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VEGETATION
of the
KAWEKA RANGE

by

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Vegetation of the Kaweka Range

By N. L. ELDER

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Abstract

THE Kaweka Range, a short section of the Cook Strait-East Cape mountain axis of the North Island, lying between 39° 05' and 39° 30' S., is distinguished by several special features. It is probably the driest section of the axis; it originally carried a considerable depth of pumice from the Taupo and earlier showers; and sheep were run over the greater part of it from the earliest days of European settlement. Much of the present-day plant cover has been affected by stocking and burning; while the pumice cover is especially subject to erosion.

Consequently the following survey is concerned largely with an induced vegetation and the changes taking place in it, and special attention has necessarily been given to the scanty historical evidence of the pre-European cover. The period of investigation, 33 years, has been long enough to yield evidence of appreciable changes and to permit the recording of some vestiges, now vanished, of the former cover.

That part of the area not affected by direct human action has features of ecological significance. It abuts on the silver-beech forest of the northern Kaimanawa Range and contains part of the ecotone between pure silver-beech and pure mountain-beech forest, though these forests are not in a virgin state, since for a long period red deer have been in undisturbed occupation. Evidence of wide fluctuations in browsing pressure without human interference is of significance; while there has been a recent invasion of part of the area by Japanese deer, with the consequent development of different browsing patterns.

BOUNDARIES

THE Oamaru and Mohaka Rivers (Map 1) form a convenient northern boundary with the Kaimanawa-Ahimanawa forests; the upper Taruarau and Ngaruroro Rivers a western boundary with the Ngamatea Plateau tussock; the lower courses of these rivers a southern boundary; and the limit of pasture on the Hawke's Bay side the eastern boundary. This gives a rectangle 25 miles by 16 miles; the southern portion, the downfaulted area between the Ruahine Range and the Kaweka Range proper, being included because it carries a similar vegetation which has a similar history of use.

STRUCTURE

The Kaweka Range is a greywacke block sloping gently to the N.W. from the high scarp (5,657ft maximum). This escarpment is the highest point in Hawke's Bay, and on its eastern side is separated from the more easterly Black Birch Range and the McIntosh Plateau by a fault—the Kaweka fault.

The gentle slope west of the Kaweka crest falls away for about 12 miles between the Ngaruroro and Mohaka stream systems to the Oamaru valley. The surface is cut up into a series of ridges and plateau remains. Remnants of the slope may be seen on looking across the Ngaruroro into the upper valley of the Taruarau.

Subsidiary ridges run roughly north and south, for instance the Black Birch Range and Don Juan. The ridge of the Manson Country continues the line of the Pukuohikarua Ridge. Te Iringa and the Comet continue the line of the main Kaweka Range across the Ngaruroro. Faults separate all the mentioned ranges.

FAULT LINES

Indications of recent fault movements are conspicuous both on the ground and in aerial photographs, along the eastern slopes and foothills, particularly in the Black Birch Range, in the vicinity of Kuripapango, and at the mouth of the Omahaki

Stream. These indications are in the form of trenches with a difference in level at the present day of the order of 6–20ft. No direct effect on vegetation is apparent unless perhaps on certain rock faces in the Makino tributary of the Mohaka. It should be put on record that no effects of the Hawke's Bay earthquake of 1931 (or, more particularly, of the after-shock that most affected Puketitiri) have been observed. (The main ridges and a route up the face of the range were traversed in 1930 and topographical photographs taken.) Minor earthquake shocks not noticed in the plains have occasionally been felt along the foot of the range.

DRAINAGE

The Mohaka River, running south-eastwards, cuts across the grain of the country and forms the northern boundary of the range; it then turns northwards below the upper end of the Black Birch Range.

The Ngaruroro and Taruarau running southwards in their upper courses form the western boundaries of the Kaweka Range and Hogget Block respectively. The Taruarau then turns east, cutting through the mountain axis between the Comet and the main Ruahine Range to form the southern boundary of the area under consideration.

The Ngaruroro cuts through the mountain structure in alternate transverse and longitudinal valleys, first separating Te Pukuohikarua Ridge from the Manson Country, then running south between the latter and the southern Kaweka. It then turns east again to cut off Te Iringa from the rest of the range and, at Kuri-papango, resumes a southerly course as far as its confluence with the Taruarau.

LITHOGRAPHY

Greywacke and Argillites

Although massive greywacke shows in cliffs and pinnacles at all points on the range, much-contorted, closely banded mudstones are conspicuous on some of the eastern spurs and near the head of the Tutaekuri River. These mudstones are very friable, and in consequence the areas in which they occur show active erosion on a large scale. This affects the Makahu, Donald, and Tutaekuri drainage systems and especially Kiwi Creek, which runs from Studholme's Saddle into the Ngaruroro.

Limestone

There are two prominent limestone scarps on the east and two conspicuous uplifted blocks on the south of the Blowhard. There are also several smaller outcrops on approximately the same horizon on the Black Birch Range and south of Te Iringa.

Pumice

Pumice showers have blanketed the whole area to a depth of several feet. The Hawke's Bay soil survey lists these as immature pumice podzols formed from volcanic ash 3 feet deep in the Kaweka, Te Pohue, Titiokura, and Taupo series. Several showers are represented but cannot readily be distinguished under present conditions.

