THE CONSEQUENCES FOR WILDLIFE OF EXPANDING NEW ZEALAND'S FOREST INDUSTRY

P. C. Bull *

ABSTRACT

Information about wildlife (especially birds) in pine forests in New Zealand is reviewed as a basis for assessing likely effects of further expansion of the forest industry. Faunal diversity increases with the age of the pine trees though it rarely, if ever, becomes as high in pine forests as in unmodified native forests in equivalent sites. Long-rotation pine forests provide useful habitats for some (but not all) native animals and will further benefit nature conservation if they reduce the demand for native timbers. On the other hand, exotic forestry conflicts with nature conservation when new forests replace native vegetation or give rise to industries that modify or pollute natural waterways. The value of exotic forests as wildlife habitats could be improved by establishing corridors of native vegetation within the forest, by including trees which provide a seasonal succession of nectar or berries, by cropping the forest on a patchwork basis and on a long rotation for sawlogs rather than a short rotation for pulp, by controlling pests with sprays and baits safe to non-target species, and by encouraging further research on the habitat requirements of native animals.

INTRODUCTION

This paper, originally prepared as a background document for the 1981 New Zealand Forestry Conference on “Exotic Forests: Their importance to New Zealand’s future”, examines some of the likely consequences for wildlife of further expanding New Zealand’s forest industry; it also suggests ways to maximise the favourable consequences and to minimise the undesirable ones.

The term “wildlife” means different things to different people; it is used here in its widest sense to cover all kinds of free-living animals, including invertebrates. The paper deals mainly with birds because they have been better studied than most other groups, and they are more widely understood and appreciated by

*Ecology Division, DSIR, Lower Hutt.
people with only a general interest in natural history. Nevertheless, species belonging to less well-known groups of animals should also be protected.

This paper consists of four main sections: the first summarises the value and present status of native animals in New Zealand forests, the second reviews what is known about birds and other wildlife in exotic forests, the third uses this and other information to predict future trends, and the fourth suggests some ways in which exotic forests might be improved as habitats for wildlife.

THE WILDLIFE OF NEW ZEALAND FORESTS

**Value of the Resource**

Accommodating the needs of birds and other wildlife may add to the costs of producing wood, so it is well to recall at the outset that wildlife is also a very valuable resource even though, unlike wood, its value can rarely be measured in dollars.

The most outstanding feature of the native fauna of New Zealand forests is that it contains a high proportion of animals whose near relatives elsewhere in the world became extinct millions of years ago. These include the short-tailed bat* the kiwis, the wattlebirds (e.g., kokako), the New Zealand wrens (e.g., rifleman), the native frogs (*Leiopelma* spp.), and, among the invertebrates, the large and beautiful carnivorous snails (*Powelliphanta*). The ancestors of some of these animals are believed to have lived in ancient Gondwanaland, the great southern continent which later split into the land masses now known as South America, Africa, India, Antarctica and Australia. New Zealand has remained isolated since it drifted away from these other lands some 80 million years ago, and this has permitted the survival of species which elsewhere were exterminated by animals (mainly mammals) that evolved later.

Although each species is important in its own right, the fauna and flora are collectively even more important since jointly they permit study of the ways in which animals and plants interact to produce a stable community. Key species overseas in various ecological processes (e.g., the recycling of nutrients) are often represented in New Zealand by quite different groups of animals and plants. The study of these New Zealand organisms, some of them evolved in isolation for tens of millions of years, helps us

*The scientific names of mammals and birds mentioned in the text are listed in Appendix 1.
to understand better the ecological processes that maintain the quality of soil, water and air. New Zealand's various "living fossils" are of worldwide interest, a fact attested to by the many distinguished overseas scientists who come here to study and enjoy our endemic fauna. New Zealand therefore has a special international responsibility to ensure that what remains of this unique resource is carefully conserved for the future. A more detailed but non-technical account of these values and responsibilities is provided by the Nature Conservation Council's Information Leaflet No. 19 (1980).

But it is not only overseas scientists who value New Zealand's wildlife; many New Zealanders from all walks of life appreciate the aesthetic qualities of the native fauna and the habitats in which it lives. This is indicated by the third of a million people who signed the Maruia Declaration calling for a halt to the logging of indigenous forests, by the 32 000 who belong to the Royal Forest and Bird Protection Society, and by the many thousands of other New Zealanders who enjoy wildlife as members of scientific societies, tramping clubs and hunting organisations.

Nor are wildlife values confined to scientific or aesthetic considerations. Birds, for instance, also have values which are directly relevant to the well-being and productivity of the forest itself. Although the role of birds in suppressing insect pests in forests has not yet been studied in New Zealand it seems likely, on the basis of overseas studies (Tinbergen and Klomp, 1960; Gibb, 1966; Buckner, 1966), that birds are sometimes important in this respect; the silvereye, a common species in New Zealand, has been found effective in reducing overwintering larvae of codling moth in Nelson orchards (Wearing, 1975). Berry-eating birds such as pigeons and tuis distribute the seeds of native plants (including podocarps) and thereby assist regeneration in native forests and elsewhere (Beveridge, 1964; McEwen, 1978). Tuis and bellbirds also cross-pollinate native plants (McCann, 1952), and Guest (1979, p. 27) has drawn attention to the value of birds in recycling nutrients in forests.

