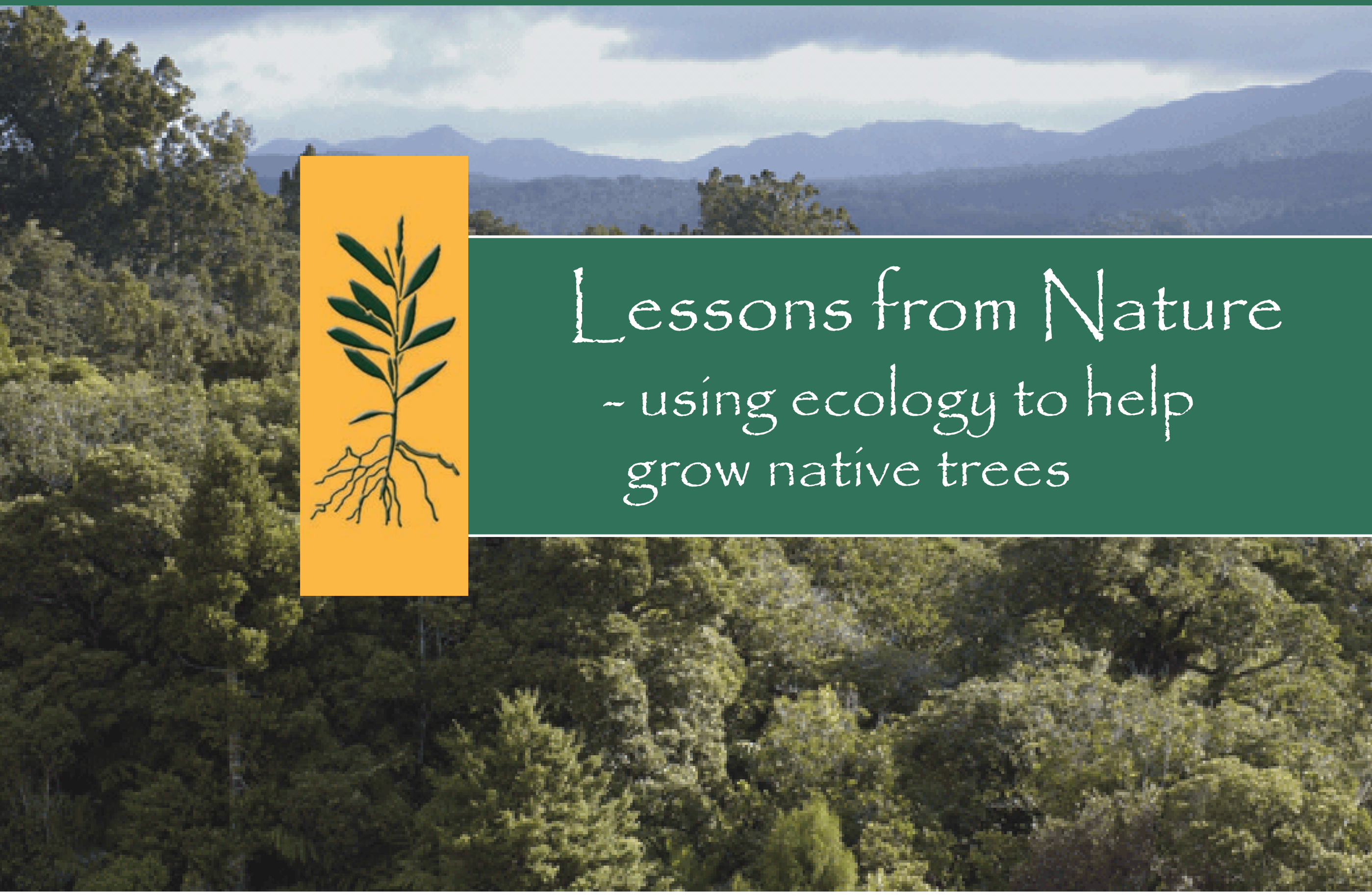


Lessons from Nature

- using ecology to help grow native trees

INTRODUCTION: Lessons from Nature

Forests covered about 80% of New Zealand prior to human arrival (Leathwick et al. 2003). With human settlement, however, most of these forests were cleared particularly in the lowlands, so that original forests now cover only about 23%. But the environments on this cleared land remain those supportive of trees, so the natural tendency of vegetation growing there is to develop into forest. Regrowing forests on previously cleared land in New Zealand is therefore an exercise in directing and accelerating the natural progression of vegetation change.

