presents ten of the most common types of plantations—each designed for a different purpose on the farm. For each type of plantation, we show how bee forage can be included. We describe how the structure and function of the plantation guides the design and selection of plants. This is followed by examples with photographs and a handy plant list indicating which plants we have found that work well as bee forage for each plantation type. The plantation types presented are: Riparian Protection, Land Stabilisation, Shelterbelts, Paddock Shade and Shelter, Native Bush Biodiversity, Farm Roads, Amenity, Edible Plantations, Apiaries and Beekeeper Yards, and Mānuka Honey Plantations.

Section 3. How to Prepare a Planting Plan covers the main procedures to follow when preparing any planting plan for a new or existing plantation. It describes success factors and gives checklists for creating a site plan. It describes how to design the plantation and select plant species. The spacing and arrangement of plants as well as planning the planting operations are also covered.

Section 4. How to Prepare a Bee Forage Plan shows how to work with tools that help you to select the best bee forage species for your situation. The best-practice strategy is to make sure that you can supply pollen and nectar to the bees with sufficient quantity and diversity of bee forage when they need it; that is, no gaps in the supply. The best-practice strategy also includes making sure you avoid planting any bee forage species that will distract the bees away from their designated target plants that you want bees to visit for pollination (e.g., clover or a certain crop) or for nectar collection for honey (e.g., clover or certain monoflorals). The steps are to construct an initial plant list with a flowering calendar, then create a species diversity chart, followed by a bee forage profile. In some cases, you may need to combine bee forage profiles into an annual bee forage budget that covers several sites in a wider area.

Section 5. How to Establish a Plantation presents ideas and advice on the procedures and equipment that are best-practice examples for preparing the site, establishing the plants, and maintaining the plants over time.

For further reading, we have listed key references and our Trees for Bees NZ publications that can be downloaded as PDFs from our website www.treesforbeesnz.org/information.

Section 2

TEN TYPES OF BEE PLANTATIONS FOR FARMS

Honey bee collecting pollen on willow catkins *(Salix sp.)*

2 TEN TYPES OF BEE PLANTATIONS FOR FARMS

There are many opportunities for installing goal-oriented plantations that benefit both your farm operations as well as bees. Ten main farm plantation types are described in this section. Each type is designed to meet different goals for specific farm operations or other land use benefits (Table 2-1). This results in efficient plantations that fulfil at least two or more purposes for the farmer or landowner. Which type of plantation to plant will depend on what areas are available for planting or where you need to plant to achieve a particular purpose.

For each type of plantation, we provide information on how simple it is to incorporate bee forage plants that are well-suited to different farm goals. We include information on the structure, function and layout of each type of plantation and provide illustrations using examples from our demonstration farms.

We then list some of the best bee forage species that we have commonly used for each type of plantation. Many additional bee plant species are also useful for any plantation type but in this section, we have listed those for which we have the most experience and are also successful.

You may wish to consider other bee plants; if so, you can refer to our updated master plant lists on https://treesforbeesnz.org/how-to-plant-guides. Many other bee forage species can also be used, and some may be more suitable for your geographic regions in terms of climatic or soil conditions.

Table 2-1. Ten types of plantations for establishing bee forage on farms.

Location on Farm	Description of Purpose
1. Riparian	Protect waterways from run-off and livestock.
2. Land stabilisation	Protect eroding land from soil degradation.
3. Shelterbelts	Protect pasture, crops and livestock from wind and weather.
4. Paddock shade and shelter	Provide shade and shelter to livestock.
5. Native bush	Protect and/or enhance remnant native bush biodiversity.
6. Roads, avenues, and stock laneways	Provide shade and shelter for livestock and workers throughout the farm.
7. Amenity	Provide visual amenity to farm workers and visitors.
8. Edible plantations	Provide a diversity of food to land owners, workers and community.
9. Apiary sites	Provide secure apiary sites for beekeepers.
10. Mānuka plantations	Diversify farm income through mānuka honey plantations.

Much of the land available for bee forage plantations could be described as marginal land that is unproductive and adds little or no value to the farm. As such, marginal land can take a wide range of forms – scrubby paddocks on a wet and shady face, tight corners in paddocks that make stock movement difficult, steep escarpments that stock will not graze or are dangerous to work, and gully bottoms that can trap or smother stock.

The primary purpose of planting these types of marginal land is to take an area that is unproductive or problematic and turn it into an area with a land use that adds value to the farming operation. This might include establishing a production forest woodlot; fencing off an escarpment, paddock corner, or gully; or establishing native and/or exotic plants for shade, shelter, or riparian protection. An important further benefit of planting on marginal or problematic land is that it often allows the farmer to reconfigure their paddocks to be more effective and productive.

Figure 2-1. Farm map of Kintail Farm showing bee forage planting locations.

Figure 2-1 shows an example of how a wide range of different on-farm planting can incorporate trees for bees plants. In this case, at Kintail Farm at Takapau, Central Hawke's Bay. In addition to being a sheep, beef and cropping farm, it also provided sites for raising queens and new nucleus colonies. With increased bee forage planting they can now also use the farm for the recovery of weak and sick hives, temporary holding of hives between pollination and honey work, and overwintering hives.

Referring to the plantation types shown in Table 2-1, the types of planting where bee forage have been incorporated in this example include (1) riparian planting, (2) land stabilisation, (3) shelterbelts, (4) paddock shade and shelter, (6) avenues and laneways, (7) amenity, and (9) apiary sites.

Honey bee collecting nectar on prickly leaved paperbark *(Melaleucea styphelioides)*

Figure 2-2. Before planting: Livestock trapped in a low-lying, wet gully in the Wharekopae River headwaters at Pembroke Station, Gisborne.

An example of marginal land is shown in this problematic gully that forms part of the Wharekopae River headwaters on Pembroke Station near Gisborne (see before planting in Figure 2-2). This gully has a wet and occasionally swampy bottom that was a trap for livestock. Pasture quality in the gully was low, and the gully sides too wet and steep to allow pasture improvement, thereby providing limited grazing value.

Because this land is in the Wharekopae River headwaters, this gully is also part of the Rere Water Quality Enhancement Project, initiated in 2015 to address issues of water quality in the catchment. This project includes all 15 sheep and beef farms in the upper Wharekopae catchment, Gisborne District Council (GDC), Ministry for the Environment (MfE), and Beef and Lamb New Zealand (https://www.cawthron.org.nz/news/community/2019/2019-nz-riverstory-finalist-wharekopae-river-gisborne/).

While planning the fencing and planting of this gully pre-dated the formation of the above group, the farmer was very aware of the water quality issues and wanted to fence and protect this area. The farmer was also very aware of a lack of pollinators for their clover crop, and as part of their pasture improvement programme wanted to ensure, as far as possible, that there would be sufficient pollinators available. Working with their beekeeper and the Trees for Bees NZ team, a plant list was developed to meet the multiple objectives of riparian protection and pollinator support, including honey bees, native bees and bumble bees.

Figure 2-3. After planting: Gully after it was retired, fenced and planted with native riparian bee forage plants in the Wharekopae River headwaters at Pembroke Station, Gisborne.

Figure 2-3 shows this same gully in 2021 after it was fenced and planted in 2016. By fencing off the gully the riparian zone could be protected from livestock, and the planting enabled control of sediment and nutrients. An effective boundary was also established either side of the gully, which allowed the farmer to further develop these paddocks and improve overall farm performance.

The focus of planting in this gully was on hardy native shrub and tree species, as the site is exposed and at altitude, with feral deer also present, so plant survival is a primary consideration. By keeping a cover of pasture grasses while the native plants establish, nutrient run-off and sedimentation are controlled. The native species included mānuka, kānuka, flaxes, cabbage tree, akepiro, akiraho, akeake, houhere, korokio, mingimingi and lemonwood. In addition to being hardy species, all these plants are recognised in the Trees for Bees NZ plant list as superior bee forage, supporting not only honey bees for clover pollination, but also bumble bees and native bees.

2.1 Riparian protection

Primary Purpose

The primary purpose for riparian planting is to protect waterways from run-off–soil, nutrient, or stock effluent (McPherson and Newstrom-Lloyd, 2019). A secondary purpose is to protect stream margins from erosion, and to provide shade for cooling the water. Finally, an increasingly important purpose is to use riparian planting to achieve additional environmental goals such as habitat protection, biodiversity conservation and carbon sequestration.

Integrating Bee Plants

Bee forage plants can readily be integrated into riparian zone planting, as there are a wide range of both native and exotic species well suited to riparian zones. Regional Councils and the Department of Conservation (DOC) have produced plant lists for riparian planting. While most of these riparian guides refer primarily to native species, in the right situation, exotic species also work well.

We have used native species in the majority of the Trees for Bees NZ riparian plantations, but excellent exotic species are included in more modified environments and wherever there is reduced risk of potentially introducing invasive plants that will encroach on native bush.

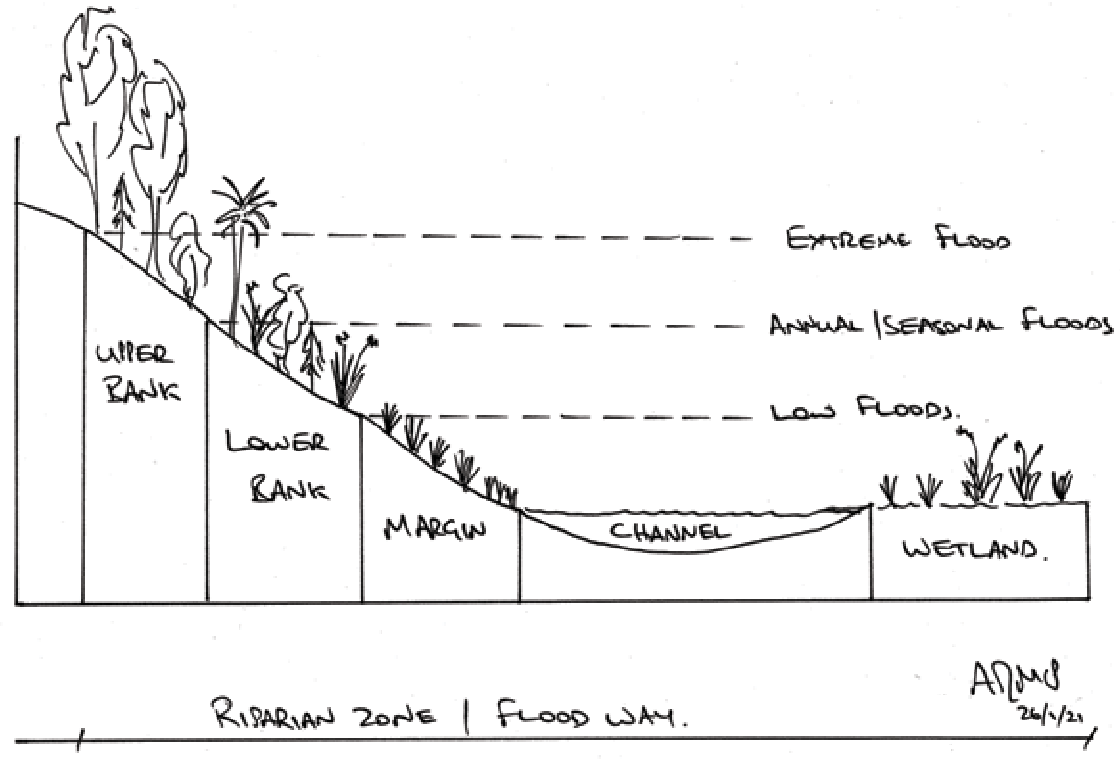
For our list of native riparian bee plants, we selected the most commonly used native species from the regional guides throughout New Zealand which, based on our research, are also the best bee forage species (see Table 2-2). For our list of exotic riparian bee plants, we selected the exotic species used in Trees for Bees NZ demonstration farms (see Table 2-3). More riparian species are listed in the *Riparian Planting Handbook* and *Winning with Willows* at www.treesforbeesnz.org/how-to-plant-guides.

Structure and Function

Riparian planting is typically structured by flood risk zones (Figure 2-4). The immediate riparian margin (next to the water) includes wetlands subject to frequent flooding. The lower bank region, adjacent to the margin, might experience sporadic or annual seasonal floods. The upper bank, on higher ground, might only be inundated in extreme floods.

Since the riparian margins flood the most often, they should only be established with sedges, grasses, and reeds so that water flow in a flood is not impeded. The lower banks do not flood as often so they can be planted with flaxes, smaller shrubs and other plants that can tolerate occasional wet feet, including willows (especially smaller shrub willows). The upper banks have much less risk of flooding and can be planted with a mix of shrubs and large tree species, including plants that require drier ground to grow.

Establishing the plants at a wide spacing will encourage ground cover growth (e.g., grasses) which is crucial for controlling sediment and nutrient run-off. Wide spacing will also ensure all sides of the plant are in full sun, which encourages more prolific flowering on all sides of the plant.



Zones	Upper Bank	Lower Bank	Margin	Channel	Wetland
Ground moisture	Dry	Damp	Wet	Aquatic	Aquatic
Flooding	Extreme floods	Annual/ seasonal floods	Low floods	Low floods	Low floods
Species	Larger trees	Flaxes	Reeds	N/A	Reeds
	Shrubs	Small shrubs	Sedges	N/A	Sedges
	Grasses	Grasses	Grasses	N/A	Grasses
	Dry tolerance	Wet tolerance	Flood tolerance	N/A	Flood tolerance
Purpose	**Grasses**–spread surface water flow, trap sediment, and absorb nutrients. They don't impede water flow. **Trees/shrubs**–roots stabilise streambank, canopy shades stream and keeps water cool, organic soils remove nitrogen.				

Figure 2-4. Riparian zones and plant types.

Figure 2-5. Riparian plantation with native bee forage at Puketiti Station, King Country.

Example 2.1 (a)

Mangaorongo Stream, Puketiti Station, Piopio, King Country (Figure 2-5)

The farmer fenced and planted approximately 4km of stream over four years in anticipation of tightening water quality requirements, and with funding support from Environment Waikato. The fencing required also enabled them to reorganise some of their paddocks and to construct a stock laneway to facilitate stock movement.

The riparian zone was established in a mix of native shrub and small tree species to provide bee forage support year-round. Native species planted at Puketiti included grasses *(Carex secta, C. virgata, Cortaderia fulvida),* flax, cabbage tree, mānuka and kānuka, *Pittosporum* species, koromiko, houhere, ribbonwood, akeake and karamu.

Figure 2-6. Riparian plantation with exotic trees on upper bank (water channel to the right of photo adjacent to the poplar shelterbelt) at Callaghan Farm, Staveley, Mid Canterbury.

Example 2.1 (b)

Flynn Stream, Callaghan Farm, Staveley, Mid Canterbury (Figure 2-6)

The farmer has fenced and planted small sections of stream over the past five years with a mix of exotic and native species, with the native species planting receiving financial support from Environment Canterbury.

Both native and exotic species selected include bee forage species for year-round apiary support. The exotic species planted at Callaghan farm included Norway and sugar maples, red alder, manna ash and swamp, English, Portuguese, Turkish and Mediterranean oaks. Shrubs included winter hazel, hawthorn, mulberry, and Chilean myrtle, and the ground cover was borage.

Riparian bee plant lists

Table 2-2 lists the most commonly used native species according to information in the regional riparian guides throughout New Zealand. Table 2-3 is an additional list of the exotic species used in the Trees for Bees NZ Demonstration Farms for riparian plantations.

Table 2-2. Native riparian bee plants ranked as most commonly used in riparian plant guides.

Location	Botanical Name	Common Name	Flowering Time	
Upper Bank			**Start**	**Finish**
Trees	*Carpodetus serratus*	putaputawētā	November	March
	Fuchsia excorticata	kōtukutuku; tree fuchsia	June	January
	Griselinia littoralis	broadleaf; māihīhi; kāpuka	November	January
	Hedycarya arborea	pigeonwood; porokaiwhiri	October	November
	Kunzea ericoides	kānuka	October	February
	Pittosporum eugenioides	lemonwood; tarata	October	December
	Pittosporum tenuifolium	kōhūhū; black matipo	October	December
	Plagianthus regius	ribbonwood; manatu	October	January
	Pseudopanax arboreus	five finger; whauwhaupaku	July	September
	Pseudopanax crassifolius	lancewood; horoeka	January	February
	Schefflera digitata	seven finger; patē; patetē	January	May
	Sophora microphylla	kōwhai; weeping kōwhai	August	November
Shrubs	*Aristotelia serrata*	makomako; wineberry	September	December
	Coprosma propinqua	mikimiki; mingimingi	September	November
	Coprosma robusta	karamū; glossy karamū	August	September
	Dodonaea viscosa	akeake	August	January
	Hebe stricta	koromiko	March	May
	Myrsine australis	māpou; red matipo	February	May
Lower Bank				
Trees	*Cordyline australis*	cabbage tree; ti kōuka	September	January
	Laurelia novae-zelandiae	pukatea	October	November
	Melicytus ramiflorus	māhoe; whiteywood	November	February
Shrubs	*Leptospermum scoparium*	mānuka	September	February
	Olearia fimbriata	small-leaved tree daisy	January	February
	Olearia lineata	twiggy tree daisy	November	January
	Phormium tenax	flax; harakeke	September	January

Table 2-3. Exotic riparian bee plants from north temperate regions used in riparian planting.

Location	Botanical Name	Common Name	Flowering Time	
Upper Bank			**Start**	**Finish**
Trees	*Acer negundo*	box elder	September	October
	Alnus formosana	Taiwan alder	April	May
	Fagus sylvatica pendulata	weeping European beech	October	November
	Fraxinus ornus	manna ash	September	November
	Parrotia persica	Persian ironwood	August	September
	Prunus mume	Japanese apricot	July	August
	Prunus padus	European bird cherry	September	November
	Pyrus calleryana	Chinese ornamental pear	September	October
	Quercus palustris	pin oak	September	November
	Quercus petraea	sessile oak	September	November
Shrubs	*Chaenomales japonica*	Japanese quince	September	October
	Chamaecytisus palmensis	tree lucerne; tagasaste	May	October
	Crataegus crus-galli	cockspur thorn	September	November
	Elaeagnus pungens	elaeagnus	March	May
	Gordonia axillaris	fried egg plant	April	August
	Luma apiculata	Chilean myrtle	September	November
	Michelia yunnanensis	Yunnan bush michelia	May	September
	Pseudocydonia sinensis	false or Chinese quince	September	October
	Salix spp.	shrub or osier willows	August	November
	Viburnum tinus	laurustinus	April	June
Lower Bank				
Trees	*Acer rubrum*	red maple	September	October
	Alnus glutinosa v barbata	Turkish black alder	September	October
Shrubs	*Amelanchier canadensis*	shad bush	August	November
	Salix spp.	shrub or osier willows	August	November
	Malus sieboldii	Japanese bush crabapple	September	November

2.2 Land stabilisation

Primary Purpose

Land stabilisation is a significant issue in many parts of New Zealand's hill country, particularly where previous forest cover has been cleared for pastoral farming. Traditional remedies for erosion control have included willow and poplar pole planting.

The primary purpose of land stabilisation planting is to protect hillsides from eroding and the consequent siltation of waterways. Both willows and poplars also help reduce phosphorus (P) run-off on farms by recycling inorganic P to organic P (https://www.poplarandwillow.org.nz/).

Integrating Bee Plants

Many types of excellent bee forage plants can be integrated into land stabilisation planting. The two key species groups used in land stabilisation are also key bee forage species: willows for pollen and poplars for resin.

Willows are an absolutely vital source of pollen and nectar for spring nutrition for bee colonies to build up (Newstrom-Lloyd et al., 2015). Poplars are also used by bees for pollen but are more important as a source of resinous exudate used by bees to make propolis for hive hygiene and a sealant.

Other species that can be used for erosion control that also provide bee nutrition include alders for spring and autumn pollen, and tree lucerne for very early spring bee forage. Native species can also be employed where livestock are excluded, especially deep-rooted species such as koromiko *(Hebe stricta)*.

Structure and Function

Depending on the nature of land instability, you might need to establish wide-spaced trees on the wettest or most eroded sites or fence off and plant localised or extensive areas. In both situations preference should be given to species with strong root systems, ability to tolerate wet sites, and rapid growth.

Where planting wide-spaced trees on pasture, willow and poplar poles have been preferred as you can use a sleeve to protect them from sheep and cattle. Cattle must be excluded for up to three years to avoid damage to the poles. Where other species such as alder are used, care will need to be taken to avoid stock damage.

Where gullies or entire paddocks need to be fenced off, stock can be excluded, which means a wider variety of plant species can be used, including both native and exotic species.

Figure 2-7. Wet and unstable ground showing slumping caused by tunnel erosion at Katoa Station, Te Araroa, East Cape.

Figure 2-8. Wet and unstable ground planted with willows and alders (with white stakes) at Katoa Station, Te Araroa, East Cape.

Example 2.2 (a)

Katoa Station paddock stabilisation, Te Araroa, East Cape (Figure 2-7 / Figure 2-8)

This is not a steep paddock, but with moderately high rainfall and the presence of springs, it is very wet. This means that there are areas of slumping in the small gullies and tunnel erosion, where tunnels can form beneath the surface of the paddock, later collapsing.

Golden willow poles, which provide excellent spring pollen and nectar, have been established over several years, focusing on some of the more severe slumping and collapsed tunnels. These have been supplemented by a mix of spring and autumn flowering alders in recent years.

Figure 2-9. Wet and unstable ground planted with mānuka and willows at Puketoro Station, Raukumara, East Cape.