Birds also serve as sensitive monitors of environmental pollution. Indeed, on several occasions, the environmental hazards of certain agricultural chemicals (DDT for instance) were first recognised as a result of studies on bird populations in the United States and in Britain. Finally, game animals provide sport, meat or skins, thereby supporting lucrative industries (though sometimes at the expense of other values).
Present Status of the Fauna

A recent review by Mills and Williams (1978) lists seven species of native forest birds which were formerly present on one or both of the main islands but which are now probably extinct there: the little spotted kiwi, stitchbird and saddleback (these three persisting on offshore islands) and the laughing owl, bush wren, huia and piopio. In addition, the kakapo is extinct in the North Island and the kokako probably so in the South Island; several other forest species are rare or restricted in distribution (e.g., red-crowned and orange-fronted parakeets, kaka and yellowhead). It is unfortunate that the species which have proved least able to survive the destruction and modification of forests are predominantly those with no near relatives elsewhere in the world (McDowall, 1969).

Of other native forest animals the bats, some of the geckos (lizards), and the native frogs have declined in numbers or range, as have the large parapatrid snails and a few other invertebrates. There is, however, no adequate information on which to assess the current status of many of the invertebrates. Judging from the almost complete destruction of lowland forest in some districts, it is likely that many invertebrates have already become extinct — some of them without ever becoming known to science.

The decline of New Zealand’s forest fauna has been variously attributed to predation, competition with introduced species, disease, loss (or modification) of habitat, or to various combinations of these factors (Bull and Whitaker, 1975). Falla (1955) pointed out that some of New Zealand’s native birds may require a combination of high and low altitude forest to provide a long seasonal succession of blossoms and ripening fruits, and that the loss of so much lowland forest may explain the scarcity of birds in many mountain forests. Recent studies of birds near Reefton (Dawson et al., 1978; P. R. Wilson et al., pers. comm.) and in Nelson Lakes National Park (R. H. Taylor et al., pers. comm.) support this view. The size of forest areas is also important. Principles developed from studies of the bird faunas of islands apply also to “islands” of forests in “seas” of other habitats (Diamond, 1973). Hackwell and Dawson (1980) have demonstrated that these principles apply to forest birds in New Zealand, as was assumed earlier by Fleming (1975). Briefly, the principles are:

(1) That the larger the area of forest, the more kinds of animals it will contain, and (2) that small areas of habitat close together
(or linked by corridors of similar vegetation) will contain more kinds of animals than will more isolated areas of similar size. Because most of New Zealand was formerly clothed in forest (about 80% of the land area was in forest when the first Polynesian arrived), the endemic terrestrial fauna consists mainly of forest-dwelling animals. Thus, in New Zealand more than in most other countries, the native fauna depends for its survival on the preservation of substantial areas of each of the many types of forest habitat.

The area of indigenous forest in New Zealand has been reduced by some 67% since the arrival of European man, and nearly all of this reduction has been in the lowland forests (Environmental Council, 1979). Given a reduction of this magnitude, the principles of island biogeography predict that extinctions will occur among birds and other animals until the number of species surviving is suited to the reduced area of forest. Extinctions have certainly occurred already and there will probably be more as the fauna slowly adjusts to the smaller area of forest. On the other hand, some species now on the verge of extinction may, given suitable conditions, become abundant again; certain native birds have already done so (Turbott, 1961).

The question that now arises is to what extent the planting of new (exotic) forests will accelerate or retard the process of adjustment. To answer this it is necessary to consider the extent and nature of the forests, and to review what is known about them as habitats for the native fauna.

EXOTIC FORESTS AS WILDLIFE HABITAT

New Zealand’s Exotic Forests

The area of exotic forest in New Zealand stood at 741 000 ha in March 1978; 83% of this land was in radiata pine, nearly 7% in Douglas fir and the rest in other species (Levack, 1979). While some stands are over 50 years old, 60% of the area is now in trees less than 10 years old, and new plantings (90% Pinus radiata) have risen from 23 000 ha in 1970 to more than 40 000 ha/year for the past six years (Development Finance Corporation, 1980). Intended new plantings of exotics (as distinct from restocking of existing plantations) involve a gradual decline from 224 000 ha for the five years 1976-80 to 75 000 ha during 2011-2015 (Levack, 1979). By the turn of the century New Zealand could have an exotic resource of 1.5 million hectares (more than double the present area) and, in time, a resource of 2.3 million
hectares or 8.7% of the total land area of New Zealand (N.Z. Forest Service, 1980). The present forest area alone will be capable of doubling the national wood supply on a sustained basis from the mid-1990s, while the establishment of new forest areas at projected planting rates will contribute to an eventual four-fold increase in national wood supply (Development Finance Corporation, 1980).

