

A CENTURY OF CHANGE IN THE FORESTS OF THE RUAHINE RANGE, NORTH ISLAND, NEW ZEALAND : 1870-1970

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SUMMARY: Botanists describing the Ruahine Range prior to 1920 made no mention of the forest debility described by later writers. In the 1870s and 1880s the lowland forests were cleared from round the southern half of the range and grazing commenced on the northern and western plateaux. Opossums (*Trichosurus vulpecula*) were liberated in the 1880s and red deer (*Cervus elaphus*) first entered the range about 1900. By the mid-1920s deer had modified forests; in the northern part of the range. By 1940 deer damage was extensive and opossum damage had been noted. During the 1950s some forest canopies were severely damaged by opossums, and considerable forest collapse occurred during the 1960s. There has been subsequent recovery in some places and continuing forest deterioration in others.

INTRODUCTION

The Ruahine Range (Fig. 1) runs from near the Ngaruroro-Taruarau River junction in the north to Wharite Peak in the south, a distance of some 90 km. Since 1870 considerable changes have occurred in the forests of the Ruahine Range. Throughout the range forests have been modified, largely by introduced animals, particularly opossums (*Trichosurus vulpecula*), deer (*Cervus elaphus* and *Cervus nippon*), and goats (*Capra hircus*). In many parts of the range forest deterioration has occurred, particularly since 1920. Deterioration may consist of a greatly reduced shrub tier; the loss of ferns, moss, and humus from the forest floor; or defoliation, death and collapse of the forest canopy. In a simplified form, the observations of changes are summarised in Table 1.

No objective measurement of these changes was made before 1970, and this paper attempts to describe the patterns of change by examining in chronological order the field descriptions recorded by various people who have travelled or worked in the range. Throughout this paper botanical names have been brought up to date and measurements converted to metric.

THE FORESTS PRIOR TO 1870

Maori habitation of the Ruahine Range appears to have been light and sporadic. Pre-European fires occurred in several places in the north-west Ruahine Range from the Mokai Patea through to the Pohokura basin. Some of the burned areas were near known Maori routes across the range (Elder, 1965). Batley (1956) found that totara (*Podocarpus totara*) in the north-west Ruahine Range had been

damaged by bark stripping by the Maori, in earlier times.

Between 1845 and 1852 the botanist William Colenso crossed the Ruahine Range several times, his usual route being across the northern portion of the Mokai Patea Range, over Puketaramea to Te Atua Mahuru, and down the Makaroro River to Hawkes Bay. In his published account of these journeys (Colenso, 1884) he included detailed descriptions of the vegetation. Although he mentioned encountering dead, decaying, and windthrown trees, and fallen logs in riverbeds, there is nothing in his text to suggest any form of unnatural or spectacular forest debility. On the contrary, he wrote eloquently at times on the richness and health of the vegetation.

Wild pigs (*Sus scrofa*) were liberated in the North Island in the 18th century and by 1840 were probably established in the Ruahine Range area. Colenso (1884) mentioned that pig hunting had been conducted on the flanks of the Mokai Patea prior to his visit in 1848. He also recorded the presence, prior to 1850, of landslides on both sides of the range. Recent work by Grant (1965) and Stephens (1977) provides further evidence of periodic storm damage and slope instability in the Ruahine Range during the past few centuries.

The forests of the Ruahine Range prior to 1870 may be regarded as having been largely uninfluenced by European man or his introduced animals.

THE PERIOD 1870 TO 1920

Between 1870 and 1920 the forests in the region of the Ruahine Range started to undergo consider-

TABLE 1. *The main changes in forests of the Ruahine Range from 1870 to 1970.*

Period	Main changes	Causes
Pre-1870	Forest generally healthy and complete, with only slight modification. Erosion scars present.	Maori fires and barkstripping. Rainstorms.
1870 to 1920	Clearing of foothill forests, and also of some parts of the range. Opossums and red deer enter the range; sheep and cattle present.	European fires; sheep and cattle grazing.
1920 to 1940	Severe modification of beech forests. Goats noted in south; opossums noted in north.	Deer.
1940 to 1950	Canopy defoliation in rata-kamahi forests. Damage to kaikawaka.	Opossums. Deer.
1950 to 1960	Heavy mortality in rata-kamahi forests. Reduction or elimination of understorey species throughout range. Defoliation of red beech. Widespread ill-thrift of kaikawaka. Increase in frequency of "slips".	Opossums. Deer, goats. Insects. Unknown.
1960 to 1970	Widespread collapse of former rata-kamahi forest. Introduction of conifers and willows for erosion control. Continuing ill-thrift of kaikawaka. Continuing high incidence of slips. Some indications of forest recovery.	Forest instability. Death, decay, wind. Concern for stability. Unknown. Forest instability. Decline in deer numbers.