Figure 2-10. Wet and unstable land in the background planted with willows and alders at Waitahaia Station, Raukumara, East Cape.

Example 2.2 (b)	**Paddock and gully stabilisation, Raukumara, East Cape** (Figure 2-9 / Figure 2-10) Figure 2-9 shows wet and unstable land at Puketoro Station. Willows have been established in the more actively moving gullies, with the easier country retired from grazing and established in mānuka. Figure 2-10 shows well-established exotic land stabilisation in gullies with native bush regenerating underneath.

Figure 2-11. Escarpment with slumping land at Riverlea Station, Piopio, King Country.

Figure 2-12. Escarpment three years after planting with mixed natives and exotic bee forage at Riverlea Station, Piopio, King Country.

Example 2.2 (c)	**Riverlea Station escarpment stabilisation, Piopio, King Country** (Figure 2-11 / Figure 2-12) This steep escarpment at Ingleby NZ LP's Riverlea Station at Piopio, King Country is a wet site with slumping land, affecting the boundary fence at the bottom of the slope. The site had limited grazing value and was a constant issue with stock getting through the boundary fence. By fencing the top of the slope on firm ground an effective boundary was established and planting a mix of native and exotic species helped stabilise the land and supply bee forage. Plants established at Riverlea included willows and alders on the wettest areas, along with tree lucerne, five finger, flax, cabbage trees, koromiko, and houhere.

Figure 2-13. Year 2014, steep face above river before planting at Waioma Station, Gisborne.

Figure 2-14. Year 2019, five years after planting 400 tagasaste trees on ridge above steep face at Waioma Station, with farmers Ben and Anna Roberts.

Example 2.2 (d)

Waioma Station escarpment, Wharekopae Valley, Gisborne (Figure 2-13 / Figure 2-14)

This extremely steep face was dangerous for both stock and farm workers and not productive for grazing. The area at the top of the ridge was fenced off, tree lucerne (tagasaste) established along the ridge line with koromiko planted on the mid-slopes. Both these species have become well established and produced seedlings that germinated further down the face. This progressively helped to stabilise the face and protect the river below from filling in. The plantation also provides key autumn and very early spring bee forage for the apiary located nearby.

Land stabilisation bee plant list

Table 2-4. Native and exotic bee plants used for land stabilisation.

Type	Botanical Name	Common Name	Flowering Time	
Native			**Start**	**Finish**
Trees	*Cordyline australis*	cabbage tree; ti kōuka	September	January
	Laurelia novae-zelandiae	pukatea	October	November
Shrubs	*Hebe stricta*	koromiko	March	May
	Phormium cookianum	mountain flax	October	January
	Phormium tenax	flax; harakeke	November	January
Exotic				
Trees	*Alnus glutinosa subsp. barbata*	Turkish black alder	September	October
	Alnus cordata	Italian alder	September	October
	Alnus cremastogyne	mountain alder	September	October
	Alnus nitida	Himalayan alder	April	May
	Eucalyptus ovata	swamp gum; black gum	March	June
	Eucalyptus rodwayi	swamp peppermint	March	April
	Populus trichocarpa	black cottonwood	October	November
	Populus x euramericana tasman	Tasman poplar	September	October
	Quercus palustris	pin oak	September	November
	Quercus robur	English oak	September	November
	Salix spp.	willow	August	November
Shrubs	*Amelanchier canadensis*	shad bush	August	November
	Chamaecytisus palmensis	tree lucerne; tagasaste	May	October

2.3 Shelterbelts

Primary Purpose

The purpose of shelterbelts is to protect stock, pastures, or crops from exposure to wind and sun. This improves productivity by reducing transpiration losses in pasture or crops and stress from heat or cold in stock.

Traditionally, farmers have planted shelterbelts with forestry species such as conifers (pine or macrocarpa), poplars/willows, and eucalypts, while orchardists relied on species such as Italian alder. Although these fast-growing species provide quick shelter, they can also become overgrown, requiring ongoing maintenance or periodic removal. Hence interest has grown in shelterbelts with longer-lived species that require less maintenance and provide multiple benefits.

Another consideration is the risk of surface tree roots encroaching into farmland (e.g., poplars), and whether the proposed shelter hosts any pests or pathogens for neighbouring farmland or orchards.

Integrating Bee Plants

Bee forage plants for shelterbelts can be taller specimen trees (e.g., poplar, willow, alder, oak), smaller shrubs (e.g., *Michelia, Camellia,* blossom species such as crab apples) or native species (e.g., koromiko, *Olearia* and *Myrsine)*. How they are integrated depends on the height of the shelter required, the structure (single/double or more rows, hedgerow), and evergreen or deciduous.

Structure and Function

Shelterbelts are typically aligned across the prevailing wind, although their exact location might be determined by roads, farm tracks, rivers, or existing fence lines. A further consideration, especially with evergreen shelter, is to orient them north to south to reduce pasture shading.

Successful shelterbelts must provide effective shelter low-down and more diffuse shelter higher up to avoid turbulence downwind by letting some wind through. For example, combine evergreen low shelter species and widely spaced taller trees such as trees with narrow crowns or deciduous trees.

Single/double row shelterbelts (Figure 2-15) are most common on farms, where space is limited (2–5m width). In this case, use low growing evergreen species (e.g., native shrubs, slow growing conifers) with taller deciduous species (e.g., poplars or oaks). For single-row shelterbelts, plant the different species alternately. For double-row shelterbelts, plant low growing species on the windward side.

Three-tier shelterbelts (Figure 2-16) can be planted if there is more space available (5–8m+ width). In this case, use low evergreen shelter on the windward side with tall shelter in the middle, and less hardy bee forage species such as *Michelia* and *Camellia* and blossom species on the leeward side.

Hedgerow-type shelters can be established where you do not want or cannot have high shelter. Here, use shrubs and small tree species. For example, sites that are very exposed at high altitudes have the risk of overmature trees blowing over or sites where centre pivots may be installed.

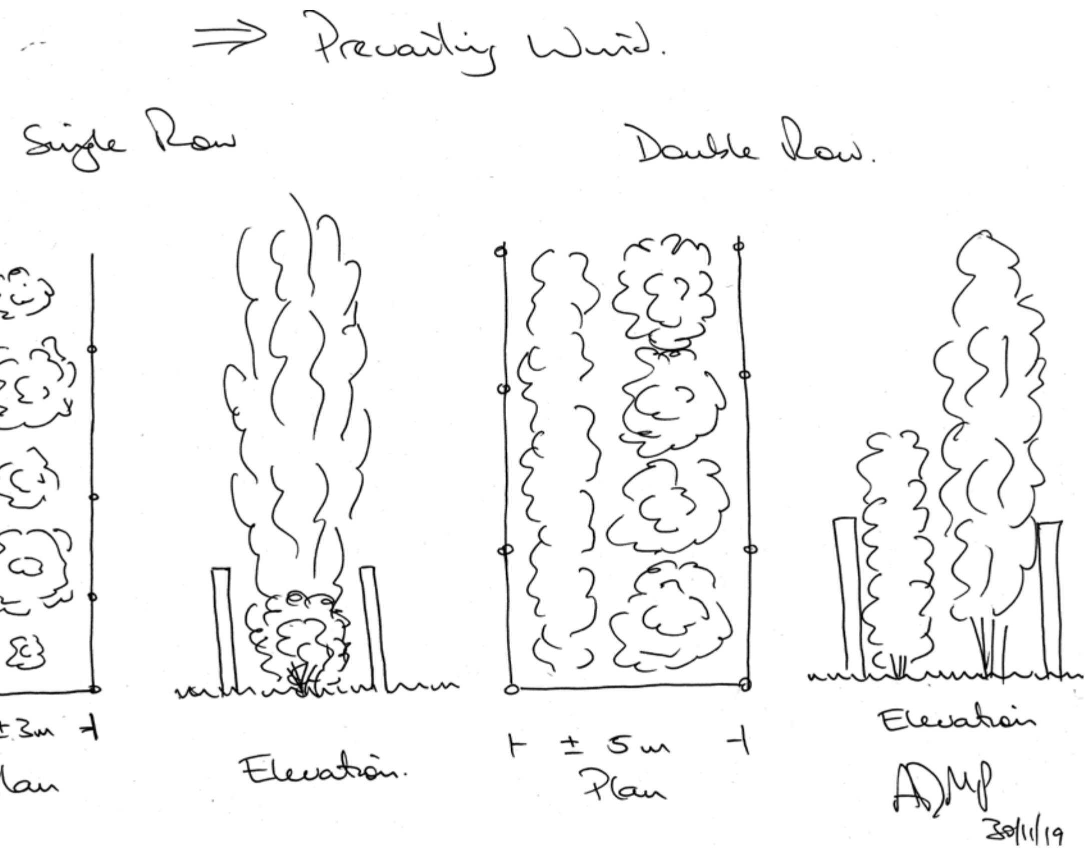


Figure 2-15. Single-row and double-row shelterbelt designs.

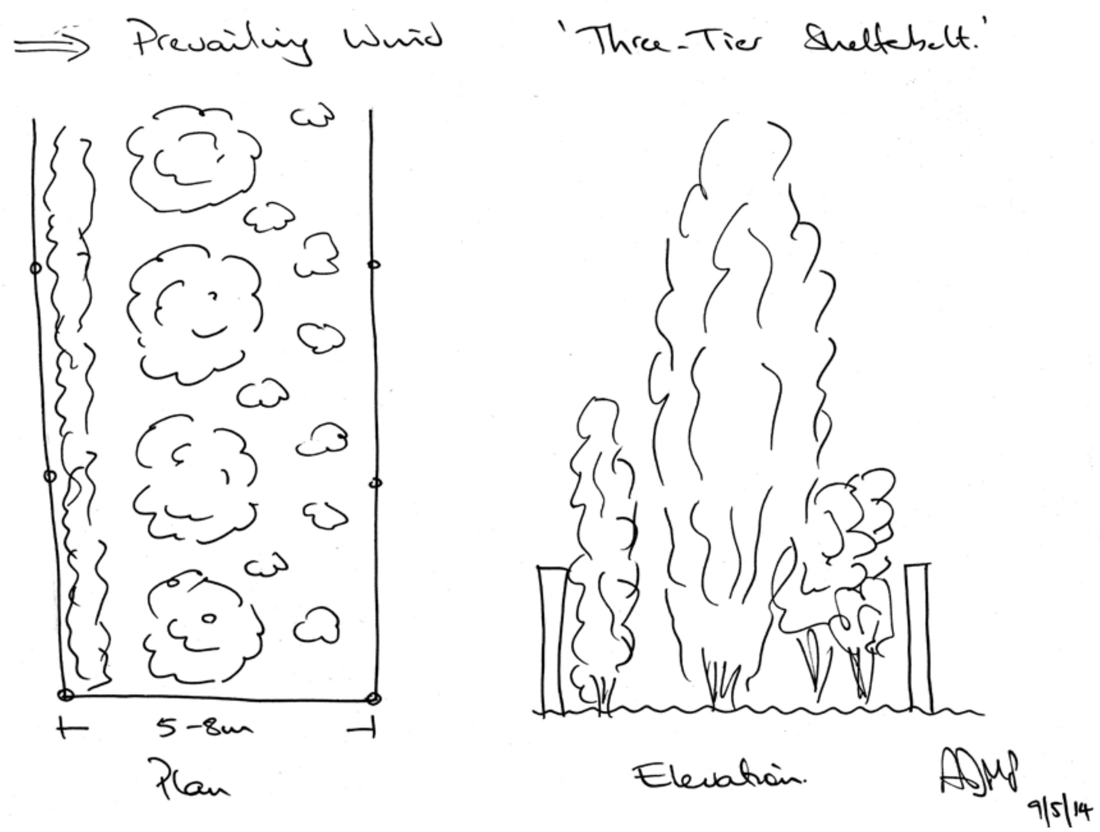


Figure 2-16. Three-tier shelterbelt design.

Figure 2-17. Single-row shelterbelt with mānuka and alder alternating, Tapuaeroa Valley, Ruatoria, East Cape.

Example 2.3 (a)	**Single-row shelterbelt, Tapuaeroa Valley, Ruatoria, East Cape** (Figure 2-17) A single-row shelterbelt was established on this farm to provide shelter to an apiary site from the wind flowing down a river valley. Because space was limited a single-row design was used, with mānuka providing the low shelter and some summer bee forage, and Italian alder *(Alnus cordata)* providing the high shelter and spring pollen. The alder is deciduous and does not have a heavy crown, so it will not shade too heavily in summer or winter. It is deep rooting, so will not affect the paddock, and it is wind firm so has a reduced risk of blowing over.

Figure 2-18. Three-tier shelterbelt as a dust screen at Matahiia Station, near Ruatoria, Gisborne with beekeeper Bill Savage.

Example 2.3 (b)	**Three-tier shelterbelt, Matahiia Station, Ruatoria, East Cape** (Figure 2-18) This shelterbelt has been established as a dust screen to protect the farmhouse from the noise and dust from the logging trucks passing on the road in front. The site was formerly poor for overwintering apiary sites, because of a lack of flowering species from late winter until the willows started flowering, but but now can support 20 to 34 hives since the flowering begun 2–3 years after planting. The shelterbelt consists of evergreen *Camellia* and *Michelia* species closest to the road for autumn and early spring bee forage, with deciduous trees (oak and chestnut) and spring blossom species (shad bush, hawthorn and crab apple) on the side facing the homestead for spring bee forage.

Figure 2-19. Multi-row shelterbelt with *Michelia, Cotinus* and *Malus* at Kintail Honey, Takapau, Hawke's Bay.

Example 2.3 (c)

Multi-row hedgerow shelterbelt, Kintail Honey, Takapau, Hawke's Bay (Figure 2-19)

This shelterbelt was established to replace a pine shelterbelt that had become overmature and was expensive to remove. As such, the farmer wished to have more permanent shelter that did not get over 3-4m in height, as they were considering centre pivot irrigation.

The windward side was established with sasanqua camellia species, which found the strong southerly winds too harsh and so wind cloth was used. In future shelterbelts of this nature, hardy native shrubs such as *Olearia paniculata* or *Myrsine australis,* both which provide autumn bee forage, would be used.

The centre was planted with evergreen *Michelia yunnanensis* (in flower in the photo) and *Cotinus coggryia,* with the *Michelia* providing autumn to early spring bee forage and the *Cotinus* early summer. The leeward side was established with bush crab apples for spring blossom and bee forage.

Shelterbelt bee plant list

Table 2-5. Native and exotic bee plants for shelterbelts.

Location	Botanical Name	Common Name	Flowering Time	
Native (low shelter)			**Start**	**Finish**
Windward	*Coprosma repens*	taupata; mirror plant	June	February
	Corokia cotoneaster	korokio; mountain korokio	September	November
	Dodonaea viscosa	akeake	August	January
	Leptospermum scoparium	mānuka	September	February
	Myrsine australis	māpou; red matipo	February	May
	Olearia lineata	twiggy tree daisy	November	January
	Olearia paniculata	akiraho; golden akeake	March	May
	Phormium tenax	flax; harakeke	November	January
Native (high shelter)				
Centre	*Cordyline australis*	cabbage tree; ti kōuka	September	January
	Hoheria populnea	houhere; lacebark	January	June
	Hoheria sexstylosa	houhere; lacebark	February	June
	Pittosporum eugenoides	lemonwood; tarata	October	December
	Pittosporum tenuifolium	kōhūhū; black matipo	October	December
	Plagianthus regius	ribbonwood; manatu	October	January
Native (optional)				
Leeward	*Coprosma robusta*	karamū; glossy karamū	August	September
	Hebe stricta	koromiko	March	May
Exotic (low shelter)				
Windward	*Chamaecytisus palmensis*	tree lucerne; tagasaste	May	October
	Ceanothus spp.	California lilac	September	December
	Choisya ternata	Mexican orange blossom	September	November
	Corylus avellana	European hazelnut	September	November
	Elaeagnus ebbingei	oleaster; silverberry	March	May
	Viburnum tinus	laurustinus	April	June
Exotic (high shelter)				
Centre	*Acer campestre*	field maple	September	October
	Alnus cordata	Italian alder	September	October
	Carpinus betulus	European hornbeam	September	October
	Eucalyptus spp.	eucalyptus	April	September
	Liriodendron tulipifera fastigiata	upright tulip tree	October	November
	Quercus robur v. fastigiata	upright English oak	September	November
Exotic (optional)				
Leeward	*Amelanchier canadensis*	shad bush	August	November
	Camellia japonica; C. sasanqua	camellia japonica or sasanqua	July	September
	Gordonia axillaris	fried egg tree	April	August
	Gordonia yunnanensis	fried egg tree	April	August
	Malus sieboldii	Japanese bush crabapple	September	December
	Michelia yunnanensis	Yunnan bush michelia	May	September
	Pseudocydonia sinensis	false or Chinese quince	September	October
	Pyrus calleryana	Chinese ornamental pear	September	October

2.4 Paddock shade and shelter

Primary Purpose	Paddock shade and shelter has the same primary purpose as shelterbelts– to protect stock, pasture, and crops from exposure to wind and sun. The improvement in pasture and stock productivity results from reduced transpiration losses in pasture and less stress in stock due to excessive heat or cold. Paddock shade and shelter differs from shelterbelts in that instead of rows of trees and shrubs, the shelter is planted in small groups or as single trees in the middle or at the margins of the paddock.
Integrating Bee Plants	A broad range of paddock shade and shelter trees and shrubs can offer outstanding bee forage. For example, single tall specimen trees, such as willows, alders, oaks, and maples, can provide an enormous amount of pollen and nectar. Shrub species can be established under specimen trees such as small blossom species as well as herbs like rosemary and lavender. How these plants are integrated depends on the size and structure of the shade and shelter (fence line, fence corner, paddock centre), the type of tree guards proposed, and livestock limitations.
Structure and Function	Paddock shade and shelter can be installed by using existing fence lines. For example, areas can be fenced off in paddock corners for specimen trees and shrubs (Figure 2-20 and 2-21). This is useful for eliminating problem corners where stock become overcrowded. Alternatively, areas can be fenced off at any point along a straight fence line utilising the existing fence for half of the barrier (Figure 2-20 and 2-23). Paddock shade and shelter can be established in the middle of a paddock by installing tree guards around specimen trees and underplanting shrubs (Figure 2-20 and 2-22). Providing shelter and water in less grazed areas can encourage more even paddock utilisation by livestock. The type of livestock farmed will determine the best method of fencing– whether it is post and rail, posts or waratahs and electric fence. Cattle and horses need to be kept away from browsing specimen trees and shrubs by using post and rail and/or electric fence. In contrast, sheep can be prevented from browsing by placing a sleeve around the stem of the trees, which also works for cattle with willow or poplar poles. To allow lambs to get under and eat the grass without damaging trees, set an electric fence bottom wire at a height that only lets lambs under. Wooden tree guards are ideal for shade and shelter in the middle of a paddock (Figure 2-22). They must be large and sturdy, so they are expensive but long lasting. The size of the tree guard must match the reach of the animal–horses have a longer reach than cattle. You can use a combination of posts and electric fence if you have a reliable power source. Finally, you could use a sheet of concrete reinforcing steel around the tree secured by waratahs or posts driven into the ground (section 5.3).

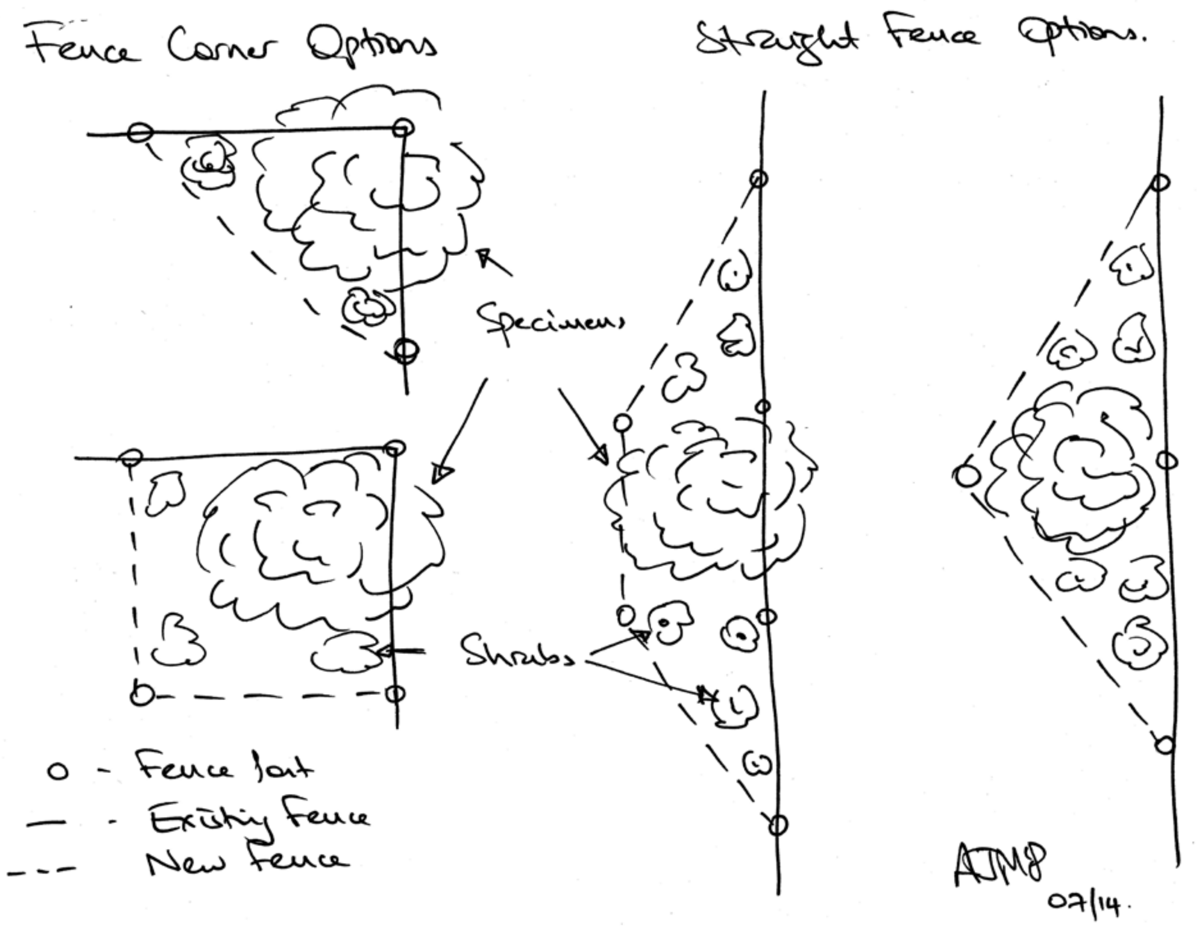


Figure 2-20. Layout options for fence corner and fence line barriers for stock.