The Taupo shower destroyed earlier vegetation west of the range crest, charred tree trunks and branches being plentiful up to 3 feet below the present surface. Above the bush line much of this pumice cover has been removed, and it has disappeared almost entirely from the crest of the range, but occasional hummocks occur there. Tongues of pumice held together by subalpine vegetation, mostly snow-grass, are characteristic of the slopes, even on steep gradients. These usually overhang at their lower margins and are being eaten away by frost action. Lumps of pumice up to 9in long occur as far east as the crest, and a charred band is frequently present here, suggesting that a previous subalpine vegetation has been destroyed by

hot ash. But the texture above this shows evidence of wind drift, and it is possible that recent burning followed by wind drift is responsible. No evidence of sub-surface burnt vegetation is apparent to the east of the main crest.

Ignimbrite

On the extreme western boundary limited deposits of ignimbrite occur in the Oamaru Valley and in the upper Ngaruroro.

RAINFALL

There are no meteorological records from the neighbourhood of the range. A belt of low rainfall (40–45 inches) is considered to cross the North Island from Wanganui to Napier at the Taruarau Gap, and long-established records from Mangaohane (39·5in) and Whanawhana (41in) confirm this, though the rain gauge recently established at Kuripapango gives considerably higher figures. The lack of definite climatic information in this gap is particularly unfortunate, as it leaves the cause of the discontinuous forest pattern in doubt. Whereas on the south side of the gap on the Ruahine Range these patterns can fairly be attributed to the drowning out of forest by the formation of peat, presumably marking a recent climatic change to cooler, wetter, and/or cloudier conditions, on the northern side of the gap the cause of forest/tussock patterns is by no means so clear. As far as the Kaweka Range is concerned there is no evidence supporting the hypothesis of a climatic change towards cooler, wetter conditions.

Beyond the northern extremity of the range Poronui Station receives a rainfall of 77in, and the Kaimanawa Range immediately above it may be considered to have about 100in.

All that can be deduced from this is that the Kawekas are likely to have a rainfall ranging from 40in–45in in the south-east to as much as 80in–90in on the extreme north-western boundary.

SUNSHINE

For three years (1938–41) observations of cloud levels along the Ruahine and Kaweka Ranges were made from the Hawke's Bay plains. These show that the ranges form a uniform barrier to easterlies and westerlies, north of the Manawatu Gorge. Winds from south-west to south-east supply most of the rain to Hawke's Bay and most of the cloud to the eastern side of the ranges. As the effect of these southerlies weakens in their passage north, there is a steady decrease of cloud and an increase of sunshine from south to north.

Cloudless days average 34% for the Kawekas as compared with 28% for the central Ruahine and 22% (Zotov) for the Tararua Range.

As rainfall increases sharply north of the Mohaka River, the Kaweka Range may be considered the sunniest and driest portion of the North Island axis ranges.

WIND

Forest margins and trees on exposed ridges are usually well grown and erect, showing little influence of wind, in marked contrast to the gnarled marginal trees and wind roofs of corresponding situations in the Ruahine Range. At the same time, with so much exposed pumice soil, wind has a disproportionate effect in open places.

SNOW

Snowfall varies. Above 5,000ft it may lie for up to five consecutive months in winter, but it may not persist until after midwinter; while drifts rarely persist until midsummer. After a particularly heavy fall snow may persist for a month at 3,000ft, and may do considerable damage to forest well below this level by stripping branches,

for instance in the Oamaru Valley after one heavy snowfall with high wind in July, 1954.

In stands of induced pole beech at higher altitudes localized damage may be severe, poles being snapped, uprooted, or bent into hoops. This has been observed both in narrow bands along a contour and also in basins with an easterly aspect. Damage in the former case appears to be due to exceptional ice formation, probably followed by heavy snowfall. One such belt was observed in the Cook's Horn Basin in the winter of 1936, and a second, more extensive one some time between 1940 and 1943. Similar damage had occurred near Kiwi Saddle prior to 1938; but the second type of snow break, apparently due to wet snow lodging on lee slopes in south-westerly gales, did equally spectacular damage in the hollow just north of Kiwi Saddle in September, 1956, where several acres of pole timber have been almost completely destroyed (Fig. 4). This particular snowfall appears to have been responsible for widespread damage, not only in pole timber, from Kiwi Saddle north-west at least as far as Otutu Bush.

HISTORY

The Kaweka, like the Kaimanawa Range, forms a block of high country with comparatively low easy country surrounding it on all sides. Consequently the Maori principal routes lay on its margins, the ranges themselves being penetrated only by hunters, traditionally hunting for kiwi, which are frequent in both ranges at the present day.

The Mohaka and Oamaru Valleys form a main route to the interior, and some settlements along this route persisted into European times. The settlements, Otorehinanui and Ngaawapurua, according to tradition, lay off this route: they were probably refuges, or at most lay on a minor route. Another main route into the interior ran through the Kuripapango Gap along the general line of the present Inland Patea Road. Fragments of obsidian have been picked up at two points in the Oamaru Valley and also on the Black Birch Range, on the line of traditional routes.

Recorded information dates from 1851, and refers almost entirely to the south-eastern part of the area. In 1851 Colenso crossed to the Inland Patea by the Ngaruroro-Kuripapango route. "Bousefield's Map" (but see note under reference) bears the legend against the Southern Kaweka, "Hills covered with black birch; principally dead". Colenso similarly notes at Kuripapango, "Tawai (*Fagus*) forests which formerly covered several of the nooks and crests of the mountainous hills and cliffs having been withered and destroyed".

The Kaweka Reserve (50,000 acres) was bought by the Crown in 1859 and the Mangatainoka Block (17,000 acres) in 1875.

The central forest block (roughly the "Area 2" of this paper) was gazetted State Forest in 1900. About 1905 the pastoral runs (the main range and the eastern approaches) were mustered off and lay derelict till 1940, when they were added to the existing State Forest. In the 1950's further marginal areas totalling over 20,000 acres were added, to give a total area of 127,000 acres of State Forest at the present day.

