

Ecology and management of Pureora Forest Park

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Introduction

This is not an exhaustive bibliography but the 277 papers comprise all the published and unpublished items relevant to the Park that could be located over a 12 month period.

The original terms of reference from the Department of Conservation stated that the bibliography should deal with flora and fauna values and pest management in the park. The scope has been somewhat broadened to encompass ecological values and management in the broadest sense, including descriptive material, research papers, forest history, management plans and the restoration of forest condition and wildlife following direct or indirect human impact (especially from the introduction of browsing animals and predators).

The period covered is 1950-1999. Pureora (State) Forest Park was formed in 1978 after a New Zealand Forest Service seminar held in Taupo to consider management proposals for the Rangitoto/Hauhungaroa Ranges. The vigorous discussions during the 1970s by scientists, forest managers, environmentalists and an increasingly informed and interested public resulted in changes to indigenous forest policy and cessation of all logging in the Park in the early 1980s.

On the demise of the New Zealand Forest Service in 1987 the Department of Conservation took over management responsibility with particular concern for pest control and the protection or restoration of forest and threatened species.

After 1978 all virgin (unlogged) forest within the Park was included within "ecological areas" as scientific reserves and much of the research and management undertaken over the past 20 years has been done within these ecological areas. (See location map.)

Scientific interest in the Volcanic Plateau region of the central North Island (encompassing the present park) where much of the forest was probably destroyed by the great Taupo eruption of 130 AD, was first expressed by brief papers in the *New Zealand Science Review* of the early 1950s, referring to a 'West Taupo Project'; these were followed by the writings of Peter McKelvey, based on the work of the National Forest Survey (1946-55) and stimulated interest in hypotheses of vegetation succession following forest devastation that led to development of the fine podocarp forests that, with their surviving wildlife, constitute the main feature of the park today.

The bulk of annotated papers in this bibliography were written by members of the New Zealand Forest Service, the Forest Research Institute, Rotorua, and the Department of Conservation, while scientists of Landcare Research have produced scientific papers and contract reports in recent years.

Most of the annotated papers have been located through perusal of the technical records and literature lists of NZ Forest Research Ltd and the Waikato

Conservancy of the Department of Conservation, the libraries of which allowed loan of journals and copies of both unpublished and published papers.

A 1985 workshop held at Pureora on 'Ecological research in the central North Island Volcanic Plateau Region' referred to most of the studies then being carried out in Pureora Forest Park and nearly all have since been the subjects of published papers or internal reports.

Current work overseen by the Department of Conservation has introduced such new concepts as 'mainland islands' with vigorous programmes for predator control and 'adaptive management'; increases in the breeding rates of forest birds will soon be described in papers that will supplement those included in this bibliography.

The keyword index is a rough guide to areas of activity, sites, and common and scientific names used in the papers or annotations. The term 'Pureora Forest Park' is included for only a few annotations of items that refer broadly to the Park. Before the 1978 formation of Pureora Forest Park (sometimes also called 'Pureora Conservation Park' in recent years) the words 'Pureora' or 'Pureora Forest' were used to cover Pureora State Forest, including both indigenous forest and exotic plantations. The areas that would be included in Pureora State Forest Park were the six constituent state forests of Pureora, Tihoi, Waituhi, Hurakia, Taringamotu, and Wharepunga. Waihaha was part of Tihoi State Forest. In the keyword index such terms as Waihaha and Waipapa refer to stream catchments that are substantially the same as the ecological areas.

All annotated papers have specific or general relevance to the Park and, with few exceptions, have been read in full. Some 30 titles have no annotations, usually those referring to soils, geology, species lists, and maps; some of these were referred to by authors of annotated papers but were not located in time for inclusion in this bibliography.

Comments in annotations included in square brackets are those of two of the compilers (A E Beveridge and M C Smale), who have maintained interest in the area for over 40 years and 20 years, respectively.

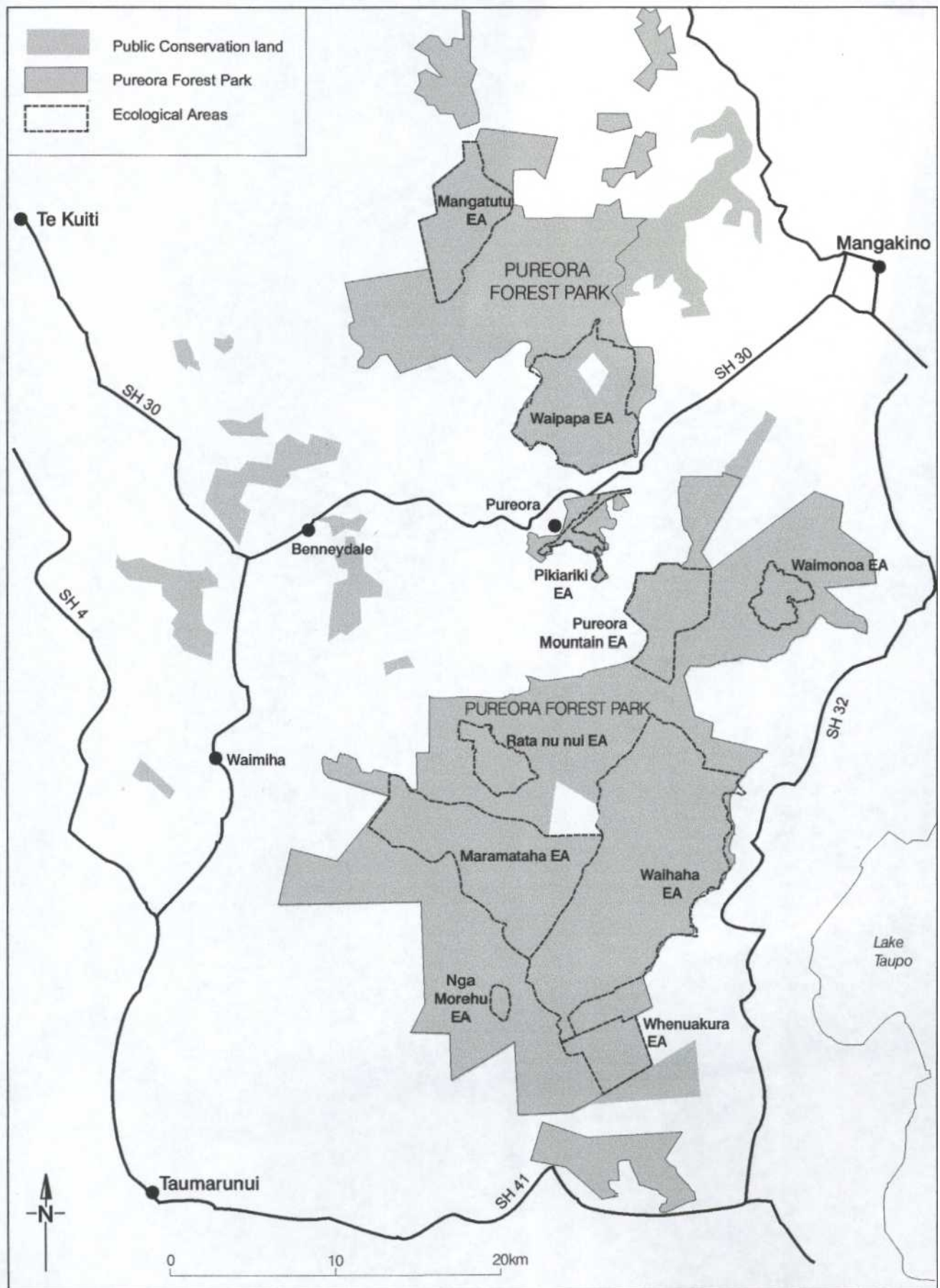
Several bibliographies on indigenous forest and wildlife have been checked for items on Pureora. These are Orwin 1974, Boyd 1993, Leamy & Hayward 1986 and Poulton 1986 (on kokako).

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National Forestry Library, Rotorua, and staff in the library, technical records and publications sections, at the Forest Research Institute, Rotorua; Dr John Herbert for facilitating searches for papers at the Forest Research Institute; Dr Mike Wilcox for providing some botanical references and giving us a copy of his recent paper on the Flora and vegetation of Pureora; Diana Carter of Waikato Conservancy, who typed our handwritten annotations from index cards to a software programme, and Jenny Hurst, who edited an earlier version of the manuscript.

Pureora Forest Park - Ecological Areas



Annotated bibliography on the ecology and management of Pureora Forest (Conservation) Park

A E Beveridge, M C Smale, A S Holzapfel (comp.)

1. Anon. 1975: King Country biggest burn-off this century. - Beechleaves 2: 1-2.
A polemic directed against proposals by NZ Forest Products to clear some 30,000 ha of cutover forest, including the western flanks of the Hauhungaroa Range, for planting of exotics.
Keywords: indigenous forest - clearing, burning, conversion to exotics, Hauhungaroa Range
2. Anon. 1978: Forests: West Taupo forests. - New Zealand Commission for the Environment Newsletter July: 1-4.
This contribution to the newsletter is part of the Commission's submission to the Minister of Forests, commenting on management proposals for State Forests in the Rangitoto and Hauhungaroa Ranges, presented at the Taupo Seminar in March 1978 (see annotation for New Zealand Forest Service 1978 a, 1978 b). This critique of the New Zealand Forest Service proposals emphasises some deficiencies in approach to the problems, and lack of information about environmental impacts, in particular recreational use of the forests and wildlife values. A recommendation was that priority be given to the Wildlife Service to investigate the effects of selective logging on wildlife habitat, particularly kokako habitat (soon to be implemented - see annotations for Crawley 1981, Hay 1981, 1984, Leathwick 1981).
Keywords: management proposals, Rangitoto-Hauhungaroa Ranges
3. Anon. 1980: Research group progressing with study of kokako. - Forest and Bird 216: 7-10.
Describes the initiation and early progress of an intensive three-year study of the kokako and its habitat and the impact of selective logging on birdlife in several study areas, including three in Pureora Forest. The study period coincides with a moratorium on logging at Pureora from December 1978 to December 1981. A chart is shown for seasonal food items eaten by kokako at Pureora, with a list of 25 plant foods, in addition to the sixpenny scale insect which provides 50% of kokako diet in December and January. Other highly-preferred items are fruits of kaikomako, fivefinger and putaputaweta.
Keywords: kokako - research, kokako, kokako - diet
4. Anon. 1981: Pureora Forest Park - a haven of the kokako. - Forest and Bird 221: 8-14.
A general account of the Park (then with an area of 71,470 ha) and its features, including an outline of geology, vegetation, regeneration and wildlife. The 11 dedicated scientific reserves are briefly described, created for 'permanent reservation of representative examples of ecological patterns, with all the facets of geology, soils, vegetation and wildlife taken into account'. The current attitude of the NZ Forest Service to reduction in logging within the park is given, following a revision of indigenous forest policy (New Zealand Forest Service 1977). Includes colour photo of dense podocarp forest (Pikariki) and map of the park.
Keywords: Pureora Forest Park, scientific reserves

5. Anon. 1982: Waihaha is now safe. - Bush Telegraph 8: 1-2.
Outlines conservation and political campaigns for cessation of logging within the area of Pureora Forest Park, leading to virgin forests being placed in Ecological Areas.
Keywords: Waihaha, reservation
6. Barnett, S.C. & Speed, H.J. 1994: Kokako and kiwi survey, Waihaha Ecological Area, Pureora Forest Park. - Department of Conservation, Waikato Conservancy (unpublished report). - Hamilton. 9 p.
A survey of these two species was undertaken in the virgin forest catchments of the Waihora, Mangatu and Waihaha streams at altitudes between 500m and 840m a.s.l. from 10-14 January 1994, before a possum control operation in the following winter. Taped bird calls were played at listening sites. No kiwi or kokako were heard or seen during the survey which will be repeated in April. The history of the few records of kiwi and kokako in the Waihaha area is given and the conclusion is reached that both species were present in the Waihaha area until recently but may now not be present at all. Observations are recorded on other threatened bird species, including kaka, kakariki and blue duck.
Keywords: kokako, kiwi, Waihaha, bird survey, kaka, kakariki, blue duck, threatened birds
7. Baumgart, I.L. 1952: The soils of West Taupo. - New Zealand Science Review 10: 88-89.
Geology and soils are described for an area which includes the Hauhungaroa Range and the south-eastern part of the present Pureora Forest Park. Soils have formed on various volcanic ash showers, including Mairoa ash that underlies the pumice ash of the Taupo eruption [c. 130 AD]. The Taupo eruption destroyed all vegetation in the study area and was followed by rapid erosion of loose pumice on slopes with development of broad-leaved forest on underlying ash showers. Wash-filled flats and river terraces were formed of unsorted pumice and the formation later of a cemented pan near the surface is described. The nature of forest edge ecotones is referred to and the development of podocarp forest with strongly podzolised soils under podocarps.
Keywords: West Taupo soils, geology, volcanic ash showers, Taupo eruption, podocarp forest development, soils - vegetation.
8. Beadel, S.M. 1988: A botanical foray to Whenuakura Clearing, 12-13 November 1988. - Rotorua Botanical Society Newsletter 15: 38-43.
As an appendix to a general account of plants found in the clearing (part of which is in the Whenuakura Ecological Area) there is a list of vascular taxa (34) additional to those listed by Druce (1972).
Keywords: species list - flora, Whenuakura Clearing
9. Bell, A. 1976: Scrub associations and podocarp regeneration in the Pouakani Ecotone. - New Zealand Forest Service, Forest Research Institute, Forest Health and Improvement Division Project Record No. 830 (unpublished report). - Rotorua. 13 p.
Vegetation types and podocarp regeneration were assessed in 1960 and 1976 along a 200m line transect of successive permanently-marked 2x2m plots. The transect, located in the Waipapa Ecological Area, extends outwards from the high forest margin through zones of shrub hardwoods, manuka and monoao (*Dracophyllum subulatum*). The distribution and composition of vegetation types were thought to be influenced by microtopography, cold air drainage, droughty pumice soil and seed dispersal mechanisms. Podocarp regeneration was best developed in a narrow belt of large kamahi between tall podocarp / tawa forest and scrub associations, was present in patches of broad-leaved shrub hardwoods but absent from monoao-dominant frost flats.

Manuka dominated above frost flats in 1960, with shrub hardwoods dominating above on ridges and knobs. Manuka was mainly dead or moribund in 1976. Manuka has nursed small podocarp seedlings, many of which were not persistent unless reaching heights of 2-3m. Successional trends are discussed. Development of podocarp forest does not spread out uniformly from the high forest margin but a mosaic of developing podocarps may result from patchy re-establishment in shrub hardwoods on higher ground, separated by frosty depressions. Rimu, totara, matai, kahikatea and tanekaha are all abundant as seedlings, but not miro, in the relatively harsh environment. Well-established podocarp seedlings had a mean annual height increment of only 6-12 cm from 1960-1976 as new growth can be damaged by frost and cold wind. A species list is given in an appendix. Figures indicate a substantial increase in stocking of established podocarp seedlings in the period 1960-76. Includes two colour photos, 6 figures. Keywords: ecotone, forest succession, podocarp regeneration, scrub, Pouakani Forest

10. Bellingham, P. 1982: Some ecological aspects of matai (*Podocarpus spicatus* R. Br. ex Mirbel) in West Taupo indigenous forests. - BForSc thesis, University of Canterbury.
Growth rates of matai were examined from a podocarp - hardwood forest at Waihora, West Taupo (750 m a.s.l.). The forest was dominated by rimu (*Dacrydium cupressinum*, 65 % of stems), while matai was the subdominant podocarp (20 % of stems). Six complete stump sections of logged matai were removed (0.5 m above ground) and rings counted along three radial axes. The average stump diameter was 1017 mm (range 752-1384 mm). Diameter growth rates were very slow (mean 1.5 +/- 0.2 mm / yr.) and were variable among the six individuals (range: 0.51-3.8 mm / yr.). The average age of the six individuals was 685 years (range 570-810 years) and there was no relationship between age and diameter. The trees are on average 100 years older than matai from nearby TIM. The range of ages of matai within the Waihora stand (240 years) does not support a single cohort recruitment, and gives some support to mixed stands as would be generated by mosaic succession.
Keywords: matai, ecology, West Taupo, succession - mosaic
11. Bergin, D.O. 1986: Native forest restoration by planting, p. 51. - 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.
Group planting of tall nursery-raised podocarps on selected micro - sites in light wells of selectively-logged forest or cutover forest is recommended where natural regeneration is sparse. On open sites nurse species may need to be planted first to provide shelter.
Includes abstract of address.
See annotations for Steward 1981, Guest 1985.
Keywords: restoration planting, podocarp planting trials
12. Bergin, D.O. & Kimberley, M.O. 1992: Provenance variation in *Podocarpus totara*. - New Zealand Journal of Ecology 16(1): 5-13.
In a three year nursery study of *P. totara* from 42 sites throughout New Zealand, seedlings from two provenances were raised from Pureora and Hurakia within Pureora Forest Park. During their third year in the nursery, seedlings of these provenances had increments of 49 and 51 cm, near the top end for all provenances. The Hurakia provenance also showed good stem form in common with many provenances that showed faster growth rates. An evaluation was also made of differences between seed lots of Podocarpus half and those of suspected hybrids from 24 trees in Pureora Forest Park

where both *P. hallii* and *P. totara* are present; foliage and bark characteristic of some trees suggest that hybridisation occurs. Seed shape and length differ between *P. totara* and *P. hallii* but the putative hybrids from Pureora had seed lengths within the range of both species, suggesting, either that these trees are not actually hybrids, or that the hybridisation is somewhat complex, e.g., involving back crossing of F1 or F2 generations. In the discussion of the seedling variation within provenance it is recommended that large-scale planting for ecological purposes should use seed of local origin and similar altitude in order to obtain trees with the same genetic integrity and which are suited to the local climatic conditions.