Figure 2-21. Paddock corner planted with sasanqua camellia and manna ash at Rere, Gisborne Jeremy Williams, retired farmer.

Figure 2-22. Paddock with wooden tree guards around diverse exotic trees at Kintail Honey, Takapau, Hawke's Bay.

Example 2.4 (a)	**Paddock centre shade and shelter, Kintail Honey, Takapau, Hawke's Bay** (Figure 2-22) A diverse range of specimen trees were established to replace senescent poplars and willows. This included specimen trees such as box elder, Norway and sugar maples, scarlet and hybrid English oaks, American white ash, honey locust and red horse chestnut–all for spring bee forage. Large wooden tree guards were established to protect the trees from cattle, and the spaces in the guards underplanted with rosemary for year-round bee forage. This site is unique in that it is also a queen raising yard for Kintail Honey. The ability to manage livestock and bees in the same space requires specific training and management strategies and is not recommended in most situations.

Figure 2-23. Paddock shade and shelter in a fenced-off triangle in the fence line at Peter Hair's farm at Lake Repongaere, Gisborne with beekeeper Paul Badger.

Example 2.4 (b)	**Paddock margin shade and shelter, Lake Repongaere, Gisborne** (Figure 2-23) Paddock shade and shelter were established around the margins of this paddock to provide spring bee forage to support nearby apiaries that had been experiencing a bee forage shortage in October. The species established included pin oak, trident maple and manna ash specimen trees and underplanted with rosemary and hawthorn. The tree guards were a combination of a wooden top rail and wire fence lower down.

Figure 2-24. Paddock shade along a fence line at Puketoro Station, Raukumara, East Cape.

Example 2.4 (c)

Paddock margin shade and shelter, Puketoro Station, Raukumara, East Cape (Figure 2-24)

Paddock shade and shelter were established along an access road adjacent to margins of several paddocks using Northern Pin oak, which is a hardy oak with good autumn colour and provides spring bee forage.

The tree guards used treated timber stakes connected by wire and covered with windbreak cloth. Protection from stock browsing the paddocks was achieved by the electric fence on the paddock side.

Paddock shade and shelter bee plant list

Table 2-6. Native and exotic plants for paddock shade and shelter.

Type	Botanical Name	Common Name	Flowering Time	
Native			**Start**	**Finish**
Shade	*Cordyline australis*	cabbage tree; ti kōuka	September	January
	Hoheria populnea	houhere; lacebark	January	June
	Hoheria sexstylosa	houhere; lacebark	February	June
	Kunzea ericoides	kānuka	October	February
	Sophora microphylla	kōwhai; weeping kōwhai	August	November
	Sophora tetraptera	large-leaved kōwhai	September	November
	Vitex lucens	pūriri	May	September
Underplanting	*Coprosma propinqua*	mikimiki; mingimingi	September	November
	Discaria toumatou	matagouri; tūmatakuru	October	January
	Hebe stricta	koromiko	March	May
	Myrsine divaricata	weeping matipo or mapou	July	November
	Phormium cookianum	mountain flax	October	January
Exotic				
Shade	*Acer negundo*	box elder	September	October
	Aesculus x carnea	red horse chestnut	September	November
	Alnus rubra	red alder	September	October
	Eucalyptus leucoxylon 'Rosea'	Tasmanian yellow gum	April	September
	Fraxinus ornus	manna ash	September	November
	Liriodendron tulipifera	tulip tree	October	November
	Quercus robur	English oak	September	November
	Tilia cordata	small-leaved lime	December	February
Underplanting	*Camellia japonica; C. sasanqua*	camellia japonica or sasanqua	July	September
	Ceanothus 'Yankee Point'	California lilac yankee point	September	December
	Chaenomales japonica	flowering quince	September	October
	Choisya ternata	Mexican orange blossom	September	November
	Lavandula dentata	fringed or French lavender	September	December
	Phacellia tanacetifolia	phacelia	February	March
	Pseudocydonia sinensis	false or Chinese quince	September	October
	Rosmarinus officinalis	rosemary	September	June
	Thymus vulgaris	thyme	September	December
	Viburnum japonicum	Japanese viburnum	April	June

2.5 Native bush biodiversity

Primary Purpose	The establishment of new native bush and restoration of existing native bush is gaining importance in New Zealand. The aim is to promote native plant biodiversity, improve habitat for native birds, bees and other fauna, and for carbon sequestration. Pollinators that benefit from native flowering plants include birds, bats, lizards, bees (native and introduced), butterflies, moths, and flies.
Integrating Bee Plants	Native bush has long been recognised by beekeepers as an excellent source of bee forage. To increase bee forage supply, the best way is to protect native bush by excluding livestock (fencing) and controlling pests such as deer, possums, goats, rats, stoats, cats, and wasps. Pest control can be achieved by trapping, shooting, or bait stations, and will also help increase bird and invertebrate numbers. By reducing the grazing and browsing of native plants, the regeneration of native bush is significantly enhanced, and flowering will increase for birds, bees and other pollinators. Designing a native bush plantation depends on which pollinators you want to support. To specifically support honey bees, the focus should be on native species that flower in late winter, early spring, and autumn when honey bee forage deficits occur. The rich diversity of native flowers in summer coincides with the season of honey harvesting and pollination services by honey bees. Native bees are dormant over winter and active in late spring and summer when the majority of native plants flower. Bumble bees have a critical demand in late winter and early spring.
Structure and Function	Existing native bush can be enriched or extended through new plantings. Shelter and riparian plantations provide good opportunities to incorporate native plants. By using native plants sourced from your local area you will be promoting 'eco-sourcing' for conservation and ensuring that your plants are adapted to your climate. In contrast to much of the current restoration planting with high stocking rates (stems/ha), native plantings designed for pollinators need much lower stocking rates to increase the supply of flowers. If stocking rates are too high, the sides of the plants will become shaded and fail to produce flowers. While high stocking rates quickly establish an area, it is expensive and you end up with overstocked sites with canopy flowering only, unless you remove some of the plants causing the shading at additional expense. For new native plantations, start with pioneer species (e.g., mānuka or kānuka, akeake, *Coprosma, Olearia, Hebe (Veronica), Hoheria, Aristotelia, Pittosporum,* and *Myrsine).* If pest control is good, more vulnerable but important plants such as early spring flowering five finger can be included. Once these are established, interplant with large tree species such as kāmahi, pūriri and rewarewa.

Figure 2-25. Native bush area fenced off to exclude livestock to protect flowering bee plants.

Example 2.5 (a)	**Fencing existing bush, Riverlea Station, Piopio, King Country** (Figure 2-25) Like many sheep and beef farms, Riverlea Station has several small and isolated blocks of native bush scattered throughout the farm. Often these blocks are left unfenced and are used as shelter for livestock. Over time the livestock eat the regenerating bush understory, and the bush starts to deteriorate. To counter this decline, the small native bush blocks were fenced to exclude livestock. Additional planting was undertaken where there were significant gaps, and additional pest control undertaken to supplement the council possum control programme. Significant regeneration of native species was noticed within 18 months of fencing, and the general health of the bush blocks is improving. Additional planting included *Coprosma, Pittosporum* and *Hebe* species, akeake, cabbage tree, mānuka/kānuka, wineberry, houhere and kōwhai. Livestock still gain shelter around the margins of these bush blocks, which has been supplemented by the establishment of paddock shade and shelter.

Figure 2-26. Native bee plants established near farm entrance and existing QE-II native bush reserve at Puketiti Station, Piopio, King Country.

Example 2.5 (b)

Supplementary planting, Puketiti Station, Piopio, King Country (Figure 2-26)

Puketiti Station has several areas of native bush, including two areas of QE-II reserve. One of the reserves, adjacent to the entrance of the farm, is also adjacent to a wet area unsuited to grazing.

To better utilise this area and enhance the entrance to the farm, it was fenced off and planted in a mix of native tree and shrub species. Because it was a former paddock, weed control was required to control pasture grasses. This involved a pre-plant spray and mulch applied around the base of the plants, which enabled them to get above the weeds.

Supplementary planting included *Coprosma, Pittosporum* and *Hebe* species, akeake, cabbage tree, mānuka/kānuka, flax, wineberry, putaputawētā, houhere, kāmahi and kōwhai.

Figure 2-27. Native bee plants established at margin of native bush to support nearby apiary at Rangitukia, East Cape.

Example 2.5 (c)

Supplementary planting, Naati Beez, Rangitukia, East Cape (Figure 2-27)

Naati Beez is a local group of Ngāti Porou beekeepers in Rangitukia directed by Rangi Raroa and the late Willie Kaa. The main goal of the project is to create long-term residential apiary sites to support honey harvesting by using locally sourced native plants.

Areas of retired pasture adjacent to native bush were established in native bee forage species, specifically selected to address critical early spring and autumn flowering to support a nearby apiary. These included five finger, *Hoheria,* koromiko, *Coprosma,* pūriri, and *Pittosporum* species.

Key challenges faced included feral deer and goat populations, which were particularly attracted to five finger and *Coprosma.* For this reason, wire mesh plant protectors were used to help keep pests away from the young seedlings.

Figure 2-28. Native regeneration growing under exotic species at Matahiia Station, Ruatoria, East Cape.

Example 2.5 (d)

Native regeneration under exotic species, Matahiia Station, Ruatoria, East Cape (Figure 2-28)

Native regeneration will take place in areas established with exotic species, especially deciduous hardwoods such as poplar and willow species, and under species with light crowns, including eucalypts.

In this case, poplar and willow species were established at Matahiia Station for land stabilisation adjacent to existing native bush, and the native species have started to establish beneath the exotic species. In time it will be possible to remove the exotic species through felling and/or poisoning, leaving the remaining native bush in place.

As with other examples of native regeneration, control of feral pests such as possums, deer and goats is critical.

Native biodiversity bee plant list

Table 2-7. Native bee plants for native biodiversity bush.

Type	Botanical Name	Common Name	Flowering Time	
Native			Start	Finish
Trees	*Carpodetus serratus*	putaputawētā	November	March
	Cordyline australis	cabbage tree; ti kōuka	September	January
	Dysoxylum spectabile	kohekohe	March	June
	Fuchsia excorticata	kōtukutuku; tree fuchsia	June	January
	Griselinia littoralis	broadleaf; māihīhi; kāpuka	November	January
	Hoheria populnea	houhere; lacebark	January	June
	Hoheria sexstylosa	houhere; lacebark	February	June
	Knightia excelsa	rewarewa	September	December
	Laurelia novae-zelandiae	pukatea	October	November
	Pennantia corymbosa	kaikōmako	November	February
	Pittosporum eugenioides	lemonwood; tarata	October	December
	Pittosporum tenuifolium	kōhūhū; black matipo	October	December
	Pseudopanax arboreus	five finger; whauwhaupaku	July	September
	Schefflera digitata	seven finger; patē; patetē	January	May
	Weinmannia racemosa	kāmahi	October	January
	Vitex lucens	pūriri	May	September
Shrubs	*Aristotelia serrata*	makomako; wineberry	September	December
	Coprosma grandifolia	kanono; manono	April	May
	Coprosma robusta	karamū; glossy karamū	August	September
	Corokia cotoneaster	korokio; mountain korokio	September	November
	Geniostoma rupestre var. ligustrifolium	hangehange	September	November
	Hebe stricta	koromiko	March	May
	Myrsine australis	māpou; red matipo	February	May
	Olearia furfuracea	akepiro	October	January
	Olearia paniculata	akiraho, golden akeake	March	May
	Phormium tenax	flax; harakeke	November	January

2.6 Roads, avenues and laneways

Primary Purpose	The primary purpose of planting along farm roads, tracks and livestock races/laneways (accessways) is to provide shade and shelter to livestock being moved around the farm and for farm workers. Establishing planting along accessways can also provide an avenue-like effect, significantly enhancing the aesthetics of a farm, and fulfilling an amenity function.
Integrating Bee Plants	Establishing large specimen trees that are also bee forage species (e.g., oak, ash, maple, linden or lime tree, tulip tree*)* allows you to provide significant quantities of pollen and nectar from a relatively small footprint. Where the specimen trees are also fenced off to exclude livestock, there is an opportunity to underplant with shrub and herb species to further enhance your bee forage resources.
Structure and Function	Planting along accessways is typically structured as a row of trees, on one or both sides of the accessway being planted. Because many of the specimen trees used for such planting are slower growing, larger-grade trees are often used to give immediate effect. Plant spacing is dictated by many factors, including desired visibility either side of the accessway, mature tree height and canopy width, aesthetics and plant cost (large-grade trees are expensive). Some people prefer a close-planted shady avenue look, whereas others prefer widely spaced trees. Large trees such as the English oak can reach 30m in width at maturity, and so can be planted at 20–30m centres and still provide an avenue effect. Smaller size trees like manna ash are best planted at 10m centres. When planting along roads, avenues, laneways, or tracks, it is possible to use existing fence lines and difficult fence corners to construct cost-effective tree guards for a wide range of species. Most native species are not suited to planting as avenues, as they are more suited to growing in a bush environment. Nevertheless, some species such as cabbage trees, houhere, pūriri, native beech and kōwhai can be established as specimens for avenues.

Figure 2-29. Widely spaced avenue of large exotic specimen trees in wooden tree guards along a stock laneway at Matahiia Station, near Ruatoria, Gisborne.

Example 2.6 (a)	**Livestock laneway, Matahiia Station, Ruatoria, East Cape** (Figure 2-29) During farm development at Matahiia Station, new laneways were constructed to facilitate livestock movement, allowing stock to move along at their leisure, with the trees providing necessary shelter during hot summer weather. Figure 2-29 shows the avenue of Norway maple *(Acer platanoides)* and chestnut *(Aesculus x carnea)*, along a stock laneway from holding paddock to woolshed.

Figure 2-30. Closely spaced avenue of flowering manna ash underplanted with English lavender at Kintail Honey, Takapau, Hawke's Bay.

Example 2.6 (b)

Farm track, Kintail Honey, Takapau, Hawke's Bay (Figure 2-30)

Avenue of manna ash *(Fraxinus ornus)* underplanted with English lavender at Kintail Honey in Takapau, Hawke's Bay.

This is a small tree (10m at maturity), so they can be planted close together (10m centres), which also makes for a spectacular display when they are in full flower, enhanced by the close underplanting of lavender.

Road, avenue and laneway bee plant list

Table 2-8. Exotic bee plants for roads, avenues and laneways.

Type	Botanical Name	Common Name	Flowering Time	
			Start	Finish
Specimens	*Acer negundo*	box elder	September	October
	Aesculus x carnea	red horse chestnut	September	November
	Alnus rubra	red alder	September	October
	Eucalyptus leucoxylon 'Rosea'	Tasmanian yellow gum	April	September
	Fraxinus ornus	manna ash	September	November
	Gleditsia triacanthos	honey locust	October	November
	Liriodendron tulipifera	tulip tree	October	November
	Prunus x yedoensis	Yoshino cherry	September	October
	Quercus palustris	pin oak	September	November
	Quercus robur x petraea	English oak	September	November
Underplanting	*Camellia japonica; C. sasanqua*	camellia japonica or sasanqua	July	September
	Ceanothus 'Yankee Point'	California lilac Yankee Point	September	December
	Chaenomales japonica	flowering quince	September	October
	Choisya ternata	Mexican orange blossom	September	November
	Lavandula dentata	fringed or French lavender	September	December
	Phacellia tanacetifolia	phacelia	February	March
	Pseudocydonia sinensis	false or Chinese quince	September	October
	Rosmarinus officinalis	rosemary	September	June
	Thymus vulgaris	thyme	September	December
	Viburnum japonicum	Japanese viburnum	April	June

2.7 Amenity

Primary Purpose	The primary purpose of amenity planting is to beautify farms. Nevertheless, amenity species can also be included in a wide variety of functional farm planting situations, from shelterbelts to paddock shade and shelter to laneways and riparian planting. The focus here is on incorporating amenity planting into the farm rather than garden planting per se. As such, when talking about amenity planting, we are referring to situations such as farm entrances and entrance avenues, ponds, specimen trees, and amenity woodlots.
Integrating Bee Plants	Because one aspect of amenity planting includes the use of flowers for amenity, then it is a logical extension to include bee forage plants as part of your planting mix. Mature specimen trees have the value of large amounts of flowers and hence pollen and nectar, for a relatively small footprint, and are a valuable component of any bee forage planting. Even when amenity trees do not have obvious ornamental flowers; for example oaks, maples, and alders, they can still provide a very valuable bee forage function since they supply good quantities of pollen and/or nectar.
Structure and Function	Amenity planting allows you to experiment with plant form and leaf or flower colours for beautifying an entrance, around the house or other buildings and throughout the farm. Farm structures such as entrances, homesteads and yards provide an excellent framework around which to establish amenity planting of specimen trees and flowering shrubs. The specific planting structure employed will be dictated by the area to be planted and the visual amenity required. Farm entrances provide a framework for a pair of large specimen trees such as oaks or beech to frame a gateway, or an avenue of large trees up to the homestead – broad canopy trees like oaks or tulip trees, or their more upright (fastigiate) forms. Amenity planting can also be very useful for providing shade and shelter around farm utility buildings, woolsheds and sheep and cattle yards. Shearing, crutching, and docking are all hot and tiring jobs, and having some shade to work under is always welcome. Many farms will also include ponds linked to their streams and water races. An extension of riparian planting is to use amenity species around the ponds for visual amenity and shade. Some farmers are also keen duck shooters and include plants like crab apples and oaks as part of their pond planting. This can not only help to manage the ducks' flight path, but also provides feed for the ducks and forage for the bees.

Figure 2-31. Amenity planting of oaks and blossom bee plants for duck pond in vineyard at TW Wines, Gisborne.

Example 2.7 (a)	**Duck pond, TW Wines, Gisborne** (Figure 2-31) While bees are not required for grape pollination, vineyards do make a great location for hive wintering sites if you have the right bee feed species established. Bees are also useful in the vineyard, because they clean out the fruit pulp and juice from bird-damaged grapes, thereby preventing diseases. A mix of spring flowering bee forage which also provides shade and feed for ducks was planted around a farm pond at TW Wines. The smaller blossom plants are on the pond margin with the taller oaks located higher on the pond's upper bank. The blossom species are Japanese bush crab apple *(Malus sieboldii)* and Chinese ornamental pear *(Pyrus calleryana)* for early spring flowering and summer fruit for ducks. The oak trees are Portuguese oak *(Quercus faginea)* and Hungarian oak *(Q. frainetto)* for later spring flowering and summer/autumn acorns to feed ducks.

Figure 2-32 Entrance avenue of hybrid English oaks *(Quercus robur x petraea)* at Bog Roy Station, Omarama, North Otago.

Figure 2-33 Parkland adjacent to entrance avenue at Bog Roy Station, Omarama, North Otago.

Example 2.7 (b)

Farm entrance, Bog Roy Station, Omarama, North Otago (Figure 2-32 / Figure 2-33)

Establishment of specimen trees has been used to give more amenity value to the entrance at Bog Roy Station in the upper Waitaki Valley.

Previously, this area contained low-quality grasses and was used for storing wrapped silage and hay bales. A mix of deciduous trees were established from 2012 to 2014, including oaks *(Quercus robur x petraea* as specimens along the driveway, *Q. robur v. fastigiata* along the fence line, and Q. palustris along the driveway inside the farm gate), beech *(Fagus sylvatica)*, hornbeam *(Carpinus betulus)* and Norway and red maples.

Amenity bee plant list

Table 2-9. Native and exotic bee plants for amenity.