INTRODUCED ANIMALS

The first certain evidence of stocking is the record of the mustering of the main range and Blowhard in September, 1873, from Waiwhare, but stock may have been put on the northern part of the range a year or two earlier. The stock comprised merino wethers.

Pig were already established on the Blowhard when stocking began, and were hunted regularly from 1875 onwards; so were wild dog.

Rabbits first appeared a little after 1890 and reached their peak numbers about 1905, the densest infestation occurring in the southern part of the range, particu-

larly around Studholme's Saddle (4,600ft). A few even appeared on the crest of the range. Poisoning was carried out on a considerable scale at that time and rabbits have not been seen at least at higher altitudes, since 1924.

The first red deer, a stray stag, was not reported on Don Juan until 1901, but the strongly marked age gap in mountain-beech regeneration in the Central Kaweka suggests that a considerable deer population built up there at any rate soon after that date. The evidence of changes in deer population in this area without appreciable human interference is of special interest.

Japanese deer liberated in 1905 in a valley in the upper Mohaka have comparatively recently started to spread, particularly down the main valley, and have reached the eastern face of the range within the last ten years.

Wild sheep have persisted on the higher part of the range since mustering off, and are at the present day well established in spite of attempts to shoot them out. They are of merino type, though it is interesting to note that at the time of mustering off, the original merino flocks had been bred to Romney Marsh for upwards of ten years and merino characteristics were considered to have largely disappeared.

FIRE

Pre-European burning for cultivation is a probability along the slopes of the Mohaka Valley. This practice, described by Elsdon Best as "whakaota", continued at least up to 1900 in the neighbouring Ahimanawa margins. There are also vague oral traditions of former fires on the eastern face of the range, one of which has it that a single fire ran from Puketitiri to the crest of the range. Though the vegetation of the Blowhard 100 years ago suggests a succession following fire, there is no direct supporting evidence, and the soils indicate that the cover has been fern or tussock over a long period.

Colenso (1851-2) mentions recent fires in the lower country (the Blowhard, which he describes as fern country) both in fern and in forest islands, and this, together with the numerous references to burns seen on his travels, suggests that fires had a considerable effect on vegetation before the arrival of Europeans, at any rate near Maori routes and settlements.

The first record of deliberate burning in connection with stocking and fern crushing concerns the Blowhard in 1876. In the dry summer of 1878-79, two extensive fires swept the McIntosh Plateau and the crest of the range. Ring counts in beech regeneration at various points in the southern Kaweka date fires as having occurred from the early 1870's up to about 1885, over wide areas from the Taruarau to the Tutaekuri River.

More recent fires in limited areas are indicated by traces of spot fires on the McIntosh where scars on trees surrounding charred stumps give two dates, about 1900 and 1910. Even-aged regeneration on either side of Dick's Spur, the main mustering route on the northern end of the Kawekas, gives 1905 as the probable date of the last fire.

The Blowhard is particularly vulnerable to fire as it is traversed by the Inland Patea Road. A considerable area of this was swept by a scrub fire in the drought of 1946.

Tussock burning is a regular practice at the present day in the upper Taruarau and Ngaruroro valleys, and this affects all the western forest margins with trifling exceptions. In the Ngaawapurua Valley the tussock cover, apparently unaffected by fire in 1931, has deteriorated markedly over the last 25 years, and deterioration appears to be general in all the western tussock. No burning is known to have taken place recently on the tussock of the Manson country, but the stripping of pumice topsoil and the replacement of tussock and forest by celmisia and scrub suggest that deterioration occurred earlier, with fire an important factor.

VEGETATION

Species Distribution

Where the Napier-Taupo road passes through the gap between the forests of the Huiarau and Ahimanawa Ranges, there is a distinct floristic boundary. Between this and the Kaweka lies the Ahimanawa Range. *Dracophyllum latifolium* and *Phyllocladus trichomanoides* do not extend as far south as this line; *Phyllocladus glaucus* and *Gaultheria oppositifolia* just reach it, while *Quintinia serrata* extends a short distance into the Ahimanawa. *Ixerba brexioides* is not now known south of the road, but has been reported from forest near Puketitiri, now destroyed. Thus there is no northern element in the Kaweka flora.

On the other hand, though there is a general relationship with the Ruahine vegetation, several physiognomic species are absent, notably *Libocedrus bidwillii*, *Danthonia cunninghamii* and *Olearia colensoi*. *Dacrydium biforme*, apart from a solitary doubtfully identified hand specimen, is likewise absent, while *Senecio elegansifolius* is rare, apparently confined to a few river cliffs in the valley bottom of the head of the Tutaekuri. While the boundaries of *Libocedrus* and *Olearia* lie well outside the area, the absence, or virtual absence of *Dacrydium* is perplexing, as it is prominent on either side in both Ruahine and Ahimanawa Ranges, though not in the Kaimanawa. A comparison with the Northern Kaimanawa suggests that the absence of *Danthonia cunninghamii* may be due to long continued browsing by deer.

A number of species link the Kaweka with the Kaimanawa and the volcanic plateau: *Dracophyllum strictum*, *D. subulatum*, *Aristotelia fruticosa*, *Myosotis australis* and *Caladenia lyallii*. To the west *Cyathodes colensoi*, *Coprosma petrei* and *Carmichaelia orbiculata* appear on the upper Taruarau boundary, and *Senecio glaucophyllus* v. *raoulii* on the upper Ngaruroro boundary of the Kaweka. An endemic of the Inland Patea, *Hebe colensoi*, extends to this as well as to the Ruahine and Kaimanawa, but another, *Myosotis eximia*, does not cross the Taruarau-Ngaruroro boundary.

