BIODIVERSITY ON FARMLAND

"Good Management Practices"
A report on research on the enhancement of biodiversity on farmland.

Ministry for the Environment – Manatū Mō Te Taiao – Sustainable Management Fund	Selwyn Sustainable Agriculture Society Inc
	Watties
Agriculture NEW ZEALAND – A Wrightson Business	LINCOLN UNIVERSITY – Te Whare Wānaka O Aoraki
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"Good management practices"

This booklet is produced for New Zealand farmers and other land owners to demonstrate how biodiversity can be enhanced to give multi-value benefits for production, conservation, recreation, historical, cultural, aesthetic and Maori needs. It is an outcome of the "Strategies to Enhance Biodiversity on Mixed Cropping Farms" project (1999 – 2003), funded by the Ministry for the Environment (MfE) Sustainable Management Fund. The project was run in conjunction with the Selwyn Sustainable Agriculture Society Inc. (SSAS) and key partners Lincoln University, Heinz Wattie's Ltd. and Agriculture New Zealand.

The aim of this project has been to create and put into practice farm biodiversity plans at two sites in New Zealand for research, demonstration and technology transfer. The first site is Kowhai Farm, Heinz Wattie's Organic Farm at Lincoln University in Canterbury and the second is a commercial farm near Gisborne in Tairawhiti. The project has demonstrated multi-value biodiversity with a strong emphasis on Functional Agricultural Biodiversity (FAB) by identifying those aspects of biodiversity which can be enhanced or added to a cropping system to improve "ecosystem services" (ES). These services can be wide ranging in type and provide agricultural benefits below and above ground in crops, other production areas, fence-line margins and recreation areas. They include pollination, biological control of pests, diseases and weeds, mineralization of nutrients from decaying plant residues, shelter for livestock. They also include the capture of carbon from the air, which is relevant to the 'Kyoto Protocol' relating to the burning of fossil fuels and enhanced global carbon dioxide concentrations (see Box 1). The information in this booklet records the activities, outcomes and recommendations of the project in Tairawhiti and Canterbury. This booklet also includes work on assessing and enhancing ES on farmland, funded by the Foundation for Research, Science and Technology (FRST) via programme LINX 0303: "Biodiversity, ecosystem services and sustainable agriculture".

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Introduction to Biodiversity

BIODIVERSITY or "the variety of life" was introduced as a concept at the Rio Earth Summit in 1992.

Biodiversity is short for biological diversity. It means the variety of all living things: plants, animals and micro-organisms; the genes they carry and the land and water ecosystems of which they are a part.

Biodiversity has been evolving since the beginning of life. It provides us with fresh air, clean water and fertile soil and is the basis of the interconnected web of life on earth.

Biodiversity is essential for the survival of all species, including humans. It is the source of our foods, medicines and industrial raw materials. Our economic prosperity is dependent on it, from agriculture to tourism. In fact, the value of biodiversity – providing these ecosystem services – has recently been calculated at US$33 trillion per year world-wide. This figure is put into context by the fact that the world's annual GDP is US$18 trillion.

In New Zealand, farmers have a key role in maintaining and enhancing the biodiversity on their land, while doing their best to manage pests, diseases and weeds in a sustainable way. A new way of describing farmers' role in this context, which is being used in Europe and is open to active debate is as 'photosynthesis managers' and 'ecosystem-service providers'!

The many values of biodiversity to individuals and to society are summarised in Box 1.

The skylark – a valued introduced species in agricultural areas

Box 1: The value of biodiversity

- **Commercial production benefits**

  Direct:
  - Species are used and harvested to produce food, medicine, clothing and timber

  Indirect:
  - Pollination
  - Biological control of pests, weeds and diseases
  - Shelter
  - Weed suppression
  - Erosion management, nutrient retention
  - Improving soil microbial and earthworm activity
  - The maintenance of clean air and water

- **Other economic benefits**
  - Enhanced land values
  - Supporting a 'clean green image' – potentially important for retaining overseas market access
  - Tourism
  - The potential for payments for enhancing or protecting biodiversity (especially in Europe).

- **Aesthetic benefits**
  - People enjoy seeing species, landscapes and the ecosystems in which they live.

- **Existence benefits**
  - The value we place on knowing species and ecosystems remain in existence, e.g., New Zealand would be culturally diminished if, for example, one or more of our kiwi species, or the bellbird became extinct.

- **Cultural benefits**
  - The Maori concept of kaitiakitanga.

- **Conservation benefits**
  - Providing habitat for threatened or endangered species of flora and fauna

- **Recreation benefits**

Biodiversity on Farmland – Functional Agricultural Biodiversity (FAB)

Most recent research activity on biodiversity has focussed on threatened habitats and ecosystems such as tropical rain-forests, coral reefs etc. However, in most developing countries some of the greatest threats to biodiversity are caused by agriculture and some of the greatest losses have occurred in these highly-modified landscapes. In New Zealand, for example, 750,000 hectares of the Canterbury Plains are among the most highly modified natural landscapes in the country. Many people believe that the greatest progress in restoring biodiversity in the future will take place not in "natural" areas such as native forests but in agricultural landscapes. When biodiversity is lost from farmed areas, it is not simply a matter of the loss of species of conservation value, because many of the organisms that occur in farmland provide substantial benefits to production, as mentioned above. This type of biodiversity is often called Functional Agricultural Biodiversity (FAB) and its functions, sometimes known as "ecosystem services", can be wide-ranging and of value to the farmer.

Examples of the ecosystem services which can be enhanced when biodiversity is maintained or restored in farmland include:

- pollination of crops (see the photo below)
- biological control of pests, diseases and weeds
- stock shelter
- management of wind erosion of soil
- improved pasture and crop production
- maintenance of soil organic carbon and structure

Other non-production values of added farmland biodiversity include:

- conservation
- aesthetics
- recreation
- historical and cultural value
- the Maori concept of kaitiakitanga.

A bumble bee

The Maori concept of kaitiakitanga

Kaitiakitanga broadly covers the concept of stewardship of the land and of the animals and plants living there. It has four major components, all of which can be provided by biologically rich farmland.

These components are

i) cultural value, such as a plant's role as a key component of plantings around a marae; (e.g., cabbage trees - ti kouka);

ii) taonga raranga, which encapsulates the value of a living thing for manufacturing (e.g., weaving flax - harakeke);

iii) mahinga kai, which refers to the food value of certain plants and animals (e.g., bracken fern (rahurahu), an important Maori food source);

iv) rongoa Maori which refers to living things of medicinal importance (e.g., *Hebe salicifolia* - koromiko, which has been used to treat dysentery).

Components of farm biodiversity

In September 2000, a farm trail was established on Kowhai Farm. This trail encourages visitors to explore the added biodiversity along paddock margins. At many points along the trail illustrated boards explain the type and functions of biodiversity which have been enhanced at that location. Information from these boards is presented in this 'Components of Farm Biodiversity' section.

Included on these pages is "How to …  " information, and in some cases monitoring and trial results are also featured.

Part of the farm trail in its early stages, showing one of the interpretation boards and bumble bee motels

Trees and shrubs

Trees and shrubs should be selected for planting on farmland partly based on their role in providing ecosystem services – see earlier and page 13. The services provided by these plantings include shelter for stock, pasture and crops and the provision of pollen and nectar for birds, bees and other beneficial insects. Such plantings can also suppress weeds, minimise soil erosion, and have aesthetic, conservation, historical, cultural and recreational values. These plantings on Kowhai Farm support the expression of kaitiakitanga, which is the exercise of guardianship by tangata whenua.

Biodiversity plantings at Kowhai Farm

After 18 months the biodiversity plantings of native woody plants on Kowhai Farm had progressed well.

Springs Road plantings: August 2000, Lincoln University in the background (photo Philip Simpson)

Springs Road plantings: January 2002

The Kowhai Farm site is typical of many Canterbury farms, being exposed to wind and frost. The plantings also suffered a severe drought during the 2000/2001 summer, resulting in some plant losses.

Plant losses were carefully monitored over the first two growing seasons. Cabbage tree (*Cordyline australis*), *Corokia cotoneaster*, *Pittosporum tenuifolium* and ribbonwood (*Plagianthus regius*) had 100% survival. Other species proved less suitable for use in such an exposed site, in particular rohutu (*Lophomyrtus obcordata*) and *Olearia paniculata*, of which only 58% and 38% survived, respectively (see Figure 1).