Keywords: totara, Hall's totara, *Podocarpus totara*, *Podocarpus hallii*, provenance variation, seedling growth, seedling habit, totara hybrids

13. Best, H.A. 1977: The King Country land-use study: Indigenous wildlife. - Fauna Service Unit report 8B. - New Zealand Wildlife Service, Wellington.

This report outlines the distribution and habitat requirements of eleven species of wildlife considered to be 'more sensitive' or 'more critical' in the King Country. Most locations are within or near the present boundaries of Pureora Forest Park, in the Rangitoto and Hauhungaroa Ranges. The principles of wildlife conservation and their application in the King Country are given. The report ends with recommendations that there should be no further land clearing or conversion to exotics in the remaining indigenous forests of the Rangitoto and Hauhungaroa Ranges and that core reserves be set aside. Maps are referred to as showing the location of critical species discussed but are not attached to the report. The critical species mapped and discussed are:

1. The native frog, *Leiopelma hochstetteri* (Rangitoto Range)
2. North Island brown kiwi (widespread in the King Country south of Pureora Mountain)
3. Blue duck in streams on both sides of the Hauhungaroa Range from (Mt) Pureora South
4. New Zealand falcon. The King Country has the best habitats in the North Island
5. The New Zealand parrots (kaka and parakeet species). Wide ranging in larger tracts of less modified indigenous forests of the King Country below about 750m a.s.l. On the west side of the Hauhungaroa Range, parakeets have been found in high densities in northern Hurakia Forest.
6. North Island robin: In pockets of high forest and older second growth. Easy terrain in Rangitoto Range and from Tihoi to Waihaha on the eastern side of the Hauhungaroa Range. Three areas in Hurakia Forest.
7. Fernbirds: in widely scattered areas of swamp, scrub and heathland.
8. North Island kokako: mainly in unlogged dense podocarp and podocarp/hardwood forest north of the south-east flank of Pureora Mountain.
9. Long-tailed bat: incomplete account of distribution at this time.

This Fauna Survey Unit report is also published as "Technical Report C on Indigenous Wildlife", compiled by the New Zealand Wildlife Service in: King Country land use study: Technical Reports, p35-43. New Zealand Department of Lands and Survey, Wellington 1978. Land Use Series No. 3. Keywords: bird survey, King Country East, threatened birds, bird habitat, wildlife values, land use

14. Best, H.A. & Pike, D.J. 1977: King Country Land Use Study. Wildlife: a review, p. 5-14. - In: New Zealand Wildlife Service (ed.), Fauna Survey Unit Report 8 - New Zealand Wildlife Service, Wellington.

In 1976 and 1977 the Wildlife Service was involved in this large-scale land use study together with many other Government departments. The land-use study followed a 1975 NZ Forest Products Environmental Impact Report on

proposals for planting radiata pine on 60,000 ha of land within the southern King Country. The study region included all the forest and vegetation within the present Pureora Forest Park. A sieve planning technique was used, involving preparation of maps and coloured overlays to present information. One of the aims of the Wildlife Service involvement was to define areas of value to indigenous wildlife, based on data collected through forest fauna surveys since 1971. Species classed as critical for conservation are listed and 'areas of ranked importance for conservation of wildlife have been based on maintaining a representative pattern of their habitats throughout the study area'.

Keywords: land use, wildlife values, conservation, habitat reservation, King Country

15. Beveridge, A.E. 1962: Growth of podocarp seedlings in Pureora Forest Nursery. - New Zealand Forestry Research Note 32. - New Zealand Forest Service, Forest Research Institute, Rotorua.
Describes methods of raising podocarps and tanekaha on the old Pureora nursery site at 550m a.s.l. where clearing of a dense podocarp forest in 1948 left a relatively infertile Taupo pumice subsoil. Only kahikatea was raised from seed whilst other podocarps consisted of wildlings 5-25cm tall, removed mainly from disturbed roadside sites in dense podocarp forest (in the present Pikiariki Ecological Area). Tanekaha wildlings were collected beneath nurse species (mainly *Halocarpus bidwillii* in scrub at 450m a.s.l. Wildlings were lifted in spring 1958 and transplanted to veneer tubes placed in a bush house covered by clear wire mesh, or to nursery beds covered by frames admitting 30% light. Addition of organic matter and forest topsoil to tubes and beds was required for satisfactory growth of totara, kahikatea and tanekaha. Rimu grew steadily at the same rate in any of the various potting media tried. The only substantial damage to seedlings on this rather harsh site was caused to exposed, actively-growing shoots of totara and tanekaha by unseasonal frosts and a cold February gale. Wildlings were measured for height according to treatments over the first year when some were large enough for planting out at 30-40 cm height. The remainder were treated with balanced fertiliser and planted out after 2 years in the nursery. [Of the 2000 wildlings raised, totara and tanekaha were planted in Waipapa scrub ecotones, or totara alone on a cleared site with a eucalypt nurse species adjacent to the present Pikiariki Ecological Area.].
Keywords: podocarp seedlings, Pureora Forest nursery, wildling podocarps
16. Beveridge, A.E. 1964: Dispersal and destruction of seed in Central North Island podocarp forests. - Proceedings of the New Zealand Ecological Society 11: 48-55.
Seed crop studies were carried out over a period of 7 years (1958-64) in podocarp forest near Pureora at a time when possums were just arriving in the region and had no readily discernible impact on vegetation. Observations were made of birds feeding in the crowns of fruiting podocarps and data on abundance of seed, its condition and seed destroying agents were collected from seed traps. Podocarp species showed marked periodicity in seeding, rimu producing the most irregular seed crops. The most active indigenous seed dispersers were the native pigeon, tuis, bellbirds and silvereyes, sometimes in local concentrations. Blackbirds are the main introduced seed-dispersing species for indigenous shrubs while flocks of starlings gathered to feed on heavy crops of kahikatea. Rimu seed is highly palatable to seed-eating birds, rodents and insects; chaffinches and other finches feed in tree crowns, also wetas; a high proportion of seeds become detached from the receptacles in the tree crowns prior to seedfall; ship rats are numerous and widespread in Pureora Forest and destroy quantities of rimu, miro and hinau seed. Seeds of green miro fruits are broken open by kaka, and totara seeds by parakeets. The pigeon is the main disperser of miro, matai and tawa seed.

[Fallen tawa seeds are eaten by possums in other Central North Island forests during winter and developing fruits are opened in summer, whilst ship rats are not known to eat tawa seed].

Keywords: seed dispersal, seed destruction, podocarp seed crops, seed traps

17. Beveridge, A.E. 1967: Longevity of podocarp seed under forest conditions, p. 32. - In: New Zealand Forest Service (ed.), Annual report of the Forest Research Institute, Rotorua, for 1966 - New Zealand Forest Service, Wellington.
In a trial to test longevity of podocarp seed collected in autumn, samples of seed contained in nylon mesh packets were buried beneath litter in podocarp/tawa forest, Pureora. Packets were lifted annually and seed sown to test germination. All kahikatea seed germinated in the first spring after seedfall. A proportion of totara and rimu seed remained dormant for one year, but all seed had germinated in the packets 18 months after seed fall. [Some packets of rimu seed buried up to 10cm deep, in forest humus, in plots fenced against pigs, were pulled to the surface and opened; the seeds were missing or opened in the way that ship rats do]. The hard-coated seeds of miro and matai remained dormant and viable for three years [and finally after five years]; the buried seed, when sown, germinated more quickly than fresh seed.
Keywords: podocarp seed longevity, germination
18. Beveridge, A.E. 1973: Regeneration of podocarps in a central North Island forest. - New Zealand Journal of Forestry 18(1): 23-35.
The main study area for outlining the regeneration characteristics of podocarps lies within and near the present Waipapa Ecological Area in Pureora Forest Park. Possums had made little or no impact on the vegetation during the main study period (1957-70). In virgin forest, podocarp seedlings are suppressed beneath a tall canopy of dense shrub hardwoods and tree ferns but develop beneath a gradually-opening hardwood canopy, particularly that of large, old kamahi of epiphytic origin. A cycle of podocarp replacement is described by a sequence of windfall of old, single or grouped podocarps; tree ferns; epiphytic kamahi and large shrubs on tree ferns and logs; opening canopy of ageing hardwoods; recruitment and slow continued development of grouped podocarp saplings. [The full cycle from the death of trees to a new generation of mature podocarps is likely to take from 600-1000 years]. Prolific podocarp regeneration in succession after fire beneath *Leptospermum* and kamahi is described. Canopy opening by logging has induced podocarp regeneration with seedlings becoming established along extraction tracks near retained seed trees. Information is given on podocarp seed production, seed dispersal, germination and natural longevity, seedling survival and growth and injurious agencies.
Keywords: podocarp regeneration, podocarp seeding, forest cycles, Pureora
19. Beveridge, A.E. 1975: Selective logging of indigenous forests. - What's New in Forest Research 23: 1-4.
Outlines the aims and early impact of a 1961 trial to conduct controlled selective logging in podocarp/tawa forest in the Pouakani block of Pureora Forest, one of the two earliest attempts to selectively log indigenous forests in the central North Island. One third of the merchantable volume was removed in two blocks by felling groups of podocarps and a few tawa. Stability of residual trees was comparable in logged blocks and the unlogged control. Early regrowth is described in areas disturbed by logging. The pioneer species on disturbed ground were wineberry [later succeeded by pate, fivefinger and mahoe] and fuchsia with tree fern regrowth abundant amongst logging debris. Rimu seedlings became established along main log extraction tracks. Tawa regeneration developed at gap margins and coppice shoots

were produced from damaged stems. [Early impact of browsing animals was light as possums were absent (or very scarce) at the time of logging].
Keywords: selective logging, Pureora, regeneration, forest management trials

20. Beveridge, A.E. 1979: Management of the central North Island indigenous forests (Sanderson Memorial address). - *Forest and Bird* 214: 25-33.
A review of the situation at a time when there was considerable discussion on the future of these forests, including Pureora Forest Park. Reference is made to changes in indigenous forest policy, management trials and regeneration of podocarp species. Six colour photos including: a road through selectively-logged podocarp/tawa forest in Pureora Forest; low-density podocarp forest in Tihoi Forest with vigorous rimu regeneration beneath old thin-crowned or dead matai and totara, and a tanekaha pole stand on a ridge [an example of cyclic regeneration in podocarp forest].
Keywords: forest management, Pureora
21. Beveridge, A.E. 1983: Regeneration of podocarp forests and maintenance of productivity, p. 93-108. - In: Thompson, K., Hodder, A.P. & Edmonds, A.S. (eds.), *Lowland forests of New Zealand. Proceedings of symposium 27-28 May 1980 - Centre for Continuing Education and Environmental Studies Unit, University of Waikato, Hamilton.*
The paper outlines the main ecological characteristics of podocarps in lowland forest, based largely on observations in Pureora Forest Park and also interim results from selection management trials in the central North Island. Specific references to cyclic regeneration in Pureora Forest Park include the occurrence of rimu saplings and poles developing directly beneath thin-crowned or dead, large matai in parts of Tihoi Forests (Kakaho and Waitaia catchments); also the important role of kamahi in acting as a nurse for podocarp regeneration as the thinning crowns of large kamahi (and other hardwoods) gradually admit more light to podocarp seedlings established beneath them. In the Rangitoto and Hauhungaroa Ranges, good seedling regeneration of podocarps is widespread in both virgin and logged forest, while in the more disturbed parts of Tihoi Forest and Hurakia Forest, pole-sized podocarps are locally abundant.
Keywords: regeneration, podocarp forest, podocarps
22. Beveridge, A.E. 1986: Ecological research of the Indigenous Forest Management group at the Forest Research Institute, Rotorua, p. 18-26. - 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.*
Pureora Forest has been one of several central North Island forests where ecological work has been done since the mid 1950s, ancillary to the establishment of selective logging trials with emphasis on podocarp regeneration and autecology of tree species, and latterly on the vegetation and wildlife of ecological areas. Includes 26 references.
Keywords: ecological research, forest management trials, podocarp regeneration, autecology of trees, Ecological Areas - vegetation, Ecological Areas - wildlife
23. Beveridge, A.E., Bergin, D.O. & Pardy, G.F. 1985: Planting podocarps in disturbed indigenous forests of the central North Island. - *New Zealand Journal of Forestry* 30(1): 144-158.
Objectives and methods of establishing nursery-raised podocarps and tanekaha in partially-logged forest, scrub and open sites are outlined. The general aim is to restore a tall forest canopy, using species in the original

forest. Many thousands of seedlings have been planted out in Pureora Forest Park, in recent years with seedlings raised from local seed (earlier using potted wildtngs). At Pureora best first year growth of rimu (30-45cm in height increment) has been obtained with 5 year old planting stock potted in the fifth year in the nursery and planted in freshly-logged gaps on weed-free, disturbed ground near Pikiariki Ecological Area. Group-planted rimu and kahikatea in gaps in reverted cutover forest or partially-logged forest have reached 4-7m in height in 20 years, while tanekaha planted in gaps in kamahi pole stands or scrub has reached 8m in height during the same period. See also Guest 1985, Steward 1981, Steward and Bergin 1991, Steward and Pardy 1990.

