

134. Innes, J.G. 1986 b: Introduced mammals, p. 33. - In: Veale, B. & Innes, J. (eds.), Ecological research in the central North Island Volcanic Plateau region. Proceedings of a New Zealand Forest Service workshop, Pureora - New Zealand Forest Service, Forest Research Institute, Rotorua.  
Summary of a regional overview. Of the 20 wild animal species found on the central North Island Volcanic Plateau, most attention has been given to browsing animals but 'the impact of most mammals is only slowly becoming known'. Little is known of some species, e.g., feral pig. Small mammals have hitherto received little attention (but see 3 papers by King et al. 1996 for studies at Pureora).  
Keywords: browsing mammals, small mammals, volcanic plateau
135. Innes, J.G. 1987 a: Are North Island kokako killed by aerial 1080 operations? Research results to September 1987. - Forest Research Institute (unpublished report). - Rotorua.  
See summaries in Forest Research Institute 1986, 1988, 1989.  
Keywords: kokako, aerial poisoning, 1080
136. Innes, J.G., Calder, R.D. & Williams, D.S. 1991: Native meets exotic - kokako and pine forest. - What's New in Forest Research 209: 1-4.  
In 1983 there were reports of kokako in pine plantations from Pureora Forest Park as well as from other central North Island plantations. Whilst this pamphlet refers mainly to a study of kokako in Rotoehu pine plantations there are observations and conclusions that can be extended to Pureora. Kokako move, sing and feed freely in pine plantations rather than reside or breed there. Fast growing pines may be the quickest way (within 15 years) to establish forest corridors between isolated native forest blocks and help protect the bird's future survival. The long-term objective is to restore native forest to these sites. [The north and south blocks of Pureora Forest Park are isolated by a narrow strip of farmland, pine plantations and native forest remnants.].  
Keywords: kokako - pine forest, bird corridors
137. Innes, J.G. & Hay, J.R. 1995: The nesting of the North Island kokako (*Callaeas cinerea wilsoni*) - review of accounts from 1880-1989. - Notornis 42: 79-93.  
This paper reviews what is known of kokako nesting, incorporating observations for 6 nests found in Pureora Forest between 1981 and 1983 from mid to late summer. A detailed account is given for a nest located in Bismarck Road, Pikiariki Ecological Area. This nest, a large structure of twigs, was built after failure of an earlier nest and was typically placed at a height of 7m with dense overhead shade in a mahoe with lawyer vines. Observations were made on 25 days between 31 January to 12 March with hatching of two chicks on 8 February. Details for the 6 Pureora nests are included in the section on breeding biology. The adult behaviour of the Bismarck Road pair of kokako is described before and during incubation and data are presented in three figures for times of the female on the nest and visits by the male. Adult and nestling behaviour is also described for the nestling period, their food being mainly scale insects and to a lesser extent leaves and fruit of fivefinger, bush lawyer, wineberry, supplejack and putaputaweta. The chicks fledged after 32 days. It is suggested in discussion and abstract that 'several aspects of kokako nesting evolved in response to diurnal avian predation and that their behaviour gives ineffective protection against nocturnal, arboreal, introduced mammal predators such as rats, stoats or possums'.  
Keywords: kokako, kokako - nesting, kokako - behaviour, kokako - predators, Pikiariki Ecological Area

138. Innes, J.G., Hay, J.R., Flux, I, Bradfield, P., Speed, H.J. & Jansen, P. 1999: Successful recovery of North Island kokako *Callaeas cinerea wilsoni* populations by adaptive management. - *Biological Conservation* 87: 201-214.
- This definitive paper does not refer specifically to Pureora but the review of past work on kokako nesting and predators, and the results of an 8 year experiment in other central North Island forests (Mapara, Kaharoa and Rotoehu) to control predators and improve success of kokako breeding is highly relevant to current work to maintain a 'mainland island' in the Waipapa Ecological Area. The main introduced predators of kokako have been identified as possums and ship rats with less importance attached to mustelids and feral cats in the context of the experiments reported on. Predation is a more immediate cause of kokako declines than competition for food. After 8 years of pest control at Mapara, the number of kokako breeding pairs increased eight fold. The paper has a full discussion on the causes of kokako decline and the implications of trial results and previous work for kokako management on the mainland. The 72 listed references include 11 papers annotated in this bibliography.
- Keywords: kokako, kokako - decline, kokako - predators, possums, ship rat, adaptive management, kokako - recovery
139. Innes, J.G., Warburton, B., Williams, D.S., Speed, H.J. & Bradfield, P. 1995: Large scale poisoning of ship rats (*Rattus rattus*) in indigenous forests of the North Island, New Zealand. - *New Zealand Journal of Ecology* 19(1): 5-18.
- The impact of poison operations on ship rats in four study areas of central North Island podocarp/tawa forest is described. One of the study areas with populations of kokako was Pikiariki Ecological Area in Pureora Forest Park. Methods used and results obtained in the Pikiariki trial are summarised. Ground poisoning was carried out over 35 ha from 25 January to 22 March 1983, using brodifacoum in 'Talon' baits. Results were assessed by monitoring through footprint tracking in tunnels and capture in Fenn traps in poisoned and untreated control blocks. Results suggested a 73% decline in tracking after poisoning. Fenn traps caught no rats after two weeks from poisoning, indicating an effective poisoning operation. Rat numbers were reduced for two months, equivalent to one breeding season. In a discussion of all poison operations it is stated that 'most ground-based and aerial poisoning operations (also killing possums) reduced indices of ship rat abundance by at least 90%.' Reference is also made to the increase of mouse tracking after successful poisoning of ship rats, whereas later data on trapping mice at Pureora and elsewhere suggested that 'mice in mature central North Island podocarp/tawa forests have very low stable populations' in the absence of any pest management. Includes 40 references.
- Keywords: ship rat, mice - feral, rodent - population control, brodifacoum, ground poisoning - small mammals
140. Innes, J.G. & Williams, D.S. 1990: The impact of poisoning on ship rat populations at Mapara (King Country) and at Pureora. - Forest Research Institute, Forest and Wildland Ecosystems Division, Northern Wildlands (unpublished contract report for Department of Conservation). - Rotorua. 9 p.
- This operation to reduce the population of ship rats during the kokako breeding season (October to March) by use of 'Talon' baits was very effective. Good control was achieved by six weeks after poisoning started and was maintained for the duration of the programme by constant replacement of baits. Reinvasion of rats from the unpoisoned surrounding forest was rapid. Methods are fully described.
- Keywords: poisoning impact, ship rat, kokako, predator control, brodifacoum

141. Innes, J.G.H., J R; Ford, M 1985: The potential impact of predator control on survival of kokako populations in reserves. - *New Zealand Journal of Ecology* 8: 149.  
Resume of presentation given at 1984 annual conference of the New Zealand Ecological Society.  
Keywords: kokako, predator control, population model, kokako - survival
142. Jane, G.T. 1979: The wild animal populations and forest conditions in the Hauhungaroa Ranges. - New Zealand Forest Service, Rotorua Conservancy (unpublished report). - Rotorua. 47 p.  
The report is based on extensive sampling of animal faecal pellets and the frequency of plant species at plots along transects. The area sampled, mainly over 700m a.s.l., includes most of Pureora Forest Park, excluding the North Block. Five regions are recognised, based on vegetation, animal densities and the history of volcanicity, logging and distribution of introduced browsing animals: deer, goats, possums and feral cattle (scarce since the 1960s). Results are given by regions and 15 forest types are recognised over the survey area. The spread of deer and possums northwards along the Hauhungaroa Range is described with their greatest impact expressed in the south, especially on the crest of the range with collapse of fuchsia in gullies and reduction of palatable species, leading to a dense pepperwood understorey in some forest types, as in podocarp forest on easy terrain in the Waihaha and Taringamotu catchments. Maps show the distribution and density of deer, possums and goats by regions. Includes 4 maps, 9 colour photos.  
Keywords: wild animal populations, forest condition, browsing damage, forest types, animal survey
143. Johnson, P.N. 1977: Notes on the botany of the King Country, p. 107-117. - In: New Zealand Department of Lands and Survey (ed.), *King country land use study: Technical reports - Land Use Series No. 3.* - New Zealand of Department of Lands and Survey, Wellington.  
Four of seven areas examined for botanical features during an eight day reconnaissance in 1976 were within or adjacent to proposed biological reserves in or near Pureora Forest Park. A list of plant species, including adventives, is given for each area examined. Map references are given for each locality. The localities in or near Pureora Forest Park were:
1. Whanganui Stream. Head of stream in Taringamotu Forest. Vegetation of the frost flat known as the Whenuakura Clearing is described, together with marginal areas and forest on the north and south sides of the valley. Profiles illustrating frost flat vegetation and altitudinal zonation of forest are shown.
  2. North of Barryville. Frost flats surrounded by unlogged forest occur by two streams at the head of the Waipapa River.
    - A. Now in the Waipapa Ecological Area.  
The horizontal zonation pattern from frost flat and stream banks through manuka scrub to shrubland and tall dense podocarp forest is described and illustrated in a vegetation profile diagram.
    - B. Frost flats outside the park boundary in the valley of the Karamarama Stream.
  3. Pureora Mountain. Vegetation is described and illustrated in a profile diagram from dwarf shrubs at the summit at 1170m down through Halls totara/kamahi forest to scattered podocarps over kamahi/quintinia below about 880m. Upper altitudinal limits are indicated for various species including 980m for rimu, 920m for miro and 860m for matai.
  4. Barryville, bog pine, above Waimiha Stream [Later made a Scientific Reserve]  
(Also in Forest Research Institute file reference 31/6/9/9 dated 1.3.77, now held at Landcare Research NZ Ltd, PB 3127, Hamilton).

Keywords: Whanganui Stream, Barryville, Pureora Mountain, species list - flora, King Country, frost flats, Whenuakura Clearing, Waipapa, Karamarama frost flat

144. King, C.M. 1984: Immigrant killers - introduced predators and the conservation of birds in New Zealand. - Oxford University Press, Auckland.  
This excellent and well-illustrated book provides a fine perspective and background for those engaged in research and conservation of New Zealand's forest and birds. Chapter 5 is titled 'predators and the conservation of contemporary wildlife in New Zealand'. The story of kokako in Pureora Forest is outlined on pages 146-148 and 185; the battle for its conservation has led to increased efforts in research of the bird and its habitat. There are photos of the last clearfelled and burned area of podocarp forest converted to pines in 1978, near the Pikiariki Ecological Area, previously identified by the Wildlife Service in 1971 as an area of outstanding value for native fauna (notably the kokako). Destruction of habitat has been the greatest cause of decline in populations of kokako. Other causes have been predation and depletion of the kokako's food supply by browsing mammals. The alternatives for preservation of the kokako are effective management in prime habitat by control of browsing animals and predators, or transferring birds to offshore islands.  
Keywords: predators - introduced, bird conservation, habitat destruction, browsing animal competition, browsing animal control, kokako - management, predator control
145. King, C.M. (ed.) 1990: The Handbook of New Zealand Mammals. - Oxford University Press, Auckland.  
The full and authoritative accounts by various authors in this handbook are valuable references for studies of the impact on indigenous vegetation and wildlife by browsing mammals and predators in Pureora Forest Park. There are accounts of 17 species distributed at present, or recently, in the Park, some of which have been the object of studies at Pureora and publications since the handbook was written, e.g., papers by King et al. 1996, on small mammals (mustelids, ship rats, feral cats, feral house mouse) annotated in this bibliography. These papers have updated some information on distribution of certain species in indigenous forest e.g., ferrets are found in indigenous forest at Pureora and hedgehogs are widely distributed in the same habitat (cf. statements on pp 325 and 102 in the Handbook). Particularly valuable for Pureora work on conservation are the sections on habitat, food and significance to the New Zealand environment for each species. The account of short-tailed bats is also of interest as the Volcanic Plateau subspecies, *Mystacina tuberculata rhyacobia*, is found in Pureora Forest Park and may be at risk from predation by feral cats and ship rats (p 129) whilst carrot baits with 1080 may be a hazard on the forest floor (p130). See also Innes et al. 1995, 1999.  
Keywords: New Zealand mammals - Handbook, browsing mammals, predators - Pureora, small mammals, 1080
146. King, C.M., Flux, M., Innes, J.G. & Fitzgerald, B.M. 1996: Population biology of small mammals in Pureora Forest Park: 1. Carnivores (*Mustela erminea*, *M. furo*, *M. nivalis* and *Felis catus*). - New Zealand Journal of Ecology 20(2): 241-251.  
The main aim of this study was to provide basic data on the population biology of potential predators of kokako and other fauna. (See annotation for King et al. 1996 for location of study areas and abundance of small animals in relation to habitat). In systematic trapping over five years (1983-1987), stoats (63) were most frequently collected; they ranged through the mosaic of forest types, but especially old exotic plantations, hunting rabbits, rats,

possums and birds. Data are given on gut contents, reproduction and age structure for the 4 mammal species. Weasels (18) were collected mainly from habitats favouring mice, such as young plantations and road verges and many had eaten mice and insects. Cats (15) and ferrets (13) hunted the native forest blocks where their main prey - rats and possums - were abundant. Birds were not recorded in gut contents of ferrets and seemed to be eaten to a small extent by cats (3 out of 13 cat guts had bird remains including a parakeet beak). There was evidence that trapping may remove stoats faster than they can be replaced as the natural density and adult mortality of stoats in this study were relatively low and relatively small numbers of young are produced each year. Stoats are more likely to be predators of kokako and other birds as weasels are smaller and rarer and cats and ferrets are also rarer and hunt birds less often. Stoats may, however, 'do less damage to local bird populations than the vastly more abundant ship rats and possums which destroy many nests'. It was concluded that 'pest control operations to protect threatened birds at Pureora should include all mustelids, rodents, feral cats and possums together, until further research suggests otherwise'.  
Keywords: cats - feral, stoat, weasel, ferret, predator diet, kokako, predator management, competition, small mammals, population biology

147. King, C.M., Innes, J.G. & Flux, M. 1986: Rodent and mustelid population studies, p. 49. - In: Veale, B. & Innes, J. (eds.), Ecological research in the central North Island Volcanic Plateau region. Proceedings of a New Zealand Forest Service workshop, Pureora - New Zealand Forest Service, Forest Research Institute, Rotorua.

Research abstract. The density and population biology of 3 species of rodents and 3 species of mustelids were being surveyed in indigenous virgin and cutover forest and exotic forest (at Pureora) to provide information useful for predator control programmes that might assist management of the kokako. Ship rats, common in both virgin and cutover forest, are the most abundant and widespread predators while stoats are scarce in all forest types sampled. [See 3 papers by King et al. 1996 for final results of these studies.).

Keywords: population surveys, mustelids, rodents, predator control, Pureora

148. King, C.M., Innes, J.G., Flux, M. & Kimberley, M.O. 1996: Population biology of small mammals in Pureora Forest Park: 2. The feral house mouse (*Mus musculus*). - New Zealand Journal of Ecology 20(2): 253-269.

The aim of this study was 'to record the measurements, population structure and reproduction of mice at Pureora in relation to habitat, season and year'. This is the third paper published on studies of small mammals trapped over 5 years in Pureora Forest Park [See King et al. 1996 a and 1996 b]. In this third study mice were most abundant in dense vegetation along road edges and in a young exotic plantation. In a discussion of previous work, the versatility of feral mice and their ability to exploit disturbed sites as the 'animal equivalent' of plant weeds' is referred to. 'Dense ground vegetation provides a damp microclimate and offers the shelter, escape cover and rich supplies of fruits, seeds and invertebrates favoured by mice' (quoted from another author). Mice apparently prefer insect to plant food (conclusion of a literature review). The authors of this paper present two hypotheses for a sudden increase in autumn in mice at Pureora: a mass emergence of insects over the previous summer with a thick ground cover (both live vegetation and accumulated humus) providing excellent burrowing conditions and protection for mice from predation by ship rats, or reduction in competition from ship rats. Mice were most abundant in a young plantation of radiata pine where ship rats were practically absent.

Keywords: mice - feral, house mouse, population structure, habitat effects, irruption

149. King, C.M., Innes, J.G., Flux, M., Kimberley, M.O., Leathwick, J.R. & Williams, D.S. 1996: Distribution and abundance of small mammals in relation to habitat in Pureora Forest Park. - *New Zealand Journal of Ecology* 20(2): 215-240.

This paper reports results from a five year study (1982-87) of rodents, mustelids, cats and hedgehogs in logged and unlogged indigenous forest and in exotic plantations of various ages in Pureora Forest Park. The three study areas with different habitats (shown in a map) were: unlogged podocarp/tawa forest in the Waipapa Ecological Area; forest logged for podocarps from 1939-1963, and retaining a tawa/hardwood canopy to the north of the Waipapa Ecological Area; and plantations established on sites where dense podocarp forest was cleared and burnt and then planted, mainly with radiata pine, from the 1950s to 1978. (The 1978 planting was adjacent to remnant dense podocarp forest in the Pikiariki Ecological Area).

Populations of kokako were present in the indigenous forest study areas. The occurrence of 11 species of small mammals in Pureora Forest Park is noted but possums (arriving in the 1960s), hares and rabbits are not included in this study. Systematic trapping was done with break-back traps and Fenn traps. Ship rats (n=1793) were absent from the young plantation, infrequent in older exotic forest and abundant in all native forest, regardless of logging history. Most Norway rats (n=43) were caught in a single trap in unlogged native forest on the bank of the Waipapa Stream. Stoats (n=57) were most abundant in the older exotic plantations but 50% were trapped in the more extensive indigenous forest; weasels (n=16) in the young plantation study areas and along road edges in native forest; and ferrets (n=11) in unlogged native forest. Most mice (n=522 collected) were scarce in unlogged native forest, more abundant in road edge cutover forest, and most abundant in a young (5-10 year old) plantation with dense ground cover. Hedgehogs (n=290), not previously known to occur in unlogged native forest, were common in unlogged native forest, far from any roads, and also in older exotic forest. The effects on small mammals of logging native forest and conversion to exotics is discussed and the implication of study findings for North Island kokako are suggested. Previously unpublished data referred to from other studies confirmed that (in Rotoehu Forest) kokako nest predators included ship rats, Australasian harriers and possums. Possums have been confirmed 'as important predators of kokako eggs, chicks and probably adults'. Other potential predators are cats and mustelids but no evidence of predation by them on kokako has been found. It is concluded that it is unlikely that predation risk to kokako is higher in logged forest than in unlogged forest, and predator control (if required) should be applied equally in logged and unlogged kokako habitat. Results from Pureora show 'that many potential predator species live in the interior of tawa-podocarp forest where most kokako survive, and that the numbers of these predators are characteristically stable from year to year rather than irruptive, so [...] threats to kokako are probably constant in all years'. See also parts 1 and 2 of studies in the same study area, published in the same number of the Journal - King, Flux et al. 1996, King, Innes et al. 1996.