Because of New Zealand's long period of geological isolation, 80% of New Zealand plant species are found nowhere else in the world. This is high by international comparison and New Zealand is recognised as one of 34 biodiversity hotspots in the world, (www.biodiversityhotspots.org). Important native tree groups represented in New Zealand are conifers in the family Podocarpaceae, members of the southern beech family Nothofagaceae, and several trees from families with subtropical affinities, such as kauri *(Agathis australis)*, puriri (*Vitex lucens)* and kohekohe *(Dysoxylum spectabile)*. The high number of plants unique to New Zealand means that we can't rely on overseas information to learn how to grow our native trees. We must develop this information within New Zealand and there is still much to learn.

kauri

Table 1 provides a somewhat conservative list of native trees that growers might consider for plantations. These species were chosen and listed in rough order for their value as timber species, and because their ecology suggests they could be adapted to some form of plantation silviculture. Other native species may be added to this list as our knowledge of them becomes more complete.

Table 1: Native trees with plantation potential

Conifers (softwoods)		Broadleaved trees (hardwoods)	
Common name	**Scientific name**	**Common name**	**Scientific name**
Kauri	*Agathis australis*	Red beech	*Nothofagus fusca*
Totara	*Podocarpus totara*	Silver beech	*Nothofagus menziesii*
Rimu	*Dacrydium cupressinum*	Black beech	*Nothofagus solandri var. solandri*
Kahikatea	*Dacrycarpus dacrydioides*	Puriri	*Vitex lucens*
Matai	*Prumnopitys taxifolia*	Rewarewa	*Knightia excelsa*
Miro	*Prumnopitys ferruginea*	Mangaeo	*Litsea calicaris*
Tanekaha	*Phyllocladus trichomanoides*	Pohutukawa	*Metrosideros excelsa*
		Kohekohe	*Dysoxylum spectabile*
		Hinau	*Elaeocarpus dentatus*
		Tawa	*Beilschmiedia tawa*
		White maire	*Nestegis lanceolata*
		Black maire	*Nestegis cunninghamii*
		Kanuka	*Kunzea ericoides*

Remnant forests can still provide us with much information about the range of native species that we might consider for plantation forestry and their ecological requirements in relation to a proposed planting site. Native forests in New Zealand can be divided into three main types:

- Beech forests that mostly occur in the South Island and at higher altitudes. Two-thirds of remaining forest in New Zealand is beech or with beech as a major component.
- Mixed conifer-broadleaved forests that occur in the lowlands of both North and South Island and the majority of the south of the North Island.
- Diverse mixed forests with kauri as a dominant that occur in the north of the North Island

Plantation Forestry

As with all tree species used in plantation forestry, New Zealand native trees evolved in natural forests where their survival, growth and reproduction were affected by the physical environments that prevailed, the disturbances (e.g., windstorms, fire, landslides) that assailed them, and by the other plants, animals, and fungi of the forest ecosystem they interacted with. Responses to these factors differ markedly between species, and identifying the environments in which each species thrives and its strategies for survival are important tools in selecting species suited to a particular site, and in choosing the most effective silvicultural regime in which to grow them.

We have, in New Zealand, developed a silvicultural regime for radiata pine *(Pinus radiata)* that reflects its natural ecology. Radiata pine is a light-demanding pioneer that tolerates infertile soils in its natural ecosystem, and our management regime for this species reflects this. Pines don't tolerate shade so we plant them in open landscapes. This also means they don't regenerate under their own canopy, so replanting is necessary. As pioneers, they have wide environmental tolerances, so they can be planted on a wide range of sites. They don't self-prune like kauri, so we must prune them for higher wood quality. Many of our native trees have different ecological requirements and characteristics to pine (and from each other), so effective silvicultural management systems for these species will differ from pine.