Keywords: podocarp planting trials, group planting, disturbed sites, height growth

24. Beveridge, A.E. & Herbert, J.W. 1978: Selective logging trials and their implications for management of the West Taupo forests, 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. Three of the four trial areas are within Pureora Forest Park and were logged in 1961, 1975 and 1976, before logging in the Park ceased in 1983. The impact of logging on the ground and residual trees, mortality and regeneration aspects described here are the results of interim assessments and have been reported on further in other papers, including a review by Smale, Beveridge and Herbert (1998). [The Tihoi trial in dense podocarp forest (1975) is now part of a remnant of this forest type in the northern part of the Tihoi block]. The low density podocarp trial (1976) is part of several hundred hectares of partially-logged forest in the same block and contains exceptionally abundant and well-advanced regeneration of podocarps to pole size, sufficient to replace the present large, scattered podocarps. Vegetation succession on ground disturbed by logging is outlined. Prolific wineberry germinates in the summer after logging in West Taupo forests but starts to die back after 10-15 years, also the time taken for smaller logging debris to disintegrate [Epiphytic growth on head logs (or on fallen stems) and large branches include kamahi and broadleaf (future podocarp nurses) and podocarp seedlings, a few of which become terrestrial and continue growing].
Keywords: selective logging, West Taupo, Rangitoto-Hauhungaroa Ranges, logging impact, podocarps, regeneration, succession, forest management trials
25. Beveridge, A.E. & Herbert, J.W. 1989: Pureora Buried Forest. - Forest Research Institute (unpublished report). - Rotorua. 18 p.
In 1983 a forest buried by a pumice flow and ash falls of the Taupo eruption (c.130 AD) was discovered during draining operations. The boggy site is located within Pureora Forest Park, 2.5 km from the Field Centre. This report outlines the various management measures and scientific investigations carried out over the ensuing five years. A podocarp forest dominated by rimu and tanekaha had been blasted flat and remained well preserved in anaerobic conditions after burial. The composition of the buried forest, which is different from that of the adjacent present day forest dominated by matai and rimu, has been determined and also some of its invertebrate fauna. This report aims to give an overall picture of work undertaken. See also Clarkson et al. 1988, Palmer et al. 1988, Green 1987.
Keywords: buried forest, Taupo eruption, scientific reserve

26. Beveridge, A.E. & Pardy, G.F. 1980: Establishing nursery-raised native trees. - *What's New in Forest Research* 86: 1-4.
The methods used, results of plantings and characteristics of planted indigenous conifers that are outlined reflect experience with planting in Pureora Forest Park as well as on other upland sites in central North Island forests. Specific results for Pureora and Tihoi forests are mentioned. Nineteen years after planting of 13 tree-groups in gaps of selectively-logged forest in a Pureora management trial, better-grown specimens of totara and kahikatea were 3-5m tall and emerging from competing regrowth; only one release cutting was done at 15 years. Twenty years after line planting of totara and tanekaha in 4m tall manuka scrub in ecotones in Pureora Forest there was 80% survival but unseasonal frosts retarded the growth of both species. Tanekaha grew better (up to 6m in 15 years) in canopy gaps made in pole kamahi. [On freshly-cleared indigenous forest sites near Pikiariki Ecological Area, planted and among naturally-regenerated shrub hardwoods have proved to be suitable 'nurses' for planted rimu, kahikatea and totara]. See also Steward 1981, Guest 1985, Beveridge et al. 1985.
Keywords: podocarp planting, group planting, nurse plants, selectively logged forest, planting in scrub
27. Beveridge, A.E. & Smale, M.C. 1981: Seeding of native species, p. 31-38. - In: Chavasse, C.G.R. (ed.), *Forest nursery and establishment practice in New Zealand. Proceedings of Symposium No. 22.* - New Zealand Forest Service, Forest Research Institute, Rotorua.
This paper outlines the seeding characteristics of podocarps with information based mainly on central North Island forests and Pureora Forest in particular. Periodicity of seeding (recurring at intervals) is very marked in rimu. At Pureora rimu seed crops were closely observed over 20 years (1958-78) with heavy seedfalls enabling large collections of seed to be made for raising seedling in nurseries in 1958 (after a May storm) and 1978. Good seed crops of rimu (over 500 seeds per square metre), assessed by means of seed traps placed beneath seeding rimu, also occurred in 1962, 1965 and 1966.
Keywords: podocarp seed crops
28. Boyd, M.J. 1993: Conservation and management of New Zealand's indigenous forests - A selected bibliography 1848-1990. - M.J. Boyd, Auckland.
This bibliography lists 2,230 references and has an index of Keywords. Many items referring to the various forests now included in Pureora Forest Park may be found by using the Keywords 'Pureora State Forest Park', 'Hauhungaroa Range', 'Rangitoto Range', 'Tihoi State Forest', 'Waihaha State Forest', 'Hurakia State Forest', 'West Taupo State Forests' and in a broader context 'Volcanicity' and 'King Country'. Some 50 items are also annotated in the present bibliography. Marleene Boyd states that her bibliography does not contain many items already listed in the bibliography of New Zealand Forest Service publications compiled by Leamy and Hayward 1986 (annotated in the current bibliography).
Keywords: bibliography, conservation, forest management, indigenous forest
29. Brejaart, R. 1998: Rata-nu-nui forest condition. - Department of Conservation, Waikato Conservancy (unpublished report). - Hamilton. 12 p.
This report outlines the current condition of rata-dominant forest in the 922 ha Rata-nu-nui Ecological Area, Pureora Forest Park. A possum control operation was carried out in 1994, using aerial application of 1080 carrot bait. There was an early improvement in the condition of the northern rata but both rata and totara have declined during the past two years with an increase in trap-rate catch of possums. The understorey is in poor condition

through depletion of palatable species by deer. Annual monitoring of northern rata is done from aerial photography and ground viewing points. Monitoring methods for vegetation and browsing animals (deer and possums, goats being absent) are given in an appendix. There are recommendations for further monitoring and another possum control operation in 1999. The ecological area is a significant habitat for kakariki while kaka and New Zealand falcon are also present.

Keywords: forest condition, forest condition - monitoring, Rata-nu-nui Ecological Area, possum control, monitoring, aerial poisoning, browsing damage, northern rata, 1080

30. Brejaart, R. & de Monchy, P. 1998: Waihaha Forest Condition 1997/98 Field Season. - Department of Conservation, Waikato Conservancy (unpublished report). - Hamilton. 19 p.
- This report outlines the current condition of forest in the Waihaha Ecological Area and reviews past work to monitor browsing impact on vegetation and control of possums. Condition assessments have been made annually on indicator species on transects over four years since a large-scale possum control operation was carried out in winter 1994, using aerially-applied 1080 on carrot baits. Totara (*Podocarpus hallii* and *P. totara*) has declined in the year to 1997/98 (summer assessment), following possum control, while kamahi may also have declined. Aerial monitoring of totara indicated earlier improvement, then decline to a condition comparable with that before possum control. Ground sampling methods are described. The forest understorey is in 'poor to moderate' condition with little change over the past two years. Deer are preventing regeneration of palatable species. The ecological area is considered to be goat-free. One objective for the 1994 possum control operation was to improve the condition of totara, the species being highly preferred by possums. It is suggested that species more sensitive to possum impacts (such as mistletoe and *Dactylanthus*) should be added to species currently monitored, and that control of deer should be considered. Includes 22 references.
- See also Nugent et al. 1997.
- Keywords: forest condition, Waihaha, possum impact, totara, 1080
31. Broome, K. 1995: The impact of wild animals in Pureora North Block 1982-1993: a remeasurement of permanent plots and exclosures. - Department of Conservation, Waikato Conservancy (unpublished report). - Hamilton. 46 p.
- Vegetation trends are assessed over 12 years, following remeasurement of plots in 1993. Species preferred by possums, deer and goats have continued to decline. There has been substantial mortality of some possum-preferred species and an overall decrease in basal area of preferred canopy species. Plots were first established in 1975 after substantial change induced by browsing but forest condition has not improved since, despite frequent animal control measures (shown in maps of appendix). Seedlings palatable to deer and goats have remained scarce above a height of 45cm while unpalatable species have increased. This trend is reversed in fenced exclosure plots which show the diversity and abundance of preferred plant species in the absence of deer and goats. Graphs show stem density in understorey size classes for each ungulate-preferred and non-preferred species. Mean crown densities for possum-preferred species show severe depletion of some species. The report concludes that deer populations must be strongly reduced to allow adequate regeneration and that the level of control measures needed is in conflict with the objectives of a Recreational Hunting Area. There has been no funding for deer control and barely adequate funding for possum and goat control. Regular monitoring of indicator animal species as well as plant species is required for adequate

protection of the forest ecosystem. Appendices present data and maps on wild animal distribution and location of bird species recorded during surveys. Keywords: animal impact, vegetation assessment, permanent plots, exclosures, mortality - possum-preferred species, palatability, forest condition, stem density, deer impact, possum impact, vegetation trends, animal control

32. Broome, K. 1996: Waihaha forest condition 1996. - Waikato Conservancy, Department of Conservation (unpublished report). - Hamilton. 7 p.
The report outlines the current condition of vegetation and trends relevant to wild animal management, following a possum control operation in 1994. This operation resulted in a 1.5% residual catch rate and reduced deer numbers by 50%. Dramatic improvements in the condition of mahoe, (Hall's) totara and kamahi occurred between 1994 and 1995 and the improvement was maintained in 1996 when mahoe fruited for the first time. An appendix describes vegetation monitoring techniques - crown density scores, helicopter monitoring and ground assessments along standard routes. See also Broome 1997 and Brejaart & de Monchy 1998 (reporting a decline in the condition of totara and possibly kamahi).
Keywords: forest condition, Waihaha, possum control, vegetation monitoring, crown density
33. Broome, K. 1997: Waihaha Forest Condition 1997. - Waikato Conservancy, Department of Conservation (unpublished report). - Hamilton. 8 p.
Recent trends in vegetation condition and browsing animal numbers are given, following an extensive possum control operation in 1994 which achieved the objective of improved forest canopy condition. The rediscovery of mistletoe and *Dactylanthus* (by Landcare staff) is recorded. There is some indication that forest recovery has peaked. Vegetation monitoring techniques for animal control are outlined in an appendix. See also other reports on Waihaha Forest Condition: Broome 1996, Brejaart & de Monchy 1998.
Keywords: forest condition, Waihaha, possum control, vegetation monitoring
34. Broome, K. & Clegg, S.E. 1990: Wild animals and their impact in the Rangitoto Range and the Waipapa Ecological Area. - Department of Conservation, Waikato Conservancy (unpublished report). - Hamilton. 58

This report reviews past and current work to monitor the impact of deer, goats and possums on the vegetation in and near the North Block of Pureora Forest Park. Surveys have been done since 1974, using vegetation assessment in 20 x 20m permanent plots, animal population assessment of faecal pellet counts on transects and other methods. The usefulness of different methods is discussed and data are presented in a series of graphs and maps. A first account is given of changes in vegetation 5 years after establishment of 9 pairs of exclosure plots. Photos and descriptions are given of the vegetation in each plot, showing that there has been a marked increase in palatable species in the fenced plots. The report deals separately with the Rangitoto Range and the Waipapa Ecological Area. The history of wild animal introduction and spread is given. Both areas have populations of kokako and high wildlife values. The Rangitoto Range has had a longer history of goat populations and high populations of browsing animals. The Waipapa has been free from goats and possums are more recent arrivals [said to be in the 1970s but present from about 1960]. Records are given for hunting and trapping kills and maps show location of poisoning operations and animal distribution. The review concludes that deer populations are stable in the Waipapa but palatable species in the understorey of all forest types are at risk. It is predicted that species palatable to possums, e.g.,

kamahi as an important component of most forest types, are threatened with irreversible decline within the next 2-5 years. Further strong animal control measures are required, especially against possums in the Waipapa Ecological area. The report has a wide ranging list of 45 references. See also Llewellyn 1991 for comment on possum control.

Keywords: animal impact, animal survey, forest condition, permanent plots, exclosures, deer impact, possum impact, understorey vegetation, palatability, Waipapa Ecological Area, Rangitoto Range, animal control, vegetation assessment

35. Broome, K. & Krystyniak, S. 1985: Wild animals of the Hauhungaroa Ranges. - New Zealand Forest Service (unpublished report). - Auckland. 40 p.
This report aims to give an updated picture of the animal populations of the Hauhungaroa Range and the changes that have occurred in the previous 7 years. Results are based on monitoring the densities and distribution of deer, goats, possums and pigs, mainly by faecal pellet counts, but using all available information. Two intensive surveys were made in 1982/83 and compared with a similar survey in 1978/79. Methods are detailed and statistical tests applied. Density and distribution of animals are shown in a series of maps and figures with data stratified according to vegetation type, altitude and region. It was concluded that deer, goats and possums had increased their distribution and densities since 1978 and that methods of control (hunting, including recovery of deer by helicopter) had been unsuccessful. Deer had highest densities in podocarp/hardwood forest and lowest numbers in exotic forest but there was correlation with accessibility for hunters. Goats had slowly extended their range from the west (possibly along old logging tracks) but no viable goat populations were thought to be established in forests east of the divide. Possums had very variable densities and distribution with rapid changes. Pigs were in low numbers throughout. Recommendations include more recreational hunting, determining priority areas for animal control and requirement of a detailed animal control plan. See also Llewellyn 1991.
Keywords: wild animal - control, red deer, goats, possums, pigs, faecal pellet survey, Hauhungaroa Range, wild animal - monitoring, animal survey
36. Bull, P.C. 1952: Birds and mammals of Western Taupo. - New Zealand Science Review 10(6): 91.
In this brief outline the rich bird life is referred to, with comments that kiwi were now very rare or absent, and that once numerous wekas were not found in a survey of the project area. and were said to have 'all disappeared following the arrival of stoats in the region about 1912'. Of introduced birds only blackbirds, redpolls, thrushes and chaffinches were numerous and it is implied that magpies and mynas had not yet arrived. Opossums had a restricted distribution and hedgehogs had not been recorded. Includes map of the project area.
Keywords: West Taupo - birds, West Taupo - mammals
37. Burstall, S.W. & Sale, E.V. 1984: Great trees of New Zealand. - Reed, Wellington.
This book contains descriptions and measurements of two of the largest totara (*Podocarpus totara*) to be found in Pureora Forest Park, i.e., a tree of 333cm diameter in the Waihaha catchment, eastern Hauhungaroa Range, with photo of base of the tree (p. 120), and a tree found in 1980 of 282cm diameter on 'the northern slopes of the Hauhungaroa Range' (p. 12). Two other 'Great trees' listed are growing just outside the Park boundary: The 'Pouakani totara' with a diameter of 363cm, said to possibly be a veteran of the forest developed after the Taupo eruption (130 AD) and estimated to be about 1500 years old (pp 86-88 with photos of the trunk and the whole tree),

and a rimu of 253cm diameter on farm land adjacent to the Park (pp 118-119 with 2 photos).

Keywords: totara giants, Hauhungaroa Range

38. Calder, B. & Deuss, F. 1985: The effects of 1080 poisoning on bird populations in Motere, Pureora Forest Park, Winter 1984. - New Zealand Forest Service (unpublished report). - Auckland. 39 p.
Discusses results of monitoring bird populations before and after a 1080 aerial poisoning operation, applying wheat-based pellets to kill possums in a 1700 ha block of dense podocarp forest within the present Waihaha Ecological Area. The main monitoring method was 5 minute bird counts in the target block and a control block some 8 km distant with comparable but lightly-logged forest. Counting stations were located at average altitudes of 600-700m a.s.l. All data were subjected to statistical analysis and no significant reductions in bird populations of 20 species were detected from the 5 minute counts. Four dead birds (3 tomtits and one blackbird) were recovered by searchers. The counts included the more common forest birds and several species listed at medium or high risk; these included kaka, falcon and kakariki for which additional information was collected. Territory mapping was recommended for falcon (with 6 known territories in the park) and further research into the vulnerability of kaka to poisoning. The phenomenon of winter flocking with mixing of several indigenous bird species for feeding was observed (p19), including the mixing of kakariki and whiteheads, sometimes with bellbirds, fantails, tomtits, silvereyes and chaffinches.
Keywords: aerial poisoning, bird populations - monitoring, Waihaha, kaka, New Zealand falcon, kakariki, 1080
39. Calder, B. & King, D.R. 1986 a: Kaka and Kokako Survey -Pikariki Ecological Area distribution map. - Forest Research Institute, Rotorua.

Keywords: kaka, kokako, Pikariki Ecological Area, bird survey
40. Calder, B. & King, D.R. 1986 b: Observations on aspects of kokako biology and ecology. - New Zealand Forest Service, Forest Research Institute (unpublished report). - Rotorua.