Keywords: rodents, mustelids, cats - feral, hedgehogs, habitat preferences, logging, podocarp/tawa forest, kokako, conservation

150. King, S. 1978: The podocarp rainforest of Pureora. - New Zealand Environment 19: 13-19.  
A plea by an ardent conservationist to follow recommendations by the Wildlife Service and create adequate reserves for kokako in the areas of podocarp forest classed as outstanding wildlife habitat. Calls are also made to cease all logging in Pureora Forest, to initiate intensive research on the kokako and other indigenous birds and to create an educational reserve in the remnant strip of podocarp forest at Pikiariki.  
[Four ecological areas with kokako populations were established in Pureora Forest Park in 1978: these were Waipapa Ecological Area of 4000 ha, Mangatutu Ecological area, Pikiariki Ecological Area of 457 ha and Pureora Mountain EA of 2,257 had.  
Keywords: podocarp forest, Pureora, reservation - Pureora, wildlife values - Pureora

151. Knowles, B. & Beveridge, A.E. 1982: Biological flora of New Zealand 9: *Beilschmiedia tawa* (A. Cunn.) Benth et Hook. f. ex Kirk (Lauraceae) tawa. - New Zealand Journal of Botany 20: 37-54.  
While this aimed to be an account of all that was known about tawa, there are numerous references to ecological and growth characteristics of tawa at Pureora, viz. Growth rings: Discs cut from relatively fast-grown small tawa released by felling overhead rimu showed 1 parenchyma band per year. Fruiting: First fruits ripen in February and most ripe fruits usually fall in March. Seed crops are borne annually but fluctuate considerably in abundance with 100 or more fallen fruits per square metre beneath parent trees in good seed years. Pigs eat fruit from the forest floor but rats do not [Possums in other central North Island forests (Mamaku, Rotoehu) are known to destroy immature seed in tree crowns in summer and to eat fallen seed in winter]. Seed dispersal: Kokako have been seen to pluck the fruit and drop the seed after pecking at the pulp while native pigeon swallow whole fruit and distribute the seed. Growth rates: Variable but trees commonly have annual stem diameter increments of 1-3mm. Regeneration in mature forest: Replacement of individual rimu trees occurs where dense clumps of tawa poles grow in small canopy gaps resulting from gradual deterioration of rimu crowns. Succession after volcanic eruption: Discussed by McKelvey for the Hauhungaroa Range. Tawa enters the succession late because of its intolerance of immature soils. For other papers on growth of tawa at Pureora see Smale 1982, 1986, Smale et al. 1986, Smale & Kimberley 1981, 1986.  
Keywords: *Beilschmiedia tawa*, tawa ecology, phenology, regeneration, seed dispersal, succession, growth rate, seed destruction, biological flora

152. Krzystyniak, S. 1984: Pureora North Block animal survey, summer 1983. - New Zealand Forest Service (unpublished report). - Auckland. 48

This block is a recreational hunting area. The density of deer, goats and possums was assessed in the summer of 1983/84, using faecal pellet count methods as in previous similar surveys in 1975 and 1981. The distribution of animals is presented in maps by management (hunting) units. Deer and goat density was highest in the Mangatutu Ecological Area, though lower than in 1981. Deer density has increased in the Waipapa Ecological Area despite hunting pressure while possum pellet density was highest in the same area. Major concern is expressed for the impact on the high indigenous wildlife values of the Waipapa. Five minute bird counts were made of both more common birds and threatened species, including kokako, and locations are mapped. A limited search for amphibians and reptiles located a population of Hochstetter's frog (*Leiopelma hochstetteri*) in the Rangitoto Range while one specimen was found of each of the common skink (*Cyclodina omatum*), the tree skink (*Leiopisma striatum*) and the green gecko (*Naultinus elegans punctatus*). The copper skink (*Cyclodina aenum*) is

said to be 'fairly common' and several specimens have been found in Pureora Village.

Keywords: animal survey, animal density, animal impact, kokako, threatened species, reptiles

153. Leamy, K. & Hayward, J. 1986: Indigenous forestry. A Bibliography: Works by New Zealand Forest Service personnel. - New Zealand Forest Service, Head Office Library, Wellington.  
There are 1397 references to published works of which some 50 are relevant to Pureora Forest Park and are annotated in this current bibliography (1999). There is an author index and a species index.  
Keywords: bibliography, New Zealand Forest Service, indigenous forestry
154. Leathwick, J.R. 1981: The vegetation of kokako and general bird study areas in some central North Island indigenous forests. - New Zealand Wildlife Service, Forest Bird Research Group (unpublished report). - Wellington. 300 p.  
This report presents not only detailed information on the vegetation of seven bird study areas in central North Island forests but reviews the impact on forest structure from selective logging trials and the impact of browsing mammals on vegetation, as well as presenting results of a study of the phenology of the main species of shrubs and trees and an analysis of possum diet assessed from faecal pellets. Accounts are given of each study area, covering four areas for study of the kokako and three for general bird studies. Two of the kokako study areas are located in the Waipapa and Pikiariki Ecological Areas and one of the general bird study areas is located in the North Block of Pureora Forest Park. An outline is given of events leading to the formation of the Forest Bird Research Group with its roles of research into kokako biology and habitat and the impact of selective logging on bird populations. The forest types described were sampled by the Point Height Intercept method, giving measures of the forest structure and density of vegetation and species abundance. It was concluded that there was a low impact on forest structure by selective logging in the study blocks at the logging levels used. There are photos of the forest in different study areas. The results of the phenology study and the diet of possums are included in two papers subsequently published: Leathwick 1984; Leathwick et al. 1983. This report provides a background for the other studies by members of the Forest Bird Research Group: Hay 1981, 1984; Harrison and Saunders 1981; Crawley 1981, giving a summary report of all studies and recommendations by the Forest Bird Research Group. All these reports and papers are annotated in this bibliography.  
Keywords: kokako, vegetation, bird populations, selective logging, forest structure, phenology, possum - diet, Forest Bird Research Group, selective logging impact
155. Leathwick, J.R. 1984 a: Discovery of the sedge *Gahnia rigida* at Pureora. - Rotorua Botanical Society Newsletter 3: 16-17.  
This large sedge was found growing around the margins of wetlands in the Waipapa Ecological Area, indicating a disjunct distribution for a species only found previously in the western South Island and near Wellington.  
Keywords: *Gahnia rigida*, Waipapa Ecological Area



156. Leathwick, J.R. 1984 b: Phenology of some common trees, shrubs and Hanes in four central North Island forests. - Forest Research Institute Bulletin 72: 1-46.
- The phenology of some common trees, shrubs and Hanes was studied for two years in Pureora Forest as well as in Whirinaki, Mapara and Rotoehu Forests. The Pureora study was made in the Waipapa Ecological Area (rimu/tawa forest) and the Pikiariki Educational Area (matai-dominant). The study period extended from August 1979 to July 1981. For each species, from six to twelve mature individuals were tagged and monitored at monthly intervals. The Pureora study included 26 species - 6 podocarps, tawa, kamahi, hinau, rewarewa, 14 shrub hardwoods and 3 vines (supplejack, lawyer, *Parsonia heterophylla*). Ten phenological phases were used in following the development of leaves, flowers and fruits from leaf buds to seed dispersal. Results by these phases are shown in charts for each species with observational notes. A wide range of phenological patterns was observed and there were marked fluctuations in the amounts of flowers and fruits produced in different years. While most species at Pureora flowered and fruited over periods of up to 6 months (spring to autumn) other species showed complex patterns with periods of 12 to 18 months from pollination to fruit ripening; such patterns were shown by tawa, matai, miro, rimu, putaputaweta, pigeonwood, *Coprosma australis* and supplejack.
- Keywords: phenology, indigenous species, Waipapa Ecological Area, Pikiariki Ecological Area
157. Leathwick, J.R. 1987: Waipapa Ecological Area: a study of vegetation pattern in a scientific reserve. - Forest Research Institute Bulletin 130: 1-82.
- The vegetation types of forest, scrub, shrubland and mires in the 4000 ha Waipapa Ecological Area in Pureora Forest Park are identified, described and mapped in 22 map units. Data from the survey are analysed by ordination and classification methods. The objective of the survey was to provide botanical information, using quantitative methods that can give bases for management of scientific reserves and other protected natural areas. Development of the ecological area concept is outlined. A history and description are given of the study area, including references to indigenous and introduced wildlife. A list of 385 vascular taxa, including 53 adventives, is given in an appendix. The results of ordination and classification of plots and species are presented in figures and tables and there are 9 photos of different vegetation types. Forest covers 70% of the reserve with rimu and tawa prominent in five of nine forest types. Podocarp regeneration has become established in several of the scrub types. The current vegetation pattern has been strongly influenced by small-scale change in topography and/or fire disturbance, important factors including frost intensity and changes in drainage and fertility, often resulting from differences in the depth and nature of Taupo pumice deposits. Includes foldout coloured map of vegetation types, and 111 references.
- Keywords: vegetation pattern, vegetation types, scientific reserve, Waipapa Ecological Area, species list - flora, ordination - of vegetation data, vegetation - classification, vegetation map
158. Leathwick, J.R. 1990 a: Vegetation map of the Pureora Mountain Ecological Area, North Island, New Zealand. Scale 1:15 875. - Forest Research Institute Bulletin 157: 16.
- This bulletin contains a shorter account of the vegetation of Pureora Mountain Ecological Area than that given in the author's previous and more comprehensive paper (Leathwick et al. 1988). There are concise accounts of the physical features of the reserve and wildlife, a brief discussion of the vegetation pattern and description of 15 map units (vegetation types) shown in the colour map. An appendix lists wildlife occurring in the reserve. The

kokako is included and it is noted (p5) that recent reports indicate their presence at low altitude in the north of the reserve. See also Clarkson 1984 and Clarkson & Clarkson 1984 for vegetation of mountain mires. Includes foldout colour map, 7 photos.

Keywords: vegetation, Pureora Mountain Ecological Area, Hauhungaroa Range vegetation map, vegetation types

159. Leathwick, J.R. 1990 b: Vegetation map of the Waipapa Ecological Area, Scale: 1:12500. - Forest Research Institute Bulletin 158: 1-16.

This is a bulletin of convenient size for field use, containing a concise account of this ecological area (one of 10 in Pureora Forest Park, (shown here on a location map) based on the comprehensive paper by Leathwick et al. (1988). The format of the bulletin is that also used for Bulletin No 137 (Leathwick 1990) on the Pureora Mountain Ecological Area and outlines the physical features of the reserve, its wildlife, the influence of fire and topography on the vegetation and gives brief descriptions of the composition and distribution of 21 vegetation types of forest, scrub and shrubland shown on the colour map. An appendix lists wildlife occurring in the reserve, including threatened species such as kokako, kaka, yellow-crowned parakeet and New Zealand falcon. Includes coloured foldout map, and 7 photos.

Keywords: vegetation, Waipapa Ecological Area, vegetation map, vegetation types

160. Leathwick, J.R., Hay, J.R. & Fitzgerald, A.E. 1983: The influence of browsing by introduced mammals on the decline of the North Island kokako, - The New Zealand Journal of Ecology 6: 55-70.

The diet of kokako, was studied in three central North Island habitats over 3 years (1978-1981), the period of a logging moratorium. The Pureora study area was a 40 ha block of slightly-modified podocarp forest adjacent to the Pikiariki Ecological Area. The other two study areas were in Mapara and Rotoehu Forests. Possum diet was studied in Pureora and Mapara and a literature review was made of the diet of possums, red deer and feral goat. Goats were absent from the Pureora study area but possums have steadily increased since arrival in the 1960s and deer have never reached high densities [small mammals of 7 species were studied in Pureora Forest in the 1980s - see annotations in this bibliography for 3 papers by King et al. 1996]. There is considerable overlap between the diets of kokako and the three mammalian browsers with leaves and/or fruit of some species eaten by all. The browsers have reduced the abundance of preferred kokako, food plants in much of the remaining kokako habitat. It is concluded that 'the present distribution of kokako suggests that their decline has been caused not only by forest clearance and introduced predators, but also by impoverishment of habitat resulting from the introduction of browsing mammals.' The vegetation in the Pureora study area is podocarp forest dominated by matai with locally abundant rimu and a diverse hardwood canopy. The diets of kokako, and possums in relation to forest composition in the three study areas are shown in charts indicating overlap, particularly marked in some shrub species. At Pureora, major food items for kokako included fruit of fivefinger, raukawa, kaikomako, putaputaweta, matai and supplejack, and leaves of mahoe, while possum food included leaves of fivefinger, raukawa, mahoe and supplejack as important items in their diet (fruits not referred to).

Keywords: kokako - decline, kokako, - diet, browsing mammals, possum - diet, red deer - diet, competition, food preference, habitat impoverishment

161. Leathwick, J.R., Innes, J.G., Williams, D.S. & King, C.M. 1990: Analysis of rodent and mustelid trap success in native and exotic forest at Pureora. - Forest Research Institute, Forest and Wildland Ecosystems Division, Northern Wildlands (unpublished contract report for Department of Conservation). - Rotorua. 8 p.  
Results are given for an initial analysis of trapping data collected in Pureora Forest (Conservation) Park over a 5 year period (1983-1987 inclusive). Trapping was done in an unlogged podocarp/tawa forest, forest logged for podocarps before 1970 and exotic forest and vegetation was recorded at each trap site along rodent and mustelid lines. The study confirmed that stoats, ferrets, weasels and ship rats are all potential predators in all the habitats occupied by kokako at Pureora (with largest population in unlogged and logged forest of the north block). Ship rats are abundant in unlogged native forest and even more numerous in logged native forest; average capture rates were 9-10/100 trap nights on mustelid lines with Fenn traps, twice those on rodent lines with snap traps. There was a low capture rate for mustelids; stoats were widespread at 0.2 -0.3/100 trap nights with lower capture rates for ferrets and weasels. Mice and hedgehogs were also caught in native forest as well in exotic forest while only a few Norway rats were trapped by the Waipapa Stream. It is concluded that if predator control is needed to protect nesting kokako it will be needed on a continuing year to year basis. [Further interpretation and reporting of results are implied.].  
Keywords: rodent trapping, mustelid trapping, Pureora, predator control
162. Leathwick, J.R., Wallace, S.W. & Williams, D.S. 1988: The vegetation of the Pureora Mountain Ecological Area, West Taupo, New Zealand. - *New Zealand Journal of Botany* 26(2): 259-280.  
The vegetation pattern of the Pureora Mountain Ecological Area is described. Data were analysed using ordination and classification techniques. The reserve of 2257 ha ranges in altitude from 660m a.s.l. to 1165m at the summit of Mt Pureora and contains a sequence from submontane conifer-broad-leaved forest to subalpine shrub-mossland. Floristic change is associated with altitude and local variation in topography. Both the pattern and flora reflect not only current site factors but also the effects of the Taupo eruption of ca 1820 BP when most of the vegetation was probably destroyed. There are brief accounts of geology, tephra, soils and climate. Both deer and possum numbers have probably increased in recent years. Classification of plots and species indicated 14 vegetation types which are described and shown in the foldout map. Anomalies in distribution of species are discussed with regional comparisons. A list of 241 vascular species recorded in the Pureora Mountain Ecological Area is given in an appendix. See Leathwick 1990 a for a concise account and map. Includes coloured fold-out map, and 61 references.  
Keywords: vegetation - pattern, scrub, mossfield, West Taupo, Hauhungaroa Range, scientific reserve, vegetation - classification, ordination - of vegetation data, vegetation map, Pureora Mountain Ecological Area
163. Leigh, A.H. & Clegg, S.E. 1989: Maniapoto District wild animal management plan 1989 to 1999. - Department of Conservation (unpublished report). - Hamilton. 153 p.  
The plan reviews the history of establishment of introduced mammals in the Maniapoto District and their impact on indigenous vegetation and wildlife. This district covers much of the King Country with Pureora Forest Park on the eastern side. Thus Pureora Forest Park often features in descriptions of the district, the characteristics of each species of introduced mammals and threatened wildlife, prescriptions for management, animal control and monitoring of animal impacts. A wealth of detail is given from the many references and information in the form of personal communications some years before research publications appeared (e.g., small mammal predators).

Two chapters cover recreational and commercial hunting [The eating of tawa seed is wrongly attributed to ship rats and not possums (p43). (See Knowles and Beveridge 1982)]. The long-tailed bat is said to be recorded from Pureora Forest Park (p9) and more recently the short-tailed bat has been found near Pureora (see Ecroyd, 1993) [The long-tailed cuckoo is included as a rare species (p 10) but is a common summer visitor in central North Island forests]. Nationally or regionally-threatened species occurring in the Pureora Forest Park include kaka, New Zealand falcon, blue duck, short-tailed bat, long-tailed bat, yellow-crowned parakeets, fernbird, robin and striped skink. Hochstetter's frog is recorded as a rare species. The chapter on conservation values refers to areas rated as "outstanding" in terms of wildlife value, "exceptional" in terms of botanical value, or both. Such areas include most of the ecological areas in the Park and the wildlife features of each are described. Includes 10 appendices, 7 maps, 85 references.

Keywords: management plan, Maniapoto District, browsing damage, threatened species, introduced mammals, Ecological Areas - wildlife, conservation values

164. Lim, V. 1996: Contingent valuation study of Pureora State Forest Park. - University of Waikato (unpublished report). - Hamilton.

(Unpublished report of an investigation submitted in partial fulfilment of the requirement of the degree of Bachelor of Management Studies of the University of Waikato, Hamilton, for the Department of Conservation, Waikato Conservancy, Hamilton). This report describes and evaluates a technique used to measure the social or non-market values of Pureora Forest Park by means of a questionnaire and interviews with DOC staff.

Recreational facilities are outlined in a discussion of DOC's management functions in the park. Hitherto DOC has mainly used scientific data to enable it to fulfil its main roles of controlling pests and protecting threatened species. It is suggested that economic theory should be useful in applying techniques to assess the non-market values of the Park's resources and the perceptions of the public.

Keywords: Pureora - non-market values

165. Llewellyn, M.R. 1991: Assessment of possum kill of an aerial 1080 control operation, Waipapa Ecological Area, Pureora. - Plateau Forest Survey (unpublished report prepared for Department of Conservation, Hamilton). - Rotorua. 10 p.

