Trees For Bees

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# HANDBOOK FOR MĀNUKA PLANTATIONS AND FARMS

## Profitable and sustainable manuka honey harvesting

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Manatū Ahu Matua
Sustainable Farming Fund

*Mānuka plantation age 4 years - Puketoro East Cape.*

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*Photos on front cover shows a honey bee and a New Zealand native bee in a mānuka flower.*

*Koromiko flowering 3 years - Riverlea Piopio*

# PREFACE

The mānuka honey sector is experiencing unprecedented demand which is leading to rapid expansion in terms of the number of hives and geographical coverage. This expansion has placed significant pressure on spring-build-up and over-wintering sites for bee hives, not only for the honey sector but also for pollination services.

To meet the demand for more honey (especially mānuka) and alleviate the overcrowding and overstocking issues, the apiculture industry has recognised that the best option is for new mānuka plantations to be accompanied by installations of spring and autumn bee forage to bracket the mānuka honey harvest, and for increased planting of bee forage around home yard, apiary and over-wintering sites. This promotes a long-term sustainable and profitable apiculture industry, for both pollination services and honey harvesting.

Trees for Bees' goal is to determine the best plants that cover the critical flowering times in spring and autumn and provide high quality and quantity pollen and nectar to boost bee nutrition. We incorporate these high performance plants into effective on-farm and apiary planting designs to alleviate the overcrowding and overstocking issues. Since 2011, twenty seven demonstration farms have been set up and 60,000 bee forage plants established, with bee forage plantations in the North and South Islands.

This handbook is intended to provide practical advice to beekeepers, landowners and investors considering establishing or investing in mānuka plantations, including supporting bee forage.

Happy planting.

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# 1. INTRODUCTION

This handbook provides information on important principles of successful mānuka plantations that will support decision-making for workable investments leading to excellent mānuka honey harvests. The topics covered here are selected to fill the information gaps not covered in other resources provided to the mānuka honey industry by other researchers and consultants (e.g. Boffa Miskell 2017, Comvita 2014, MPI 2017b, Wearmouth 2016, etc.).

Strong growth in the mānuka honey sector over the past decade has led to widespread expansion of honey harvesting in existing natural mānuka forested areas. This has resulted in a rapid increase in the number of bee colonies in New Zealand and a growing interest in the installation of new mānuka plantations. Expansion of the mānuka sector is a key component in the government's primary sector expansion goals, and new participants will be interested in understanding the strategic drivers in this sector.

### 1.1 Principles for successful mānuka plantations

A good mānuka honey harvest depends on a good bee workforce to collect the nectar. Strategies are available to maximise the quantity and purity of mānuka honey harvests when the biological and ecological actualities of bee-flower interactions are taken into consideration. For example, mānuka only flowers for about six weeks each year but honey bees require year-round food to build up colony strength to be ready for the summer honey harvest and to develop strong bees for winter survival postharvest. Hence provision of sufficient year-round floral resources is vitally important. Furthermore, bee floral preferences depend on what other floral resources are within the bee's foraging area and this influences the purity of the mānuka honey harvest. These types of factors significantly influence economic gains so information about them will assist landowners, investors, and beekeepers who wish to participate in the rapidly developing mānuka industry.

When new plantations of mānuka are installed, it is most important that supporting bee forage is also established to supply the required numbers of strong bee colonies to obtain good honey harvests. Natural bee forage consists primarily of pollen and nectar from flowers. A good supply of supporting bee forage throughout the seasons is essential to sustaining the number, strength and health of bee colonies needed to produce good mānuka honey yields. Installation of bee forage plantations to provide spring and autumn flowering when the mānuka is not in flower will contribute profoundly to a profitable mānuka honey operation.

The information presented in this handbook is derived from more than seven years of experience working with landowners, beekeepers, and nurseries installing bee forage and mānuka plantations and conducting research on bees and flowers for the Trees for Bees NZ research programme, supported by the Ministry of Primary Industries Sustainable Farming Fund and industry sponsors. The handbook covers information on how to envision and analyse the proposed mānuka honey harvesting system based on how bee–flower interactions influence the quality and quantity of the honey harvest, how best to plant mānuka and to install bee forage support, how to design plantations and apiary systems, and how to examine some of the factors influencing economic returns from mānuka investments.

### 1.2 Emergence of the mānuka honey sector

Mānuka honey and the resultant interest in mānuka apiculture are both being driven by strong demand in the medical market for high activity honey and the associated demand in the health food industry, which has led to record prices for medical grade and high activity mānuka honey (Van Eaton 2014). Broader health applications include the use of mānuka in cough syrups and lozenges, lip balms and moisturisers. There are also perceived health benefits of ingesting mānuka honey (although clinical evidence is so far lacking). High activity mānuka honey now achieves a premium price on supermarket and health food store shelves. This has had a flow-on effect to less active mānuka honey, as well as other New Zealand monofloral and clover-based honeys now achieving record prices.

Due to this increase in demand and the limitations of existing natural mānuka resources (in that there is limited ability to increase production from a finite area), there is now considerable interest in establishing new plantations of mānuka to supply monofloral, high-active and medical grade honey. As a consequence, mānuka has emerged as an alternative land use on hill country and unproductive marginal land.

### 1.3 Challenges in the mānuka honey sector

Fast growing industries are accompanied by emerging challenges. The boom in the mānuka industry since the mid 2000's has seen New Zealand's hive numbers more than double, with exponential growth in hive numbers in the last five years (Newstrom-Lloyd 2015, 2016). This means that existing natural mānuka areas are being harvested more intensively which is leading the demand for land to go into new mānuka plantations. This dramatic increase in hive numbers places pressure not only on the mānuka resources for honey bees and native bees, but also on floral resources to feed the bee colonies prior to and following the mānuka flowering season.

The limits of the carrying capacity are therefore not resulting only from the limits of available mānuka trees but also the limits of the necessary off-season bee forage to sustain the colonies needed to harvest the mānuka honey. A honey bee colony is a complex population with a queen and different age class bees living in a hive and operating as a unit or 'superorganism'. The different age classes must be balanced correctly for the colony to survive. Each bee colony lives in a hive and many hives are aggregated into an apiary site managed by the beekeeper. The goal is to maintain healthy age-class balanced colonies and keep all the colonies within the apiary at equal strength to prevent the colonies from robbing honey from each other. Balanced colonies and balanced apiary sites promote cost effective honey harvesting.

*Escarpment 2 years after planting - five finger - Kintail*

It is critical that the number of colonies (hives) per apiary does not exceed the carrying capacity of the floral resources in the foraging area. Hive numbers can exceed carrying capacity due to overcrowding too many apiaries in one foraging area and from overstocking an individual apiary with too many hives. Keeping the colony numbers in the bee foraging area at or just under the carrying capacity will ensure a maximum honey harvest. Too many bees will result in reduced honey yields because bees use up about one third to one half of the honey harvest to sustain the colony, a typical overstocking problem. In addition, too close proximity of apiaries or overloaded apiaries foster increased spread and incidence of bee pests and diseases. Overcrowding and overstocking puts bees at risk for starvation and malnutrition which leads to lower resistance to pests, diseases, and pesticides.

Lower hive stocking rates and increased planting of bee forage in areas allows for a level of reserves in available natural forage to be built up to take into account season fluctuations and sever weather events which will become more frequent through anthropogenic climate change. Many hives starve and suffer from elevated levels of pathogens in spring if they are under stress and living 'on the edge' in terms of available bee forage. It is recommended to build resilience into available bee forage by ensuring there is always a buffer of natural feed available.

Any selection of bee forage should include some plants with long flowering periods such as Tagasaste (tree lucerne, *Chamaecytisus palmensis*) and Koromiko (*Hebe* or *Veronica stricta*), so as to be available to bees in between successive bad weather events. Having over lapping flowering times from various plants helps to ensure this as well.

While many beekeepers now provide supplements (e.g., protein patties), for extra bee food, a diversity and abundance of fresh natural pollen has been shown to be central to bee health and colony growth (Black, 2006; Brodschneider & Crailsheim, 2010; Di Pasquale et al., 2013; DeGrandi-Hoffman et al., 2015). Supplements are excellent emergency rations for poor weather conditions that restrict bee flight for foraging trips but they are costly to supply for extended periods. A diet primarily based on supplementary feed does not measure up to fresh natural pollen, as it is impossible to precisely replicate the mix of nutrients and trace elements required by the bees at any one time. In addition, some supplement formulas have excessive amounts of certain nutrients that become toxic to bees when in excess. Too little is known about the nutritional requirements for honey bees to allow extended use of supplements at this stage (Doug Somerville, pers. com.).

For these reasons, to meet the demand for more mānuka and alleviate the overcrowding and overstocking issues, the mānuka industry has recognised that the best option is for new mānuka plantations to be accompanied by installations of spring and autumn bee forage to bracket the mānuka honey harvest during the off-season. This option promotes a long-term sustainable and profitable mānuka industry by promoting healthy strong bees.

A second challenge resulting from overcrowding and overstocking has been the conservation risk for the preservation of other pollinators that also rely on the same pollen and nectar resources in natural areas. Native insect pollinators, primarily bees, moths, butterflies and flies, derive sustenance not only from mānuka flowers but also other plant species that are shared with honey bees in areas of high density mānuka apiaries. The competitive resource pressure on native insect flower visitors has been outlined by Newstrom-Lloyd (2013), Beard (2015) and the Department of Conservation (2015) but little data is yet available to document the extent of this issue. Nonetheless, to forestall or remedy such problems, installations of more off-season bee forage to support more numerous new mānuka plantations will help supply the demand for mānuka while at the same time protect native pollinator ecosystems from overexploitation. This ensures that the mānuka honey industry is not only sustainable and profitable but also environmentally responsible – an added market value.

### 1.4 Factors to promote successful plantations

The strategies and information presented in this handbook cover many important aspects that will contribute to establishing successful mānuka plantations which fundamentally rely on the bees to harvest the mānuka nectar. The factors and strategies presented empower the landowner and partners to maximise the honey harvest, install optimal mānuka plantations, establish the best bee forage for off season support, and manage the economic variables with informed decision making.

# 2. MAXIMISING HONEY HARVESTS

Understanding bee—flower interactions plays a significant role in maximising the yield and purity of a mānuka honey harvest. Important factors are (1) the colony's annual supply and demand for pollen and nectar; (2) the bee's foraging range in relation to the scale of the plantations; (3) the bee's floral preferences and risk of distraction away from the targeted mānuka plants and (4) the flowering calendar and annual bee forage budget.

### 2.1 Annual supply and demand of pollen and nectar

A honey bee colony passes through different phases of pollen and nectar demand throughout its annual cycle. The colony's size in each phase is shown in Figure 1 depicting the annual build-up and decline of a bee population in one hive in relation to typical bee activities in most of New Zealand (Matheson and Reid 2011). For each phase, the bee forage budget must supply pollen for protein to feed the brood, queen and emerging worker bees and nectar for carbohydrates to supply energy to all bees as well as to make wax and royal jelly. Water is also needed for making royal jelly and cooling the hive. Seeley (1995) estimates that for one bee colony (hive) the total annual bee forage budget is about 20 kg pollen, 120 kg nectar and 25 litres of water.

The first phase of the annual colony cycle is in the **winter** season when the bees are normally resting especially in temperate climates with cold winters. In New Zealand, most honey bee colonies overwinter for one to three months from roughly late May to early August. As winter is approaching, the bee population starts to diminish until it reaches its lowest population size of about 10,000 bees per colony for the winter. In the coldest regions, the colony often has little to no brood (which presents an advantage for varroa control). Since New Zealand has mild winters in many regions it is possible on warm sunny days for bees to fly out of the hive to forage if there are available flowers close by. The queen will resume laying eggs at some point in the mid to late winter to start preparing for the next phase.

The second phase is in the early to mid-**spring** season which is by far the most critical because this is when the colony intensifies brood rearing to build-up the population size. The queen increases brood production while worker bees collect massive amounts of pollen to feed the new brood and huge quantities of nectar to make foundation wax and royal jelly as well to fuel foraging flights. At this time, the beekeeper needs to gain an exponential growth rate for the bees to reach a peak population size of about 60,000 to 80,000

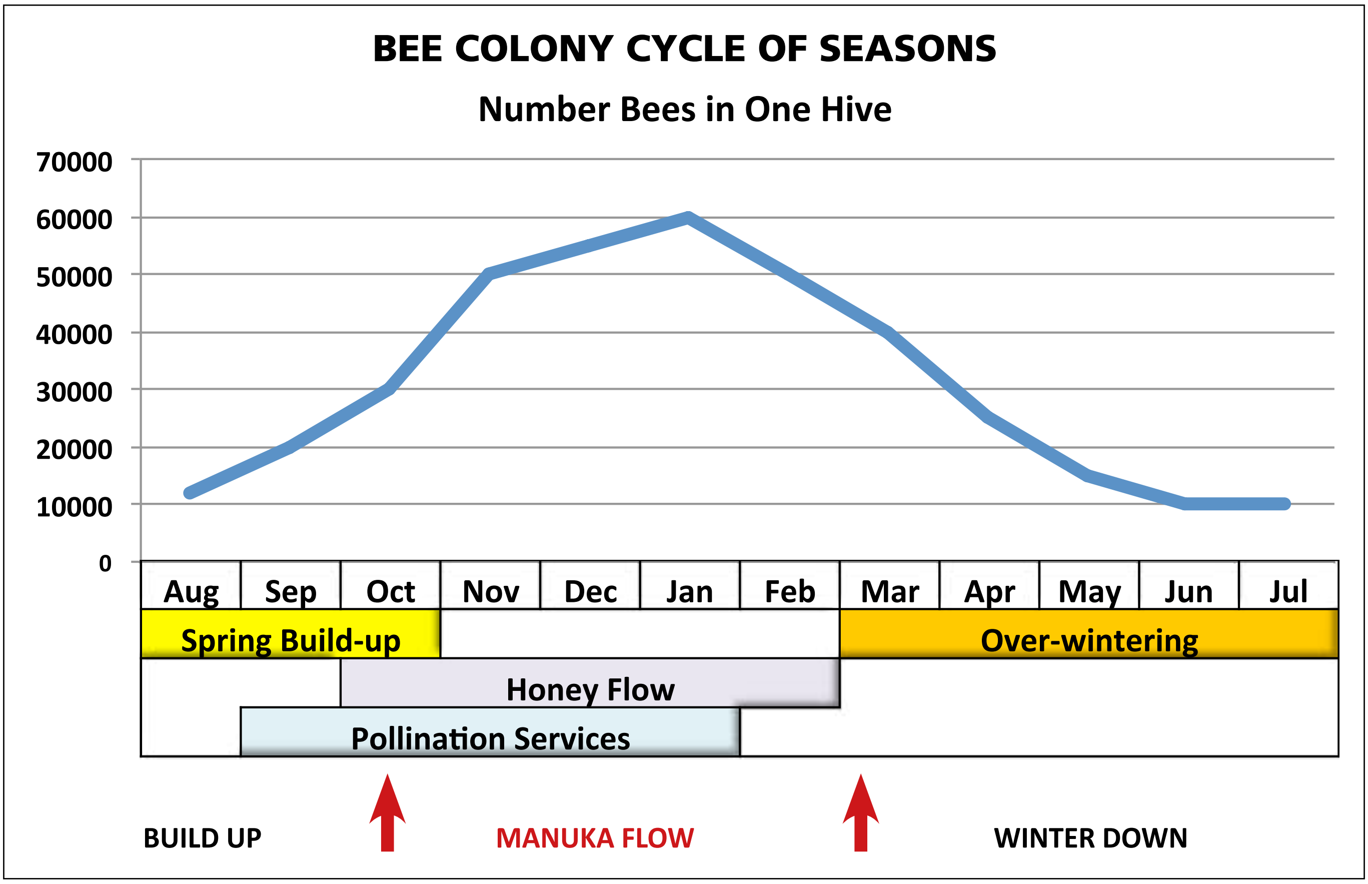


*Figure 1. Bee colony annual cycle showing pollen and nectar demand and typical activities for each season.*

bees in time for honey harvest. This requires a significant supply of nutritious pollen to raise new brood rapidly. This population growth must be sustained through spring because any interruption in pollen supply results in bees cannibalising the youngest larvae to feed protein to the older brood. This is the worst case apart from colony death by starvation, as any cannibalising has a compounding effect on colony population growth and can cause population crashes. This becomes a timing issue as any break in colony build-up in spring cannot be made up later.