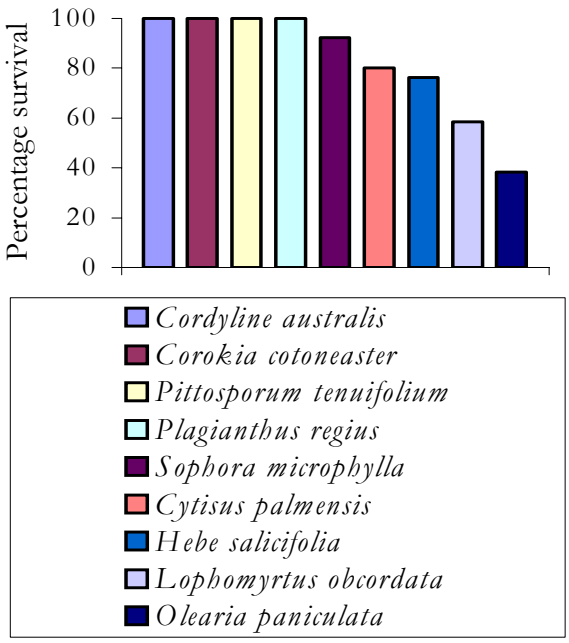

Figure 1: Percentage survival of species used in biodiversity plantings on Kowhai Farm

The New Zealand Tree Crops Association representative on the project's Canterbury Liaison Group suggested that the inclusion of a deep rooting (not lateral rooting) fast growing shelter tree species e.g. Alder *Alnus glutinosa*, would enhance the establishment of native plants in such an exposed site by providing "nursery shelter". Alders also fix nitrogen and provide a potential return from firewood. Timber production also offers potential returns, although this has yet to be proven for New Zealand-grown alder. The liaison group also discussed the potential problem for arable farming of cabbage tree leaf blow into the paddock, especially from the north boundary.
It was decided to monitor the situation over the coming years, with the possibility of some tree removal in the future if problems do occur.
Plantings on other more sheltered locations of Kowhai Farm have shown successful establishment of tree lucerne (*Cytisus palmensis*) and kowhai (*Sophora microphylla*), both of which are nitrogen fixers and providers of a valuable source of pollen and nectar in spring. Harakeke (New Zealand flax) has established very well in exposed sites on Kowhai Farm.

Shelter in Canterbury

In Canterbury, effective shelterbelts can increase stock, pasture and crop production as well as provide control over soil erosion by wind.

Shelter can be provided in two forms:

1. Solid hedged, dense, impermeable stock shelter (3-5 metres tall) usually running east-west, giving almost wind-still conditions, with decreasing wind reduction out to 10-12 heights. This is useful for lambing and shearing. Potential problems include stock camping in limited areas, causing pugging and nitrogen build-up.

2. Tall, filtering, porous, 'broad acre' shelter (20+ metres tall) usually running north-south giving no wind-still areas, but with maximum wind speed reduction around 6-7 heights increasing to open speed at 15-25 heights. Aimed at reducing excessive moisture losses and encouraging stock to spread out over a wider area.

A challenge with any shelter planting is to obtain good site dominance so that weeds are not a continuing management problem.

Plantings of large and small trees should be 1.5 to 2 metres from the fence. Trimming is essential with most species to retain shape and porosity – the trimmings should be allowed to fall inside the fence to provide weed suppression etc.

For species choice in Canterbury, tree species have been grouped by Nick Ledgard at Forest Research, University of Canterbury into three hardiness categories – primary, secondary and tertiary. The range of species for guaranteed success on the most exposed sites is small, and this increases as more shelter is provided. This is summarised below.

Hardiness categories for Canterbury trees

Primary Suitable for first line of defence Tolerant of full exposure to wind/drought Tough, '365-day' tree, no failures Limited range of species	**Pines**: radiata, Corsican, pinaster, ponderosa **Cypresses:** Leyland, arizonica, torulosa, macrocarpa **Cedars**: deodar, atlantica **Eucalypts:** globulus, viminalis, nitens gunnii, cordata, rodwayii, cinerea, pauciflora **Poplars** (moister sites only): Lombardy, Crow's Nest, Kawa, Tasman, Eridano. Yeogi, Veronese etc **Survival is the prime concern**
Secondary Tolerate moderate exposure Often planted in lee of primary species Greater range of species	**Exotic trees and shrubs:** Picea (spruce) firs, Larix (larch), Sequoia dendron (sequoia; redwood), pine nut and cone spp., Acacias, birch, alder, oak, ash, elm, Acer (maples), cherry, willows, Liquidambar, Viburnum, Arbutus (strawberry tree), laurel, Photinia, Grevillea **Native species:** Cabbage trees, flax, Pittosporum, Olearia, kowhai, Corokia, Plagianthus (ribbonwood) **Amenity aspects deserve more consideration**
Tertiary Least tolerant of exposure Sheltered positions Usually better soils Often associated with homes / gardens Wide range of species	The range of native and introduced species is wide. **Amenity aspects important**

How to ….

Before planting trees and shrubs it is important to identify the desired function or benefit of the planting and to assess the physical environment, as both will dictate the choice of plant species. Seek advice for your location from local people including farmers, plant nursery staff, the Farm Forestry Association, the Tree Crops Association and your Regional Council (See "**Shelter in Canterbury**" below).

ACHIEVING SUCCESSFUL PLANTINGS:
Obtain good-quality plants (in planting bags or bare-rooted), and keep the plants moist and in the shade until planting. Plant in late winter. Planting in lines makes subsequent maintenance easier. It is important not to plant potentially large trees near fence lines, as branches overhanging fences may impede machinery and cause electric fences to short. Subsequent trimming of the maturing trees and shrubs is easier if they are in lines, as is weed management, whether by the application of mulches. using a mechanical method such as a 'weed eater' or using a herbicide spray. A useful way of minimising weed growth and water loss around each tree is by establishing a mulch or weed mat. Some useful techniques are:

(i) Use two synthetic fertiliser bags/tree. Use a craft knife or similar to make a cut from mid-way along one side of the bag to the centre of the bag. Slide the bag around the planted tree. Do the same with the second bag, from the opposite direction. Anchor the bags with stones or soil. A layer of organic mulch can then be placed over the bags or the whole planted area, if desired – see *'Paddock margin management and grasses in the field margin'* on page 16.
(ii) Lay corrugated or other thick cardboard around trees using the same 'cut to centre' technique as with fertiliser bags.
(iii) Lay old carpet around trees.
(iv) Lay thick layers of newspapers.
(v) Use commercially available weed mat.

Mulch options include:

(i) Stones or gravel (this is excellent for moisture retention in low rainfall areas as the stones do not absorb moisture as organic mulch does).
(ii) Organic mulch/straw - see *'Paddock margin management and grasses in the field margin'* on page 16.
(iii) Bark.

For Canterbury, a useful guide to establishing native plantings is: *'Establishing Shelter in Canterbury with Nature Conservation in Mind'*, available from Environment Canterbury. This also describes weed management techniques. Environment Canterbury also has an excellent guide for farm shelter design.

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Kaitiakitanga

Kaitiakitanga is a Maori environmental ethic directed at nurturing resources that are indigenous to Aotearoa New Zealand so that their regenerative capacity is maintained or enhanced. Kaitiaki are tangata whenua holding the mana whenua of a particular area. They are responsible for resources on ancestral land and have an inter-generational responsibility to build these for future use and well-being. There are four major components of kaitiakitanga, all of which can be provided by biologically rich farmland. These are:
(i) protecting cultural values of tangata whenua,
(ii) conservation of taonga raranga/ whatu (plants for manufacturing, weaving),
(iii) conservation of mahinga kai (food sources),
(iv) conservation of rongoa Maori (traditional Maori medical plants and herbs).

Populations of naturally occurring puha (native and endemic sowthistles, which are a food plant valued by Maori) are declining, so the plant has been grown commercially near Gisborne as part of this MfE project. The plant is closely related to lettuce, is high in vitamin C and is used in salads and stews (see pages 20-21).

Paddock margin management, including grasses in the field margin

Part of the 1.2 km of paddock margin plantings on Kowhai Farm in their early stage

Since synthetic herbicides (weed killers) became readily available in the 1970s, 'conventional' farmers have used them to control weeds. The result on many properties has been a sharp reduction in biodiversity. On Kowhai Farm, the planting of paddock margins to increase biodiversity introduces the challenge of managing potentially harmful weed species without herbicides in the margins. In conventional farming, herbicides can be used to control weeds within the crop. In organic farming, synthetic herbicides are not allowed, so effective mechanical, biological and thermal methods to manage weeds are needed.

A 3m-wide grass strip around all paddocks on Kowhai Farm provides a barrier to perennial weeds invading the crops from the fence lines. Mechanical, hand-held 'weed-eaters' are used to manage persistent perennial weeds such as thistles and docks in the double fence lines. Native and non-native grasses have also been planted along the fence line to evaluate their potential to out-compete perennial weeds, as well as adding to the aesthetic, production and conservation value of the paddock margins. A linseed straw mulch was added in some plots and grass growth was compared between plots mulched in this way, or un-mulched. This work was funded by the Brian Mason Trust.

A Kowhai Farm fence line in 1999, prior to organic conversion.

The same fence line (now double) one year later

Planting native grasses along the fence lines is a good example of multi-purpose biodiversity on farmland. Some grass species are highly competitive and can smother pernicious weeds such as thistles, preventing them from spreading out into the adjacent crop. Grass plantings are also likely to harbour large numbers of spiders and predatory insects that are useful in the biological control of pests. Some of the grass species are now rare in New Zealand, so planting them on farmland contributes to their conservation. Some of the invertebrates living in or on them may also be rare, as may some of the birds benefiting from the shelter and nest sites the grasses provide. The native grass species have aesthetic and conservation potential, as well as a role to play in kaitiakitanga.

Carex buchananii with linseed-straw mulch (left) and without mulch (right)

Poa cita, silver tussock without mulch (left) and with mulch (right)

Invertebrate predators

Many of the vegetated margins on Kowhai Farm could be refuges for beneficial insects and spiders. Work was carried out in the summer of 2001/2002 to investigate the movement of these beneficial insects into adjacent crops and to assess their rates of predation on artificial prey placed at distances from the margin.