An assessment of the effectiveness of an aerial drop of 1080 poison in cereal pellets over the whole Waipapa Ecological Area in mid June 1991 showed that a relatively low kill of 61% of the possum population was achieved. Probable factors contributing to this result were the leaching of toxic baits by high rainfall and an abundance of strongly-preferred food sources of rimu and kahikatea fruit during exceptionally heavy fruiting. Possum faecal pellets were measured along transects in the Waipapa Ecological Area. In a nearby unpoisoned area of podocarp forest of comparable type possum pellets were counted 'to measure natural changes in pellet densities in order to derive a corrected percentage kill estimate'. It is suggested that a heavy fruiting of rimu and kahikatea may have contributed to low bait acceptance. See also Dale 1975, Broome & Clegg 1990.

Keywords: possum control, possum assessment, aerial poisoning, Waipapa, podocarp fruiting - effects, 1080

166. Mardon, A. 1990: A predator control programme mounted to protect the contents of North Island kokako nests, Pikiariki Ecological Area 1989-90. - Department of Conservation (unpublished report). - Hamilton. 12 p. This programme was carried out from October to March, targeting ship rats, mustelids and feral cats within three known kokako territories in the modified podocarp forest of the Pikiariki Ecological Area. The object was to reduce predators (particularly ship rats) during the kokako breeding season. Talon was placed in bait tunnels for ship rats and Fenn traps were set for mustelids. The high number of rat baits taken initially and comparison with data from Mapara Forest, together with results of snap trapping rats in one kokako territory, and a control area at the close of the control operation, indicated that rat numbers were substantially reduced within the kokako territories for the period of the project. The Fenn traps caught 5 stoats and 2 ferrets while four feral cats were shot but none trapped. Details are given of kokako behaviour while following three pairs. Despite some signs of nesting, no nests were found. In September 1990, roll calls contacted all 11 birds identified as present in the 1989 survey (down from 31 birds in 1981). Improvements to techniques are suggested.  
Keywords: kokako, kokako - nesting, predator control, Pikiariki Ecological Area
167. Marsh, S.L. 1996: Kokako monitoring through an aerial 1080 carrot operation, Pureora Forest 1996. - Department of Conservation, Waikato Conservancy (unpublished report). - Hamilton. 22 p. Thirty four kokako were monitored before and after a possum control operation using aeriually-applied 1080 screened carrot baits in and adjacent to the western side of Pureora Forest North Block. Monitoring over 1500 ha covered part of the Mangatutu Ecological Area in unlogged rimu/tawa forest and an area of forest called the Tunawaea Block, modified by logging and including part of Pureora Forest Park and the adjacent Cowan Wildlife Refuge. All 34 kokako survived the poison operation until the baits became non-toxic. A strict protocol was applied to roll calls, using kokako dialect tapes to record responses and map location of birds. It was concluded that screened carrot baits are safe for kokako. Three dead North Island robins were found and 2 kereru, probably killed by 1080. A total of 62 kokako were found in the trial areas, including 8 juveniles. Details of roll calls and maps of bird location are given in appendices. The kokako population here was not considered to be in decline. An appendix gives observations on other threatened species - kaka, kakariki, blue duck and kiwi.  
Keywords: kokako - monitoring, aerial poisoning, possum control, Mangatutu Ecological Area, threatened birds, 1080
168. McEwen, W.M. 1978: The food of the New Zealand pigeon (*Hemiphaga novaeseelandiae novaeseelandiae*). - New Zealand Journal of Ecology 1: 99-108. In this study the contents of the alimentary tracts of 144 native pigeons (80% of the total number) shot by poachers and confiscated by the Wildlife Service were from central North Island habitats; observations of plant material taken while feeding provided further data. Samples from gut examinations were seasonally biased as most birds were poached while feeding on miro berries which are ripe from May to August in central North Island forests, including Pureora. Few other foods are eaten while pigeons are feeding on miro with berries and seeds cramming the alimentary tract but observations at Pureora show that tawa berries are a common food in late summer and that podocarp fruits other than miro may be eaten in autumn (particularly kahikatea when fruiting heavily). Succulent berries of species such as fuchsia, wineberry and mahoe are common foods in summer. It appears anomalous that some fruits believed to be eaten frequently by pigeons feature infrequently in lists of published observations, e.g. pigeonwood, hinau and pokaka while totara is

not recorded, though a probable food. The study was undertaken "to try to determine the role of the New Zealand pigeon in the dispersal of seed (from succulent fruits) in indigenous forests of central North Island". In a discussion on seed dispersal and food habits the concentration of pigeons where there is an abundance of food, and seasonal migrations are referred to, also the dropping of seed from perching trees of both large hardwoods and podocarps with important consequences for the regeneration of mixed podocarp/hardwood forests. In seral shrubland, native pigeons have a role in distributing tawa, miro and other podocarps when attracted by berry-producing shrubs of the earlier successional phase. See also Beveridge 1964, 1973.

Keywords: New Zealand pigeon - diet, New Zealand pigeon - feeding habits, seed dispersal

169. McKelvey, P.J. 1953: Forest colonisation after recent volcanicity at West Taupo. - *New Zealand Journal of Forestry* 6(5): 435-48.  
This early descriptive account of the development and pattern of West Taupo forests in relation to soils formed by the tephra of the Taupo eruption has stimulated much discussion about the origin and nature of the podocarp and podocarp/hardwood forests flanking the Hauhungaroa Range. [The ideas presented on forest colonisation were later expanded in the more comprehensive account of the West Taupo forests in McKelvey 1963.] The paper outlines the topography and geology of the West Taupo tract in the study area which extends from Mount Titiraupenga in the north to the southern eruptive centre south-west of Lake Taupo and includes much of the area covered by the present Pureora Forest Park. Forest associations based on altitude, podocarp stocking and the presence or absence of significant hardwood elements are described and shown in a map. Vegetation around swampy clearings and at the forest edge is described and anomalies in post-eruption colonisation are discussed.  
Keywords: forest colonisation, volcanicity, Taupo eruption, forest types, forest pattern, West Taupo, Hauhungaroa Range
170. McKelvey, P.J. 1959: Animal damage in North Island protection forests. - *New Zealand Science Review* 17(2): 28-34.  
The consequences of different degrees of browsing damage and threats to the health and stability of forest and soils are discussed. Protection forests of the Rangitoto and Hauhungaroa ranges are classed as important to keep in good condition as they carry podocarp/hardwood forests, even if over 3000 ft a.s.l. (920m) and hold the headwaters of the Waikato, Waipa and Wanganui Rivers. At the time of writing this paper, these central North Island forests were only lightly depleted by animals north of the Wanganui River with red deer, a recent arrival, dispersed throughout the forest tract and adding to the former impact of wild cattle. In the northern part the shrub tier had been only lightly reduced and still contained a high proportion of palatables while the forest floor was intact. This situation contrasted with that in some valley sides in the upper catchment of the Wanganui River where shrub hardwoods were dead and being replaced by a dense growth of unpalatables with no forest-floor covering.  
Keywords: animal impact, Rangitoto-Hauhungaroa Ranges, headwater protection, red deer, cattle - feral

171. McKelvey, P.J. 1963: The synecology of the West Taupo indigenous forest. - New Zealand Forest Service Bulletin 14: 126p, 12 maps.  
A first comprehensive and seminal ecological account of the West Taupo forests based on data collected by the National Forest Survey of 1946 to 1955. The area surveyed includes the present Pureora Forest Park. The bulletin covers the composition and pattern of the forests with a detailed description of the forest types. The historical development of the forest in relation to volcanicity - the Taupo eruption of 130 AD - is discussed and the hypothesis is presented that the dense podocarps nearest Lake Taupo are the youngest forests and represent a pioneering stage in the centripetal (towards Lake Taupo) colonisation of the sterile pumice surface which followed the eruption. There is a transition of forest types away from Lake Taupo with 'diminishing prominence of podocarps, then increasing prominence of hardwoods, particularly of tawa'. The influences of geology, soils, climate, fire, man and introduced mammals are discussed. The bulletin is accompanied by twelve 1:63360 forest type maps showing forest canopy composition as it was c.1952 in Pureora Forest Park and adjacent areas. [Subsequent logging and clearfelling mean that the maps are of considerable historical value.] Discussion of the volcanic succession hypothesis and cyclic regeneration is included in Veale and Innes (1986). Includes 16 photos.  
Keywords: synecology, West Taupo forests, Taupo eruption, volcanic succession hypothesis, podocarps, vegetation maps - West Taupo
172. McKelvey, P.J. 1986: Future research perspectives, p. 54-57. - In: Veale, B. & Innes, J. (eds.), Ecological research in the central North Island Volcanic Plateau region. Proceedings of a New Zealand Forest Service workshop, Pureora - New Zealand Forest Service, Forest Research Institute, Rotorua.  
The author suggests construction of ecosystem models to predict trends. Current succession and trends may be studied by permanent study plots such as the ecological transects (several are located in the Pureora Mountain Ecological Area and Waipapa Ecological Area). The volcanic succession hypothesis is discussed briefly and a model presented for succession in podocarp forest. The dense podocarp stage could consist of more than one generation rather than one colonising first crop. The distribution and behaviour of birds along compositional and environmental gradients should be studied, also the distribution and role of invertebrates.  
Keywords: research perspectives, forest pattern, vegetation trends, volcanic succession hypothesis
173. McPherson, S.J. 1973: Technical Report: Pikiariki Ecological Area Road Block, Pureora Forest. - New Zealand Forest Service (unpublished report). - Auckland.  
  
Keywords: Pikiariki Ecological Area
174. Meenken, D., Fechny, T. & Innes, J.G. 1994: Population size and breeding success of North Island kokako in the Waipapa Ecological Area, Pureora Forest Park. - Notornis 41: 109-115.  
This paper describes walk-through surveys along transect lines and territory mapping over 1300 ha of the Waipapa Ecological Area. The surveys were done from January to March 1991, including the later part of the kokako breeding season. Thirty four territories were located with 17 containing a pair of birds. Four pairs (23%) fledged a total of seven juveniles. These results 'suggest that there has been a decline of up to 60% in kokako density in the Waipapa Ecological Area since the previous survey in 1980-81'. Active management is prescribed as tested in the central North Island forests of Mapara and Kaharoa where fledging of young is much higher (50% and 85% respectively) after reduction of mammal pests.

Keywords: kokako - populations, Pureora, kokako - monitoring, kokako - decline, Waipapa Ecological Area, kokako - breeding, kokako - management

175. Molloy, G.J., Rockell, J.D. & Ure, J. 1978: Introduction to the State Forests of the Rangitoto and Hauhungaroa Ranges, p. (no continuous pagination). - In: New Zealand Forest Service (ed.), Management proposals for State Forests of the Rangitoto and Hauhungaroa Ranges, Central North Island, Taupo, 28-30 March 1978. - Transcript of proceedings - New Zealand Forest Service, Wellington.  
The Conservators of Forests for Auckland, Wellington and Rotorua briefly describe the State Forests within their conservancies and outline their past management, mainly the history of logging the indigenous forest. In Pureora Forest (Auckland) logging of podocarps started in 1945 with planting of exotic species on cleared indigenous forest sites. Clearfelling and conversion to exotics ceased in North Pureora in the Okahukura Valley in 1975, to be replaced by partial logging. In the south block the last clearfelling and conversion was done near Pikiariki Ecological Area in September 1977. The Wellington statement covers Taringamotu and Waituhi Forests while the Rotorua statement covers Tihoi Forest, containing the Waihaha Block where the forest south of the Waihora River remained as virgin forest, though classed as 'a long term timber reserve'. An appendix to the Auckland account gives a 'Background to the King Country Land Use Study' following a proposal [subsequently withdrawn] by NZ Forest Products to convert 31,000 hectares of cutover indigenous State Forest to exotics on the western side of the Hauhungaroa Range.  
Keywords: logging history, forest management Pureora, partial logging, King Country land use study, indigenous forest - clearing
176. Moynihan, K.T. 1986: Wildlife and sites of special wildlife interest in the Western Waikato region. - Indigenous Wildlife, Fauna Survey Unit, New Zealand Wildlife Service, Department of Internal Affairs 41 - Wellington. 100 p.  
Most of this report covers an area to the north and west of Pureora Forest Park but it includes the ecological districts of Ranginui and Pureora on the western Volcanic Plateau. Three sites of 'special wildlife interest' are identified in the northern part of the park and their vegetation and wildlife features are described (pp 23-25 and Appendix I). These sites are Pureora Mountain and the Rangitoto-Pureora Forest Block (including the Pikiariki Ecological Area). Recommendations of the Wildlife Service for a biosphere reserve centred on Pureora Forest Park and extension of ecological areas. (See Imboden 1978). Includes appendices.  
Keywords: wildlife values - Pureora
177. Murphy, B. 1984: Pikiariki Ecological Area, its pattern, processes and management. - BForSc thesis, University of Canterbury.  
A detailed account is given of this 457 ha ecological area, including a site description, soils, forest types, birdlife, predators and environmental hazards that include wind damage and fire. The Easter storm of 1982 resulted in 138 podocarp windfalls in a selectively-logged part. An historical background is given that includes logging in and near the ecological area and its establishment in 1978 in the face of pressures to continue logging while environmentalists emphasised its value as an outstanding wildlife habitat, particularly for kokako which have been central to management activities. Kokako populations have been surveyed and predators trapped. The extent, shape and design of the reserve are deficient and it is concluded that the forest (dominated by podocarps) and birdlife are in an unstable condition. Management measures suggested include planting of indigenous species round margins exposed by clear felling up to 1978. Hazards to birdlife include rats, stoats and browsing mammals with possums having a critical



role. [Restoration planting with indigenous shrubs and trees was done by group planting on cleared margins in 1981 - 1983 by the NZ Forest Service and planting by the Native Forest Restoration Trust was done in the same period beneath gaps in *Pinus nigra* plantations north of the Pikiariki shrub ecotone, See New Zealand Native Forest Restoration Trust 1981). Includes 83 references, appendices 35p, 13 colour photos, maps of vegetation pattern. Keywords: Pikiariki Ecological Area, forest pattern, forest management, wildlife, predators, predator control, kokako, hazards - environmental, windfall

178. Native Forests Action Council (New Zealand) 1977: The podocarp rainforests of Pureora, an outstanding wildlife habitat. Submissions to the Minister of Forests, Minister for the Environment, Minister of Internal Affairs on proposed wildlife sanctuary. - Educational and Research Centre, Native Forests Action Council - Nelson. 55 p. This report presents the case for immediate cessation of logging at Pikiariki and 'as soon as possible' in Pureora State Forest. Enlargement of the proposed Waipapa Reserve is strongly urged. The high indigenous wildlife value of the remaining podocarp forest is emphasised, particularly in areas that still support good populations of kokako and other threatened species. The situation is described in 1977 at a time when there were long-term commitments to sawmillers for timber from Pureora State Forest and an area containing large totara at Pikiariki was still being partially logged, following clearance and burning of adjacent forest. (For subsequent events see Hay 1981).  
Keywords: podocarp forest - Pureora, reservation - Pureora, logging cessation, wildlife values - Pureora
179. Nature Conservation Council 1978: West Taupo Forest Seminar - management for State Forests of the Rangitoto and Hauhungaroa Ranges, Central North Island. - Newsletter Nature Conservation Council 27: 1-4.  
Gives an appraisal of conservation issues raised at the seminar and full support for the recommendations of the Wildlife Service (see Imboden 1978).  
Keywords: Taupo Seminar, conservation values
180. New Zealand Commission for the Environment 1975: Environmental Impact Audit: NZ Forest Products Ltd - reforestation proposals in the King Country. - New Zealand Commission for the Environment - Wellington. 16 p.  
The main impact of NZ Forest Products proposals that are relevant to the forests later included in Pureora Forest Park would apply to Hurakia Forest on the western flanks of the Hauhungaroa Range. The proposals include conversion to exotic plantations of 31,000 ha of indigenous cutover forest, including part of Hurakia Forest. The Commission includes as an appendix to their report the 'NZ Wildlife Service Fauna Survey Unit Report on Hurakia Forest State Forest 97" of 5 May 1975. Includes 3 appendices. See also Crook 1975.  
Keywords: environmental impact audit, King Country land use, conversion to exotics

181. New Zealand Department of Lands and Survey 1978: King Country Land Use Study: Final report. - Land Use Series No. 4. - New Zealand Department of Lands and Survey, Wellington.  
A summary of information from an extensive inter-departmental study to aid regional land-use planning, carried out 'as land-use conflicts were developing and initial environmental auditing had been undertaken'. The study region includes part of Pureora Forest Park and adjacent areas to the west. Wildlife maps are in the series NZMS 288. Includes technical reports on wildlife and botanical features: See Best and Pike 1977 (outlining the origin and purpose of the King Country Land Use Study) and Johnson 1977.  
Keywords: King Country East, land use, environmental values
182. New Zealand Forest Products 1975: Environmental Impact Report: reforestation proposals in the King Country. - New Zealand Forest Products -Auckland. 135 p.  
The proposal to plant *Pinus radiata* on 80,000 ha of land, much of it termed 'virtually derelict' is outlined in an appendix to this report (pp 126-130). Broad vegetation types for the area west of the crest of the Hauhungaroa Range are shown in a colour map (No 1) and include types classed as scrub, cutover bush, virgin bush and proposed reserves within State Forests, notably Hurakia, now within Pureora Forest Park. The proposals include conversion of some 17,000 ha of State Forest and Crown land, much of it logged since the 1920s for podocarps, often leaving a tawa canopy. At this time most tawa from cleared land was used for pulpwood by NZ Forest Products. The text consists mainly of descriptions, intentions and correspondence on consultations with potentially interested organisations (pp39 -105). The New Zealand Forest Service outlines the history of logging in the State Forests included in proposals. The views of those concerned with conservation include the Nature Conservation Council, indicating high bird populations in the cutover forest; the Wildlife Service of the Department of Internal Affairs, pointing out that surveys of the State Forests by the Fauna Survey Unit had shown large populations of blue duck in several streams of Hurakia Forest, extensive areas of regenerating podocarp forest supporting high densities of kaka and parakeets, and kiwis in various forests of the King Country; the Department of Scientific and Industrial Research, giving substantial accounts of geology and soils (pp 90-96) and brief notes on the biology of the area where little scientific research had been done.  
[Vigorous opposition to clearing of cutover indigenous forest was expressed by the Native Forest Action Council - see Anon 1975; also annotations for New Zealand Forest Service 1975 for a different evaluation of the cutover State Forests].  
Keywords: land clearing, conversion to exotics, wildlife values, cutover forest, Hurakia Forest, King Country, land use
183. New Zealand Forest Service 1975: Environmental assessment for State Forests in the South East King Country. - New Zealand Forest Service - Wellington. 21 p.  
The assessment covers Hurakia and Taringamotu Forests and was written in response to a report by NZ Forest Products ( see New Zealand Forest Products 1975) which involved clearing of logged forest and conversion to exotics over part of Hurakia Forest. Although this Forest Service report envisaged further wood production from Hurakia Forest the provisions of a new New Zealand Forest Policy (published 1977) were taken into account and much of the descriptive material is based on a survey of trees and regeneration using plots of 0.01 ha; these descriptions, particularly those of broad vegetation cover types, given in an Appendix, are still relevant and useful for understanding a forest about which little had been known. The forest was zoned using a sieve-planning exercise and the survey results and zones are shown in six maps. The cutover or logged forest consisted of an

open or closed tawa canopy and some areas of dense podocarp regeneration, all types reflecting the different densities of podocarp trees in the original forest from which most of the merchantable podocarps had been logged (since the 1920s), leaving tawa. The areas of dense podocarp regeneration with poles of rimu, totara, miro and tanekaha, resulted from burning after logging of dense podocarp forest, especially north of the Maramataha Stream, often developing beneath a nurse canopy of manuka, lancewood, kamahi and other hardwoods which also fringe extensive clearings of grass, blackberry and bracken fern. See Crook 1975 for a survey of birdlife in Hurakia Forest. Includes 2 appendices, 6 foldout maps.