If the colony does not reach peak size on time then a maximum honey harvest will not be attained because only a small number of mature bee foragers are available to collect nectar. In this case the colony is not able to store surplus nectar because all resources are still supplying the population build-up. In other words, any mānuka nectar collected in this situation will go to sustaining the bees during colony build-up, not to storing surplus mānuka nectar for honey.

The third phase is in the summer season when the pollen demand continues for sustaining the colony, but there should also be enough bees available to focus on collecting surplus nectar for honey stores to provide for winter. It is this surplus honey that provides the harvest for beekeepers. Summer bees live for only six to nine weeks and so the turn-over of new emerging brood still requires some pollen supply during summer. From late spring through summer, the surplus nectar flow starts for mānuka, but also for many other plants that may flower at similar times such as tawari ***(Ixerba brexioides),*** rewarewa ***(Knightia excelsa)*** and kamahi ***(Weinmania racemosa)*** or clover ***(Trifolium repens).***

The timing of nectar flow for any mānuka cultivar depends on the genetics of the cultivar in combination with the weather patterns of the region where it is planted – primarily temperature and rainfall. For some elite mānuka cultivars it is important to ensure that the weather patterns in the region of the proposed plantation match the mānuka flower and bee activities. It is possible for cold and rain to prevent nectar flow at the right time or bee flight opportunities during mānuka flowering. It is also possible that the bee colony may not be able to build up fast enough to match an early flowering time due to poor weather or pollen dearth. Extending the mānuka flowering season by combining early, middle and late flowering cultivars therefore need to be tested on site to ensure that these factors coincide to produce a good honey flow at the right time for the bees to collect. Using locally adapted cultivars such as eco-sourced plants would not have this issue but they also may not have the highest activity and densest flower production that are features of elite cultivars.

During summer mānuka flowering, it is sometimes best to ensure that there are alternative pollen sources available, as honey bees do not usually collect mānuka pollen for their brood in summer. Although native bees are commonly seen avidly collecting mānuka pollen and nectar in summer, we have observed that honey bees tend to focus only on mānuka nectar and not pollen in the summer (Newstrom-Lloyd 2017). Honey bees and native bees both dislodge pollen into the nectary while working the flower, so the nectar will always contain some pollen grains but honey bees have rarely been observed to collect pollen pellets during the summer mānuka honey flow. It may not be cost effective for honey bees because mānuka pollen grains are extremely small and the anthers holding the pollen face inwards so it may be too inconvenient for honey bees to collect when there are better pollen sources available nearby. Therefore, in some cases the honey bees may need a pollen source to keep the colony going if few other pollen sources are available.

The fourth and final phase is in the autumn season when bees are preparing for winter. This is the second most critical phase because the new brood raised at this time become “winter bees”. In contrast to summer bees (living for 6 to 9 weeks only), winter bees must survive for two to three months depending on the duration and severity of the winter. Winter bees spend all or most of their time in the hive keeping warm by clustering together near the honey and pollen stores. To survive this long, the winter bees must be robust with high levels of protein and fat stored in their bodies – hence the need for good pollen and nectar sources in autumn. Additionally, the colony must replace the stored honey that was removed during the honey harvest by the beekeeper if insufficient honey has been left in the hive. An alternative is for the beekeeper to leave a supply of sugar syrup but this is not ideal compared to honey stores and incurs a labour and materials cost. If a good pollen and nectar supply in autumn is not available to raise strong winter bees, then the colony may become too weak to survive winter and succumb to pests and pathogens as well as starvation. Even if a weak colony does survive it may still be too small to build-up rapidly enough in the spring in time for honey harvest. For this reason, autumn pollen and nectar supply is as crucial as the spring supply because it ultimately contributes to maximum honey harvesting capacity of the colonies in the summer.

**2.2 Foraging range and scale of plantations**

An understanding of how the bee foraging range relates to the scale of the mānuka plantation and interacts with surrounding vegetation, topography and apiary sites is important for maximizing the mānuka honey harvest. Bee flight is unrestricted by fences so the foraging range can be very large depending on the type and extent of the flower patches within flying distance. From the mānuka honey harvest perspective, this means that bees are capable of flying to any nearby competing nectar source and will do so if a more abundant and superior nectar source is available within foraging range. From the apiary density perspective, it means that all floral resources within the foraging range, including the mānuka, will be available to all other neighbouring bee colonies within the same foraging range (Newstrom-Lloyd 2016).

Bees will fly various distances depending on the location of the most profitable flower patches in the vicinity of the apiary.

The longest distance recorded for honey bee flights have been 13.5 km but we do not know what the maximum distance could be (Beekman and Ratnieks 2000). Honey bees are known to fly an average of 5.5 km and up to 10 km away for good nectar sources, for example to collect resources from heather ***(Calluna vulgaris)*** the UK. Such long distances are not common, however, because most records show bees tend to forage close to the apiary: for example, more than 90 % of the foraging trips typically occur within four km of a hive (Beekman et al. 2004). Beekeepers in New Zealand have considered that a separation distance for apiaries should be two to three km and this has always been observed by traditional beekeepers in the past. The circular area around an apiary with a one km radius covers an area of 314 hectares while a 2 km radius covers 1256 ha and a 3 km radius covers 2827 hectares. These areas are the potential extent of the foraging ranges to consider when assessing the opportunities for competing flowers that may distract the bees from mānuka or competing apiaries that may be placed too close to the mānuka plantation itself or to the spring and autumn bee forage.

Bees cannot be prevented from foraging to any area by placing obstacles in their path. Bees are conservative and will fly as high as they need to, but not much higher than the height of any obstacle in its path, yet they are capable of flying as high as at least 30 m and probably more (British Beekeeping Association 2017). This means that a high shelter belt or variation in topography will not prevent bees from going over to the next paddock or farm.

The foraging range that bees actually do use affects the quantity and quality of the honey yield. When bees have to fly further than optimal, they require more nectar to fuel their long return flights and this leads to lower honey yields (Newstrom-Lloyd 2015, 2016). Any overcrowded or overstocked apiaries closer than the recommended separation distance forces all bees to forage further afield with consequent reduction in honey yields and purity for everyone with apiaries in the area. A greater number of colonies within a foraging area uses up more honey because more bees require more maintenance nectar to sustain the colony. When carrying capacity is exceeded, bees are forced onto alternative less desirable nectar sources resulting in diluted multifloral honey.

To counteract any of these types of risks it is optimal to aim for the largest scale of mānuka honey plantation and bee forage support plantation as possible. The larger the scale, the more likely the landowner will gain influence and control over access to the target mānuka plantation and its supporting spring and autumn forage. Larger scale also allows more abundant large sized mass plantings of mānuka and bee forage support plants. Large patches of the same species of flower are very attractive to bees because they can forage much more efficiently in massed plantings.

The recommended size for the mānuka plantation and its supporting spring and autumn forage needs to be considered in the context of the surrounding existing floral resources near the proposed site as well as the ease of access that could allow competing apiaries on the borders of the property. If it is not possible to achieve a large scale on one property, be it a single large planted area or a number of smaller planted areas, it can be useful to develop cooperative agreements with neighbouring landowners. To this end, some farm and iwi collectives are being formed to create large scale systems for producing mānuka honey, thereby achieving economy of scale to protect against competition from distracting flowering plants with superior nectar production and from competing or overstocked apiaries coming into the foraging range.

Other factors that influence decisions about the scale and location of the mānuka plantation and the supporting bee forage plants are practical limitations such as time, space and resources as well as how well the plantations fit into the other operations on the same land. It is cost effective to use multi-purpose bee forage plants that also fulfil other purposes such as shade and shelter, erosion control, riparian protection, or native biodiversity etc. (McPherson and Newstrom-Lloyd 2017).

It is vital to recognise the attributes of a well sited apiary and what it can do for honey production. Factors such as being in the sun for much of the day, aspect in terms of good air drainage and being out of excessive shade, having shelter from prevailing winds, having available fresh water and having good access are critical success factors for a good apiary site. Having an apiary site on an exposed site to wind will not ensure an average of good yields over successive seasons. See section 4.

**2.3 Bee floral preferences and distraction from target**

One of the most critical success factors for mānuka plantations is an estimation of how likely the bees would be to collect nectar from the mānuka plants in preference to any other competing floral resources that may distract the bees away from the mānuka. Any competing nectar source coming into flower within the foraging range when the plantation mānuka is in flower may be preferred by the bees which results in a multi-floral honey or even no mānuka honey. This is why scale is so important because bees forage optimally by selecting the most profitable food patches in their foraging range and will not necessarily fly to a more preferred nectar source if it is a long distance away. However, beekeepers have reported that they have seen bees fly right over mānuka bush to go to more nectar-rich monofloral honey sources such as tawari ***(Ixerba brexioides),*** rewarewa ***(Knightia excelsa)*** and kamahi ***(Weinmania racemosa)*** as well as any nearby nectar-rich clover ***(Trifolium repens).***

Distraction from target (mānuka) can happen even when the bees start out on the mānuka flowers but then get redirected to other better sources. The colony has scout bees that are out searching for flower patches over a large foraging area when needed. The scouts fly high enough to survey candidate flowering plants in the broader landscape and then zero in on the largest patch that can be spotted readily from a height (Tautz 2008). When they visit the patch, they evaluate the flowers for pollen or nectar (whichever the colony needs most) and then bring the information back to the hive to communicate the location, abundance and resource quality to the forager bees waiting in the hive. Very quickly (hours) a multitude of forager bees can be recruited to take advantage of a newly discovered resource.

The goal therefore is to have the mānuka plantation rank as the largest most nectar rich flowering patch in the area so that the bees prefer the mānuka and stay with it until it has finished flowering. To compete for the attention of bees to harvest nectar, a mānuka plantation must be more profitable to the bees than all nearby other sources. Profitability is measured as the net energy gained per energy expended (Dornhaus et al. 2006). Bees have a hierarchy of floral preferences based on how cost effective it is to forage in a given flower patch compared to others. Cost effectiveness depends on having large flower patches with flowers that (1) produce a high volume of nectar with high sugar concentration; (2) require the least work to handle the flower to get the nectar; and (3) entail the least distance to travel from flower to flower within the patch; as well as the shortest distance to get to the patch. A very large mānuka patch with densely aggregated flowers per plant and a high production of sugar rich nectar could compete well with a very small patch of flowers of another plant species with higher nectar volume per flower but less densely aggregated flowers or more scattered plants. It is the sum total of all these factors that determines which flower patches the bees will be most attracted to.

Since nectar sources such as rewarewa, tawari and kamahi have much more nectar per flower than mānuka flowers (often over 100 times more) it will be relevant to assess their regional flowering times and local abundance and density within the foraging range. Although a mānuka flower may produce only a few microliters of nectar (Figure 2) while a pohutukawa ***(Metrosideros excelsa)*** may produce over 100 microliters (Figure 3) per day, the pohutukawa has much more dilute sugar concentration and so may not be preferred. Clover flowers in large pastures are favoured by bees and often provide a pollen source during mānuka flowering but in some cases, clover does not yield nectar in abundance every year (see below data on variability in clover versus mānuka nectar flow over a 22-year time series). Some modern clover cultivars are poor in nectar production and not attractive to bees. Nonetheless it is possible and common to obtain clover nectar and no or little mānuka nectar in some locations.

*Figure 2. Mānuka flowers showing the nectary with small bubbles of nectar exuding from the nectar disk in the centre of the flower. The nectar produced is concentrated in sugars and measures only one to few microliters per day which is typical of flowers that are adapted to small insect pollination such as bees and flies. Flowers are long lived and produce nectar for 4 to 6 days.*

Strategies to manipulate distracting floral resources during the mānuka honey flow are possible, especially for plants such as clover. For example, in some pastoral farms the clover flowers are mowed or grazed off when mānuka comes into flower. The farmers rotate one paddock to allow full clover flowering to replenish the seed supply in one year and another paddock in the next. An extreme solution would be to remove competing plants but many of them are excellent monofloral honey sources in their own right which spreads the risks if in some years when the mānuka has poor flowering, such as in the 2016-2017 honey harvest.

Various levels of effort can be put into assessing the surrounding floral resources and apiary sites. Several methods can be used such as conducting vegetation analyses with an ecologist or botanist or by talking to local farmers and beekeepers or by trial and error during the development of the mānuka plantation. The Trees for Bees team has developed a new Apiary Assessment Tool for determining what pollen and nectar sources are available in the foraging range of an apiary site. This tool involves collecting pollen and nectar samples over a one-year period to determine what pollen and nectar sources are being brought into the hive. These methods are described in booklet "The Power of Pollen Profiles" (Newstrom-Lloyd, Raine, and Li 2017). The tool is helpful for discovering what gaps exist in pollen and nectar supply for the bee forage budget at an apiary site as well.

## 2.4 Estimating the bee forage profile using a flowering calendar

To estimate a bee forage profile, we make a chart of the estimated amount and diversity of bee forage species for each month of the year. This chart is based on a flowering calendar which is a list of candidate plants that bees may use in any month of the year with their times of flowering. The bee forage profile is used to visualise how well the forage resources match the expected seasonal demands for pollen and nectar as shown in Figure 1. Flowering calendars and bee forage profiles can be used to assess either the pre-existing floral resources at the site or the proposed bee forage planting list for the site. When it is not convenient to assess the flowering times for the pre-existing plants, the flowering calendar and bee forage profile can be used solely for planning the proposed bee forage plantation. In some cases, there are too many unknowns about the identity and flowering times of existing species at the site, or there are too many species to enumerate in the time available. The Apiary Assessment Tool mentioned above can also be used to discover and estimate flowering times for pre-existing plants. However, many local beekeepers, based on experience, are

*Figure 3. Pohutukawa flowers showing the nectary that looks like a big bowl filled a large pool of nectar measuring in the hundreds of microliters. The nectar produced is relatively dilute in sugars which is typical of flowers adapted to bird pollination.*

*Bee forage shelterbelt - Matahiia East Cape*

familiar with the general flowering times of the most important bee plants and this is how they assess the potential bee forage profile for an apiary site.

