AN ECOLOGICAL BASIS FOR BEECH MANAGEMENT IN NEW ZEALAND

J. WARDLE*

ABSTRACT

The beech species tolerate relatively harsh environments compared with most other New Zealand trees. They are the physiognomic dominants of the mountains, in the drier and southern regions, and on poorly drained and infertile soils. In these areas they form forests which are usually simple, both in structure and composition, and, except in the most extreme situations, they regenerate here with ease.

As the site improves and the diversity of the forest increases, the reproductive behaviour of the beeches places them at a competitive disadvantage with other elements of the flora. They do not sucker readily, seeding is intermittent, and the seedlings are poor competitors and require light for development. The beeches have difficulty in establishing where ferns, herbs and shrubs cover the forest floor, and suitable sites become restricted to freshly exposed mineral surfaces, stumps and fallen logs. Though the potential for rapid growth of beech is probably better in forests growing under these more optimal conditions than elsewhere, good regeneration may be difficult to achieve without appropriate manipulation of the stands.

INTRODUCTION

Three major physiognomic elements can be recognised in the New Zealand native forests; the softwoods, the beeches and the broad-leaved hardwoods. The softwoods are predominantly podocarps of the genera *Podocarpus, Dacrycarpus* and *Dacrydium*, but include also the kauri and two species of *Libocedrus*. The broad-leaved hardwoods are the hardwoods other than beech, and include *Weinmannia, Beilschmiedia, Quintinia, Elaeocarpus, Laurelia, Metrosideros* and many other genera.

Beech is an important element in two-thirds of New Zealand's native forests. The remaining third has little or no beech at all. Beeches either totally dominate the forest to form "pure beech

*Forest Research Institute, N.Z. Forest Service, P.O. Box 31-011, Christchurch.

forest" or they occur in mixtures with one or both of the other elements to form "mixed beech forest". Pure beech forest dominated by one or more of the beech species accounts for approximately 46% of the total indigenous forest area of New Zealand, while mixed beech forest accounts for another 22%. The distribution and the interaction of the beeches, both with each other and with the softwood/broad-leaved hardwood elements of the New Zealand forests, is strongly influenced by certain ecological characteristics of the species. These characteristics have considerable bearing on the choice of potentially suitable sites, species and practices for beech management.

COMPARISON OF ECOLOGICAL CHARACTERISTICS — BEECH AND SOFTWOOD/BROAD-LEAVED HARDWOOD FOREST

The beech element has been described as largely synonymous with "subantarctic" rain forest while the other elements form "subtropical" rain forest. The beeches are generally capable of tolerating harsher climates, and poorer soils than the softwoods and broad-leaved hardwoods. They increase in abundance along the environmental gradients that lead away from the moist, mild, fertile optimum. They are most prevalent at high altitudes, in the drier eastern and central regions of both main islands, on relatively infertile and poorly drained soils, and in the south. Thus 84% of the total indigenous forest area in the South Island is either pure or mixed beech, while in the North Island beech occurs in only 40% of the forests.

Conversely, the beeches tend to give way to softwood/broad-leaved hardwood forest at low altitudes, in the moister western and coastal regions, to the north, and on the better drained and more fertile soils. This is not because the beeches do not like these sites, but because certain features of their autecology place them at a relative disadvantage with the softwoods and broad-leaved hardwoods. These features are mostly associated with reproductive behaviour and the conditions required for seedling establishment.

Seedlings of beech need more light for establishment than many of the common components of the softwood/broad-leaved hardwood forests. Once established, they can tolerate some degree of shade and can compete successfully with most other species.

The beeches require exposed mineral soil, or only a thin moss or litter layer for successful establishment. Seedlings are unable

to establish where the fern cover or herbaceous turf is dense, or where the layers of raw litter covering the forest floor are thick. Neither do they have the facility of *Weinmannia* and *Metrosideros* for establishing epiphytically on the trunks of tree ferns and other trees.

The New Zealand forests become more complex towards the lower altitudes and higher rainfall areas. They become richer in species, and the cover of ferns and herbs on the forest floor usually increases. The basal area and living biomass of the forest also increase so that the sites suitable for the successful establishment of beech seedlings become progressively reduced. The beeches become opportunists in these lower and wetter forests, establishing on fallen logs, dead stumps, and root plates of windfalls; sites elevated above the dense ground cover of ferns and other understorey plants. They also establish on the bare mineral surfaces exposed where the forest has been totally removed from the site by mass movement. However, to be successful here, the beeches must become established before a mat of other vegetation develops. Furthermore, the tenancy by the beeches on these sites is short-lived. Other more shade-tolerant broad-leaved hardwoods develop beneath them and eventually replace them. The affinity of the beeches for bare mineral surfaces accounts for the riparian distribution of beech along many of the waterways within the softwood/broad-leaved hardwood belt. Generally, more opportunities are provided along newly formed gravel terraces and on riparian erosion scars for establishment of beech than elsewhere in these forests.