Keywords: kokako - behaviour, Pikariki Ecological Area
41. Chavasse, C.G.R. & Johns, J.H. 1983: Pureora Forest Park, p. 62-71. - In: New Zealand Forest Parks - Government Printer, Wellington.
Contains a 'fact sheet', map, 3 colour photos and a brief essay of descriptive and historical nature. Mentions logging of native trees which ceased in 1983.
Keywords: Forest parks - Pureora
42. Clarkson, B.D. 1986: Botany of the Central North Island Volcanic Plateau, p. 28. - 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 only. Eight characteristic botanical features of the region are outlined, including comment on the monoao, kanuka and manuka scrub with typical associated flora, mainly fire-induced and largely converted to pines or pasture, open habitats with species of unusual distribution, and adventive species dominating waste land.
Keywords: Botany - central North Island

43. Clarkson, B.D. & Clarkson, B.R. 1984: Vegetation of central Hauhungaroa mires. - New Zealand Forest Service, Forest Research Institute FRI 31/6/17/6 (unpublished report). - Rotorua. 19 p. Includes maps.
Keywords: Hauhungaroa Range, Maramataha Ecological Area, pakihi mire, Waione - Mangatukutuku mire, Taringamotu mire, silver pine, species list - flora, Waihaha Reserve, Pureora Mountain, King Country East, Ongarue mire
44. Clarkson, B.D., Clarkson, B.R. & McGlone, M.S. 1986: Vegetation history of some West Taupo mires, p. 34-37. - 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.
An outline is given of an address based on vegetation surveys of seven mires within the Pureora Ecological District and Pureora Forest Park, and reconstruction of historical vegetation using macrofossil and pollen analysis. All the mires sit on a layer of Taupo pumice deposited 1850 years ago during the Taupo eruption which blasted flat shrubland and forest over the whole Hauhungaroa Range and left a landscape largely bare of vegetation. The pre-Taupo and present vegetation of mires and surrounds of shrubland and forest is described, along with past vegetation succession and probable future trends. Two mires in the Waipapa Ecological Area have charred logs of *Halocarpus bidwillii* on the peat surface, indicating that a former shrub mire was burnt by Polynesian fires. The buried forest mire near Pureora Village developed after the Taupo eruption destroyed a tanekaha-rimu forest with several species suggesting a warmer climate than now. Mires on the crest of the Hauhungaroa Range have silver pine in the shrub margins. After the Taupo eruption, colonising vegetation led successionaly on dry land to a shrubland with *Halocarpus bidwillii* and then *Phyllocladus alpinus*. Forest invasion began later with totara and matai prominent. It is estimated that within 450 years of the eruption, tall forest had returned.
Keywords: vegetation history, mire, Taupo eruption, Pureora, Hauhungaroa Range, Waipapa Ecological Area, colonisation hypothesis, West Taupo
45. Clarkson, B.R. 1984: Vegetation of three mountain mires, West Taupo, New Zealand. - New Zealand Journal of Botany 22: 361-375.
The vegetation pattern of three mountain mires in the upper Ongarue catchment, Pureora Mountain Ecological Area, is described and a species list presented for both vascular and non-vascular plants. Systematically-collected data were analysed by ordination and classification techniques. These showed a sequence from sedge-fernland through shrubland to forest along a gradient of increasingly better drainage. The largest mire of 15 ha at an altitude of 820m is concave in profile and has *Gleichenia dicarpa* dominant over most of the sedge-fernland growing on peat in the central part. Bog pine and mountain toatoa are common in the peripheral shrubland. A soil profile is presented, showing that the surface peat layer lies over Taupo pumice and an older woody peat layer. Thus it is suggested 'that a shrub mire dominated by bog pine, mountain toatoa, and possibly toatoa existed before the Taupo eruption'. Deteriorating drainage after the Taupo eruption possibly favoured the current herbaceous species.
Keywords: vegetation, mire, Ongarue River, West Taupo, Pureora Mountain Ecological Area, Hauhungaroa Range, peat, vegetation map, species list - flora, vegetation - classification, ordination - of vegetation data

46. Clarkson, B.R., McGlone, M.S., Lowe, D.J. & Clarkson, B.D. 1995: Macrofossils and pollen representing forests of the pre-Taupo volcanic eruption (c 1850 yr. BP) era at Pureora and Benneydale, central North Island, New Zealand. - *Journal of the Royal Society of New Zealand* 25(2): 263-281.
Forest at Pureora and Benneydale (20 km distant) was buried by the Taupo eruption of c.1850 yr. BP. This paper gives the results of analysing pollen and macrofossil (litter and wood) data from peat layers below the Taupo tephra on the two sites. The conclusion was that conifer/broad-leaved forest of similar forest type and species composition existed at each site. Tables in appendices give lists of species identified from pollen and macrofossil samples. There is a photo of the buried forest site at Pureora showing logs (mainly rimu and tanekaha) exposed along a ditch excavated through the wetland. See also Clarkson et al. 1988.
Keywords: macrofossils - litter / - wood, buried forest, pollen profile, Pureora, Taupo ignimbrite, Taupo eruption
47. Clarkson, B.R., Patel, R.N. & Clarkson, B.D. 1988: Composition and structure of forest overwhelmed at Pureora, Central North Island, New Zealand, during the Taupo eruption (c. AD 130). - *Journal of the Royal Society of New Zealand* 18(4): 417-436.
Draining of mires on the study site revealed a buried forest of tall podocarps dominated by rimu and tanekaha. Vegetation was systematically sampled 12-15 months after the discovery in 1983 of many large logs with only minor charring. From leaves, seeds and wood recovered, 40 vascular species were identified and their relative abundance recorded. Some plant macrofossils are illustrated. Classification and ordination techniques applied indicated that the forest was of one type with minor variations such as small areas of wetland. Comparison with adjacent present-day forest in the Pikiariki Ecological Area reveals some major differences. Matai and rimu dominate the nearby tall podocarp forest with tawa, mahoe and kamahi - species not recorded in the buried forest - common. Kiekie, *Gahnia xanthocarpa* and kaikawaka were present in the buried forest but are absent today from the Pureora district. [Kaikawaka occurs in the Whenuakura Clearing, in the south-east part of Pureora Forest Park - see Wallace 1988]. The Taupo tephra has improved soil aeration, drainage and fertility, and there has possibly been a deterioration in climate. Distribution of some species before and after the Taupo eruption is discussed, 40 references. Soil profile in Appendix.
Keywords: buried forest, Pureora, Pikiariki Ecological Area, Taupo pumice, plant macrofossils, podocarp, rimu, tanekaha, Taupo eruption
48. Clegg, S.E. 1986: Resurvey of Pureora North Block 1981/82. - New Zealand Forest Service (unpublished report). - Auckland. 47 p.
A second survey to assess forest condition in relation to impact of browsing animals (red deer and possums) was made in the summer of 1981/82. The aim was to detect changes in the vegetation since the first survey of 1974/75. Remeasurement was based on thirty-two 20x20 m permanent plots. Results indicate a 25 % reduction in the basal area of possum-preferred hardwoods and a virtual absence of ungulate-preferred woody species within the browse range of ungulates. A broad description is given of the 17,000 ha surveyed block containing the Mangatutu and Waipapa Ecological Areas. The methods of data processing and analysis are given. Eight computer-generated vegetation types were recognised, and are described in detail in an appendix together with graphs showing stem density by size class for dominant species of each type. A list of species palatable to deer and / or possums is given and data are analysed according to palatability of the species, with graphs showing changes in basal area for 16 species for the 7 year period of assessment. The kamahi / mahoe and high altitude forest types contain the

greatest proportions of possum-preferred species and are being rapidly modified. In discussion it is suggested that high intensity animal control should be applied in the Waipapa Ecological Area with the aim of maintaining its biological diversity. See also Clegg 1987.

Keywords: Waipapa Ecological Area, animal impact, palatability, vegetation types, basal area, red deer, pigs, possums, forest condition, vegetation assessment, permanent plots, survey

49. Clegg, S.E. 1987: Resurvey of the forests of Pureora North Block (seedlings and saplings), 1985/86. - Department of Conservation (unpublished report). - Auckland. 26 p.
This report is an extension of that by Clegg (1986) and updates the condition of understorey vegetation in relation to impact of browsing animals, mainly deer and possums with goats in localised areas. This is the third survey of vegetation in 20 x 20m permanent plots and follows those of 1974/75 and 1981/82. This assessment is confined to seedling and sapling density in 57 plots, using size classes within the browsing range of 16-135cm. Data for 1985/86 are presented graphically for comparison with those of 1981/82 and cover 15 palatable and 5 unpalatable species and various groupings of preferred and non-preferred species. Results showed that there had been little change in seedling/ sapling density overall in 4 years, an increase in the density of ungulate-preferred woody species in the Mangatutu and Waipapa hunting blocks that include the two ecological areas and (as in the previous survey) a virtual absence of ungulate-preferred species within the browse range of ungulates. New introductory information includes a brief history of more recent animal control measures in the North Block with some use of 1080 poisoning. Hunting and possum trapping statistics are given for the 5 hunting blocks based on catchments.
Keywords: animal impact, seedling/sapling - density, deer impact, possum impact, goats, vegetation assessment, permanent plots, forest condition, 1080
50. Clegg, S.E. 1990: Mires in Pureora Forest Park: an assessment of condition. - Department of Conservation, Waikato Conservancy (unpublished report). - Hamilton. 12 p.
A monitoring programme has been started to determine the impact of deer, weeds and humans on the Pureora mires, most of which are less than 10 ha in extent (ranging from 0.3 to 100 ha) at altitudes of 540-945m a.s.l. Aerial colour photos were taken and helicopter inspections made at all sites in 1990 with ground inspection at two sites. The condition, vegetation type and main botanical features of some 12 mires are described and comparisons made with earlier aerial photos and assessments. The Hauhungaroa mires are in better condition than the Waipapa mires where commercial hunting has been excluded and vegetation badly damaged by tracking/wallowing by deer and human tracking. Willow invasion may be a greater weed threat than introduced *Juncus* spp. Human impact at some sites includes camping and rubbish. Recommendations are made for annual field checks and measurements to preserve rare plant species.
Keywords: mire, fragile sites, weed invasion, Hauhungaroa Range, injurious agents
51. Clegg, S.E. 1991: Monitoring indicator communities in the Waipapa Ecological Area (Pureora Forest Park). - Department of Conservation, Waikato Conservancy (unpublished report). - Hamilton. 8 p.
This report gives the results of assessing possum and deer browsing impact on preferred species as a measure of monitoring the effectiveness of control operations by recreational hunters and aerial 1080 poisoning. Two forest types have been identified as constituting preferred habitats and in 1991 eighteen permanent 20 x 20m plots were established in these types within

the Waipapa Ecological Area. The two types were 'S 1' rimu - (lancewood/kamahahi scrub) and 'F2' (*Cyathea* - wheki-fivefinger forest). Canopy browsing by possum was evident in every plot and in F2 deer density was not low enough to allow highly-preferred species to survive within browse range. Tables summarise tree scores for browsing impact. Kamahahi and fivefinger were the most palatable species with some dead trees. Fuchsia was recorded dead in some plots of F2.
Keywords: Waipapa, indicator communities - monitoring, possum impact, deer impact, permanent plots, preferred habitats, animal impact, 1080

52. Compton, E.A. & Steward, G.A. 1993: Survey of regeneration in stands of *Pinus radiata* in the central North Island. - Forest Research Institute, Forest Technology Division Project Record No 3594 (unpublished report). - Rotorua. 22 p.

The composition and density of indigenous and adventive vegetation beneath *Pinus radiata* stands were assessed on three study sites, including 19 plots of first rotation pines in the Pureora North Block. (The other two study areas were in Mangatu and Gwavas Forests). The potential role for exotics in providing wildlife corridors with invading indigenous vegetation (e.g., for kokako at Pureora) is referred to. The Department of Conservation administers about 1000 ha of exotic forest within Pureora Forest Park, most of which is destined for conversion back to indigenous forest. In the Pureora North Block, five shrub-hardwood species are amongst the ten most common indigenous species in the pine stands: wineberry, karamu, narrow-leaved mahoe, fuchsia and lancewood. The other common species constituting ground cover are bracken, *Dicksonia squarrosa*, *Histiopteris incisa*, *Blechnum capense* and bush lawyer (*Rubus cissoides*). A full list of indigenous species in the pine stands is given in an appendix. The comment is made that further plots could be placed in the southern block of Pureora Forest [where site preparation methods were difficult, resulting in a more intimate mixture of planted conifers and residual indigenous forest; abundant regeneration of totara, matai and kahikatea with some rimu occurs beneath thinned Douglas fir stands and the lighter canopies of Corsican pine and eucalypts near shrub ecotones and podocarp high forest].

Keywords: regeneration survey, indigenous species, *Pinus radiata* stands, Pureora

53. Crawley, M.C. 1981: Studies of the kokako, forest bird populations and vegetation in some central North Island indigenous forests: summary report and recommendations. - New Zealand Wildlife Service, Kokako and Forest Bird Research Co-ordinating Committee - Wellington. 41 p. Brief accounts are given of the aims, methods, results and conclusions of studies (from September 1978 to September 1981) by members of the Forest Bird Research Group. Separate annotations in this bibliography are given for the detailed reports on the three research projects: Hay, 1981 on kokako; Harrison and Saunders, 1981 on forest bird populations and Leathwick 1981, on the vegetation. These reports have 550 pages of text with many tables, graphs, references and appendices, so this summary report gives a convenient, concise account of the three studies and recommendations resulting from the work. An outline is given of background information leading to the formation of the Forest Bird Research Group and the Kokako and Forest Bird Research Co-ordinating Committee in 1978. The basic objectives of the study were:

1. to investigate the habitat requirements of the kokako and the impact that selective logging may have on it;
2. to assess the impact of selective logging on forest bird populations in general.

The kokako studies were undertaken in a 40 ha block of unlogged podocarp forest, now in the Pikiariki Ecological Area, and in several areas in north

Pureora, in both selectively-logged forest and unlogged forest. (The other kokako study areas were in Mapara and Rotoehu Forests). One of the 3 study areas for bird populations was a 670 ha area of podocarp/tawa forest in north Pureora, containing both freshly selectively-logged and unlogged forest as a control. (The other two study areas were in Whirinaki Forest). In the vegetation study, forest structure and species composition was assessed in logged and unlogged forest and studies were made of the phenology of many plant species and the diet of possums for comparison with the diet of kokako (Pikiariki and Mapara). Major findings for the 3 general studies are given in the summary report; for kokako on foods and feeding behaviour, population parameters, effects of selective logging and competition from possums; for bird populations at Pureora there were differences in counts for 5 species between logged and unlogged forest but 'overall no significant differences in bird numbers directly attributable to selective logging were found'. For the vegetation study two papers have been published, i.e., on phenology findings (Leathwick 1984) and confirmation of the overlap between the diets of kokako and possums (Leathwick et al. 1985). Both these papers are annotated in the present bibliography, also a summary of the kokako study (Hay 1984). [A number of the recommendations listed in the summary report have been implemented over the past 20 years: cessation of logging in Crown forests; extension of the Waipapa Ecological Area to include more virgin forest; control of browsing mammals and predators in areas of high kokako density; periodic monitoring of kokako populations and vegetation; research on the ecology of some mobile or long-lived bird species such as falcon, kaka, parakeet and native pigeon].