To first step is to construct the Flowering Calendar by creating a matrix with the rows as the list of plant species (either pre-existing or proposed candidates for planting) and the columns as the months of the year starting with June as the first month. For each row, insert the number one into each cell to indicate which months the plant species is typically in flower as shown in Figure 4 and 5. The flowering calendars in Figure 4 and 5 are only some examples of native plant species but a more complete species list of bee plants can be downloaded from www.treesforbeesnz.org/publications. The online candidate species list is more complete and is continually updated by the Trees for Bees NZ team. These flowering times are national level flowering times not local or regional, and to adjust these flowering times to your area requires local knowledge of flowering times which may not be available.

We use this flowering chart to select candidate bee forage species to plant. Selecting candidate plants is an iterative process which involves filtering and adjusting the list based on flowering times, attractiveness to bees, value of pollen and/or nectar, and multi-functional purposes for the use of the plant and the growing conditions at the proposed site (frost, snow, drought, wind etc.). This process benefits enormously from seeking advice from diverse sources such as farm planting advisers, nurseries, beekeepers and other plant or beekeeping experts who are skilled in landscaping, plant knowledge and beekeeping.

The second step is to create a Species Diversity Profile which consists of a bar chart of the total number of species in flower summed over each month as enumerated from the Flowering Calendar (see hypothetical examples in Figures 6 and 7). To visualise this profile, create a simple bar chart based on the column totals. To make sure the bees will attend to your target plant at the right time -- i.e. the mānuka when it flowers in summer -- it is important to ensure that no candidate species selected will flower at the same time and therefore compete with the mānuka, except for a few plants that provide good pollen but very little nectar. This means you will need to have general knowledge about when the mānuka will most likely be in flower, and this will vary depending on location. Although the mānuka start date will shift from year to year it will still be within the range of a few weeks within a season.

For the Species Diversity Profile, the goal is to have at least ten species flowering each month, except in winter when the bees are resting. This diversity provides "backup" species in case some plants scheduled to flower at certain times sometimes start flowering at different times than expected. It also provides alternative flowers if some species skip flowering for one or many years or become diseased or die. In addition, a greater diversity of plant species provides better nutrition for the bees (Di Pasquale et al., 2013). If it is not possible to reach ten species per month, then at least maximise the number of species per month as much as you are able.

*Figures 4 and 5 on following pages. A Flowering Calendar for a list of selected candidate native species with flowering time data derived from the national level flowering times. Five Finger is an excellent choice as a spring build up plant.*

# Trees for Bees NZ Bee Plant Flowering Times in selected plant species reported to be visited by honey bees in New Zealand

This list includes selected bee plants listed in the NZ literature plus some reported by beekeepers and discovered in the Trees for Bees NZ field work. The list is not exhaustive and includes plants that may make minor contributions to bee forage or are not practical for planting on farms or other types of planting programs. Some plants are more suitable to the farm garden or in urban areas. The list is meant to show flowering times for selected species primarily reported in the literature. The flowering times are taken from the New Zealand Floras and present a national level duration of flowering. Many more plants have been reported as attractive to honey bees and will be added to the list when the flowering time data can be obtained. Also, many plants are being added from our field work to collect pollen for protein analysis. To see newly discovered species not from the NZ literature but from field observations by Trees for Bees NZ in Gisborne and Canterbury consult the list on protein content on www.treesforbeesnz.org.

| Biostatus | Botanical Name | Common Name | Life Form | Flowering | Winter/Early Spring | | | | Spring/ Early Summer | | Summer | | | | Early Winter | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | June | July | August | September | October | November | December | January | February | March | April | May |
| Exotic | *Anagallis arvensis* | Scarlet pimpernel | Annual | Jan-Dec | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Native | *Epacris pauciflora* | Tamingi | Shrub | Jan-Dec | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Exotic | *Oxalis corniculata* | Oxalis | Perennial | Jan-Dec | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Native | *Fuchsia excorticata* | Tree fuchsia | Tree/Shrub | Jun-Jan | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | |
| Native | *Melicytus lanceolatus* | Narrow-leaved mahoe | Tree/Shrub | Jun-Dec | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | |
| Native | *Myrsine divaricata* | Weeping matipo | Shrub | Jun-Nov | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | |
| Cultivated | *Acacia pycnantha* | Golden wattle | Tree/Shrub | Jun-Oct | 1 | 1 | 1 | 1 | 1 | | | | | | | |
| Native | *Pseudopanax arboreus* | Five-finger | Tree | Jun-Aug | 1 | 1 | 1 | | | | | | | | | |
| Exotic | *Medicago nigra* | Burr clover | Annual | Jul-May | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Native | *Myoporum laetum* | Ngaio | Tree/Shrub | Jul-Apr | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| Native | *Oxalis magellanica* | White oxalis | Perennial | Jul-Apr | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| Exotic | *Eucalyptus viminalis* | Ribbon gum | Tree | Jul-Apr | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| Exotic | *Trifolium repens* | White clover | Herb | Jul-Mar | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Native | *Passiflora tetrandra* | Kohia | Liana | Jul-Mar | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Exotic | *Fumaria muralis* | Scrambling fumitory | Annual/Climber | Aug-Jan-(Jul) | x | x | 1 | 1 | 1 | 1 | 1 | 1 | x | x | x | x |
| Native | *Alseuosmia macrophylla* | Korotaiko | Shrub | Aug-Dec | | | 1 | 1 | 1 | 1 | 1 | | | | | |
| Native | *Rubus cissoides* | Bush lawyer | Liana | Aug-Dec | | | 1 | 1 | 1 | 1 | 1 | | | | | |
| Native | *Olearia rani* | Heketara | Tree/Shrub | Aug-Nov | | | 1 | 1 | 1 | 1 | | | | | | |
| Exotic | *Eucalyptus globulus* | Blue gum | Tree | Aug-Nov | | | 1 | 1 | 1 | 1 | | | | | | |
| Exotic | *Medicago arborea* | Tree medick | Perennial | Aug-Nov | | | 1 | 1 | 1 | 1 | | | | | | |
| Exotic | *Prunus persica* | Peach | Tree | Aug-Oct | | | 1 | 1 | 1 | | | | | | | |
| Native | *Metrosideros carminea* | Crimson rata | Liana | Aug-Oct | | | 1 | 1 | 1 | | | | | | | |
| Native | *Brachyglottis repanda* | Wharangi | Tree/Shrub | Aug-Oct | | | 1 | 1 | 1 | | | | | | | |
| Exotic | *Salix babylonica* | Weeping willow | Tree | Aug-Sep | | | 1 | 1 | | | | | | | | |
| Exotic | *Borago officinalis* | Borage | Biennial | Sep-May | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Exotic | *Bellis perennis* | English Daisy | Perennial | Sep-Mar-(Aug) | | | x | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Native | *Calystegia tuguriorum* | New Zealand bindweed | | Sep-Mar | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Native | *Linum monogynum* | Linen flax | Perennial | Sep-Mar | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Native | *Leptospermum scoparium* | Manuka | Tree/Shrub | Sep-Mar | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Native | *Pimelea arenaria* | Sand pimelea | | Sep-Mar | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Exotic | *Stellaria media* | Chickweed | Annual | (Jul)-Sep-Feb-(Jun) | x | x | | 1 | 1 | 1 | 1 | 1 | 1 | x | x | x |
| Exotic | *Calystegia sepium* | Pink bindweed | | Sep-Feb | | | | 1 | 1 | 1 | 1 | 1 | 1 | | | |
| Exotic | *Trifolium subterraneum* | Subclover | Herb | Sep-Feb | | | | 1 | 1 | 1 | 1 | 1 | 1 | | | |
| Native | *Kunzea ericoides* | Kānuka | Tree/Shrub | Sep-Feb | | | | 1 | 1 | 1 | 1 | 1 | 1 | | | |

| Biostatus | Botanical Name | Common Name | Life Form | Flowering | Winter/Early Spring | | | | Spring/ Early Summer | | Summer | | | | Early Winter | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | June | July | August | September | October | November | December | January | February | March | April | May |
| Native | *Pittosporum umbellatum* | Haekaro | Tree | Sep-Jan | | | | 1 | 1 | 1 | 1 | 1 | | | | |
| Native | *Dodonaea viscosa* | Akeake | Tree/Shrub | Sep-Jan | | | | 1 | 1 | 1 | 1 | 1 | | | | |
| Native | *Pittosporum ralphii* | Ralph's Kohuhu | Shrub | Sep-Dec-(Jun) | x | | | 1 | 1 | 1 | 1 | x | x | x | x | x |
| Native | *Pittosporum crassifolium* | Karo | Tree | Sep-Dec | | | | 1 | 1 | 1 | 1 | | | | | |
| Exotic | *Lavandula stoechas* | Lavender | Shrub | Sep-Dec | | | | 1 | 1 | 1 | 1 | | | | | |
| Native | *Raukaua edgerleyi* | Raukawa | Tree | Sep-Dec | | | | 1 | 1 | 1 | 1 | | | | | |
| Native | *Aristotelia serrata* | Wineberry | Tree | Sep-Dec | | | | 1 | 1 | 1 | 1 | | | | | |
| Native | *Hedycarya arborea* | Pigeonwood | Tree | Sep-Dec | | | | 1 | 1 | 1 | 1 | | | | | |
| Native | *Beilschmiedia tawa* | Tawa | Tree | Sep-Dec | | | | 1 | 1 | 1 | 1 | | | | | |
| Native | *Pimelea tomentosa* | Pimelea | | Sep-Dec | | | | 1 | 1 | 1 | 1 | | | | | |
| Native | *Pseudowintera axillaris* | Lowland horopito | Tree/Shrub | Sep-Dec | | | | 1 | 1 | 1 | 1 | | | | | |
| Native | *Beilschmiedia tarairi* | Taraire | Tree | Sep-Dec | | | | 1 | 1 | 1 | 1 | | | | | |
| Native | *Weinmannia silvicola* | Kāmahi | Tree | Sep-Dec | | | | 1 | 1 | 1 | 1 | | | | | |
| Native | *Plagianthus regius subsp. regius* | Ribbonwood | Tree | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Exotic | *Corylus avellana* | Hazelnut | Shrub | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Native | *Plagianthus regius* | Ribbonwood | Trees/Shrub | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Cultivated | *Grevillea banksii* | Spider plant | Tree/Shrub | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Native | *Geniostoma rupestre var. ligustrifolium* | Hangehange | Shrub | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Exotic | *Malus ×domestica* | Apple | Tree | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Native | *Plagianthus divaricatus* | Marsh ribbonwood | Shrub | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Native | *Melicope simplex* | Poataniwha | Shrub | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Native | *Freycinetia banksii* | Kiekie | Perennial/Climber | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Exotic | *Eucalyptus pauciflora subsp. niphophila* | Snow gum | Tree | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Exotic | *Rosmarinus officinalis* | Rosemary | Shrub | Sep-Nov | | | | 1 | 1 | 1 | | | 1 | 1 | | |
| Native | *Pomaderris phylicifolia* | Whatitiri | Shrub | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Cultivated | *Hakea saligna* | Pincushion tree | Tree/Shrub | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Native | *Leucopogon fasciculatus* | Mingimingi | Shrub | Sep-Nov | | | | 1 | 1 | 1 | | | | | | |
| Native | *Melicope ternata* | Houkūmara | Shrub | Sep-Oct | | | | 1 | 1 | | | | | | | |
| Native | *Litsea calicaris* | Mangeao, Tanageao | Tree | Sep-Oct | | | | 1 | 1 | | | | | | | |
| Cultivated | *Pyrus communis* | Pear | Tree | Sep-Oct | | | | 1 | 1 | | | | | | | |
| Native | *Pomaderris kumeraho* | Gum-digger's soap | Shrub | Sep-Oct | | | | 1 | 1 | | | | | | | |
| Native | *Astelia solandri* | Kowharawhara | | Oct-Jun | 1 | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Native | *Euphrasia zelandica* | Eyebright | Annual | Oct-Apr | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| Exotic | *Trifolium pratense* | Red clover | Herb | Oct-Mar | | | | | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Native | *Brachyglottis bellidioides* | Brachyglottis | Shrub | Oct-Mar | | | | | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Native | *Pseudopanax colensoi* | Three-finger | Tree/Shrub | (Jun)-Oct-Mar | x | x | x | x | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Native | *Carmichaelia australis* | North Island broom | Shrub | Oct-Feb | | | | | 1 | 1 | 1 | 1 | 1 | | | |
| Native | *Elaeocarpus dentatus* | Hangehange | Tree | Oct-Feb | | | | | 1 | 1 | 1 | 1 | 1 | | | |
| Exotic | *Veronica agrestis* | Speedwell | Annual | Oct-Feb | | | | | 1 | 1 | 1 | 1 | 1 | | | |