'Prey facsimiles' of freeze-killed blowfly eggs were placed out at set distances from the field margin to the centre of the pea and ryecorn crops in paddocks A4 and A3, respectively. Transects were placed running from the 'beetle bank' in A4 and from the plantings of native grasses in the margin of A3 as well as their adjacent 'conventional' fence lines so that treatment comparisons could be made. The number of remaining blowfly eggs was counted to assess 'predation' rates at each distance.

For the pea crop, predation rates were highest within the native grasses, reducing towards the centre of the crop (see Figure 2). In the ryecorn, predation rate remained fairly constant across both control and beetle bank transects (see Figure 3). This is likely to be due to the refuge/sheltered environment created by this tall, dense crop.

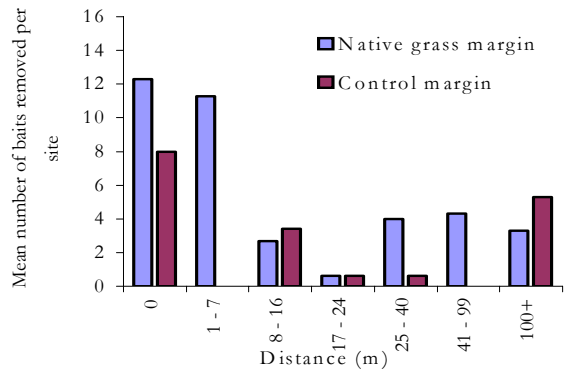


Figure 2: Invertebrate predation in the pea crop

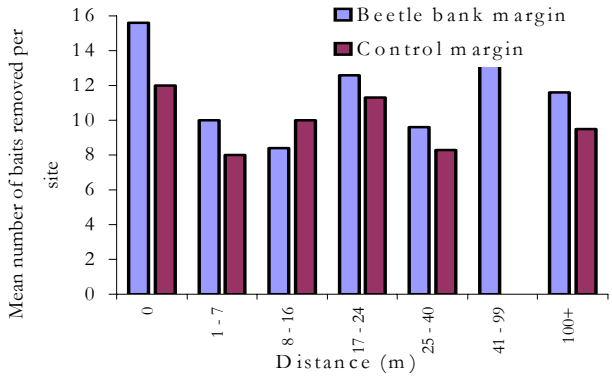


Figure 3: Invertebrate predation in the ryecorn crop

How to …

Native grasses

Establish the grasses from plants in pots, not from seed. Clear the land of weeds, either by mechanical means or with non-persistent herbicides. Cover the area to be planted with an organic mulch (pea, wheat, barley, linseed, etc., straw). On Kowhai Farm, linseed straw was used – it has a very high carbon/nitrogen ratio and continues working as a mulch for several years. Other organic mulches decompose more quickly. Plant the grasses at 0.5 – 1.0 m spacings, depending on mature size, if eventual complete cover is required. Remove any perennial weeds, such as thistles, which may penetrate the mulch – by digging them out or by individually spraying them with herbicide.

Beetle bank

This grass-covered ridge on the edge of paddock A5 (see map in Farm Biodiversity Plan, Appendix 2) is a "beetle bank" - an over-wintering refuge for spiders and beneficial insects such as ground beetles. These animals are valuable in biological control of pests but many conventional farming systems offer few permanent habitats for them. The beetle bank with its cover of the European grass cocksfoot (*Dactylis glomerata*) provides a relatively dry and temperature-stable permanent habitat. Work funded by Heinz Wattie's at Lincoln University has shown that densities of beneficial insects on a two year old beetle bank are over 500 per square metre, compared with under 20 per square metre on non banked areas. On a typical bank there may be up to one million of these animals. In spring many of them, most of which are flightless, emigrate from the bank and enter the adjacent paddock where they feed on a wide range of pests. In Britain, where beetle banks were first investigated, the beetles travelled up to 60 metres from each side of the bank in spring. The term 'beetle bank' has even found a place in the Oxford English Dictionary!

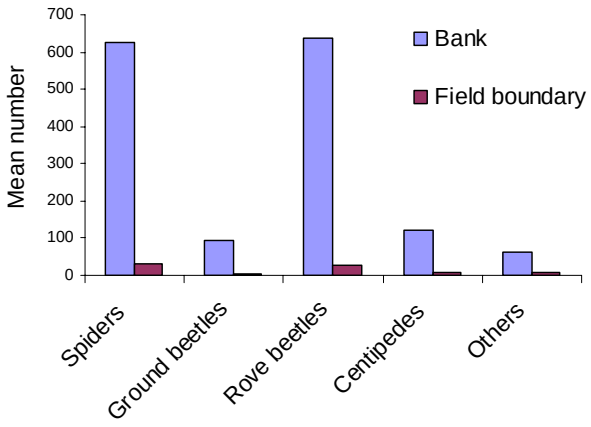


Figure 4: Mean number of predatory arthropods/m2 found in turf samples from beetle banks and their adjacent field boundaries – New Zealand data from Dr Nadine Berry.

A beetle bank

⊥ A paddock margin on Kowhai Farm before a beetle bank was added – an image which evokes Shakespeare's 'blasted heath'!

How to …

Create a beetle bank across the centre of the paddock or, as on Kowhai Farm, along a fence line. Do this by ploughing in one direction to create a ridge approximately 1.5 m wide. Then plough from the opposite direction to throw more soil onto the bank. The new ridge, before soil compaction, should be about 0.4 m high. Sow cocksfoot grass seed by hand or machine at around 3 g/m^2. Later, selective herbicides for broad-leaved weeds can be used. Once the grass establishes and begins to form a dense, tussocky cover, there should be few subsequent weed problems.

Conserving puha in Tairawhiti – an example of mahinga kai

Regarded as a delicacy by the ancient Greeks, puha or the common sow-thistle has been eaten as a green vegetable by people in many parts of the world for thousands of years. When the northern hemisphere sow-thistle arrived in New Zealand over two hundred years ago it became an important food item in the diet of the Maori people, replacing the less palatable New Zealand native species. It is now less common, so this Ministry for the Environment (MfE) project helped to make the plant widely available again in the East Cape (Tairawhiti) region.

Puha (or puwha) - a favourite vegetable green of Maori, comes from Europe, North Africa and West Asia. It has soft green leaves, small yellow dandelion-like yellow flowers and a milky sap. The fluffy seed heads allow the wind to spread the seeds widely. When and how it arrived in this country is uncertain; however it was present at the time of Cook's second visit in 1772 as it was recorded that the crew of the *Resolution* ate it in salads, and boiled it with green peas and broth. Its botanical name is *Sonchus oleraceus.* It is also known by Maori as *rauriki, puha rauriki* or *puha pororua*. *Rauriki* is also often used as a general name for all kinds of sow-thistle.

The original puha of the Maori was *puha rauroroa* or *Sonchus kirkii* - a native species which has a whitish bloom on the leaf surfaces and is usually found near the coast. It is tougher and more bitter than *Sonchus oleraceus* and was seldom eaten once the introduced species became available. Another introduced species - the prickly sow thistle or *Sonchus asper* also became popular, and is preferred to the smooth leafed species for some methods of preparation such as for bottling with mussels. It is known as *tiotio, puha tiotio* or *taweke.*

The sow-thistle has long been recognised as an edible plant, and nearly two thousand years ago the Roman philosopher and historian Pliny the Elder wrote of the nutritional and medicinal value of the plant. It was regarded as an important green vegetable by the ancient Greeks well before the time of Christ. Pliny recommended it as food for nursing mothers. Puha has a high dietary fibre content and compared with most other vegetables it is high in vitamins C and A. It is also high in iron and calcium. Puha is often cooked and mashed with potatoes as a food for young babies when they are being introduced to solids.

Traditionally, Maori steamed puha with other food in an umu or hangi, although over-cooking destroys much of the nutritional value; its use in salads is probably better in this respect. Colenso recorded in 1880 that it was often cooked with fresh fish. Today the usual method is to boil it with potatoes and meat - usually pork, but also with bacon bones, muttonbirds and sometimes with mutton or beef bones. Puha and pork when cooked together are complementary, with the pork moderating the natural bitter taste of the puha, and the puha adding flavour to the pork. The water the puha is cooked in (with or without meat) makes a good soup base. While puha is still widely eaten by Maori people it is also eaten by some Pakeha New Zealanders - a legacy of recommendations made during the Depression in the 1920s and later during the second world war when food was often in short supply.

Puha grows wild on cultivated land and in waste places and is usually gathered in spring and autumn when the plants are producing new growth. Market gardeners often collect and sell the puha which is growing amongst their cultivated crops. People collect seed and sow it in the garden as a crop. Bunches of puha are often offered for sale at weekend markets and at roadside vegetable and produce stalls. Stallholders have reported that they could usually sell far more than they can obtain. A significant proportion is bought through the produce auction markets with some being gathered locally. Buying puha often represents good value for those who haven't the time or access to the plant, as it is usually cleaned and all the inedible parts have been removed.