Celmisia incana is shared with the Ruahine and the volcanic plateau, though it is curiously absent from the intervening Kaimanawa Range. Two plants with a limited North Island distribution, *Epilobium pychnostachyon* and *Helichrysum depressum*, occur in the Kaweka.

A prostrate *Hebe*, not certainly identified, which is confined to exposed shingle slopes, is a possible endemic, and the Kaweka Range is the main centre of distribution of the hairy *Pimelea lyallii* which extends also on to the Northern Ruahine.

Since evidence of the destruction of vegetation by the Taupo shower is clear as far as the main crest of the range, a large part of the area must have been re-colonized within the past 1800 years. It may be postulated that chance is a factor in the occurrence and distribution of species, while it is possible that pumice soils may be unfavourable to certain species.

ALTITUDINAL BELTS

These can be reconstructed only sketchily in the eastern and southern parts of the range, as the original vegetation to the highest crests has been affected by grazing and repeated burning between the 1870's and 1905.

Most of the northern and western portion, however, has not been touched by fire, and shows four main altitudinal belts, which are here distinguished by their dominant species:

1. Subalpine vegetation, dominated largely by *Danthonia tussock*.
2. Forest in which mountain beech (*Nothofagus cliffortioides*) is dominant.
3. Red-beech (*N. fusca*) or silver-beech (*N. menziesii*) forest.

4. (a) Manuka (*Leptospermum scoparium*) scrub land, possibly all induced, with relics of beech/podocarp forest, or
 (b) *Danthonia rigida* tussock.

The timber line at several points reaches 4,800ft, which is remarkably high compared with the average for the Ruahine Range of 4,400ft. This high timber line and the absence of *Olearia colensoi* (which extends to higher altitudes than any other large subalpine shrub) results in a sharp transition from forest to *Danthonia flavescens* tussock. Low-growing shrubs occur in the tussock community, but a sub-alpine scrub belt is generally absent.

The lowest belt surrounds the range; *Danthonia rigida* tussock along the western boundary in the upper reaches of the Ngaruroro and Taruarau, manuka scrub dominant on the other three sides. The *Danthonia* is a succession in the recolonization of the Taupo pumice shower, but the manuka scrub is to a considerable degree, perhaps wholly, induced by burning.

There is widespread evidence of recent burning, and evidence both written and visual of the invasion of manuka in several localities within European times, but there appears to be also long-established manuka along the Mohaka boundary of the range, which may link up with the evidence of pre-European fires in the Ahimanawa Range and the Taupo district.

NATURAL AREAS

The present composition of the vegetation, together with the reconstruction of the former cover, divides the Kaweka into four areas from north-west to south-east, the first two being under comparatively unaltered forest, the last two having a broken cover of various forms induced by stocking and burning.

AREA 1. NORTHERN	Forest: silver beech present.
AREA 2. CENTRAL	Forest: no silver beech.
AREA 3. EASTERN AND SOUTHERN	Induced scrub - tussock - forest complex.
AREA 4. FOOTHILLS	Induced scrub-fern with islands of beech or podocarp forest.

BOUNDARIES

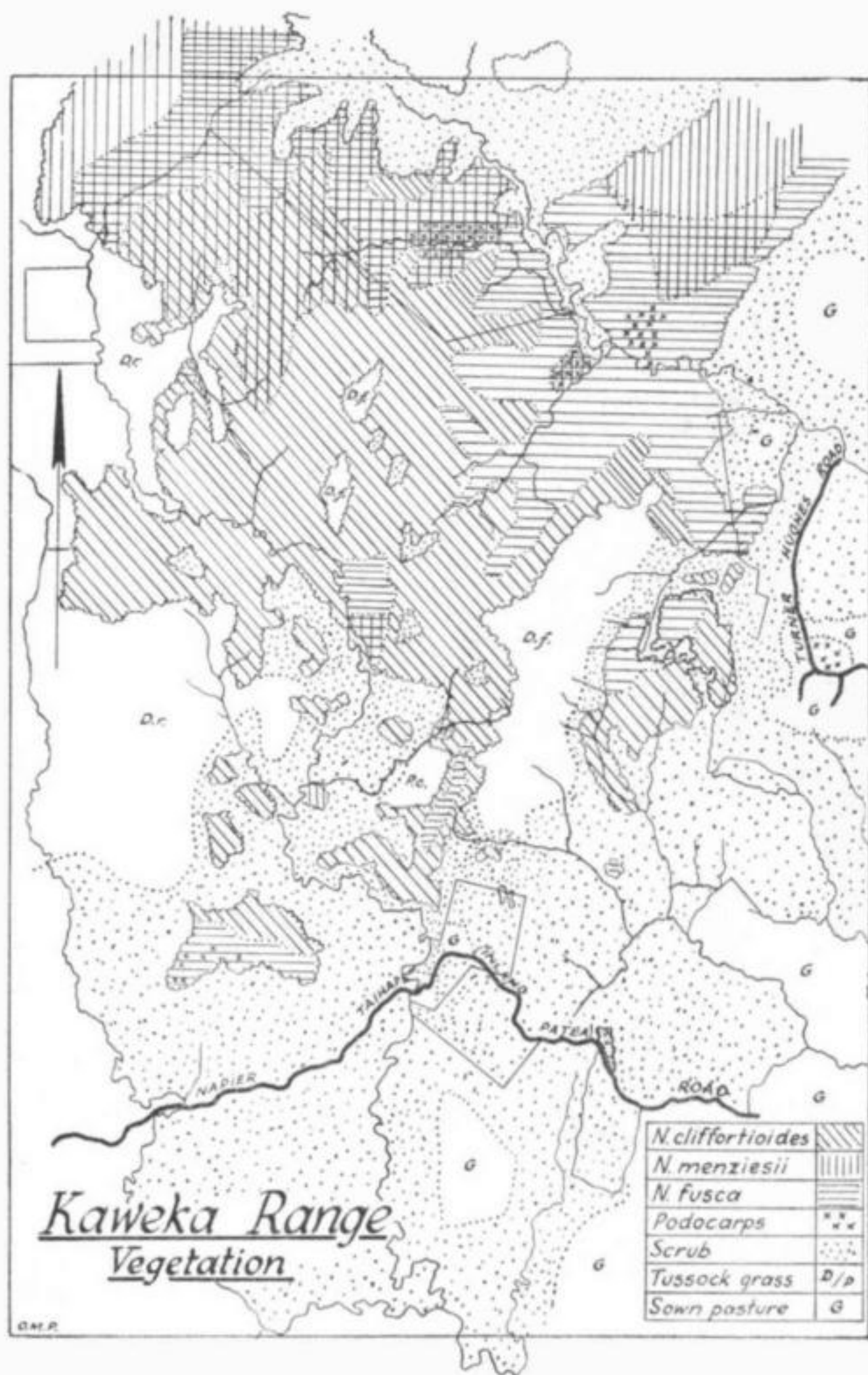
Between Areas 1 and 2. A line from Ruatakaikare Trig to Te Pukuohikarua Trig, continuing to the mouth of the Mangatainoka River. Silver beech occurs down both the Ngaruroro and Mohaka rivers below this boundary, but essentially as a colonizer of river terraces.