| Biostatus | Botanical Name | Common Name | Life Form | Flowering | Winter/Early Spring | | | | Spring/ Early Summer | | Summer | | | | Early Winter | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | June | July | August | September | October | November | December | January | February | March | April | May |
| Native | *Discaria toumatou* | Matagouri | Tree/Shrub | Oct-Jan | | | | | 1 | 1 | 1 | 1 | | | | |
| Exotic | *Digitalis purpurea* | Foxglove | Perennial | Oct-Jan | | | | | 1 | 1 | 1 | 1 | | | | |
| Native | *Metrosideros diffusa* | Rata vines | Liana | Oct-Jan | | | | | 1 | 1 | 1 | 1 | | | | |
| Native | *Elaeocarpus hookerianus* | Puka | Tree | Oct-Jan | | | | | 1 | 1 | 1 | 1 | | | | |
| Native | *Olearia furfuracea* | Tanguru | Tree/Shrub | Oct-Jan | | | | | 1 | 1 | 1 | 1 | | | | |
| Native | *Astelia nervosa* | Kakaha | | Oct-Dec | | | | | 1 | 1 | 1 | | | | | |
| Native | *Pittosporum eugenioides* | Lemonwood | Tree | Oct-Dec | | | | | 1 | 1 | 1 | | | | | |
| Native | *Knightia excelsa* | Rewarewa | Tree | Oct-Dec | | | | | 1 | 1 | 1 | | | | | |
| Native | *Cordyline australis* | Cabbage tree | Tree | Oct-Dec | | | | | 1 | 1 | 1 | | | | | |
| Exotic | *Trifolium incarnatum* | Crimson clover | Herb | Oct-Dec | | | | | 1 | 1 | 1 | | | | | |
| Native | *Alectryon excelsus* | Tokitoki, Titoki | Tree | Oct-Dec | | | | | 1 | 1 | 1 | | | | | |
| Native | *Aristotelia fruticosa* | Mountain wineberry | Tree/Shrub | Oct-Dec | | | | | 1 | 1 | 1 | | | | | |
| Native | *Griselinia lucida* | Pukatea | Tree/Shrub | Oct-Dec | | | | | 1 | 1 | 1 | | | | | |
| Native | *Laurelia novae-zelandiae* | Pukatea | Tree | Oct-Dec | | | | | 1 | 1 | 1 | | | | | |
| Native | *Acaena novae-zelandiae* | Red bidibid | | Oct-Dec | | | | | 1 | 1 | 1 | | | | | |
| Native | *Quintinia serrata* | Quintinia | Tree | Oct-Nov | | | | | 1 | 1 | | | | | | |
| Native | *Quintinia acutifolia* | Westland quintinia | Tree | Oct-Nov | | | | | 1 | 1 | | | | | | |
| Native | *Nestegis cunninghamii* | Black maire | Tree | Oct-Nov | | | | | 1 | 1 | | | | | | |
| Exotic | *Callistemon citrinus 'Splendens'* | Crimson Bottlebrush | | Oct | | | | | 1 | | | | | | | |
| Native | *Syzygium maire* | Swamp maire | Tree | Nov-Jun | 1 | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Exotic | *Polygonum aviculare* | Wireweed | Biennial | Nov-Jun | 1 | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Exotic | *Foeniculum vulgare* | Fennel | Perennial | Nov-May | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Exotic | *Mentha pulegium* | Pennyroyal | Herb | Nov-May | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Exotic | *Medicago lupulina* | Black medick | Perennial | Nov-May | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Exotic | *Lotus angustissimus* | Slender birdsfoot trefoil | Herb | Nov-May | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Exotic | *Trifolium fragiferum* | Strawberry clover | Herb | Nov-May | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Exotic | *Medicago sativa* | Lucerne | Perennial | Nov-May | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Native | *Rhopalostylis sapida* | Nikau palm | Tree | Nov-Apr | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | |
| Exotic | *Malva sylvestris* | Mallow | Herb | Nov-Apr | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | |
| Native | *Brachyglottis perdicioides* | Raukumara | Shrub | Nov-Apr | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | |
| Exotic | *Trifolium hybridum* | Alsike clover | Herb | Nov-Mar | | | | | | 1 | 1 | 1 | 1 | 1 | | |
| Indigenous | *Rumex flexuosus* | Maori dock | Herb | Nov-Mar | | | | | | 1 | 1 | 1 | 1 | 1 | | |
| Native | *Carpodetus serratus* | Marble leaf | Tree | Nov-Mar | | | | | | 1 | 1 | 1 | 1 | 1 | | |
| Exotic | *Eucalyptus regnans* | Swamp gum | Tree | Nov-Mar | | | | | | 1 | 1 | 1 | 1 | 1 | | |
| Native | *Anisotome pilifera* | Alpine carrot leaf | Herb | Nov-Mar | | | | | | 1 | 1 | 1 | 1 | 1 | | |
| Native | *Pseudowintera colorata* | Mountain horopito | Shrub | Nov-Mar | | | | | | 1 | 1 | 1 | 1 | 1 | | |
| Native | *Pennantia corymbosa* | Kahikōmako | Tree | Nov-Feb | | | | | | 1 | 1 | 1 | 1 | | | |
| Native | *Gaultheria antipoda* | Bush snowberry | | Nov-Feb | | | | | | 1 | 1 | 1 | 1 | | | |
| Native | *Melicytus ramiflorus* | Whiteywood | Tree | Nov-Feb | | | | | | 1 | 1 | 1 | 1 | | | |
| Native | *Lophomyrtus bullata* | Ramarama | Tree/Shrub | Nov-Feb | | | | | | 1 | 1 | 1 | 1 | | | |
| Native | *Hoheria lyallii* | Mountain lacebark | Tree | Nov-Feb | | | | | | 1 | 1 | 1 | 1 | | | |

| Biostatus | Botanical Name | Common Name | Life Form | Flowering | Winter/Early Spring | | | | Spring/ Early Summer | | Summer | | | | Early Winter | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | June | July | August | September | October | November | December | January | February | March | April | May |
| Native | *Traversia baccharoides* | Traversia | Shrub | Jan-Feb | | | | | | | | 1 | 1 | | | |
| Native | *Metrosideros fulgens* | Scarlet rata | Liana | Feb-Jun | 1 | | | | | | | | 1 | 1 | 1 | 1 |
| Native | *Schefflera digitata* | Seven-finger | Tree | Feb-Mar | | | | | | | | | 1 | 1 | | |
| Exotic | *Eucalyptus leucoxylon* | White ironbark | Tree | Mar-Nov | 1 | 1 | 1 | 1 | 1 | 1 | | | | 1 | 1 | 1 |
| Exotic | *Eucalyptus rodway* | Rodway Black Gum | Tree | Mar-Jun | 1 | | | | | | | | | 1 | 1 | 1 |
| Native | *Dysoxylum spectabile* | Kohekohe | Tree | Mar-Jun | 1 | | | | | | | | | 1 | 1 | 1 |
| Native | *Astelia trinervia* | Kauri grass | | Mar-Jun | 1 | | | | | | | | | 1 | 1 | 1 |
| Native | *Olearia paniculata* | Akepiro | Tree/Shrub | Mar-May | | | | | | | | | | 1 | 1 | 1 |
| Native | *Astelia banksii* | Horahora | | Mar-Apr-Jun | 1 | | | | | | | | | 1 | 1 | x |
| Native | *Hoheria populnea* | Lacebark | Tree | Mar-Apr-(Jun) | x | | | | | | | | | 1 | 1 | x |
| Exotic | *Chamaecytisus palmensis* | Tree lucerne | Tree | May-Oct | 1 | 1 | 1 | 1 | 1 | | | | | | | 1 |
| | **Total species flowering each month** | | | | **18** | **16** | **26** | **66** | **92** | **119** | **115** | **90** | **72** | **57** | **31** | **21** |

*Figures 4 and 5. A Flowering Calendar for a list of selected candidate native species with flowering time data derived from the national level flowering times. Five Finger is an excellent choice as a spring build up plant.*

The third step is to create a Bee Forage Profile. Once the species diversity profile is complete, the bee forage profile is a new bar chart constructed by creating a new identical matrix but inserting the number of plants for each species to replace the number one in each cell. This is done primarily for the proposed candidate plants that will planted for bee forage as it is often not convenient to enumerate the numbers of all the pre-existing plants. The column totals will now reflect the number of plants for each species for each month. To manipulate the shape of the profile for the bee forage budget simply increase or decrease the numbers of plants for each species accordingly. The bee forage profile will reveal any serious gaps for existing floral resources (if you have this data available and are doing this chart) and will help guide the shape of the bee forage profile for the proposed bee forage plantation.

To Illustrate how to interpret a bee forage profile; a hypothetical example is given in Figure 6 where a sudden pollen deficit occurs in October in the existing flora. This "October crash" is a well-known pollen dearth time that was a widespread problem in both the North and South Islands where farm biodiversity provided insufficient pollen supply after the willows finished flowering but before the clover started flowering. Tree for Bees resolved this problem on our demonstration farms by installing maples, oaks, and ash trees among other October flowering species. Such farm trees flowering in October also provided shade and shelter for livestock and amenity which demonstrates how to use multi-function plants that also feed the bees.

The October crash with the spring time pollen dearth was readily resolved, but it has been much more difficult to resolve cases of pollen or nectar dearth in autumn as shown in the next hypothetical example in Figure 7. The problem here is that our New Zealand flora for both native and exotic plants has very few candidate plants flowering in autumn. Nevertheless, we have discovered some reliable autumn flowering species such as lacebark ***(Hoheria populnea, H. sexstylosa)***, koromiko ***(Hebe stricta),*** and akiraho ***(Olearia paniculata)*** among others and these can be planted in high numbers to provide enough floral resources for autumn and it is often difficult to reach a high diversity score per month for autumn.

To work towards the best shape for the profile in the Bee Forage Profile, the goal is to have few plants flowering in winter (June/July) when the bees should be resting if it is cold, and then rapidly increasing flower availability (especially for pollen) from August to November for spring build-up of the colonies. Flowering plant numbers drop back over summer while bees are on pollination services and/or honey gathering. For example, when mānuka is in flower – see yellow highlighted row for mānuka in Figure 4, competing nectar sources are undesirable so plants flowering at this time should not be selected as candidates unless they provide good pollen with little nectar. Finally, in late summer to autumn, the flowering plant numbers are built up again to prepare the bees for winter. More information and upcoming tools can be found on our website www.treesforbees.org.

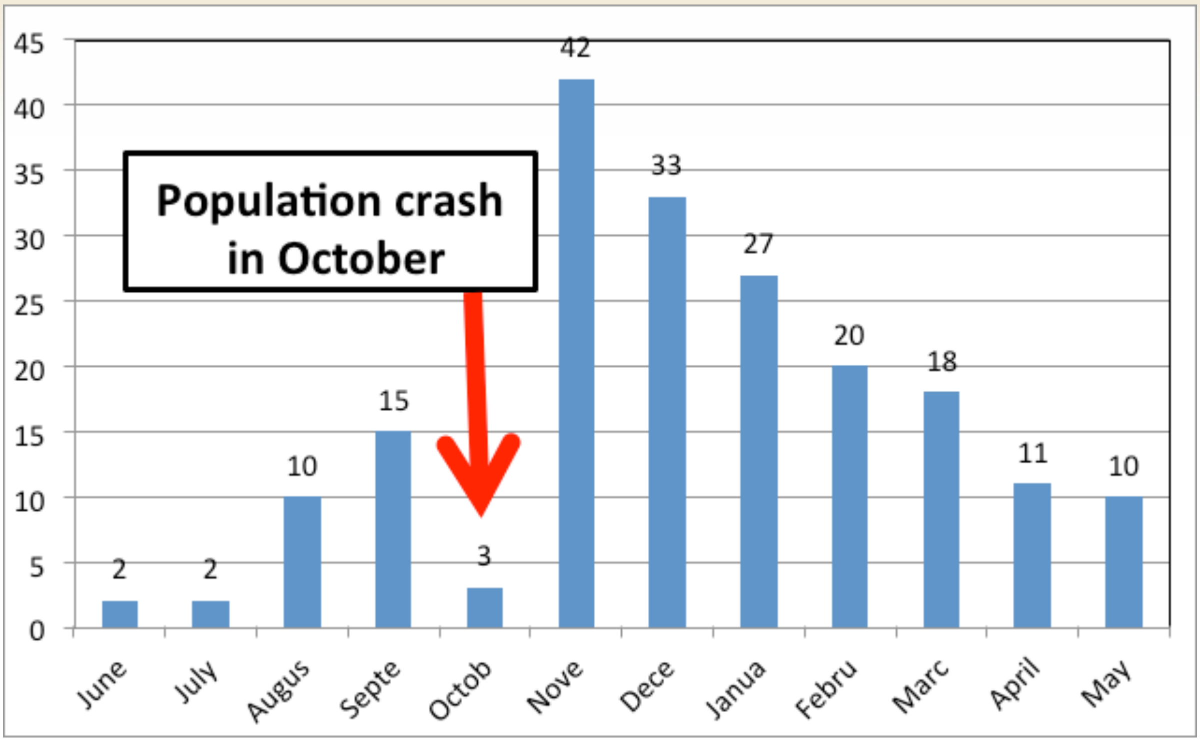


*Figure 6. Hypothetical example of a Bee Forage Profile: This bee forage annual profile chart shows the number of plants from different species that are flowering in each month of the year for one foraging area. This bee forage profile illustrates a serious deficit in October just after two months of spring build-up have occurred.*

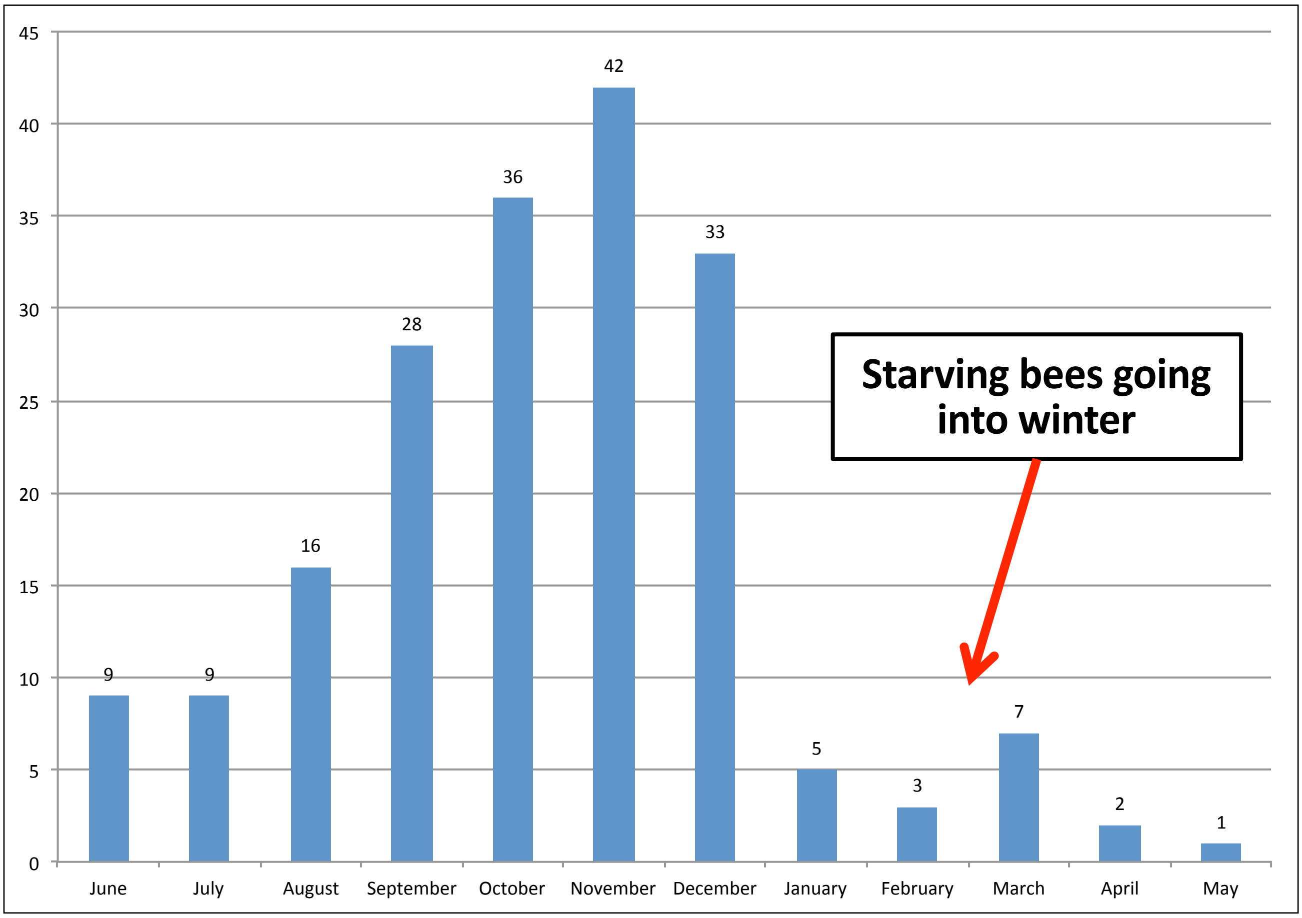


*Figure 7. Hypothetical example of a Bee Forage Profile: This bee forage annual profile chart shows the number of plants from different species that are flowering in each month of the year for one foraging area. This bee forage profile illustrates a serious deficit in late summer through autumn when the winter bees are developing.*

# 3. PLANTING MĀNUKA

Establishing the mānuka plantation itself has several considerations to optimize the honey harvest. This entails working towards high density flowering per plant and the highest flowering surface area per hectare. Spacing of plants, establishment practices for installation and weed and animal pest protection as well as managing establishment costs will contribute to a successful plantation.