Most of this new planting will be on "undeveloped or reverting scrub land or unstable agricultural country like some of the pastoral Poverty Bay hinterland" (Levack, 1979). Levack states (p. 160) that "... indigenous forest areas are not considered suitable for exotic afforestation". The official management policy for New Zealand's publicly owned indigenous forests lays down that "state indigenous forests should be clear felled and converted to farm land or exotic forests only when other land in the region is either unavailable or unsuited for further development to meet the Government's social and economic goals, regionally or nationally" (N.Z. Forest Service, 1977). The honouring of contracts let before the adoption of this policy, and the exceptions permitted under the policy, meant that 27 304 ha of State indigenous forests would be converted to exotics during 1975-84; 59% of this area had already been converted by 1979 (Environmental Council, 1979). On p. 23 of its report the Environmental Council "anticipated that conversion of up to 1 000 ha of indigenous forest per year will continue on the West Coast for some time after 1984 to provide exotic forest to sustain the sawmilling industry in the long term as well as to provide an immediate supply of timber to the mills in the next few years". Apart from such authorised conversions of indigenous forest to exotics, other areas of indigenous vegetation, valuable as wildlife habitat, may be freely converted because they are regarded as scrub rather than forest.

While the Forest Service has promised restraint in the conversion of publicly owned indigenous forest to exotics, it has no authority over privately owned forests. The Environmental Council's Report (1979, p. 1) therefore recommends that "protection of forests not in State tenure and therefore not covered by the Indigenous Forest Policy should be actively encouraged through the Queen Elizabeth II Trust, through the provisions of regional and district schemes under the Town and Country Planning Act, and under the Reserves Act". Despite this recommendation, it seems likely that further areas of privately owned indigenous forest will be converted to exotics, with adverse consequences
for native fauna. Indeed, rural development loans encourage land owners to replace relict forest and scrub lands (potential new indigenous forest) with pasture or exotic plantations (N.Z. Institute of Foresters, 1980).

Pine plantations have two major limitations as a habitat for the native fauna. First, most are monocultures (usually of \textit{P. radiata}), and consequently contain a limited diversity of birds and other animals. However, as the pines mature (or are thinned and pruned) more light is admitted to the forest floor, and an understorey of shrubs often appears. This shrub layer may develop earlier if the trees are widely spaced. The more complex forest structure, with a pine canopy above and a diversity of shrubs below, allows a greater diversity of birds; any pockets of native vegetation which may escape conversion to pines will have a similarly beneficial effect on birds and on other native fauna. In particular, birds that feed on nectar or berries seem to get much of their food from the epiphytes and lianes which are common in many of New Zealand's native forests; plants important in this respect in the Orongorongo Valley near Wellington include \textit{Griselinia lucida}, \textit{Collospermum hastatum}, \textit{Astelia solandri}, \textit{Metrosideros fulgens}, \textit{M. diffusa}, \textit{M. perforata}, \textit{Ripogonum scandens} and \textit{Freycinetia baueriana} (B. M. Fitzgerald, pers. comm., October 1980).

The second disadvantage of pine forests for native fauna is that the forest is usually clearfelled on a relatively short rotation. \textit{P. radiata} produces a sawlog in 25 to 30 years (Development Finance Corporation, 1980), but trees can be used for pulp at a much younger age. Because of past variations in the amount of land planted in pines each year, the various age classes of trees are unequally represented in existing pine forests. Meeting the predicted demand for timber will therefore require changes in the mean age at which trees are felled. Levack (1979) suggests that the mean age of trees at clearfelling will decline from 48 years during 1976-80 to 29 years during 1996-2000; trees for pulping may, of course, be felled much earlier. It is, however, only mature forests with an understorey of shrubs which provide a suitable habitat for certain species of native birds, and once commercial forests reach this stage their further life may be very short indeed. Birds displaced by clearfelling are unlikely to find safety in unfelled stands nearby because such stands will usually already contain as many birds as they can support. While the short life-span of pine forests reduces their effectiveness as habitat
for some native birds, it may exclude altogether animals such as lizards and snails which have slower rates of spread.

**Exotic Forests as Habitats for Birds**

Exotic forests provide a variety of habitats for birds. Apart from the forest proper, roads and firebreaks provide the open country required by species such as pipits and harriers, and there are sometimes wetlands or patches of native bush or scrub left unplanted, each of these supporting its characteristic birds (Jackson, 1971; Heinekamp and Ramsay, 1973).

Ryder (1948) and Weeks (1949) were the first to draw attention to the comparatively rich birdlife in and around Kaingaroa Forest. Although they listed species from the whole management area, including wetland species and visitors from nearby native forests, they reported that several species were widespread in the pine forests themselves. Native species in this category were the grey warbler, pied tit, robin, fantail, whitehead, silveryeye, the two cuckoos and, to a lesser extent, the morepork and New Zealand falcon. In addition, tuis and bellbirds were often present where pine plantations bordered native forest or where fuchsia, wineberry or eucalypts provided nectar or berries.