able change. In the south, extensive tracts of forest were cleared on both sides of the range, and by 1900 the present pattern of farming in the Manawatu and southern Hawkes Bay had emerged. Apart from localised fires and incursions of cattle, the forest on the flanks of the southern Ruahines remained largely intact. However, removal of forest from adjacent piedmont fans prior to 1920 contributed to river instability in this region in later decades (Mosley, 1978). In the north and west the easier and more open country was grazed from the 1880s and burning of the grass and scrubland, and some forest, was associated with this. A serious fire also destroyed much forest in the upper Tukituki (Moorcock) area in the 1880s (Elder, 1965).

Opossums were liberated in the Pohangina Valley in 1883 (Pracy, 1962). During the same year red deer were liberated at Matapiro, about 25 km east of the north-eastern Ruahines (Logan and Harris, 1967) and probably entered the Ruahine Range about 1900. By 1918 deer were common in the northern Ruahines (Elder, 1957). Further red deer liberations were made on the western flanks of the range between 1902 and 1922. Although some of the Ruahine erosion has been attributed to the development of high deer populations, there is also

evidence that erosion and instability were features of the Ruahine Range before the deer build-up of about 1920. Alexander McKay (1888) observed that the Mangaatua Stream used to spread widely when in flood, and deposited large quantities of shingle and boulders over the higher part of the alluvial flat. In a later paper (McKay, 1900), he described large landslips in the headwaters of the Makaretu River. Kennedy (1914) mentioned slips in the mountains as being a source of shingle in the Ngaruroro, and Aston (1914) referred to the extensive shingle slips of the Ruahine tops.

Apart from the changes caused by fires and localised storms there is no evidence that the Ruahine forests were seriously damaged or unhealthy before 1920. Two well-known botanists, B. C. Aston and F. Hutchinson, spent three days in the Makaretu headwaters in 1913 and crossed the northern Ruahines near Colenso's route in January 1914. Aston made a solo trip to Wharite Peak two months later (Aston, 1914). Although they had observed kamahi (*Weinmannia racemosa*), rata (*Metrosideros robusta*), tree fuchsia (*Fuchsia excorticata*) and kaikawaka (*Libocedrus bidwillii*), all of which showed widespread mortality or ill-thrift 50 years later, they made no mention of any

damage. In fact, Aston (1914) noted that at 823 m on the Mokai Patea ridge such plants as tree fuchsia, broadleaf (*Griselinia littoralis*) and lacebark (*Hoheria sexstylosa*) "... flourish in a marvellous manner."

Given the observational powers of Colenso, Hutchinson, and Aston, and the fashion in those days towards written detail, it is difficult to believe that such forest debility as was later described could have escaped notice or gone unrecorded. It must be concluded that before 1920 the Ruahine Range forests were generally in a healthy condition.

THE PERIOD 1920 TO 1940

By the mid-1920s there was a high deer population on the northern Ruahine plateau. At that time (Elder, 1965) the forest floor was bared, roots were exposed, and by 1932 the mountain beech (*Nothofagus solandri* var. *cliffortioides*) forest was already a shell on the slopes of the north-eastern plateau, which was the area of the densest deer population. Nearly all undergrowth had then been browsed out in some basins. Elder (1965) also reported that by 1935 there was sign of deer along the whole line of tops from the Ngamoko Range to Kereru. High deer populations during the period 1930 to 1940 arrested beech seedling development in the north-eastern Ruahines. This was demonstrated by Widdowson (1960) after a study of age-class distribution of mountain beech and red beech (*Nothofagus fusca*) pole stands.

Photographs of the Mangapuaka (Kumeti) Stream taken in the mid-1920s and in 1936 illustrate that the forest canopy had an unthrifty appearance in those years. Mosley (1977) quotes the photographer (Mr G. Miller) as recalling that the forest understorey was more open in the early 1930s than in 1977. This suggests that the canopy, though unthrifty, still provided a substantial cover.