	Botanical Name	Common Name	Flowering Time	
Native			Start	Finish
Trees	*Carpodetus serratus*	putaputawētā	November	March
	Cordyline australis	cabbage tree; ti kōuka	September	January
	Fuchsia excorticata	kōtukutuku; tree fuchsia	June	January
	Hoheria sexstylosa	houhere; lacebark	February	June
	Pennantia corymbosa	kaikōmako	November	February
	Pittosporum eugenioides	lemonwood; tarata	October	December
	Plagianthus regius	ribbonwood; manatu	October	January
	Sophora microphylla	kōwhai; weeping kōwhai	August	November
	Vitex lucens	pūriri	May	September
Shrubs	*Arthropodium cirratum*	rengarenga; renga lily	September	December
	Aristotelia serrata	makomako; wineberry	September	December
	Dodonaea viscosa	akeake	August	January
	Hebe stricta	koromiko	March	May
	Parsonsia heterophylla	NZ jasmine; akakaikiore	October	December
	Phormium tenax	flax; harakeke	November	January
Exotic				
Trees	*Acer negundo*	box elder	September	October
	Aesculus x carnea	red horse chestnut	September	November
	Alnus rubra	red alder	September	October
	Eucalyptus leucoxylon 'Rosea'	Tasmanian yellow gum	April	September
	Fraxinus ornus	manna ash	September	November
	Gleditsia triacanthos	honey locust	October	November
	Liriodendron tulipifera	tulip tree	October	November
	Prunus mume	Japanese apricot	July	August
	Prunus yedoensis	Yoshino cherry	September	October
	Quercus palustris	pin oak	September	November
	Quercus petraea x Q. robur	hybrid English oak	September	November
	Tilia platyphyllos	large-leaved lime	December	February
Shrubs	*Camellia japonica; C. sasanqua*	camellia japonica or sasanqua	July	September
	Gordonia axillaris	fried egg plant	April	August
	Michelia yunnanensis	Yunnan bush michelia	May	September
	Malus spp.	crabapple	September	November
	Pseudocydonia sinensis	false or Chinese quince	September	October
	Pyrus calleryana	Chinese ornamental pear	September	October

2.8 Edible plantations

Primary Purpose	The primary purpose of an edible plantation is the production of food, but a large number of species for orchards, nutteries and gardens (especially herb gardens) are also excellent sources of high-quality pollen and nectar for bees.
Integrating Bee Plants	**Orchards:** Bees play a crucial role in pollinating edible tree, shrub and herbaceous crops. A home or farm orchard is a good way to provide early spring bee feed. Pears, apples and citrus are all producers of high-quality pollen (>25% protein) and, depending on the cultivar, flowering can extend from early to late spring. Some citrus flower in autumn but most flower in spring. **Nutteries:** Orchards for walnuts, hazelnuts, macadamia nuts etc. can provide important spring and autumn bee feed. Hazelnuts are an excellent source of pollen for bees. In warm climates, hazelnuts can start producing pollen from late autumn through winter. In a colder climate (e.g., inland South Island), the catkins will form in autumn but won't start shedding pollen until it warms up in the spring. Walnut orchards provide good early spring pollen. **Vegetable and herb gardens:** The honey bee's best friend in the vegetable garden are herbs, particularly oregano, rosemary, lavender, borage, sage, and thyme. Keeping a border of lavender or rosemary will greatly help bees. If you periodically cut back the lavender it will keep flowering while rosemary naturally flowers twice–in spring and autumn. You may need to cut herbs back if they are flowering at the same time as your target pollination plant. For example, depending on the density and quantity of flowers, the bees may prefer herb flowers such as lavender that will distract them from the target flowers such as pipfruit that need pollination.
Structure and Function	Edible plantations do not need to be large, because single trees or a small number of plants all make a difference. Layout is critical to have polliniser plants spaced correctly for the types of crops that need polliniser plants. Be careful to organise the flowering times in the garden so that the bees are not distracted from your target crop species. Your nursery should be able to assist with layout suggestions for your specific site. When selecting edible plants, especially citrus cultivars, you should check that the specific cultivar does produce pollen and nectar. Also check the plants you are planning to establish to find out if they are potential hosts for any plant pathogens, and whether pest control programmes might require the use of pesticides which would harm the bees.

Figure 2-34. Farm orchard of cherries, plums, pears and apples at Omarama Station, North Otago.

Example 2.8 (a)	**Farm entrance orchard, Omarama Station, North Otago.** (Figure 2-34) An orchard was established adjacent to the entrance to Omarama Station. It comprises a variety of blossom species including cherries, plums, greengage, pears, and eating apples. A nearby orchard also includes quince, crab apples and cooking apples. The orchard at the entrance was established not only to provide fruit for the farm, but also for the local school nearby, where pupils are welcome to help themselves. The orchard has also been used as an outdoor classroom for pupils to learn about fruit trees and honey bees. In this example from North Otago, the main selections for the orchard were pip and stone fruits which are adapted to cold winters. The flowers in these types of fruit trees in the Rose family are uniform with open-dish flowers that reliably produce high quality pollen and nectar. In contrast, some citrus fruits have highly modified flowers in the modern cultivars because of the consumer demand for seedless fruit. Before selecting citrus cultivars, check out the flowers to see what they deliver for bees. Some highly modified mandarin cultivars do not deliver nectar and some cultivars of Valencia oranges do not deliver pollen. Grower's associations often provide information on the flowers and growing requirements for home or commercial orchards (e.g., www.citrus.co.nz). See citrus Star Performer (www.treesforbeesnz.org/publications).

Figure 2-35. Rosemary border established at Eastwoodhill Arboretum, Gisborne.

Example 2.8 (b)

Rosemary border, Gisborne. (Figure 2-35)

Rosemary border established between lawn and garden. Most of the Mediterranean herbs (oregano, salvia, sage, savory, marjoram) are extremely good bee plants and they evolved with the honey bee and bumble bee in the Europe and the Middle East.

Using herbs, fruits, and vegetables for dual-purpose plantations to supply bee forage can be an interesting adventure for the gardener. Flowers of most culinary herbs are particularly attractive to bees and many of these provide flowers and leaves at the same time. Fruit trees and flowering shrubs are obvious candidates for good bee forage but what about vegetables? Many vegetables are technically fruits and provide flowers with abundant pollen (e.g., pumpkin, squash, cucumber, zucchini, tomato, beans, corn, and okra etc.). Balancing out bee preferences and the different plants competing for bee visits to gain pollination will be a trial-and-error exercise as you develop your edible garden.

On the other hand, leafy or root vegetables are normally harvested before flowering starts. However, if they do mature and flower before you can pick them, the bees will be able to enjoy the flowers. For example, if you let fennel, arugula, lettuce, or any of the brassicas go to flower, you will see abundant bees foraging on them. You may wish to purposely let some plants go to flower so that you can feed bees.

Edible plantation bee plant list

Table 2-10. Edible bee plants for orchard, nutteries and herb gardens.

Type	Botanical Name	Common Name	Flowering Time	
			Start	Finish
Pipfruit	*Malus × domestica*	Apple	September	November
	Malus spp.	Crab apple	September	November
	Cydonia oblonga	Quince	October	November
	Pyrus communis	Pear	September	October
Stonefruit	*Prunus domestica*	Plum	September	November
	Prunus mume	Japanese apricot	July	August
	Prunus persica	Peach	August	November
Citrus	*Citrus sinensis*	Orange	December	January
	Citrus limon	Lemon	December	January
	Citrus aurantifolia	lime	intermittent throughout the year	
	Citrus paradisi	grapefruit	September	October
Exotic	*Feijoa sellowiana* Apollo	feijoa apollo	September	December
	Eriobotrya japonica	loquat	April	November
Nuts	*Corylus avellana*	European hazelnut	September	December
	Corylus colurna	Turkish hazelnut	September	December
	Carya illinoinensis	pecan	October	November
	Juglans regia	common walnut	November	December
	Macadamia integrifolia	macadamia	June	March
Berries	*Ribes sanguineum*	flowering currant	August	November
	Ribes uva-crispa	gooseberry	August	November
	Rubus idaeus	raspberry	August	November
Herbs	*Lavandula dentata*	fringed or French lavender	all year	all year
	Lavandula angustifolia	English lavender	September	January
	Rosmarinus officinalis	rosemary	September	June
	Thymus vulgaris	thyme	September	December
	Salvia officinalis	sage	April	May
	Origanum vulgare	oregano	January	March

2.9 Apiaries and beekeeper yards

Primary Purpose

The primary purpose of dedicated apiary sites and beekeeper yards is to provide a safe place and good nutrition for the beekeeper's bees. At these sites, bee forage plantations must provide pollen and nectar to support the bee life cycle throughout the year if the bees are kept there all year long.

Where an apiary site might be required for only part of the year, bee forage planting focuses on plants that support the apiary for its particular purpose (e.g., spring build-up, pollen source during mānuka flowering, autumn preparation, overwintering, raising queens or nucleus hives).

Integrating Bee Plants

Apiary sites on farms can be focused on providing pollen and nectar for any or all four different seasons: spring build-up, summer pollination services or honey collecting, autumn preparation and overwintering.

A permanent apiary site would provide for all four seasons, while a seasonal apiary site would regularly alternate between two sites, particularly if one site is too cold in the winter to host the bees or bees are moved out for short-term pollination services. For arable farms, where bees are required to pollinate non-preferred crops (e.g., onions and carrots), then the bees from the residential apiary would be taken elsewhere for pollination services in a different area. This is because naïve bees need to be introduced to achieve pollination on non-preferred crops. Migratory systems of apiaries have multiple sites from north to south to follow the honey flow, usually for mānuka or other valuable monofloral honey.

Structure and Function

Experienced beekeepers look at many factors when assessing a location for placing a new apiary, so it is best to consult an experienced beekeeper. In general, the following factors in descending order of importance are critical for locating a new apiary site (Foster 2014; Kauri Park Nursery Newsletter).

1. Shelter from cold and prevailing winds.
2. Sun for much of the day including low-angle sunlight in winter for overwintering sites.
3. Good safe access for beekeeper vehicles.
4. A site elevated away from potential flooding.
5. Good air drainage to avoid cold air sinks and excessive shading.
6. Fresh water available for the bees.
7. Location away from heavily used areas by stock or people.
8. Good levels of bee forage within bee foraging range of 2 to 5 km.
9. Low level of competition from nearby apiaries (ideally 2 to 3 km).

Figure 2-36. Shed shelter and screening planting to support bee yard and Queen raising at TW Wines, Gisborne.

Example 2.9 (a)

Bee yard and Queen raising, TW Wines, Gisborne (Figure 2-36)

An extensive network of bee forage has been established at TW Wines to support a residential bee yard and queen-raising.

The opportunity has been taken to incorporate bee plants into avenue planting (tulip tree, Yoshino cherry), shed shelter and screening *(Michelia, Camellia* and blossom species), pond planting (blossom and oaks), land stabilisation (oaks, maples, ash, poplar and willow), boundary shelter *(*houhere, koromiko and *Olearia),* and general amenity (magnolia, maples, oaks and ash).

Figure 2-36 above shows farmer Paul Tietjen of TW Wines, MP Chlöe Swarbrick, and beekeeper Barry Foster alongside shelter established with sasanqua camellia, *Michelia yunnanensis,* and blossom species.

Figure 2-37. Bee forage being established under centre pivot on an arable farm at Dorey, Mid Canterbury.

Example 2.9 (b)

Planting to support permanent apiaries on arable farm, Dorey, Mid Canterbury (Figure 2 37)

Bee forage was established at an existing apiary site, in a region where spring pollen has typically been lacking – most of the shelterbelts in the area are pine.

The first area was established in a shelterbelt of *Ceanothus,* alder, Mexican orange blossom, five finger and rosemary in 2011/12.

A second area was established in 2017-19 around the apiary with a low rosemary hedge in front, with *Ceanothus,* Mexican orange blossom, crab apple, Japanese quince, maples and ash for spring flowering, and *Viburnum, Escallonia* and strawberry tree for autumn flowering.

Further planting has used the area under centre pivots where they are parked up and not being used. These areas are less suited to arable cropping but ideal for low-growing bee forage to support the nearby apiaries. Low-growing (maximum height 3m) bee forage species were used – Mexican orange blossom, *Escallonia* species and *Viburnum tinus.*

Apiary site bee plant list

The following list of species for apiary sites focuses on shrub species to be located adjacent to the apiary.

Note that for the native shelter, *Corokia cotoneaster* and *Olearia lineata* are spring flowering, whereas *Myrsine australis* and *Olearia paniculata* are autumn flowering.

For the exotic shelter species, tree lucerne is very early spring, ceanothus and Mexican orange blossom are spring flowering (although Mexican orange blossom can also flower again midautumn), and *Elaeagnus, Escallonia* and *Viburnum* are late summer to autumn flowering.

Table 2-11. Native and exotic bee plants for apiary sites and beekeeper yards.

Type	Botanical Name	Common Name	Flowering Time	
Native			**Start**	**Finish**
Shelter	*Corokia cotoneaster*	korokio; mountain korokia	September	November
	Myrsine australis	māpou; red matipo	February	May
	Olearia lineata	twiggy tree daisy	November	January
	Olearia paniculata	akiraho; golden akeake	March	May
Spring	*Coprosma repens*	taupata	June	February
	Pseudopanax arboreus	five finger; whauwhaupaku	July	September
	Pittosporum crassifolium	karo	September	December
	Pittosporum eugenioides	lemonwood; tarata	October	December
Autumn	*Hebe stricta*	koromiko	March	May
	Hoheria sexstylosa	houhere; lacebark	February	June
Exotic				
Shelter	*Chamaecytisus palmensis*	tree lucerne; tagasaste	May	October
	Ceanothus spp.	California lilac	September	December
	Choisya ternata	Mexican orange blossom	September	November
	Elaeagnus ebbingei	oleaster; silverberry	March	May
	Viburnum tinus	laurustinus	April	June
Spring	*Prunus mume*	Japanese apricot	July	August
	Amelanchier canadensis	shad bush	August	November
	Pyrus calleryana	Chinese ornamental pear	September	October
	Chaenomales japonica	flowering quince	September	October
	Pseudocydonia sinensis	false or Chinese quince	September	October
	Malus spp.	crabapple	September	November
Autumn	*Arbutus unedo*	strawberry tree	April	May
	Gordonia axillaris	fried egg plant	April	August
	Michelia yunnanensis	Yunnan bush michelia	May	September
	Camellia japonica; C. sasanqua	camellia japonica or sasanqua	July	September

2.10 Mānuka honey

Primary Purpose

The expansion of the mānuka honey industry has resulted in a significant increase in the number of hives and apiary sites, resulting in overcrowding of overwintering sites when winter preparation and/or spring-build up bee forage are essential.

Therefore, the primary purpose of establishing bee forage for mānuka plantations is to provide additional overwintering and spring build-up sites, whether these are located at the plantation site or elsewhere. This is to ensure that a source of pollen and nectar will be available for the bee colonies before and after the mānuka honey harvest season. At some sites with monocultures of mānuka, a source of pollen during the mānuka honey harvest may also be needed.

A source of pollen during the mānuka harvest is typically only required if the site is for permanent apiaries, or if it is part of a series of mānuka sites where the hives are placed during the harvest. In many cases where the hives are built-up off-site and only visit a single mānuka honey site, the bees may have enough stored enough pollen for the honey harvest period. In addition, the surrounding vegetation within 5 km may have sources of pollen during the harvest.

Integrating Bee Plants

When establishing bee forage to support overwintering apiaries away from the mānuka honey site (natural forest or plantation), follow the guidelines for apiary planting (section 2.9).

When establishing bee forage to support mānuka plantations on-site, differentiate between permanent and honey harvesting apiaries. Permanent apiaries, where the bees reside all year long, will require year-round bee forage; whereas short-term honey harvesting apiaries may or may not require bee forage on the shoulders either side of the mānuka season.

When planting mānuka plantations, the location for supporting bee forage species should be at the apiary sites and in areas where the mānuka is not going to be established. For example, areas where mānuka will not grow or flower well–such as riparian areas, gully bottoms, and exposed ridge tops. Sometimes bee forage can also be planted along track margins.

Structure and Function

For autumn and early spring forage it is best to locate bee plants as near to the apiary site as possible. Because the days are shorter and the weather can be more changeable, the intention is to keep the bees foraging much closer to the hive to maximise the number of trips to and from the hive and minimise the risk of being caught out by a weather change. The bee forage planted for apiary shelter is a key area to locate autumn and early spring flowering species.

If required, pollen sources during the mānuka flowering season can be established near the apiary, or within the plantation along riparian zones and where shelter and screening is required. If you are planting pollen sources for during the mānuka harvest, be sure to select pollen-dominant bee forage plants because if they are nectar-dominant they will contaminate or at least reduce the quality of the mānuka honey and may distract your bees away from the mānuka.

Figure 2-38. Steep escarpment used to establish bee forage plantation to support mānuka plantation at Taurapa Station, Cape Sanctuary, Hawke's Bay.

Example 2.10 (a)

Taurapa Station mānuka plantation, Ocean Beach, Hawke's Bay (Figure 2-38)

This mānuka plantation was established in 2017 and required bee forage to support permanent apiaries. Recent Hawke's Bay Regional Council riparian planting was within foraging distance of the mānuka plantation, and so the species mix used in this planting needed to be included in planning the flowering calendar for the desired species mix for the mānuka plantation bee forage (Section 4.8).

Because the previous riparian planting programme had used native species, it was heavy in late spring and summer flowering, which overlapped with mānuka flowering. Consequently, the new bee forage planting to be installed focused on early spring and autumn species to balance out the flowering calendar. The plant list included predominantly native species with exotic species for important flowering periods, specifically eucalypts for late summer/autumn nectar, and tree lucerne for very early spring pollen and nectar.

Key native species used included five finger for early spring pollen and nectar, *Coprosma* and *Pittosporum* species for spring, *Olearia* species for a summer pollen source and along with *Myrsine* and *Hoheria* for autumn flowering.

Mānuka honey pollen dominant bee plant list

As noted earlier, a source of pollen during the mānuka harvest is typically only required if the site is for permanent apiaries, or if it is part of a series of mānuka sites the hives are being taken to. In many cases where the hives are built-up off-site and only visit a single mānuka honey site, they will typically have stored enough pollen for the honey harvest period.

If pollen sources during the mānuka harvesting time are necessary, then several native species can be used that are excellent producers of pollen, with little or no nectar production that would dilute the mānuka honey during the summer mānuka flow. These will fulfil the requirement of some mānuka plantations that lack summer pollen sources as honey bees have not been observed to harvest pollen from mānuka plants in summer. A number of these species start flowering in spring, so will also assist with the spring build-up of hives. Key genera shown here include *Coprosma, Olearia* and *Griselinia*. Note that there are *Coprosma* and *Olearia* species that also flower in autumn, so make sure you select the correct ones.

Table 2-12. Native pollen-dominant bee plants for summer pollen supply in mānuka plantations.

Type	Botanical	Common	Flowering Time	
			Start	Finish
Trees	*Laurelia novae-zelandiae*	pukatea	October	November
	Podocarus totara	tōtara	October	December
	Dacrycarpus dacrydioides	kahikatea, white pine	October	January
	Griselinia littoralis	broadleaf; māihīhi; kāpuka	November	January
Shrubs	*Olearia cheesmanii*	streamside tree daisy	August	January
	Coprosma robusta	karamū; glossy karamū	August	September
	Coprosma lucida	karamū; shining karamu	September	November
	Aristotelia serrata	makomako; wineberry	September	December
	Olearia furfuracea	akepiro	October	January
	Olearia rani	heketara	November	February

Section 3

HOW TO PREPARE A PLANTING PLAN

Honey bee collecting nectar on Shantung maple *(Acer truncatum)*

3 HOW TO PREPARE A PLANTING PLAN

Having an overall plan is important for the success of plant survival and growth, and meeting the goals of the plantation for your farm purposes as well as whatever bee services you have targeted. Planning a bee forage plantation is like planning any farm planting, with the added step to consider the bee forage profile and targeted bee activity. This is called 'adding the bee layer' to any farm plantation. The steps to balance and target the bee forage profile as presented in Section 4 will ensure that the bees do the job that you have targeted them for and your new plantation contributes to the health and abundance of bees for your situation.

Many farmers and landowners are already familiar with the main principles and procedures for planning any farm plantation. A planting plan doesn't need to be a long document, but you need to identify:

- the area to be planted
- how much land
- how many plants
- which species
- the various operational tasks around sourcing plants
- preparing the site and organising planting
- ongoing maintenance.

Having an overall plan and consulting with nurseries, farm planting advisors and local beekeepers will help ensure that your planting is successful and meets your desired goals.

It is also important to recognise that you do not have to plant all areas at once. Many of our more successful demonstration farms have been planted over several years.

3.1 Success factors for a planting plan

Before embarking on a planting programme on your farm for any purpose, including bees, you need to be aware of a number of factors that are critical to the success of your planting and make sure you've prepared properly by completing key tasks.

Table 3-1. Factors for Success

Factor	Comments
Site and climate	Understand the limitations of your local climate and the specific site(s) you are planning to plant. This will influence the range and type of plants suitable and may also influence the planting designs.
Space available for planting	This will influence the number of plants to be established, but also the size of the plants and whether they fit into the space properly.
Time, money and labour available	Not only do you need to consider the cost of the plants and establishing them, but also fencing/tree guards, pest and weed control, and ongoing maintenance. It can take several years for plants to properly establish and they may require ongoing maintenance.
Best time of year for planting	Planting is often undertaken during winter when plants are dormant. This is especially so for bare-rooted plants which get 'lifted' in winter. Bagged plants allow a bit more flexibility and can be planted whenever the conditions suit. Autumn is a good season to plant, as it can still be warm enough for root growth before winter. Spring is also a suitable season, provided the risk of summer drought can be managed.
Weediness of candidate plants	A number of exotic plants are recognised as weed species, and either need to be avoided, or to have a proper weed management plan.
Toxicity of candidate plants to animals	Plants can be toxic to humans, stock, other animals, and bees. Toxic plants need to be avoided or managed carefully depending on the risks.
Protection from browsing	Most plants are susceptible to browsing damage, whether this be pests such as goats, deer, possums, hares and rabbits, or from livestock. This may require plans for pest control, fencing and tree guards.
How the plants fit in with existing land use	Whatever we plant, we want it to look good. Both native and exotic species have their attributes which make them suited to different areas. Native species are perhaps best suited to the wilder and more natural parts of farms and have found a particular niche in riparian planting. However, exotic species also work well in riparian planting, and are also well suited to solitary specimen trees, avenues and around yards and buildings.
Mass planting	Where possible, mass planting of candidate bee forage species is encouraged to maximise the size of the flowering patch. Larger patches of flowers of the same species are more attractive to bees.