Gibb (1961) confirmed and quantified these observations at Kaingaroa, although he recorded moreporks, falcons, the two cuckoos, tuis and bellbirds only irregularly within the plantations. During the breeding season, pied tits, whiteheads and silveryeyes were all more numerous in a 28-year-old plantation of *P. radiata* than in less well-grown 25-26-year-old plantations of *P. ponderosa, P. nigra* and *Pseudotsuga menziesii (= taxifolia)*. Although whiteheads were plentiful in the well-grown *P. radiata* (about 3.1 birds/ha) they were almost absent from poorly grown *P. ponderosa*, but grey warblers were equally common in both habitats (1.1 birds/ha). Grey warblers were surprisingly numerous in *Ps. menziesii* (1.6 birds/ha) possibly because their light weight and ability to hover enabled them to feed successfully in the rather flimsy foliage. Robins were more frequent in the *P. nigra* plantation (0.1/ha), where they benefited from the exposure of invertebrates by wild pigs searching for the roots of this pine, a favourite food.

The plantations also harboured considerable numbers of introduced birds, the more numerous species in *P. radiata* in summer being the chaffinch (3.6 birds/ha), blackbird (1.1), hedge sparrow (0.6) and song thrush (0.3); others recorded irregularly
within the plantations were the pheasant, California quail, skylark, greenfinch, goldfinch, redpoll and yellowhammer.

With an overall density of about 12.2 adult birds per hectare (including introduced species), the well-grown compartments of *P. radiata* had appreciably more birds than the other habitats sampled. Compartments of *P. ponderosa* had the next highest density with about 8.3 birds/ha. Although the *P. ponderosa* was poorly grown and thinly stocked, it usually had a dense undergrowth of *Leptospermum* and *Dracophyllum* with some grass. Compartments of *P. nigra* and *Ps. menziesii* were usually very dense, with little light penetrating the canopy, and had relatively few breeding birds — about 6.0 birds/ha in each.

Outside the breeding season, the greatest density of birds was still to be found in *P. radiata*, the commonest species in order of frequency being whiteheads, silvereyes, grey warblers and pied tits. This order follows that recorded by Caughley (1960), also in Kaingaroa, except that Caughley’s data ranked silvereyes fourth instead of second.

Gibb compared his estimates of bird populations from Kaingaroa with the limited data available from other habitats. He found the Kaingaroa densities (6.1 to 12.2 birds/ha) slightly exceeded those from native beech (*Nothofagus*) forest in the South Island (3.5 to 8.3 birds/ha; Kikkawa, 1960a) but were less than the 15.5 to 22.0/ha recorded from offshore islands with scrub or low forest (Turbott, 1940; Turbott and Bull, 1954; Kikkawa, 1960b) and much less than the 25.0/ha recorded by Kikkawa (1960a, b) for gardens and regenerating forest. No comparable figures were available for podocarp forests.

A result of Gibb’s work was the surprising discovery that some native birds were as numerous in the Kaingaroa pines as in almost any native forest, and a good deal more numerous than in most of it. This was most striking with the whiteheads, and only slightly less so with the pied tit and robin.

Two native species not found in Gibb’s study area at Kaingaroa in 1958-9 have been recorded in pine forests elsewhere: brown kiwis in Northland (Ogle and Anderson, 1979; Corbett et al., 1979) and riflemen in Matea (Caughley, 1960), Kaingaroa (Harrison, 1978), Karioi (Challies, 1960; Harrison, 1978) and Balmoral (Riney and Batcheler, 1959) forests. Caughley saw riflemen in “a mature stand of *Pinus radiata*”, Challies “only in stands of unthinned, mature *Pinus radiata* (planted 1927)” and some (perhaps most) of Harrison’s birds were in *Pinus radiata* planted in 1951 (i.e., 46 years old). Kiwis in Waitangi State Forest in
Northland, however, were found in pines of all ages (from 3 to 40 years old) though they preferred the old stands, particularly those that had a thick (10 cm) ground cover of pine needles; the greatest concentration of kiwis (estimated at about one per hectare) occurred under some exotic stands that had previously been thinned and pruned and contained a dense ground cover of slash (Brian Reid, N.Z. Wildlife Service, pers. comm., October 1980). Corbett et al. (1979) claimed that their study of kiwis in Northland showed that "the widely held notion that kiwis live only within native bush pockets and not in pure stands is false" and that the density of kiwis in Waitangi Forest was "one of the highest ever found in any forest type".

While tuis and bellbirds sometimes appear in pine forests when nectar-bearing plants are in blossom (and may even live in pine forests with native bush nearby as in Nelson), a few other forest birds are seen in pine forests rarely, if at all. Examples are the N.Z. pigeon, kaka, the two parakeets, and kokako and, in the South Island, the yellowhead.

In the South Island, Maplesden (1978) studied the occurrence of four species of native insectivorous birds in exotic plantations at Golden Downs Forest, Nelson. In August she found grey warblers at 73% of her recording stations, robins at 18%, brown creepers at 15%, and tomtits at only 6%; the comparable figures for December were 44, 17, 13 and 4%, respectively. Grey warblers were common throughout, brown creepers mainly in 10 to 20-year-old plantations, and robins in the older stands of radiata pine and Douglas fir, especially stands with the least amount of understorey.