In 1937, R. Kean and F. Newcombe of the Department of Internal Affairs crossed the range via Waipawa Saddle and the Kawhatau and Waikamaka headwaters and were in no doubt about the severity of deer damage. They noted (Kean and Newcombe, 1937) that in the head of the Waikamaka large tussock grasses amongst fallen timber in the bush had been entirely eaten and they observed that *Pseudopanax colensoi* and *Senecio elaeagnifolius* plants had been killed by heavy deer browse. They recorded that in a forested flat in the Kawhatau headwaters all leaf mould had vanished from the forest floor, the roots lying on bare sand and shingle. All the ferns were gone, the only trace being small stumps, probably of *Polystichum vestitum*, and all undershrubs were killed, many having been de-barked. Similar damage

occurred on flats down the Waikamaka; on one such flat under red beech the following description was made: "... practically all undershrubs except tree fuchsia, *Coprosma rhamnoides* and *Pseudopanax anomalus* have been killed; mahoe (*Melicactus ramiflorus*) and broad leaf torn to the ground; fivefinger (*Pseudopanax arboreus*) barked completely to 1.5 or 1.8 m in height and of course dead; a scene of desolation. A few minute herbs and the grass *Microlaena avenacea* remain on the forest floor."

Kean and Newcombe (1937) described in considerable detail the destruction by deer of kiokio (*Blechnum capense*) and the importance of its rhizomes in stabilising loose slopes, and stated: "On one place where recent slipping had occurred on previously fixed steep scree slopes the area immediately adjacent was found to still have traces of the fern on it. It may be safely assumed in this case that deer had been responsible for the commencement of the slipping." They described deer damage to sub-alpine scrub as particularly severe, and noted browsing on tutu (*Coriaria* sp.), mountain flax (*Phormium cookianum*), koromiko (*Hebe salicifolia*), *Coprosma robusta*, *Senecio elaeagnifolius*, and *Astelia nervosa*. *Aciphylla* plants were particularly badly damaged and it appeared as though many would die. *Pseudopanax colensoi* was in many cases killed, while "mountain wineberry" (*Aristotelia fruticosa*?), and broadleaf "... were badly knocked about." They described groups of trees and shrubs which had been killed by ringbarking, including "... *Pseudopanax colensoi*, broadleaf, "mountain wineberry", *Senecio elaeagnifolius*, *Hoheria populnea*, and *Pittosporum rigidum*." Kean and Newcombe also referred to an unusual prevalence of tree mortality in mountain beech forests of the Waikamaka and Kawhatau which they attributed to causes other than deer. They speculated on the possibility of fire or insect damage.

The Department of Internal Affairs carried out the first Ruahine deer destruction operation in the summer of 1938-39, killing 4718 deer. Reporting on this in 1939, Field Officer E. B. Davidson commented "It was found that certain portions of the bush, such as the Gull Stream, Big Hill Stream, Koau Stream, and the Mangatera River with its tributaries were pretty well eaten out by deer; the Kawhatau not so much, and progressively less in the rivers to the south of the Kawhatau." Near Lake Colenso "... the bush is completely bare of any undergrowth in the lower portions, and I have never seen so much damage done in any part of even the South Island bush." He noted that opossum

signs were seen in quantity in forests in the Mangatera Valley, especially near Lake Colenso, and also on the eastern side of the range north of the Waipawa River.

THE PERIOD 1940 TO 1950

In 1940 botanist A. P. Druce noted that kamahi along the track up to Wharite Peak appeared to be in poor condition, but at that date the possibility of defoliation by opossums was not considered (Elder, 1958).

A brief (one page) account of the Ruahine vegetation was published in a Wellington Botanical Society Bulletin in 1944 and although a paragraph is devoted to the kamahi-rata-rimu (*Dacrydium cupressinum*) forests of the southern Ruahines, no mention was made of any sign of ill health. Similarly, kaikawaka and pink pine (*Dacrydium biforme*) are mentioned without any comment on ill health.

The first report of damage to kaikawaka come from Department of Internal Affairs Field Officer A. Douglas who in 1947 wrote of the Mangatera catchment: "The largest stand of kaikawaka in the Ruahines grows here; deer do not eat it but use the young whippy trees for antler rubbing." Douglas also described heavy deer use in the Ikawetia: "Both sides of the river are covered with beech (*Nothofagus*) and the undergrowth is eaten right out."

In 1947 another Field Officer, L. T. Pracy, inspected the southern Ruahine Range and reported heavy opossum populations in the lower reaches of stream catchments and around the periphery of the range (Pracy, 1963). He also reported the presence of goats, cattle and deer in various catchments. He noted "considerable" defoliation of the canopy in some lower catchments and made the following list of ". . . species recorded as killed by constant defoliation": tree fuchsia, wineberry (*Aristotelia serrata*), tree tutu (*Coriaria arborea*), fivefinger, kamahi; lace bark, rangiora (*Brachyglottis repanda*), toro (*Myrsine salicina*), *Senecio kirkii*, raukawa (*Pseudopanax edgerleyi*) and titoki (*Alectryon excelsum*). He recorded severe defoliation on nine other species and light defoliation on a further five species. Pracy returned to the southern Ruahines in 1949 (op. cit.) and noted an increase in the extent of foliage damage and also noticed more sign of deer and goats, the latter being numerous in favourable habitats.