(a) beech forest

Native forest in New Zealand comprise three main types – (a) beech forest, (b) mixed conifer-broadleaved forests, and (c) diverse mixed forest with kauri. Most of our native trees have different ecological requirements to radiata pine, pictured at the bottom of the page.

(b) mixed conifer-broadleaved forests

(c) diverse mixed forest with kauri

Radiata pine is a light-demanding pioneer of infertile soils that is successfully planted throughout New Zealand on a wide range of landscapes.

ENVIRONMENTAL TOLERANCES AND SPECIES DISTRIBUTIONS

Geographical

Tree species do not occur randomly or ubiquitously across the landscape, but have defined geographical distributions. Some species are widespread while others are much more limited in their ranges. For example, rimu *(Dracrydium cupressinum)* is a widespread species that gains its maximum abundances on the central plateau of the North Island, and the west and south coasts of the South Island (Figure 1). Silver pine *(Manoao colensoi)* is also widespread but is most abundant on the west coast of the South Island. In comparison, kauri and mangaeo *(Litsea calicaris)* are much more restricted in distribution to the north of the North Island with greatest abundances attained in Northland and Waikato/Bay of Plenty respectively (Figure 1).

Figure. 1: Natural distributions of rimu, silver pine, kauri, and mangaeo (Hinds & Reid 1957)

Temperature and water

These variations in distribution reflect the ability of different species to grow at different parts of environmental gradients. Analysis of species distributions in remnant forests along temperature gradients suggest that kauri, kohekohe, and taraire *(Beilschmiedia tarairi)* are most abundant in areas with relatively high annual temperatures and winter minimum temperatures well above 0°C; rimu and tawa ‘prefer’ moderate annual temperatures and winter temperatures still slightly above 0°C; while matai *(Prumnopitys taxifolia)* and the beech species *(Northofagus* spp.) occur at highest abundance at relatively low annual temperatures and winter minimums below 0°C (Figure 2).

Species also distribute themselves along gradients that reflect water availability. In this case, matai, kohekohe and titoki *(Alectryou excelsus)* are abundant in areas with droughty soils and low humidities, whereas most of the beech species, rimu and kamahi *(Weinmannia racemosa)* require moist soils and high humidities (Figure 3).

A note of caution with these analyses is that they are based on natural forests which include the effects of competition between tree species, so a species position on these graphs may not reflect the exact point at which it grows optimally without competition.

Information on the natural distributions and environmental tolerances of native tree species is important when deciding on appropriate species to plant at any site. The composition of local remnant forests can be a guide to which species grow successfully in a region. In some cases, microsites occur within landscapes that can provide environments different from the regional average, e.g., warmer or more humid, and these can provide rare opportunities for species that naturally may have limited occurrence in a particular region.

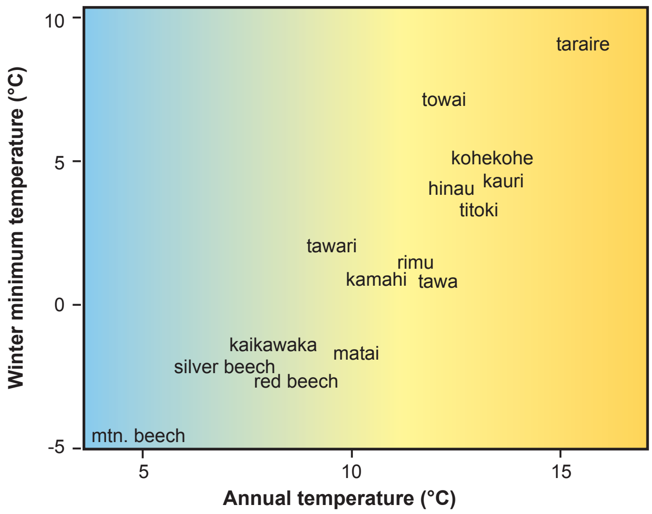


Figure 2: Annual and winter minimum temperatures at which some New Zealand tree species reach their maximum abundances (Leathwick et al. 2003).