Keywords: environmental assessment, King Country East, tawa, podocarp regeneration, podocarp regeneration survey

184. New Zealand Forest Service 1977: Management policy for New Zealand's Indigenous State Forests. - New Zealand Forest Service, Wellington.

This revised policy provides for further timber production from some North Island podocarp forests, including some of the West Taupo forests zoned as 'periodic-yield areas' or 'partial logging areas'. An aerial colour photo is shown of an experimental selection logging area and surrounds in Tihoi Forest on the eastern side of Pureora Forest Park. [All logging of indigenous forest in the Park ceased in 1983].

Keywords: forest management policy, selective logging

185. New Zealand Forest Service (ed.) 1978 a: Management proposals for State Forests of the Rangitoto and Hauhungaroa Ranges, Central North Island, Taupo, 28-30 March . - Papers presented. - New Zealand Forest Service, Wellington.

This is one of three large volumes resulting from the Taupo seminar where the future management of these forests was discussed. The establishment of Pureora Forest Park was announced by the Minister of Forests at the conclusion of the seminar and all logging in the park ceased by 1983. This volume contains the 16 papers presented at the seminar, six of which are annotated in this bibliography (refer to New Zealand Forest Service 1978 b). Also annotated are the transcript of the proceedings (New Zealand Forest Service 1978 b) , a summary of submissions presented to the Minister of Forests following the seminar (New Zealand Forest Service 1978 c) , and the King Country Regional Management Plan, 1983-1993 (New Zealand Forest Service 1984) which covers implementation of policy and management resulting from the seminar.

Keywords: management proposals, Rangitoto-Hauhungaroa Ranges, Taupo Seminar

186. New Zealand Forest Service 1978 b: Management proposals for State Forests of the Rangitoto and Hauhungaroa Ranges, Central North Island, Taupo, 28-30 March 1978. - Transcript of proceedings. - New Zealand Forest Service, Wellington.

This transcript covers presentation and discussion of all papers presented at the seminar, preceded by an introduction by the three forest conservators, responsible for administration of 85,000 ha of State Forests under consideration and ending in a 13 page summing up of the proceedings by A. Kirkland. An historic background is given for the various forests with dates for starting of logging (from 1920s), Forest Service clearfelling and conversion to exotics (1949-1978 in Pureora Forest) and partial logging (from 1975). Kirkland represented the NZ Forest Service view of management proposals which reflected the Government's revised 1975 policy for indigenous forests (published 1977 - New Zealand Forest Service). About two thirds of the forest was zoned for reservation of various kinds and one third was to be modified by continued indigenous timber production through selective logging. Of the papers presented, the following are annotated separately in this bibliography:

Beveridge & Herbert 1978; Field & Robinson 1978; Herbert 1978 a; Imboden 1978; Nicholls 1978. See also a summary of submissions to the seminar (New Zealand Forest Service 1978 c) and a third volume on management proposals (New Zealand Forest Service 1978 a).  
Keywords: management proposals, Rangitoto-Hauhungaroa Ranges, Taupo Seminar - transcript

187. New Zealand Forest Service 1978 c: Submissions on the West Taupo State Forests. - New Zealand Forest Service - Wellington. 67 p.  
A summary of the submissions presented to the Minister of Forests following the seminar on "Management proposals for State Forests of the Rangitoto and Hauhungaroa Ranges, central North Island", held at Taupo, 28-30 March 1978 (New Zealand Forest Service, 1978 a, b). Submissions were received from a wide range of interested groups and individuals, both against or in support of continued logging. Amongst major submissions wanting cessation of all logging over a short period are those from the Native Forest Action Council and the Waihaha Forest Preservation Committee, both of which are annotated in this bibliography.  
Keywords: management proposals, Rangitoto-Hauhungaroa Ranges, Taupo Seminar - submissions
188. New Zealand Forest Service 1978 d: Central North Island indigenous forest policy. - New Zealand Forest Service, Wellington.  
This policy, announced by the Minister of Forests on 7 August 1978, refers mainly to the West Taupo forests and Pureora Forest, these forests with all the State Forests of the Hauhungaroa and Rangitoto Ranges being included in the Pureora State Forest Park. A 3 year moratorium on logging in the North Block of Pureora to allow studies of the kokako, and the Waihaha Forest south of the Waihora Stream was to end in 1981 when the policy would be reconsidered. The level of logging was to be greatly reduced during the moratorium. Background information was supplied for central North Island forests in general and for the West Taupo forests in particular. Following a seminar on the forests of the Rangitoto and Hauhungaroa Ranges, held in Taupo in March 1978 (New Zealand Forest Service 1978 b), the Minister invited submissions on the management proposals (New Zealand Forest Service 1978 c). [Subsequently all logging in Pureora Forest Park ceased in 1983 with the last partial-logging operation in the Waihora catchment].  
Keywords: indigenous forest policy, Taupo Seminar
189. New Zealand Forest Service 1979: Pureora State Forest Park management plan (draft) April 1 1980 - March 31 1990. - New Zealand Forest Service, Auckland Conservancy, Auckland.  
This draft plan was written at a time when there was much uncertainty about the direction of forest policy and management and soon after the establishment of Pureora Forest Park. Thus many of the management prescriptions soon became obsolete and no final plan was produced. The plan incorporated provisions of a revised policy for indigenous forests (New Zealand Forest Service 1977) and logging of indigenous forest continued on a very small scale until it ceased in 1983 with recognition of the outstanding wildlife values of some areas of the park. There are outlines of physical, biological and historical aspects and an account of recreation and amenity values. Appendix 4 contains descriptions of ten proposed ecological areas. Includes 11 appendices, 6 maps.  
Keywords: Pureora Forest Park - management plan
190. New Zealand Forest Service 1980: Regional management plan for Taupo State Forests 1979-1989. - New Zealand Forest Service (Rotorua Conservancy), Wellington.

This plan was written at the time of a moratorium on logging of indigenous forest, except for a small area of podocarp forest to be partially logged in the Waihora catchment. The western boundary of the region was then the crest of the Hauhungaroa Range, including Tihoi State Forest, containing the Waihaha Block. Plan prescriptions had to take note of the new policy for indigenous forests (New Zealand Forest Service 1977) so there were proposals for ecological areas. In the late 1970s kokako were present in the northern part of Tihoi forest (Kakaho catchment) in dense podocarp forest (p38)\* Red deer were present in very high numbers in less accessible parts of the Waihaha Block (p41, p60 and map 10 showing deer density in Tihoi Forest 1979). Possums required most effort in animal control, especially in the Tihoi area where they were spreading bovine Tb; control was mainly done by commercial trappers.

\* [Kokako were observed in 1975 in and near the control block of the selective logging trial in dense podocarp forest.]

Keywords: management plan, Taupo, Tihoi Forest

191. New Zealand Forest Service 1981: Pureora Recreational Hunting Area: wild animal control plan. - New Zealand Forest Service (Auckland Conservancy) - Auckland. 49 p.

This plan prescribes management of recreational hunting for control of red deer and pigs in a recreational hunting area of 18,700 ha that comprises the North Block of Pureora Forest Park on the eastern side of the Rangitoto Range. The history of wild animal introduction and spread is outlined and descriptions are given of the land resource, forests, vegetation condition and deer herd condition. This review draws on reports annotated separately in this bibliography (Dale, 1975; New Zealand Department of Lands and Survey 1978; see also Jane 1979, New Zealand Forest Service 1980, Deuss 1981). Pig hunting with dogs is permitted but it is noted that special measures for animal control may be required for the Mangatutu and Waipapa Ecological Areas included in the RHA. Written at the time of a moratorium on logging indigenous forest, about half the RHA was zoned for timber production but logging soon ceased. The report notes that the Wildlife Service described the forests of this area as being the most important habitat for indigenous forest communities in the North Island. The relative densities of deer, possums and goats are shown in maps of the appendices, and their distribution in 1980. Includes 8 maps.

Keywords: wild animal control, recreational hunting, red deer density, possum density, goat density, Mangatutu, Waipapa

192. New Zealand Forest Service 1982: The broad forest pattern - The North Island kokako - the podocarps - Pureora summit tracks - recreation - totara track - wildlife. - New Zealand Forest Service (Auckland Conservancy), Auckland.

Pureora Forest Park brochure.

Keywords: Pureora Forest Park

193. New Zealand Forest Service 1984: King Country regional management plan: 1983-1993. - New Zealand Forest Service, Auckland Conservancy, Auckland.
- Although this plan could not be fully implemented before the demise of the New Zealand Forest Service in 1987, it provides a useful historical overview of changing policies and events up to 1984. Some 50% of the text and appendices refer to indigenous forest matters other than timber production and much of the material applies to Pureora Forest Park, created in 1978 following the Taupo seminar on 'Management Proposals for State Forests of the Rangitoto and Hauhungaroa Ranges, Central North Island'. See annotations in this bibliography for a transcript of proceedings, and submissions to the Minister of Forests (New Zealand Forest Service 1978 a, 1978 b, 1978 c), also new indigenous forest policies for management of central North Island forests (New Zealand Forest Service 1977). Pureora Forest Park included six former State Forests (Pureora, Hurakia, Tihoi and Crown land, Wharepuhunga, Taringamotu and Waituhi) and at time of writing was 80,313 ha in area. A foldout map (No 3) shows zonation into protection, production and recreation zones with the location of 13 gazetted and proposed ecological areas in the park containing all the areas of virgin forest. Proposed ecological areas are described in an appendix (pp 88-92) and a further appendix (pp 93-97) contains an account by the Scientific Co-ordinating Committee of 'uses acceptable for ecological areas'. An 'Indigenous Re-establishment Work Plan' for Pureora Forest Park, 1982-1987 (Appendix pages 124-135) contains ambitious planting proposals for specified cutover and partially-logged sites and the procedures and principles outlined are still relevant. Work carried out during the period 1978-1980 is outlined and research referred to. Plantings of podocarps were made in the Waipa catchment of Pureora North Block (sample plot A710 with data held at the Forest Research Institute), Okahukura Basin of the North Block and in two clear-felled areas near Pikiariki Ecological Area (sample plot A810) covering 70 ha. [The latter plantings, inspected in 1998, were mainly successful but remain to be adequately assessed]. Includes maps, 48 references.
- Keywords: management plan - regional, King Country, Rangitoto-Hauhungaroa Ranges, Ecological Areas
194. New Zealand Geological Survey 1960: Geological map of New Zealand, Sheet 8, Taupo, scale 1:250,000. - Department of Scientific and Industrial Research, Wellington.
- Keywords: geological map, Taupo
195. New Zealand Native Forest Restoration Trust 1981: Pureora Forest Indigenous Restoration Trials, Pikiariki Ecological Area. - New Zealand Native Forest Restoration Trust (unpublished report typescript). - Auckland. 15 p.
- Mainly proposals for planting native species to restore podocarp forest on part of the 380 ha area where podocarp forest was cleared and burnt in 1977 following logging. Trials and operational planting of podocarps and shrub hardwoods were to be carried out adjacent to the present Pikiariki Ecological Area to protect exposed margins and extend the indigenous forest. By 1980 25 ha had been planted by the New Zealand Forest Service with 14,000 rimu, totara and kahikatea seedlings 2 years after planting of *Eucalyptus delegatensis* intended as a shelterwood. Other plantings of indigenous species were to be made in gaps of thinned *Pinus radiata* plantations and by NFORT in groups of *Pinus nigra* north of the Pikiariki Ecological Area shrub ecotone. Groups of podocarps and shrubs were also planted in regrowth of a cleared area adjacent to Pikiariki Ecological Area on the southern side. The NZ Forest Service plantings are included in Sample Plot A810 with records kept at the Forest Research Institute, Rotorua. [By autumn 1998 groups of

all planted podocarp species were well established in the eucalypt area and bushier specimens with heights of 4 to 6m were starting to bear seed. Eucalypts had unthrifty crowns with dieback symptoms, providing shelter but not suppressing native species.].  
Keywords: restoration planting, podocarp planting trials, Pikiariki Ecological Area

196. New Zealand Native Forest Restoration Trust 1992: *The Living Forests of New Zealand*. - David Bateman Ltd and the New Zealand Forests Restoration Trust, Auckland.  
Pages 98-105 of this well-illustrated book contain a brief account of the remnants of dense podocarp forest with ancient totara in 'Central Pureora', mentioning the efforts of environmentalists to halt logging in 1978. The great ecological value of podocarp forest as a wildlife habitat is emphasised and reference is made to a proposal to restore podocarps to an area of 6000 ha of pine plantations following logging. (See Pureora Forest Restoration Project 1994) These pages include 13 colour photos of the forest at or near Pureora and at Waihora Lagoon, also a photo of kokako feeding its chicks. See also New Zealand Native Forest Restoration Trust 1981 for restoration trials with planting of indigenous species near Pikiariki Ecological Area.  
Keywords: dense podocarp forest, ecological values, wildlife habitat, podocarp forest restoration
197. Nicholls, J.L. 1976: A revised classification of the North Island indigenous forests. - *New Zealand Journal of Forestry* 21(1): 105-132. A schedule of forest classes and forest types is given in a revised classification of the 1957 provisional classification (McKelvey and Nicholls 1957). The prominent tree species and distribution of each class and type are given. Forest types in the classes of L (softwoods) and M (rimu-matai-hardwoods) are well represented on the Hauhungaroa Range and eastern King Country with some types in class G (highland softwoods-hardwoods) and areas of Class N (tawa), the result of removal of podocarps by logging, fire and gales.  
Keywords: forest types, forest classes, Hauhungaroa Range
198. Nicholls, J.L. 1978: Scientific Reserves recommended by the Scientific Co-ordinating Committee, p. (no continuous pagination). - In: New Zealand Forest Service (ed.), *Management proposals for State Forests of the Rangitoto and Hauhungaroa Ranges, Central North Island, Taupo, 28-30 March 1978*. - Transcript of proceedings - New Zealand Forest Service, Wellington.  
There is a description of the geology and landscape of the Rangitoto and Hauhungaroa Ranges and an outline of the general principles for establishment of scientific reserves. The proposals recommended by the Scientific Co-ordinating Committee provide for larger reserves than those previously proposed by the New Zealand Forest Service. Concise accounts of eleven proposed ecological areas are given viz. Mangatutu, Waipapa, Pikiariki, Pureora Mountain, Oruangunga, Rata-nunui, Maramataha, Waimonoa, Waihaha, Nga Morehu and Whenuakura; ten of these are within the boundaries of the present Pureora Forest Park and locations are shown in a map. Appendices contain guidelines for scientific reservation and for management and use of ecological areas.  
Keywords: scientific reserve, Rangitoto-Hauhungaroa Ranges, geology, landscape
199. Nicholls, J.L. 1986: A descriptive view of the central North Island volcanic upland., p. 2-17. - In: Veale, B. & Innes, J. (eds.), *Ecological research in the central North Island Volcanic Plateau region*.

Proceedings of a New Zealand Forest Service workshop, Pureora - New Zealand Forest Service, Forest Research Institute, Rotorua.

This paper introduced the workshop proceedings as one of two keynote addresses and contains sections and maps on geology and landforms, volcanicity over the last 20,000 years (with map of topsoil-forming tephra and geography), forest classes in 1840 and land use 1840-1985 (with map and overlay for 1985 land use). It is concluded that most of the remaining forest will be reserved from logging and clearing and that 'the ecosystems of greatest ecological value should all be distinguished and given special legal status'.

Keywords: volcanic plateau - overview, volcanicity, tephra, vegetation changes, land use

200. Norton, D.A., Herbert, J.W. & Beveridge, A.E. 1988: The ecology of *Dacrydium cupressinum*: a review. - New Zealand Journal of Botany 26: 27-62.

There are numerous extracts and discussions concerning work done on rimu in Pureora Forest Park and this review gives a broad perspective to such studies. Included are accounts of reproductive periodicity, quantity of seedfall, soundness and viability of seed, seed dispersal and destruction, growth rates and seedling ecology. There are discussions of the history and population dynamics of dense podocarp forest and rimu-broad-leaved forest, examining the hypotheses of McKelvey (1963) for West Taupo forests in the light of more recent work. Examples of cyclic regeneration are given for Pureora and Tihoi Forests with the general conclusion (p56) that "rimu, as with several other New Zealand indigenous conifers, is able to maintain itself at a site through some kind of forest cycle".

Keywords: *Dacrydium cupressinum*, ecology, literature review - rimu, podocarp forest

201. Nugent, G., Fraser, K.W. & Sweetapple, P.J. 1997: Comparison of red deer and possum diets and impacts in podocarp-hardwood forest, Waihaha catchment, Pureora Conservation Park. - Science for Conservation 50: 1-61.