3.2 Site plan checklist

A key step early in the planning process is to undertake an assessment of the potential sites to be planted, not only in terms of physical characteristics, but also the purpose of any planting. Completing the following checklist will help you clarify your thinking.

Table 3-2. Site plan checklist for planning a bee forage plantation.

Farm/block name:	
Location	e.g., paddock name reference, mark on farm map, GPS coordinates
Type	e.g., escarpment, riparian, paddock shade and shelter, shelterbelt
Planned Farm Purpose	e.g., land stabilisation, water quality protection, stock protection
Shape	e.g., narrow strip, irregular block. Helps define planting design options.
Area	Measure length x width in metres to give square metres (divide by 10,000 for hectares). Or use your farm map tool (e.g., FarmIQ, Smart maps) or Google Earth.
Exposure	e.g., exposed to southerly wind, sheltered site, sun/shade partial or full
Soils	e.g., loam, alluvial, etc., including any limitations – e.g., low fertility, clay pan, pH, waterlogged
Rainfall	Annual rainfall, including any seasonal patterns and variations (e.g. summer dry)
Access	Any nearby farm roads/tracks, suitable for small truck, 4WD or ATV
Beekeeper	Name and contact details if available
Planned Bee Purpose	Pollination/honey. Focus why a beekeeper or farmer wants hives on land – e.g., spring build-up, overwintering for honey and/or pollination work. Type of bee-honey bee, bumble bee, native bees, exotic solitary bees.
Flowering Calendar	Balancing – time of flowering required to supply bees – e.g., early/late spring, midsummer to autumn. Targeting – time of flowering to prevent competition that will distract bees off target plants. For example, if hives are required to focus on pollinating specific crops (e.g., clover pollination, arable/horticulture crop pollination, honey collection), then avoid plants that flower at the same time.
Constraints	Location relative to stock/personnel movement – may influence location of apiary and the need for screening plants (e.g., so bees will fly high above a track to reduce risk of bee stings if people are in flight path). On farm operations, e.g., timing and type of fertilisers, herbicides and pesticides, irrigation (bees don't like getting wet).
Comments	Any other factors relevant to the planting and/or beekeeping operation.

3.3 Plantation design checklist

Having completed your site plan checklist, you can now proceed to more detailed planning of specific planting sites, reaffirming the purpose of planting and likely timelines, key characteristics of the planting sites and preparation requirements, and the species you wish to plant.

Note that this is an iterative process. As you progress with your plans you may find that subsequent ideas get you thinking about your earlier plans and force a rethink – this is all part of the process.

Site	Description and mark location on farm map
Purpose	Farm planting purpose – e.g., shade, shelter, etc. Bee forage supply purpose – e.g., spring, autumn, over-wintering Timeline for project – if over a number of years, consider what the specific focus is each year. This might be sub-areas of the total area in consecutive years, or it might be larger specimen trees in the first year, smaller shrub species in the second year, ground cover in the third year (or the other way round). Alternatively, the first year might be fencing and pest control, the second year weed control (especially where there are serious weed problems), with planting the third year. The key point here is that this must work for you as farmer/landowner.
Sites	Specific planting sites can be described in terms of location, purpose, size and shape. Any particular operational requirements and likely timing can be described (e.g., fencing, tree guards, weed/pest control), which can then be incorporated into your detailed planning for your planting operation. At this stage you will be starting to think about specific design elements. For example, is the shelterbelt going to be single-row or double-row, or three-tier? Do you want evergreen or autumn colour trees for your livestock laneway? Do you want native or exotic species for your riparian planting? How big do you want the trees around the stock yards to be?
Species	Based on your planting purpose and site-specific plans you can start selecting plant species to suit your specific purposes. Care needs to be taken to select plants that are not toxic to humans, livestock, other relevant animals, or bees and are not a weed risk. Refer to your local council for weed lists. This will include selecting plants based on size (height and width), whether they are evergreen or deciduous, hardiness, timing of flowering, colour, etc. The Trees for Bees website includes plant lists for a wide range of bee forage species and the Star Performer series highlights a number of key plants. Most nurseries provide comprehensive lists of plants and their characteristics and they will be happy to advise. Once you know the area to be planted and the species used, you can then assess the number of plants required (section 3.4).

3.4 Spacing and arranging plants

A key principle of planting bee forage species is to be sure not to overcrowd – let the plants grow into the space for their mature size so that they can maximise their surface flowering area. By using larger trees combined with shrubs and ground cover species you are producing a three-dimensional matrix of plants to fully utilise the available space for bee forage.

As a rule, large trees are planted 20–30 metres apart, medium trees 15–25m, small trees 7–12m, and shrubs 3–5m (Table 3-3). For hedges and shelterbelts, plants are spaced around 1.5m apart for a single row, or two offset rows with the plants in each row 3m apart. Unless planting a hedge/shelterbelt, try to avoid planting trees in straight rows. Stagger them a little to help make it look more natural.

Table 3-3. Spacing distances for different plant heights at maturity.

Plant Type	Spacing	Explanation
Grasses/Ground Cover	**1.0 m**	Allows for a grass/ground cover sward to protect mineral soil
Hedges/Shelterbelts	**1.5-3.0 m**	Single row 1.5m apart. Double row 3m apart both within and between rows. Second row plants offset mid-way between the first-row plants.
Shrubs (2-4m high)	**3.0-5.0 m**	Allows for shrubs to grow bushy and maximise surface flowering area while leaving gaps for grass/ground cover.
Small trees (5-10m high)	**7.0-12.0 m**	Allows for trees to grow to their full size while leaving gaps for under-planted shrubs and grass/ground cover.
Medium trees (10-20m high)	**15.0-25.0 m**	
Large trees (20+m high)	**20.0-30.0 m**	

Where possible, mass planting of the same bee forage species should be used to maximise the size of the flowering patch, making it more attractive to the bees. Large clusters of the same species improve the bee's foraging efficiency and maximise the chance that the flower patch will be discovered by the bees. Larger size trees can be interplanted at wider spacing amongst shrub species.

3.5 Planning your planting operations

Specific details of the various components of planting operations are covered in Section 5. The following checklist summarises key factors to consider in your planning.

Table 3-4. Planting Operations Checklist

Operation	Description
Preparing a planting budget	Preparing a planting plan and budget allows you to make sure you have got all aspects of the planting programme covered, provides a checklist for completion, and a budget against which costs can be measured. Some of these costs can be managed by the farmer, for example undertaking the land preparation and planting work themselves and buying small-grade plants and growing on themselves.
Sourcing plants	Plants should ideally be ordered the spring/summer before they are required, but some harder to obtain plants may need to be ordered further ahead. Most local nurseries will stock many of the plants required. For larger volumes and specialist requirements you may have to go further afield.
Site preparation	Site preparation includes fencing, weed and pest control, and soil cultivation:
Fencing	Determine whether fencing needs to be established prior to planting. For example, to ensure livestock and pests such as goats and deer are kept out.
Weed control	Weed control is essential to give the bee forage plants the best chance of successful establishment and good growth. Depending on the type and extent of weeds this can be undertaken up to 18-24 months before planting.
Pest control	Pre-planting pest control is essential to prevent damage to newly planted bee forage and may be required on an ongoing basis.
Soil cultivation	Soil cultivation is required to ensure the plants roots can develop properly. It is usually undertaken at the time of planting, but it can also be undertaken ahead of time if required.
Planting	Organise your planting workers as soon as possible. These may be local contractors, casual labour, or farm workers. Make sure they have a clear understanding of what is required, and you have a good supervisor to provide instruction and monitor planting quality.
Tree guards	Tree guards may be required to protect from weeds and browsing livestock and pests. These are usually installed at the time of planting and there are a wide range of tree guards available.
Irrigation	Irrigation for the first 1-2 years may be necessary in drier areas, whether this involves extending spray irrigators, establishing trickle irrigation, or having workers water the plants in dry conditions.
Maintenance	Ongoing maintenance for 3-5 years post planting, especially protection from weeds and pests, and ensuring fences are maintained, are essential tasks.

Section 4

HOW TO PREPARE A BEE FORAGE PLAN

Honey bee collecting pollen in Florentine crabapple *(Malus florentina)*

4 HOW TO PREPARE A BEE FORAGE PLAN

A good bee forage plan can easily meet multiple farm goals. Trees for Bees NZ has developed several planning tools to help maximise bee health by optimising flower abundance and targeting flowering times. Targeting goals include supplying bees to pollinate clover pastures or crops for fruit or seed production. Other goals are to provide bee forage for apiaries on or near the farm to support beekeepers engaged in important pollination services for the wider arable or horticultural region. A bee forage plan can be kept very simple without using these tools but to maximise benefits, the tools are particularly useful.

4.1 Guidelines for preparing a bee forage plan

The most effective bee forage plantations are **balanced** – with no gaps in bee forage supply and plenty of floral resources at critical times of the year. Local beekeepers with long-term experience know when deficits in bee forage occur most frequently in their region. Times of pollen dearth are often in spring and autumn, but some regions have periods in late summer when pollen and nectar shortages are hard for bees to get through. Once gaps are filled and sufficient bee forage is available at critical times, then the plantation is well balanced for bee colony requirements.

Some bee forage plantations on farms are **targeted** – with a focus on certain activities that a farmer wants bees to perform on the farm such as pollination services or honey production. If you know when the target plants will flower, you can ensure that no competing plants flower at the same time to distract the bees away from the target. Too much competition could draw bees away from the target, resulting in poor or no pollination; or dilution and downgrading of a honey type.

However, bees scout for flowers from a distance, and 'key in' to large patches of flowers that deliver abundant pollen and nectar. Therefore, in certain situations, a showy competing plant species could benefit the target plant by drawing distant bees to the site. If more bees come to the site, it is likely that some would move over onto the target plant which they will discover once they are at close range. To achieve this scenario, you would need to experiment with the abundance of flowers of the attractant and target to ensure the target plant is not avoided by the bees altogether.

Bees frequently scout for plants at high altitudes, so they will easily discover plant species that are clustered into large patches. Such a critical mass of flowers will also ensure cost-effective foraging because bees often need to learn how to handle a new flower efficiently and so a few isolated plants may not be worth it to them. If you are planting a small plantation, you will therefore have a trade-off between planting a sufficient diversity of flowers to cover the seasons versus planting a large enough patch to attract the bees (e.g., at least one square metre but bigger patches are better).

When selecting bee plants, it is also important to avoid any plants that could be toxic to your animals near the site and any plants that could become invasive on your farm or on any nearby conservation land. Many different factors need to be considered when selecting candidate plants but there is a large range to choose from and the templates in Section 2 are helpful. See bee plant lists at www.treesforbeesnz.org/how-to-plant-guides.

4.2 Tools for planning

Balancing and targeting a bee forage plantation is greatly assisted by using tools such as tables and charts to visualise bee forage flowering times, diversity, and abundance. These tools can be used in a sequence of steps starting with a **candidate plant list** that includes flowering times, which is then translated into a **flowering calendar** to visualise the monthly progression of flowering times. This calendar is used to generate two charts: one for visualising **bee forage species diversity** and the other for visualising the **bee forage profile** (which shows the how many plants of each bee forage species is planned for the site). In some cases, with multiple plantations, it is useful to combine two or more bee forage profiles into one overall **bee forage budget.** This covers a wider area such as the whole farm or an estimated bee foraging range of one or more apiaries. Bee foraging ranges depend on the surrounding floral resources but can be anywhere from 3 to 10 km radius.

These tools are most often used to create new plantations, but they can also be used for visualising the contribution of pre-existing plants at the site. However, you will need to obtain information on the identity of the pre-existing plant species, their abundance, and flowering times for which the information is not always readily available. Therefore, the tools are usually used only for the new plantation and any pre-existing background bee forage is an optional addition.

Tools for planning a bee forage plantation.

1. **Candidate Planting List –** The list of candidate bee plant species selected for planting with the months in which they start and end flowering (plus any other data as needed).
2. **Flowering Calendar –** A tool to visualise the progression of monthly flowering over the calendar year for the selected candidate species for the plantation.
3. **Species Diversity Chart –** A bar chart derived from the flowering calendar showing the number of species in flower for each month as an indicator of the bee plant diversity in your plan.
4. **Bee Forage Profile –** A bar chart showing the number of plants to be planted for each species to indicate the relative abundance of bee forage supply for each month over the year.
5. **Bee Forage Budget –** A bar chart created by combining two or more bee forage profiles to see how to adjust the resulting cumulative profile over a wider area and multiple plantations.

Honey bee collecting pollen and nectar in clover *(Trifolium sp.)*

4.3 The bee colony life cycle

To balance a bee forage plan for a new plantation, we must consider the changing demands for pollen and nectar supply throughout the annual life cycle of a bee colony. A bee colony is the population of bees that dwell in one beehive. The bee population size and the structure of life stages in the colony changes through the seasons of the year. A bee colony goes through a sequence of stages: from wintertime rest with few bees, to springtime build-up with intense brood raising, then summertime pollination or honey production with peak population size, and finally, in autumn, a marked decline in population size and preparation for the next winter rest (Figure 4-1). Bee colonies living in areas with warm winters have shorter rest periods depending on the climate.

Management of access to floral resources to support the bee colony annual life cycle is critical for all beekeepers. However, beekeepers generally do not own land and therefore they rely on farmers and other landowners for access to floral resources.

In New Zealand, the greatest diversity and abundance of flowering occurs in late spring through summer. Fewer plant species flower in autumn and very few in winter depending on the how cold the climate is. This means that early spring and autumn are the most common periods of bee forage shortages in New Zealand. The beekeeper seasons listed here are based on Matheson & Reid (2018).

During **winter,** the typical bee colony is at rest in the hive and the size of the bee population in a hive is at its smallest – from 5,000 to 10,000 bees (Figure 4-1). These winter bees cluster together to survive the cold and may take flight on warm days but risk any sudden weather changes.

From **late winter** through **early spring** the size of the bee population grows exponentially and the demand for floral resources increases rapidly. Plentiful spring pollen and nectar are vital for bee colonies to build up to the size required for pollination services and honey harvesting – about 50,000 to 70,000 bees/hive. Large, strong colonies with the maximum number of bees provide better pollination services and collect more nectar for honey production.

From **late spring** through **summer** the bees are active in pollination services and honey production. This is the time of the highest diversity and greatest abundance of floral resources. If colonies have not reached full strength by the time they are needed for pollination, then crop yields may be compromised. If the colonies are not at full strength as soon as the target nectar flow starts, then the bees will use the target nectar for colony growth and the beekeeper harvests less honey.

From **late summer** through **autumn,** bee colonies have a crucial need for both pollen and nectar because they must produce a new generation of young bees that are long-lived and robust enough to survive winter. From mid-summer through to the end of autumn, colonies need plenty of high-protein pollen to raise a new generation of healthy winter bees and enough nectar to restore any winter honey stores that may have been removed by the beekeeper.

A late summer drought, as can often occur in parts of New Zealand, can cause nectar to stop flowing and flowering abundance to decrease, so planting drought-tolerant tolerant bee forage will help to keep colonies strong. The increasing and more widespread drought periods and unsettled weather means we need to be planting more resilient bee forage plants.

If sufficient protein-rich pollen has been supplied to the new brood during autumn then this new cohort will be vigorous enough to survive the long winter months. A large healthy colony going into winter and surviving into spring results in a larger population of healthy adults to give the colony a better start to expand rapidly once early spring plants start flowering.

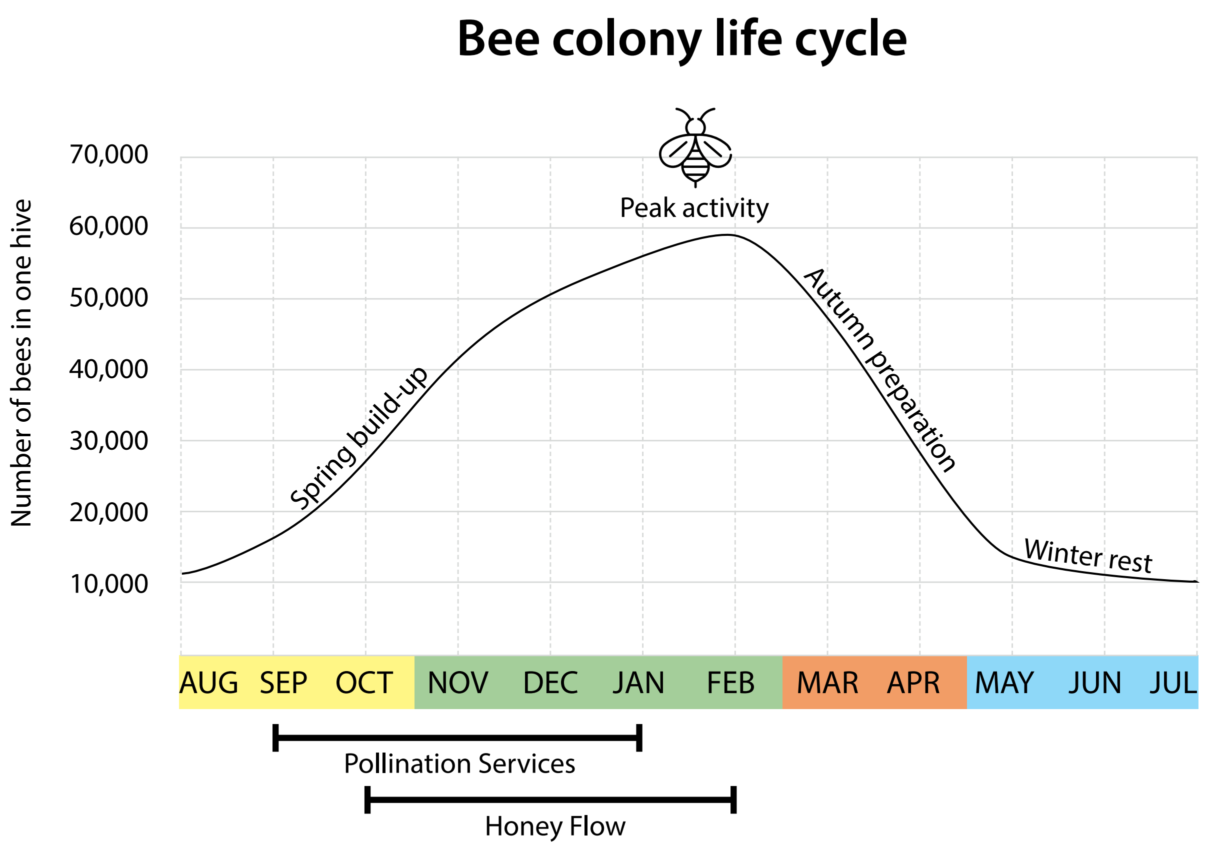


Figure 4-1. Bee Colony Life Cycle with seasonal changes from August to July. Spring = yellow; Summer = green; Autumn = orange; Winter = blue (Matheson & Reid, 2018)

4.4 Step one – Candidate planting list

Table 4-1. Step one: An example of a candidate planting list with flowering times.

Candidate bee plant list

Botanical name	Common name	Life Form	Flowering Time	
			Start	End
Chamaecytisus palmensis	tree lucerne; tagasaste	*Shrub*	May	Oct
Michelia yunnanensis	Yunnan bush michelia	*Shrub*	May	Sep
Pseudopanax arboreus	five finger; whauwhaupaku	*Tree*	Jul	Sep
Amelanchier canadensis	shad bush	*Shrub*	Aug	Nov
Fraxinus ornus	manna ash	*Tree*	Sep	Nov
Choisya ternata	Mexican orange blossom	*Shrub*	Sep	Nov
Ceanothus spp.	California lilac	*Shrub*	Sep	Dec
Pittosporum eugenioides	lemonwood; tarata	*Tree*	Oct	Dec
Hoheria sexstylosa	houhere; lacebark	*Tree*	Feb	Jun
Hebe stricta	koromiko	*Shrub*	Mar	May

To plan a bee forage plantation, the first step is to make a list of **candidate bee plant species** that you want to select for the site (Table 4-1). The selection of each bee forage plant species or cultivar is based on the type of plantation (shade, shelter, riparian protection, etc.); the space available (plant size); the growing conditions of the site (frost, snow, drought, wind etc.); and the desired flowering periods needed for the bees. Advice on growing conditions is available from your local nurseries, beekeepers, farm planting advisers and regional councils.

This table for the candidate planting list specifies each species in a row with columns showing the botanical and common names of the plant species; the estimated start and end times of flowering; and any other relevant data needed such as life form, height of mature plant, deciduous/evergreen etc. It is best to use botanical names so that there is no confusion, especially when common names refer to more than one botanical species.