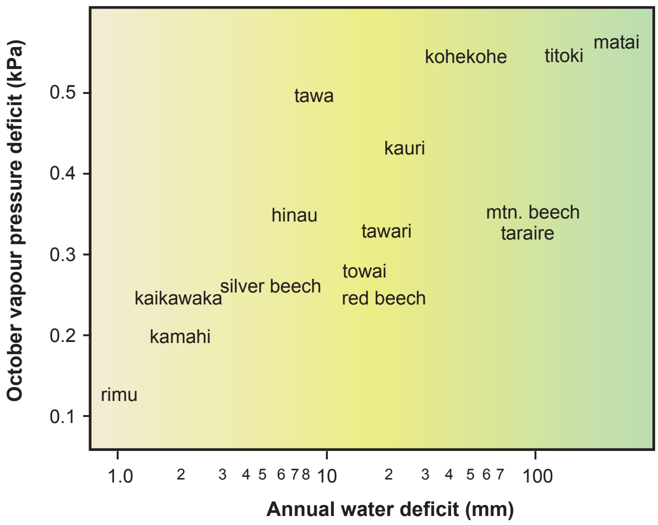


Figure 3: Annual soil water deficits (i.e. dryness of the soil) and October vapour pressure deficits (i.e. dryness of the air) at which some New Zealand tree species reach their maximum abundances (Leathwick et al. 2003).

rimu

Rimu performs better if planted in small gaps that mimic canopy gaps created by a windfall.

kahikatea

Shade-intolerant kahikatea can dominate regeneration on open sites.

kohekohe

Kohekohe has intermediate tolerance of shade and prefers to regenerate in a forest gap created by a windfall.

mangeao

The natural distribution of mangeao is limited to the upper North Island.

RESPONSE TO DISTURBANCE

Kahikatea (left) and totara (right) regenerate after catastrophic disturbance such as fire or flood to form relatively even aged stands. Such species are likely to do well planted in single species stands.

In a natural forest with a complete and shady canopy, opportunities for tree seedlings to successfully grow into the upper tiers are limited in time and space. Most must wait until an existing tree (or group of trees) dies and opens up a canopy gap. Canopy gaps in natural forests generally form when there is some form of disturbance to the forest by, for example, a wind storm or the tree fall of a senescent individual. Disturbances that affect forests come at a range of scales and frequencies, and seedlings of different tree species have different characteristics that allow them to specialise in different types of canopy gaps. However, the range of regeneration behaviours observed can be broadly grouped into 3 types - catastrophic, gap-phase, and continuous.

Totara regenerates after catastrophic disturbance and may form a relatively even-aged stand.

- **Catastrophic** - occurs after some stand-destroying event such as a fire, flood, windstorm, avalanche, etc., when a large canopy gap is created sufficient for many trees. Species that target regeneration in these gaps have seedlings that are shade-intolerant, but tolerant of the exposure to winds and sometimes dry conditions that can occur in these openings. Often one species will dominate regeneration in these openings leading to an even-aged stand of that species. Examples are totara *(Podocarpus totara)* , kahikatea *(Dacrycarpus dacrydioides)*, and, to a limited extent, kauri. This suggests that these species do well in plantations under relatively high light conditions and can tolerate some exposure.

- **Gap-phase** - occurs when regeneration of species occurs in small to intermediate-sized gaps caused by the death of one or a small group of trees. These gaps may be caused, for example, by individual trees falling during windstorms. Species that target regeneration under these circumstances are intermediate in their shade-tolerance but are often sensitive to exposure (open conditions) as seedlings. Many species adopt this strategy, including rimu, puriri, mangaeo, kohekohe, and hinau *(Eleocarpus dentatus)*. For these species, silviculture that mimics these canopy gaps is likely to be successful. This means providing adequate side shelter in the form of nurse plants or by artificial means is important, with no or a very sparse canopy immediately above the seedling to ensure light for growth. Continuous cover forestry seeks to mimic this natural form of regeneration, in which mixed species plantations are likely.