Between Areas 2 and 3. Area 2 is roughly the original (1900) State Forest, No. 21, and its boundary with area 3 is the limit of burning on the pastoral runs—approximately south along the present timber line on the west side of the main crest to a point above Studholme's Saddle, then west to the Ngaruroro River and upstream.

Between Areas 3 and 4. This boundary divides what was fern land with islands of podocarp forest or beech containing podocarps, from the high tussock land with beech forest, and is substantially an altitudinal boundary, following the 3,000ft contour. This division is not altogether satisfactory, but it enables the eastern foothills (Black Birch and Don Juan), the southern plateau (McIntosh and Blowhard) and the subsidiary ranges (Burns and Comet) to be considered as a whole.

Area 1. Northern Kaweka.

FOREST. This is essentially an ecotone between the silver beech/red beech forest of the Northern Kaimanawa and Ahimanawa Ranges, and the mountain beech/red beech forest of the Central Kaweka Range (Map 2).



SILVER BEECH. The main feature is the relationship of silver beech to the other two species. 4,200ft is a critical altitude above which mountain beech is dominant; scattered large, heavily branched trees of silver beech occur at higher altitudes, but are confined almost entirely to sheltered locations where there is no younger growth. Mountain beech is here clearly supplanting silver beech. Between 4,200ft and 4,000ft, however, abundant silver-beech generation 4ft to 7ft high under a mountain beech canopy, is characteristic. This is of more than limited occurrence, as it has also been observed on the Kaimanawa side of the ecotone in the Waio-tapuritia Valley, and further afield above Rangataua on the slopes of Ruapehu.

Its vigour here in forest otherwise heavily browsed by deer, both red and Japanese, is unexpected and perplexing.

Below 4,000ft the relationship between the two species is less clear. There is a complicated patchwork of pure stands of one or the other species and of areas where the two are apparently codominant, with large canopy trees. Here silver beech is approximately three times the age of mountain beech of comparable size, and pockets of pure silver beech tend to be overmature with a discontinuous canopy, while the mountain beech is younger and more vigorous.

It appears possible that in this situation the two species may alternate, with shade-tolerant silver beech favoured under a mountain-beech canopy and eventually supplanting it; the longer-lived silver beech with its denser canopy then suppressing all regeneration until, with over-maturity, gaps in the silver-beech canopy favour light-demanding mountain beech. Not all stages of this sequence have been observed, as the browsing of a large deer population distorts the pattern of regeneration.

RED BEECH. What should be the red-beech zone (below 3,600ft), is occupied largely by *Danthonia rigida* tussock in the Ngaruroro Valley and by tongues of induced manuka scrub in the Mohaka. Between the two, red beech with silver beech sub-dominant occupies the Oamaru Valley, which is a geographical, not an ecological boundary.

Despite the manuka scrub, red beech is more or less continuous down the Mohaka Valley, but in the Ngaruroro the zone is pinched out. Mountain beech not only occurs above it, but also forms the forest margin with tussock grassland below it. The last continuous red beech forest forms a narrow tongue in the Purungetungetu Valley near the head of the Oamaru, and here it is all-aged and appears self-perpetuating. South of this red beech appears only sporadically, though there are several pockets down the Ngaruroro River.

Bogs. A line of three small clearings is conspicuous on aerial photographs at the head of the Purungetungetu Stream, and a fourth at the head of the Ngaawapurua. All are bogs on sloping surfaces, and appear to have been formed by a heavy wash of pumice from steep neighbouring slopes blocking pre-existing drainage systems. All have a well established bog vegetation on peat of varying depths underlain by a hard pan. Their altitude is about 3,300ft—i.e., in the red beech/silver beech zone, but each is surrounded by a belt of mountain beech, which forms a series of concentric rings. The inner ring, together with scattered trees on hummocks within the bog, is of stunted trees of considerable age with heavy growth of *Usnea*; the second is of taller, largely moribund trees, the third of still taller, healthy mountain beech. Behind, there is an abrupt change to silver beech forest.