THE PERIOD 1950 TO 1960

In 1950 R. A. Batley, after inspecting the western slopes of Aorangi, noted that the forest undergrowth

had suffered considerably from the inroads of deer.

Ample indication of the presence of opossums was also clearly visible. In 1953 an anonymous writer quoted Mr A. P. Druce as reporting that: "Round the base of the cliffs (of Mount Aorangi) appears to be a favourite haunt for deer, which have done considerable damage to the flora there." (Anon, 1953).

In the southern Ruahines in 1951, Elder observed heavy mortality of rata in the Tamaki valley and noted that by 1952 canopy defoliation was becoming conspicuous from the plains (Elder, 1958). Pracy returned to the southern Ruahines in 1953 and considered that opossum distribution was complete throughout the area and that they were at peak density in some localities around the lower forest fringe. There was also increased deer sign (Pracy, 1963). He made a further survey in 1955 (op. cit.) and noted severe defoliation extending throughout the forest. A further nine plants were added to his list of species which could be killed by repeated defoliation. They are: rata, tawa (*Beilschmiedia tawa*), mamaku (*Cyathea medullaris*), hekatara (*Olearia ram*), raurekau (*Coprosma australis*), mountain totara (*Podocarpus hallii*), pokaka (*Elaeocarpus hookerianus*), *Senecio elaeagnifolius*, and *Olearia arborescens*. He recorded moderate to heavy damage on mahoe, hinau (*Elaeocarpus dentatus*), pate (*Schefflera digitata*), *Pseudopanax simplex*, rata vine (*Metrosideros fulgens*), bush lawyer (*Rubus australis*), supplejack (*Rhipogonum scandens*), and kaikomako (*Pennantia corymbosa*). He also observed a severe attack of white scale insect (*Anoplaspis metrosideri*) on rata in the Tamaki catchment. Opossums were noted as being in poor condition in many catchments, with animals feeding in daylight, and dead animals found. In some catchments there was extensive bark biting of peppertree (*Pseudowintera colorata*). These various observations suggest that in the mid-1950s the opossum population in the southern Ruahines had exceeded its food supply and that animals were utilizing a wide range of foods intensively in the competition for survival. Subsequent events indicated that this was the period of demise of large areas of kamahi-dominated forest canopy of mid-valley slopes.

Further north Kelman and Kelly (1953), after a soil conservation survey of the upper Tukituki, also commented on the changes wrought by deer: "The composition of the forests has changed considerably since the introduction of deer and other wildlife. Many species have virtually been eliminated, including tree fuchsia, wineberry, and various species of *Coprosma*, *Uncinia*, and *Pseudopanax*. This reduction of secondary species has resulted

in the opening up of the forest beneath the canopy . . .".

Not all change was attributed to animals. N. L. Elder was actively observing and recording in the 1950s and in an early report (1955) he referred to mountain beech timberline retreat and to a general deterioration in mountain beech forest, and sought to relate these phenomena to changes in climate or microclimate. The concept was further developed in his 1965 publication, and he concluded that a considerable amount of the vegetation change had occurred during the past 200 years. About the mid-1950s he also started reporting widespread heartrot in kaikawaka, and a general absence of seedlings or saplings in the upper part of the altitudinal range. A high proportion of dead crowns was noted in some areas of kaikawaka or kaikawaka-red beech forest. One of Elder's companions described the situation succinctly (Jackson, 1957): "Much of the red beech above 975 m is overmature, stagheaded, and frequently dead. On the southern face of Titapu the canopy cover is frequently less than 25%. The slopes from Colenso down to the Kawhatau River show poor regeneration, largely due to a very heavy ground cover of *Dicksonia lanata*, *Blechnum discolor*, *B. fluviatile* and *Polystichum*."

Below 1100 m mountain beech . . . does not appear to be thrifty, mortality rates being high.

In the scrub associations between 1160 m and 1250 m the current mortality rate of kaikawaka is high and large, old, standing dead trees are numerous. Recruitment below the pole size is rare. On the other hand, at lower elevations, kaikawaka has been an active colonizer into fire-induced *Celmisia/Cassinia* associations."

Another observer (Logan, 1955) pondered on the senescence of timberline forest in some areas in the Manawatu headwaters and also expressed the view that factors other than animals were involved. He wrote: "Although or because much of this forest is decadent, animals are playing an increasingly important part. Goats and deer, in increasing numbers, are opening the forest understorey and in places completely eliminating all ground cover. Opossums are rapidly destroying the upper canopy, much of it already past its prime."