- **Continuous** - occurs when seedlings attain maturity under a relatively closed forest canopy. In practice, there are few species that adopt this mode, and most are characterised by shade-tolerant seedlings that are able to persist for long periods of time with little to no growth, then grow when nearby gaps provide pulses of light, e.g., miro *(Prumnopitys ferruginea)*, tawa *(Beilschmiedia tawa)*. They tend to occur in forests with a broken or uneven canopy, in which there are sporadic opportunities for light to reach the forest floor, or adopt other life history strategies to gain light, e.g., northern rata *(Metrosideros robusta)* starts life as an epiphyte in the boughs of other trees, and sends its roots down to the ground. A strategy similar to the gap-phase specialists is probably applicable to these species, with emphasis on side shelter and overhead light.

Therefore, knowledge of the natural regeneration characteristics of the species being grown can indicate the relative importance of shelter and light to plantation success.

RELATIONSHIPS WITH OTHER FOREST SPECIES

Our native plants have evolved with a host of other plants, animals and micro-organisms in New Zealand's natural forests, and relationships with these species need also to be considered when growing native trees in plantations. These relationships can be positive or negative for tree growth.

Positive relationships

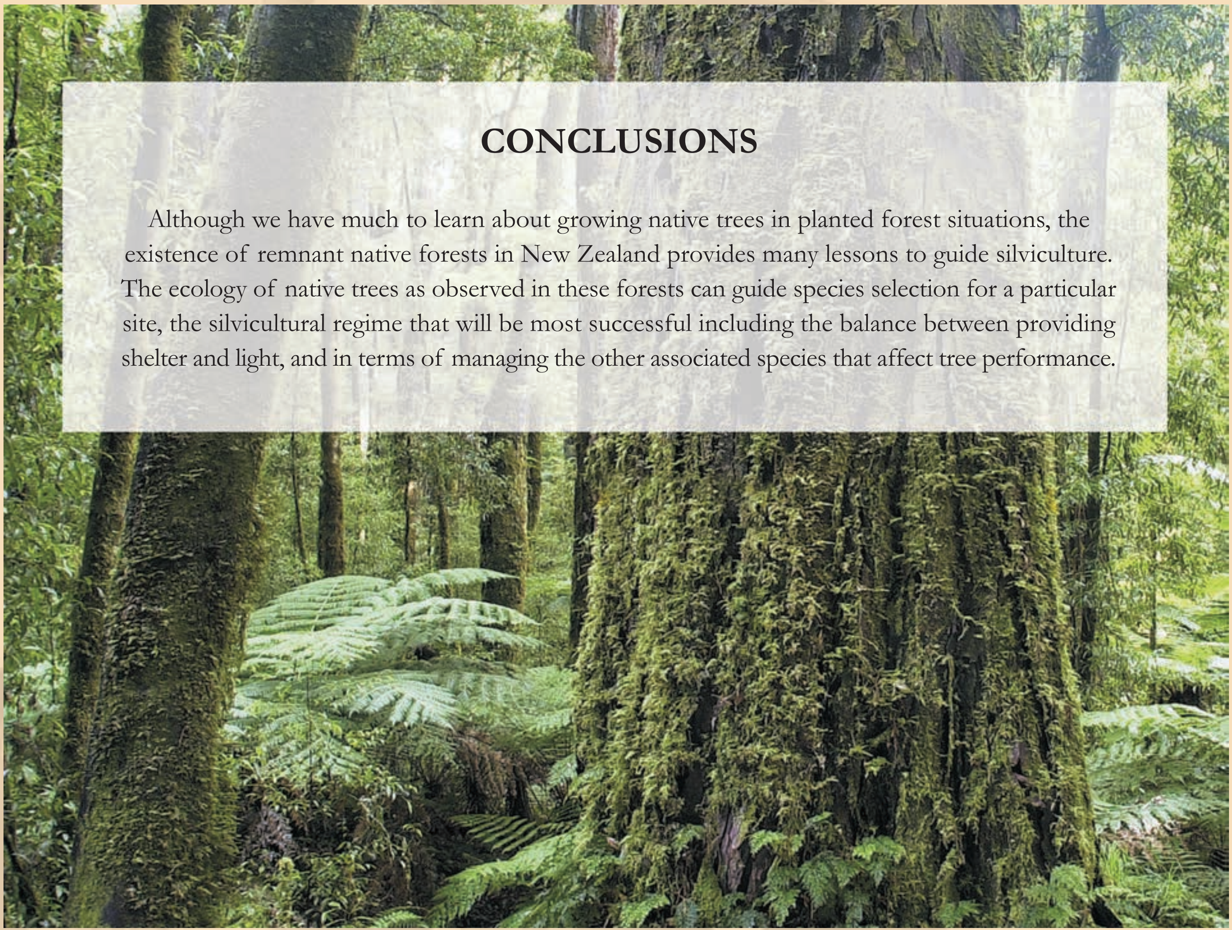
An example of a positive relationship is that between beech and ectomycorrhizal fungi. The roots of *Nothofagus* species form associations with specialised fungi that enhance the ability of those trees to gain soil nutrients, particularly phosphorus. This association is so strong that *Nothofagus* trees without such an association do very poorly. Although there are more than 226 species of fungi that are likely ectomycorrhizal partners of *Nothofagus* species in New Zealand forests, many natural soils in New Zealand lack fungi to assist the growth of beech. Therefore, when planting beech into soils that have not supported forest for a while, it is prudent to include soil or litter from a natural beech forest in or around the planting hole as a form of inoculation.