Before cooking, the older woody parts, dead or damaged leaves and any flowers, are discarded and the stems and leaves are roughly bruised and washed in water to remove the bitter milky sap. The bitter taste of puha is recognised in the Maori proverb - *Ka katokato i te rau pororua* - I am plucking the leaves of

the pororua (puha) one by one which means - *To hear unpleasant words about oneself is like eating bitter puha.*

Puha was used by Maori for numerous medicinal purposes - one of the frequently recorded uses was as an antidote for the bite of the katipo spider. Sap from the plant was applied to the wound to counteract the poison and prevent swelling. Puha leaves were applied to cuts and wounds to prevent infection, and *waipuha* or water in which puha had been boiled, was drunk to cure stomach complaints and loss of appetite. It was also used to ease the effects of poisoning from eating incorrectly prepared karaka seeds or tutu berries. The high vitamin C content of puha made it a good tonic to prevent or cure scurvy - it was used by Captain Cook for this purpose, as mentioned above. It was also used as a blood purifier and as a mild laxative.

After the young shoots of the puha had been picked the milky sap that accumulated at the top of the broken stems that remained was collected and left in the sun until it became a thick creamy mass. This was chewed as a form of chewing gum called *pia* or *ngau.* The initial bitter taste disappeared after chewing for some time. The gum was greatly enjoyed and it improved the health of the gums and helped to keep the teeth clean.

Despite the historical, cultural and culinary values of puha, its populations are thought to be declining through agricultural intensification and road-side management [1].

As part of this MfE project, puha plants in Gisborne were collected and sent by courier to Lincoln University. They were grown to flowering in long day-length glasshouses and the seed produced (75,000!) was sent to the Centre for Plant Reproduction and Seed Technology at Massey University. Here, it was dressed and germination viability was assessed. It was then sent to Mason Smith who runs Norfolk Nurseries near Gisborne (email: norfolk@xtra.co.nz).

Mason then produced commercial quantities of seedlings in cell trays which were made available to Richard Foon, a commercial vegetable grower in Gisborne – Makaraka Veges (see picture). Bunches became available for sale soon afterwards at $2.95 each. Richard sold around 50 boxes at 12 bunches per box. He also sent some bunches to markets in Rotorua and Tauranga. Total sales were therefore around 600 bunches. He expects subsequent sales to be much higher. This may be the first example of this type of farmland biodiversity i.e., 'wild' kai, being improved via a little ecological and commercial expertise, to the benefit of Maori and Pakeha alike.

⊥ Puha growing at Makaraka Veges, Gisborne

Modified with permission from:
Harris, G.F., 1999. Puha – Weed or Vegetable? Te Karaka – The Ngai Tahu Journal. 10: 20-21.

[1] Information derived from Murdoch, R. (1994). Maori healing and herbal: New Zealand ethnobotanical sourcebook. Paraparaumu, N.Z., Viking Sevenseas, with permission

Harakeke (NZ flax)

Harakeke (New Zealand flax or *Phormium tenax*) is the most important of the fibre plants used by Maori in weaving and plaiting. Over generations, Maori weavers have cultivated selections of harakeke best suited for particular purposes. Among the special harakeke growing at Kowhai Farm are:
Kohunga and Taeore — their long, silky muka (fibre) is used in cloak making.
Paoa — when plaited, its yellow–green leaves dry to a rich gold.
Ngaro — used for piupiu (skirts) because the muka is long and strips easily from the blade.
Maeneene — distinguished by smudged brown margins.
The durable blades are used for whariki (mats).
Awahou — the stiff blades make very strong kete (baskets) which dry white after boiling.
With thanks to Manaaki Whenua - Landcare Research and Cath Brown of Te Runanga o Taumutu

A well trimmed harakeke. The rito (growing shoot) and the leaves on either side of it are never cut.

Muka (fibre) is scraped from the harakeke leaf with a mussel shell

Weaving a kete

The yellow-green leaves of Paoa dry to a rich golden yellow

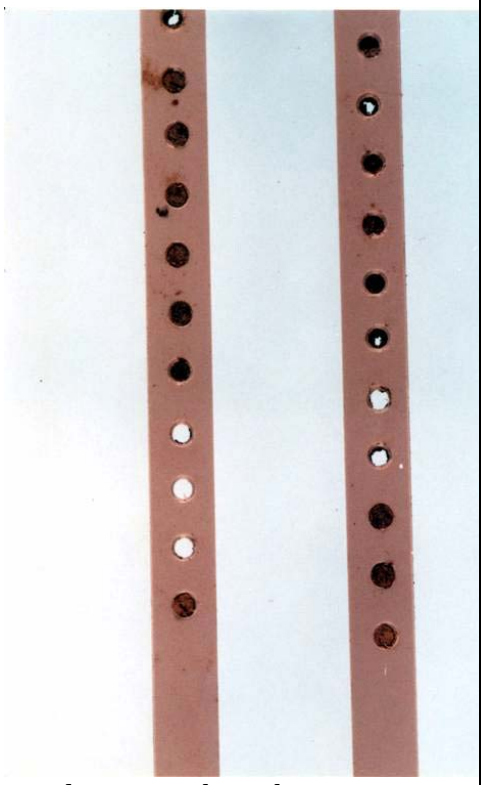
How to …

Buy harakeke plants in pots. To aid establishment of large plants, cut the top third of the leaves off. Mulch as necessary. Large mature clumps of harakeke can be divided to provide planting stock. Cut the leaves back to approximately 30cm before planting, to balance the reduced root mass.

Biodiversity of soil microorganisms

When farms convert to organic agriculture, there is often an improvement in soil quality over time, especially in organic carbon levels. This improvement is being monitored by Crop and Food Research on Kowhai Farm. As soil conditions improve the populations and activity of those soil bacteria, fungi and small arthropods associated with the breakdown of organic matter should increase. The "Bait Lamina Probes" used here contain a series of holes in each of which a diet mixture has been inserted. The rates at which the bait "plugs" are broken down are being used to measure soil activity at different depths, over time and between different farm habitats.

The ingredients of the lamina probe diet mixture: cellulose, carbon and bran



Bait lamina probes, showing some bait plugs that have been "eaten" by soil microorganisms

How to …

If you wish to purchase bait lamina probes, contact Harvey Barraclough on 06 328 5068 or Steve Wratten (wrattens@lincoln.ac.nz) at Lincoln University. These probes will have no bait inserted. To make your own bait, mix the following ingredients together in water: 65% cellulose, 15% agar, 10% bentonite (sold in home brew shops) and 10% wheat bran (ground into a powder), then heat until agar has dissolved.
To find out more about how to use the probes, for example to compare soil at different sites on your land, e.g., restored compared with bare areas, you may wish to read a biodiversity school educational pack, funded by the Community Trust (New Zealand). Aimed at high schools, it contains a practical guide, seeds, a video and lamina probes.

Contact: Peter Smith
Educational Solutions Ltd
PO Box 100
Lincoln, Canterbury
Ph: 03 325 2052, Fax: 03 325 2278
Email: edsol@xtra.co.nz

Use five probes per site. Use a barbeque skewer to make five holes and put one probe in each hole, with the uppermost baited hole in the probe 2 cm below the soil surface. Try to ensure, by firming the soil, that the probe is in contact with the soil.

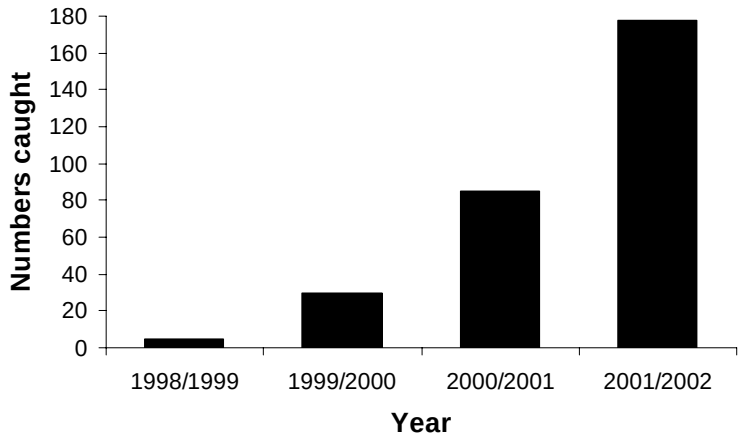
Check the probes every two weeks in winter and weekly in summer. Finally, remove and assess the probes when around half the baits have disappeared at the site at which they have disappeared most rapidly.

Monitoring populations of beneficial insects

Yellow insect traps along a fence line

Yellow ice-cream containers set along the fence line of paddock A3 contain water, detergent and a preservative. They are highly attractive to beneficial insects such as hover flies, ladybirds, parasitic wasps and bees.

The traps have been at this site since 1994 and have been emptied regularly since that time to monitor populations of these insects. This enables the numbers of these beneficial insects to be compared before, during and after the conversion of Kowhai Farm from conventional to organic agriculture (as biodiversity on the farm is added and matures). We expect the populations to increase as the diversity of native and non-native plants on the farm increases. Biological control agents need pollen and nectar for protein and energy(see page 25), as well as shelter provided by the field margin plants. Before conversion, herbicides removed most of the latter. Numbers of parasitic wasps (Ichneumonidae), which lay eggs in or on caterpillars and other insects, have increased over time (see graph – below), indicating that this trapping method may give a good representation of changes in insect populations and communities over time.