An unpublished Forest Service report on Ruahine Range deer control operations for 1957-58 stated of the Pohangina that a high proportion of the canopy was dead and the forest badly depleted at ground level, particularly at higher elevations. Aerial photographs showed that this had occurred within a decade. The damage was attributed to a combination of opossums, deer, and goats.

By the mid-1950s opossums were established up to timberline in forests of the Tukituki catchment. Grant (1956) described intensive bark chewing by opossums on red beech and miro (*Podocarpus ferrugineus*), and on mountain beech up to 920 m, leading to dead foliage on affected branches. In the same year, Elder (1957a) observed opossum browsing in subalpine scrub at 1250 m in the Oroua headwaters. During the winter of 1958 abundant opossum sign was repeatedly recorded along the Ruahine Range tops at the 1220-1370 m level from Nomans Hut to Howletts Hut (Elder, 1960b).

On the western side of the range, Jackson (1957) noted that in the Waikamaka catchment opossums had practically eliminated *Pseudopanax* species (except *P. sinclairii*) and they appeared to be largely concentrated in gullies (where tree fuchsia was being rapidly killed out) and in wineberry areas along the disturbed forest margins. He also described localised intensive deer browse on one site on the Mokai Patea Range: ". . . all young beech are clipped close: larger trees have their laterals reduced to stubs; *Pseudopanax* species and the preferred coprosmas have been eliminated; *Polystichum* left as residual tufts; *Coprosma pseudo-cuneata* is heavily browsed (and frequently killed) and even the usually unpalatable *Phyllocladus alpinus* shows browse line." He described another area as follows: "On the steep faces overlooking the Waikamaka, where shrubs are the main cover, mortality is so high and the surface so cut up that shingle is already actively overrunning the residual ground vegetation and it would take little more to induce wholesale erosion."

In the southern Ruahines Elder (1957b) recorded that south of Apati Saddle, canopy deaths had become: ". . . noticeable by 1952, widespread by 1955, and general by 1957." The effect, however, was patchy. For example, in the same report Elder describes walking up Delaware Ridge: "Though dead rata is conspicuous and some moribund kamahi noticeable in the Pohangina valley immediately to the north, kamahi forest with projecting kaikawaka and totara is healthy along the ridge for some 4.8 km beyond the trig (Delaware) and to an altitude of about 914 m." In his 1958 report, Elder again records the anomaly of small islands of live kamahi contrasting strongly with surrounding areas of dead trees. This phenomenon of patchiness was also noted by Cunningham in 1959 on Opawe Ridge: "In the kamahi/fuchsia/wineberry forest where the ridge forks west of Maharahara no living fuchsia or wineberry could be seen, but there are a few scattered groups of kamahi still undamaged by opossums." Further down the ridge were:

"Abundant dead kamahi, rata, fuchsia, and wine-berry. Defoliation and bark chewing also noted on mahoe, lacebark, hinau, tawa, hekatara, and maire (i.e., *Nestegis* sp.) (Cunningham, 1971).

Elder (1957a) noted a characteristic paucity of bird life in the Ruahines by comparison with the ranges further north, and viewed this as an important ecological factor in seed distribution and insect control.

Although much of the forest deterioration in the Ruahines was attributed to opossums and ungulates, the presence of rodents was not overlooked. Elder (1957a) recorded large numbers of mice in beech forests late in 1955, following a heavy seed fall the previous autumn. Pracy (1959) took the rat population into account when planning bait for a large operation to poison opossums in the Opawe catchment that year, and Ellis (1960) noted the presence of rats and mice in the Makaroro forests.

Defoliation of red beech by the caterpillar of *Epichorista emphanes* was reported from various catchments (Oroua, Kawhatau, Tukituki, Ikawatea) between 1956 and 1958 (N.Z. Forest Service, 1966).

THE PERIOD 1960 TO 1970

During the 1960s the animal/plant relationships became even more complex as forests recovered in some areas but deterioration continued in others. However, a start was made towards quantifying the changes.

The Forest Research Institute was active in the area about the beginning of the decade. In the summer of 1960-61 field parties collected data for the forest type maps subsequently published in 1970 (Nicholls, 1970). Unpublished Forest Service reports from this period contain many photographs illustrating forest deterioration (McKelvey, 1960; Nicholls, 1962). In the following year plots were established throughout the range to monitor future changes in the vegetation, and during the course of this work comprehensive notes were made on forest condition. These were later assembled in unpublished reports (Wallis, 1966; Cunningham, 1966).