The relative impacts of red deer and possums on the vegetation of a podocarp-dominated forest were investigated in a 25 km<sup>2</sup> study area in the headwaters of the Waihaha and Waitaia Streams at altitudes ranging between 650m and 850m a.s.l. The work was carried out between 1990 and 1993 as part of a 5 year study, presenting results before deer and possum control was implemented in the winter of 1994. Animal density was assessed from faecal pellet counts on plots along transects and possums were also trapped. Forest composition and forage availability were determined by overstorey stem density and basal area, litter fall production from litter fall traps and browse tier biomass and edible litterfall by harvesting all potentially edible foliage within 2m of ground level. Four effective deer exclosures were also established. Diet and forage consumption were determined from examining the rumen contents of deer killed by shooting and the stomach contents of poisoned possums. Quantified data are presented by 17 figures and tables in the text and by 10 appendices tabulating measurements by plant species. Deer density was c. 6 deer/km<sup>2</sup> and possum density up to 3 possums/ha. Food preferences of deer and possums are given with seasonal variations and show little overlap in main food items. Broadleaf and lancewood were the two main foods for deer which ate mostly adult tree foliage, much of it as litterfall. Possums relied heavily on fruits in good seasons but crops sometimes failed (1992) and Hall's totara foliage was their main food. Many large trees of Hall's totara were reported to be dead or dying but neither possums nor deer browsed regeneration. In this area, rimu was not eaten by possums or deer and regeneration was common.



There was little browsing of other conifers - matai, miro, *Phyllocladus*. Summaries are given for browsing impact on 22 key woody species. The epiphytic habit of some species aids survival. Kamahi is the only species with foliage important to both possums and deer. Possums and deer consumed about 88 kg and 30 kg of forage/ha/yr., respectively, or 3.3% of total annual foliage production for possum and 1.1% for deer. Because of these low figures it is concluded that major dieback (with the exception of Hall's totara) or changes in abundance of the most common species appear unlikely. Deer have a dominant influence on patterns of regeneration and greater consideration for their control is recommended to protect vegetation biodiversity. Further research needs are assessed. Conceptual models of deer and possum impacts are presented. Includes 32 references.  
Keywords: forest ecology, totara, podocarp forest, possums, red deer, red deer - diet, browse tier, biomass - vegetation, litterfall, Waihaha, Waitaia, possum - diet, browsing damage

203. Ogden, J. & West, C.J. 1981: Annual rings in *Beilschmiedia tawa* (Lauraceae). - *New Zealand Journal of Botany* 19: 397-400.  
In this study cross sections from eight tawa released by selective felling of emergent podocarps in the area of a 1961 management trial (now in the Waipapa Ecological Area) were examined to determine the nature of growth rings delimited by parenchyma bands. It was concluded that the growth rings in these tawa, during 19 years of relatively fast growth since 'release', were annual. A wider study of tawa in the region indicated that annual diameter growth rates of trees over 20 cm diameter at 1.4m height were 1-4mm and that trees over 30 cm diameter are over 100 years old. Growth of tawa seedlings is very slow and much of the 'advance growth' accumulated on the forest floor is 60-80 years old. Maximum longevity of tawa trees is probably in the range of 300-400 years. [A stem section of slow-grown tawa examined by Donaldson and Smale (unpublished report) showed indistinct rings that could not be correlated with annual growth]. See also Smale and Kimberley 1981, 1986 for growth rates of tawa.  
Keywords: *Beilschmiedia tawa*, tawa, growth rings
202. O'Loughlin, C.L. 1978: Hydrology of the Hauhungaroa Range State Forests in relation to forest management practices, p. (no continuous pagination). - In: New Zealand Forest Service (ed.), Management proposals for State Forests of the Rangitoto and Hauhungaroa Ranges, Central North Island, Taupo, 28-30 March 1978. - Transcript of proceedings - New Zealand Forest Service, Wellington.  
Keywords: hydrology, Hauhungaroa Range
204. Orwin, J. 1974: Annotated bibliography on the ecology of New Zealand indigenous forest and scrub 1929-1970. - *New Zealand Journal of Botany* 12(1): 45-113.  
This bibliography of 416 items contains only five papers directly relevant to the ecology of West Taupo vegetation, viz. Beveridge (1964), Druce (1952), McKelvey (1953), (1963) and Poole (1950). These items are annotated separately in the present bibliography.  
Keywords: bibliography, indigenous forest, scrub, forest ecology

205. Palmer, J.G. 1986: Buried forest chronology, p. 38. - In: Veale, B. & Innes, J. (eds.), Ecological research in the central North Island Volcanic Plateau region. Proceedings of a New Zealand Forest Service workshop, Pureora - New Zealand Forest Service, Forest Research Institute, Rotorua.  
This abstract reports some early results from a study of tanekaha logs in the buried forest at Pureora. For fuller results see Palmer et al. 1988. The buried forest trees had a slow growth rate and a high mean sensitivity, the latter point being 'encouraging for climate reconstruction' experienced by the buried trees before the Taupo eruption of 1800 BP.  
Keywords: buried forest, Pureora, chronology, tanekaha, Taupo eruption
206. Palmer, J.G., Ogden, J. & Patel, R.N. 1988: A 426 floating tree-ring chronology from *Phyllocladus trichomanoides* buried by the Taupo eruption at Pureora, central North Island, New Zealand. - Journal of the Royal Society of New Zealand 18(4): 407-415.  
A 426-year chronology was developed, based on a study of growth ring patterns in *Phyllocladus trichomanoides* cross sections from logs preserved in a forest buried by pumice of the Taupo eruption. The site of the buried forest near Pureora and its discovery in 1983 are described. Recent work indicates a date of AD 186 for the Taupo eruption rather than the previously quoted AD 131. Owing to uncertainty about the correct date, an arbitrary floating date of zero was used for the eruption year. The chronology from the buried forest trees is compared with chronologies based on living trees at 4 other sites. The correlations between trees from both the buried forest and Waihora lagoon sites (both in Pureora Forest Park) indicate good potential for reconstruction of the climate over the period in which tanekaha trees grew before being buried. Mean ring width of 18 trees from the buried forest was 0.71 mm, indicating a slow growth rate.  
Keywords: dendrochronology, buried forest, *Phyllocladus trichomanoides*, Taupo eruption, Pureora, tanekaha
207. Pardy, G.F. 1981: Assessment of dead and damaged trees thirteen years after selective logging in medium-density podocarp/tawa forest, Pureora Forest. - New Zealand Forest Service, Forest Research Institute Internal Report 15 - Rotorua.  
See Forest Research Institute 1975 b, 1982 a for summary accounts of tree stability.  
Keywords: logging impact, selective logging, podocarp planting trials, tawa forest, Pureora Forest
208. Pardy, G.F. 1982: Post-logging assessment of tree condition, 1961, Pureora selective management trial. - New Zealand Forest Service, Forest Research Institute, Production Forestry Division Project Record 15 (unpublished report). - Rotorua. 22 p.  
This report gives details of tree mortality and health assessments at 14 years and 21 years after all trees (c.1400) in a 45 ha trial area of podocarp/tawa forest were tagged, cruised for volume and mapped in 1959. In 1961 two 15 ha blocks were carefully selectively logged to remove about one third of merchantable volume and a third block was left as an unlogged control. The report is still valuable, not so much for management aspects, but for information on forest composition and stand stability of a previously-widespread forest type for which evidence has accumulated of increasing natural mortality of veteran podocarps. The 1980 assessment, 19 years after logging showed that tree losses in the unlogged control block (at 9%) were slightly greater than in the logged blocks (7 and 8%). Losses in the last period of assessment (1974-1980) showed that there was a marked post-logging increase in the rate of podocarp mortality over the previous period (1961-74). The cause of loss in podocarps was increasingly the snapping of

stems that had marked stem or butt rots, and death of standing trees, rather than uprooting by windthrow of the large root systems. The condition of tree crowns, stems and butts was assessed in 1980, indicating that 70% had healthy crowns and the rest were unthrifty, moribund or dead, often having severe decay in stems or butts. The relatively high rate of tree mortality in the unlogged control block in this forest type contrasts with a much lower mortality in an unlogged block of a dense podocarp forest trial at Tihoi and far greater losses in selectively-logged blocks (see Pardy 1987). See also Forest Research Institute 1975 b, 1982 a, 1982 b, Smale et al. 1987, 1998. Includes tabular data in 14 appendices, location maps.

Keywords: selective logging trial, Pureora, podocarp/tawa forest, logging impact, tree mortality, stand stability

209. Pardy, G.F. 1984: The early impact of selective logging in low density podocarp forest, Tihoi. - New Zealand Forest Service, Forest Research Institute, Production Forestry Division Project Record No. 647 (unpublished report). - Rotorua. 28 p.
- In a selection management trial over 35 ha of low density podocarp forest at 600-650m a.s.l., 51% of the podocarp volume was removed. Owing to the scattered distribution of large emergent podocarps 85% of residual trees received no direct damage from logging and none was severely damaged [This trial is one of five selection management trials carried out in central North Island forests to test alternatives to the clear felling of indigenous forests, practised generally until 1975 and at Pureora to 1978 (Pikiariki area). As all logging in North Island State Forests ceased in 1984, the value of this trial is the insight gained into the structure and stability of a forest type where the old, emergent podocarps are being replaced by pole-sized regeneration which should lead to a further stand of mixed dense podocarps, with rimu replacing senescent matai. The broad results of this trial and the other four selection management trials are reviewed by Smale et al. 19981. The forest of the trial area had 14.5 podocarp trees/ha, mainly large, deep-crowned rimu, emergent over frequent hinau (7.5 trees/ha) and a few tawa, maire and other hardwood trees. The whole area had an abundance of mixed podocarp regeneration with rimu, Hall's totara, miro and tanekaha being the most common species and occurring in all tiers from seedlings to poles. A survey of podocarp regeneration before logging showed 280 stems/ha between 1-30 cm dbh. Tables give forest composition by tree and regeneration species, also assessments of tree condition at 2 years and 6 years after logging and the numbers of tree losses by windfall or standing death. All 650 trees were tagged and measured and crown condition assessed; 32 of the 52 trees that died in the 6 year period were 'culls' - trees with stem or butt rots or other defects. Half of all trees lost died standing. Tree losses in 6 unlogged blocks were only slightly lower than in the 29 logged blocks (0.2 trees/ha/yr. vs. 0.3 trees/ha/yr. respectively).
- Keywords: selective logging trial, Tihoi Forest, podocarps - scattered, regeneration, forest cycles, logging impact, tree mortality, forest composition
210. Pardy, G.F. 1987: The early impact of selective logging in dense podocarp forest, Tihoi. - New Zealand Forest Service, Forest Research Institute, Forest Health and Improvement Division Project Record No. 1573 (unpublished report). - Rotorua. 22 p.
- This report records the changes in composition and structure of a dense, rimu-dominant podocarp stand, occurring over a period of eight years (1975-83) after selective logging of two blocks and retention of an unlogged control block. The total trial area, including unlogged buffers, covered 44 ha and in the three experimental blocks (36 ha) all trees over 30 cm dbh were tagged, mapped and measured for diameter and assessed for timber volume (cruised). Trees with measurable wood volume were classed as 'merchantable' whilst those with obvious defects (usually stem and butt rots)

were classed as 'culls'. Results here refer to podocarps only although the report refers to both podocarps and hardwoods. Natural losses of podocarps in the unlogged control with 553 merchantable trees and 133 'culls' (58% of matai) amounted to only 7 and 5 trees respectively after 8 years (1.7%). In the two blocks logged for 30% and 55% of total volume, there were 958 merchantable podocarps and 391 culls remaining after logging; losses after eight years amounted to 15% and 51% respectively. It was concluded that forest structure and stability had been seriously diminished through windthrow by the high levels of logging - the alternative to clear felling at the time of the trial (1974). Further interest in this trial could be held for the development of tagged natural and planted podocarps and the long-term consequence of a logging comparable to the effect of a severe storm [Tihoi Forest was not affected by Cyclone Bernie in 1982). Other annotated papers on this trial are: Herbert and Beveridge 1977, Beveridge and Herbert 1978, Herbert 1980 and Veale 1986. Includes 15 tables, location map.  
Keywords: selective logging trial, logging impact, Tihoi Forest, dense podocarp forest, stand stability, tree mortality

211. Pardy, G.F. 1990: Performance of tanekaha and totara planted in groups beneath poisoned kamahi-dominated scrub (Pureora Forest). - Forest Research Institute, Indigenous Forest Management Group Project Record 2543 - Rotorua. 7 p.  
This report gives growth and survival of totara and tanekaha seedlings 16 years after planting in groups of 25 seedlings (1960) beneath partial canopy gaps of kamahi-dominant ecotone shrubland (between podocarp/tawa high forest and heathland of manuka and monoao) now in Waipapa Ecological Area [At 550m a.s.l. the site is near the upper altitudinal limit for totara (*Podocarpus totara*) and tanekaha but natural regeneration of both species is abundant in manuka with suppressed seedlings on the planting site]. Species associated with 4-6m tall kamahi were lancewood, broadleaf, fivefinger and kohuhu and there was a light ground cover of *Blechnum capense*. Applications of stem-applied arboricides were effective on all canopy species except large kamahi so that irregular gaps were made. Increased light promoted growth of *Blechnum* fern which partly suppressed planted seedlings [Both totara and tanekaha are light-demanding species with totara having a greater light requirement]; planted seedlings had insufficient light over most groups and annual height increment was only 5-13 cm in all but one large gap which enabled tanekaha to have annual height growth of 24 cm. Despite loss of some planted seedlings from pig rooting for fern rhizomes and damage from falling debris, survival of totara and tanekaha after 16 years was c.80%. [Relatively rapid changes in shrubland succession have been observed over 40 years with cohorts of kamahi, manuka, 100-120 year old kanuka and kohuhu dying in the Waipapa Ecological Area and a marked increase in lancewood, often with development of natural podocarp regeneration. Dense pole stands of multi-stemmed kamahi died on some sites in the early 1960s before impact of possums. Other totara and tanekaha plantings in manuka have grown with more vigour in the vicinity of this plot, labelled 4/60 on the location map]. For a study of podocarp regeneration in manuka scrub see Bell 1976, and for ecology of frost flat heathland see Smale 1990 a, 1990 b. Includes locality plans.  
Keywords: tanekaha, totara, planted seedlings - indigenous conifers, seedling survival, growth rate, shrubland ecotone
212. Poole, A.L. 1950 a: The distribution of toatoa. - New Zealand Journal of Forestry 6(2): 145.  
A brief discussion on the southern limit of *Phyllocladus glaucus* and its extension by the frequent occurrence of the species in the Waihora catchment on the eastern slopes of the Hauhungaroa Range at elevations

between 2000 and 2500 ft (615m to 770m) where there are occasional trees up to 60cm diameter. Smaller trees and seedlings occur up to the top of the range at an elevation of 3700 ft (1140m).

[In the Kakaho and Waimonoa catchments there are toatoa pole stands and occasional toatoa trees up to 100 cm diameter. Toatoa occurs commonly at least 12 km further south in the upper Waihaha catchment.].

Keywords: toatoa, *Phyllocladus glaucus*, Waihora, Hauhungaroa Range

213. Poole, A.L. 1950 b: A pocket of silver beech - West Taupo. - New Zealand Journal of Forestry 6(2): 144-145.

The 'curious occurrence' of silver beech on the eastern slopes of the Hauhungaroa Range is described, this range being otherwise mainly covered with podocarp-broad-leaved forest. The pocket of silver beech, 'a few hundred acres in extent', is confined to a valley towards the head of the Waihaha River at an elevation of about 1400 ft (430m) and lies below the podocarp forest where it abuts on *Leptospermum* scrub. The beech mainly forms a pure stand and "has the appearance of being a remnant and of being rapidly invaded by podocarps".

Keywords: silver beech, Waihaha River, Hauhungaroa Range

214. Poole, A.L. 1953: The vegetation. - Proceedings of the New Zealand Ecological Society 1: 13.

A brief discussion of succession back to podocarp forest from tussock and shrubland through slowly advancing narrow ecotones. The suggestion is made, however, that 'rimu forests may have advanced through belts of pioneering vegetation too wide to be termed ecotones' but similar to the pioneering of podocarp forest in induced *Leptospermum* following man-destroyed forest' [See also Druce 1952. These papers mainly refer to the West Taupo region].

Keywords: podocarps, succession, ecotones, rimu, West Taupo, podocarp forest development

215. Poulton, S.S. (ed.) 1986: The kokako *Callaeas cinerea wilsoni*, *Callaeas cinerea cinerea*. A comprehensive bibliography (annotated). - Library School, National Library of New Zealand, Wellington (unpublished).

This (draft?) bibliography up to January 1986 has several references to observations of kokako in Pureora Forest from the classified summarised notes in 'Notornis'. There are annotations for some papers on kokako in central North Island forests and 10 papers that refer specifically to kokako in Pureora Forest, the main area for kokako habitat in the West Taupo region.

In this Pureora bibliography the following papers have been annotated further as they generally indicate a wider scope than that of the kokako bibliography: Crawley (1981); Crook et al. (1971, 1972); Fitzgerald (1984); Harrison and Saunders (1981); Hay (1981, 1984); Imboden (1978); Krzystyniak (1984); Leathwick (1981).