### 3.1 Suitable locations for plantation mānuka

When establishing mānuka for honey production, it is important to ensure as far as possible that the site you are selecting is suitable for this purpose. While a site might grow mānuka, it does not guarantee that it will produce a good nectar flow for honey production.

A few key points to consider are:

- Is there some wild mānuka in the area? If not, then the site might not be suited to it. If it is predominantly kānuka, then it might be too dry for mānuka.
- Do local beekeepers collect honey off this wild mānuka, how reliable is the nectar flow and how good is the honey produced?
- When does the wild mānuka flower? When selecting seedlings to plant it is important that they flower when conditions are optimal for nectar production in the area, and this is when the wild mānuka population is flowering.
- Rainfall and temperature are important. While not fully understood, anecdotal evidence suggests that rainfall needs to be over 1600mm per annum, although this may vary by region. In terms of temperature, it is suggested that temperatures in the high teens/low twenties are required during flowering to get a good nectar flow, and again there may be regional variation.
- Having settled weather during the flowering season is also important. If the nectar flow stops during bad weather it can take three days of settled weather for the mānuka nectar flow to start again.

For these reasons it is important that you talk to local beekeepers when considering the suitability of potential planting sites.

### 3.2 Mānuka lifecycle and time to mature

Mānuka is a colonising species, with various estimates of longevity between 30 and 60 years, growing through to 5-6m in height and 2-4m in width at maturity. It is generally recognised that planted mānuka doesn't start fully flowering until about 6-7 years of age, when it will typically be 2-3m in height and 1-2m in width. It is therefore at this stage through to maturity that should determine the appropriate spacing for mānuka seedlings.

The opportunity does exist for the plantation owner to manage the mānuka as an orchard, thinning out (removing) surplus plants, side trimming and topping them to promote new growth and manage plant size, and clearing defined areas to establish a mix of "age classes" and floral profiles. The extent to which this is feasible will depend on the productivity of the plantation, mānuka honey yields and financial returns, and the cost of these management options. The plantation will naturally revert to native bush over time and this will need to be managed if honey production is to be maintained.

### 3.3 Mānuka plant spacing

No firm guidelines exist for the correct spacing of mānuka seedlings in plantations to maximise flowering. Native plant restoration (revegetation) planting systems can use plant spacing (stocking) as high as 2,500-4,444 stems per hectare (sph), (refer Boffa Miskell 2017). Government and Council-funded programmes (e.g. Afforestation Grant Scheme, Erosion Control Funding Programme) for land stabilisation and riparian protection typically have a minimum stocking specified of at least 1200sph. Elsewhere, planting stocking of 1100-1600 sph has been promoted, with the higher stocking suggested to maximise flowering at an early age. Up to 2500 sph has also been promoted for producing mānuka oil, and in other cases as low as 825 sph has been established where the landowner wanted bushy mānuka plants to maximise flowering surface area.

An important consideration when determining plant spacing is how to maximise flowering surface area per hectare in order to obtain the highest possible honey yield. As noted above, for some this is interpreted as planting more seedlings, and for others planting fewer. When assessing maximum flowering surface area, it is important to understand the life cycle of mānuka, and in particular when it exhibits maximum flowering.

A further consideration is that you don't want full canopy cover in your mature mānuka plantation. Full canopy cover is counterproductive because you will only get top canopy flowers and not flowers on the sides of plants, which are shaded, and so flowering surface area per hectare is reduced. Plant layout is also a consideration to maximise effective flowering surface area, with the preferred options being the offsetting of plants established in rows, or wider spaced rows and closer spacing within rows, and the rows aligned to the sun.

While lower to medium stocking rates are recommended if you are seeking to grow mānuka for honey production only, it may be beneficial to use higher stocking rates for oil production where you are on easy contour land which allows machine access and you can mechanically harvest the mānuka for oil.

Table 1 shows an outline of the range of establishment stocking options suggested for mānuka plantations for honey production, together with an estimate of surface flowering area at age 4 years and at maturity – assumed here to be 5m high and 3m diameter (McPherson and McPherson 2017). As manuka reaches 5-6m in height at maturity and 2-4m in width, it is important to have a plant spacing that accommodates this mature size to maximise flowering surface area for the life of the plantation.

| Stocking (sph) | Square spacing (m) | Row spacing (m) | | Flowering Surface Area (m2/ha) | |
|---|---|---|---|---|---|
| | | Between rows | Within rows | Age 4 | Mature |
| 625 | 4 x 4 | 8 | 2 | 2,024 | 13,971 |
| 825 | 3.5 x 3.5 | 6 | 2 | 2,672 | 15,702 |
| 1100 | 3 x 3 | 4.5 | 2 | 3,562 | 17,386 |
| 1600 | 2.5 x 2.5 | 3 | 2 | 3,847 | 14,819 |
| 2500 | 2 x 2 | 3 | 1.3 | 3,844 | 11,191 |
| 4444 | 1.5 x 1.5 | 2.5 | 0.9 | 3,709 | 9,438 |

*Table 1. Influence of mānuka plant spacing on estimated flowering surface area at age 4 years and at maturity.*

Therefore, while flowering area is highest at age 4 years for the higher stocking levels of 1600-4444 sph, this is before the plants reach an age where they start fully flowering, and is while the plants are still to reach their mature size. Once they have done so, maximum flowering surface area is achieved by lower to moderate stocking rates of 825-1100 sph. Note that this doesn't include the cost of establishment at these different spacings, which affects the cost per m² of flowering area, and this is addressed below. On the basis of flowering surface area, and taking into account that maximum flowering doesn't start until the plants are 2-3m tall and 1-2m wide, we would recommend 1100 sph as an upper limit (or 1200 sph to allow for 10% seedling loss), but note that stocking lower than this achieves acceptable flowering surface area (McPherson and McPherson, 2017).

The following photos (Figures 8 and 9) show mānuka seedlings at age 4 years on the East Coast. These were established at 1200sph, with the site grazed before planting, a single spot spray for weed control at the time of planting and no subsequent weed control. Note that while there is grass regrowth this is not impeding the plants. The seedlings at this age are now reaching 2.5m in height and 1m in diameter and are currently flowering almost to ground level. While there is still plenty of space between plants, by the time they reach a mature size of 5-6m height and 2-4m diameter, most of the site will be occupied by the mānuka, but there will still be sufficient space for them to flower deep into the crown (i.e. on the sides of the plant), maximising flowering surface area per hectare.

*Figure 8. Mānuka plantation, East Coast at four years old. Established 2012 at plant stocking rate of 1200 sph.*

*Figure 9. Mānuka plantation, East Coast, established 2012. Four-year-old mānuka plant has grown well above grass competition.*

*Photos: Kauri Park Nurseries*

### 3.4 Mānuka plant protection for weeds and pests

Weed control is essential for the successful establishment of mānuka plantations, and the key to success is good weed control prior to and at the time of planting to give the mānuka seedlings the best chance of survival and fast early growth. If this is achieved, then the mānuka should keep ahead of any weed species and you should not require any further weed control. In some cases (e.g. tobacco weed), it may be necessary to undertake further weed control, but this should be assessed on a case by case basis.

If planting on a former pasture site graze the area hard before planting to get the grass as short as possible. You then have the option to pre-plant or post-plant spot spray to control grass regrowth. Depending on the weed species, you may only require a glyphosate-based herbicide, but if hardier weeds are present then a residual might also be necessary. Care must be taken with residual herbicides that the recommended stand-down time before planting is observed, so as not to adversely impact on the survival and growth of the mānuka. Your planting advisor should be able to assist with recommendations.

You should only require a further release spray during late spring/early summer if there is strong grass growth that threatens to smother the mānuka seedlings. If pre-plant grazing isn't possible you still have the option of a pre/post-plant spot spray or a pre-plant blanket spray. Spot spraying is preferred, as it doesn't remove all the vegetation cover.

If planting on a former forest site, or in areas where there are aggressive weeds such as gorse, blackberry and other woody weeds, then an aerial pre-plant spray including a residual herbicide will be necessary. This is because you will have limited opportunities for release spraying after planting, due to the nature of the weeds and the chemicals required, and that mānuka seedlings can be extremely hard to locate when small. While gorse is seen by some as a problem species, if it is effectively controlled prior to planting and the mānuka seedlings are established effectively, then having some gorse regrowth coming up behind the mānuka can actually be beneficial to the beekeeping operation. This is because gorse flowers before the mānuka and is an extremely effective source of pollen for spring build-up of bee colonies. It enables the beekeeper to locate their hives adjacent to the mānuka before it comes into flower, knowing that the colonies will be in good shape once the mānuka starts to flower. As the mānuka grows it will ultimately overshadow the gorse.

Animal pest control prior to planting is critical for successful mānuka establishment, and this also extends to ensuring livestock are excluded from the planting area. Key pests include deer, goats, possums, hares and rabbits, and it only takes a small number of any of these to wreak extensive damage. Where possible, a pre-plant shooting, trapping and/or poisoning programme is essential to ensure pest numbers are as low as possible. Ongoing pest control is also important to keep numbers under check.

### 3.5 Mānuka plantation establishment costs

A further consideration for plant spacing is establishment cost, with this increasing proportionately with the number of seedlings planted. The cost of establishing mānuka plantations will have a significant bearing on the economic returns to the party covering the cost of establishment, and so must be kept within reasonable bounds. Furthermore, since plantation mānuka is most likely to be established on marginal farm land, then its key land-use competition will likely be plantation forestry investment. In this context, the cost of establishing mānuka plantations needs to be largely consistent with that for plantation forestry investment. What this requires is the investor to think more along the lines of plantation forestry in terms of seedling, planting and weed control methods and costs.

With seedlings, this means using smaller grade root trainer or plant cells to keep plant costs down (around $0.75/plant). If well grown and conditioned and combined with effective weed control, then the seedlings will be well established by the time weed growth recommences and should stay ahead of the weeds. For the planting of these seedlings, the use of smaller grade plants will enable planting costs to also remain at an acceptable level of around $0.70/plant. Fertiliser tabs can be included here at approximately $0.10/plant.

Pre-plant weed control is essential for successful seedling establishment, whether this be grazing and spot spray, or blanket aerial spraying. Costs can vary from $0.35/seedling for spot spraying up to $500/ha for aerial blanket spraying of difficult weed species. Effective pre-plant weed control is also important

| Stocking (sph) | Seedlings | | Planting | | Fert tabs | | Pre-plant | Planting | Releasing Costs | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $ | 0.75 | $ | 0.70 | $ | 0.10 | control | cost/ha | Year 1 | Years 2-5 |
| **625** | $ | 469 | $ | 438 | $ | 63 | $ 500 | $ 1,469 | $ 219 | $ 1,750 |
| **825** | $ | 619 | $ | 578 | $ | 83 | $ 500 | $ 1,779 | $ 289 | $ 2,310 |
| **1100** | **$** | **825** | **$** | **770** | **$** | **110** | **$ 500** | **$ 2,205** | **$ 385** | **$ 3,080** |
| **1600** | $ | 1,200 | $ | 1,120 | $ | 160 | $ 500 | $ 2,980 | $ 560 | $ 4,480 |
| **2500** | $ | 1,875 | $ | 1,750 | $ | 250 | $ 500 | $ 4,375 | $ 875 | $ 7,000 |
| **4444** | $ | 3,333 | $ | 3,111 | $ | 444 | $ 500 | $ 7,388 | $ 1,555 | $ 12,443 |

*Table 2. Plantation establishment and releasing costs for different plant stocking rates.*

from a cost management perspective, as repeated release spraying operations quickly mount up in cost (for example, the twice-yearly release spray for 3-5 years as suggested by a revegetation planting model (Boffa Miskell, 2017).

Table 2 shows a summary of the impact of stocking rates on establishment and ongoing releasing costs. At 1100sph, the total cost of pre-plant weed control and planting should be about $2,205/ha, with the possibility of a further $385/ha if a single release spray is required after planting. This reduces to $1,469-$1,779/ha for lower stocking (plus year 1 releasing of $219-$289/ha), and more than doubles to $4,375-$7,388/ha for the revegetation planting stocking recommendations of 2500-4444 sph (plus year 1 releasing of $875-$1,555/ha).

If release spraying is required following planting, a single release spray will add about 15-20% to establishment costs, which, if required, is accepted practice in plantation forestry. However, extending this to twice-yearly releasing for up to 5 years after planting more than doubles the cost of establishment, and is not considered financially viable.

Returning to the question of plant spacing and flowering area, the data presented earlier is combined in Table 3 with establishment and year 1 releasing costs to calculate the cost per square meter of flowering surface area. The costs are represented as the cash cost of establishment and releasing, as well as their compound cost to age 10 years (at 4% compound rate), to reflect the value of that cash cost over time.

Table 3 shows that while there is no great difference in the estimated flowering surface area at maturity between 825 and 1600 sph, the cash cost per m² of flowering surface area almost doubles between 825 and 1600 sph from $0.13/m² to $0.24/m². The ratios remain the same if you look at the costs compounded for 10 years.

There are a number of other factors to consider for managing flowering surface area, including aspect, seedling survival rates, the nature of any weeds on the site, and the ability to manage the crop through thinning and trimming. Nevertheless, plant spacings at the lower end of the spectrum (825-1100 sph) are the most effective for flowering surface area and the most cost effective, whereas higher plant stocking rates for revegetation type plantings of 2500-4444 sph do not maximise surface flowering area and are 3-6 times the cost per unit flowering surface area.

| Stocking (sph) | Flowering Surface Area (m2/ha) | Cost per ha | | Cost/m2 Flowering Surface Area | |
|---|---|---|---|---|---|
| | | Cash | Compound | Cash | Compound |
| **625** | 13,971 | $ 1,688 | $ 2,498 | $ 0.12 | $ 0.18 |
| **825** | 15,702 | $ 2,068 | $ 3,060 | $ 0.13 | $ 0.19 |
| **1100** | 17,386 | $ 2,590 | $ 3,834 | $ 0.15 | $ 0.22 |
| **1600** | 14,819 | $ 3,540 | $ 5,240 | $ 0.24 | $ 0.35 |
| **2500** | 11,191 | $ 5,250 | $ 7,771 | $ 0.47 | $ 0.69 |
| **4444** | 9,438 | $ 8,944 | $ 13,239 | $ 0.95 | $ 1.40 |

*Table 3. Influence of plant stocking rate on cost per unit estimated potential flowering surface area.*

# 4. APIARY AND BEE FORAGE LOCATION AND PLANTING

Planning and installing apiary sites and bee forage in support of mānuka plantations requires a diverse set of skills and experience, and you may need to involve a number of the following: landowner, farmer, nursery, planting advisors, and beekeeper. Consulting an experienced beekeeper in your region is a very useful first step.