The outstanding contribution of the decade was Elder's 1965 publication on vegetation of the range, in which he presented observations and records accumulated over several decades. He touched on the relationship between deer damage and slope instability and considered that in the Waipawa headwaters the increase of slip faces could fairly certainly be attributed to deer. Slips frequently started where deer had congregated on sunny slopes, their trampling destroying the moss and root cover, after which the exposed rock began to disintegrate.

He noted that for some localities, however, deer damage was only part of the story.

After an inspection of the Pohangina catchment in 1966, McKelvey (1966) noted the importance of deer in preventing recovery of slip faces: "Noxious animals are precluding the revegetation slips by forest; their activities induce swards of grass and fern which are inadequate to stabilize the slopes and there is much evidence of old slips, now covered in grass and fern, becoming active again. Nowhere was there seen old slips in stages of reversion to high forest."

A significant development of the mid-1960s was the use of introduced plants for erosion control. A small area near Pohangina Saddle had been planted with pines and spruces in 1953 but heavy browsing by deer, sheep and hares had prevented their development. From 1965 onwards, poplars, willows, pines and other conifers were planted in the headwaters of southern Ruahine catchments, in an attempt to arrest erosion. Similar planting was done on a small scale in the Tukituki headwaters in the late 1960s.

Elder (1965) drew attention to the common occurrence throughout the Ruahine red beech forests, of a predominance of large old trees forming a discontinuous canopy. The forest floor is frequently dense with *Dicksonia lanata* or *Blechnum discolor* and there is often a paucity of young red beech trees or seedlings. Elder considered that the *Dicksonia lanata* had only become widespread since the introduction of deer. Although he noted that this dense fern cover inhibits seedling development he also pointed out that neither species of fern flourishes in full sunlight and suggested that further opening of the canopy would give rise to major changes. In 1969 J. Ogden of Massey University commenced a series of studies in this class of forest on the slopes of Mt. Colenso, aimed at understanding the mechanics of change. This work subsequently led to publications by Ogden (1971) and June and Ogden (1975, and 1978).

Accumulated observations from the Ruahine Range in the 1960s made it clear that except in the north-west, kaikawaka was generally unthrifty, that heart rot was common even in young trees, and that seedlings were rare at altitudes above 1070 m. Dead trees were common, and in some areas whole stands had died: "The ridge dividing the north-west branch of the Mangaatua from the Whareroa once carried a kaikawaka-pink pine forest with a canopy at 6 to 9 m. These trees are now dead but still standing. The present discontinuous canopy is now 3 to 4 m tall." (Cunningham, 1966). There is still no

clear explanation for the widespread debility of kaikawaka.

A heavy snowfall in the winter of 1961 caused considerable damage to western Ruahine forests from the southern Ngamoko Range to the Mangatera. "Limbs and branches up to 15 cm diameter were torn off red and mountain beech, and to a lesser extent from kamahi, mahoe, fuchsia, and more rarely pink pine, Hall's totara and kaikawaka. In some places even sub-canopy peppertree was damaged." (Cunningham, 1966).

In a report on beech regeneration in cut-over forest north of the Makaroro River, Ellis (1960) recorded ghost moth (*Aenetus virescens*), the buprestid bark beetle *Nascioides enysi* and *Pseopholax* sp. on red and mountain beech pole stands and considered that they were responsible for some mortality. He recorded *Navomorpha sulcatum* larvae defoliating wineberry, and Elder (1960a) also noted that insect damage to wineberry was extensive in this area. *Nascioides enysi* was found to be associated with damaged beech forest canopy at lower elevations of Ohara Stream in 1961 (Wallis, 1966). Pook (1962) reported widespread mortality of red and mountain beech in the Makaroro headwaters. A wide range of size and dominance classes was represented, and *Nascioides enysi* was found to infest the underbark of all trees examined. (Later studies suggest that in such cases beech mortality may be attributed to *Platypus* rather than to *Nascioides-Milligan*, 1972).

In 1963 Pracy reviewed his earlier observations of opossums in the southern Ruahines and commented that the situation there had been aggravated by goats, cattle, pigs and deer. These ground-browsing ungulates had, by depleting the shrub tier vegetation and opening up tracks, improved access to food and nesting for opossums, and changed a relatively restrictive habitat to a favourable one. In the mid-1960s there were still some palatable plants available for opossums, for example Cunningham (1971) observed that there were still many pockets of healthy kamahi left in the upper Pohangimi in 1966.