A more comprehensive study of birds in exotic forests in the Nelson region is now nearing completion (Clout, 1980a). This study, based on regular monthly counts over two years (1977-79), compares bird populations in six plantations of *Pinus radiata* and one of *Pseudotsuga menziesii* which differ in age and in their degree of isolation from native forest (five areas of which were also studied). The bird populations were assessed by 5-minute counts (Dawson and Bull, 1975) which provide indices of abundance, not actual densities of birds. The data have not yet been fully analysed but the following interim results (Clout, 1980a) seem relevant to the present review.

First, there were five native species (N.Z. pigeon, rifleman, tomtit, bellbird and tui) which were consistently more abundant in native forest, the pigeon and rifleman being virtually restricted to native forest. Secondly, there were two other native species
(brown creeper and robin) which were abundant in old \emph{P. radiata} and \emph{Ps. menziesii} at Golden Downs but rare or absent in all other study areas. Thirdly, there were five ubiquitous species (grey warbler, fantail, song thrush, blackbird and silvereye) which were similarly abundant in both exotic and native forest. Fourthly, there was a group of introduced species, mainly finches (but also including California quail, skylark, and hedge sparrow), which were more abundant in exotic forest. Several other species (harrier, weka, shining cuckoo, and kingfisher) were recorded occasionally or seasonally in both exotic and native forest, and parrots were virtually absent from all the areas studied.

The numbers of tuis and bellbirds varied markedly between different patches of native forest (bellbirds from c.1.5 per count to 6-7 per count), perhaps reflecting differences in the availability of honeydew, produced by the scale insect \emph{Ultracoelostoma assimile} which infests native beech trees (\emph{Nothofagus} spp.). Both bellbirds and tuis occurred regularly in the exotic forest study areas, with bellbirds averaging about 0.5 per count in several stands. This contrasts with the irregular occurrence of both species in the exotic stands (distant from native bush) surveyed by Gibb (1961) in Kaingaroa. The relative proximity of most of the Nelson exotic stands to areas of native forest may explain the difference. Results from Golden Downs (Nelson) show seasonal patterns of abundance for both bellbird and tui which were concentrated in native forest patches in the winter.

An earlier (1979) Ecology Division DSIR file report by Clout on his Nelson work concludes “In general the older exotic stands provide a better habitat for native birds than younger stands. Very young, open stands are particularly poor native bird habitats, supporting only the ubiquitous silvereye, fantail and grey warbler. Exotic stands seem to reach their optimum as native bird habitat towards the end of their life, just before they are felled and revert to bare ground. Finally, the results from Golden Downs clearly illustrate the value of patches of native forest within exotic forests as holding habitat for native birds. It is doubtful whether species such as the bellbird, tui and kereru could exist without access to native forest . . .”

\emph{Exotic Forests as a Habitat for Other Animals}

Bats, New Zealand’s only native land mammals, are rare in exotic forests perhaps because of the scarcity of decaying trees for roosts. There is, however, one record of some 20 long-tailed
bats being found in a decaying \textit{Pinus radiata} tree near Tokoroa (Daniel, 1981). On the other hand, many kinds of introduced mammals are common in exotic forests. For instance, Riney and Batcheler (1959) found possums, black rats, mice, rabbits, hares and red deer in Balmoral forest, and Gibb (1961) reported that red deer, feral pigs and feral horses roamed the Kaingaroa forests while rabbits, hares, stoats and ferrets frequented the forest edge and open spaces. Clout (1977) studied the ecology of possums in pine forests near Tokoroa and found that the populations of only some 2 to 3 possums per hectare sometimes caused appreciable damage in younger stands of \textit{P. radiata}; comparable damage had been reported from all of the other large exotic forests in New Zealand. Near Auckland, Badan (1979) found mice plentiful in a 3-year-old pine plantation, but much less so in a mature pine plantation, and Clout (1980b) discovered that ship rats are sometimes abundant in \textit{P. radiata} plantations near Tokoroa. The presence of mammals in pine forests may adversely affect bird life through competition for food (possums eat nectar- and berry-producing plants and rodents take insects and seeds), through predation (e.g., by stoats, especially if sudden reductions in rodent populations leave them short of food) or through the accidental killing of birds with poison or traps put out for possums (Harrison, 1978).

Except for the presence of skinks (\textit{Leiolopisma} sp.) in Balmoral Forest (Riney and Batcheler, 1959), little is known about the occurrence of reptiles or amphibians in pine forests. They appear to be rare in this habitat, but a slow spread into pine forests by some lizards is quite conceivable considering that the gecko \textit{Naultinus elegans} has been found living in barberry hedges on farmland (B. W. Thomas, pers. comm., 21.7.80).