Induced Forest Margins

It is not safe to say that any outer forest margin of the Kaweka has not been affected by fire. At present there are three types of forest margin in Area 1:

1. Mountain beech—*Danthonia rigida* tussock in the upper Ngaruroro and Ngaawapurua;
2. Silver beech—*Festuca novae-zealandiae* at the head of the Mohaka;
3. Beech-manuka in the Mohaka Valley.

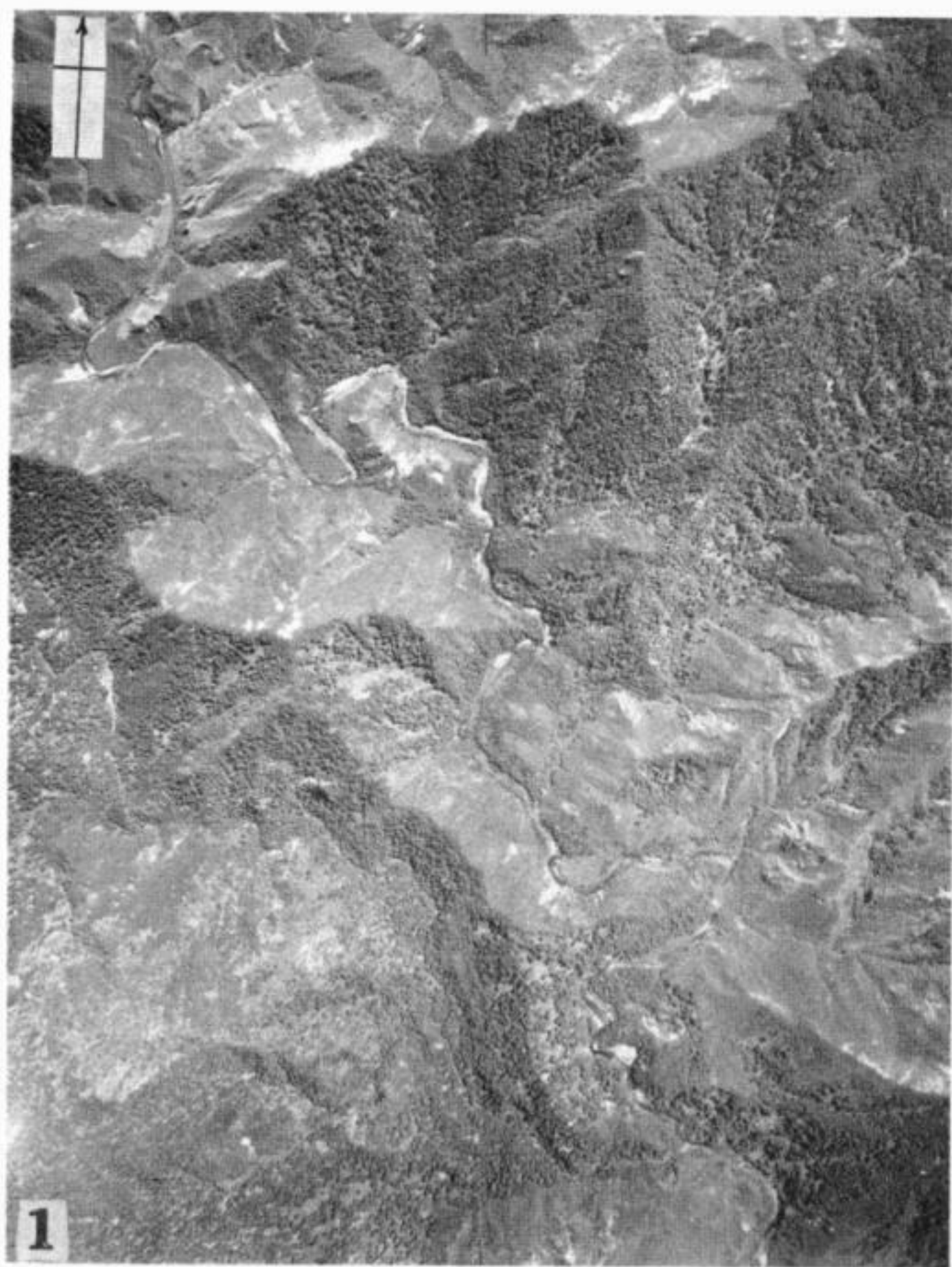


Photo: Crown copyright. Lands and Survey Dept.

PLATE A. PHOTO 1.—Scrub/forest patterns, Mohaka Valley.



PLATE B. PHOTO 2.—Fire-induced scrubland, Ngaruroro Valley, from Te Iringa. Trig. 7.



PLATE C. PHOTO 3.—Stabilizing scree, Cook's Horn Basin. PHOTO 4.—Snow break, July, 1956, Kiwi Saddle. PHOTO 5.—Pumice gullying 4,600ft, Studholme's Saddle.



PLATE D. PHOTO 6.—Frost terrace margin, 5,500ft, near Kaweka Trig. PHOTO 7.—Black Birch Range across Kaweka Fault, near Kaweka Trig. PHOTO 8.—Forest margin unaffected by fire, Ngaawapurua.