The southern Ruahines attracted increasing comment and concern throughout the 1960s. After a reconnaissance flight over the range, Jackson (1961a) noted: ". . . devastation by opossums on western slopes of the southern Ruahines on a most extensive scale from the Pohangina south. The leatherwood (i.e., *Olearia colensoi*) belt of the southern Ruahines appeared to be virtually intact and conspicuously healthy." Ground inspection proved the latter to be generally true, but in 1962 even the leatherwood belt was being penetrated by animals in some

places: "Up Takapari from West Tamaki/Cattle Creek Saddle-lower scrub line of kamahi, broadleaf, *Pseudopanax colensoi*, leatherwood, fuchsia, pink pine; this heavily tracked and browsed by deer, many plants dying as a consequence. . . . Main divide north of Wharite trig: leatherwood association canopy intact, but shrub tier and floor cover show serious damage from deer and goats. Fuchsia present in gullies. South from Wharite trig-cover of leatherwood (many dying) and peppertree plus waterfern (i.e., *Histiopteris incisa*)/*microlaena* interspersed by dead kaikawaka and dead or dying pink pine." (Cunningham, 1971).

Cunningham (op. cit.) also noted that at lower levels in 1962 forest deterioration was in some places well advanced: "From Mid-Pohangina Hut eastward up spur. From 550 m to 600 m all kamahi dead, leaving a dense sward of *Microlaena*, *Blechnum discolor*, *Uncinia*, and waterfern plus scattered broadleaf and occasional rimu. Above 670 m most kamahi trees are still alive but the shrub tier is seriously depleted, and the forest floor is bare except for scattered *Blechnum discolor*."

In 1964 a helicopter flight in the Pohangina and Oroua catchments provided opportunity for further comment: ". . . down Pohangina and round to Piripiri, generally about 80-100 m above the river and slightly on the eastern side. Forest deterioration becomes increasingly evident on the mid and lower valley slopes as one proceeds down-valley, but the most striking features are the dead and dying beech trees on most of the steep faces just above the river, and the riparian slip activity or poor condition riverside vegetation. Seriously damaged forest continues round into the Piripiri headwaters. Amazed at uniformity and severity of forest damage in Coal, Cone, and Umutoi Creeks. The original high canopy has almost gone and is replaced by a lower vegetation itself severely damaged and in poor health. The predominant colour is not green, but brown. This continues round the upper part of the southern Oroua catchment." (Cunningham, 1971). Elsewhere, (op. cit., p. 41) it was suggested that deterioration of the kamahi canopy was causing deterioration of associated emergent trees, due to exposure.

J. L. Nicholls (1970), writing explanatory notes to the Ruahine Forest Class map, included the following comments related to the southern Ruahines: "Rimu-General Hardwoods: . . . in this region most rata have died during the last 15 years, with many of the formerly abundant kamahi." And ". . . large standing dead rata, among groves of skeletal kamahi." Of the "Highland and Steep land Softwoods-Hardwoods" which lie in the southern

third of the range his comments include: ". . . with scattered often dead or dying Hall's totara . . ." and ". . . large areas of standing dead kamahi."

During the 1960s descriptions of forest deterioration further north also occurred in many reports. Some examples follow. N. L. Elder visited Colenso Lake in 1961, and after describing the botany of the lake region he commented: "Generally the area appears to have had a long history of deer use and more recently of opossum. Dead fuchsia still stands, most wineberry is dead, with heavily browsed survivors, and alliacebarks were hard browsed." A little further south, Cunningham (1971) described crossing the Pourangaki Valley to the Oroua in January 1962: "From Wooden Peg across Pourangaki to Maungamahue. Leatherwood belt in good condition, but below this the kaikawaka-kamahi belt has been completely opened up by browsing and trampling; a few scattered, divaricating non-palatables form the shrub tier-the floor a maze of bare tracks amongst a sward of waterfern. Mountain beech on the steep upper slopes is severely modified-only scattered peppertree in the shrub tier; considerable snow break to canopy, forest floor almost completely bare loose soil and rocks. Further down in the red beech/Hall's totara zone the condition is better, with improved shrub tier and ground cover, but canopy very open after the heavy winter snowfall. From Pourangaki River up steep ridge to Maungamahue-red beech forest with canopy opened up by snow damage. Light tracking; shrub tier of peppertree, wineberry, *Dicksonia lanata*, waterfern, and with fuchsia common in gullies. Upper valley slopes with kaikawaka/mountain beech has been severely opened out and trampled by animals-looks like a cattle yard! At the timberline is an area of 1 or 2 hectares damaged by fire many years ago-50% of trees are dead, and ground cover comprises short turf. Alpine grassland up to Maungamahue is in good condition, there are few slips, and several of these show signs of healing. Inspected northernmost headwaters of Oroua, just E of Maungamahue. Grassland and sub-alpine scrub in good condition, upper forest of kaikawaka/pink pine with red beech downslope, this very heavily browsed, tracked, and trampled. Shrub tier reduced to scattered peppertrees, forest floor bare, many rocks exposed. River headwaters heavily aggraded. Many tributary rivulets in the upper headwaters are deeply incised gullies."