The New Zealand beeches do not reproduce vegetatively to any extent. After wind damage, which is a common occurrence in the New Zealand forests, or after fire or logging, some of the broad-leaved hardwoods such as *Weinmannia* and *Quintinia* are able to resprout and rapidly occupy the site, while the beeches must rely on seed. But at best, seeding in the beeches is intermittent. Seed years can be separated by intervals of 3 to 5 years when virtually no seed is produced at all. Opportunities for the establishment of beech seedlings are therefore lost, while other species which seed more regularly are able to establish and occupy available niches in the intervals between beech seed years.

Likewise the mechanism for seed dispersal is relatively inefficient in the beeches. The podocarps and many of the broad-leaved hardwoods have seeds which are bird dispersed and can

be transported long distances from the seed source. Other broad-leaved hardwoods such as *Quintinia, Metrosideros* and *Weinmannia* have very light seeds which are carried long distances by air currents. But the beeches have nuts which are relatively heavy, and they are not dispersed by birds. They are seldom carried more than a few hundred metres from the seed source, except perhaps along creeks and rivers. Again, therefore, the beeches are at a disadvantage compared with the softwoods and broad-leaved hardwoods.

DISTRIBUTION OF THE INDIVIDUAL BEECH TAXA

There are five beeches altogether in New Zealand: mountain, silver, red, hard and black beech. They are included within four species, one of which has two recognised varieties (mountain and black). The distribution of these taxa, relative to one another, and to the softwood/broad-leaved hardwood forest is shown in the stylised diagram (Fig. 1).

Mountain beech occurs mainly on middle and upper slopes in the drier eastern and central mountain regions, where it is the main subalpine timberline tree. It forms extensive natural

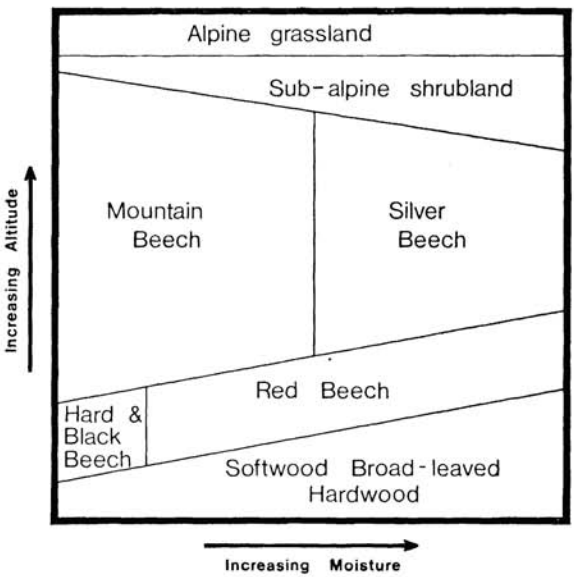

FIG. 1: *Stylised diagram of the distribution of the five New Zealand beeches along altitudinal and moisture gradients.*

monocultures, often with few other vascular species and a bare forest floor except for seedlings of mountain beech, litter and a little moss. It also occurs on poorly drained and infertile soils in the high rainfall districts west of the Main Divide and descends on these sites to quite low altitudes. Here, though, its distribution is usually rather local. Mountain beech is the hardiest of the beeches and the most capable of growing on adverse sites.

Silver beech is also associated with the mountain regions, but, in contrast with mountain beech, it occurs most often in the wetter western areas, and it does descend to the coast in the south. Usually the forest is richer in species than mountain beech, and there is often a fern or shrub understorey. It forms extensive areas of pure forest at high altitudes, but where the rainfall is lower it codominates with mountain beech, while on the middle slopes silver beech and red beech occur together over extensive areas.

Red, hard and black beech are not as hardy as silver or mountain beech. Red beech is a tree of the mid-slopes and terraces and usually demands more fertile soils than the other beeches. Often broad-leaved hardwood species, particularly kamahi (*Weinmannia racemosa*), form a subcanopy to red beech forest and scattered podocarps may occur as well. The incidence of these species in red beech forest increases towards lower altitudes and where the rainfall is high — as the ecotone with the softwood/broad-leaved hardwood forest is approached. The density and diversity of fern species covering the forest floor also increase towards this ecotone.

Hard beech and black beech have more localised distributions than the other three beeches. They are relatively minor species which occur even further down the slope than red beech. These two beeches often occur within the softwood/broad-leaved hardwood belt, forming stands on specialised sites such as dry ridge crests and infertile soils, and in successions on river terraces. There is usually a high component of broad-leaved hardwood species in hard beech and black beech stands, which includes *Weinmannia, Quintinia, Beilschmiedia* (tawa) and other genera. This broad-leaved hardwood component is usually even more pronounced than in the red beech stands and there is usually a dense understorey of ferns and other species.