A review of information on invertebrates in exotic forests is currently being prepared by Dr G. W. Ramsay (Entomology Division, DSIR) who has kindly provided the following provisional summary:

"In some respects the situation of the invertebrates resembles that of the birds, although very much more has yet to be discovered about the invertebrates. The bulk of the invertebrate fauna is unlikely to colonise exotic forests as it is greatly dependent on native habitats. The number of species in exotic forests is impoverished compared with that in native forests. With the Coleoptera (beetles) for example (the only group for which there is any comparative data), only about 10\% of the fauna is present in exotic forests. Native snails seem to be rare in exotic
forests possibly because they are eliminated by burning and spread only slowly. The number of invertebrate species increases with the age and developing diversity of the exotic forest up to approximately 25 years, and thereafter levels off being similar even in 50-year-old stands. However, despite the impoverishment in numbers of species there is evidence that the number of individuals in exotic forests is similar to that in indigenous forests. At least 120 invertebrate species have been reported from New Zealand exotic forests and the number will probably increase considerably as further studies are carried out” (G. W. Ramsay, in litt., 18.9.80).

Although fresh water might be regarded as a separate habitat from pine forests, it is nevertheless greatly influenced by forestry operations such as road building, logging, burning, spraying, and processing (mill effluents). The extensive literature on these practices, particularly as they affect fish, was summarised by Morgan and Graynoth (1978), and Graynoth (1979) has pointed out some of the undesirable effects of injudicious logging on stream faunas in Nelson.

EFFECTS OF FUTURE EXOTIC FORESTRY DEVELOPMENTS ON WILDLIFE

The Kaingaroa and Nelson studies (together with ecological principles established elsewhere) provide the best guide we have as to how forest-dwelling wildlife may fare under various land-use options. The important facts are:

(1) Indigenous forest contains a greater diversity of native animals than does exotic forest, which is in turn a much better habitat for forest animals than is farmland.

(2) While some native animals (particularly certain birds) flourish in pine forests, others do not.

(3) Older pine forests, especially those with an open canopy and well developed shrub layer, contain a wider range of native animals than do younger pine forests.

(4) While these considerations are important in determining the diversity of native animals in a given forest, they do not necessarily apply to individual species. For example, robins seem to prefer an open forest floor, and brown creepers a closed canopy (M. N. Clout, pers. comm., October 1980).

If, as seems likely, pine forests will soon cover much more of New Zealand than they do at present, the consequences for wild-
life will be harmful to the extent that the pines (a) replace native vegetation and (b) are harvested on a short rotation for pulp.

Siting of New Exotic Forests

The most important consideration for the protection of native fauna is the need to avoid replacing indigenous plant communities (particularly forest but also native scrub and grassland) with pines or, worse still, farmland. Not only are many elements of the native fauna apparently unable to survive in pine forests as currently managed, but also any further reduction in the area of indigenous forest, particularly lowland forest, is likely to be accompanied by further extinctions of native fauna within the remaining parts of these forests. The government’s Indigenous Forest Policy gives some assurance of restraint in the conversion of indigenous forests controlled by the Forest Service. However, no assurances at all can be given with regard to the preservation of privately owned indigenous forests. Indeed, the restraint exercised by the private sector in converting indigenous forests to exotics seems likely to be the major factor in determining whether the consequences of future developments in the exotic forest industry are favourable or otherwise for native fauna.

Some native forest animals will certainly benefit from the establishment of more pine forests, provided the trees are planted on open country or abandoned farmland and are managed as a long-rotation crop. For instance, several native insectivorous birds have benefited from the pine plantations at Kaingaroa, though perhaps at the expense of species requiring an open habitat (a proviso that applies also to plantations on coastal sand dunes). Whether the native birds at Kaingaroa will still flourish in second generation pine forests, or in pine forests under different management regimes remains uncertain. The vast differences in habitat that result from different spacing and pruning are well illustrated by photographs in a recent DSIR discussion paper (Molloy et al., 1980, p. 146).

In general, however, the interests of nature conservation would be served best, not by planting more pines, but by protecting all native vegetation and allowing man-induced scrub lands to revert to native forest. Of course nature conservation is not the only consideration, and if there must be more pine forests then they should be sited and managed so as to minimise adverse effects on wildlife. This would involve siting plantations on land with relatively low wildlife value or potential, reserving adequate areas
of each type of natural community, managing the plantations for the benefit of wildlife, and balancing the need for new plantations against the needs of other interests.

Harvesting the Forest

The growing of trees for pulp production only is likely to be harmful to wildlife because it involves clearfelling the forest at an earlier age than for sawlogs, and, at harvest, there will be heavy demands on water resources for processing and waste disposal. While storage lakes may benefit some kinds of waterfowl, the flooding of valley floors will adversely affect other animals. Fluctuating water levels downstream from dams will harm aquatic life, freshwater fisheries and the several kinds of open-country birds that nest on river-beds. The discharge of chemical and other residues from pulp mills into waterways could provide an even greater problem, either because of the expense of removing the residues or because of serious economic consequences for freshwater fisheries and (in some places) marine farming, if the wastes are not removed at source.