Number of individuals in the parasitic wasp family Ichneumonidae caught in yellow pan traps on Kowhai Farm between November to February

How to …

Use any type of yellow plastic container (or paint plant-pot trays with yellow waterproof paint). Place each one inside another, with the lower container anchored to the ground with a piece of number 8 wire passing through its centre, and bent over to hold the tray. Three quarters fill the inner container with water and add a few drops of household detergent to break the surface tension. Stir in a tablespoon of potassium sorbate, if you can get it or 10cc of antifreeze, as a preservative. Use tweezers to remove the 'good guys' – parasitic wasps, ladybirds, hoverflies. Put them in pottles with a little methylated spirit. Your local university, college, branch of FruitFed Supplies, agricultural/horticultural consultant or other agricultural merchant may be able to help you identify them. Alternatively, send them to Lincoln University (Prof. Steve Wratten) but contact him first – see page 4.

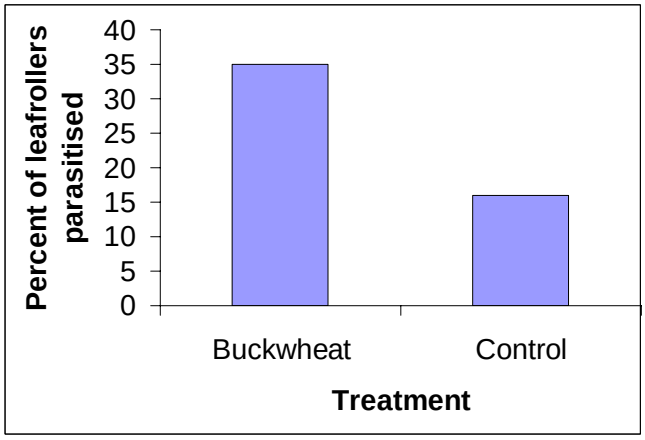
Buckwheat and other flowering plants for beneficial insects

A flower-feeding hoverfly

Many beneficial insects that are useful in biological control of pests need pollen and nectar resources. The pollen provides protein and the nectar energy. Farmland can be relatively poor in these resources, especially in the spring. Flowering gorse hedges and tagasaste (tree lucerne) are two valuable sources at this time especially for bees. Native and non-native biodiversity can be added in the form of flowering plants in paddock margins. A well-researched example is buckwheat.

The flowers of this plant are numerous and shallow, so they represent an abundant and easily accessible source of nectar and pollen. Insects such as ladybirds, hover flies and parasitic wasps use buckwheat in large numbers, and biological control of pests can be enhanced as a result. Research in orchards, vineyards and cereals has shown that buckwheat can enhance biological control of pests in these systems by enhancing the numbers, fecundity and longevity of beneficial insects.

Buckwheat is an annual plant; perennial options include the common, non-native, garden flower alyssum. Natives which can be useful in this way include many species of *Hebe*. An annual plant which has particularly abundant pollen is phacelia (tansey leaf) - available at Yates garden seed outlets. If your local shop does not have it in stock, ask them to get some. This species is highly favoured by hoverflies, which readily feed on its pollen; its nectar, however, is at the bottom of the tubular flowers, and partly protected by hairs and flaps protruding into the flower's centre. This makes it inaccessible to some parasitic wasps. It is therefore important to match the flower species to the crop/pest interaction – so seek advice from Lincoln University – see page 4.



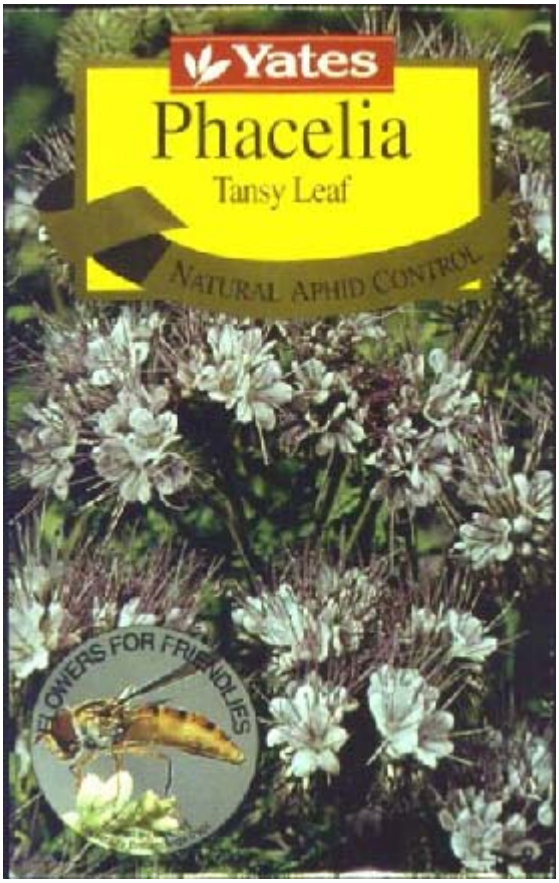
Parasitism of leafroller caterpillars in Marlborough vineyards with and without buckwheat flowers (Data from Dr. Lisa Berndt)

Agent	Targets	Feeding Plants
Hover flies	Larvae eat aphids and small caterpillars	*Phacelia*, buckwheat, parsley, mustard, alyssum
Lacewings	Larvae eat aphids, spider mites	Angelica, buckwheat, canola*, *Coreopsis*, mustard, pak choi, sunflower, alyssum, *Phacelia*
Ladybirds	Adults and larvae eat aphids, spider mites	Angelica, buckwheat, buddleia, coreopsis, coriander, dill, fennel, yarrow, alyssum, *Phacelia*
Parasitic wasps	Pests parasitised (eggs laid in pests) different species of wasps for different pest species	Canola*, cow parsley, dill, fennel, Queen Anne's lace, mustard, pak choi*, buckwheat, alyssum
Tachinid flies	Adult flies lay eggs on cutworms, leaf roller caterpillars, grass grub, etc.	Broad bean, buckwheat, canola*, cow parsley, mustard, pak choi*, Queen Anne's lace, *Phacelia*, buckwheat

* take care with all species that neighbours aren't growing a seed crop that could be contaminated from your beneficial flowers of similar crops.

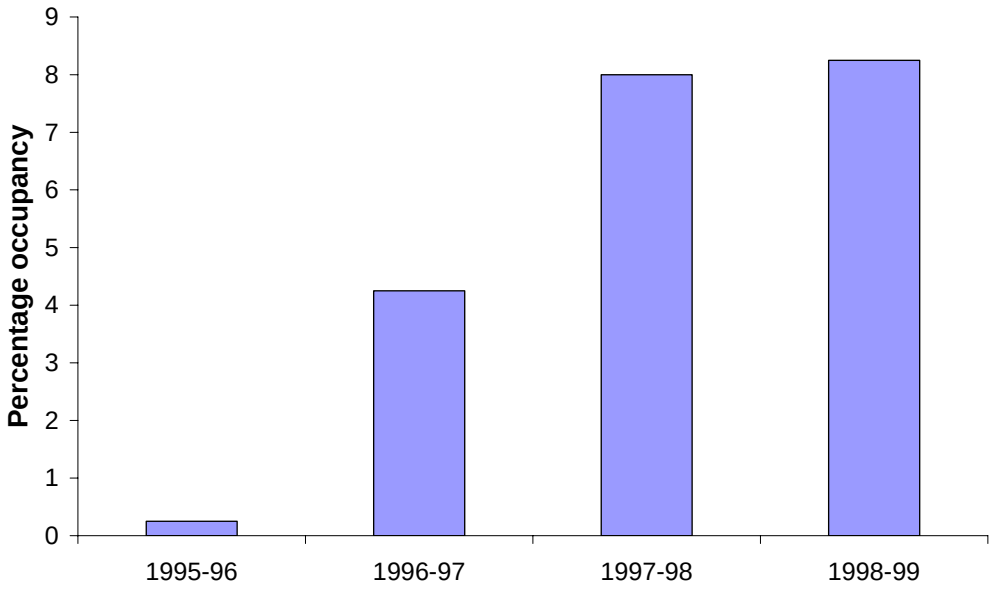
How to …

Obtain buckwheat seeds from a commercial seed merchant (FruitFed Supplies are a reliable source or Kings Seeds for smaller quantities) and drill them mechanically, or, for smaller areas, sow in hand-made drills from October at four-week intervals in 4-5 rows, 20 cm apart, on each drilling date. When flowering is half-complete, remove the top third of the plants, using a weed-eater or similar machine – this will encourage growth of the side shoots and will prolong the length of flowering as a result. For phacelia and alyssum, buy seeds from Yates or Kings Seeds and follow instructions on the packet. The Yates phacelia product (see below) has information on biological control in the garden, inside the packet.