**4.1 Locating apiary sites**

There are a number of factors to consider in establishing apiary locations near the mānuka plantation and in relation to bee forage plantings. These include whether the apiaries are to be stationary (year-round) or moved into the mānuka site from over-wintering and/or spring build-up sites nearby. If they are seasonally relocated off the property then over what period of time will the hives be on the property, as this will influence the planned flowering period to support bees on the property, and raises the question of how the spring and autumn forage needs are met elsewhere and the costs. Specific requirements around apiary locations need to be considered, so any protection planting required and autumn/early spring forage near the apiary sites can be planned.

The optimal arrangements of stationary (residential) or seasonal (alternating) apiary sites combine the best alternatives for summer mānuka honey flow and the spring and autumn forage supply. The residential system is best because it eliminates moving the bees which carries a labour cost and disrupts the bees. The apiary system however may require moving the bees to avoid harsh microclimates in some seasons (for example, too cold in the winter, too dry or windy in the autumn). Other systems may require moving bees for one season from the accompanying land use or farm operations, for example, pesticide use or nuisance to human activities nearby. Each situation will be different and the logistics are best worked out in collaboration between an experienced/local beekeeper and the landowner at the site(s).

In general, the following factors in descending order of importance are critical for a good apiary site, in addition to having good levels of bee forage with a lack of competition from other apiaries.

1. Shelter from cold and prevailing winds.
2. Sun for much of the day including low angle sunlight in winter for over wintering sites.
3. Good access.
4. A site elevated away from potential flooding.
5. Good air drainage to avoid cold air sinks and excessive shading.
6. Fresh water available.

All of these factors are rarely found in an unmodified site so consideration should be given in planning to engineer and adapt any given site to take into account of any of these six factors that may be missing.

The most important factor to consider when evaluating apiary options is the level of your beekeeper's skills in terms of past experience in beekeeping in your local region where the climatic changes, weather patterns, and existing local flowering times and nectar and pollen sources are well understood. A good site for the apiary in terms of protection and warmth for the bees can be more important than the distance to the mānuka plantation and bee forage areas. Having a skilled and experienced beekeeper who understands the local climate and flowering times and how to manage the hives in the region is crucial first step in identifying and establishing the location of apiary sites.

The location of the apiary site should also take into consideration the needs of the other land users at the site, especially cropping that uses pesticides, animal husbandry operations and human movements.

**4.2 Bee forage location and composition**

Once the beekeeper has decided where to place the apiary site, then the location of the bee forage plants can be determined. Establishing bee forage to support the colonies in your apiaries needs to follow the phases of the bee colony's demand for pollen and nectar through the year (Figure 1). Many beekeepers are planting year-round forage to supply fresh natural pollen and nectar because it is the least expensive and best source of nutrition for the bees.

It is best to locate bee forage plants to be installed as near to the apiary site as possible especially for the key sources for autumn and early spring forage. Apiary sites need to be sheltered from the prevailing wind, and open to the north so they receive good daily sun, particularly in winter. Therefore at least some of the bee forage shelter species for the prevailing wind should be evergreen, and these can be tall species if they are located to the south of the apiary. To the north any taller plants should be located further away, and ideally be deciduous to reduce the risk of winter shading. Smaller shrub and herb species can be used as hedging closer to the hives, leaving enough space for access and vehicle movement to service the hives.

Using the apiary site for the late summer/autumn flowering will promote colony survival through winter because the distance to the forage is short. During autumn and winter seasons, the days are shorter and the weather can be more variable with sudden changes to harsh conditions that compromise the bee's return flight to the hive. It is best to keep the bees foraging much closer to the hive so that they can maximise the number of trips to and from the hive and minimise the risk of being caught out by a weather change.

Species for early spring should also be located near the apiary sites, to minimise the flying time for bees at this critical time of year when the colony is building up its population size and the weather may be changeable. Apiary shelter is a key area to locate these species. Other suitable sites for spring time bee forage planting include riparian zones, land stabilisation planting, wet areas and other sites where the mānuka isn't being planted.

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 maximize the chance that the flower patch will be discovered by the bees as noted above. Larger size trees can be interplanted at wider spacing amongst shrub species.

Consideration also needs to be given to a number of other factors, including landowner pollination requirements (e.g. clover pasture, fruit/vegetable crops, home orchard/garden), and any requirements for biodiversity and habitat benefits (e.g. support for native bees and other insects, native birds, etc.). This includes the extent and type of any exotic bee forage species and native bush on the property or nearby, which will influence the planned flowering period to support bees on the property, and whether consideration should be given to secondary benefits such as fruit/seeds for birds.

Both native and exotic plant species are suitable bee forage. Native plant species are preferred where the plantation is adjacent to existing native forest, or for establishing support bee forage in native forest mānuka areas. This is because of the risk of exotic species spreading into the native forest, but care should also be taken to use plants local to the area you are planting (i.e. eco-sourced). Exotic species are a suitable choice in modified environments (e.g. on farms), or where they fill a critical need and the risk of spread can be managed.

### 4.3 Using flowering calendars to create bee forage profiles

Management of floral resources to support hive development is critical for all beekeepers. This covers not only spring build-up, but also managing flowering resources during the pollination services and honey harvesting seasons, and enabling colony recovery in autumn in preparation for over-wintering.

As noted earlier, the annual bee forage budget has been estimated by Seeley (1995) who reports that the annual hive requirements are approximately as follows:

- 20 kg pollen (pre-digested by nurse bees fed to queen, brood, and other workers)
- 120 kg nectar (energy for all life stages, stored as honey, produce wax -- 5 gm nectar gives 1 gm wax)
- 25 litres water (evaporative cooling of hive and vital for nurse bees for royal jelly)

To address the pollen and nectar resource needs of bee colonies, Trees for Bees has developed the flowering calendar concept into a matrix tool and profile charts that can be used to assist with planning and establishing bee floral resources. As described above, this tool can be used to assess existing floral resources, and to plan planting programmes to meet overall bee forage objectives.

*Hoheria in flower - Kintail*

The following example shown in Figures 10 to 12 from a case study demonstration farm outlines how to use the tools to design bee forage planting to support mānuka plantation establishment. This data is based on an actual planting programme in Hawke's Bay. The expected flowering time for the mānuka is late January/February. In this situation, there is existing native species riparian planting with predominantly spring and summer flowering species, but with insufficient autumn flowering species. A bee forage flowering calendar was designed to address these gaps, so that the overall flowering calendar was more balanced.

**Existing Plantation Bee Forage Profile.** The key issues here are the high number of plants flowering in January, and the almost total lack of late summer/autumn flowering species. The large number of species flowering during the mānuka season may be in competition with the mānuka flowers so no more summer flowering plants are desired. The existing species will supply pollen and hopefully not too much nectar such that the mānuka nectar harvest becomes diluted.

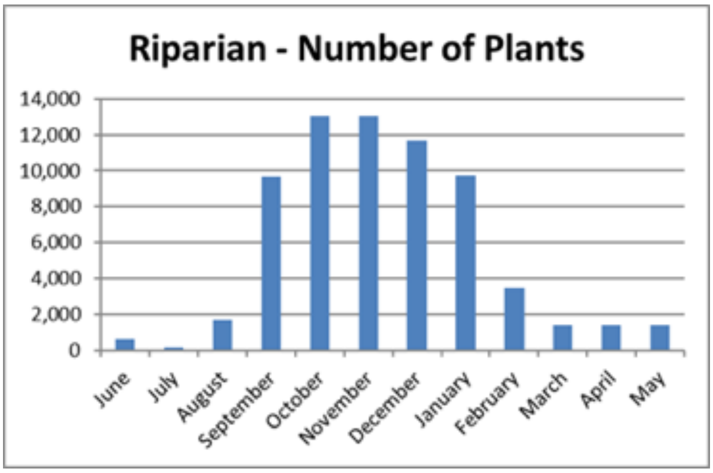


*Figure 10. Bee forage profile for existing riparian planting.*

**Proposed Bee Forage Plantation Profile.** To reshape the flowering calendar profile, Trees for Bees focussed on spring, late summer and autumn-flowering species, both in terms of number of species, but in particular with the number of later summer and autumn flowering plants, including exotic species. The shape of the flowering calendar profile is therefore "engineered" by using a larger number of plants for the species flowering at the critical times of spring and autumn.

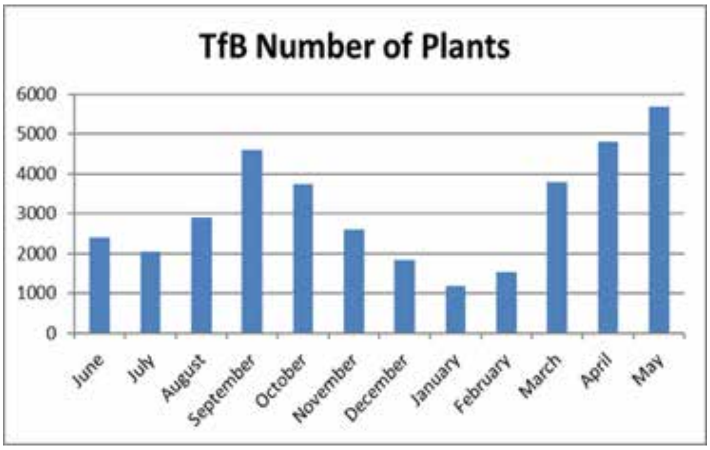


*Figure 11. Bee forage profile for proposed planting.*

**Cumulative Total of Both Existing and Proposed Bee Forage Profile.** The combined effect of the riparian and bee forage calendars is to have a more balanced profile to match the bee demand, with strong spring and summer build-up, dropping off in February, and then an increase in flowering a gradual build up from March to May.

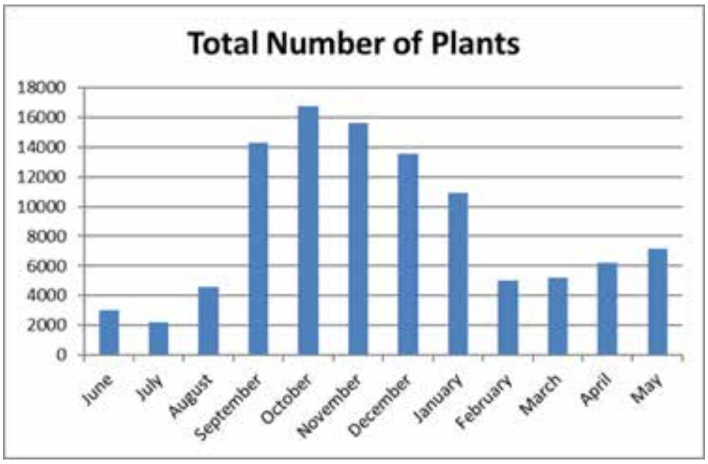


*Figure 12. Bee forage profile for combined plantings of both.*

#### 4.4 Bee forage plant spacing

The general principle is to space plants to ensure they can grow to their full size and maximum flower area without being crowded. Too close so that the sides of the plant are shaded for species that require full or partial sun for flower bud induction and for flower bud break will result in the problem of flowers only at the top of the canopy which is counterproductive.

As a rule, larger trees are planted 8-10+ metres apart, medium trees 6-8m, and shrubs 3-4m. Native species tend to be planted at around 1,000 sph, and exotic species at 500-1,000 sph, depending on the mature size of the plants. Where wider spacing is used, ground cover such as perennials and herbs can also be established among the trees and shrubs. For hedges and shelterbelts, plants are spaced around 1.5m apart in a single row, or two offset rows with the plants in each row 3m apart. Specific designs are shown at www.treesforbeesnz.org.

Unless planting a hedge/shelterbelt, try to avoid planting trees in straight rows. Stagger them a little to help make it look more natural.

#### 4.5 Bee forage plant protection weeds and pests

Animal pest control prior to planting is critical for successful bee forage establishment, and as noted earlier this also extends to ensuring livestock are excluded from the planting area. Key pests include deer, goats, possums, hares and rabbits, and it only takes a small number of any of these to wreak extensive damage. Pests such as possums feed on the most palatable plants in descending order and can have a huge impact on honey production when they are removed (Mowbray, 2002). As with mānuka plantation planting, a pre-plant shooting, trapping and/or poisoning programme is essential to ensure pest numbers are as low as possible. Ongoing pest control is also important to keep numbers under check.

Where there are small numbers of bee forage species being planted, individual tree guards can protect seedlings from browsing rabbits, hares and possums. Tree guards can help keep pests away from the plants and come in a range of styles and sizes. Small plastic sleeve/tube guards are suited to small shrubs as well as tall seedlings and poles. The sleeves also protect the plant from any spray drift when applying herbicides for weed control. For larger specimen trees, reinforcing steel guards or wooden tree guards can be constructed to keep stock and larger pest animals from damaging the plants.

As with pest control, weed control is essential for the successful establishment of bee forage support planting and the key to success is good weed control prior to and at the time of planting to give the seedlings the best chance of survival and fast early growth. If this is achieved, then the bee forage plants should keep ahead of any weed species, although subsequent weed control may be required and can be assessed on a case by case basis.

Weed control options for bee forage species are much the same as for the mānuka plantation as described above. For bee forage support species applying mulch can assist weed control, and if blanket spraying is undertaken, then you have the option of sowing a ground cover bee forage species (e.g. borage, phacelia, and some clover species).

#### 4.6 Bee forage plantation establishment and costs

The time to plant bee forage is ideally in winter, especially for bare-rooted plants, although mānuka and other native species can be successfully established in autumn if pest control is good – otherwise the pests will see these as a useful forage source over winter. Spring establishment of root trainer or bagged plants is also feasible, although you run the risk of plants not being properly established ahead of a potentially dry summer.

For cultivation and establishment of the bee forage plants, standard planting practices are followed. Use your spade to remove the grass turf where you want to plant your shrub/tree. Open up 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.

Place your plant in the hole and place the soil back around it. Make sure the plant isn't 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/foot to keep it stable, but don't stamp around the plants as you can damage the roots. Do not leave an air pocket around the roots however.

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 so that its roots can strengthen.

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 come with fertiliser. Depending on the plants purchased and the number to be established, additional slow release fertiliser tabs can be used.

The cost of establishing bee forage species depends on the number, type and size of plant being established, and whether they require tree guards, fertiliser tabs and pre-plant spraying. For native species, the cost per plant established is typically $5-6/plant, which at 1,000 sph is $5-6,000/ha. For exotic species, the cost per plant established for smaller grade plants is typically $5-15/plant, and assuming 500-1,000 sph and an average cost of $10/plant this comes to $5-10,000/ha. Therefore, as a rule of thumb you should be budgeting on $5-10,000/ha for your bee forage planting, and considering a balance of native and exotic species to meet you forage requirements in a cost-effective manner. As a general guideline you should be establishing at least 10% of your plantation area in bee forage.