Introduced Animals

Little needs to be said about how introduced birds and mammals will be affected by increased planting of exotic trees. In general, one might expect that the new forests will eventually support populations of introduced birds and mammals comparable to those in existing forests. None of these animals is in any danger of extinction, and methods exist for controlling most of the birds or mammals that are likely to become pests. Where poison is needed to reduce animals not adequately controlled by professional or recreational hunters, or by the environment, care will be needed to select baits that are safe for non-target species. In some forests, introduced game birds and deer might be managed for the benefit of sportsmen. On the other hand, trout fishing stands to suffer from the development of pulp mills and other causes of stream pollution (by no means all attributable to the forest industry).

MAXIMISING THE BENEFITS OF EXOTIC FORESTRY TO WILDLIFE

Clout's work in Nelson confirmed the importance of even quite small patches of native forest in enabling native birds to persist in areas predominantly planted in pines, and this benefit probably applies also to many other kinds of animal. Preservation of patches
of native forest, especially mature forest, is probably the most
important single measure that can be taken to protect native fauna
when exotic trees are planted or harvested. Furthermore the value
of such patches could be enhanced by encouraging regeneration
of native vegetation along stream banks or elsewhere to form
corridors between patches of relict forest, and this should be con-
cidered in the early planning stages of exotic forests.

It was also apparent at both Kaingaroa and Nelson that the old
stands of pines contained more kinds of birds than did younger
stands. It should therefore assist wildlife if some of these trees
(perhaps poorly shaped or less accessible ones) could be left when
the rest are harvested. Likewise, corridors of old pines with their
understorey of shrubs would be useful in linking isolated patches
of native forest. Permanent patches of mature forest (whether
native or exotic) not only increase the diversity of wildlife in an
area, but they also provide refuges where wildlife populations
can survive between one generation of pines and the next. With-
out such refuges, many slow-moving animals may be unable to
colonise a pine forest during the comparatively short time be-
tween when it is mature enough to provide a suitable habitat
and when it is harvested. The planting of native or exotic trees
and shrubs to provide a year-round succession of blossoms and
fruit would do much to encourage tuis, bellbirds and pigeons,
and a few overmature pine trees would provide nest sites for
cavity nesters and perhaps food for kakas.

Trees in commercial pine forests have relatively short lives, and
at best they constitute only a temporary habitat. The clearfelling
of a forest is a calamity for the animals that live in it, but their
extinction might be avoided if the felling were done on a patch-
work basis with sufficient mature forest always left to provide
colonists for younger stands as they mature.

Most of these ideas (and others such as making water reser-
voirs for firefighting more attractive for waterfowl) were dis-
cussed by Guest (1979). He also mentioned some disadvantages
to the forester; for instance, patches of native forest may en-
courage possums, and the overmature trees may harbour pests
and diseases that will later spread to younger stands. On the
other hand, the overmature trees may also harbour parasites and
predators useful in controlling pests. Likewise, patches and cor-
rridors of native bush, desirable as wildlife habitat within exotic
forests, may also be of value in controlling fires because they would
not burn as readily as pines.
Some of these measures require testing to determine their effectiveness and practicality in relation to forest management, and the possibility of undesirable side effects. A survey of animal life (including native invertebrates) in exotic forests throughout New Zealand may answer some questions and suggest other promising lines for future research or management in the interests of wildlife in exotic forests. Such research is urgent because opportunities for conserving existing vegetation are rapidly being lost, and the enrichment of forests with trees producing fruit and nectar is inevitably a long-term undertaking.

SUMMARY AND RECOMMENDATIONS

The scientific and aesthetic values of New Zealand's endemic wildlife are renowned worldwide, and the nation has a correspondingly onerous responsibility for its protection. Many elements of the terrestrial fauna evolved in the forests that formerly covered most of the country, and the survival of these animals depends on the preservation of that habitat.

Current projections suggest that New Zealand's 741 000 ha of exotic forests at 31 March 1978, will more than double by the year 2005. To the extent that new exotic forest replaces existing indigenous forest, the changes will certainly be detrimental to most forms of native wildlife and lethal to many. The value of exotic forests as a habitat for native animals (inherently less than that of indigenous forests) will be much reduced if they are harvested on a short rotation for pulp.

Ornithological studies at Kaingaroa and Nelson (where exotic forests replaced natural or man-induced scrublands) have demonstrated that old stands of *P. radiata* support good populations of several kinds of insect-eating native birds, but not parakeets, kakas or pigeons. Bird populations tended to be smaller and less diverse in younger stands of pines. More research is required to determine the extent to which the birdlife found in the Kaingaroa and Nelson studies is characteristic of exotic forests in other districts or of forests which are managed differently (spacing, pruning, age at harvest, etc.).

Many native invertebrates appear not to occur in exotic forests, probably because the habitat is unsuitable or perhaps because their rate of spread is slow in relation to the life of the trees.

Supplying the water required to process the extra wood (four times that of current quantities of wood by early next century) will have further impacts on wildlife. New lakes for water stor-
age may benefit some species but disadvantage others; fluctuating water levels, and effluents from timber processing, can only be harmful to wildlife. Apart from the scientific and aesthetic considerations dealt with here, forestry operations (like those of several other industries) could have highly undesirable economic consequences for freshwater fisheries and for marine farming.