Keywords: forest bird research, kokako - research, bird populations, Forest Bird Research Group, kokako - habitat, selective logging impact, vegetation assessment, forest structure, forest composition, phenology, possum - diet, kokako - diet, competition - browsing mammals, predator control, bird ecology

54. Crook, I. G. 1971: Will kokako survive in the North Island? - *Wildlife: a Review* 3: 35-38.
Annotated on p14 of the Kokako Bibliography (Poulton 1985). The paper implies that the query in the title may be answered by adequate reservation of prime habitat and control of browsing animals that compete for food with the kokako. The paper was written at an early stage of study of the behaviour and feeding habits of kokako and the threat of predators is mentioned. Pureora is mentioned as the major habitat of kokako in the forests of West Taupo.
Keywords: kokako - survival, habitat reservation, browsing animal control, West Taupo
55. Crook, I.G. 1973: Forest Survey. - *Wildlife - a Review* 4: 37-41.
Annotated on p 14, Kokako Bibliography - very brief. Mainly discusses problems of forest fauna survey, particularly those of conspicuousness and behaviour of different bird species when assessing abundance. The distribution of yellow-crowned parakeets is shown in a figure indicating presence or absence in 1000 yard squares of the national grid for West Taupo State Forests; as this species moves in flocks over large areas the real distribution may be greater. A table presents data for the average number of bird pairs per station for kokako, robins and yellow-crowned parakeets in three types of podocarp forest (types L1, M1, M2).
Keywords: bird survey, parakeet - yellow crowned

56. Crook, I.G. 1975: A survey of Hurakia State Forest (State Forest 97). - New Zealand Forest Service, Fauna Survey Unit 5 (unpublished report). - Wellington. 7 p.
Surveys of Hurakia Forest in October 1971 and May 1975 'show that the wide variety of cutover forest and unlogged forest and scrub communities in the area support a rich bird fauna in which all native forest-dwelling species found on the North Island mainland are represented with the apparent exception of the kokako'. In the 1971 survey of unlogged high altitude parts, small numbers of kaka were recorded and blue duck were found in several streams. The 1975 survey was done in autumn in more representative, lower altitude parts, with variable topography and diverse vegetation over a wide variety of forest and scrub communities resulting from logging at various intensities. The survey used five minute bird counts at systematically-placed stations in mainly cutover forest. Five survey blocks (shown in a location map) were recognised from Piropiro in the north to Waikoura in the south and a number of forest types are described, including tawa/rata, pole podocarps and tanekaha, podocarp forest with some large tanekaha, tawa/podocarp forest, types ranging from relatively undisturbed to heavily cutover. No blue duck were found in the lower reaches of several streams but kiwis were heard in the southern part of the forest. Fernbirds were found in clearings along the Waikoura Stream. A table lists numbers of bird per station for 11 species in different blocks. Totals of 7.4 - 9.4 birds were found per station with bellbirds the most frequent species (1.9 - 2.4 birds per station). The table includes parakeets (0.1 - 0.3 per station) in four blocks and rifleman (0.1 - 0.2 birds) in four blocks. There was a strong population of robins (up to 0.7 birds per station) in the southern blocks. Kokako were not found.
Also in FRI library, report no. 31/6/2/7 dated 5.7.75.
Keywords: Hurakia Forest, Piropiro Ecological Area, Waione, Waikoura, King Country East, bird populations, bird survey
57. Crook, I.G., Merton, D.V. & Moran, L.R. 1971: Distribution and habitats of native bird species in indigenous State Forests of the Rotorua and Taupo Districts. - Indigenous Wildlife, Fauna Survey Unit, New Zealand Wildlife Service, Department of Internal Affairs 1a - Wellington. 8 p.
This report includes most of what was then known of the distribution and abundance of kokako in central North Island forests, also the habitat requirements and behaviour of kokako. Pureora and Tihoi (including Waihaha) forests feature largely in the figures which are mainly distribution maps for threatened species, including parakeets and kaka. The use of tapes to record kokako song is described. [The two areas in Pureora Forest identified as of outstanding wildlife interest are now included in the Waipapa and Pikiariki Ecological Areas of Pureora Forest Park.] Large populations of yellow-fronted parakeets were recorded from Pureora and Tihoi with some red-fronted parakeets occurring at Pureora. Reserve establishment and management are discussed and research investigations suggested, including competition for food of kokako by ungulates and possums. Includes 18 figures. Annotated also in Poulton 1986:15.
Keywords: bird survey, threatened species, kokako, kokako - habitat, kokako - behaviour, kokako - research, kokako - review

58. Crook, I.G., Moran, L.R. & Lavers, R.B. 1972: Distribution and habitats of North Island kokako with particular reference to State Forests of West Taupo. - Indigenous Wildlife, Fauna Survey Unit, New Zealand Wildlife Service, Department of Internal Affairs 1b - Wellington. 4 p. Annotated in Kokako Bibliography, Item 16 (Poulton 1986). Pureora Forest Park contains the West Taupo State Forests referred to as being of "outstanding wildlife interest" where a biological reserve should be considered.
Keywords: kokako - distribution, kokako - habitat, West Taupo
59. Crook, I.G.I., C 1978: The Kokako. - Forest and Bird No 208: 13-16. This is a general paper on the history, distribution and habits of the kokako, including West Taupo as the location of some of the largest kokako populations. Tawa appears to be a species "of primary importance in the habitat of the kokako . in the West Taupo forests"; a study of kokako movements indicated the role of tawa in the structure of the forest, providing a ladder from understorey to podocarp crowns or the tallest trees.
Keywords: kokako - review
60. Dale, R.W. 1975: An animal and vegetation assessment of the Rangitoto Range. - New Zealand Forest Service (unpublished report). -Auckland. 48 p.
This large report gives results of an intensive survey over 31,000 ha of indigenous forest that includes the north block of Pureora Forest Park and also outlying forests to the north and west of the Park. The study is introduced by accounts of climate, soils, geology and volcanic activity, survey objectives, survey design, sampling procedure and data analysis. The main objective of the survey was to assess the impact of introduced mammals on the forests of the Rangitoto Range and to relate this impact to current animal population densities. Sampling was done along transects (marked on a location map) with 'constant count vegetation plots' and permanent 20m square plots along selected transects. 28 of the permanent plots are in unlogged or less modified forest in Pureora Forest Park. Animal densities were calculated from faecal pellet counts on plots for deer, goat, pigs and possums. Podocarp trees and regeneration densities were assessed from plot data. In the section on composition and condition of the forests, five broad forest types are recognised and described, viz.
1. podocarp/tawa/broadleaf
 2. tawa/mixed broadleaf
 3. mixed broadleaf/scrub hardwood
 4. fire-modified kamahi/rewarewa/scrub hardwood
 5. higher-altitude forest
- In a discussion of the impact of browsing animals, one of the main areas of concern referred to are the upper slopes of the Ranginui and Rangitoto blocks where depletion of canopy and ground vegetation are occurring. The logging history of blocks within the north block of Pureora Forest Park is outlined from 1939 (Ngaroma) to the present day (Okahukura Valley). The vegetation of logged areas is described. In the section on animal management, the history of animal liberations and animal control is reviewed and maps show the distribution and densities for possums, red deer and goats by animal management blocks with supporting tabulated data. The forest of the Waipapa catchment [now substantially the Waipapa Ecological Area] was the least modified forest area. It was concluded that there is severe animal modification and depletion of the forests of the Rangitoto Range but the situation is affected by much variation in animal population densities, topography, forest type and the degree of modification by man. Detailed forest type data are given in the appendices. Includes 14 appendices, many figures and tables.

Keywords: animal survey, vegetation survey, Rangitoto Range, browsing damage, animal populations, forest depletion, permanent plots, Waipapa

61. Dale, R.W. 1978: Forest and shrub type vegetation, p. 25-33. - In: New Zealand Forest Service (ed.), King Country Land Use Study: Technical Reports - Land Use Series No. 3. - New Zealand Department of Lands and Survey, Wellington.
Reports on a vegetation survey undertaken to prepare a forest and shrub type map for the region of the King Country Land Use Study which includes the present Pureora Forest Park containing most of the unlogged indigenous forest of the study region on the Rangitoto and Hauhungaroa Ranges. Vegetation maps were produced from the most recent aerial photos after field inspections and an intensive survey to collect data from line plots. The maps show the distribution of 10 broad forest types and 7 shrub types. These types are updates of Nicholls' revised classification of North Island indigenous forests (1976) with local detail, and are described with an indication of their distribution over the survey area. Survey methods are outlined.
Keywords: vegetation types, vegetation survey, King Country East, vegetation map, land use
62. de Monchy, P. 1998: Condition assessment of an *Ilex micranthus* population in Pureora Forest Park 1997/98 field season. - Waikato Conservancy, Department of Conservation (unpublished report). - Hamilton. 8 p.
A population of this mistletoe species was discovered near the Waimonoa Ecological Area, Pureora Forest Park in 1997 with hinau appearing to be the main host. Foliage cover of 40 mistletoes on 12 hinau trees was monitored and found to be in good condition. Reasons for decline of mistletoes are discussed; browsing by possums is suggested as one cause but there could be other factors. Possum control by aerial application of poison baits was carried in 1993 and 1997 with trap-catch monitoring of possums indicating low density.
Keywords: *Ilex micranthus*, mistletoe, Waimonoa Ecological Area, mistletoe decline, possum impact, aerial poisoning
63. Department of Conservation 1990: Pureora Forest Park: Hut and track information brochure. - Department of Conservation, Te Kuiti.
Besides the recreational information in this brochure the maps show the location of 10 ecological areas, stream catchments and sites of special scientific and historical interest, including the buried forest blasted down by the Taupo eruption of 130 AD and a forest observation platform, both in or near the Pikiariki Ecological Area. References are given to relevant topographical maps: NZMS 260 series (1:50,000) S16, S17, S18, T16, T17, T18.
Keywords: huts and tracks, recreation, Ecological Areas - map
64. Department of Conservation 1994: Waihaha Environmental Impact Assessment Report. - Department of Conservation, Waikato Conservancy (unpublished report). - Hamilton. 10 p.
Report on a proposal to aeriually treat Waihaha Ecological Area with 1080 carrot baits for possum control. 'Environment protection and enhancement procedures' are outlined for a proposed treatment area of 19000 ha in Pureora Forest Park, including the whole of the Waihaha Ecological Area. The proposed operation was to be carried out by helicopter in winter 1994 with the object of reducing possum populations to a sufficiently low level, enabling retention of vegetation diversity and suitable bird habit. Descriptions are given of topography, soils, vegetation and wildlife in the Waihaha Ecological Area, called the finest dense virgin podocarp forest

remaining in the North Island. There is a brief history of possum liberation, spread, control and impact on vegetation. Several aerial poisoning operations have been carried out since 1983. Species heavily browsed by possums include the two species of totara (suffering dieback), kamahi, *Pseudopanax* spp, mahoe and fuchsia. Techniques to achieve possum control are discussed and carrots are the preferred baits for 1080. Non-target birds 'of concern' in the Waihaha Ecological Area include kokako, kaka, kakariki, kiwi, kereru, blue duck and robin. There have been few recent records of kokako and kiwi but surveys and monitoring of some species are referred to and risks of 1080 poisoning to wildlife assessed. It is concluded that the possum control operation in the Waihaha Ecological Area will achieve significant conservation gains. Annual aerial photographs of totara crowns will be taken to assess effectiveness of possum control. Keywords: environmental impact report, Waihaha Ecological Area, aerial poisoning, browsing damage, 1080

65. Department of Conservation 1996: Totara Walk, Pureora Forest Park. - Department of Conservation, Waikato Conservancy, Hamilton.
A popular account for visitors walking along an 800m track through dense podocarp forest near the Pureora Field Centre. Features to be seen at 12 numbered stations are described, including trees of totara, matai, miro, rimu and kahikatea. The booklet contains a number of drawings of items described.
Keywords: totara walk, Pureora, recreation
66. Deuss, F. 1981: Animal survey 1980: Pureora State Forest Park. - New Zealand Forest Service (unpublished report). - Auckland. 31 p.
A combined presence/absence and point-distance pellet survey was carried out in the summer of 1980-81 to assess relative densities of deer, possums and goats in the North Block of Pureora Forest Park. The aim of the survey was to provide information to enable sound management of the National Recreational Hunting Area. Comparison of results were made with a previous survey in 1974. The general deer distribution pattern has not changed. Possums have concluded their colonisation of the area and have generally increased their density. Goats were not found in the Waipapa Ecological Area but were numerous in the north-western area. Pig numbers were low. Animal densities were mapped in broad vegetation types and management units. The possum distribution pattern is similar to that of deer.
Keywords: animal survey, deer distribution, deer density, possum distribution, possum density, animal trends
67. Deuss, F. 1986: Browsing mammal /vegetation survey, p. 50. - 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.
Current Research abstract. Surveys of browsing animal populations and their impact on the Pureora Park vegetation have been made since 1974. Assessments have involved faecal pellet surveys for animal populations with 20 x 20m permanent plots and enclosure plots for vegetation monitoring. The future aim is to express the objectives of animal control in terms of the health and vigour of key indicator species for palatable plants and rare birds.
Keywords: browsing mammals, vegetation monitoring
68. Druce, A.P. 1952: The vegetation of Western Taupo. - New Zealand Science Review 10(6): 89-91.
An outline of vegetation types developed under the influence of ash showers and topography, mainly in a relatively harsh environment. Different types of

succession have resulted from burning. Water-washed pumice of frost flats have *Dracophyllum subulatum* scrub and silver tussock and vegetation is subject not only to frost but also physiological drought which causes dieback of manuka on the fringes of such areas. Ecotones between podocarp/broad-leaved forest and other types of vegetation at the main forest boundary and around islands in clearings, such as the Whenuakura Plains, show forest advance in narrow belts in the recent past and this pattern of 'lineal ecotones' is opposed to 'mosaic' ecotones with *Phyllocladus* spp. Each type of ecotone produces different forest types and each forest type 'has its own distinctive ecotone'. It is stated that "no extensive regeneration of podocarps can be expected on land that has already had podocarp forests on it for some time" [but the study area did not include the more northern areas such as the Tihoi block and north Pureora where cyclic regeneration has been described (Herbert 1978, Beveridge 1978)].

Brief accounts of the soils (Baumgart) and the mammals and birds (Bull) are included as part of 'The Western Taupo Project' in the same issue of the New Zealand Science Review and are followed by summing up and conclusions (ACS Wright) and a discussion reported (p. 92 and 93).

Keywords: vegetation types, West Taupo, ecotones, succession, fire succession, ash showers

69. Druce, A.P. 1972: Higher plants (lycopods, ferns, gymnosperms, flowering plants) of Whenuakura Clearing and surrounding forest, Whanganui River, Hauhungaroa Range, West Taupo. - Botany Division, Department of Scientific and Industrial Research (unpublished report). - Wellington.

Keywords: species list - flora, Whenuakura Clearing, Whanganui Stream, Hauhungaroa Range

70. Druce, A.P. & Clarkson, B.R. 1983: Indigenous higher plants (Psilopsids, lycopods, ferns, gymnosperms, flowering plants) of Mt Pureora, Hauhungaroa Range, West Taupo, 2,300 - 3823 ft (700-1170m). - Botany Division, Department of Scientific and Industrial Research (unpublished manuscript). - Wellington. 5 p.

A list of 230 species based on visits from 1959 - 1983.

Keywords: species list - flora, Pureora Mountain Ecological Area

71. Dugdale, J.S. 1986: Insects of the central North Island, p. 29. - 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.

Abstract of regional overview. The central North Island has many endemic species, most still undescribed. New species and new locality records are continually being found. Volcanism has produced subfossil deposits dating from before the advent of the Polynesian rat and "this enables us to gauge the effects of *Rattus* on certain faunal elements".

Keywords: insects, subfossils

72. Ecroyd, C.E. 1988: *Pittosporum turneri* at Whenuakura Clearing. - Rotorua Botanical Society Newsletter 15: 44-48.
Between 500 and 1000 individuals of the rare shrub *Pittosporum turneri* grow at Whenuakura Clearing in Whenuakura Ecological Area in southern Pureora Conservation Park, apparently the second largest population after that at Erua. It may be the most viable and secure population left. [Another grew in the ecotone on the edge of the Maraeroa block west of Pureora Forest village until destroyed by forest clearance in the 1970s.] Some plants with adult foliage were flowering in mid November whereas flowering in this dioecious

species that has juvenile foliage has rarely been observed. Capsules and cotyledonary seedlings were also observed. Flowering occurs on younger plants than previously recognised and is either uncommon or the species is relatively short-lived.