The start and finish times for flowering are estimates that can be derived from different sources including local knowledge and experience, nurseries, websites, and horticultural or agricultural literature. These sources differ in their reliability, and they may report flowering times at the local, regional, or national level. For example, our list of ~ 400 Trees for Bees NZ bee plant species (www.treesforbeesnz.org/how-to-plant-guides) contains flowering times at the national level based on information from the Flora of New Zealand and websites. When your source reports flowering times at the national level (covering all New Zealand), you can estimate how much later your local flowering time would start compared to the earliest national flowering time depending on how far south you are.

The flowering calendar is based on monthly flowering, so an estimate of a few weeks earlier or later is not significant because annual shifts in flowering times can range from two to four weeks or more, but the general sequence of flowering among plant species usually remains the same. Many New Zealand plants are highly variable from year to year, and some plants skip one or more years of flowering. The type of micro-climate you have (such as coastal versus inland or high altitudes) also makes a difference in flowering times. More local sources and more experienced informants will give more reliable and precise information. Furthermore, you can develop your own flowering calendars based on your observations in your area over time.

4.5 Step two – Flowering calendar

Table 4-2. Step two: Flowering calendar derived from the planting list in Table 4-1.

	FLOWERING CALENDAR (Flowering times at the national level in NZ)											
Beekeeper seasons in NZ	Spring			Summer				Autumn		Winter		
Month of the year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Botanical name												
Chamaecytisus palmensis	✓	✓	✓							✓	✓	✓
Michelia yunnanensis	✓	✓								✓	✓	✓
Pseudopanax arboreus	✓	✓										✓
Amelanchier canadensis	✓	✓	✓	✓								
Fraxinus ornus		✓	✓	✓								
Choisya ternata		✓	✓	✓								
Ceanothus spp.		✓	✓	✓	✓							
Pittosporum eugenioides			✓	✓	✓							
Hoheria sexstylosa							✓	✓	✓	✓	✓	
Hebe stricta								✓	✓	✓		
Total number of species/month	4	7	6	5	2		1	2	2	4	3	3

The **flowering calendar** (Table 4-2) is created to visualise what the annual supply of floral resources looks like in the form of a monthly progression of flowering over the whole year for each plant species. The table is based on the candidate planting list in Table 4-1 so that each row has the species name, and the columns are a progression of twelve months of the year from August to July.

For each bee plant species in a row, mark each box to indicate in what months of the year the species is estimated to be in flower. Use a circle or tick to indicate which months the bee plant is most likely to be in flower and leave a blank to indicate not in flower. If you are using a spreadsheet to make the calculations for the chart tools in the next steps, then use the number "1" to indicate flowering and a blank cell or a zero to indicate not in flower.

Start the flowering calendar with August as the first column to best visualise the progressive rise and decline in the size of the bee population in a typical colony in New Zealand (see Figure 4-1). August is when bee colonies first start their initial brood rearing for spring build-up and clearly shows the beginning of spring build-up, a time of extremely high demand for pollen.

If you are using a spreadsheet, then the flowering progression can be more quickly visualised by arranging the rows in order of when they start flowering (see Table 4-2). To arrange the rows in a progression of start times, put all plant species that are in flower in August at the top of the rows, followed next by all plant species that start to flower in September, then all those that start to flower in October and repeat for each month until July. Note that any plants flowering in August that started in July or June will have already been put at the top of the rows. Rows in this order of the month of sequential flowering are easier to understand visually.

Next, total the number of species that are flowering in each month by counting the marks or, if using a spreadsheet, totalling the numbers "1" in each column. Record these totals in a new row at the bottom of the table or spreadsheet ready to be used to create the Species Diversity chart in the next Step. Checking the diversity must always precede creating the bee forage profile in Step Four.

In the example above, we used a list of plants to provide spring build-up and autumn preparation while keeping early/mid-summer largely free of bee forage. The flowering times selected are at the national level based on the Trees for Bees species lists at www.treesforbeesnz.org/how-to-plant-guides. By selecting plants that flower in the months you require for the bees, you are undertaking an initial screening so that when you look at the species diversity chart in Step Three you will see that there are no gaps and that the critical demand periods are covered.

4.6 Step three – Species diversity

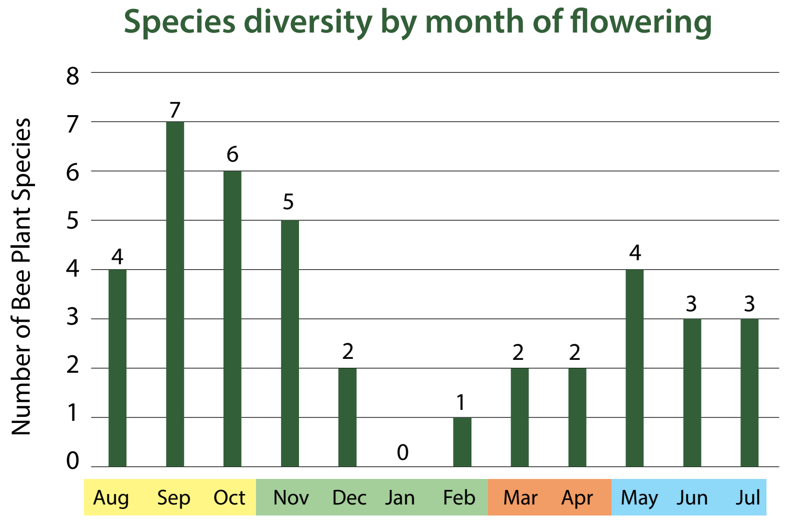


Figure 4-2. Step three: Species Diversity Chart based on flowering calendar in Table 4-2.

Constructing a bee forage **species diversity chart** is important because some bee forage species may fail to flower in any given year for various reasons. We can reduce the risk of having nothing flowering for bees in critical months by planting 'back up' species that will be in flower should one or more other species fail to flower. The goal for the plantation is to have as many species as possible flowering each month, except in winter when the bees are resting and in summer when there is already a plentiful diversity of flowering species in the landscape. There are many reasons why a certain plant may fail to flower including: poor weather conditions, diseases, pests, herbicide spray drift or the plant's natural rhythm of skipping flowering every other year or over many years.

A vertical bar chart is the best tool to visualise bee forage diversity (Figure 4-2). This chart shows the total number of different species that are estimated to be in flower for each month of the year. These totals were calculated in the bottom row in the flowering calendar in the previous Table 4-2. They have been copied over from the flowering calendar and inserted into a spreadsheet program to construct the bee forage species diversity chart.

In addition to ensuring, as far as possible, that we have sufficient diversity of flowering bee forage species in critical months, we can identify any potential deficits or gaps in flowering at critical times. In the example in Figure 4-2, we chose to plant the highest diversity in spring to support rapid bee colony growth to be ready for pollination (e.g., for clover pasture). The diversity of species declines from September to December to a very low number over summer while the bees are pollinating and gathering honey. In summer, a plentiful supply of floral resources is available, and we do not want competition for our targeted clover pollination, for example. In late summer and autumn, plant species are low initially but build up towards May before reducing in June and July for winter rest. Ideally, we would like to see more flowering plants from February and increasing to May, and to reduce further in June/July. This can be addressed by using the bee forage profile in Step Four.

Checking on bee plant diversity is an initial screening step to understand and consolidate the candidate bee plant species list so that it is robust with 'back-up' species in case of the occasional failure of some plants or species to flower.

4.7 Step four – Bee forage profile

The **Bee Forage Profile** chart is like the bee forage species diversity chart but instead of counting the number of *species* flowering per month, we are adding up the total number of *plants* that will be in flower per month. The total number of plants in flower for each month is a very rough estimate of the relative quantity of bee forage (pollen and nectar) supplied over the year in your new plantation. You can adjust and re-shape the bee forage profile to meet your goals by increasing or decreasing the number of plants for a given species. Primary bee goals could be promoting spring build-up or raising a robust generation of winter bees. Since diversity was assessed in Step Three, the focus in Step Four is on controlling how many plants of each species are needed to address the goals.

Constructing a bee forage profile has two stages. The first stage, shown in Table 4-3, is to make a new data table by using the flowering calendar template which has your current list of candidate species (copy/paste Table 4-2 to new spreadsheet). For each species, fill in the number of plants you plan to establish and repeat this for each cell in which the species is in flower (for each cell replace "1" with the number of plants you plan to plant for that species). Next, in a new row, sum each column to give the total number of plants in flower across all species for each month.

Table 4-3. Step four (a) plant numbers data for original bee forage plantation.

Botanical name	Bee forage profile – data on number of plants												Total plants needed
	Spring			Summer				Autumn		Winter			
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	
Chamaecytisus palmensis	5	5	5	-	-	-	-	-	-	5	5	5	5
Michelia yunnanensis	5	5	-	-	-	-	-	-	-	5	5	5	5
Pseudopanax arboreus	5	5	-	-	-	-	-	-	-	-	-	5	5
Amelanchier canadensis	15	15	15	15	-	-	-	-	-	-	-	-	15
Fraxinus ornus	-	10	10	10	-	-	-	-	-	-	-	-	10
Choisya ternata	-	10	10	10	-	-	-	-	-	-	-	-	10
Ceanothus impressus	-	10	10	10	10	-	-	-	-	-	-	-	10
Pittosporum eugenioides	-	-	10	10	10	-	-	-	-	-	-	-	10
Hoheria sexstylosa	-	-	-	-	-	-	20	20	20	20	20	-	20
Hebe stricta	-	-	-	-	-	-	-	10	10	10	-	-	10
Total number of plants	**30**	**60**	**60**	**55**	**20**	**-**	**20**	**30**	**30**	**40**	**30**	**15**	**100**

Working with a bee forage profile is an iterative process which involves filtering and adjusting the candidate list of plants based on when they flower and how the different plant species fit into your overall planting design. Your initial selection of candidate plants in Steps One to Three has given you a general framework for what species to plant, dictated by the purpose and design of your plantation and how much space is available. However, you may need several iterations to arrive at a profile that meets your needs for the bees and your farm operations.

In the second stage of building a bee forage profile, shown in Figure 4-3, make a new vertical bar chart based on the total number of plants in flower for each month as recorded in the column totals in Table 4-3. This new chart portrays the total number of plants (not species) that will be flowering each month. It allows you to visualise any gaps or excesses in your proposed planting plan and compare it to the bee forage profile you want to achieve for the bees in your situation.

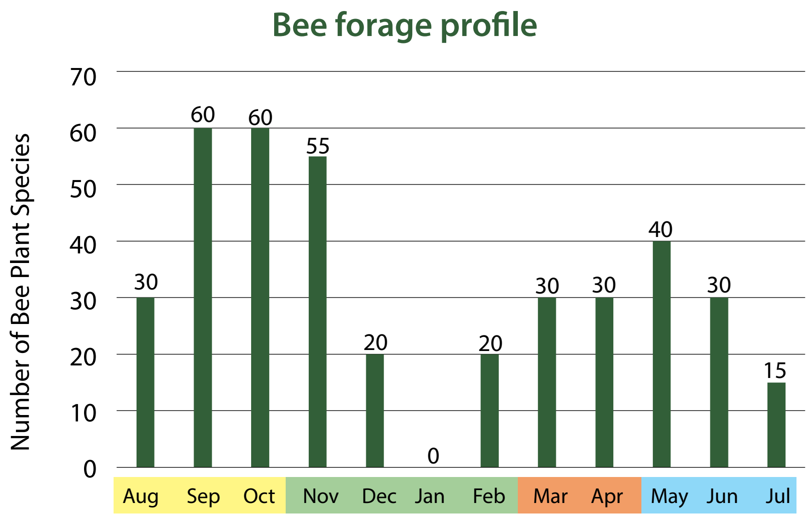


Figure 4-3. Step four (b) bee forage profile chart based on original data in Table 4 - 3.

In this example in Figure 4–3, the particular emphasis is on increased plant numbers for spring build-up and to a lesser extent for autumn preparation for winter. Not as many plants are required in late summer/autumn, as the number of bees in the colony are also declining before winter (Figure 4-1). The intention for this bee forage profile is to keep November through to January as free from flowering competition as possible to enable the bees to focus on pollination (for clover in this example). This bee forage profile in Figure 4-3 has a strong build-up of bee forage from August to October, with high plant numbers in November, and with autumn preparation starting in February through to June. Because we wish to minimise or exclude flowering plants from November to January (e.g., when the target plant, clover, is flowering) then this bee forage profile needs to be modified.

Table 4-4 shows the types of modifications we chose to make in this example. We removed two plant species that flower into December *(Ceanothus impressus* and *Pittosporum eugenioides)* and reduced the number of plants flowering in November *(Amelanchier canadensis* from 15 down to 10 plants). To keep a strong spring build-up and autumn preparation, as well as balance the number of plants back up to the total required for the plantation (100), we then increased the number of plants that flower at critical times *(Pseudopanax arboreus* July to September, *Choisya ternata* September to November, and *Hoheria sexstylosa* February to June). Note that while the *Choisya ternata* flowers into November it will be coming to an end that month, and it also flowers occasionally in May, which will assist autumn flowering to raise winter bees. Table 4-5 shows the modified bee forage profile.

Table 4–4. Summary of adjustments to the original bee forage profile in Figure 4-3.

Botanical name	Common name	Total plants originally	Adjustment to numbers	Total plants adjusted	The differences
Chamaecytisus palmensis	tree lucerne	5		5	0
Michelia yunnanensis	Yunnan bush michelia	5		5	0
Pseudopanax arboreus	five finger; whauwhaupaku	5	increase	15	10
Amelanchier canadensis	shad bush	15	reduce	10	-5
Fraxinus ornus	manna ash	10		10	0
Choisya ternata	Mexican orange blossom	10	increase	20	10
Ceanothus impressus	California lilac	10	remove	0	-10
Pittosporum eugenioides	lemonwood; tarata	10	remove	0	-10
Hoheria sexstylosa	houhere; lacebark	20	increase	25	5
Hebe stricta	koromiko	10		10	0
Total number of plants		**100**		**100**	**0**

Table 4-5. Step four (c) plant numbers data for modified bee forage profile.

Botanical name	Modified bee forage profile – data on plant numbers												Total plants needed
	Spring			Summer				Autumn		Winter			
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	
Chamaecytisus palmensis	5	5	5	-	-	-	-	-	-	5	5	5	5
Michelia yunnanensis	5	5	-	-	-	-	-	-	-	5	5	5	5
Pseudopanax arboreus	15	15	-	-	-	-	-	-	-	-	-	15	15
Amelanchier canadensis	10	10	10	10	-	-	-	-	-	-	-	-	10
Fraxinus ornus	-	10	10	10	-	-	-	-	-	-	-	-	10
Choisya ternata	-	20	20	20	-	-	-	-	-	-	-	-	20
Ceanothus impressus	-					-	-	-	-	-	-	-	
Pittosporum eugenioides	-					-	-	-	-	-	-	-	
Hoheria sexstylosa	-	-	-	-	-	-	25	25	25	25	25	-	25
Hebe stricta	-	-	-	-	-	-	-	10	10	10	-	-	10
Total number of plants	**35**	**65**	**45**	**40**	**-**	**-**	**25**	**35**	**35**	**45**	**35**	**25**	**100**

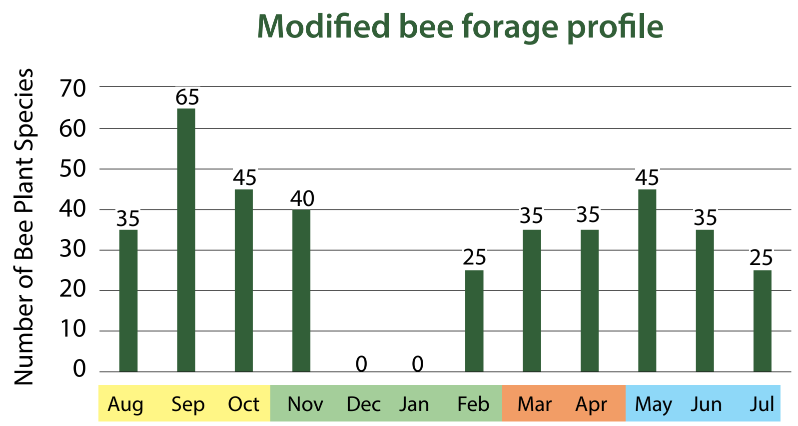


Figure 4-4. Step four (d) bee forage profile based on modified data in Table 4-5.

Based on the new column totals for the modified bee forage data in Table 4-5, we can now construct a new bee forage profile (Figure 4-4). With the above modifications to plant species and numbers, we have achieved the following: (1) fortified spring growth from August to October; (2) reduced competition significantly in November and removed competition in December and January (so that the bees are not distracted from the target plant, e.g., clover); and (3) significantly strengthened autumn flowering, starting in February and increasing through late summer and autumn to May (to support raising new winter bees). Flower abundance declines as the colony goes into winter rest in June and July. Although the competition for the target plant has been reduced and removed, other pre-existing plants not included in the profile could be flowering in competition. However, in this example, clover is highly attractive to bees so it should not be an issue. If other nearby plants are too attractive or abundant, they could interfere, but this depends on their density and abundance. Distant plants may not necessarily be a problem.

4.8 Step five - Bee forage budget

The **bee forage budget** is an optional step that combines two or more individual bee forage profiles into a single bee forage budget, for example, several different sites that are designed to service one or more apiary sites. This step involves summing over two or more bee forage profiles to obtain the cumulative total of the plants available over a wider area. It may be summing over several sites (e.g., riparian and shelterbelt planting in a 3 to 5 km bee foraging area); or it may be combining two bee forage profiles – one for the pre-existing floral resources (if you have this data) and the other for the new proposed planting. To combine two or more bee forage profiles, follow the same steps used in creating a simple bee forage profile as in Steps one to four above.

We created a bee forage budget for the following case study in a Trees for Bees NZ demonstration plantation established on a Hawke's Bay sheep and beef farm (McPherson & Newstrom-Lloyd, 2018). The expected flowering time for their new mānuka plantation honey harvest was late January/February. Based on the planned mānuka plantation area of 100 ha, we established 10% or 10 ha of bee forage to support bees year-round because the apiaries are intended to be residential (i.e., permanently placed). The site comprised the mānuka plantation, bee forage to support the mānuka established throughout the plantation in riparian zones and other areas on the farm that were not suitable for mānuka plantations, and included a pre-existing riparian planting adjacent to the plantation.

Because pre-existing native species had been planted in a riparian plantation adjacent to the property and well within the foraging range of the proposed apiary sites, a bee forage profile for this area was required so that we could balance the overall annual bee forage budget, comprising the pre-existing and proposed planting. The data on species names and plant numbers was available so no extra work to identify and count plants was needed.

Figure 4-5 shows the Bee Forage Profile for the pre-existing riparian planting. It shows a high number of plants flowering during the spring build-up and into January, comprised primarily of *Pittosporum* species, flaxes, Karamu and cabbage tree. There is an almost total lack of late summer/autumn flowering species, comprising of mostly Koromiko, Lancewood and Houhere. To produce a more balanced bee forage budget, the additional planting needed to focus primarily on late summer/autumn, and to a lesser extent spring build-up. The large number of plants flowering during the mānuka season may be in competition with the mānuka flowers, so summer flowering plants needed to be limited.

Figure 4-6 shows the bee forage profile of the proposed new Trees for Bees NZ plantation. We focused primarily on late summer and autumn-flowering species, including Koromiko, Houhere, Mapou *(Myrsine australis),* Kanono *(Coprosma grandifolia)* and *Olearia* species. Autumn-flowering eucalypts were also planted, along with tree lucerne and five finger for over winter and into early spring. Spring species included smaller quantities of *Coprosma* species, Korokio, *Pittosporum* species, and flaxes for wet areas. These selections were designed to adjust the shape of the overall bee forage budget for the wider area by using a large number of plants for the species flowering at the critical times of late summer and autumn and early spring.

Figure 4-7 shows the resulting bee forage budget based on the combination of the pre-existing bee forage profile and our new Trees for Bees NZ plantation. With the addition of the Trees for Bees NZ planting of spring, late summer and autumn-flowering species, the overall bee forage budget is more balanced, especially with the increased autumn-flowering species. However, high plant numbers flowering in January remain due to the pre-existing riparian planting of cabbage trees, flaxes, ribbonwood, and lancewood. The flaxes, cabbage trees and ribbonwood all finish flowering in January, and the lancewood starts in January, and so they may not be fully flowering when the mānuka is expected to start flowering in late January and competition may not be an issue.

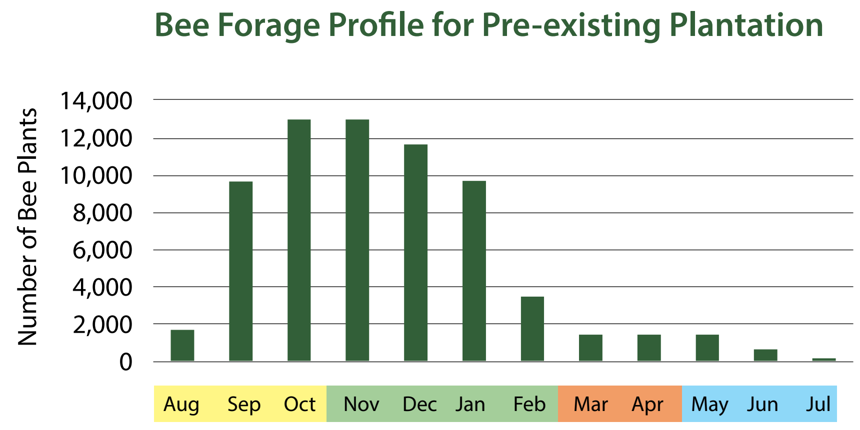


Figure 4-5. Case Study: Bee forage profile for pre-existing riparian planting at Taurapa.