# 5 ESTIMATING ECONOMIC RETURNS

This section describes and illustrates a number of success factors that impact on mānuka investment returns, from variability in yield, activity and costs, through carrying capacity and the types of arrangements entered into by landowners and beekeepers. Understanding these and their potential influence on returns is a critical aspect of planning a mānuka plantation and honey ventures. Further analysis of these impacts is given in McPherson (2016 and 2017).

The business case for plantation mānuka is driven by strong demand and high prices for mānuka honey, along with the expectation of higher yields and activity from plantation mānuka with improved cultivars. This section doesn't predict yields or returns, as these vary on a case by case basis, but rather outlines some of the key parameters that investors, landowners, and beekeepers need to understand in order to invest in an informed manner.

### 5.1 Variability in yield and quality of honey

The first parameters to understand are the inherent annual variability in mānuka honey yield (in kg honey per hive) and in the activity level of the honey. This is because there are a number of factors that impact honey yield and activity levels – the weather influences flowering intensity and the flow of nectar as well as colony growth and bee behaviour in relation to the timing of mānuka nectar flow, and any competitor flowering, (timing and intensity of flowering as well as nectar flow) and external conditions such as overcrowded or overstocked apiaries within the foraging range. The correct siting of apiaries as outlined in 4.1 has a considerable effect on honey yields as well.

The following graphs illustrate the degree of variability at two individual sites harvesting mānuka honey in the North Island and are based on actual data (for further details see McPherson 2017). Therefore, while each site will have its own characteristics you can be certain that yield and activity will vary from year to year, sometimes significantly, and you need to factor this into your cash flow projections. While these sites are for natural forest mānuka, the influence of the factors impacting yield and activity outlined below will apply equally to plantation mānuka.

Variability in honey yield at these two sites is by as much as +60% to -80% of average production (defined as 100%), and varies markedly from year to year. Factors likely to influence this yield variability are the extent and timing of flowering and weather conditions, resulting in either insufficient nectar being produced and/or the bees being unable to collect enough nectar. Increasing competition and overcrowding around mānuka resources will limit the amount of nectar able to be collected by each apiary as explained above.

Honey activity will also be influenced by the quality and timing of mānuka flowering and weather conditions during nectar production and the honey harvest. The activity level can be influenced by dilution of the mānuka honey from nectar collected from other flowering species.

Looking at the variability shown in the above graphs, we can then look at what impact this might have on beekeeping returns. The following table (Table 4) shows a possible range of variability in honey yield (kg/hive) and activity (here reflected in the price of honey in $/kg). In addition, variability in annual

| Factor | Base Case | Minimum | Maximum |
|---|---|---|---|
| **Yield (kg/hive)** | 30 | 6 | 48 |
| **Price ($/kg)** | $ 30 | $ 5 | $ 60 |
| **Costs ($/hive)** | $ 300 | $ 100 | $ 500 |

*Table 4. Yield, cost and price variables for mānuka honey production.*

hive management costs are included, which reflect the range currently being reported by beekeepers.

Net income per hive (sales less costs) are calculated based on the factors in Table 5, with 100% being net income at the base case yield, price and cost assumptions. Each factor is tested by calculating the change in net income for the minimum and maximum value for that factor, with the other factors remaining at their base case value. This enables you to determine which factors have the greatest impact on net income. The results are shown in the following graph (Figure 15).

From this we can see that changes in yield and price have a significant impact on net income, with the change in net income being larger than the change in yield or price. Note that yield can have a greater negative impact as yield can be zero, whereas price is unlikely to reach zero. While costs do have an impact, the degree of change (± 67%) results in less than 50% change in net income and so it is less significant than yield or price.

Furthermore, while the beekeeper can have some influence over yield and price (as a proxy for mānuka honey activity) through having well located apiary sites, good apiary management and adequate bee forage support plants, much of this is still beyond their control because of variability in flowering behaviour, nectar production and weather conditions. It is therefore vital that some resilience is built into the beekeepers' and plantation owners' businesses to accommodate this variability.

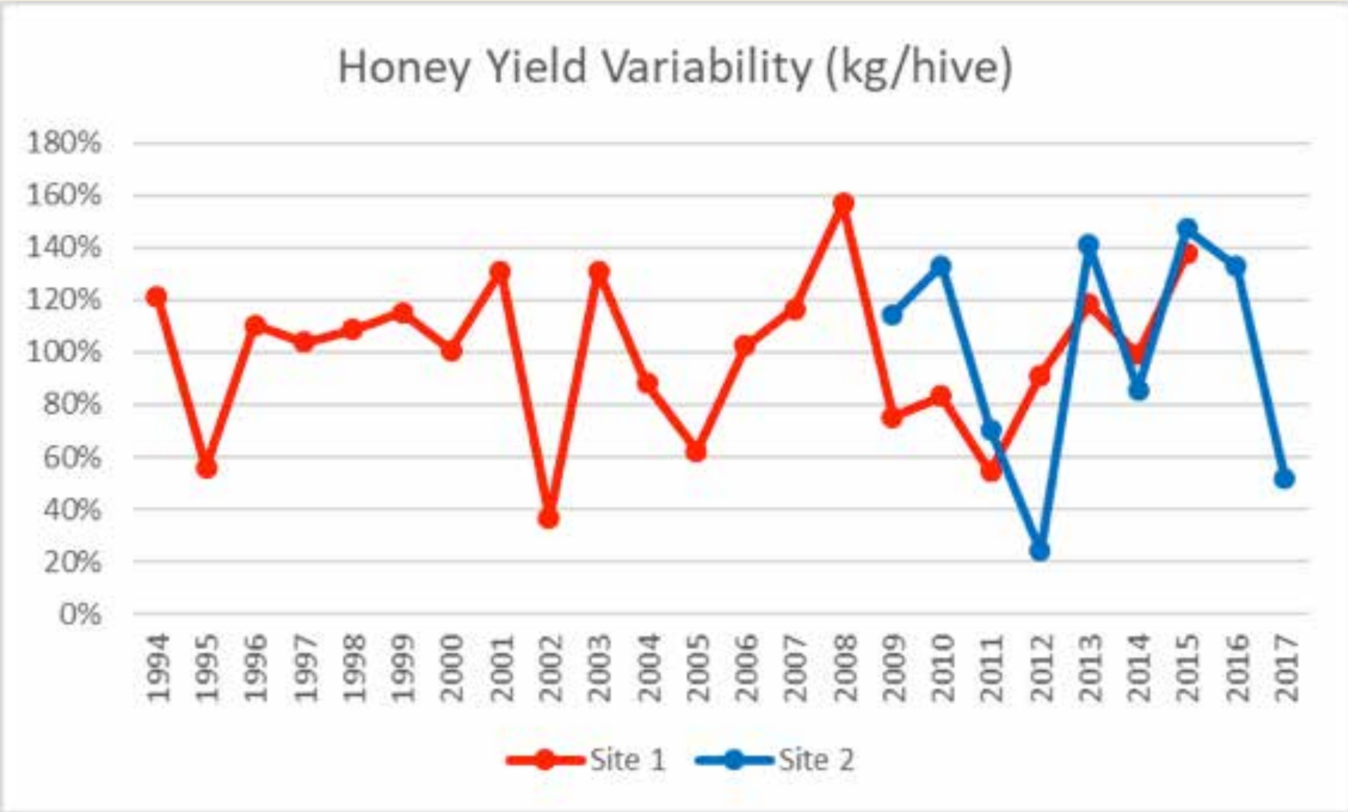


*Figure 13. Variability of the honey yield at two sites in New Zealand. Scores show above and below the long-term average which is at 100%.*

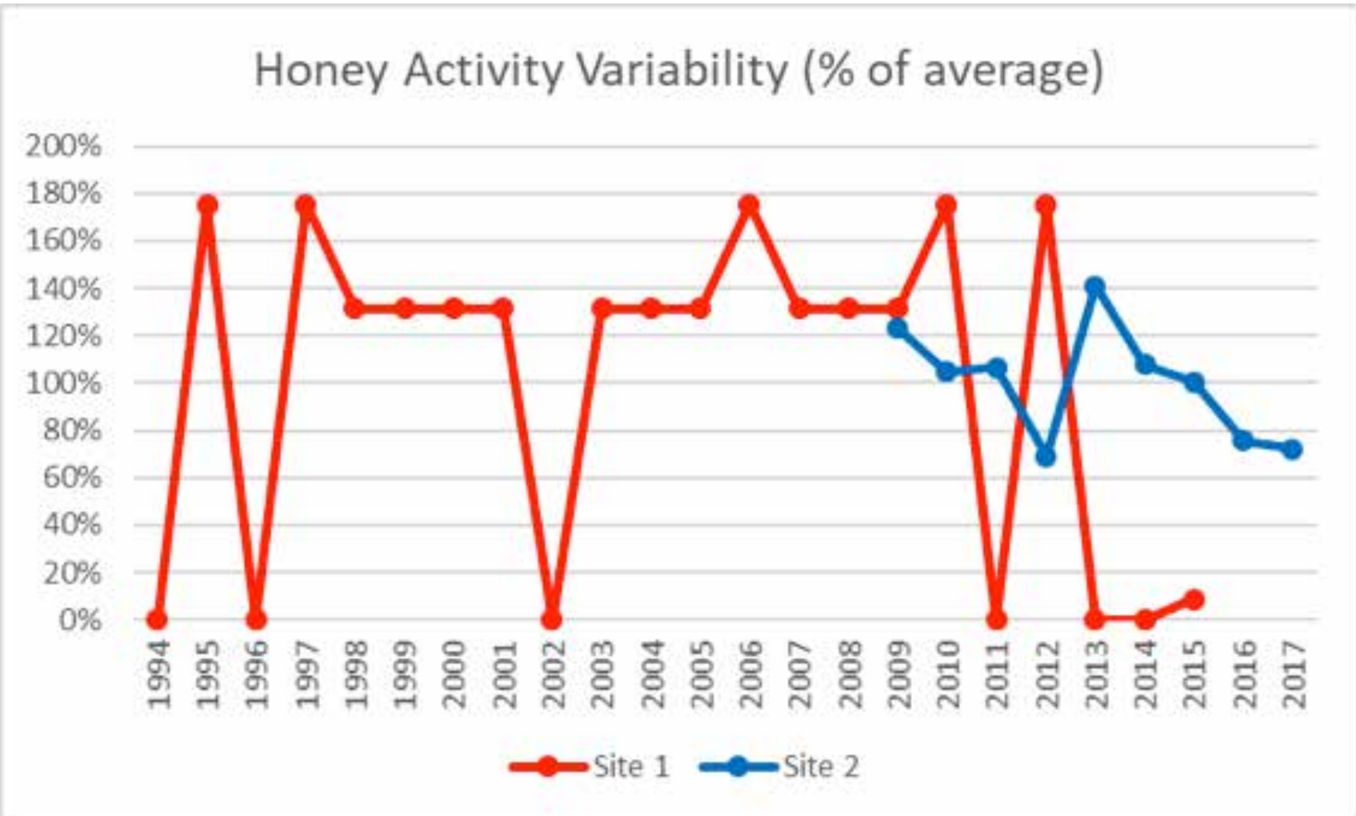


*Figure 14. Variability of mānuka honey bio-activity at two sites in New Zealand. Scores show above and below the long-term average which is at 100%. 0% activity means no active honey was collected.*

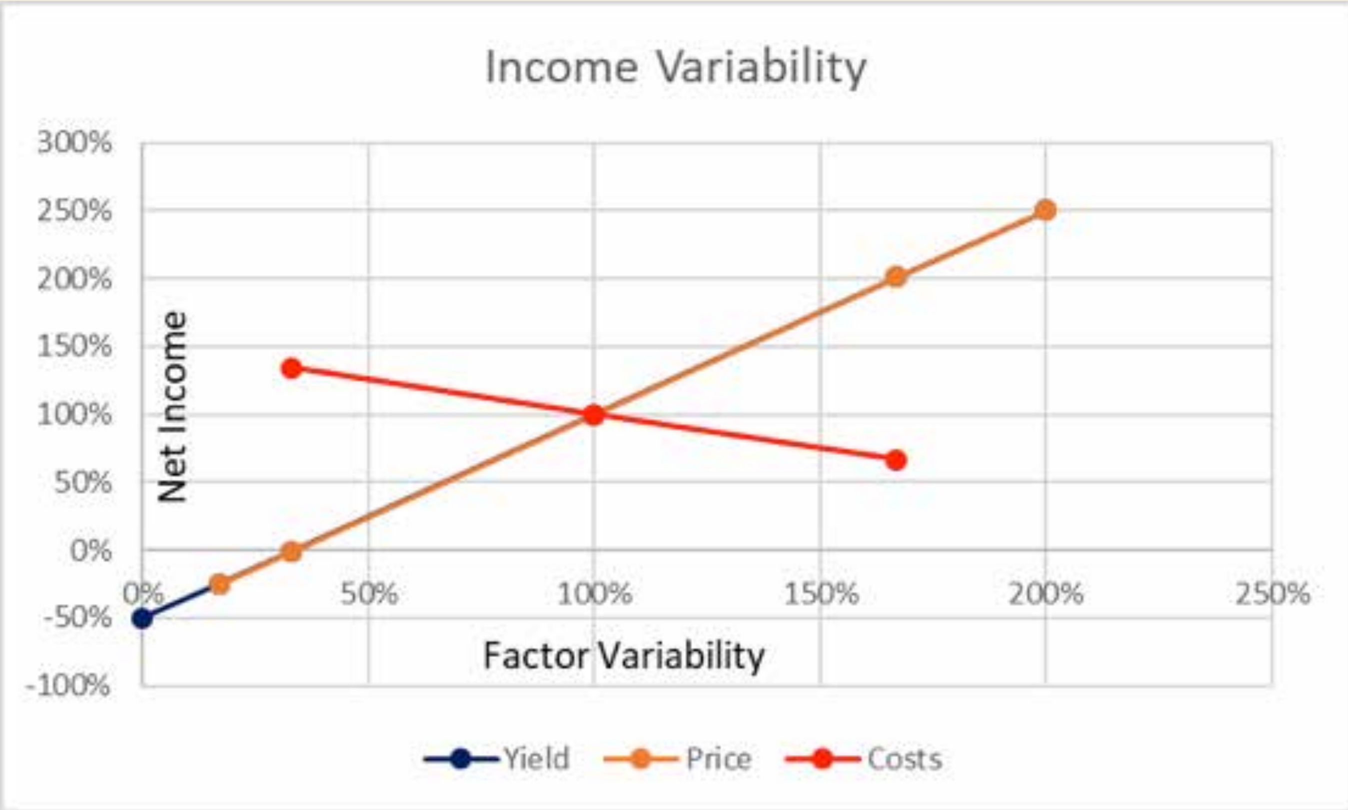


*Figure 15. Impact of yield, price and costs on apiary net income.*

**5.2 Carrying capacity and competition**

There is often the temptation to consider putting more hives into your apiary site or increasing the number of apiary sites in your location in the hopes that this will translate into more honey harvested. It is important to understand what the impact of overstocking will be in terms of net income from honey. With the rapid expansion in the number of hives in New Zealand there is concern that we may be exceeding carrying capacity in many regions. Traditionally, beekeepers have used their local knowledge and experience of long-term yields from apiary sites to know what the optimal carrying capacity is, with a common rule of thumb for mānuka sites of 1 hive per hectare of mānuka. With the increase in hive numbers and increased density in New Zealand, there is an increased risk that carrying capacity could be exceeded.