Wallis (1966) described the red beech forests of the north-east Ruahines as being in very poor condition. Near their upper limits, in gullies and on northern faces, regeneration was poor, the shrub

tier was sparse or virtually absent, and the forest floor consisted of bare soil or greywacke parent material. He reported that in the Ikawatea the forests generally were far from satisfactory and the scrub hardwood forest of the gullies was in extremely poor condition throughout with heavy opossum damage, running shingle common beneath the trees, and active slips at higher levels. Cunningham (1966) reported that during the summer of 1961-62 forest survey parties saw about 30 to 40 deer per day in the headwaters of the Makirikiri (a tributary of the Ikawatea).

There were, however, some indications of recovery in the 1960s. Jackson (1961b) reported: "Considerable seedling regeneration and regrowth of palatable species such as the broad leaved coprosmas is apparent on the Waipawa terraces." Keating (1964) described red beech regeneration after logging in the Makaroro area, and noted that it could be improved by machine scarifying, particularly just after seedfall. Cunningham (1971) described a 1964 visit to Opawe Ridge: "Up Opawe Ridge to enclosure plots. Canopy fairly open but in good health. Opossum sign not abundant. Around lower enclosure recovery is good; ground cover in particular is much improved, many unpalatables and some palatables (mahoe, pigeonwood i.e. *Hedycarya arborea*, putaputaweta i.e. *Carpodetus serratus*) up to knee or waist height all along track. Tawa seedlings and saplings are thriving. Under the former kamahi forest (standing dead trees) is good growth of sedges and unpalatable spp., while inside the lower enclosure plot species such as *Cordy line banksii*, *C. indivisa*, *Coprosma robusta*, *C. foetidissima*, pigeonwood, and mahoe are about 1.2 m high. Up to top enclosure plot the canopy is more open-chiefly toro and peppertree, a few kamahi still alive. Kaikawaka, mostly unhealthy and regeneration of them absent, but seedlings of pink pine are common. On a 1969 visit to the Pohangina, Cunningham (op. cit.) noted that forest canopy on mid- and lower-valley slopes appeared healthier probably because a lot of the dead trees had collapsed. There was a warning note, however: "General impression of trends in the Pohangina is that in spite of encouraging signs of improvement in the canopy cover, the former stability provided by kamahi will diminish as the dead roots decay, and further-possibly extensive-slipping can be expected within the next two decades."

FROM 1970 TO THE PRESENT

The period since 1970 has been notable for the quantity of written material on the Ruahine Range.

At least 48 reports (18 of them published) have been produced since 1969 describing changes in the vegetation and aspects of erosion. Most have been written by Forest Service, Ministry of Works and Development, University, or Catchment Board staff. It is not intended to try and unravel the complex changes revealed by these reports. The generalisation is that a new phase of growth has occurred throughout much of the range, but that in many places forest deterioration is continuing and the area of exposed subsoil and rock is increasing.

Considerable progress has been made towards measuring forest condition and change, and in this respect reports by James and Beaumont (1971), Austin (1975), and Cuddihy (1977) are major contributions. The studies by Ogden (1971) and June and Ogden (1975 and 1978) on beech forests flanking Mt. Colenso have also added greatly to our understanding of the mechanics of change. Since 1975 monthly observations of kamahi forest have been made on two sites in the southern Ruahines, and results indicate that once opened, the forest canopy can suffer sustained physical damage from strong winds (Stoodley, 1978). From the meteorological station at Wharite Peak we know that the winds there are exceptionally strong and sustained (827 km/day average). Mosley (1977; 1978) reviewed the situation in the southern Ruahines in terms of erosion and sediment, and Cunningham and Stribling (1978) attempted a similar review for the range as a whole.

CONCLUSIONS

The main changes in the Ruahine Range forests from 1870 to 1970 are summarised in Table 1. The observational evidence suggests that although long-term climatic changes may have adversely affected mountain beech and kaikawaka at high elevations, the forests of the Ruahine Range were generally in good health before 1920. Between 1920 and 1930 the influence of introduced animals became apparent, and between 1920 and 1960 deer, goats and opossums had a profound and deleterious effect on the forests throughout the range. In the southern Ruahines, opossums, in particular, severely damaged the forest canopy to such an extent that wind-related physical forces have inhibited recovery. It is possible that there has been an increase in the effects of fungal and insect pathogens as a consequence of these accumulated changes.

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