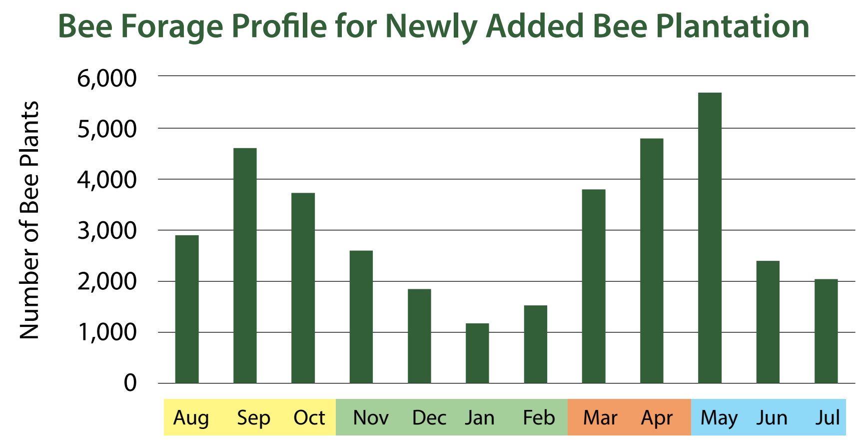


Figure 4-6. Case Study: Bee forage profile for the newly added bee plantation at Taurapa.

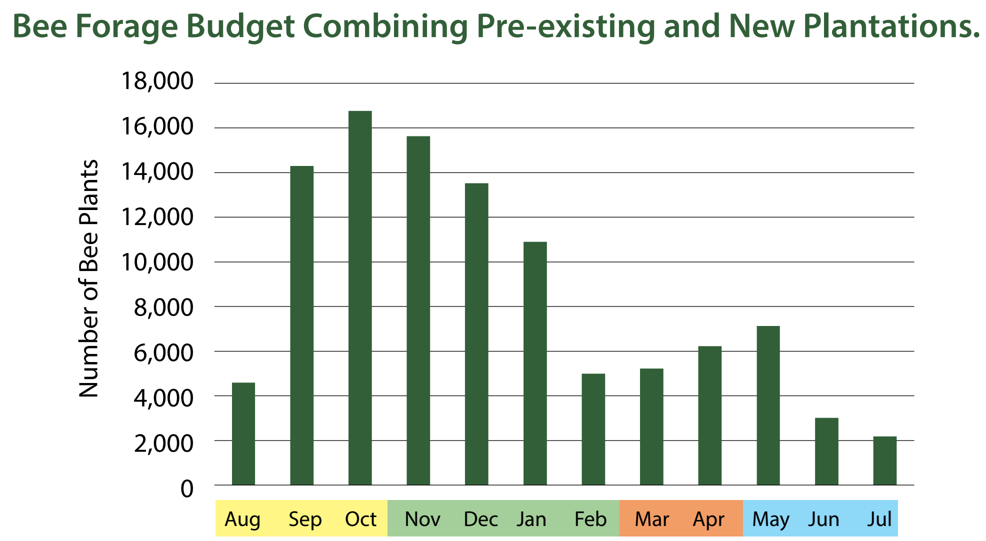


Figure 4-7. Case Study: Bee forage budget for combined pre-existing and new bee forage.

Honey bee collecting nectar in mānuka flower *(Leptospermum scoparium).*

Section 5

HOW TO ESTABLISH A PLANTATION

Honey bee collecting nectar in honey locust *(Gleditsia triacanthos).*

5.1 Selecting and sourcing plants

Weediness of candidate plants	Do not plant potentially invasive plants because of the risk of on-farm weed control issues in pasture or crops. Some weedy species can become widespread environmental weeds in native ecosystem environments (e.g., wilding pines, sycamore, prunus). A number of exotic plants are recognised as weed species, and either need to be avoided, or to have a proper weed management plan. Weed plant lists for your region will be found on the DOC website or your District/Regional Council. Trees for Bees endeavours to avoid species that are known weed plants.
Toxicity of candidate plants	Plants can be toxic to stock, other animals or bees, and these plants need to be avoided where possible, and managed carefully otherwise. For example, karaka *(Corynocarpus laevigatus)* is a great plant for our native birds, and the flesh of the fruit is edible, but the flowers are highly toxic to bees and the kernel is highly toxic to humans and pets (e.g., dogs). Tutu *(Coriaria arborea)* is highly toxic to cattle, and while honey bees will benefit from its nectar in the spring, tutu contamination of honey from honey dew in summer is a very real issue and can be poisonous. Honey is tested for tutin levels by the Ministry for Primary Industries. Internet searches will help identify which plants and what part of the plant is toxic to particular organisms.
Sourcing	Most local nurseries will stock many of the plants required. For larger volumes and specialist requirements there are regional and national specialist nurseries. Some nurseries will grow on demand for large orders. While plants should ideally be ordered the spring/summer before they are required, you might need to order some harder-to-get plants a year or more in advance.
Grade	A wide range of seedling grades (sizes) are available. Most plants are supplied in pots, although some nurseries specialise in bare-rooted seedlings. Bare-rooted seedlings need to be planted as soon as they are delivered, whereas you have more flexibility with pot-grown plants. Small-grade seedlings (e.g., 5/7cm tubes, 50 cell tubes) are cheaper to buy, which may be important where you have large numbers of plants to establish. However, they can take longer until they start flowering and the smaller size of the seedling can mean they are more susceptible to adverse conditions. When planting these grades of seedlings, you need to make sure your weed control is very good and establish the plants early in the season, so they get some root development before summer. Large-grade seedlings (0.5-2.5L) are typically more robust and reliable to establish and will often flower sooner but cost more than the smaller grades. Specimen trees can be purchased in 5-10L bags through to 45L+. Advantages of buying large-grade trees include the immediate visual impact, and that the trees are often quick to first flowering.

1.5m standard 25L grade *Chaenomales speciosa* “Yokuku” (winter flowering quince) with farmer Annabelle Subtil, Omarama Station.

Figure 5-1. Large-grade specimen tree.

From left to right, with a planting spade for scale:

Root trainer *Chamaecytisus palmensis* (tree lucerne);

1.5L pot *Discaria toumatu* (matagouri);

2.5L pot *Coprosma rugosa* (needle-leaved mountain coprosma)

Figure 5-2. Small-grade seedlings.

5.2 Site preparation

Fencing	Fencing may be required prior to planting to keep livestock and/or pests (e.g., deer, goats) out. Fencing needs to be appropriate for the animals being excluded, whether this is extending an existing fence line or constructing a tree guard. In some cases, a single electric wire is fine; in other cases a full 7-8 wire fence is needed. Extensions above the top of a fence and using electric wire may be required if there are deer nearby. Maintaining fencing after planting until such time as the plants can withstand some browsing is a crucial task, as livestock can cause a lot of damage to plants in a very short period of time.
Weed Control	The type of weed control required will be determined by the nature of the weeds. Scrub weeds like gorse, broom and blackberry require effective total control before planting, otherwise they will re-establish as significant weed species in your plantation. Pre-plant spraying with an effective herbicide is essential and may need to be repeated over 1-2 years before planting. For grass or pasture control, options include grazing the site before planting and/or a pre-plant weed spray. Spraying can be a blanket spray over the whole site, but spot-spraying at the desired planting spacing is preferred as you retain some ground cover, especially near waterways. Use glyphosate to control grasses and include terbuthylazine for a degree of residual weed control. If you are using a residual spray, make sure you observe the stand down period before planting, so you don’t harm the seedlings. You might need a further spray during late spring/early summer following planting for any vigorous regrowth, making sure the plants are protected from any spray. Complete control of rank grasses prior to planting bee forage species is not essential, as the rank grasses will not compete as aggressively for moisture and can provide a degree of screening and protection for the plants. Instead, spot-spray where plants are to be established prior to planting. This can be on grazed pasture allowing the surrounding grass to regrow, or in amongst rank grasses. A second pre-plant spray may be required if there is vigorous grass regrowth. Applying a mulch around the bee forage plant following planting will assist weed control, and there is also the option of sowing a ground cover bee forage species (e.g., borage, phacelia, and some clover species).
Pest Control	Pest control is crucial for plant survival. Key pests include deer, goats, possums, hares, and rabbits. The most effective pest control is pre-plant, through a combination of shooting, trapping, and poisoning as appropriate for the pest. Keeping long grass to camouflage the plants is also an option. Ongoing pest monitoring and control is essential, especially for palatable species such as five finger. Tree guards will also protect seedlings from browsing rabbits, hares, and possums. They will also help protect trees from livestock and from weeds.
Soil cultivation	Soil cultivation is usually undertaken at the time of planting, and can be undertaken with a planting spade, post hole borer or even a small excavator (Figure 5-3). However, if you have difficult soil conditions such as a soil pan or heavy soils that don’t drain readily, then some pre-planting preparation such as ripping may be required.

Figure 5-3. Digging planting holes with a small excavator, Omarama Station.

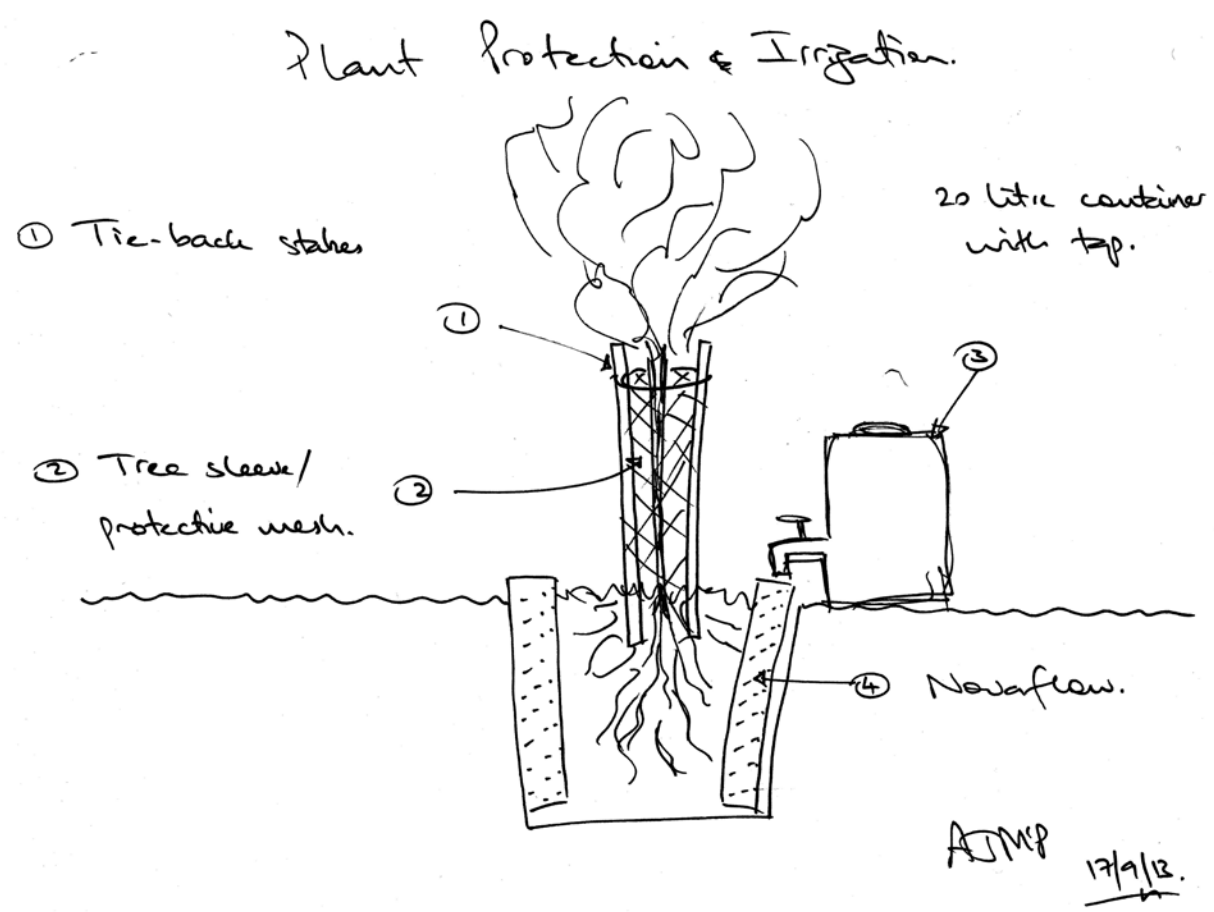
Figure 5-4. Planting trees in a fenced-off riparian zone, Omarama Station.

5.3 Establishing plants

Planting	Use your spade to remove the grass turf where you want to plant your shrub/tree. Open a hole slightly larger than the plant's roots, and make sure the soil around the edge and the bottom of the hole is loose; otherwise the plant's roots can be constrained on the sides – especially in clay soils. Place your plant in the hole and place the soil back around it. Make sure the plant is not placed too deeply – lift it up to ground level or even a slightly raised mound if required. Firm the soil around the plant with hands/feet to keep it stable, but do not stamp around the plants as you can damage the roots. Do not leave an air pocket around the roots, however. For large numbers of large-grade seedlings, you may wish to use a post hole borer or small digger for the planting holes (Figure 5-3).
Fertiliser	Fertiliser should be applied at the time of planting – either in the planting hole or in a slit to the side of the plant. Slow-release fertiliser tablets or pelletised fertiliser can be used to give one season of fertiliser and will help get the plants established. Use one to two tablets for each plant, depending on plant size, dropped into the planting hole. Bagged and root trainer plants include a slow-release fertiliser, which will give one season of support and will help get the plants established. Bare-rooted seedlings do not include fertiliser. Depending on the plants purchased and the number to be established, additional slow-release fertiliser tabs can be used.
Staking, protecting and irrigating (Table 5-1) (Figure 5-5) (Figure 5-6)	Use a stake if required to assist plant stability for the first couple of years. These should be at right angles to the prevailing wind and allow the plant to move slightly so that its roots can strengthen from that movement. For smaller trees a single stake adjacent to the tree may be sufficient. For medium-size trees, use two stakes on opposite sides around 30-50cm from the tree. For large trees and/or windy sites, 3 stakes might be required. Irrigation may be necessary in drier areas, whether this involves extending spray irrigators, establishing trickle irrigation, using old drench containers to water 1-2 times a week, or having workers water the plants in dry conditions.

How to plant a large specimen tree

1. If you're going to be delayed a few days before planting, put the trees in a shady area and lightly water every couple of days.
2. Dig the hole larger than the bags the trees came in – about 20cm around the side and underneath.
3. Put some good soil and compost if available in the bottom of the hole. If the sides in the hole are smooth, loosen this soil up with a spade to help roots grow through.
4. Water the hole – about half a bucket will be fine.
5. Take the bag off the tree – you might need to cut it off. Check that the roots aren't winding around tight in the bag – on the sides and/or bottom. If so, cut down the side of the root/soil ball with a spade/knife and also across the bottom – this frees the roots up to grow down into the soil; otherwise they might remain constrained by the size of the planter bag.
6. Place the tree in the hole – the top of the root area should be level with the ground. Place two pieces of drainage coil, one either side of the tree – these should be long enough to reach the bottom of the hole and be just above ground level. Put some more soil/compost mix around it, firm down with hands and/or feet, and finish filling the hole with the best of the soil dug out of the hole. You can use the turves as they sometimes contain the best top soil – just turn them upside down so the grass won't grow again. Water the tree again – another half bucket to bucket depending on how dry the soil is.
7. Finish off with some mulch – old bailage etc.
8. Put a wooden stake or waratah either side of the tree and tie back with webbing or similar to hold the tree firm in wind in the first year or two. For these larger trees the stakes will need to be 1.8m.
9. The tree guard needs to be big enough to keep whatever stock are in the paddock from eating the tree. For cattle a 2.5-3m side square guard should be sufficient. For sheep, a smaller guard can be used and it doesn't need to be wood.
10. You can use the sheets of reinforcing steel used for concrete floors rolled into a cylinder and then tied – fold the top edge wires out which will keep stock away, and secure to ground with waratahs. You can keep the bottom a few inches off the ground so that stock can graze this grass without damaging the tree. In areas where stock damage is likely to be minimal, but you want to protect from rabbits/hares, you can use chicken wire tied to a stake.



1	**Tie-back stakes**	1-2 stakes to hold the tree firm (refer Table 5-1). Tie backs hold the stem in place and depend on the windiness of the site. They can be rubber ties, old tire tubes, old stockings, bailing twine, or wire within some hose so the tree isn't damaged. Tighten so the tree is held firmly but can still move a little in the wind, which will help the tree roots develop. Be sure not to wrap right around the trunk and cut-off nutrient flow under the bark. You should be able to take the ties off after 1 to 2 years.
2	**Tree sleeve/ protective mesh**	Use commercially available tree sleeves to protect against hares and rabbits and any chemical weed sprays. Alternatively, use chicken wire/ mesh, held to the ground with wire pegs.
3	**20 litre container with tap**	Irrigation can also be provided for individual trees using a 10-20 litre container with a tap. The container is placed above the drainage coil with the tap set for it to empty over 2-3 hours, allowing water to penetrate deeply. Each plant should get a minimum of 10 litres each time.
4	**Drainage coil (e.g. Novaflow)**	50-100mm wide drainage coil. This can be on one side of the planting hole for smaller plants, or either side for larger plants. Cut to a length slightly deeper than the planting hole so that the top pokes out of the ground. Place into the hole before filling with soil. If using drainage coil either side of the hole, alternate between the two sides each watering.

Figure 5-5. Options for staking, protecting and irrigating trees.

Figure 5-6. Staking, protecting and irrigating. Bog Roy Station.

Table 5-1. Types of stakes to use for supporting different sizes of plants (by height).

Tree size	Stakes
<1m	Bamboo cane or electric fence poly rod Proprietary sleeve or corrugated tree guard – e.g., Combiguard sleeve, KBC corrugated plastic guard
1-2m	1.5-1.8m x 25 x 25mm timber stake or fencing waratah
2m+	1.8-2.1m x 50 x 50mm timber stake or fencing waratah


Figure 5-7. Combi-guard plastic sleeves and bamboo stakes for native seedlings.

Sleeve tree guards come in a range of sizes and use bamboo stakes. They can come with an optional weed mat. Use these for smaller plants and make sure the stakes are placed at each corner to pull the sleeve tight.

Larger sleeves (550 x 180mm with a single 900mm bamboo stake) can be used for taller plants.


Figure 5-8. Taller specimen tree staked with tree protection and irrigation.

Tree tied back to two waratahs with twine and rubber straps. Drainage coil pipe split and placed over stem to protect from stock damage. Irrigation provided using one buried drainage coil that can be filled with water as required.

Various proprietary options exist for protecting medium trees from browsing damage. This one with Paul Tietjen at TW Wines in Gisborne is a plastic mesh, fixed to the ground using electric fence poly rods.

Figure 5-9. Tree guard made from plastic mesh with poly rod stakes.

Heavy duty wire mesh, such as used in concrete foundations or as a fencing product, can be used to make a cage around trees to keep livestock away.

In this case wooden posts have been used to fix the cage to the ground, but waratahs can also be used.

Figure 5-10. Large wire cage with wooden posts surround willow tree seedling.

5.4 How to maintain a plantation

Long-term maintenance of your planting is essential to ensure survival and that you see the gains from all your hard work. At its simplest level this means:

Making sure the **fences** remain intact and livestock are kept away from the plants. Once the plants get to a size where they can withstand livestock, you can start by introducing lambs for short periods to help control grass growth (i.e. a few hours – not days).

Weed control – especially in the first couple of years. If you have good pre-plant weed control and mulch around your plants, then this may be sufficient to get them established. If weed growth is vigorous and is competing with the plants, then further spraying or cutting back of weeds and/or the application of further mulch might be necessary.

Irrigation if you have dry conditions.