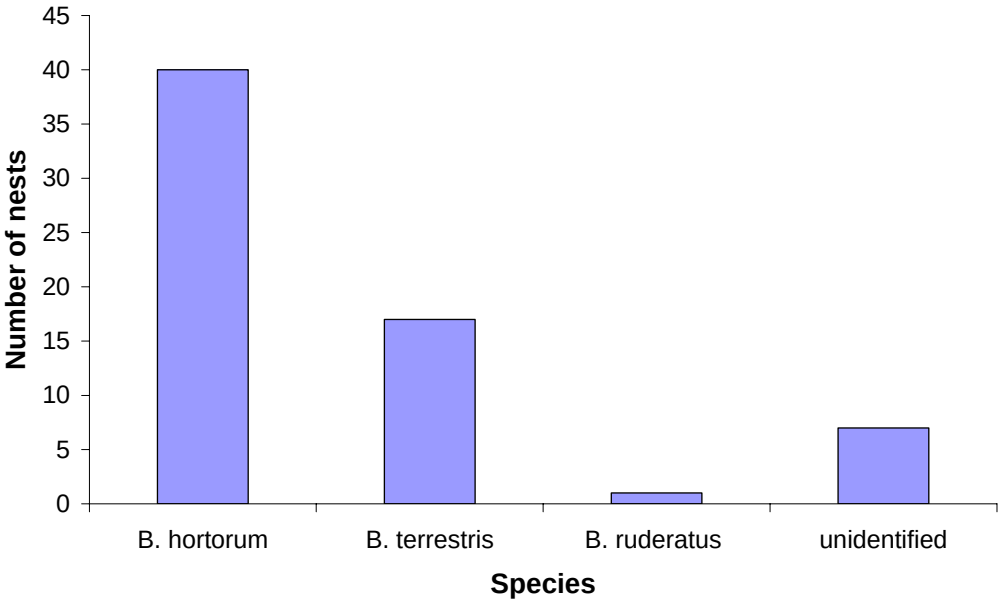


Bumble bee motels

Bumble bees were introduced to New Zealand from Britain in the second half of the 19th century and are pollinators of some key crops, especially red clover and lucerne. In the spring, bumble bee queens need suitable sites to initiate their nests. In Europe, these would typically be abandoned mouse nests, but these are not common on New Zealand farmland. Bumble bee motels are an attempt to provide additional nest sites for bumble bees. There are 80 'motels' around the paddock margins of Kowhai Farm and many have active nests in summer. Along with the planting of spring-time nectar and pollen sources for bumble bees, these motels enhance one important aspect of non-native biodiversity on farmland: pollinators.

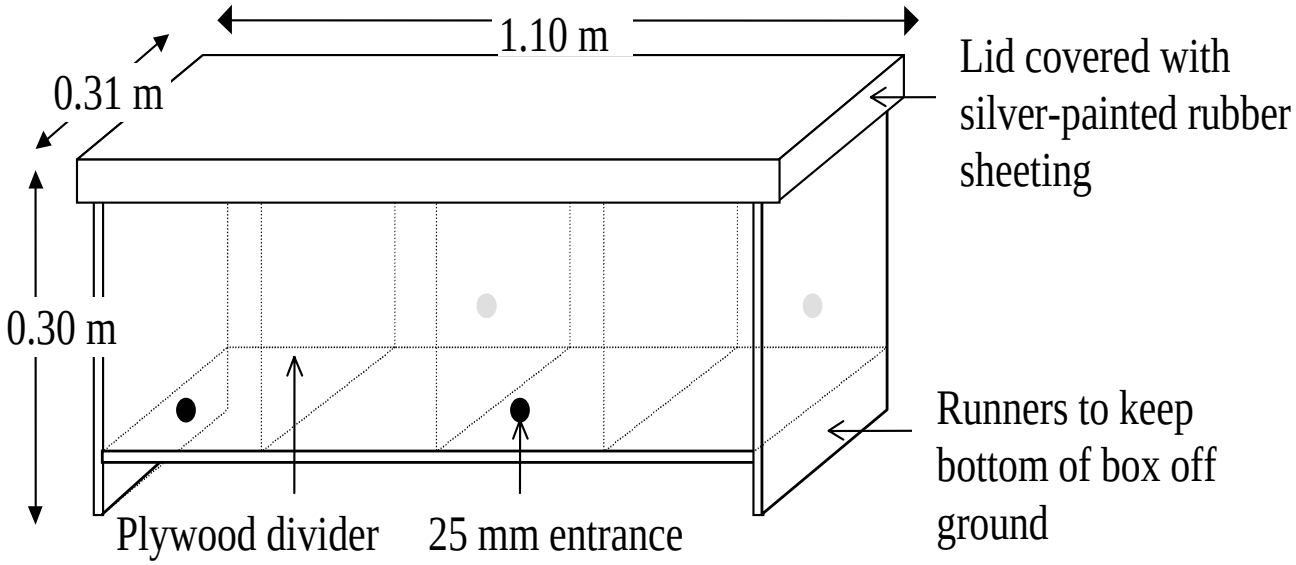


Occupancy of 'motels' by bumble bees at Lincoln 1995-99 (number of compartments = 320 in units of four) (from Barron, M.C., Wratten, S.D. and Donovan, B.J. (2000). Agricultural and Forest Entomology 2, 141-146).



Number of nests founded by different species of bumble bees in 'motels' over four years 1995-99 (from Barron, M.C. Wratten, S.D. and Donovan, B.J. (2000). Agricultural and Forest Entomology 2, 141-146.

Bumble bee motel diagram



A bumble bee motel, showing the 'mezzanine floor' in one unit. The other three units have upholstery padding in place.

Inside a bumble bee mote

How to …

Bumble bee motels are constructed from 4 mm plywood; the lids are covered in silver-coated rubber. The boxes are divided into four compartments, each supplied with two pieces of upholstery padding and a 25 mm entrance hole – see bumble bee motel diagram above. The upholstery padding is supplied as two layers, separated by a plastic sheet. Cut the padding into 30cm x 30cm squares, peel the two layers apart and remove the plastic sheet. Use both of the separated layers in each motel unit, placed on top of the 'mezzanine floor'. This is a piece of Coreflute cut to fit the unit, and drilled with c.100 3 mm holes. The holes help minimise condensation and let some of the bees' waste fall through. The 'mezzanine floor' is suspended 5cm above the motel floor by resting it on four nails pushed through the two unit walls on the long sides of the motel.

Motel deign based on the ideas of Dr Barry Donovan, DSIR, Lincoln, Canterbury

Wasp hotels

These 'hotels' are provided for the introduced predatory wasp *Ancistrocerus gazella*. The wasp is 15 – 17 mm long and nests in holes or cracks in walls or wood. The female wasp captures small caterpillars which it paralyses by stinging. It then takes up to 20 caterpillars to its tubular nest where it lays eggs suspended from the roof. It seals the caterpillars in with a mud wall. Wasp larvae hatch from the egg, consume the caterpillars, pupate and then the new adult wasps bite their way through the mud seals. Cropping farms have few natural nest sites, so these 'hotels' provide wasp habitat. Typical caterpillar pests on mixed cropping farms include larvae of the cabbage white butterfly and the diamond back moth. This work was carried out in collaboration with Williams & Kettle FruitFed Supplies and the hotels are based on a design by John Clearwater.

A wasp hotel set in a buckwheat border (photo courtesy of FruitFed Supplies Ltd)

A parasitoid wasp laying its egg inside a caterpillar

How to …

You can make your own 'hotels' or, for the cost of freight only, you can obtain one or more from:

Linda Haughey
Crop Monitoring Services Manager
Williams & Kettle FruitFed Supplies
PO Box 322, Hastings
Ph: (06) 873 0954
Fax: (06) 876 3305
Mobile: 0274 791 511
Email: lhaughey@fruitfedsupplies.co.nz

To make your own 'hotel', take a piece of untreated 'three by two' wood (i.e., 75 mm x 50 mm in cross section) and 400 mm long. Try to get Lawson cypress – or pine will do. Drill around 30 holes 5 mm in diameter and 70 mm deep in one side of the wood. Repeat for a second block of wood. Bend a piece of galvanised iron sheeting into an angle of approximately 100^{o}. Bolt the blocks one above the other on the inside of one of the two angled faces of the iron and mount the 'hotel' on a fence line so that the wooden blocks are sheltered from rain by the angle 'roof' – see photograph above. Assess the hotels over the ensuing weeks for mud-sealed holes.

Weta motels and wooden discs as refuges

Weta in a motel

Weta motels

Hollowed-out untreated pine blocks are used to simulate the cavities found in mature trees that are used by weta. Weta are a group of insects related to grasshoppers that are endemic to New Zealand. On Kowhai Farm, it will take many years for the newly planted trees to become old enough to develop cavities, so by using these motels the successional process is accelerated until cave or tree weta colonise the trees. The motels make useful refuges for other groups such as endemic spiders and pseudoscorpions that shelter and breed in them.

Pseudoscorpion in a weta motel

Wooden discs

Similarly, discs or blocks of untreated pine can be used to simulate the fallen branches found in mature native forests. These discs harbour native and endemic invertebrates such as predatory spiders and ground beetles, as well as snails, slugs, earthworms, flatworms, harvestmen, slaters and even endemic skinks (a type of lizard). The changes in populations of these animals can be monitored by carefully lifting the discs and counting the individuals. The larger animals can be marked to assess their movements.

Native snail

Native slug and flatworm

Ground beetle – in the family Carabidae

How to …

Weta Motels

Take a piece of untreated wood about 150 mm long and 50 mm square. Use a chisel or a machine to take out a groove 25 mm wide along the whole length of the wooden block. Tie the block to a wooden fence post, groove side down. Assess for occupancy at intervals.