Keywords: *Pittosporum turneri*, Whenuakura Ecological Area

73. Ecroyd, C.E. 1993: In search of the Wood Rose. - *Forest and Bird* 267: 24-28.
A detailed description is given of this fully parasitic flowering plant classed as "vulnerable" as a threatened species and now recorded mainly in central North Island in secondary forest, including Pureora Forest Park. At Pureora infrared photography showed that short-tailed bats frequently feed at night on the abundant nectar produced by both male and female plants and thus act as pollinators. Kiore on Little Barrier Island feed on the flowers and ship rats at Pureora visit the flowers. Possums eat the flowers which can be effectively protected by wire mesh which admits entry of the bats. The "wooden roses" refer to the swollen junction between host plant and the inflorescences of *Dactylanthus* that produce objects of beauty [previously removed in quantity from Pureora Forest for collectors]. For a fuller account see Ecroyd 1996. Includes 8 photos of *Dactylanthus taylorii*, distribution map.
Keywords: *Dactylanthus taylorii*, Wood rose, possum impact
74. Ecroyd, C.E. 1996: The ecology of *Dactylanthus taylorii* and threats to its survival. - *New Zealand Journal of Ecology* 20(1): 81-100.
This is a comprehensive account of the root parasite *Dactylanthus taylorii*, compiled from 37 study sites over the range of the plant's distribution in the North Island. Three of the study sites are in Pureora Ecological District at 560m a.s.l. and data from them are presented in five tables. Time lapse video monitoring at a Pureora site recorded short-tailed bats feeding on the nectar of *Dactylanthus* flowers and there is evidence that the flowers are adapted for pollination by bats. Rats frequently visited the flowers and occasionally destroy them. Possums browse and destroy most unprotected inflorescences. See also Ecroyd, 1993.
Keywords: *Dactylanthus taylorii*, ecology, threatened plants, conservation, bats - short-tailed, possums
75. Edmonds, A.S. 1978: Pureora Forest - What next? The fate of the West Taupo indigenous forests. - *Environment News* May: 2-3.
The question of whether further logging should be allowed in the remaining virgin forest of West Taupo has become a strongly-debated environmental and political issue. Logging at Pikiariki Ecological Area, Pureora, was suspended following the action of tree sitters in January 1978. The papers to be presented at a March meeting for a Taupo seminar on management proposals for the West Taupo State Forests of the Rangitoto and Hauhungaroa Ranges (New Zealand Forest Service 1978) are listed and are to be made available for the public.
Keywords: Pureora Forest - management, indigenous forest policy, Pikiariki Ecological Area, logging cessation, Taupo Seminar
76. Edmonds, A.S. 1983: Pureora Forest Park - the conservation view. - *Forest and Bird* 223: 14-17.
An oft-repeated plea expressing the general view of conservationists and many of the interested public that logging should cease in central North Island State Forests [which occurred in 1984. New Zealand Forest Service plans, including the last King Country Regional Management Plan, 1983-1993, (see New Zealand Forest Service 1984) were never implemented].
Keywords: Pureora Forest Park, conservation, logging cessation

77. Fechny, T.M. & Meenken, D.M. 1991: A survey of North Island kokako (*Callaeas cinerea wilsoni*) in the Waipapa Ecological Area, Pureora Forest Park, New Zealand. - Department of Conservation, Waikato Conservancy (unpublished report). - Hamilton. 22 p.
The southern third (1300 ha) of virgin forest of the Waipapa Ecological Area was surveyed for North Island kokako during the summer of 1990-91. A total of 34 kokako territories were located with pairs of birds on 17 territories. Seven juveniles were found. The study area consisted of easy terrain at 500-600m a.s.l. with rimu/tawa forest predominant. Two 'walk through surveys' along 20 transect lines marked at 300m intervals were made from dawn to mid morning in January and March. Tapes of kokako calls were played at 250m intervals. The territories of 10 pairs of birds were mapped, as well as the location of all birds. Few kokako calls were made in response to tapes after 9 am. The density of kokako territories (at 0.026/ha) over the survey area was lower than a 1979 survey over 90 ha of the same study area.
Keywords: kokako - survey, Waipapa Ecological Area
78. Field, D.A. & Robinson, E.D. 1978: (a) Management proposals for State Forests of the Hauhungaroa-Rangitoto Ranges
(b) Production forestry potential in the State Forests of the Hauhungaroa-Rangitoto Ranges, p. (no continues 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.
These two papers may be considered together. Written at a time when New Zealand Forest Service foresters were modifying their views on management of the indigenous forests as a result of policy changes and pressure from the interested public and environmentalists against the logging of state indigenous forests, the papers are still mainly concerned with timber resources, sawmill commitments and continued controlled selective logging to produce a small volume of podocarp and tawa wood. There is some coverage of protection, recreation and vegetation types as well as production, and management zones are shown in a map. The logging history of different forests is outlined, and also surveys (paper (b)) to assess regeneration as well as wood volume and forest condition, past management practices and research work. In a discussion on possible management of tawa (paper (a)) it is stated that these forests contain 12,500 ha of 'closed' and 'open' canopy tawa as hardwoods remaining after logging of podocarps at various intensities. In paper (b) scrubland vegetation is considered as a special type owing to its capacity for developing into high forest. In a discussion on forest ecology (paper (b)) six forest classes are recognised. It is noted that presence or absence of tawa 'is believed to have important implications for the distribution and abundance of some birds and for the success or failure of podocarp regeneration'.
Paper (a) includes 3 maps.
Keywords: forest management options, Rangitoto-Hauhungaroa Ranges, logging history, selective logging, vegetation types, regeneration survey, scrub, Taupo Seminar

79. Fitzgerald, A.E. 1984: Diet overlap between kokako and the common brushtail possum in the central North Island, New Zealand., p. 569-573. - In: Smith, A. & Hume, I. (eds.), Possums and Gliders - Australian Mammal Society, Sydney.
This is a shorter account of the marked overlap in diet between kokako and possum than that in the paper of Leathwick et al. (1983). The two study areas were Mapara and Pureora Forests (Pikariki Ecological Area). For the Pureora study a table lists 16 plant species with leaves, fruit or flowers eaten by kokako (42% of diet from 8 species). Of these 16 species, 9 were also eaten by possums, with leaves identified by faecal pellet analysis. Food species favoured by both kokako and possums were mahoe, *Pseudopanax* species and supplejack. Only leaf diet of possum could be identified in this study but other studies have shown that possums eat leaves, flowers and fruits of many of the plant species eaten by kokako. During the study period (1979-1981) tawa leaves were included in possum diet and to a lesser extent in kokako diet.
Keywords: possums, kokako, kokako - habitat, kokako - diet, competition
80. Forest Research Institute 1975 a: Podocarp regeneration survey, Tihoi Forest, p. 23-24. - In: New Zealand Forest Service (ed.), Annual report of the Forest Research Institute, Rotorua, for 1974 - New Zealand Forest Service, Wellington.
The area surveyed, in the catchments of the Kakaho and Waimonoa Streams, is unique in the abundance and distribution of podocarp advance growth. A bar graph shows size class distribution of podocarps in the Kakaho catchment. There is adequate replacement of existing mature trees, a feature not often found in North Island podocarp forests. See Herbert 1977 for a fuller annotation.
Keywords: podocarp regeneration survey, Tihoi Forest
81. Forest Research Institute 1975 b: Tree stability in podocarp/tawa forest, Pureora, p. 22-23. - In: New Zealand Forest Service (ed.), Annual report of the Forest Research Institute, Rotorua, for 1974 - New Zealand Forest Service, Wellington.
Tree losses in the period 1959-1973 were assessed in a 1961 selectively-logged trial in Pureora Forest. Trees were tagged in virgin forest two years before selective logging of two blocks with a third block left as an unlogged control. Loss of merchantable trees in the three blocks was consistent at 6% of 625 trees in the control and 6% of 644 trees remaining after selective logging (a loss of 0.43% of all trees / year). The total number of dead and 'moribund' trees over 14 years was 78, of which only 4 were uprooted; 37 trees had stems snapped beneath the crowns or died standing and 37 appeared moribund* or had badly-damaged crowns. The loss of 51 rimu, the predominant tree, amounted to 8% of the original trees whilst 3% of tawa trees were lost.
[*: The podocarps were aged mainly between 500 and 700 years and an element has become senescent with storm-battered crowns and extending basal and stem rots. Most of the podocarp trees assessed as 'moribund' in 1973 were found to have died by the next assessment of tree mortality in 1980. See Parry 1981, 1982; Forest Research Institute 1982 a].
Keywords: tree stability, selective logging trial, podocarp/tawa forest, tree mortality

82. Forest Research Institute 1976: A selective logging trial in dense podocarp forest, Tihoi, p. 20-22. - In: New Zealand Forest Service (ed.), Annual report of the Forest Research Institute, Rotorua, for 1975 - New Zealand Forest Service, Wellington.
This was a first attempt to selectively log dense podocarp forest in the central North Island, in an area destined for clear felling. An aerial photo shows the experimental area of 3 blocks, comprising removal of 55% and 30% of timber volume and the unlogged control. Logging damage was assessed in terms of ground disturbance, slash deposits and damage to roots, stems and crowns of residual trees. Full accounts are annotated for Herbert 1980, and Herbert & Beveridge 1977; see also Parry 1987.
Keywords: selective-logging trial, Tihoi Forest, dense podocarp forest, tree damage, ground disturbance
83. Forest Research Institute 1979: The rimu seed crop in 1978, Central North Island forests., p. 24-25. - In: New Zealand Forest Service (ed.), Annual report of the Forest Research Institute, Rotorua, for 1978 - New Zealand Forest Service, Wellington.
Most observations were made in Pureora Forest during autumn 1978 when the best rimu seed crop for 10 years was experienced in central North Island forests. The bulk of sound seed fell during periods of strong winds in mid-April and early May. During calm periods most falling material consisted of ripe receptacles detached from the seed and split seed coats, indicating the extent to which finches were eating seed contents. Whiteheads and silvereyes were confirmed as dispersers of rimu seed, in addition to bellbirds and tuis. The best method of seed collection was to place nylon-mesh sheets, raised from the ground, beneath large, emergent free crowns of fruiting rimu (a dioecious species) in podocarp/tawa forest. A single tree in Pureora forest produced 5000 sound fallen seed per square metre and an estimated crop of 2 million seed. Frequent collection from sheets is required as ship rats feed on fallen seed and possums eat fleshy receptacles, some with seed attached.
Keywords: rimu, seed crops, seed destruction, seed collection
84. Forest Research Institute 1982 a: Tree stability in podocarp/tawa forest, Pureora, p. 14-15. - In: New Zealand Forest Service (ed.), Annual report of the Forest Research Institute, Rotorua, for 1981 - New Zealand Forest Service, Wellington.
In the summer of 1980/81 a further assessment was made of tree mortality in a trial selectively logged in 1961 with an unlogged control (see Forest Research Institute 1975 b for 1973 assessment). Over the whole trial area 36 podocarps had been lost by the 1973/74 summer, in the categories of uprooting, stem breakage below the crowns, or natural senescence. By 1980, 93 podocarps had been lost with 24% uprooted, 36% with snapped stems and 40% dead standing. There were no substantial differences in the percentages of podocarp trees lost over the period of 21 years (between first measurement and the 1980 assessment) in each of the two selectively-logged blocks and the control block (6.9%, 8.3% and 9% respectively). Over the 21 year period, mean annual diameter increment of mature podocarp trees was in the range of 1 to 1.5 mm. Replacement of dead podocarps depends on their mode of death, with existing tawa occupying the space left by standing dead trees, or ferns and hardwoods invading after windthrow or windbreak.
Keywords: tree stability, selective logging trial, podocarp/tawa forest, tree mortality, Pureora
85. Forest Research Institute 1982 b: Totara dieback. - What's New in Forest Research 110: 1-4.
A study of totara dieback was carried out by regular monitoring of trees in the Tihoi block of Pureora Forest Park. The unhealthy appearance of many totara is considered to be the result of large-scale bud and shoot deaths. A

number of insect and fungal species which can damage totara buds and shoots were identified but none could be conclusively determined to be the causal agents of the dieback. [See also annotation for the study by Nugent et al. 1997, where the foliage of Hall's totara in Waihaha Forest was found to be the main food item of possums and many trees were dead or dying]. Includes photo of totara at forest edge showing dieback.

Keywords: totara dieback, Tihoi Forest

86. Forest Research Institute 1983: Experimental predator control at Pureora, p. 10. - In: New Zealand Forest Service (ed.), Annual Report of the Forest Research Institute, Rotorua, for 1982 - New Zealand Forest Service, Wellington.
Previous work in central North Island forests with kokako found that predation of kokako eggs and nestlings was severe. This account outlines establishment of a trial to assess the cost and success of an anti-predator operation at Pureora, aimed at reducing numbers of potential predators (stoats and ship rats in particular) for the duration of the kokako breeding season (November to March). Predator populations are being monitored by use of tracking tunnels, some of which are placed in trees. Few tracks were found up trees. See also Innes et al. 1999.
Keywords: predator control, kokako - predators
87. Forest Research Institute 1985: The buried forest at Pureora, p. 13-14. - In: New Zealand Forest Service (ed.), Annual Report of the Forest Research Institute, Rotorua, for 1984 - New Zealand Forest Service, Wellington.
An introductory note to the rimu/tanekaha forest buried by tephra of the Taupo eruption of ca 130 AD and preserved under bog conditions until revealed by drain digging in November 1983. Subsequent studies were made, resulting in papers on composition and structure (Clarkson et al. 1988), insects (Green 1987) and tree chronology (Palmer et al. 1988). These papers are annotated. There is a photo of a drain on the bog site, revealing a large, buried rimu which lies on the pre-eruption forest floor.
Keywords: buried forest, Pureora, Taupo eruption
88. Forest Research Institute 1986: Likely impact of possum poisoning operations on North Island kokako, p. 23. - In: New Zealand Forest Service (ed.), Annual Report of Forest Research Institute, Rotorua, for 1985 - New Zealand Forest Service, Wellington.
Recent research suggests that possums may compete with kokako for certain foods. Possum reduction may therefore assist kokako populations. Possum control is normally done by spreading toxic pellets from the air, so hazards to kokako must be assessed. In a trial in Pureora Forest, non-toxic pellets were placed on feeding platforms where kokako can be enticed by berry fruits. No kokako has so far been seen to disturb or peck at pellets. Non-toxic pellets dropped from the air have also failed to attract kokako under observation.
Keywords: kokako, possum poisoning
89. Forest Research Institute 1988: Monitoring of kokako after aerial application of 1080 poison baits to control possums., p. 18. - In: New Zealand Forest Service (ed.), Annual Report of the Forest Research Institute, Rotorua, for 1987 - New Zealand Forest Service, Wellington.
After initial trials with non-toxic baits (see Forest Research Institute 1986), 52 kokako were monitored in Pureora Forest Park (Rangitoto Range) after aerial application of 1080 baits to kill possums. One bird possibly died as a result of 1080 poisoning, though this was not confirmed. It was concluded that 1080 drops against possums do not have serious impacts on kokako

and should improve the quality of their habitat through reducing competition for food.

Keywords: kokako - monitoring, aerial poisoning, kokako - survival, 1080

90. Forest Research Institute 1989: Monitoring of kokako after possum control operations, p. 14. - In: New Zealand Forest Service (ed.), Annual Report of the Forest Research Institute, Rotorua, for 1988 - Forest Research Institute, Rotorua.

Monitoring of kokako included populations in the Rangitoto Range. Of 68 kokako exposed to aerially-applied 1080 poison baits, 2 possibly died as a result of 1080 poisoning, though this could not be confirmed. No disappearances of a further 41 kokako occurred during monitoring of ground-based gin trapping and cyanide poisoning. (See also Forest Research Institute 1986 and 1988).

Keywords: kokako - survival, possum control operations, 1080

91. Franklin, D.A. 1964: *Gaultheria* hybrids at Pureora. - New Zealand Journal of Botany 2(4): 367-379.
The study area for four populations of *Gaultheria* species and hybrids was located in fire-induced scrub associations within the Taparoa clearing, now in the Waipapa Ecological Area. The populations sampled consisted of *G. antipoda* and *G. paniculata* with hybrids between these species. Although limited hybridism is occurring, the two species remain distinct and it was concluded that "the structure of the population is in part related to the habitat".

Keywords: *Gaultheria* hybrids, scrub - fire-induced, Waipapa Ecological Area

92. Fraser, K.W. 1996: The effect of recreational hunters on deer populations in Pureora Conservation Park. - Science for Conservation 31: 1-39.
Data on red deer were collected from diaries of recreational hunters from 1989-1993 and a postal survey was conducted. The data are described and analysed with suggestions for improving method of collection. Further information was obtained from study of the jawbones of deer which gave data on sex, age and condition. The diary data on sightings and kills were correlated with data from faecal pellet surveys, with good results, suggesting that information from hunters should be used for monitoring deer densities at Pureora at considerably less cost than faecal pellet surveys. While the Recreational Hunting Area comprises the north block of Pureora Conservation (Forest) Park, recreational hunters operate over the whole park with commercial helicopter operations confined to the south block.

Keywords: red deer, recreational hunting, faecal pellet survey

93. Fraser, K.W., Coleman, J.D. & Nugent, G. 1995: Optimal buffer widths for control of possums in the Hauhungaroa Range: 1994 - initial population reductions and Tb prevalence in possums, deer, and pigs. - LC 9495/119 (unpublished Landcare Research contract report). - 32 p.
Faecal pellet surveys were used to determine indices of possum, deer and pig population densities before and after aerial-1080 control in four forested treatment areas. Possum densities were reduced by 78-96% in the four treatment areas and pre-feeding with 1080 carrot baits did not appear necessary. Examinations of killed animals showed a high prevalence of Tb in deer populations, contrasting with low Tb prevalence in possums while most pigs were probably infected. The significance of these results for reducing reservoirs for Tb infection is discussed.