Table 5-2. Monthly task list for establishing and maintaining plants

December – January
Irrigation if required
February
Pre-marking of valuable (moister) sites in drier areas for subsequent planting Irrigation and fertiliser if required Insect control by spraying if required but be careful of your bees Grass and weed control of existing planting (mulching, weeding and/or spraying)
March – April
Prune dead wood if any for existing plants Grass and weed control for existing planting (mulching, weeding and/or spraying) Graze areas to be planted over winter if required Pre-mark planting sites – make large tree surrounds and complete fencing work Spot spray planting area for weeds/grass with a selective weed killer
May – June
Plant native seedlings to get root growth before winter
July – August
Plant or transplant deciduous trees now while they are at their most dormant
September – October
Alternative time for planting native seedlings – as early as possible in spring Apply mulch if required before weeds start growing
November – December
Disease and insect control Watering (from December if required)
Year Round
Periodic checks for survival, health, and protection with remedial action as required

List of bee plant species with their common names used in this Handbook

Plant species	Common names
Acer campestre	field maple
Acer negundo	box elder
Acer rubrum	red maple
Aesculus x carnea	red horse chestnut
Alnus cordata	Italian alder
Alnus cremastogyne	mountain alder
Alnus formosana	Taiwan alder
Alnus glutinosa subsp. barbata	Turkish black alder
Alnus nitida	Himalayan alder
Alnus rubra	red alder
Amelanchier canadensis	shad bush
Arbutus unedo	strawberry tree
Aristotelia serrata	makomako; wineberry
Arthropodium cirratum	rengarenga; renga lily
Camellia japonica; C. sasanqua	Japanese/sasanqua camellia
Camellia sasanqua 'Setsugekka'	setsugekka camellia
Carpinus betulus	European hornbeam
Carpodetus serratus	putaputawētā
Carya illinoinensis	pecan
Ceanothus spp.	California lilac
Ceanothus 'Yankee Point'	California lilac yankee point
Chaenomales japonica	flowering quince
Chamaecytisus palmensis	tree lucerne; tagasaste
Choisya ternata	Mexican orange blossom
Citrus aurantifolia	lime
Citrus limon	lemon
Citrus paradisi	grapefruit
Citrus sinensis	orange
Coprosma grandifolia	kanono; manono
Coprosma lucida	karamu, shining karamu
Coprosma propinqua	mikimiki; mingimingi
Coprosma repens	taupata
Coprosma robusta	karamū; glossy karamū
Cordyline australis	cabbage tree; ti kōuka
Corokia cotoneaster	korokio; mountain korokia

Plant species	Common names
Corylus avellana	European hazelnut
Corylus colurna	Turkish tree hazel
Crataegus crus-galli	cockspur thorn
Cydonia oblonga	quince
Dacrycarpus dacrydioides	kahikatea; white pine
Discaria toumatou	matagouri; tūmatakuru
Dodonaea viscosa	akeake
Dysoxylum spectabile	kohekohe
Elaeagnus ebbingei	oleaster; silverberry
Elaeagnus pungens	thorny oleaster; silverthorn
Eriobotrya japonica	loquat
Eucalyptus leucoxylon 'Rosea'	Tasmanian yellow gum
Eucalyptus ovata	swamp gum; black gum
Eucalyptus rodwayi	swamp peppermint
Eucalyptus spp.	eucalypts
Fagus sylvatica pendulata	weeping European beech
Feijoa sellowiana 'Apollo'	feijoa Apollo
Fraxinus ornus	manna ash
Fuchsia excorticata	kōtukutuku; tree fuchsia
Geniostoma rupestre var. ligustrifolium	hangehange
Gleditsia triacanthos	honey locust
Gordonia axillaris	fried egg plant
Gordonia yunnanensis	fried egg plant
Griselinia littoralis	broadleaf; kāpuka; pāpāuma
Hebe stricta	koromiko
Hedycarya arborea	pigeonwood; porokaiwhiri
Hoheria populnea	houhere; lacebark
Hoheria sexstylosa	houhere; lacebark
Juglans regia	common walnut
Knightia excelsa	rewarewa
Kunzea ericoides	kānuka
Laurelia novae-zelandiae	pukatea
Lavandula angustifolia	English lavender

Plant species	Common names
Lavandula dentata	fringed or french lavender
Leptospermum scoparium	mānuka
Liriodendron tulipifera	tulip tree
Liriodendron tulipifera fastigiata	upright tulip tree
Luma apiculata	Chilean myrtle
Macadamia integrifolia	macadamia
Malus × domestica	apple
Malus sieboldii	Japanese bush crabapple
Malus spp.	crabapple
Melicytus ramiflorus	māhoe; whiteywood
Michelia yunnanensis	Yunnan bush michelia
Myrsine australis	māpou; red matipo
Myrsine divaricata	weeping matipo or mapou
Olearia cheesmanii	Streamside tree daisy
Olearia fimbriata	small-leaved tree daisy
Olearia furfuracea	akepiro
Olearia lineata	twiggy tree daisy
Olearia paniculata	akiraho; golden akeake
Olearia rani	heketara
Origanum vulgare	oregano
Parrotia persica	Persian ironwood
Parsonsia heterophylla	NZ jasmine; akakaikiore
Pennantia corymbosa	kaikōmako
Phacellia tanacetifolia	phacelia
Phormium cookianum	mountain flax
Phormium tenax	flax; harakeke
Pittosporum crassifolium	karo
Pittosporum eugenioides	lemonwood; tarata
Pittosporum tenuifolium	kōhūhū; black matipo
Plagianthus regius	ribbonwood; manatu
Podocarpus totara	tōtara
Populus trichocarpa	black cottonwood
Populus x euramericana tasman	Tasman poplar
Prunus domestica	plum
Prunus mume	Japanese apricot
Prunus padus	European bird cherry

Plant species	Common names
Prunus persica	peach
Prunus x yedoensis	Yoshino cherry
Pseudocydonia sinensis	false quince
Pseudopanax arboreus	five finger; whauwhaupaku
Pseudopanax crassifolius	lancewood; horoeka
Pyrus calleryana	Chinese ornamental pear
Pyrus communis	pear
Quercus palustris	pin oak
Quercus petraea	sessile oak
Quercus petraea x Q. robur	hybrid English oak
Quercus robur	English oak
Quercus robur v. fastigiata	upright English oak
Ribes sanguineum	flowering currant
Ribes uva-crispa	gooseberry
Rosmarinus officinalis	rosemary
Rubus idaeus	raspberry
Salix spp.	shrub or osier willow
Salix spp.	willow
Salvia officinalis	sage
Schefflera digitata	seven finger; patē; patetē
Sophora microphylla	kōwhai; weeping kōwhai
Sophora tetraptera	large-leaved kōwhai
Thymus vulgaris	thyme
Tilia cordata	small-leaved lime
Tilia platyphyllos	large-leaved lime
Viburnum japonicum	Japanese viburnum
Viburnum tinus	laurustinus
Vitex lucens	pūriri
Weinmannia racemosa	kāmahi

List of bee plant common names with corresponding botanical names

Common names	Botanical names
akakaikiore	*Parsonsia heterophylla*
akeake	*Dodonaea viscosa*
akepiro	*Olearia furfuracea*
akiraho	*Olearia paniculata*
apple	*Malus × domestica*
black cottonwood	*Populus trichocarpa*
black gum	*Eucalyptus ovata*
black matipo	*Pittosporum tenuifolium*
box elder	*Acer negundo*
broadleaf	*Griselinia littoralis*
cabbage tree	*Cordyline australis*
California lilac	*Ceanothus* spp.
California lilac yankee point	*Ceanothus 'Yankee Point'*
Chilean myrtle	*Luma apiculata*
Chinese ornamental pear	*Pyrus calleryana*
cockspur thorn	*Crataegus crus-galli*
common walnut	*Juglans regia*
crabapple	*Malus* spp.
English lavender	*Lavandula angustifolia*
English oak	*Quercus robur*
eucalypts	*Eucalyptus* spp.
European bird cherry	*Prunus padus*
European hazelnut	*Corylus avellana*
European hornbeam	*Carpinus betulus*
false quince	*Pseudocydonia sinensis*
feijoa Apollo	*Feijoa sellowiana 'Apollo'*
field maple	*Acer campestre*
five finger	*Pseudopanax arboreus*
flax	*Phormium tenax*
flowering currant	*Ribes sanguineum*
flowering quince	*Chaenomales japonica*
French lavender	*Lavandula dentata*
fried egg plant	*Gordonia axillaris*
fried egg plant	*Gordonia yunnanensis*
fringed lavender	*Lavandula dentata*
glossy karamu	*Coprosma robusta*
golden akeake	*Olearia paniculata*
gooseberry	*Ribes uva-crispa*
grapefruit	*Citrus paradisi*
hangehange	*Geniostoma rupestre var. ligustrifolium*
harakeke	*Phormium tenax*

Common names	Botanical names
heketara	*Olearia rani*
Himalayan alder	*Alnus nitida*
honey locust	*Gleditsia triacanthos*
horoeka	*Pseudopanax crassifolius*
houhere	*Hoheria populnea*
houhere	*Hoheria sexstylosa*
hybrid English oak	*Quercus petraea x Q. robur*
Italian alder	*Alnus cordata*
Japanese apricot	*Prunus mume*
Japanese bush crabapple	*Malus sieboldii*
Japanese viburnum	*Viburnum japonicum*
Japanese/sasanqua camellia	*Camellia japonica; C. sasanqua*
kahikatea	*Dacrycarpus dacrydioides*
kaikōmako	*Pennantia corymbosa*
kāmahi	*Weinmannia racemosa*
kanono	*Coprosma grandifolia*
kānuka	*Kunzea ericoides*
kāpuka	*Griselinia littoralis*
karamu	*Coprosma lucida*
karamu	*Coprosma robusta*
karo	*Pittosporum crassifolium*
kohekohe	*Dysoxylum spectabile*
kōhūhū	*Pittosporum tenuifolium*
korokio	*Corokia cotoneaster*
koromiko	*Hebe stricta*
kōtukutuku	*Fuchsia excorticata*
kōwhai	*Sophora microphylla*
lacebark	*Hoheria populnea*
lacebark	*Hoheria sexstylosa*
lancewood	*Pseudopanax crassifolius*
large-leaved kōwhai	*Sophora tetraptera*
large-leaved lime	*Tilia platyphyllos*
laurustinus	*Viburnum tinus*
lemon	*Citrus limon*
lemonwood	*Pittosporum eugenioides*
lime	*Citrus aurantifolia*
loquat	*Eriobotrya japonica*
macadamia	*Macadamia integrifolia*
māhoe	*Melicytus ramiflorus*
makomako	*Aristotelia serrata*
manatu	*Plagianthus regius*
manna ash	*Fraxinus ornus*

Common names	Botanical names
manono	*Coprosma grandifolia*
mānuka	*Leptospermum scoparium*
māpou	*Myrsine australis*
matagouri	*Discaria toumatou*
Mexican orange blossom	*Choisya ternata*
mikimiki	*Coprosma propinqua*
mingimingi	*Coprosma propinqua*
mountain alder	*Alnus cremastogyne*
mountain flax	*Phormium cookianum*
mountain korokia	*Corokia cotoneaster*
New Zealand flax	*Phormium tenax*
NZ jasmine	*Parsonsia heterophylla*
oleaster	*Elaeagnus ebbingei*
orange	*Citrus sinensis*
oregano	*Origanum vulgare*
osier willow	*Salix* spp.
pāpāuma	*Griselinia littoralis*
patē	*Schefflera digitata*
patetē	*Schefflera digitata*
peach	*Prunus persica*
pear	*Pyrus communis*
pecan	*Carya illinoinensis*
Persian ironwood	*Parrotia persica*
phacelia	*Phacellia tanacetifolia*
pigeonwood	*Hedycarya arborea*
pin oak	*Quercus palustris*
plum	*Prunus domestica*
porokaiwhiri	*Hedycarya arborea*
pukatea	*Laurelia novae-zelandiae*
pūriri	*Vitex lucens*
putaputawētā	*Carpodetus serratus*
quince	*Cydonia oblonga*
raspberry	*Rubus idaeus*
red alder	*Alnus rubra*
red horse chestnut	*Aesculus x carnea*
red maple	*Acer rubrum*
red matipo	*Myrsine australis*
renga lily	*Arthropodium cirratum*
rengarenga	*Arthropodium cirratum*
rewarewa	*Knightia excelsa*
ribbonwood	*Plagianthus regius*
rosemary	*Rosmarinus officinalis*
sage	*Salvia officinalis*
sessile oak	*Quercus petraea*
setsugekka camellia	*Camellia sasanqua 'Setsugekka'*
seven finger	*Schefflera digitata*

Common names	Botanical names
shad bush	*Amelanchier canadensis*
shining karamu	*Coprosma lucida*
shrub willow	*Salix* spp.
silverberry	*Elaeagnus ebbingei*
silverthorn	*Elaeagnus pungens*
small-leaved lime	*Tilia cordata*
small-leaved tree daisy	*Olearia fimbriata*
strawberry tree	*Arbutus unedo*
streamside tree daisy	*Olearia cheesmanii*
swamp gum	*Eucalyptus ovata*
swamp peppermint	*Eucalyptus rodwayi*
tagasaste	*Chamaecytisus palmensis*
Taiwan alder	*Alnus formosana*
tarata	*Pittosporum eugenioides*
Tasman poplar	*Populus x euramericana tasman*
Tasmanian yellow gum	*Eucalyptus leucoxylon 'Rosea'*
taupata	*Coprosma repens*
thorny oleaster	*Elaeagnus pungens*
thyme	*Thymus vulgaris*
ti kōuka	*Cordyline australis*
tōtara	*Podocarpus totara*
tree fuchsia	*Fuchsia excorticata*
tree lucerne	*Chamaecytisus palmensis*
tulip tree	*Liriodendron tulipifera*
tūmatakuru	*Discaria toumatou*
Turkish black alder	*Alnus glutinosa subsp. barbata*
Turkish tree hazel	*Corylus colurna*
twiggy tree daisy	*Olearia lineata*
upright English oak	*Quercus robur v. fastigiata*
upright tulip tree	*Liriodendron tulipifera fastigiata*
weeping European beech	*Fagus sylvatica pendulata*
weeping kōwhai	*Sophora microphylla*
weeping mapou	*Myrsine divaricata*
weeping matipo	*Myrsine divaricata*
whauwhaupaku	*Pseudopanax arboreus*
white pine	*Dacrycarpus dacrydioides*
whiteywood	*Melicytus ramiflorus*
willow	*Salix* spp.
wineberry	*Aristotelia serrata*
Yoshino cherry	*Prunus x yedoensis*
Yunnan bush michelia	*Michelia yunnanensis*

References

Di Pasquale, G., Salignon, M., Le Conte, Y., Belzunces, L. P., Decourtye, A., Kretzschmar, A., & Alaux, C. (2013). Influence of pollen nutrition on honey bee health: do pollen quality and diversity matter? *PLoS ONE, 8*(8). e72016.

Foster, B. J. (2014). Designing the ideal apiary site. Kauri Park Nursery. http://www.kauriparknurseries.co.nz/designing-ideal-apiary-site/

Matheson, A., & Reid, M. (2018). *Practical Beekeeping in New Zealand* (2nd ed.), Auckland, New Zealand: Exisle Publishing.

McPherson, A. J. (2016). Mānuka – a viable alternative land use for New Zealand's hill country? *New Zealand Journal of Forestry, (61)*3, 11–19.

McPherson, A. J., & Newstrom-Lloyd, L. E. (2018). Handbook for Mānuka Plantations and Farms: PDF available at https://treesforbeesnz.org/how-to-plant-guides.

McPherson, A. J., & Newstrom-Lloyd, L. E. (2019). Riparian planting handbook. PDF available at https://treesforbeesnz.org/how-to-plant-guides.

Newstrom L. E., & Robertson, A. (2005). Progress in understanding pollination systems in New Zealand (Godley Review). *New Zealand Journal of Botany, 43,* 1–59.

Newstrom-Lloyd, L. E., (2013). Pollination in New Zealand. In Dymond, J. (Ed.) *Ecosystem Services in New Zealand – Conditions and Trends.* pp. 408–431. Lincoln, New Zealand: Manaaki Whenua Press.

The New Zealand Trees for Bees Research Trust

The **New Zealand Trees for Bees Research Trust** is a not-for-profit organisation focused on keeping our pollinators, particularly honey bees, healthy. Our mission is to research, promote and demonstrate the benefits of planting pollinator (especially bee) forage plants to support our pollinators in the environment and in the primary productive sector. Our mission is also to provide outreach and educational services and to publish our research results, for which this Handbook was published.

The Trust was formed in 2019 with Jeremy Williams, Ross Little, Des Kavanagh, Linda Newstrom-Lloyd and Angus McPherson as Trustees.

www.treesforbeesnz.org

Trees for Bees NZ resources online

PLANTING FOR BEES

PDFs at https://treesforbeesnz.org/how-to-plant-guides

A guide to planting for bees. 2017 by A. McPherson, L. Newstrom-Lloyd, M. Gonzalez, T. Roper. (Booklet)

Bee plant flowering times. 2014 by L. Newstrom-Lloyd. (Handout)

Designing and planting for Trees for Bees. 2014 by A. McPherson. (Power Point Presentation)

Handbook for mānuka plantations and farms. 2018 by A. McPherson & L. Newstrom-Lloyd. (Booklet)

How to plant trees for bees on farms. 2014 by A. McPherson & L. Newstrom-Lloyd. (Brochure)

Regional plant guides. 2009 by L. Newstrom-Lloyd at https://treesforbeesnz.org/regional-plant-guides

Riparian planting handbook. 2019 by A. McPherson & L. Newstrom-Lloyd. (Booklet)

Winning with willows. 2015 by L. Newstrom-Lloyd, I. McIvor, T. Jones, M. Gabarret, B. Polturat. (Booklet)

BEE PLANTS AND FLOWERS

PDFs at https://treesforbeesnz.org/bees-flowers-pollen

Bee Plant Flowering Times. 2014 by L. Newstrom-Lloyd. (Handout).

Pollen pellet colour, purity, and Identification. 2014 by L. Newstrom-Lloyd, F. Scheele, I. Raine, X. Li, M. Bonzalex, T. Roper. (Handout).

Protein content of pollen in selected bee plants. 2014 by L. Newstrom-Lloyd. (Handout)

Star Performer Bee Plants. 2016 to 2020 by L. Newstrom-Lloyd & A. McPherson. (14 articles in *The New Zealand Beekeeper* (pip fruit, NZ flax, five finger, lacebark, rosemary, tagasaste, manna ash, California lilac, citrus, tulip tree, alder, walnut, oak, flowering quince). https://treesforbeesnz.org/star-performer-bee-plants. (Articles)

Sustainable beekeeping by and for Māori landowners. 2016 By I. Raine, X. Li, L. Newstrom-Lloyd, A. McPherson, W. Kaa, R. Raroa, R. Kaa, M. Taaremaia. (Poster)

The ABCs of flowers and bees. 2015 by L. Newstrom-Lloyd. (Handout).

The Power of Pollen Profiles. 2017 by L. Newstrom-Lloyd, I. Raine & X. Li. (Booklet)

Urban Trees for Bees. 2011 by L. Newstrom-Lloyd & Maureen Maxwell. (Brochure)

ONLINE TOOLS

https://treesforbeesnz.org/onlinetools

The New Zealand Willow Identification Key (completed)

The New Zealand Bee Pollen Catalogue (in progress)

The Trees for Bees Flower Catalogue (in progress)

Handbooks, Templates and Planning Tools (in progress)

Articles in *The New Zealand Beekeeper* – (listed in reverse chronological order)

PDFs at https://treesforbeesnz.org/articles

Show me the money tree. 2019 (October) by A. McPherson & L. Newstrom-Lloyd.

Trees for Bees is scaling up planting in New Zealand. 2019 (April) by L. Newstrom-Lloyd & A. McPherson.

Looking after your own patch. 2018 (June) by A. McPherson.

Pondering pollen over and under representation in nectar. 2017 (November) by L. Newstrom-Lloyd, I. Raine & X. Li.

How to decipher a pollen profile. 2017 (October) by L. Newstrom-Lloyd, I. Raine & X. Li.

What spacing for mānuka seedlings? 2017 (October) by A. McPherson & J. McPherson.

What's the use of pollen? 2017 (May) by L. Newstrom-Lloyd.

Annual variation in mānuka honey yields – what does it mean? 2017 (April) by A. McPherson

Mānuka mysteries – the biology of a flower. 2017 (March) by L. Newstrom-Lloyd.

Bees without borders: what is the limit? 2016 (October) by L. Newstrom-Lloyd.

The Naati Beez challenge to Trees for Bees. 2016 (September) by L. Newstrom-Lloyd.

Naati Beez planting trees for bees for East Coast mānuka support. 2016 (August) by L. Newstrom-Lloyd, A. McPherson, I. Raine & X. Li.

Strategic planting for bee feed. 2016 (June) by L. Newstrom-Lloyd, A. McPherson & M. Gonzalez.

Big trees to plant for spring nutrition. 2016 (May) by L. Newstrom-Lloyd & A. McPherson.

Nutrition, nosema and neonics: what's food got to do with it? 2016 (April) by L. Newstrom-Lloyd.

What to plant for autumn bee nutrition? 2016 (March) by A. McPherson & L. Newstrom-Lloyd.

Getting ready for winter: planning your bee feed planting. 2016 (February) by A. McPherson.

Managing mānuka for carrying capacity and competition. 2015 (December) by L. Newstrom-Lloyd.

Winning with willows: diverse species flowering. 2015 (November) by L. Newstrom-Lloyd.

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Angus J. McPherson

Angus is a forestry consultant and farm planting adviser with over 35 years of experience in forestry. He has a B.For. Sc. (Hons) from University of Canterbury (New Zealand) and a PhD (Forestry) from the University College of North Wales (Bangor) and has worked on a wide variety of forestry projects throughout the Asia-Pacific region. Angus has worked on farm planting projects throughout New Zealand, covering production and carbon forestry, farm greenhouse gas (GHG) balances, land stabilisation and riparian zones, farm shade and shelter, amenity planting, mānuka plantations and bee forage. With the Trees for Bees team, he has developed design templates and planning tools to assist farmers and beekeepers to install plentiful high-performance pollen and nectar sources to promote bee health.

Linda E. Newstrom-Lloyd

Linda Newstrom-Lloyd is a botanist and pollination biologist conducting research in New Zealand on the best bee forage to improve the quantity and quality of bee nutrition using native and exotic bee plants. Linda received her Ph.D. in botany from the University of California at Berkeley, USA and has previously worked on pollination research in California, Mexico, and Costa Rica. Linda moved to New Zealand in 1994 to conduct research on the New Zealand flora. She has been engaged in the New Zealand beekeeping industry for the last twelve years to research and promote strategic bee forage plantations that will provide optimum bee nutrition. Linda conducts the Trees for Bees NZ field work and organizes lab work to determine which plants provide the best nutrition for bees in New Zealand.

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