MANAGEMENT IMPLICATIONS

The problems of establishment experienced by all the beeches where fern or herbaceous cover on the forest floor is dense, and

where intra-stand competition is intense, have been outlined. It can be reasoned that, in general, regeneration of the beech species on the higher and drier sites will be easier to achieve than for the beeches normally associated with lower altitudes, better soils and higher rainfalls *i.e.*, conditions approaching the optimum for forest growth. Beeches on the higher and drier sites do not have the same competitive problems associated with dense fern and herbs. Regeneration of mountain beech should be easier to obtain, therefore, than regeneration of silver beech, which in turn should be easier to obtain than red, hard or black beech. The most difficult of all would be hard beech.

Most exploitation of beech forest for wood has taken place in the low-altitude silver beech forests in Southland, and in the red and hard beech forests in the North Westland/Buller area. In the North Westland/Buller area usually only choice trees of beech have been extracted and the main attention of the sawmillers has been the podocarps which these stands contain. Both here, and in Southland, regeneration of beech after timber extraction is often inhibited by "weeds". In Southland, where concerted effort has been made in some areas to encourage silver beech regeneration, scarification of the dense fern cover on the forest floor has often been required to provide a suitable seedbed. In the North Westland/Buller area, "weed" problems, especially with hard beech, have often prevented adequate restocking of the forest after logging and some thousands of hectares have been left in a derelict state.

It could be suggested, therefore, that if we are concerned with regenerating the beech stands after exploitation for timber, then perhaps we are dealing with the wrong species of beech in the wrong places.

It would probably be much easier to obtain regeneration of mountain and red beech in the drier montane forests, and much more straightforward silvicultural systems could possibly be applied, but there are other considerations as well as the ecological ones. Timber properties, distance from market and relative growth rates all have to be taken into account. Silver beech is, for instance, considered the most amenable of our beech timbers.

The structure and composition of the New Zealand beech forests is often governed by disturbances. Wind and snow damage, drought and mass movement are frequent occurrences in our beech forests, especially in those which occupy the mountain ranges. At certain critical stages in stand development, even re-

latively minor disturbances by these agencies lead to population outbreaks of various pests and diseases, and extensive tree mortality.

Regeneration of the forests tends to be linked to these events, and this accounts for the often even-aged structure of beech forests. The different beech species respond to these disturbances in different ways. Red and mountain beech are more light-demanding than silver beech. After disturbance in stands of these species there is a surge of seedling establishment and growth followed by long intervals during which only limited establishment occurs until there is further disturbance, or until the stand reaches a senescent state and starts to disintegrate thus allowing more light to reach the forest floor.

Thus, mortality and regeneration tend to be synchronised into limited periods in the life of the stand. Silver beech, which is more shade-tolerant, can develop under shade conditions too dense for the other two species. Even where even-aged stands of this species develop after disturbance, the mixed aged structure tends to be attained over time, provided no further disturbances occur.

There are important implications from this when we are dealing with species mixtures. As mentioned before, extensive areas of forest are codominated, either by mountain and silver beech, or by red and silver beech. After some type of disturbance has destroyed, or badly damaged, the canopy of these mixed forests, seedlings of the light-demanding red and mountain beech have a definite advantage. They respond rapidly to the increased light, and gain the ascendancy over the slower growing, shade-tolerant, silver beech in stand composition. The more frequently the forest is damaged, the greater the component of red or mountain beech we can expect. On the other hand, stable conditions favour silver beech. Being the more shade-tolerant species, it will tend to replace mountain and red beech in these mixed stands with time. Logging operations simulate natural disturbances. Extraction of timber from mixed stands will encourage regeneration of the more opportunistic light-demanding species. It has often been noted in Southland that logging in mixed mountain/silver beech forest encourages mountain beech seedlings at the expense of silver beech. Ecologically and silviculturally, mountain beech would prove the more amenable to management, but again, it is not the species we want at present. It is the relatively shade-demanding silver beech which is considered to have the most desirable timber properties.

CONCLUDING STATEMENTS

This paper has emphasised the ecological properties of beech forests which are important in management for wood production. These same properties have wider implications. The relative inability of the beeches to establish in a dense turf ground cover has implications for game management. The favoured food plants in beech forest for ungulates, such as red deer, are the seral shrub-hardwood species which occur in disturbed areas. High animal use of these areas often leads to the formation of a dense turf cover. This can inhibit the establishment of seedlings of beech, slowing down or preventing the return to forest.

As far as management for wood is concerned, ecological considerations conflict to some degree with economic ones in the beech forests. Most exploitation of beech has been at low altitudes where "weed" problems make adequate regeneration of the beech species most difficult to achieve. This has led to the formation of large areas of virtually derelict forest.

In Southland, at least, we have emphasised the re-establishment of silver beech over the silviculturally more amenable, light-demanding mountain beech since silver beech has the more attractive timber properties.

The easiest beech forests to maintain and manage silviculturally are probably the simple mountain beech monocultures of the central and eastern high country, forests which because of their location and current market requirements, have received little attention.