Keywords: kokako - bibliography

216. Pullar, W.A. 1973: Isopachs of tephra, Central North Island, New Zealand. Scale 1:100000. - New Zealand Soil Bureau Map 133/1-7, to accompany New Zealand Soil Survey Report 31, New Zealand Soil Bureau, Department of Scientific and Industrial Research, Wellington

Keywords: tephra

217. Pureora Forest Restoration Project 1994: Report from a Workshop held at Pureora 1-2 March 1994, convened by the Department of Conservation. - Department of Conservation (unpublished report). - Wellington. 18 p.  
The workshop was convened in response to a request from Cabinet for more detail about the New Zealand Native Forests Restoration Trust's proposal to restore indigenous forest to some 5000 ha after logging of exotic forest plantations in Pureora Forest Park. The workshop agreed that the Trust's proposals were achievable and practical and made a number of recommendations that would improve Pureora Forest Park as a habitat for indigenous wildlife with its threatened species. Priority was to be given to the central block of the Park for reestablishment of podocarp forest in areas of exotic plantations. Restoration should be achieved by planting groups of indigenous species in canopy gaps, especially podocarps, to supplement natural regeneration in high priority areas, starting some years in advance of harvesting radiata pine and Douglas fir (details given in an appendix). [While there is a research basis for establishing podocarp groups with and without nurse species, further research would be required to test techniques on new sites. Some work envisaged in this report has been carried out over the past 5 years, e.g., predator control, weed control and monitoring of threatened species but there has been no new work on restoration techniques and no recent evaluation of podocarps successfully established by planting over periods of 20-40 years adjacent to the Waipapa and Pikiariki Ecological Areas]. Includes map.  
Keywords: indigenous forest restoration Pureora, podocarp, group planting
218. Ramsay, G.W. 1986: Mites from the Pureora Buried Forest. - *The Weta* 9(1): 2-3.  
A small sample of the decomposed forest floor litter and humus of the forest buried by the Taupo eruption of 130 AD was searched for arthropod remains which include 6 specimens of five species of oribatid mites. These mites are still extant and probably feed on fungal hyphae in the forest litter; they persist in this situation owing to their hard exoskeletons.  
Keywords: mites - oribatid, buried forest, Pureora
219. Ranum, A. 1994 a: Effect of a 1080 poison operation on the abundance of ship rats (*Rattus rattus*) in the Pikiariki Ecological Area, Pureora Forest Park. - Department of Conservation, Waikato Conservancy (unpublished typescript). - Hamilton. 6 p.  
A poison operation to reduce the number of ship rats during a kokako breeding season was carried out in podocarp forest in a part of Pikiariki Ecological Area. Poison pellets were placed at bait stations along transects from October to December 1993. Post-poisoning monitoring gave figures of 7.5 catches per 100 trap nights in the poisoned area and 43.5 catches per 100 trap nights in the control area. No pre-poisoning monitoring of rat numbers was done and possum or mouse interference may have affected results. The rat population reduction of 83% was lower than the objective of 95%.  
Keywords: Pikiariki Ecological Area, ship rat, predator control, poison baits - 1080, 1080
220. Ranum, A. 1994 b: Survey for North Island kokako (*Callaeas cinerea wilsoni*) in the Pikiariki Ecological Area, Pureora Forest Park. - Held at Department of Conservation, Waikato Conservancy (unpublished typescript). - Hamilton.  
This survey of the declining population of kokako in the 457 ha Pikiariki Ecological Area follows several surveys carried out since 1978, more recently in 1986 and 1990. Predator control operations were carried out in 1990 and 1993. In the current survey (Nov 1993 - Feb 1994), using taped calls, 14

kokako were located but 'due to uncertainties inherent in the survey technique, this may correspond to only eight individual birds. Only 2 pairs were found. Possible errors in the survey are discussed. It is concluded that the kokako population can only be sustained with further predator control before and after the breeding season. The easily-accessible ecological area is often visited by people wanting to see or hear kokako but the reserve of podocarp forest is irregular in shape and prone to windthrow in selectively-logged parts so that the kokako habitat can be diminished.

Keywords: kokako - survey, kokako - decline, kokako - population trends, Pikiariki Ecological Area, predator control

221. Rasch, G., Barnett, T.J. & Speed, H.J. 1986: A survey of at-risk bird species in the Waipa Valley possum control area. - New Zealand Forest Service (unpublished report). - Auckland.

Keywords: threatened birds, Waipa Valley, possum control

222. Rasch, G., Speed, H.J., Bradfield, P. & Buckingham, R. 1986: Report on an experimental drop of 1080 over kokako in the Rangitoto Range. - New Zealand Forest Service (unpublished internal report). - Auckland. Three populations of kokako were carefully monitored before and after an aerial 1080 pollard bait operation to control possums, carried out in winter 1986. The three study areas were within, or near, the western boundary of the north block of Pureora Forest Park, in the upper catchment of the Waipa River. There was a tawa canopy over most of the study areas but podocarps had been logged at different times (in the 1940s and 1950s in Okahukura Forest along the Tunawaea Stream and in the Pureora North Block in the 1970s). The kokako monitoring technique involved territory mapping and roll calling. The territories of 23 kokako were mapped and the presence of these birds was confirmed before and after the poison drops. Twenty two birds were found three weeks after the final poison drop, and it was concluded that one bird was poisoned. A further 7 birds (whose territories were not well known) survived as well, giving a survival rate of 29 out of 30 kokako. The monitoring method is discussed and previous work in Pikiariki Ecological Area and elsewhere is referred to. The location of bird territories in the 3 study areas is shown in a map.

Keywords: kokako - monitoring, aerial poisoning, kokako - survival, possum control, Rangitoto Range, kokako - territories, kokako - hazards, 1080

223. Relph, D. 1991: Caterpillar killer. - New Zealand Geographic Magazine 12: 115-119.

This fungus which invades caterpillars of forest dwelling *Porina* moths is common on Mount Pureora; its life history is described.

Keywords: *Cordyceps robertsii*, vegetable caterpillar, *Porina* moths, Pureora Mountain

224. Rijkse, W.C. 1986 a: Soils of Taupo region: Interim maps and legend. - Department of Scientific and Industrial Research, Soil Bureau Report No RO 1.2 - Rotorua.

Keywords: soils - Taupo Region, maps - Taupo Region

225. Rijkse, W.C. 1986 b: Soil sequences of central North Island, p. 27. - In: Veale, B. & Innes, J. (eds.), Ecological research in the central North Island Volcanic Plateau region. Proceedings of a New Zealand Forest Service workshop, Pureora - New Zealand Forest Service, Forest Research Institute, Rotorua.  
 Taupo pumice is the major parent material of soils in the central North Island and is broadly divided into airfall tephra, flow tephra and water-sorted pumice. There is increasing podzolisation of the soil series and further scope for work in soil/vegetation relationships. See Rijkse 1986, Rijkse and Wilde 1977, and Pullar 1973, also brief accounts of tephra and soils for Waipapa Ecological Area and Pureora Mountain Ecological Areas by Leathwick 1990, 1988.  
 Keywords: soil sequences, Taupo pumice
226. Rijkse, W.C. & Wilde, R.H. 1977: Soil map of the King Country - Sheet 1. Scale 1: 63 360. New Zealand Soil Bureau map 170/1, 1 ed. In: New Zealand Department of Lands and Survey, King Country Land Use Study: Technical information. - New Zealand Department of Lands and Survey, Wellington.  
 Keywords: soils, King Country, land use
227. Royal Forest and Bird Protection Society 1980: Policy for New Zealand's remaining indigenous forest. - Royal Forest and Bird Protection Society of New Zealand, Wellington.  
 This is the society's policy for all New Zealand's indigenous forest and the only specific mention of Pureora is the caption for a photo taken of clearfelled and burnt dense podocarp forest against a background of standing forest, now included in Pikiariki Ecological Area. [Photo taken 1978 one of the last examples of clearfelling and burning virgin indigenous State Forest in the North Island. Main area subsequently planted with radiata pine. Planting trials with podocarp groups and indigenous shrub species were established in regrowth of marginal cleared area adjacent to the podocarp forest in 1980.].  
 Keywords: indigenous forest policy
228. Saunders, A. 1986: Ecological research in the Central North Island - a wildlife officer's viewpoint, p. 30-31. - In: Veale, B. & Innes, J. (eds.), Ecological research in the central North Island Volcanic Plateau region. Proceedings of a New Zealand Forest Service workshop, Pureora - New Zealand Forest Service, Forest Research Institute, Rotorua.  
 The viability of some rare and endangered species such as the New Zealand falcon, blue duck, kaka, kakariki, kiwi and kokako should be assessed and adequate habitat reserved.  
 Keywords: native wildlife research
229. Shaw, C.G.III. 1976: Rust on *Phyllocladus trichomanoides* - the first recorded on a member of the *Podocarpaceae*. - Transactions of the British Mycological Society 67(3): 506-509.  
 A new species of rust fungus (*Caom peltatum*) was found to occur only on cladodes of tanekaha in the Tihoi-Arataki area of Pureora Forest Park. The author concludes that "the presence of a rust on the Podocarpaceae in New Zealand suggests that some re-evaluation of the origins and distribution of coniferous rusts may be necessary.  
 [Note: *Phyllocladus* has also been placed in its own family Phyllocladaceae.].  
 Keywords: rust fungus, tanekaha, *Phyllocladus trichomanoides*, Tihoi Forest



230. Shaw, W.B. 1983: Tropical Cyclones: Determinants of pattern and structure in New Zealand's Indigenous Forests. - *Pacific Science* 37(4): 405-414.  
 This paper deals generally with the frequency and effect of tropical cyclones in New Zealand. Some central North Island forests were substantially damaged by Cyclone Bernie in April 1982 and the storm regime from both tropical cyclones and severe storms of extratropical origin could 'be a major factor in moulding stand composition and structure' in some regions. A map shows the widespread localities of damage to indigenous forest caused by Cyclone Bernie and these include Pureora Forest Park. In discussion it is suggested that 'many tree species may have experienced 50-100 severe storms during their life history' and that forests affected by relatively recent volcanic activity such as the Taupo eruption of 130 AD may have had the imprint of such storms, producing in part, the mosaics of mixed age and species that are a feature of the West Taupo forest. As well as blowdown, senescent trees (such as occur in the podocarp forests) may also suffer a decline in health after storm damage. Gap phase regeneration, as recorded for tropical forests, may also occur in New Zealand forests.  
 Keywords: tropical cyclones, forest pattern, storm damage, forest structure, forest composition, cyclone Bernie, tree senescence
231. Shaw, W.B. 1986 a: Vascular plants of Mangatu Stream ca 550-800m, West Taupo: provisional list. - New Zealand Forest Service, Forest Research Institute FRI 31/6/18/4 (File Note). - Rotorua. 3 p.  
 Keywords: species list - flora, Mangatutu Ecological Area, West Taupo
232. Shaw, W.B. 1986 b: Vascular plants of Waihora Lagoon, ca 640m, West Taupo: provisional list. - New Zealand Forest Service, Forest Research Institute FRI 31/6/18/4 (File note). - Rotorua. 1 p.  
 Keywords: species list - flora, Waihora, West Taupo
233. Smale, M.C. 1982: Vegetative regrowth of *Beilschmiedia tawa* after selective logging at Pureora and Rotoehu. - *New Zealand Journal of Forestry Science* 12(3): 442-447.  
 Just over half the tawa trees felled 21 years earlier in the 1961 selective logging trial at north Pureora were found to have coppiced from the stump. Height growth rates appeared similar to those of natural seedlings in well-lit conditions. Coppice shoots are more likely to develop when subsidiary stems are left at time of logging, but their value is limited by the abundance of well-developed natural regeneration in most tawa-dominant forests. [Small tawa stems, crushed during logging, and windfallen stems also produce coppice shoots, which may be browsed by deer. See Knowles & Beveridge 1982: 38].  
 Keywords: tawa coppice, selective logging trial, Pureora
234. Smale, M.C. 1986: Changes over 24 years in two plots in tawa (*Beilschmiedia tawa*) - dominant forest in Pureora State Forest Park, p. 41. - In: Veale, B. & Innes, J. (eds.), *Ecological research in the central North Island Volcanic Plateau region*. Proceedings of a New Zealand Forest Service workshop, Pureora - New Zealand Forest Service, Forest Research Institute, Rotorua.  
 In two 0.4 ha plots monitored over 24 years in podocarp/tawa forest in Waipapa Ecological Area, canopy podocarp populations declined by 0.5%/year while canopy tawa increased by 2%/year. In the plot dominated by rimu, tawa saplings and poles also increased. Where matai was dominant, however, a decline in tawa saplings and poles suggested that the trend towards increasing tawa prominence in the canopy might be short-

lived, matai - as opposed to rimu - dominance indicating that the site may be less than ideal for tawa.

Keywords: podocarp/tawa forest, dominance trends

235. Smale, M.C. 1990 a: Ecology of *Dracophyllum*-dominant heathland on frost flats at Rangitaiki and north Pureora, central North Island. - *New Zealand Journal of Botany* 28: 225-228.  
The structure, composition, and dynamics of frost flat heathland dominated by monoao (*Dracophyllum subulatum*) in the Taparoa Clearing, Waipapa Ecological Area, where two communities had previously been described and mapped, are discussed. Regeneration 'waves' of monoao occur after disturbance (i.e., fire), and monoao dominance has been maintained by periodic fire. In its absence, reversion to tall forest via early successional forest trees and shrubs is likely on most sites. See also Smale 1990 b.  
Keywords: frost flat heathland, frost flat - ecology, succession, weed invasion
236. Smale, M.C. 1990 b: Ecology and management of frost flat heathland. - *What's New in Forest Research* 187: 1-4.  
One of two study areas was located in the Taparoa Clearing of the Waipapa Ecological Area, Pureora Forest Park, at an altitude of 550m. The frost-prone, infertile shrubland is dominated by monoao (*Dracophyllum subulatum*) which was aged at up to 90 years. The commonest plants of the community are listed. Topography is the main factor controlling vegetation which has developed after fire. Succession to forest is postulated through shrub species and development of conifers, particularly rimu, though monoao may persist in the frostiest hollows. Invasion by adventive weeds is the main threat to the diversity and survival of frost flat heathland. See also Smale 1990 a.  
Keywords: frost flat heathland, ecology, succession, weed invasion
237. Smale, M.C., Bathgate, J.L. & Guest, R. 1986: Current prospects for tawa. - *New Zealand Forestry* 31: 13-18.  
The ecology, silviculture, and management prospects for tawa forest in the middle North Island are reviewed, using data from forests including Pureora Conservation Park [= Pureora Forest Park]. It is concluded that, despite low productivity compared with kauri and beeches, careful application of a selection management system could provide a small sustained yield sufficient for a cottage industry consuming c. 1000 m<sup>3</sup> annually, provided that the timber was sufficiently highly valued.  
Keywords: tawa management prospects
238. Smale, M.C., Beveridge, A.E. & Herbert, J.W. 1998: Selection silviculture trials in North Island native forests: impacts on the residual forest and their implications for sustainable forest management. - *New Zealand Forestry* 43(3): 19-30.  
Three of the five trials discussed lie within Pureora Forest Park, viz. a trial established in 1961 in podocarp/tawa forest of Pureora Forest (the Pouakani block included in the present Waipapa Ecological Area); a trial established in 1975 in dense podocarp forest, Tihoi Forest; a 1976 trial in low density podocarp forest, Tihoi Forest. These trials were established at a time when clearfelling of indigenous forest was still practised, often with conversion to exotic conifers. The objective of the trials was to provide an alternative to destructive logging and leave the old podocarp element in a relatively stable condition while enabling natural regeneration to proceed. This paper reviews results in terms of the impact of logging on the forests, providing insights into stand structure, stability of residual trees, regeneration of the forest types and successional trends after logging. A significant finding was that there was generally net volume decrement in both logged and unlogged forest in these forest types with large podocarps aged mainly from 400-700 years; the senescent element is subject to windfall or standing death. Forest

recovery after harvesting has been documented quantitatively in podocarp/tawa forest at Pureora with thickets of putaputaweta and small-leaved coprosma over dense ferns on compacted sites 24 years later, often with rimu saplings. Less disturbed sites were colonised by wineberry and fuchsia, most wineberry collapsing after 15-20 years and fuchsia succumbing to browsing by invading possums. Rimu and tawa saplings and matai seedlings are now frequent on these sites. After the earlier colonisation of slash by wineberry, fuchsia, pate, five finger, kamahi and ferns, the broad-leaved species in the 1961 Pureora trial mostly succumbed to possums after their arrival nearly a decade later and these sites are now (1998) dominated by tree ferns and ground ferns. See also Forest Research Institute 1975 a, 1975 b, 1976, 1982 a, 1982 b, Pardy 1981, 1984, 1987; Smale et al. 1987. Includes 6 tables, and 50 references.

Keywords: selection silviculture trial - review, podocarp forest, Pureora, Tihoi, logging impact, vegetation regrowth, tree mortality, stand stability, stand structure, regeneration, vegetation trends

239. Smale, M.C., Beveridge, A.E., Pardy, G.F. & Steward, G.A. 1987: Selective logging in podocarp/tawa forest at Pureora and Whirinaki. - *New Zealand Journal of Forestry Science* 17(1): 29-50.  
This annotation is confined to the Pureora trial, now located within the Waipapa Ecological Area. Aspects most relevant for ecological understanding of a once extensive forest type are trends in tree mortality, growth and regeneration in both disturbed and virgin forest. These trends have been assessed in this trial over periods of 19 years in three 15 ha blocks, one an unlogged control and two with one third of their merchantable volume removed by logging in 1961. Natural mortality of merchantable trees was assessed over 19 years at the significantly high rate of 0.4% trees/annum in virgin forest, a higher rate than in the logged forest. Rates of loss would be higher if unmerchantable trees were accounted for. The predominant podocarps, rimu and matai, are mature or senescent and many are predisposed by natural defect to die over several decades with a continued decline in volume increment; a net loss of increment has been recorded in all three trial blocks. Windfall accounted for two-thirds of mortality with snapping of stems being more common than uprooting, and standing death common in rimu. Canopy replacement, plant succession on disturbed ground and regeneration were studied in growth plots and transects. Loss of large emergent podocarps by natural mortality or logging has directly released patches of well-developed tawa advance growth, accelerating the natural canopy replacement process. More severe ground disturbance by logging destroyed limited areas of forest and browsing (initially from deer and later by possums) may have interrupted succession back to high forest, especially through death of kamahi. Ribbons of podocarp regeneration (mainly rimu) have become established along sections of log extraction tracks released or 'nursed' by colonising species, dying wineberry and longer-living putaputaweta. Regeneration sampling showed that, a decade or so after logging, both podocarp and tawa seedlings had reached relatively high prelogging levels with the addition of successful group plantings of podocarps. See also Forest Research Institute 1975 a, 1975 b, 1982 a, Smale et al. 1998.  
Keywords: podocarp / tawa forest, selective logging trial, tree mortality, volume increment, canopy replacement, succession, regeneration, *Beilschmiedia tawa*
240. Smale, M. C. & Kimberley, M. O. 1981: Factors affecting growth of tawa trees in unlogged and selectively logged forest, Pureora. - Forest Research Institute, Indigenous Forest Management Group Report No. 33 - Rotorua.

The diameter growth of 213 tawa trees was assessed over 22 years in the 1961 selective logging trial at north Pureora and related to a variety of site and tree characteristics. Annual diameter growth over all trees was 1.6 mm. Growth was slower on ridges (probably due to exposure), in trees with obviously unhealthy crowns, and in trees in close competition with other tawa or emergent podocarps. Given the patent sensitivity of the species to exposure, canopy disruption should be minimised on exposed sites in any selective harvesting operations.

Keywords: tawa growth, selective logging trial, Pureora

241. Smale, M.C. & Kimberley, M.O. 1986: Growth of naturally-regenerated *Beilschmiedia tawa* and podocarps in unlogged and selectively-logged podocarp/tawa forest, Pureora. - New Zealand Journal of Forestry Science 16(2): 131-141.