Wooden discs

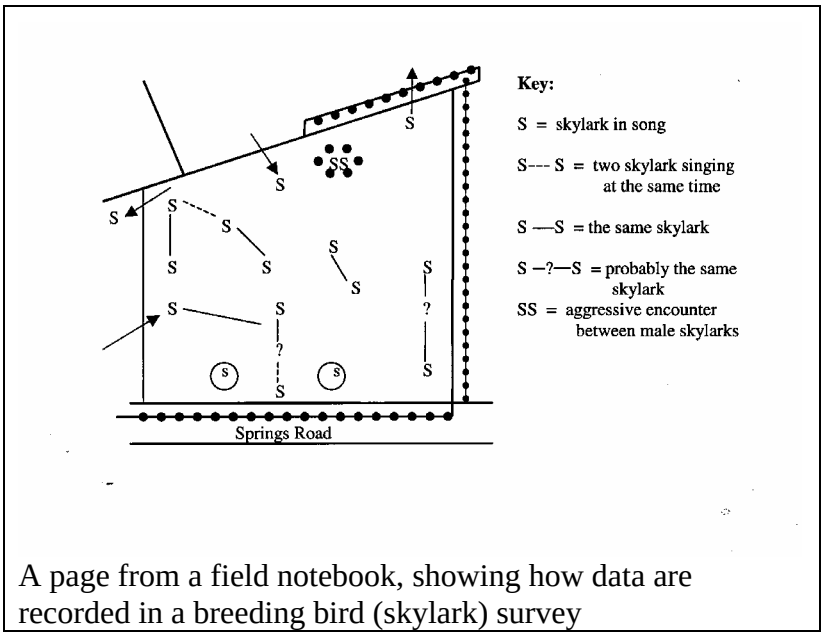
These are slices across untreated pine-tree trunks, placed on the ground with grooves (see above) against the soil surface.

Bird diversity

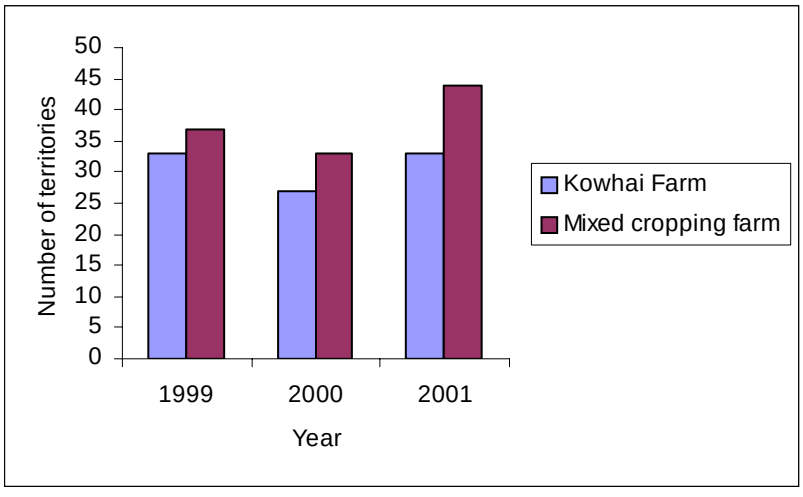
A skylark

In western Europe, populations of many species of farmland birds are in decline. For example, during the last 20 years, skylark populations have declined by 60% in the United Kingdom. An annual programme of breeding bird surveys on Kowhai Farm and a matched area of the University's mixed cropping farm was initiated in the spring of 1999.

The number and activity of all species of breeding birds are recorded on maps over several visits. This information is used to determine the number of territories of each species on the farm. Those surveys can provide information on bird numbers over time and can show the effects of organic management practices and plantings of native and endemic trees and shrubs. By understanding why harmless European bird species are abundant in New Zealand, it should be possible to conserve them better here and in western Europe. The only native New Zealand bird breeding on the farm in 1999/ 2000 and 2000/ 2001 was the South Island Pied Oystercatcher, although even this species also occurs in Europe.



A page from a field notebook, showing how data are recorded in a breeding bird (skylark) survey



Skylark numbers on the two study farms

How to …

To assess breeding bird populations on your farm, use a large-scale map and make repeated walks along paddock margins noting the location and behaviour of each bird on the map. Ignore gulls, etc., flying over the land. Devise some symbols (see above) to represent the birds' activity. After three or four weekly or two-weekly visits, patterns should start to emerge. Eventually, lines can be drawn around clusters of observations, and each cluster is likely to be a territory. This process is demonstrated in the video which is part of a school biodiversity package recently produced, with Community Trust funding. See page 23.

Efficiency and environmental effects of mechanical weeding

A project funded by the Agricultural Marketing and Research Development Trust (AGMARDT) compared the effects of three mechanical weed control treatments on plant biodiversity in terms of the soil weed seed bank and weed populations. Crop biomass and yield, invertebrate populations and soil quality were also measured over three years in paddocks A2-A5. The trial design was a linear randomised complete block with four treatments and five replicates (20 plots paddock). The treatments were: tine weeder, spoon weeder, inter-row hoe and a control, which was unweeded during the crop growing season. After harvest of the summer crop all plots received the same treatment as the rest of the field until the following spring. The summer crop was then sown and the treatments were repeated in the same area of land. Some of the key results can be found on the Lincoln University web page: http://www.lincoln.ac.nz

Spoon weeding

Tine weeding

Inter-row hoeing

Summary: Strategies to enhance biodiversity on mixed cropping farms

The added biodiversity on Kowhai Farm has matured as the farm passed the threshold of full BIO-GRO status in July 2002. Its pivotal position adjacent to Springs and Ellesmere Junction Roads near Lincoln, Lincoln University and the surrounding farmland has guaranteed high profile. Media attention has been high, and the farm received an Environment Canterbury environmental award in 2002. A United Kingdom Parliamentary Select Committee visited in 2002, hundreds of visitors each year pass through the farm's main gate and the farm has been nominated for other environmental awards. This MfE-funded project has been crucial in these advances. In 2003, a drive, walk or cycle through mid-Canterbury reveals many paddock margin plantings which mimic those on Kowhai Farm. The MfE funding has led to support from the Community Trust to take the concept of 'ecosystem services' to high school students (see page 23) and to funding from the Foundation for Research, Science and Technology, ($3.3 million over six years) for evaluation and enhancement of ecosystem services in key agricultural and horticultural sectors in New Zealand. The MfE work also helped to secure the creation at Lincoln University of the Royal Society of New Zealand-funded ($25 million) Centre of Research Excellence: 'National Centre for Advanced Bio-Protection Technologies'.

Appendix 1.

"PROFITING WITH NATURE – on your cropping farm"
Selwyn Sustainable Agriculture Society Field Day

This was the title of a field day held at Simon and Angela Osborne's Leeston property in June 2002. The programme included practical demonstrations and discussion on how to profit from the natural resources and biodiversity on farms: the soil, earthworms, beneficial insects and plants.

The many values to individuals and to society of biodiversity were re-emphasised. These include:

- commercial production benefits
    - Directly: food, medicines and clothing
    - Indirectly: pollination, biological control and more productive soils etc

- other direct economic benefits (e.g., enhanced land values, tourism)

- aesthetic benefits (people enjoy viewing species and the ecosystems in which they live)

- "existence value", which is the value we place on knowing species and ecosystems remain in existence.

The field day focused on the indirect commercial production benefits of having a healthy productive soil and a range of animal and plant species on the farm.

Take-home messages to enhance biodiversity and give benefits on YOUR farm:

- **Monitor** insect and weed populations before spraying – a spray may not be necessary
- **Choose selective pesticides** to minimise environmental impact
- **Target** the problem pest
- **Avoid** organophosphates and other broad-spectrum pesticides, which can needlessly kill harmless and potentially beneficial insects and spiders
- **Encourage earthworms** as they provide many benefits
- **Minimise or eliminate cultivation** to avoid damage to earthworm populations and the soil's physical and biological status
- **Choose machinery carefully** to minimise its impact on the soil
- **Retain crop residues** and mulches to improve the soil's nutrient levels, organic matter and structure
- **Rotate crops** to create a balance of species living on the farm
- **Use pasture** to provide a restorative phase for soil organic matter and structure
- **Retain habitats** for insects and spiders with grass and diverse plant species along fence lines and in shelterbelts
- **Include native plants** in mixed shelterbelts, paddock corners and woodlots
- **Adopt good practice** to ensure successful plant establishment and management in shelterbelts and woodlots

The field day was held with financial support from the Ministry for the Environment's Sustainable Management Fund.

Appendix 2.

Farm Biodiversity Plan – Kowhai Farm

Heinz Wattie's
Organic Farm
Lincoln University

Farm Biodiversity Plan

Kowhai Farm

This plan aims to introduce the concept of biodiversity to the farm by establishing native and introduced plantings on field margins, shelters for beneficial insects, enhanced populations of wild food plants, etc.

Aesthetic, conservation and production benefits can include:

- Re-introduction of native or endemic plant species
- Providing habitat for native, endemic and introduced species
- Biological pest control by beneficial micro-organisms, insects and birds
- Weed suppression, fewer agrichemicals, shelter, enhanced pollination and erosion management

BIODIVERSITY or "the variety of life" was introduced as a concept at the Rio Earth Summit in 1992.