Keywords: possum control, Hauhungaroa Range, red deer, aerial poisoning, 1080

94. Froggatt, P.C. 1981: Stratigraphy and nature of the Taupo Pumice Formation. - *New Zealand Journal of Geology and Geophysics* 24: 231-48.
- Keywords: Taupo pumice, Taupo eruption
95. Froggatt, P.C., Wilson, C.J. & Walker, G.P. 1981: Orientation of logs in the Taupo Ignimbrite as an indicator of flow direction and vent position. - *Geology* 9: 109-111.
- Keywords: Taupo ignimbrite, Taupo eruption
96. Gardner, R.O. 1978: Notes on the vegetation and flora of Waimiha River near Pureora, Central North Island 1700-1800 (ft a.s.l.). - New Zealand Forest Service, Forest Research Institute File note FRI 31/6/10/9 (unpublished report). - Rotorua. 4 p.
- Keywords: Waimiha River, Pureora Forest Park, species list - flora, King Country East
97. Grange, L.I. 1931: Volcanic-ash showers. A geological reconnaissance of volcanic-ash showers of the central part of the North Island. - *New Zealand Journal of Science and Technology* 12: 228-40.
- Keywords: volcanic ash showers, geology, West Taupo
98. Green, C.J. 1986: Invertebrate fauna of the buried forest at Pureora, p. 39. - 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.
- Some early results from recovery of subfossil invertebrate fragments, reported on fully by Green (1987). Beetles and mites are best represented with some species of bugs (Hemiptera), cockroaches and ants. Two giant weevils, believed to be extinct, were found but presumably survived the Taupo eruption of 130 AD as they have been found in limestone shafts near Te Kuiti from carbon dated 1680 years BP.
- Keywords: invertebrate fauna, buried forest, Pureora, Taupo eruption
99. Green, C.J. 1987: Insects of the buried forest at Pureora. - New Zealand Forest Service, Forest Research Institute (unpublished manuscript). - Rotorua. 25 p.
- Results are given for recovering subfossil insect fragments from the podocarp forest buried by the Taupo eruption of approx. 130 AD. When the anaerobic, acid (pH 3.5 - 4.9) bogs were drained, samples were obtained from the buried layer of litter and humus of the forest floor beneath the Taupo ash, as well as from tree bark and rotten logs. A total of 210 insect species were identified, mainly beetles (Coleoptera). A technique of coating the hard, chitinous fragments of exoskeletons with paraffin and recovering them by flotation was successful. Weevils were relatively well preserved (68 species). There are 19 figures illustrating 'reconstructed' insects. The insects of nearby present-day podocarp forest were studied for comparison with the subfossil species. All insects identified in the buried forest are present in the central North Island today, with the notable exception of 2 species of giant, flightless weevils of the genera *Anagotus* and *Tymbopiptus*, assumed to be extinct in New Zealand, possibly through predation by rats. Includes 36 references.
- Keywords: insects, buried forest, Taupo eruption, Pureora

100. Greene, T.C. 1998: The effects of compound 1080 on populations of specific non-target species, Waihaha Ecological Area, Pureora Forest Park, Winter 1994. - *Science for Conservation* 69: 1-54.
Monitoring of 21 kaka and 19 blue ducks before and after an extensive winter aerial 1080 possum control operation within dense podocarp forest of Waihaha Ecological Area led to the conclusion that all birds were likely to have survived. Birds were caught by nets and radio tagged so that their movements could be monitored from the air and from the ground. The techniques of preparing carrot baits, capturing, tagging and monitoring of birds are discussed with reference to previous work and the habits of kaka and blue duck. Maps show the aerial position fixes for some individual birds. Death of some other non-target species was recorded incidentally but could not all be attributed with certainty to poison operations. In a discussion on the use of 1080 carrot baits it is suggested that survival of New Zealand pigeons should be monitored in future operations. Recommendations are made for improving equipment and monitoring techniques. As ship rats, as well as possums, are controlled by 1080 baits, longer term monitoring should be done to record whether or not there are indirect effects such as prey switching by stoats.
Keywords: Waihaha Ecological Area, dense podocarp forest, kaka, blue duck, possum control, aerial poisoning, 1080
101. Grindley, G.W. 1960: Sheet 8 Taupo Geological map of New Zealand. 1:250,000, 1 ed. - Department of Scientific and Industrial Research, Wellington.

Keywords: geological map, Taupo
102. Guest, R. 1985: Establishment of nursery-raised indigenous seedlings in selectively-logged forest in Pureora Forest Park. - *New Zealand Journal of Forestry* 30(1): 159-166.
Nursery-raised seedlings of rimu, kahikatea, totara and matai were established in groups of three to five seedlings in gaps of freshly-logged podocarp/tawa forest after removal of 30-60% of timber volume. Survival after 6 to 8 years, following an average of three treatments to release seedlings from competing vegetation, mainly wineberry, was very high at over 90% for all species on most sites. Rimu and kahikatea showed strong apical dominance and grew in height at rates approaching 20 cm/year. Totara and matai grew more slowly and many totara seedlings developed a bushy habit. There was no response to fertiliser applied at time of planting. The two sites planted were in Tihoi Forest at an altitude of 700m a.s.l. and the North Block of Pureora Forest at 575m. The Tihoi trial was planted [against later practice] with seedlings from widespread provenances, including totara and kahikatea from the South Island whilst Pureora plantings were from local seed sources. See also Steward 1981 for 15 year growth of unreleased podocarp seedlings planted in canopy gaps.
Keywords: podocarp planting, podocarp seedling growth, selective logging, seedling survival
103. Hackwell, K. 1980: A new interpretation of the ecology and history of the central North Island forests following the Taupo eruption, 120 (?) AD. - (Photocopies of 11 transparencies presented at the Ecological Society of New Zealand Conference, 27 August 1980, Wellington). - 8 p.
It is suggested that the dense podocarp forests of West Taupo [now in Pureora Forest Park] are not an even-aged first 'crop' resulting from later colonisation of deep pumice soils nearest to Lake Taupo, following complete destruction of the pre-eruption forest. These forests may be two or three generations old, one generation of dense podocarps being able to produce a further dense podocarp stand. The existence of fragmented patches of beech

near the lake suggest that some forest survived the eruption, protected by sheltering topographic features; colonisation of devastated areas then proceeded rapidly from vegetation with podocarps (and other species with succulent fruits) being dispersed widely by birds. For discussion of successional hypotheses see McKelvey 1963, 1986; Herbert 1980, 1986 a, 1986 b.

Keywords: historical ecology, Taupo eruption, dense podocarp forest, colonisation hypothesis

104. Harrison, M. & Saunders, A.J. 1981: A comparison of bird populations in logged and unlogged indigenous forest areas within Pureora and Whirinaki Forests, North Island, New Zealand. - New Zealand Wildlife Service, Forest Bird Research Group - Wellington. 86 p.
This report presents the results of an intensive statistical analysis of over 6000 five-minute bird counts made over a 2 and a half year period (1978-81) in 3 study areas of podocarp/tawa forest in central North Island. One such study area was located in a 670 ha block of forest in the Pureora North Block that included adjacent areas that were unlogged and freshly selectively logged of approximately 30% of timber volume. The general objective was to assess the impact of selective logging on bird populations. The limitations of the methodology used are discussed. Factors affecting conspicuousness of 15 indicator bird species are tested in mathematical models. The Pureora study area was chosen as a part of Pureora Forest Park previously recognised as an area of outstanding wildlife value. (The two other study areas were located in Whirinaki Forest). At Pureora the only case of significant change was that tuis appeared to favour the unlogged block. The short period over which bird numbers were recorded is emphasised and it was concluded that "no significant changes were detected which could be directly attributed to the selective logging". Other data relating to forest composition, phenology and structure were collected and current work is being done "to examine possible relationships between observed bird activity and some of these factors". The need to assess the impact of predators on bird populations is also noted. Vegetation types of study areas are described in an unpublished report of the Forest and Bird Research Group by Leathwick (1981). See Hay 1981 for information on kokako and Crawley 1981 for a summary of studies by the Forest Bird Research Group. Includes 26 tables, 53 graphs.
Keywords: bird populations, selective logging impact, forest structure, phenology, forest composition, bird survey
105. Hay, J.R. 1981: The kokako. - New Zealand Wildlife Service, Forest Bird Research Group (unpublished report). - Wellington. 168 p.
This report reviews previous knowledge of the kokako and gives results of a three year study (1978-81) in three central North Island forests. The most intensive study of bird behaviour and feeding was done in part of the Pikiariki Ecological Area and other study areas within or adjacent to Pureora Forest Park, including parts of the Waipapa Ecological Area and the Pureora North Block. The background to the kokako project and the setting up of the Forest Bird Research Group is outlined, including the action of protestors in January 1978 to prevent further logging of the area that became Pikiariki Ecological Area. Changes in forest policy followed and it was widely recognised that the kokako was a threatened species, requiring adequate reservation of habitat and research into the bird's behaviour and habitat. Aspects of the study include kokako feeding, including seasonal food use; territory size (7.5/ha at Pikiariki), competition for food (particularly with possums); population size; breeding and predation. Details of feeding observations and food preferences at Pikiariki are tabulated in appendices and there is also a proposal for a predator and possum control pilot study. The kokako requires a high diversity of food species and food types. Recommendations to assist kokako survival include high priority for control

of browsing mammals and predators. See also associated studies of Forest Bird Research Group (Crawley 1981, Leathwick 1981, Harrison and Saunders 1981). Includes 67 references.

Keywords: kokako - review, kokako - behaviour, kokako - diet, Pikiariki Ecological Area, kokako - habitat, kokako - reservation, kokako - predators, kokako - competition, kokako - decline, kokako - populations

106. Hay, J.R. 1984: The kokako: perspective and prospect. - *Forest and Bird* 233: 6-11.

A summing up of a three year study (1978-81) of the kokako in four different forest types near Pureora: virgin dense podocarp forest in Pikiariki Ecological Area, virgin podocarp/tawa forest in Waipapa Ecological Area, selectively logged podocarp/tawa forest and an area of old cutover. The decline in North Island kokako is outlined, leading to its present status as a vulnerable species, reduced in numbers by habitat loss and threatened by predation and competition by browsing mammals for food resources. The virgin forest study areas were identified by the Wildlife Service in the 1970s as having the largest and most extensive known populations of kokako. Study methods are outlined, "designed to provide information on feeding, breeding and general habitat requirements" and to relate these to forest management. [Logging in and near the study areas ceased in 1978]. A wide variety of fruits, leaves and invertebrates is eaten by kokako with preferences for berries of fivefinger, raukawa, broadleaf, putaputaweta and kaikomako, and matai during a heavy fruiting season. Possums have been identified as a main competitor for food. Few kokako nests were found over the 3 year study period (including other study areas in Mapara and Rotoehu Forests) and all were preyed on with rats, stoats and possums suspected. A suspected possum predation of three kokako nestlings 7-10 days old was reported at Pureora on 28 January 1981. Thus few juveniles were found. Preservation of habitat and control of browsing mammals and predators are seen as highly necessary measures for kokako survival in mainland habitats.

Keywords: kokako - review, kokako - behaviour, kokako - decline, kokako - competition, kokako - hazards, kokako - habitat, kokako - predators

107. Hay, J.R. 1986: Kokako ecology, p. 47. - 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*, Abstract of current research. Pureora is a key area for conservation of a hitherto declining species, subject to habitat removal and disruption, low reproductive output and food competition. Predator and possum control could supplement the need for habitat protection.
Keywords: kokako - research, kokako - decline

108. Healy, J. 1964: Stratigraphy and chronology of late Quaternary volcanic ash in Taupo, Rotorua and Gisborne districts. - *New Zealand Geological Survey Bulletin* (n.s.) 73: 7-42.

Results carried out on Holocene ash deposits by the New Zealand Geological Survey division of the Department of Scientific and Industrial Research.

Dating of ¹⁴C specimens allows for an approximate chronology of beds of the Taupo Ash Sequence is given, and the last great eruption, which laid down the Taupo Pumice, is stated as having taken place about A.D. 130.

Keywords: volcanic ash showers, Taupo, Taupo eruption

109. Healy, J., Schofield, J.C. & Thompson, B.N. 1964: Sheet 5 Rotorua. Geological map of New Zealand 1:250,000, 1 ed. - Department of Scientific and Industrial Research, Wellington.

Keywords: geological map, Rotorua

110. Herbert, J.W. 1973: Survey of podocarp regeneration, Tihoi Forest, Part I Distribution and Abundance. Indigenous Silviculture Internal Report No. 2. - New Zealand Forest Service, Forest Research Institute (unpublished report). - Rotorua. 14 p.

Results are presented for line-transect sampling at approx. 1% over 1220 ha of low-density podocarp forest (scattered emergent podocarps over shrub hardwoods) and medium-density podocarp forest in the catchments of the Waimonoa and Kakaho Streams. Tables give the stocking of podocarp regeneration from seedlings to pole size (10-30 cm diameter) according to subcanopy type and showed that between 72 and 94% of 0.01 ha samples were stocked in 3 blocks of low-density forest, with 100% stocking for pole stands. The dense fire-induced pole stands are dominated by tanekaha with prominent totara and rimu. Totara and rimu are codominant with tanekaha in the more extensive sub-canopy types not obviously affected by fire, such as mixed shrub hardwoods or shrub hardwoods/tree ferns. An appendix gives sampling results for medium density forest, showing that this type also has abundant and well-distributed podocarp advance growth with 84% of samples stocked. Young pole tawa stands are developing under large rimu. An uncompleted survey in very dense podocarp forest indicated an abundance of podocarp seedlings and striplings (up to 2 cm dbh) but few stems in intermediate size classes.

Thus the abundant and well distributed podocarp advance growth of the low and medium-density forests at Tihoi indicate the initiation of a new forest cycle with adequate replacement of existing old podocarp trees. This situation contrasts with that in some central North Island forests where pole-sized podocarps are scarce. In a discussion of the development of the Tihoi forests it is suggested that some of the ridge-top podocarp pole stands have developed under kamahi stands (not observed on survey) which have probably been part of a fire succession. It is noted that mesophytic species such as pate (*Schefflera digitata*) and *Coprosma australis* are rare on the broken terrain surveyed, probably indicating extremely droughty soil conditions during summer. Includes tabular summaries, e.g., graphs, location plan.

Keywords: podocarp regeneration survey, Tihoi Forest, forest cycles, forest succession

111. Herbert, J.W. 1977: Raising native seedlings contained in forest duff. - Forest and Bird 204: 31-34.

Methods of collecting forest duff (humus sieved from litter) from several central North Island sites are described and results given for the variety and density of tree and shrub seedlings raised in nursery beds, following the spreading of duff. Autumn (May) collection of duff containing fallen seed, or that distributed by birds, produced best results. The most productive sites were shrub ecotones between high forest and heathland in north Pureora (now Waipapa Ecological Area). Half a cubic metre of duff collected from this site produced 20,000 seedlings in the first year, consisting of 47 indigenous shrubs and tree species; 60% were lancewood and 25% *Coprosma* species. Seed of a number of species germinated in the second year. There was evidence that many hard-coated seeds were destroyed by rats, mice or insects during winter and that bird dispersal was very active on this site. Other duff collections were made after seedfall, beneath mature podocarps and beneath pole stands of tanekaha, toatoa and totara in Tihoi Forest. Further details listing species and density of seedlings from duff taken from

different collection sites are given in an unpublished report of the same title in 1976: Indigenous Silviculture Report No 15 of the Production Forestry Division, Forest Research Institute, Rotorua. 8 photos including 6 indigenous conifers. There are lists of species and density of seedlings in nursery beds, raised from duff collected on different sites (all in Pureora Forest Park). Duff from the shrub ecotone produced seedlings from a number of species not present in the immediate vicinity of the collection sites. Characteristics of cotyledonary seedlings are described for some individual species, including 6 indigenous conifers. Includes 5 photos. Keywords: raising native seedlings, seed - in forest humus , seed collection, seed - indigenous species, Waipapa, Tihoi Forest

112. Herbert, J.W. 1977 a: Growth pattern of planted tanekaha (*Phyllocladus trichomanoides* D. Don). - *New Zealand Journal of Botany* 15(2): 513-515.

The growth pattern of three planted tanekaha was studied by counting branch whorls and bud scars on stem and ring counts in stem sections of specimens planted 16 years previously in a kamahi association at the forest edge in the present Waipapa Ecological Area. Two specimens had grown vigorously in canopy gaps and one had been suppressed. It was concluded that the most reliable method for assessing age in actively-growing (young) trees is to count resting bud scars (illustrated). False (incomplete) rings were frequent in upper stem sections but were uncommon in basal cross sections. Vigorous specimens had clearly defined and complete annual latewood bands (illustrated). The suppressed specimen with poor height growth had well-defined annual latewood bands at the stem base but the presence of fewer resting bud scars suggested lack of terminal shoot growth in some years. Counts of branch whorls could not be relied on to indicate age.