1. A few chains of forest margin protected by the stream appear to have escaped fire in the Ngaawapurua enclave. From a stream margin of *Aristotelia fruticosa* and *Dacrydium bidwillii* a slope with an almost closed cover of *Dracophyllum subulatum* runs up to a hedge of *Phyllocladus alpinus* bordering *Nothofagus cliffortioides* forest. Elsewhere *Danthonia* tussock stops abruptly at the beech margin, which has a strong browse line about 6ft above the ground. Though fire has seldom run any distance into forest, small outlying clumps of beech have been destroyed, some quite recently. The general picture is of an advancing forest kept practically stationary by tussock burning.

2. The only silver beech-fescue margin examined lies near Rouiti Pa, just outside the Kaweka boundary. Evidence of fire was not seen, but the absence of a scrub margin suggests that it has been affected by fire at some time.

3. Both sides of the Mohaka Valley are occupied by manuka scrub with tongues of beech forest on the upper slopes; the pattern appears to be fire induced. At the upper end, particularly in the Mangapapa valley, areas of manuka of different ages trace the pattern of a series of comparatively recent fires: the whole slope of Ahikaeaea (4,080ft) is partly bared, with a fringe of second-growth beech, apparently 30 to 40 years old, along the crest.

Area 2. Central Kaweka

The most interesting feature of the central area is the evidence in the upper forest of a decrease in deer population and changes in the vegetation over the past 25 years.

The central Kaweka is a dissected plateau which lies between Te Pukuohikarua Range and the main Kaweka Range; it is in forest apart from a number of tops about the 4,600ft level. On the northern side several large valleys drain into the Mohaka, while the Ngaruroro faces are steeper and shorter.

The upper forest is pure mountain beech; below 3,700ft red beech is dominant on the Mohaka slopes and in the Omarukokere valley on the Ngaruroro side, but this latter is on the boundary of the area south of which the distribution of red beech becomes sporadic.

MOUNTAIN BEECH FOREST. At the present day the tops above the timber line are dominated by low subalpine scrub with traces of *Danthonia rigida* tussock.

When the mountain beech forest was first observed in 1930, deer were abundant, track systems were exceptionally well defined and the forest interior was eaten out and clear of undergrowth. Dead standing *Nothopanax* was conspicuous throughout, but living *Nothopanax arboreum*, *Griselinia littoralis*, *Coprosma foetidissima*, *C. pseudocuneata* and *Suttonia divaricata* were noted as being present. When the same route was traversed three years later the lack of traffic on the main routes and the new growth on browsed shrubs was commented on, but no detailed observations were made. A return in 1952, however, discovered a dense regeneration of beech, 6ft to 10ft high, together with abundance of *Coprosma pseudocuneata* as an under shrub. *Nothopanax*, *Griselinia*, and *Coprosma foetidissima* were now practically absent, though occasional plants could be found in places inaccessible to deer.

Further observations made in 1954 showed the absence of beech regeneration between 20 and 40+ years old. Some *Coprosma foetidissima* and *Nothopanax* seedlings were seen. Although deer were not seen in the forest and their traces were infrequent, a few were sighted both in 1952 and 1954 on the open tops. *Danthonia rigida*, once common on these tops, is now rare and the vegetation is now a low alpine scrub dominated by *Hebes*—*H. tetragona*, *H. buxifolia*, and *H. laevis*—together with *Dracophyllum recurvum*, *Cassinia vauvilliersii*, *Dacrydium bidwillii*, and a wide variety of lower-growing plants. In spite of this preponderance of shrubs examination of the rumen of a deer shot here in December, 1952, showed a remarkably high proportion, fully 50 per cent., of grassy substances, together with recogniz-

able remains of *Blechnum minor* from the forest floor and such rare species as *Griselinia* and *Coprosma foetidissima*.

The area is comparatively inaccessible and little visited; changes in deer population and in browsing pressure were obvious several years before the start of Government culling operations, and appear to have continued without appreciable interference up to the present. There is evidence here of large changes in deer population towards a balance with the environment.

The abundance of kiwi probings in soft ground throughout the upper forest of this area is worthy of mention. Though the birds themselves have not been seen an abandoned nest has been found. Another abandoned nest in the Oamaru Valley suggests that kiwi are frequent in both areas 1 and 2.

Historically the Tapapa Block was a noted kiwi-hunting area.

RED BEECH FOREST. In strong contrast with the upper (mountain beech) zone there is now (1952, 1954) a considerable deer population in the lower (red beech) zone. Close browsing of trees of *Nothopanax* spp., freshly barked but dying or recently dead, indicates that this infestation has not been of long duration. The close contouring tracks and the behaviour of the animals suggest that mainly Japanese deer are present, but this opinion needs more expert confirmation.

Overmature red beech forest with a discontinuous canopy and practically no evidence of regeneration is an unexplained feature of north-facing slopes of the Mangatainoka Valley.

KANUKA. Several unusual pure kanuka (*Leptospermum ericoides*) stands occur in the Makino Valley and in the Mohaka Valley adjacent to it. These were first noticed on aerial photographs. One in the Mangaturutu tributary was examined and appears typical.

On steep slopes of coarse rock fragments, tall kanuka, some 50ft high and of diameter about 12in abruptly replaces red beech. Much light reaches the floor, which carries a low xerophytic undergrowth, principally *Leucopogon fasciculatus* and *Coprosma rhamnoides* with some *Carpodetus* and *Pseudowintera colorata*. The remains of one such kanuka stand suppressed by red beech occurs on a shady (south-eastern) face, but the other, with an exposed aspect, appears comparatively stable. There is no trace of a former beech cover and no evidence of beech seedlings advancing under the kanuka. The abrupt change to soil at the margins suggests that a series of rock falls is the cause of the formations, and the even age of the kanuka suggests a single cause, possibly an earthquake, opening several steep faces simultaneously.