Recommendations on ways to protect wildlife in the face of a massive expansion of exotic forestry in New Zealand require action under two main headings: (1) Conservation of the remaining indigenous forest (especially lowland forest) and (2) enhancement of exotic plantations as a habitat for wildlife. Conservation of indigenous forests will protect a much wider range of endemic animals than will improved management of exotic forests, though the latter may be of very real value to particular species including several kinds of native birds.

(1) Protection of Indigenous Forests

(a) The government's 1975 policy for State indigenous forests should be extended to all publicly owned indigenous forests. (The 1975 policy does not currently apply to forest on land controlled by government departments other than the Forest Service.)

(b) Where exceptional circumstances (such as overriding social or national considerations) require the conversion of indigenous forest to exotic plantations or pasture, an equivalent area should be planted in native trees elsewhere.

(c) Rural development loans which sometimes encourage the clearing of forest remnants on private lands should be replaced by incentives to protect native forest whether virgin, regenerating or relict.

(2) Enhancement of Exotic Plantations

(a) New plantings of exotics should link up any existing relics of indigenous forest, not replace them.

(b) Development of native vegetation should be encouraged along escarpments and stream banks to provide permanent corridors for animal dispersal into successive crops of exotic trees.

(c) Where the site permits, exotic plantations should be fringed with (or include amenity stands of) nectar- and berry-bearing trees selected to provide a continuing supply of food for birds (including game species).
(d) Harvesting of mature trees should be on a patchwork basis to ensure the continuing availability of mature forest for the species that require this. (In the interests of wildlife conservation, long-term rotation for sawlogs is greatly to be preferred to short-term rotation for pulp.)

(e) Where mature native forest is lacking, some of the poorly shaped or less accessible exotics should be left for birds that require over-mature standing trees for nest sites or as a source of insect food.

(f) Sprays and baits for pest control in forests should be selected with the welfare of non-target species in mind.

(g) More research should be undertaken to discover how best to plant, manage and harvest exotic forests to the maximum benefit of wildlife.

ACKNOWLEDGEMENTS

The author records his indebtedness to the several people, mentioned in the text, who have kindly provided unpublished information for use in this report. Colleagues in Ecology Division, DSIR (particularly D. G. Dawson, J. E. C. Flux and K. R. Hackwell), made helpful comments on an earlier draft.

REFERENCES


APPENDIX

Scientific Names of Birds and Mammals mentioned in the Text
(in alphabetical order of common names)

Birds

| Bellbird | Anthornis melanura |
| Blackbird | Turdus merula |
| Brown creeper | Finschia novaeseelandiae |
| Bush wren | Xenicus longipes |
| California quail | Lophortyx californica |
| Chaffinch | Fringilla coelebs |
| Cuckoo, Long-tailed | Eudynamys taitensis |
| Cuckoo, Shining | Chrysococcyx lucidus |
| Falcon, N.Z. | Falco novaeseelandiae |
Fantail  
Fernbird  
Goldfinch  
Greenfinch  
Grey warbler  
Harrier  
Hedge sparrow  
Huia  
Kaka  
Kakapo  
Kingfisher  
Kiwi, Brown  
Kiwi, Little spotted  
Kokako  
Owl, Laughing  
Morepork  
Parakeet, Orange-fronted  
Parakeet, Red-crown'd  
Parakeet, Yellow-crowned  
Pheasant  
Pigeon, N.Z. (Kereru)  
Piopio  
Pipit  
Redpoll  
Rifleman  
Robin  
Saddleback  
Silvereye  
Skylark  
Song thrush  
Stitchbird  
Tit (Pied tit, or Tomtit)  
Tui  
Weka  
Whitehead  
Yellowhammer  
Yellowhead  
Rhipidura fuliginosa  
Bowdleria punctata  
Carduelis carduelis  
Carduelis chloris  
Gerygone igata  
Circus approximans  
Prunella modularis  
Heteralocha acutirostris  
Nestor meridionalis  
Strigops habroptilus  
Halcyon sancta  
Apteryx australis  
Apteryx owenii  
Callaeas cinerea  
Scelogaux albicacies  
Ninox novaeseelandiae  
Cyanoramphus maleri  
Cyanoramphus novaeseelandiae  
Cyanoramphus auriceps  
Phasianus colchicus  
Hemiphaga novaeseelandiae  
Turnagra capensis  
Anthus novaeseelandiae  
Carduelis flamma  
Acanthisitta chloris  
Petroica australis  
Philasturnus carunculatus  
Zosterops lateralis  
Alauda arvensis  
Turdus philomelos  
Notiomystis cincta  
Petroica macrocephala  
Prosthemadera novaeseelandiae  
Gallirallus australis  
Mohoua albicilla  
Emberiza citrinella  
Mohoua ochracephala  

Mammals  
Mustela putorius  
Lepus europaeus  
Equus caballus  
Chalinolobus tuberculatus  
Mus musculus  
Trichosurus vulpecula  
Sus scrofa  
Oryctolagus cuniculus  
Cervus elaphus  
Rattus rattus  
Mystacina tuberculata  
Mustela erminea