| **Number of Hives** | **Current** | **Capacity** | **Over-Capacity** | |
|---|---|---|---|---|
| | **30** | **35** | **40** | **50** |
| Total honey collected (kg) | 4,050 | 4,500 | 4,500 | 4,500 |
| Colony maintenance honey (kg) | 2,700 | 3,015 | 3,446 | 4,307 |
| Colony surplus honey (kg) | 1,350 | 1,485 | 1,054 | 193 |
| **Surplus honey (kg/hive)** | **45.0** | **42.4** | **26.4** | **3.9** |
| **Winter store honey (kg/hive)** | **15.0** | **15.0** | **-** | **-** |
| **Honey for sale (kg/hive)** | **30.0** | **27.4** | **26.4** | **3.9** |
| | | | | |
| Apiary honey income ($30/kg) | $ 27,000 | $ 28,800 | $ 31,629 | $ 5,786 |
| Income per hive | $ 900 | $ 823 | $ 791 | $ 116 |
| Hive Costs - per hive | $ 300 | $ 300 | $ 400 | $ 400 |
| Hive Costs - apiary | $ 9,000 | $ 10,500 | $ 16,000 | $ 20,000 |
| **Net Income** | **$ 18,000** | **$ 18,300** | **$15,629** | **-$14,214** |

*Table 5. Variation in production and net income with different stocking rates under the same carrying capacity scenario.*

| Scenario | Description |
|---|---|
| **1. Current – 30 hives** | o 30 hives producing on average 45 kg of surplus honey, of which 15 kg is winter store and 30 kg is sold.<br>o Apiary currently operating slightly below catchment carrying capacity. |
| **2. Capacity – 35 hives** | o Increase in hive numbers reaches carrying capacity.<br>o Increased colony surplus honey but increase in number of hives reduces honey per hive, increases costs, and results in only a slight increase in net income. |
| **3. Overstocked – 40 hives** | o Further increase in hive numbers exceeds carrying capacity of catchment.<br>o Colony surplus honey declines and all surplus honey sold to maximise income so no honey is left for winter stores.<br>o Absence of winter store honey increases hive costs as supplemental bee feeding must be purchased as required, and together with increased hive numbers this inflates apiary costs and reduces net income. |
| **4. Overstocked – 50 hives** | o Further increase in hive numbers significantly increases overcapacity to the point where virtually all honey collected is required for colony maintenance.<br>o Very little surplus honey available for sale.<br>o Additional supplemental feeding required along with increased hive numbers results in a net loss for the apiary. |

*Table 6. Scenarios for carrying capacity and hive stocking rates.*

In either of these situations there will come a point where the "catchment" or foraging area in which the hives are located will reach capacity in terms of the number of hives it can support. After that point is reached, if there is a further increase in the number of hives or an extended period of inclement weather the amount of nectar available in that catchment will have to cover the additional hives as well, reducing the amount of nectar available per colony. Because the bees require more than half to two thirds of the nectar they collect for hive maintenance (Matheson 1984) the net effect of this will be a reduction in surplus honey available for sale and for winter store needs. The risk to beekeepers is that by overstocking apiary sites they will in fact end up reducing the amount of honey they harvest, while at the same time increasing their costs through managing more hives and relying more heavily on bee feed supplements. Less honey and higher costs means lower net income. The maximum stocking of an area is not desirable as it is good practice to have a buffer of capacity to help maintain good average yields and ride over the inevitable changes in seasonal weather patterns. An area's carrying capacity can be fine-tuned from seasonal production records over time, but it is better economically to slightly under stock than over stock.

Table 5 shows the impact of overstocking on honey yield, hive costs and net income, with the scenarios outlined in Table 6. It is based on a single apiary and while it is a theoretical exercise it reflects what can and what is happening under the present overstocking conditions. Four scenarios are presented.

The implication here is that beekeepers and landowners will want to understand the reality of overstocking and the consequences of exceeding carrying capacity, and proceed in a stepwise manner to determine what their sites can realistically accommodate and what level of competition from bordering apiary sites are expected. It is reassuring to know that increasing the number and scale of mānuka plantations at the same time as increasing strategically designed bee forage to support the bee colonies outside the mānuka honey flow season is one of the most important success factors that anyone can utilize.

### 5.3 Landowner -- beekeeper partnerships

There are diverse landowner – beekeeper arrangements for harvesting mānuka honey so considerations should also be given to the relative contribution of landowner and beekeeper from a cost input perspective. Pastoral landowner/beekeeper relationships have traditionally been one of mutual benefit – the landowner receives pollination for their pastoral clover crops, and the beekeeper is able to build up their hives and gather clover honey. Relationships between beekeepers and arable or horticultural crops have more complex arrangements which depend on the value of the pollination services provided compared to the value of the honey obtained, if any. This differs for different crops. Before the rise of the mānuka industry, commercial arrangements ranged from the beekeeper supplying a few jars of honey to the landowner, through to the arable/horticulture farmer paying the beekeeper hive-based fees for specific pollination services. Traditionally it has been rare for the beekeeper to pay a landowner a fee for locating their hives on the land for overwintering, or a share of income from honey collected from the land.

The rapid development of the mānuka honey industry based on a finite resource and the existing area of regenerating mānuka scrubland, has led to beekeepers offering to pay landowners for the right to have hives on their land. This has extended to over-wintering sites, and is in the form of a "set down" fee per hive, or a share of honey income or both. Where based on honey income this has tended to range between 10% and 30% of gross income, with the higher level for high-quality mānuka honey sites.

The reference point for this analysis is the plantation forestry sector, where income-sharing investment models are often based on the relative share of input costs – land, establishment of the plants and management of the tree crop, as well as annual costs. The share of income at harvest will depend on what each party pays for.

The following table (Table 7) outlines the costs associated with mānuka honey investment, on the assumption that the point of sale is raw honey ex the apiary. Both natural forest mānuka and plantation mānuka are considered.

Landowner costs include land, establishment of any mānuka forest, and annual costs for rates, insurance, weed and pest control. It's important to acknowledge that the landowner contributes the value of the land to the venture, whether that land is purchased or not, and this is typically assessed by charging a rental of 4% of land value. For natural forest mānuka there are no establishment costs (land preparation, planting or releasing). The cost of weed and pest control, rates and insurance will vary significantly depending on location, and the cost used here is conservative. This analysis doesn't include any costs associated with thinning or trimming mānuka to manage flowering but depending on the rate of growth and spacing of the manuka, this can be envisaged as a likely cost from age 10-15 years onwards. For the purpose of this analysis we can assume these costs are met equally by the landowner and beekeeper.

Beekeeper costs include the purchase of hives, whether they are purchased specifically for this venture or not, and annual running costs. Both these costs as outlined here are in the mid-range of current values. It is also worth ensuring that the beekeeper has current comprehensive Public Liability insurance cover specifically covering fire risk under the Forest & Rural Fires Act 1997 and its amendment in July 2017.

| | | |
|---|---|---|
| **Landowner Costs** | | |
| Land purchase/value ($/ha) | | $500 - $5,000 |
| Land preparation ($/ha) | $ | 500 |
| Planting ($/ha) | $ | 1,705 |
| Releasing ($/ha) | $ | 500 |
| Pests, rates, insurance ($/ha/year) | $ | 10 |
| | | |
| **Beekeeper Costs** | | |
| Hive purchase ($/hive) | $ | 750 |
| Operational Costs ($/hive/year) | $ | 300 |

*Table 7. Landowner and beekeeper plantation costs*

In comparing the respective inputs of landowner and beekeeper, these have been calculated over 25 years, being the typical life-span of a mānuka plantation. Inputs are compared on a cash basis, as well as using discounted cash-flow analysis which is a standard approach for forestry investment analysis. Land value has been assessed by charging a land rental of 4% of land value, again typical in forestry investment analysis. The discount rates used are 7% and 9% applied to pre-tax cash flows, which reflect recent forestry analysis rates depending on the level of perceived risk.

For natural mānuka forest, land value of between $500/ha and $3,000/ha has been assumed. If you accept that land value is a proxy for the quality of the mānuka growing on it, then the following discounted cash flow analysis (Table 8) supports a landowner share of 10-30% for land value up to $1,000/ha. If the contribution is assessed on a cash basis then it also supports this range of landowner share up to $3,000/ha, although it is anticipated that most scrub land would be valued at less than $1-2,000/ha unless it contained high activity mānuka or was suitable for conversion to pasture.

For plantation mānuka, the combination of land purchase/value and establishment of a mānuka crop significantly increases the landowner's share of costs, and hence expectations for a share in any returns (Table 9).

Of course, the above analyses provide just one possible investment structure, with the landowner assuming all land and mānuka-related costs, and the beekeeper all apiary-related costs. It also assumes the basis for the relationship is a share of honey income, and any potential income from carbon through registration in the Emissions Trading Scheme (ETS) has not been considered. Alternatives include the beekeeper meeting some of the land/establishment-related costs, and/or the beekeeper paying the landowner a fixed fee based on the number of beehives. Whatever type of arrangement is envisaged, it is important that all parties understand the costs, risks and returns so that they can enter into a commercially sustainable arrangement.

*Ready to plant - Waioma Gisborne*

| Land Value ($/ha) | Landowner Costs - Natural Mānuka Forest | | | | | |
|---|---|---|---|---|---|---|
| | Cash | % Total | 7% DR | % Total | 9% DR | % total |
| $ 500 | $ 760 | 9% | $ 627 | 15% | $ 608 | 17% |
| $ 1,000 | $ 1,260 | 14% | $ 1,127 | 24% | $ 1,108 | 27% |
| $ 2,000 | $ 2,260 | 23% | $ 2,127 | 37% | $ 2,108 | 41% |
| $ 3,000 | $ 3,260 | 30% | $ 3,127 | 47% | $ 3,108 | 51% |
| **Beekeeper Costs** | **$ 7,650** | **49-72%** | **$ 3,566** | **31-56%** | **$ 2,998** | **28-52%** |

*Table 8. Landowner/Beekeeper costs – natural mānuka forest.*

| Land Value ($/ha) | Landowner Costs - Plantation Mānuka | | | | | |
|---|---|---|---|---|---|---|
| | Cash | % Total | 7% DR | % Total | 9% DR | % total |
| $ 500 | $ 3,465 | 31% | $ 3,332 | 48% | $ 3,313 | 52% |
| $ 1,000 | $ 3,965 | 34% | $ 3,832 | 52% | $ 3,813 | 56% |
| $ 3,000 | $ 5,965 | 44% | $ 5,832 | 62% | $ 5,813 | 66% |
| $ 5,000 | $ 7,965 | 51% | $ 7,832 | 69% | $ 7,813 | 72% |
| **Beekeeper Costs** | **$ 7,650** | **49-69%** | **$ 3,566** | **31-52%** | **$ 2,998** | **28-48%** |

*Table 9. Landowner/Beekeeper costs – plantation mānuka forest.*


*Native riparian planting 4 years after planting - Staveley Mid Canterbury*

# 6. SUMMARY AND CHECKLIST

This handbook covers some of the important success factors to consider when investigating and planning a mānuka plantation. The rationale behind the logistics, strategies and costs for supporting a profitable and sustainable mānuka plantation has been described. The key factors are summarised here as steps to include in the decision-making process. It is assumed that other sources of information are also being used as this handbook covers selected factors in line with our area of expertise.

1. Assess Location Area:
   a. Land use and vegetation types in a 3-5 km radius around mānuka plantation site.
      i. Assess general vegetation types for clover pastures, large patches competing honey flow plants especially rewarewa, kamahi, and tawari etc.
      ii. Assess what types of large obvious patches of bee forage are available.
      iii. Consider using a Pollen Profile experiment to assist with i and ii.
   b. Assess vehicle access to within foraging range for competing or existing apiaries.

2. Optimise Scale:
   a. Maximise scale of the mānuka plantation
   b. Maximise scale of the bee forage plantations to fit in with other land and farm operations
   c. Consider cooperative arrangements with neighbours if needed.

3. Locate sites for apiaries, mānuka and bee forage plantations:
   a. Select prime area for mānuka plantation
   b. Select best locations for apiary sites with experienced beekeeper
   c. Determine optimum locations for bee forage plantations so that:
      i. Autumn and winter bee forage is closest to apiary
      ii. Spring build up bee forage is close or short distance to apiary
   d. Consider conducting a Pollen Profile experiment to gain evidence of bee preferences and available forage.
   e. Consider finding out what types of honey have been produced in the general area

4. Select List of Bee Forage plants as candidates
   a. If possible, make a Flowering Calendar of pre-existing species to look for gaps in nectar and pollen flow.
   b. Make a Flowering Calendar of proposed bee forage species to fit in with land or farm functions and other purposes where tree and shrub planting is already an option.
   c. Filter and adjust the Bee Forage Plantation species list with beekeeper and plant experts and customise the list to suit the farm or land operations.
   d. Construct the Species Diversity Profile of proposed species with each month with as close to ten species as possible. Ensure no competing species flowering at same time as mānuka flowering. Consider a pollen source for the mānuka plantation area.
   e. Construct the Bee Forage Profile with the numbers of each plant species and adjust the numbers to match the bee's annual cycle of demand for pollen and nectar.
   f. Ensure that the Bee Forage Plantation sites do not conflict with other farm or land operations (spraying crops, people's work areas, etc.).

5. Prepare your planting plan
   a. Identify sources of plants included in your species list, and order plants several months ahead of planting to ensure availability. Obtain any tree protection and fertiliser required.
   b. Make sure fencing, weed control and pest control is completed prior to planting.
   c. Have any irrigation required in place prior to planting.
   d. Secure a reputable planting contractor who is familiar with planting native and exotic shrub and tree species.
   e. Have a plan in place for ongoing protection and maintenance of your planting.
   f. Stage the planting to determine how much will be undertaken each year according to time, money and labour available.

*Koromiko in flower 2 years – Waioma Gisborne.*

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*Planted escarpment at 3 years - Riverlea Piopio*

# ABOUT THE AUTHORS

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Angus is a forestry consultant and farm planting adviser with over 35 years' experience in forestry. He has a B.For.Sc. (Hons) from University of Canterbury, NZ and a PhD in Forestry from University College of North Wales, Bangor. He 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 forestry, 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.

**Dr Linda E. Newstrom-Lloyd**

Linda 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. She received her MSc. from McGill University, Canada and her Ph.D. in botany from the University of California at Berkeley, USA. She has previously worked on pollination research in California, Mexico, and Costa Rica. She 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 promote strategic bee forage plantations that will provide optimum bee nutrition.

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