Growth rates of seedlings (<2.5 cm dbh) saplings and poles (2.5-30cm dbh) of tawa, rimu and miro assessed in plots over 22 years were similar for each species and were significantly affected by crown class - dominant co-dominant or dominated, reflecting the degree of competition and amount of overhead light. Height growth of seedlings averaged 12-13 cm/annum in dominant and co-dominant plants and 3-6 cm/annum in dominated plants. Diameter growth averaged 2-3.5mm/annum in dominant and co-dominant plants and 1-2mm/annum in dominated plants. Mortality rates of dominated seedlings were c 1%/annum over 22 years for the 3 species which maintain slowly-turning over banks of seedlings in the understorey, surviving on average for c.100 years at Pureora, and capable of responding to opening or thinning of the canopy. Tawa, as the most shade tolerant species, can develop to maturity in the understorey while miro and rimu are more gap dependent. Results are discussed in relation to other experience of these species.

Keywords: podocarps, growth rate, seedling mortality, regeneration, *Beilschmiedia tawa*, Pureora

242. Smale, M.C. & Kimberley, M.O. 1993: Regeneration patterns in montane conifer/broad-leaved forest on Mt Pureora, New Zealand. - New Zealand Journal of Forestry Science 23(2): 123-141.  
Regeneration in montane Hall's totara/kamahahi forest on Mt Pureora, Pureora Mountain Ecological Area, was sampled in the three phases - gap, building, and mature - of the forest growth cycle. Gaps were 12 years old on average, building phases 67 years, and mature phases 227 years. Diameter growth rates were faster during gap and building than mature phases. Replacement strategies of species reflected differing shade tolerances, with relatively intolerant species (e.g., small-leaved coprosmas) being gap invaders and species with intermediate tolerance (e.g., Hall's totara and broadleaf) establishing during the building phase. Alternating conifer-broad-leaved regeneration cycles appear to be operating. No unequivocal disruption of natural replacement processes of major canopy species by introduced mammals is yet evident.

Keywords: regeneration patterns, montane conifer/broad-leaved forest, cyclic regeneration

243. Smuts-Kennedy, C. 1996: Blue duck survey: 2 April 1996: Mangatutu Stream. - Department of Conservation, Waikato Conservancy (File note). - Hamilton. 3 p.  
Following two reports of blue duck seen in the Mangatutu Stream, Mangatutu Ecological Area, Pureora Forest Park, a single morning search was made of part of the stream, using a trained dog. No blue duck were found but feathers were seen in one place. It was concluded that this part of the stream (shown in map) 'supports perhaps the occasional/frequent, single

blue duck, rather than a breeding population'. It is recommended that further surveys be done in early and late summer as part of the current restoration effort in the ecological area.

Keywords: blue duck, Mangatutu Ecological Area

244. Speed, H.J. 1997 a: A survey for kokako in the proposed extension area for the Mangatutu Project. - Department of Conservation, Pureora Field Centre, Waikato Conservancy (unpublished report). - Pureora. 24 p.

Keywords: kokako - survey, Mangatutu

245. Speed, H.J. 1997 b: Mainland island hui, Waipapa: Proceedings, reports and background information. - Department of Conservation, Waikato Conservancy, Hamilton.

At this four day seminar, the work being done by the Waikato and Northland Conservancies of the Department of Conservation was widely discussed, particularly the management of 'mainland islands' and biodiversity. Of the papers presented, talks given and projects described a number of items refer directly to work undertaken in Pureora Park, particularly in the Waipapa and Waihaha Ecological Areas. In a summary of project activities (p11), those listed for Waipapa Ecological Area include possum control and monitoring, five minute bird counts and monitoring of kereru, robins, kokako and reptiles, also vegetation monitoring and weed control, research projects including studies of mustelid control, kaka monitoring and a bat survey. Research and management methods to achieve objectives are outlined. Summaries of talks and project outline comprise the bulk of the text (not paginated) and some early results of studies are given, including the fledging of 9 kaka from 3 nests in the Waipapa Ecological Area, and an indication of the important role that podocarps play in the diet of kaka. Activities over the previous 9 months for the Waipapa restoration project are outlined by Hazel Speed. Intensive management over two years is aimed at reducing rat and possum numbers to assist in more successful breeding of birds and recovery of vegetation. There are monitoring programmes for native plants and animals.

Keywords: seminar - Pureora research programme, Waipapa, Waihaha, mainland island concept, bird monitoring, bird breeding, kaka diet

246. Speed, H.J. & Bancroft, F.J. 1996: Waipapa Restoration Project Annual Report No. 1, October 1995-May 1996. - Department of Conservation, Waikato Conservancy - Hamilton. 88 p.

This project 'was designed as a long-term animal control programme with the objective of providing maximum practicable benefit to species, biological processes, and ecosystems under threat from possums and rats, with minimum risk to these values'. Toxic baits are being used to reduce the possum and rat populations over an area of 2500 ha in the Waipapa Ecological Area with the Waimonoa Ecological Area used as an untreated control. Activities covered include possum control, monitoring of possum and rat populations, monitoring of fruitfall and seed fall in traps placed beneath fuchsia, fivefinger and raukawa and a phenology study of these species and kamahi, mahoe and pate. Breeding of robins, tits, New Zealand pigeon, moreporks and kokako is being monitored. Includes 102 references. Keywords: restoration project - Waipapa, Waipapa Ecological Area, research programme, animal control, possum control, ship rat control, bird breeding

247. Speed, H.J., Bradfield, P., King, D.R., Buckingham, R.P. & Innes, J.G. 1987 a: A survey for kokako (*Callaeas cinerea wilsoni*) in the north-eastern portion of the north block of Pureora State Forest. - New Zealand Forest Service, Forest Research Institute (unpublished report). - Rotorua. 12 p.

The survey located 50 kokako over 14000 hectares of logged and unlogged tawa and podocarp/tawa forest where poison operations to control possums were to be carried out in 1987 and 1988. The study was done from October 1986 to March 1987 through listening and tape playing of kokako mews and song. The area surveyed included both forest in the north of Pureora Forest Park and on adjacent private land. Localised densities of kokako were found in 3 localities, two being in the upper catchment of the Mangatutu Stream. 96% of kokako found were near old, overgrown roads and along river gorges where contributing factors could be a better supply of fruiting shrubs and canopy breaks. The distribution patterns of kokako resulting from this survey are comparable with those of previous surveys in 1971 and 1979. Falcon and kaka observed during the survey were also mapped. See Speed et al. 1987 b.

Keywords: kokako - survey, kokako - populations - Mangatutu, kokako - calls, kokako - territory mapping, kokako - habitat

248. Speed, H.J., Bradfield, P.M., King, D.R., Buckingham, R.P. & Innes, J.G. 1987 b: The monitoring of kokako during a 1080 poison drop in the north-eastern portion of the north block of Pureora State Forest. - Department of Conservation (unpublished report). - Te Kuiti. This report describes the 1987 kokako monitoring programme to determine whether or not any loss of birds could be attributed to a poison drop to control possums, carried on 23 May. Monitoring followed a previous survey to locate areas with suitable numbers of kokako (see Speed et al. 1987 a). Maps show three areas chosen as study areas for monitoring and the territories of 20 kokako monitored. These study areas are all in unlogged 'tawa/broadleaf forest' with a dense canopy and scattered emergent podocarps. Methods of kokako monitoring are described, comprising territory mapping and roll call of birds before and up to the poison drop and following it. No monitored kokako were lost as a result of poisoning. Combined with results of monitoring kokako before and after a 1986 poison drop, 42 kokako were fully monitored and 41 survived. Keywords: kokako - monitoring, kokako - territory mapping, possum control, aerial poisoning, 1080
249. Speed, H.J., King, D.R., Bradfield, P.M. & Buckingham, R.P. 1988: Some observations made during the monitoring of North Island kokako during the 1987 possum control operation in Pureora Forest Park and environs. - Department of Conservation (unpublished report). - Te Kuiti. 14 p. Detailed observations are recorded of the behaviour of adult kokako with juveniles followed for periods between March and July in 13 territories of three study areas in the upper catchment of the Mangatutu Stream, near the northern boundary of the Park. The territories were mapped and contained six singles and seven pairs of kokako. It is suggested that at this time of the year juveniles are mobile and independent'. Three 'encounters' between kokako and raptors are described, involving karearea (NZ falcon) and kahu (Australasian harrier). The raptors approached the kokako but did not press home attacks. Keywords: kokako - behaviour, kokako - territories, kokako - raptors, Mangatutu Stream
250. Speed, H.J. & Marsh, S.L. 1995: A survey for kokako in the Mangatutu Ecological Area, Pureora Forest Park. - Department of Conservation, Waikato Conservancy (unpublished report). - Hamilton. 12 p. A part of the Mangatutu Ecological Area, consisting of virgin podocarp and montane forest, was surveyed for kokako over 4 days in the winter of 1995. The result justified work to control possums and rats in a proposed management area to improve prospects of an increase in the kokako population. Present possum populations were considered to be low, following

regular control by aerial drops of 1080 baits. Three pairs and five single kokako were located with and without the aid of tapes of recorded song. Evidence has been received that there is a higher population of kokako than that recorded in this survey and comparison of results is made with a less intensive survey made in 1987 over a larger area. A number of threatened bird species (listed) have been found in the Mangatutu Ecological Area. Further surveys are recommended and the area may be suitable for release of other endangered species.

Keywords: kokako, survey, Mangatutu Ecological Area, management area, threatened birds, 1080

251. Speed, H.J., Tallentire, K. & Jones, G. 1993: The monitoring of kokako during a 1993 aerial application of 1080 carrot baits in the central North Island. - Department of Conservation (unpublished report). - Hamilton. 17 p.
- Monitoring of kokako was done before and after a 1080 carrot bait operation targeting possums in rimu/tawa forest of the Cowan Wildlife Refuge and Okahukura State Forest. This survey area lies to the west of the north block of Pureora Forest Park in part of the catchment of the Tunawaea Stream that flows from the Mangatutu Ecological Area. Methods and results of this survey are thus comparable with studies in the park. All 10 kokako monitored until 18 days after the poison drop survived but because baits remained toxic for a further four weeks after cessation of roll calls, a strong conclusion on the risk of using the baits is not made. Appendix 2 lists feeding observations on kokako during the July/August survey period. Fruits of tawa, lancewood and toro were commonly eaten amongst a number of other species recorded.
- Keywords: kokako - aerial poisoning, kokako - monitoring, Tunawaea Stream, kokako - diet, 1080
252. Steward, G.A. 1981: Performance of podocarps planted in selectively-logged forest, Pureora. - Forest Research Institute, Indigenous Forest Management Group Report No. 30 (unpublished report). - 11 p.
- Nursery-raised seedlings of totara, rimu and kahikatea were planted in 1961 in a freshly-logged 15 ha block of a management trial area of podocarp/tawa forest now included in the Waipapa Ecological Area. The original aim was to determine whether planting of podocarps with minimum subsequent tending could usefully supplement natural regeneration. Seedlings were planted in 13-tree groups in small canopy gaps, either on ground disturbed by logging or in dense patches of tree ferns killed above ground. Few podocarp seedlings became well established on the tree fern sites owing to smothering by regrowth of *Dicksonia squarrosa* from stumps and stolons. No releasing of planted seedlings was done for the first 15 years after planting. At 10-15 years after planting dense wineberry (that germinated in disturbed humus) overtopping planted podocarps, started to die back and collapse under the weight of indigenous vines (species of *Rubus*, *Parsonsia*, *Clematis* and *Muehlenbeckia*). At first measurement in 1976, planted podocarps partly smothered were tended by cutting vines at the base and making small gaps in the regrowth canopy to allow the emergence of potential 'crop' tree leaders. Released 'crop' trees of totara and kahikatea had comparable growth and survival rates, reaching heights of 4-6m 20 years after planting (based on measurement of an average of 3 of the most vigorous trees per group). Many totara were malformed and bushy from damage caused by insects, frost and climber tangles, while most kahikatea maintained strong leaders. Many of the suppressed planted seedlings of all three species continued to survive. [Inspection of the management block in 1998, 37 years after planting, showed abundant colonisation of main logging tracks and other areas of disturbed ground by rimu, sometimes in dense thickets up to 5m tall with frequent matai seedlings, indicating a natural succession to dense podocarp

forest with rimu dominance. No browsing by possums or deer was observed on any of the three planted species].

Keywords: enrichment planting, totara - planted, kahikatea - planted, rimu - planted, selective logging gaps, podocarp planting

253. Steward, G.A. 1988: Forest Research Institute records on past silvicultural practices in New Zealand native forests. - Forest Research Institute, Indigenous Forest Management Group Project record no. 2084 (unpublished report). - Rotorua. 88 p.  
This report is a catalogue of 11 Forest Research Institute files on indigenous forest with a base number of 28 (for indigenous forest management) covering the period 1954 to 1986. The entries give author, date, title, file reference and Keywords for reports, file notes, letters, diary notes and other reference material, on such topics as seed collection, nursery practice, outplanting, forest restoration and ecology, as well as general silviculture, policy and management issues. Some 90 items refer specifically to forest now included in Pureora Forest Park. Files are held at the Forest Research Institute, Rotorua and photocopies of items may be obtained. Requests should be directed to G A Steward.  
Keywords: silvicultural tending, indigenous species, species descriptions, restoration planting, seed collection, nursery practice
254. Steward, G.A. & Bergin, D.O. 1991: Site preparation and indigenous planting of cutover forest, Pureora Forest Park. - Forest Research Institute, Forest and Wildland Ecosystems Division, Northern Wildlands Project Record 2901 (unpublished report). - Rotorua. 8 p.  
This trial was established in 1984 on a relatively open and harsh site in the Okahukura Basin of the Pureora North block to test the practicality of planting nursery-raised rimu seedlings in reverting forest heavily logged for podocarps and tawa sawlogs up to 1975. If a successful method was found it was to be applied in an extensive forest rehabilitation programme. Soil compaction, dense regrowth and poor drainage made a difficult planting site, so an attempt to improve the site was made by using a bulldozer to partly cultivate the ground, using a V blade and ripper, working along old logging tracks and avoiding residual patches of tawa and other hardwoods which often contained podocarp regeneration. Assessment six years after planting showed that growth of planted rimu was poor for all site preparation treatments. V-bladed lanes gave best results with 74% survival of rimu but the mean annual height increment of 8.4 cm was only about 30% of that achieved elsewhere on central North Island sites with more shelter, smaller canopy gaps and better drainage.  
Keywords: *Dacrydium cupressinum*, site preparation, planting sites - harsh, planting - podocarps, rimu
255. Steward, G.A. & Pardy, G.F. 1990: Performance of rimu planted in gaps after salvage logging, Pureora Forest Park. - Forest Research Institute, Forest and Wildland Ecosystems Division, Northern Wildlands Project Record No 2563 (unpublished report). - Rotorua. 10 p.  
This trial was established in 1983 in partially-logged, matai-dominant forest near Pikiariki Ecological Area, (location of trial shown on plan). The object was to test the practicality of planting rimu seedlings in recently-created canopy gaps without after-planting care, thus simulating planting after removal of windfall logs by helicopter or other low-impact method. Sawdust would be available (especially if portable saws were used) and gaps would be quickly filled with wineberry and other shrub hardwoods and ferns. After log removal (by tractors in this case), regrowth was controlled by spraying at planting spots but no releasing of rimu seedlings was done after planting. Large (over 1m tall) and small nursery-raised rimu seedlings were planted, either potted or bare rooted, with or without sawdust and plastic sheet



mulches. Assessed 6 years after planting survival was 74-95%, despite early bark biting by possums at the base of 50% of the large seedlings. The only significant difference in treatments and planting stock was that the large rimu seedlings (averaging 230cm in height) with an annual height increment of 19cm grew three times as fast as the small rimu planting stock and were competing more successfully with regrowth.

Keywords: rimu, *Dacrydium cupressinum*, planting - restoration, salvage logging, helicopters, mulching, growth rate, seedling survival, rimu planting

256. Steward, G.A., Shaw, W.B. & Krogh, L. 1987: Catalogue of Forest Research Institute records on Protected Natural Areas. - New Zealand Forest Service, Forest Research Institute, Forest Health and Improvement Division, Indigenous Forest Management Group unpublished - Rotorua.  
This report is compiled from 18 volumes of Forest Research Institute files with a base number of 31, covering a period from 1965 to 1986. The entries give author, date, title, file reference and Keywords for reports, file notes and correspondence on indigenous vegetation throughout New Zealand, documenting in particular, scientific reserves (commonly ecological areas) and giving information and comment on "species lists, lists of forest types and their distribution, maps, scientific values and regional significance of forest types". Covering both forest and shrubland, the references are useful for giving the forest pattern and scientific values of selected forest areas. Some 200 of the indexed references (out of a total of 918) apply to some 80 items which give information on forest and shrubland within Pureora Forest Park and adjacent areas. The references are arranged alphabetically by author with a keyword index appended. The major location Keywords for Pureora Forest Park are: Pureora, Waihaha, Waipapa, Hauhungaroa Range, Rangitoto Range, Tihoi, Hurakia and King Country (east). Photocopies are available from Landcare Research New Zealand Ltd, Private Bag 3127, Hamilton.  
Keywords: protected natural areas, scientific reserves, forest types, species lists, scientific values - catalogue
257. Sweet, G.B. 1978: Forests of the Rangitoto and Hauhungaroa Ranges. - New Zealand Journal of Forestry 23(1): 3-5.  
An editorial comment on management options for the forests included in Pureora Forest Park, written at a time when conflicting interests were being strongly expressed.  
Keywords: forest management options, Rangitoto-Hauhungaroa Range
258. Taylor, N.H. 1953: The soil pattern. - Proceedings of the Ecological Society of New Zealand 1: 11-12.  
An outline of ash beds over six periods is given. Significant soil formers in the West Taupo region include the Tirau Ash beneath the Taupo Ash, near Taupo, which 'feather out westward beneath the more anderic Mairoa Ash'. Both ash beds are the result of intermittent eruptions, and give rise to yellow-brown loams. The Taupo ash shower of paroxysmal origin [now dated at 130 AD] is more than 15 cm thick over 8.800 square miles, giving rise to yellow-brown pumice soils.  
Keywords: volcanic ash showers, soil pattern
259. Veale, B. & Innes, J.G. (eds.) 1986: Ecological research in the central North Island Volcanic Plateau region. Proceedings of a New Zealand Forest Service workshop, Pureora. - New Zealand Forest Service, Forest Research Institute, Rotorua.  
This publication contains contributions by 28 authors on many ecological aspects of the region, most having specific or general relevance to Pureora Forest Park and outlining current research activities. Of the two keynote

addresses, that by J L Nicholls (16pp) on a 'Descriptive overview of the Central North Island Volcanic Upland' is annotated separately in this bibliography. The second address by A E Beveridge (9pp) outlines 'Ecological Research of the Indigenous Forest Management group of the Forest Research Institute, Rotorua. Pages 27-33 consist of abstracts of addresses on Regional Overviews: Soil sequences (W C Rijkse); Climate (J W Hessel); Botany (B D Clarkson); Insects (J J Dugdale); Ecological research - a Wildlife Officer's viewpoint (A Saunders), Exotic forest ecology (D A Rook), Introduced mammals (J G Innes). A series of 15 abstracts of addresses on current research follows (pp 34-82), most of which cover work that has led to subsequent publications annotated separately. Four papers were presented on Future Research Perspectives (p54-67) (P McKelvey, P Wardle, W B Shaw, R Guest). The compilers summarise a wide-ranging discussion of the proceedings by emphasising four broad areas of research topics: Cooperative Research; impacts of possums on the vegetation and possum population control; modelling ecosystems; developing a ranking system for protected natural areas. Many of the above contributions have been annotated separately.