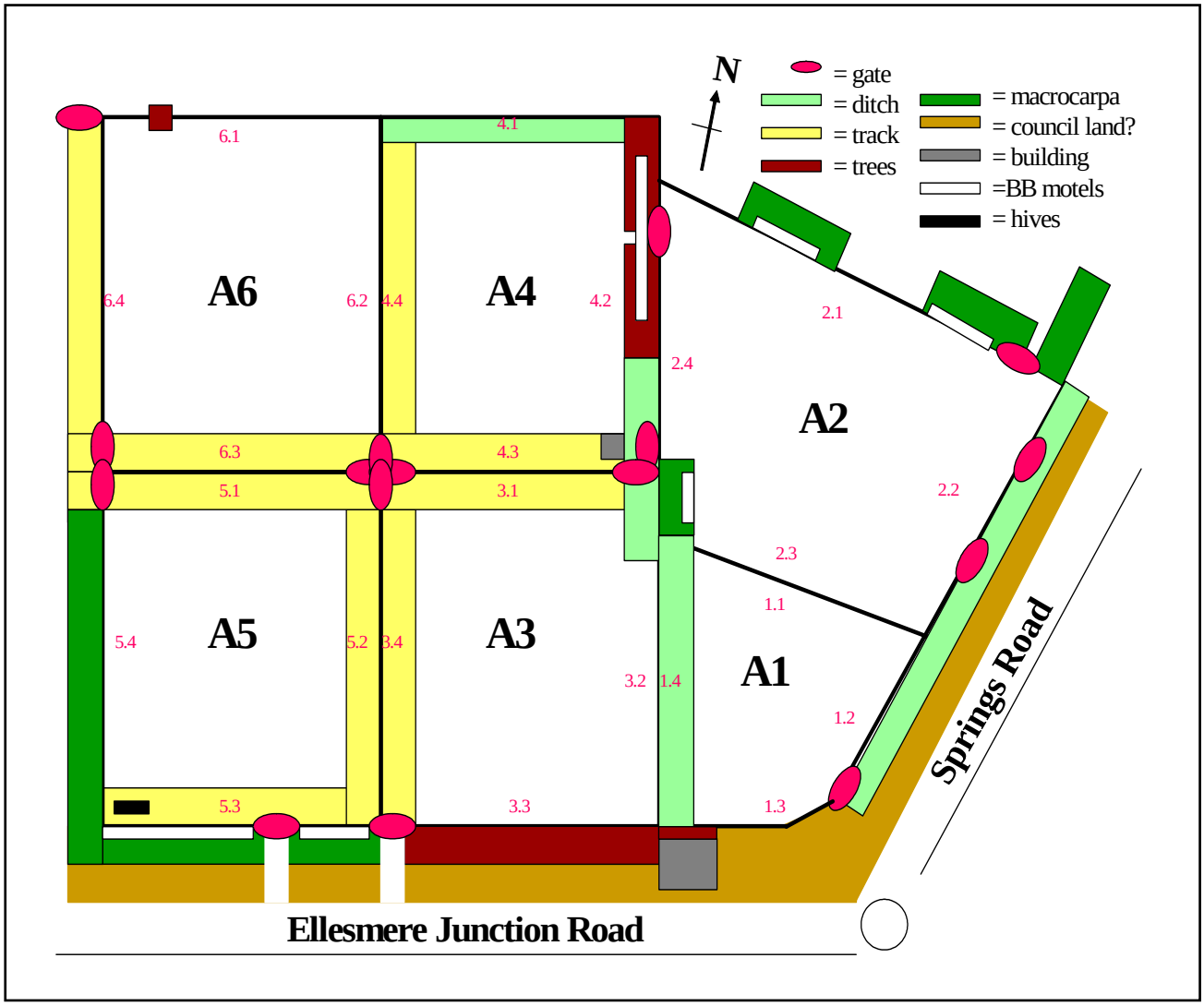
Biodiversity is short for biological diversity. It means the variety of all living things: plants, animals and micro-organisms, the genes they carry and the land and water ecosystems of which they are a part.

Biodiversity has been evolving since the beginning of life. It provides us with fresh air, clean water and fertile soil and is the basis of the interconnected web of life on earth.

Biodiversity is essential for the survival of all species, including humans. It is the source of our foods, medicines and industrial raw materials. Our economic prosperity is dependent on it, from agriculture to tourism. In fact, the value of biodiversity – providing these ecosystem services – has recently been calculated at US$33 trillion per year world-wide. This figure is put into context by the fact that the world's annual GDP is US$18 trillion.

In New Zealand, farmers have a key role in maintaining and enhancing the biodiversity on their land, while doing their best to manage pests, diseases and weeds in a sustainable way. A new way of describing farmers' role in this context, which is being used in Europe and open to active debate is 'photosynthesis managers' and 'ecosystem-service providers'!

Kowhai Farm map



Lincoln University

Key to Farm Icons

Beneficial

Aesthetic


Trees

Flowers

Grasses

Conservation

Reintroduction of native and endemic plant species

Providing habitat for native, endemic and introduced:

Birds

Insects and spiders

Fish and eels

High water quality

Production

Beneficial micro-organisms and insects, including biological control

Weed suppression

Fewer agrichemicals

Shelter

Enhanced pollination

Erosion management

Crops

Stock

Soil microbes and earthworms

Soil structure and fertility

Timber production

Kaitiaki Tanga

Cultural value

Taonga raranga

Mahinga kai

Rongoa Maori

Harmful

Potential competition with natives

Potential competition with natives

Potential weed

Potential habitat for vertebrate pests
(e.g. rabbits, stoats, ferrets, weasels, possums)

Invertebrate pests

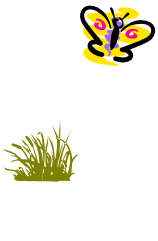
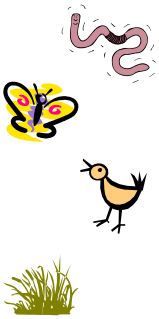
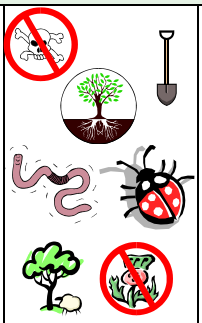
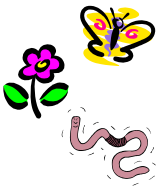
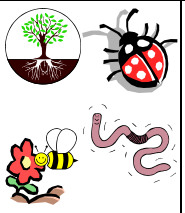
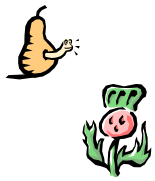
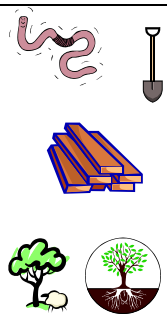
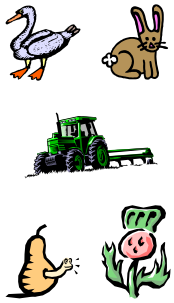
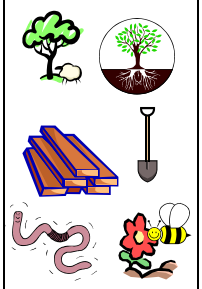
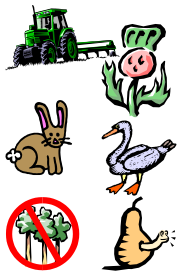
Harmful birds eating crops, bringing in weed seeds

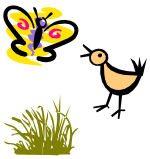
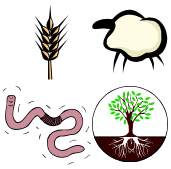
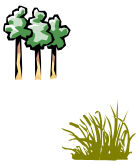
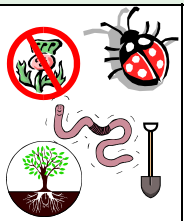
Potential tree debris affecting machinery use

Definitions

Endemic	Lives only in New Zealand, e.g., bellbird.
Native	Lives in New Zealand (not recently introduced) but also lives elsewhere, e.g., red-billed gull, pukeko.
Introduced	Accidentally or deliberately introduced e.g., German wasp, white butterfly, skylark, gorse, tree lucerne, oaks, European earthworms.
Kaitiakitanga	The exercise of guardianship and stewardship by tangata whenua.
Tangata whenua	The iwi (tribe) or hapu (subtribe) of the area.
Taonga raranga	Living things which are highly prized for use in manufacturing.
Mahinga kai	The place and products of food gathering.
Rongoa Maori	Living things of medicinal importance.
Harakeke	Flax.

Biodiversity on Canterbury farmland

	Beneficial			Kaitiaki-tanga	Potentially Harmful
	Aesthetic & Recreational	*Conservation & History*	*Production*		
Field Margins, Service and Recreation Areas					
Native grasses					
Flowers (phacelia, hebes)					
Native trees (cabbage tree, pittosporum, hoheria [ribbonwood], plagianthus [lacebark])					
Kai species (puha, watercress)					
Introduced trees (tree lucerne)					
Bumble bee motels					
Native bee nests					

	Beneficial			Kaitiaki-tanga	Potentially Harmful
	Aesthetic & Recreational	*Conservation & History*	*Production*		
Open Paddocks					
Beetle banks, native and introduced grasses					
Productive species (crops, sheep)					
Waterways & Wetlands					
Planted waterway banks					
Enhanced water flora and fauna					

† Potentially harmful practices need to be managed to prevent them from causing long-term harm.

* Historical or cultural association of understanding and appreciating the past to benefit the present and future management and decision-making.

Including homestead, wahi tapu (sacred or special site), tracks and road verges.

Appendix 3.

3) Key Contacts

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