Keywords: *Phyllocladus trichomanoides*, tanekaha, growth rings, growth pattern, annual growth

113. Herbert, J.W. 1978 a: Composition, structure and regeneration ecology of the Rangitoto-Hauhungaroa forests, 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 distribution and description of broad forest classes are for those within the present Pureora Forest Park. These include the largest single area of virgin dense podocarp forest in the North Island, both logged and unlogged podocarp/tawa and podocarp/hardwood forests, high altitude podocarp/hardwood forest and a wide range of fire-induced shrublands, often with abundant podocarp regeneration. Tables summarise regeneration data by canopy types from assessments over 7,600 ha in the Waihaha Block of Tihoi Forest. Features are the fully-stocked pole stands, mainly of tanekaha, on 5% of the area and the overall abundance of podocarp regeneration with the greatest amount in the general shrub hardwood cover type (45% of total area), sufficient to replace trees over the next century. Rimu and totara (mainly Hall's totara) will be significant elements in the future forest. The prerequisites for podocarp regeneration are viable bird populations for seed dispersal, suitable nurse species and adequate seed production. Mechanisms for establishment of podocarps are outlined and the need for a thin or dying hardwood canopy to allow development is emphasised. Regeneration characteristics and sequences are described for the forest classes and fire-induced shrublands.

Keywords: forest pattern, regeneration, Rangitoto-Hauhungaroa Ranges, forest classes, Waihaha, regeneration survey, podocarps, succession

114. Herbert, J.W. 1978 b: Proposed addition to Waipapa Ecological Area: Karamarama frost flat and surrounds. - New Zealand Forest Service, Forest Research Institute FRI 31/6/10/2 (unpublished report). - Rotorua. 7 p.
Includes map.
Keywords: Waipapa Ecological Area, Karamarama frost flat, frost flats, Pureora Forest Park, species list, forest types, monoao, kanuka, manuka, red beech, rewarewa, podocarp - dense, podocarp/hardwood, *Coprosma propinqua*, rimu
115. Herbert, J.W. 1978 c: Whirinaki Ecological Area Proposals: North Island frost flats. - New Zealand Forest Service, Forest Research Institute FRI 31/6/10/8 (Letter dated 2.5.78). - Rotorua. 3 p.

Keywords: Hauhungaroa Range, Ecological Area Proposal, Whenuakura Clearing, frost flats, Waione, Pureora Forest Park, Pokaiora clearing
116. Herbert, J.W. 1980: Structure and growth of dense podocarp forest at Tihoi, Central North Island and the impact of selective logging. - New Zealand Journal of Forestry 25(1): 44-57.
Age structure and growth rates are analysed in a rimu-dominant stand, using 139 sound stumps of felled trees. Despite the forest's even-aged appearance, the age range of podocarps spanned about 500 years. Assuming growth rings were annual, rimu trees ranged from 200-574 years in age with 61% between 400 and 500 years. On average the 14 matai were older (9 between 600 and 700 years) and the 5 miro younger (300-500 years). Diameter was an unreliable indicator of age. Four phases of growth are recognised for rimu with an annual diameter increment of 4.4mm for the fastest period and 0.89mm for the last and slowest period. Mean annual diameter increment was 1.89 mm. Estimated stand increment in a 12 ha unlogged control block was 1.79 m³/ha/yr. Loss of trees was assessed 3 years after completion of high levels of selective logging, (30% and 55% volume removed) indicating marked increases in mortality in comparison with a lower loss in the control block (2.47 m³/ha/yr.). 'Cull' podocarps with stem or butt rots comprised 18% of all trees in the original stand of the control block but 40% of windfalls.
Keywords: dense podocarp forest, Tihoi Forest, forest structure, age of trees, growth pattern, selective logging, growth rate
117. Herbert, J.W. 1981: The Waipapa Ecological Area. - New Zealand Forest Service, Forest Research Institute, Indigenous Forest Management Group (unpublished draft account). - Rotorua. 9 p.
A broad account covering geology, topography, volcanic stratigraphy, soils, birdlife, colonisation by introduced mammals, vegetation types and some botanical features. The forest and scrubland with associated wildlife represent a 3000 ha remnant (with Pikiariki Ecological Area) of a previously far more extensive ecosystem "developed on the undissected upland lying between the Hauhungaroa and Rangitoto Ranges". Particular features include the abundance of kokako in both the general podocarp/tawa forest and the dense podocarp forest (200 ha), also the mixed hardwood ecotones between high forest and grassland or heathland. A central part of the scattered podocarp forest contains emergent, very large, old kahikatea, totara and rimu over shrub hardwoods. Much of the totara has collapsed. "Large totara logs are still found in many forest-enclosed frosty depressions now dominated by short, broad-leaved shrubs and trees." Past research in the Ecological Area before its establishment includes: 1960s - National Forest Survey Transects 23 and 24, a 1961 selection management trial, totara and tanekaha trial planting in ecotonal scrub, a study of podocarp regeneration and measurement of podocarp seedfall; 1970s - two surveys of birdlife by the

Wildlife Service and a preliminary study of some shrubland and grassland communities with a species list. For a full published account see Leathwick 1987.

Keywords: Waipapa Ecological Area, experimental work

118. Herbert, J.W. 1984: Reservation of monoao-dominated vegetation in central North Island. - New Zealand Forest Service, Forest Research Institute FRI 31/6/17/5 (unpublished report). - Rotorua. 5 p. Includes map.
Keywords: monoao, frost flats, heathland, Waipapa Ecological Area, Waihaha Ecological Area
119. Herbert, J.W. 1986 a: Podocarps in West Taupo Forests, p. 43. - 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 - Forest Research Institute, Pureora. Briefly discusses McKelvey's (1953, 1963) hypothesis of volcanic succession to explain the existing pattern of the forests. Results of recent research suggest that 'these sites have been continuously occupied by podocarp-dominated forest since they were first recolonised by podocarps, perhaps 450 years after the Taupo eruption'. Some aspects of McKelvey's hypothesis could be re-examined (see McKelvey 1963, p 55, 56).
Keywords: cyclic regeneration, podocarp forest, Tihoi, volcanic succession, podocarp nurses, colonisation hypothesis
120. Herbert, J.W. 1986 b: Cyclic regeneration of podocarps at Tihoi, p. 44. - 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 phenomenon of cyclic regeneration of podocarps and an association of some regeneration with slowly deteriorating crowns of large hinau used by native pigeons as perching trees was demonstrated on an 18 ha experimental site. There was evidence of a previously more dense podocarp forest and a return to another dense podocarp forest in future. Large maire broadleaf and kamahi have also been observed to act as nurses to podocarp regeneration. Refer to McKelvey 1963: p 55, 56.
Keywords: cyclic regeneration, podocarp forest, Tihoi, volcanic succession, podocarp nurses, colonisation hypothesis
121. Herbert, J.W. & Beveridge, A.E. 1977 b: A selective logging trial in dense podocarp forest in the Central North Island. - New Zealand Journal of Forestry 22(1): 81-100.
Assesses the early impact of a first attempt at selective logging of rimu-dominant dense podocarp forest in the North Island, in the Tihoi Block of the present Pureora Forest Park. Describes measures to reduce logging damage in blocks where 30% and 55% of the merchantable volume were removed by tractor. The objective was to remove small groups of trees by directional felling, leaving other groups intact. Damage to the residual trees was assessed in terms of undercutting of root systems, compaction of root plates by tractor, debris left on root plates, debarking of tree stems and butts and crown damage. Severance of lateral roots by undercutting (8% of trees) was considered to be the most serious type of damage, likely to cause instability of large podocarps, most of which were aged between 400 and 600 years. A windfall assessment was carried out 10 months after logging and showed that 39 trees had fallen over 36 ha (6 in the unlogged control). 74% of these windfalls had internal rots or had been classed as 'culls' owing to external butt and stem rots. Subdominant miro were prone to uprooting. In the

logged blocks machines disturbed 74% of the ground to various degrees. See also Herbert 1980 and Pardy 1987 for stability 8 years after logging.

Keywords: selective logging impact, logging damage, dense podocarp forest, rimu, Tihoi Forest, windfall, podocarp windfall

122. Herbert, J.W., Steward, G.A. & Shaw, W.B. (eds.) 1987: Indigenous Forest Management Catalogue of unpublished reports. - Ministry of Forestry, Forest Research Institute, Indigenous Forest Management Group, Rotorua.
Apart from the reports and records of the Indigenous Forest Management Group, this catalogue also lists the more substantial file records dealing with conservation issues, plant and animal ecology. File notes are mainly collated in FRI file 31/6 with extensions, now held by Landcare Research NZ in Hamilton. Of the 193 items listed in this catalogue by author, title and reference, 29 are annotated in this bibliography. See also Steward, Shaw & Krogh 1987 (annotated in this bibliography) which "gives a more complete listing of file records, particularly on plant ecology, conservation values, scientific and ecological values, scientific and ecological reserves", also Steward 1988 on past silvicultural practices in native forest; includes internal reports, division reports, project records, species lists, file records.
Keywords: indigenous forest management, technical records, catalogue - indigenous forest records, reports - unpublished, indigenous forest
123. Hessel, J.W. 1986: The climate of Pureora Forest, 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.
A brief account, noting some continental characteristics of Pureora's climate in its temperature ranges (extremes of +30 degrees C and -9 degrees C). Annual rainfall averages 1850mm, falling on 180 rain days with reliability. Wind flows are generally light.
Keywords: climate - Pureora
124. Hinton, I.W. 1986: An investigation of species association and small scale forest pattern in relation to topography on an ecological transect at Pureora. - BForSc thesis, University of Canterbury.
This study was done on a permanent ecological transect (No. 24, 0.42 ha) in podocarp/tawa forest, Waipapa Ecological Area. Quantitative methods were applied to generate forest types. Statistical analysis showed a very strong relationship between forest type and topography, even on such a small scale. Hypotheses on species regeneration and succession are discussed. It is suggested that podocarp - hardwood - tawa succession could be occurring on a small scale in line with topography and soil changes. Taupo pumice and ash covered the study site to a depth of 1-2m. See Leathwick 1987 for the forest pattern over the whole of the Waipapa Ecological Area; also Williams and Leathwick 1990 for changes in the ecological transect over 25 years.
Keywords: forest pattern, ecological transects, Waipapa Ecological Area, succession, podocarp/tawa forest
125. Hughes, A.J. 1981: The vocal dynamics of the North Island kokako. - MSc thesis, University of Auckland.
Pureora Forest was one of three study areas where kokako behaviour was studied. (Thesis not seen).
Keywords: kokako - vocal behaviour

126. Hutcheson, J.A. 1988: Representative samples from arthropod communities. - *What's New in Forest Research* 167: 1-4.
A method of investigating arthropod communities with beetles used as an indicator group was tested in a shrub ecotone and adjacent mature podocarp forest of the Waipapa Ecological Area. Samples of beetles were collected at weekly intervals over spring, summer and autumn, using 'Malaise' traps of fine netting which guide insects passively to collecting jars. Samples were analysed by a classification procedure which grouped the beetles into habitat types. Over the sampling period of 26 -weeks, 5000 beetles of 361 species were captured. Shrubland samples were dominated by live plant feeders while beetle species from the forest were dominated by those involved in debris breakdown. The samples reflect both subtle and large differences in habitat types. Potential applications of the method are outlined. There are colour photos of the shrubland and forest sampled and a 'Malaise' trap.
Keywords: arthropod communities, habitat types, vegetation - classification, Waipapa Ecological Area, insects
127. Hutcheson, J.A. 1989: Arthropod diversity and abundance index for ecological areas: characteristics of Waipapa samples. - *Forest Research Institute, Forest Health and Improvement Division Project Record No 2480* (unpublished contract report). - Rotorua, 31 p.
A method of sampling terrestrial insect communities was developed involving multivariate analysis of malaise-trapped *Coleoptera*. Full details of methods and results are presented in this final report for work outlined by Hutcheson (1988) in a brief and more popular account. The great ecological importance of the invertebrate fauna is emphasised. The author states that 'the great abundance and diversity of beetles found in the vegetatively diverse successional shrubland indicates the importance of this type of habitat for our fauna and suggests that its conservation value far exceeds the status that it is afforded in the general public's perception'. Appendices give the composition and structure of the shrubland and forest sites samples. A list of beetle species caught and their site occurrence is given. Information is given on indicator species and feeding habits.
Keywords: arthropod communities, Ecological Areas, Waipapa Ecological Area, *Coleoptera*, malaise trapping, invertebrate fauna
128. Hutcheson, J.A. 1991 a: Characteristics of late summer Malaise-trapped beetle samples from different altitudes on Mount Pureora. - *Forest Research Institute, Forest Technology Division Project Record No. 3057* (unpublished report). - Rotorua. 7 p.
Beetles were collected during a three--week pilot study in late summer on Mount Pureora. Traps were placed at 830m, 900m and 1060m. The object was to determine whether or not it was possible to differentiate insect communities of different habitats. It was later found that early summer (December) was the best collection time, so firm conclusions could not be drawn from this study. Tables give details of beetles collected by family, species, abundance and trophic group.
Keywords: beetle collections, Pureora Mountain, insect community
129. Hutcheson, J.A. 1991 b: Notes on the ecology of *Ectopsis ferrugalis* Brown (Curculionidae). - *New Zealand Entomologist* 14: 41-44.
The behaviour and life cycle of this weevil in a congregating attack on a large, damaged lancewood in Waipapa Ecological Area is described. A dozen other beetle species associated with the dying lancewood are identified. The lancewood was predisposed to attack by old age, *Armillaria* infection and windbreak; a neighbouring five-finger damaged by a slasher cut also died after weevil attack. The author concludes that these examples illustrate the role that insects can play in killing weakened plants and hastening vegetation succession - in this case of two species that are prominent in

shrub ecotones with abundant podocarp regeneration near high forest in this locality.

Keywords: *Ectopsis ferrugalis* - weevil, insect attack - weakened plants, Waipapa Ecological Area, insects

130. Hynes, P. 1960: Pureora. -Auckland Botanical Society Newsletter 17(1): 1-3.
Comments on botanical species featured at some localities on Pureora Mountain and the vicinity of Pureora Forest Headquarters following a 3 day field trip, 29 January to 1 February.
Keywords: botanical survey
131. Imboden, C. 1978: Wildlife values and wildlife conservation in the Hauhungaroa and Rangitoto 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.
Previous wildlife surveys in the West Taupo forests, carried out over a period of seven years, are reviewed. Most of the remaining podocarp/hardwood forests have been given habitat ratings of outstanding or high wildlife value and classification of habitats is shown on a map. Extracts are given of information on wildlife species of special interest from a report made for the King Country Land Use Study. (See Best 1977). A fuller account of the biological importance and status of the North Island kokako in the Hauhungaroa-Rangitoto Ranges is given as part of a review over the whole North Island. Deficiencies in knowledge and research at this time are emphasised [some of which have been remedied over the past 20 years]. The general picture for the kokako was one of decline, though good populations of the bird occurred on easy terrain in dense podocarp forest and podocarp/tawa forest in parts of Pureora Forest. The importance of forest structure, slope and altitude for kokako habitat is emphasised. Extensions to ecological areas and the establishment of a biosphere reserve in the central North Island are proposed. An appendix lists the general recommendations of the Wildlife Service, including cessation of clear felling or conversion of Crown-owned indigenous forests in the Central North Island and no logging in uncommitted forest.
Keywords: wildlife values, wildlife surveys, habitat classes, kokako, kokako - decline, kokako - habitat, Wildlife Service recommendations
132. Innes, J.G. 1984: Raepahu Ecological Area for fernbirds. - New Zealand Forest Service, Forest Research Institute FRI file 33/11 (unpublished report). - Rotorua. 4 p.
Keywords: Raepahu Ecological Area, fernbird
133. Innes, J.G. 1986 a: Kokako management, p. 48. - 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. Options for management are browsing animal (competitors) control, predator control, and restorative planting. All kokako nests located should be protected. Clear criteria for decisions on control operations are lacking. Current research emphasises the need to ensure that aerial applications against possums do not pose a threat to kokako.
Keywords: kokako - management, kokako - research