Negative relationships

Examples of negative relationships for plantation foresters are those between some native insect herbivores and our native trees. Puriri or ghost moth (*Aenetus virescens*) is New Zealand's largest native moth and only found in the North Island. Its caterpillars live for between 3-5 years, initially feeding on fungal fruiting bodies on the forest floor. However, as the caterpillar grows larger, it bores a tunnel into one of a number of native trees including puriri, beech, black maire *(Nestegis cunninghamii)*, putaputaweta *(Carpodetus serratus)*, wineberry *(Aristotelia serrata)*, and lacebark *(Hoheria populnea)*. It covers the entrance of these tunnels with webbing and feeds on the live callus tissue around the entrance hole. Such tunnels negatively impact the timber quality of infested trees. Although no control mechanism is widely recommended, kerosene injected into holes seems to kill the caterpillar. Also, there may be an opportunity to prevent the caterpillar's journey from the forest floor up the trunk by some form of protection of the lower trunk (as has previously been used for codling moth).

Another herbivore of native trees that could be a problem for native plantations is the cicada (*Amphipsalta cingulata*). The females of this species lay eggs into small branches and twigs in a herring bone pattern. This can occur so aggressively that the branchlet drops off. Lloyd (1949) noted such damage on a range of native conifers including rimu, miro, kahikatea and totara. This type of damage can be negative when it occurs on the leader, delaying growth while a new leader is established. Lloyd (1949) thought that this damage was most severe in situations with ample light, so the use of side-shelter or nurse plants may have other advantages.

Insects can be a problem with young native such as the female cicada laying eggs into small branches which leaves a characteristic herringbone pattern. Such damage can weaken the stem and lead to breakage.



CONCLUSIONS

Although we have much to learn about growing native trees in planted forest situations, the existence of remnant native forests in New Zealand provides many lessons to guide silviculture. The ecology of native trees as observed in these forests can guide species selection for a particular site, the silvicultural regime that will be most successful including the balance between providing shelter and light, and in terms of managing the other associated species that affect tree performance.

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Tãne's Tree Trust promotes the successful planting and sustainable management of New Zealand native trees and shrubs for multiple uses.

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