Keywords: ecological research, volcanic plateau, Pureora workshop

260. Veale, B.J. 1986: Natural regeneration in selectively-logged management trials in podocarp forests of the central North Island. - New Zealand Forest Service, Forest Research Institute, Indigenous Forest Management Group Project Record No 1170 (unpublished report). - Rotorua. 25 p.

Surveys of natural podocarp and tawa regeneration were carried out in three study areas, two of which are now in Pureora Forest Park at altitudes of 650m - 650m a.s.l., viz. a 1961 trial in podocarp/tawa forest of Pureora North Block (now in Waipapa Ecological Area) and a 1975 trial in dense podocarp forest at Tihoi. Regeneration surveys were done on line transects before and after logging (1959 and 1961) at Pureora and at 12 years and 23 years after logging (1973 and 1984). At 'nhoi only one survey was done 9 years after logging (1984). In all surveys regeneration between 15cm tall and 5cm dbh was recorded, with sampling intensity ranging from 0.73% to 2.07%. At Pureora podocarp regeneration has been abundant and well distributed since first surveyed in 1959; in 1984 over 90% of plots were stocked with a mean stocking/ha of between 5500 and 7200 (for control) stems for all three blocks. Miro constituted 50 to 60% of total podocarp stocking, and rimu 19-28% with small quantities of kahikatea and matai and rare totara. Tawa regeneration constituted 55-58% of plot stocking with means of 7200 - 8800 stems/ha. At Tihoi podocarp stocking as a percentage of plots was comparable with that at Pureora, but with lower numbers/ha (2300-3100). Miro constituted 38-48% of total podocarp stocking in three blocks, and rimu 39-43%, Halls totara comprised 15% in the block where 30% of the timber volume was removed. The density of tawa was much lower at Tihoi (500-1000 stems/ha) as there were few tawa of seed-bearing age. In general, light ground disturbance can induce podocarp regeneration but logging initially reduces both podocarp and tawa regeneration on heavily-disturbed sites logged at intensities of over 30% of trees/volume removed (e.g., 55% of volume removed in one block at Tihoi). The impact of site characteristics on podocarp regeneration is discussed. Prime sites for regeneration were those with mature podocarp trees within the distance of their own height (a nearby seed source), low to moderate tier densities in both shrub and canopy tiers, and light ground disturbances at the edge of logging tracks. Impacts of logging on major canopy species is discussed in Smale et al. 1998.

Keywords: natural regeneration sampling, selectively logged forest, selective logging trial, podocarp forest, Tihoi Forest, Pureora Forest

261. Vucetich, C.G. & Pullar, W.A. 1973: Holocene Tephra formations erupted in the Taupo area, and interbedded tephtras from other volcanic sources. - *New Zealand Journal of Geology and Geophysics* 16: 745-780.

Keywords: tephra, Taupo, Taupo eruption

262. Waihaha Forest Preservation Committee 1978: Waihaha: a submission to the Minister of Forests in response to New Zealand Forest Service management proposals for the West Taupo forests. - Waihaha Forest Preservation Committee - Taupo. 32 p.  
A well-written and comprehensive report by a responsible steering committee, representing a wide range of interests. The committee was mainly concerned with the complete preservation of the 27,000 ha of virgin podocarp forest in the Waihaha catchment with inclusion of adjacent Crown land. The report was submitted after the New Zealand Forest Seminar on 'Management Proposals for State Forests of the Rangitoto and Hauhungaroa Ranges' held at Taupo in March 1978 (New Zealand Forest Service 1978) at which the Minister of Forests announced the establishment of Pureora Forest Park. Sections professionally compiled cover geology, volcanic ash deposits and vegetation recovery, forest and shrubland types, forest regeneration and particular botanical features. The Wildlife section quotes the Wildlife Service Fauna Surveys and special features of bird life. Maori history and forest clearing are outlined. Possum populations were low after massive 1080 aerial drops in 1976 and 1977 but deer were preventing regeneration of palatable species. Includes 2 maps.

Keywords: Waihaha, reserve proposal, Taupo Seminar, wildlife values, 1080

263. Walker, G. 1980: The Taupo pumice: product of the most powerful known (ultraplinian) eruption? - *Journal of Volcanology and Geothermal Research* 8: 69-94.

Keywords: Taupo pumice, Taupo eruption

264. Wallace, S. 1984: The vegetation of a mire complex in the Waipapa Ecological Area. - *Rotorua Botanical Society Newsletter* 3: 18-21.  
The largest mire complex in Pureora Forest Park occurs beside Ngaroma Rd in Waipapa Ecological Area in the headwaters of the Waipa River. Covering 52 ha, the complex comprises two mesotrophic mires connected by a small stream and is largely surrounded by native forest (rimu/tawa) with an intervening shrubby ecotone. Plant communities and location are shown in a figure. The main plants of the mires are listed, reflecting variations in peat depth and drainage and include a margin of *Coprosma tenuicaulis* with sedges (notably *Gahnia rigida*), patches of sphagnum moss in the bog proper, and a number of interesting herbaceous species, including insectivorous plants (*Drosera* and *Utricularia* spp) and several orchids. *Prasophyllum patens* in flower is illustrated. See also Leathwick 1987.

Keywords: mire - vegetation, species list - flora, shrubland, Waipapa Ecological Area

265. Wallace, S. 1988: Origin, history and vegetation of Whenuakura Clearing. - *Rotorua Botanical Society Newsletter* 15: 32-37.  
The geological origin, human history, and present-day vegetation pattern of the 150 ha Whenuakura Clearing, 750 m a.s.l and lying partly in Whenuakura Ecological Area, southern Pureora Forest Park, are described. Locally poor drainage, a harsh microclimate, and natural fires have probably prevented forest from completely recolonising the valley floor after the last (Taupo) eruption of c. 130 AD. The fire history continued in Maori times, the clearing forming part of a major route over the Hauhungaroa Range. A variety of plant communities is present, with conifer-broad-leaved forest, tall

coprosma-monoao shrubland and short monoao shrubland on better-drained sites and mire vegetation on poorly drained ones. Out of a native vascular flora of 287 species, notable occurrences are a few mature trees of kaikawaka, with regeneration (possibly from survivors of the Taupo eruption), *Pittosporum turneri* and wire rush. Boggpine and silver pine indicate deteriorating drainage.

Keywords: Whenuakura Clearing, shrubland, frost flats, mire, species list - flora

266. Wardle, P. 1966: Biological flora of New Zealand 1: *Weinmannia racemosa* Linn. f. (Cunoniaceae) Kamahi. - New Zealand Journal of Botany 4(1): 114-131.

A general account of the ecology of kamahi, said to be particularly abundant on infertile soils with a high water-holding capacity in the Rotorua-Taupo district. Specific references to kamahi in Pureora Forest Park include: counts of growth rings in fire-induced pole stands in which kamahi is associated with tall kanuka and young rimu (at 550m a.s.l. in a 60 ha area now in Waipapa Ecological Area). The kamahi poles of 3-7 inches (7-17 cm) diam. had between 70-90 growth rings and heights of ca 40 ft (12m); in Pureora Forest Park kamahi is commonly epiphytic on tree ferns (or old logs) and those that reach a large size become perching trees for birds (mainly NZ pigeon) that disperse podocarp seed, the seedlings developing into podocarp poles beneath the thinning canopy of the old kamahi; kamahi plays an important role in fire-induced succession, becoming established in weak growth of manuka and suppressing it, or forming an understorey to tall kanuka with emergent rewarewa; seedlings of podocarps (particularly rimu) become established beneath dense canopies of young kamahi and develop as the canopy opens, sometimes leading to dense podocarp forest [Death of pole stands has been recorded in the Waipapa Ecological Area before possums had any significant impact and with low scale insect populations].

Keywords: kamahi, *Weinmannia racemosa*, flora, podocarp nurses, epiphytic habit, scrub - fire-induced, forest cycles, biological flora

267. Wardle, P. 1969: Biological flora of New Zealand 4: *Phyllocladus alpinus* Hook f. (Podocarpaceae) mountain toatoa; celery pine. - New Zealand Journal of Botany 7(1): 76-95.

General account of the ecology of this species. Specific mention of mountain toatoa in Pureora Forest and West Taupo (now included in Pureora Forest Park) is as follows: p.78: suspected hybrids between mountain toatoa and tanekaha (*P. trichomanoides*) collected from Pureora ecotones. P.82: At Pureora (in ecotones between tall forest and heathland at 540m) "male strobili were emerging on 25 October, 1966, and plants had ripe pollen and receptive ovules by 16 November. Ripe seed was collected from 12 February to 11 March 1967". "Parakeets have been seen to remove seed from green carpidia but it was presumably destroyed". On Mt Pureora "no seed was found at 1100m in 1958, 1959 and 1960, all years when there were heavy seed crops at 540m by frost flats. P.83: "Stems of separate male and female clones can occur mixed, or even grafted, in the same (multistemmed) clump"

P.90: McKelvey (1963, p 122) is quoted describing "A bog *Dacrydium*/mountain toatoa type" from Western Taupo, regarded as a stage in succession from open swamp to forest dominated by *Libocedrus bidwillii* and *Podocarpus hallii*. P.91: at Pureora and on the western margins of Pureora Forest Park "eruptions and a long history of man-caused fires have created ecotones between tussock grassland or scrub of *Leptospermum scoparium* and *Dracophyllum subulatum*, and densely stocked podocarp forest. *P. alpinus* is often abundant in these ecotones."

Keywords: mountain toatoa, *Phyllocladus alpinus*, flora, Pureora, ecotones, ecology, biological flora

268. Warren, A. 1984: The effects of 1080 poisoning on bird populations in Tihoi, Pureora State Forest Park, winter 1983. - New Zealand Forest Service (unpublished internal report). - Auckland. 34 p.  
Bird populations were monitored by the five-minute bird count method in poisoned and control blocks before and after an aerial 1080 poison operation to control possums in the winter of 1983. The poison operation, using wheat-buried pellets, was carried out over some 1500 ha on the south-western side of the Park, between the Waihaha River and Waihora Stream. Bird counts were made at 30 stations on circuits in each of the poisoned and untreated (control) blocks of the trial area. Results are presented graphically for twelve indigenous and four introduced bird species. Data were statistically analysed and showed no significant reduction in bird populations of the more common species. A search revealed no dead birds. Some limitations of the trial are recognised: the 5 minute bird count method does not adequately sample the rarer, nocturnal or aquatic species in the area (kaka, parakeet, robin, NZ falcon, morepork and blue duck); there were some differences between the poison block and the control block in altitude and vegetation. Most of the counting stations were in podocarp forest dominated by rimu. The forest was mainly virgin in the poisoned block but selectively logged in the control block.  
Keywords: aerial poisoning, possum control, bird populations, Tihoi, bird survey, 1080
269. Warren, F.M. 1965: Labour Day weekend at Taumarunui. - Auckland Botanical Society Newsletter 22(1): 6-8.  
Includes a brief account of a day's field visit to Pureora with comment on species seen near Forestry Headquarters where posts were being extracted from fallen totara (area now in Pikiariki Ecological Area). Shrubland near the Waimiha Stream was also visited.  
Keywords: Botanical visit - Pureora
270. West, C.J. 1995: Sustainability of *Beilschmiedia tawa* - dominated forest in New Zealand: population predictions based on transition matrix model analysis. - Australian Journal of Botany 43(1): 51-71.  
Data on seedfall, seedling recruitment, growth rates and mortality rates, collected over 3 years from unlogged and logged podocarp/tawa forest at north Pureora, was used in the Leslie Matrix model to determine rates of increase of five populations of tawa. The three logged populations were apparently declining while the unlogged populations were increasing. Tawa is a K-selected species capable of regeneration only within high forest. Small stems are shade-tolerant but stagnate in the absence of better light.  
Keywords: tawa - sustainability, podocarp/tawa forest, Pureora
271. Wilcox, M.D. 1999: Flora and vegetation of Pureora. - Auckland Botanical Society Journal 54(1): 44-56.  
An excellent, concise account of botanical features at eight selected sites in Pureora Forest Park, including dense podocarp forest, ecotones at the forest margin and in shrublands, frost flats, mires, the present vegetation on or near the buried forest site and altitudinal vegetation belts on Pureora Mountain. There is a note on environmental (invading) weeds. An appendix contains a full list of native vascular species (427) in the Park. The reference list has 49 items relevant to botany of the Park, most of which have been annotated in this bibliography. Includes 6 photos (5 in colour).  
Keywords: Pureora Forest Park - flora, species list - flora
272. Williams, D.S. 1991: Forest composition changes over 25 years on Pureora Mountain. - Rotorua Botanical Society Newsletter 22: 15-20.  
Remeasurement of 4 transects on Mt Pureora indicates changes and trends over 25 years (1960-85), a period of increase in numbers of deer and

possums. Transects were established in four different forest types at altitudes of 710-970m a.s.l. Plot design of transects is shown. Main trends in vegetation have been significant declines in the abundance of palatable species such as *Griselinia littoralis*, *Fuchsia excorticata* and *Pseudopanax* species, with an increase in non-palatable plants, such as *Pseudowintera colorata*. Understorey *Weinmannia racemosa* and *Pseudopanax simplex* showed effects of increased browsing. See also annotation for Williams and Leathwick 1990.

Keywords: ecological transects, vegetation trends, browsing damage, Pureora Mountain

273. Williams, D.S. & Leathwick, J.R. 1990: Remeasurement of ecological transects in some central North Island forests. - Forest Research Institute (unpublished contract report for the Department of Conservation). - Rotorua. 19 p.

This report gives the results of remeasurement of eight long-term ecological transects, some of 50 such transects established in central North Island indigenous forest in the late 1950s and early 1960s to enable assessment to be made of long-term vegetation changes. Six of these transects within the present boundaries of Pureora Forest Park were remeasured 25 years after their establishment. Each of the transects was 20 x 211m with measurements or counts of all trees, saplings and seedlings. Basal area and stem density were calculated for all species and the reports show changes in these parameters in the form of bar graphs for each transect. Of the six Pureora transects established in podocarp and podocarp/hardwood forest, two were located on Pureora mountain (altitudes 920-990m a.s.l.), two near the Ongarue River (altitudes 710 and 720m a.s.l.) and two by the Waihaha River and in the Waipapa Ecological Area (altitudes 570 and 540m a.s.l.). It was concluded that the composition of the forest in the Pureora transects has changed markedly over the last 25 years. Deer and possum populations were low at time of transect establishment but were in moderate to high densities 25 years later. It is suggested that browsing animals are the 'primary agent' responsible for these changes as most palatable plant species (e.g., fuchsia, broadleaf and *Pseudopanax* species) showed significant declines in abundance. Non-palatable plants, mountain horopito, in particular, have generally increased. These trends are likely to continue if browsing animals remain at present levels with further decline of highly-preferred species and increase of least-preferred species. Changes in major species are recorded for each transect. The order of change in the lower altitude transects is shown by the Waihaha and Waipapa transects. The Waihaha transect dominated by matai, totara (2 species), miro and tanekaha had a basal area of 85.1 m<sup>3</sup>/ha in 1958 and this had decreased by 5% (with death of two large totara) in 1993 while stem density decreased by 3%. In the Waipapa transect, where there were emergent rimu, matai and miro over tawa, total basal area of 66.9 m<sup>2</sup> in 1959 decreased by 4% by 1984 while stem density decreased by 34%. Rimu, miro, hinau and tawa increased in basal area and rimu was one of the few species to record gains in the sapling and seedling classes. It is recommended that these long-term permanent plots be maintained as they are amongst the oldest permanent plots in central North Island indigenous forest. See annotation for Williams 1991, giving changes by species for 4 transects on Pureora Mountain.

Keywords: ecological transects, vegetation trends, basal area, plant density, browsing damage, Pureora Mountain, Waihaha, Waipapa

274. Wilson, C.J., Ambraseys, N.N., Bradley, J. & Walker, G.D. 1980: A new date for the Taupo eruption, New Zealand. - Nature 288: 252-25.

Keywords: Taupo eruption

275. Wilson, C.J.N. 1986: Reconnaissance stratigraphy and volcanology of ignimbrites from Mangakino Volcano, p. 179-193. - In: Smith, I.F.M. (ed.), Late Cenozoic history in New Zealand. Royal Society of New Zealand Bulletin 23 - Royal Society of New Zealand, Wellington.

Keywords: volcanicity, Mangakino

276. Wilson, C.J.N., Loughton, B.F. & Lloyd, E.F. 1986: Volcanic history and evolution of the Maroa-Taupo area., p. 194-223. - In: Smith, I.F.M. (ed.), Late Cenozoic volcanism in New Zealand. Royal Society of New Zealand Bulletin 23 - Royal Society of New Zealand, Wellington.

Keywords: volcanicity, Taupo

277. Wright, A.C.S. 1952: West Taupo Project. Summing up and conclusions. - New Zealand Science Review 10(6): 92.

This note sums up the ecological reconnaissance of Western Taupo. The objectives were: to use a soil map as the base map for an ecological survey; to test survey techniques in a region where communities and habitats are distinct and where man's impact can be discerned; to use ecological maps to help explain farming problems by referring to indigenous factors. Reference is made to the "adverse soil factors which restrict the spread of ecotone species and inhibit the growth of other species where the rhyolite pumice has been resorted by water. A biological reserve is proposed.

Keywords: ecological research, West Taupo, ecotones

## Keyword index Pureora Bibliography

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