RIPARIAN SILVER BEECH. Both down the Ngaruroro and in the tributaries of the Mohaka (the main valley being occupied by manuka scrub) silver beech occurs well below its usual range. The general pattern is of the dispersal of seed by water, but silver beech may occur as a component of red beech forest as much as 500ft above the waterway (e.g., in the Manson country) and as much as four miles up side valleys from the main river (e.g., in the Makino valley). On the boundary of Area 1 (Mangatainoka) it forms stands pure except for scattered podocarps. Elsewhere on the river margins it is associated with mountain beech, which usually dominates.

On the Ngaruroro slope of the Manson country, silver beech makes up about 20% of the trees both on the margin and in the adjacent red-beech forest. Saplings and seedlings are plentiful. Scattered trees extend down both rivers into Area 3.

Area 3. South-East Kaweka

Practically the whole of this area, which includes the main crest of the range, has been affected by stocking and burning from the 1870's onwards, and as a result it is now a patchwork of induced communities which defy coherent description.

It presents the main erosion problems of the Kaweka, which are not only man-made but are complicated by extensive fault systems. In these erosion patterns there are particularly interesting features of regeneration and stabilization.

The most baffling ecological problem is that of the relationships of this area with the Ruahine Range in the south and with the Ahimanawa and Kaimanawa ranges in the north and west, but the first step towards solving this—viz., the reconstruction of the pre-European vegetation, cannot be taken with any confidence on account of the profound alterations that have taken place over the past 80 years.

The "hills covered with black birch; principally dead" of the early map (the one here referred to as "Bousefield's map") are written evidence of their pre-European state, and suggest a retreating mountain beech forest like that of the upper levels of the Ruahine Range, and, as has already been pointed out, unlike that of the Kaimanawa and the rest of the Kaweka. It may be significant that the boundary between this area and the Central Kaweka coincides approximately with the edge of the charred wood underlying ash showers—i.e., with the limit of complete destruction of pre-Taupo vegetation by hot ash.

At any rate, except at one point at the head of the Tutaekuri, near the boundary of the area, there is no evidence of the high timber line (c. 4,800ft) characteristic of the Central Kaweka.

Existing forest, and logs indicating former forest, do not generally occur above about 4,500ft, thus following the Ruahine pattern. Considerable areas of forest have been burnt and replaced by grassland, *Celmisia* meadow, or talus slopes within the last 80 years, but even so it seems doubtful that the forest was continuous before that.

A further problem is the status of red beech in this area. At the present day its occurrence is sporadic and confined to favourable and sheltered situations. But logs of this species occur in areas where burning has been followed by the regeneration of pure mountain beech stands; and where the two species co-exist hybrids are numerous. These facts indicate that red beech was formerly more widespread. It is doubtful, however, that it was universally present in its appropriate zone.

Red beech becomes sporadic towards the northern extremity of the Ruahine Range, and is absent from a large area of forest on the eastern side of the Kaimanawa Range. The distribution of red beech at the southern end of the Kaweka Range appears to have some affinity with this pattern.

As a satisfactory description of the area as a whole is impossible, observations have been made on the following subdivisions:

KAWEKA CREST. Kaweka Trig (5,657ft) is the highest point on the broad undulating four-mile crest of the range. Most of the surface is exposed, a waste of rock fragments with a scattered open vegetation, but sheltered hollows carry a closed cover of *Danthonia flavescens*, and occasional hummocks of pumice carrying a closer vegetation point to a former more extensive covering of soil. An extensive fire was recorded on the range in the drought of 1879, and this appears to have run well down into the beech on the western spurs; the steep eastern scarp is largely bare of vegetation and traces of fire are frequent. Caps of pumice soil carrying a closed cover of snowgrass and with tongues extending down steep slopes and undercut by the action of frost, wind, and water are characteristic of this face. On the open tops wind terracing and frost striping, developed on a large scale, are reminiscent of the Kaimanawa Range.

In an area with so large a proportion of open ground, such low-growing alpine plants as can maintain themselves and advance on to bare patches are of especial importance. At the highest altitude on lichened and comparatively stable rock fragments *Phyllachne colensoi* is abundant; various alpine species later secure a foothold on its peaty mounds.

From the banks separating wind terraces and frost-heaved ground, the sprawling *Dracophyllum recurvum*, associated with *Dacrydium laxifolium* and *celmisias*

(chiefly *C. incana*), tends to encroach slowly on to unstable shingle. A number of smaller plants, most of which are also of a sprawling habit, take advantage of the shelter provided. One true scree species, *Parahebe spathulata* with its remarkably extensive root system, is unique in its ability to establish itself on unstable ground, and has even been observed growing among frost stripes. Another scree species, *Epilobium pychnostachyon* has only recently been observed, and appears to be a rapid colonizer of suitable habitats.

Below 5,000ft the prostrate snow totara, *Podocarpus nivalis*, plays a considerable part in holding unstable slopes, forming mats up to 30ft across, in which wind-drifted soil accumulates—a seed bed for a considerable variety of other plants.

DICK'S SPUR. The eastern scarp of the range drops 2,500–3,500ft in steep spurs to the main Kaweka fault along its foot. It certainly carried more vegetation, including forest, in pre-European times, but how continuous this was is problematical.

Dick's Spur was the main mustering route down this face until about 1905, and though it now displays barren rock, occasional logs of *Podocarpus hallii* occur on it up to 4,500ft. In the eastern-facing basins on either side, however, there are at this altitude considerable areas of mountain beech regeneration unusual in that they are uniformly 40–45 years old. It would appear that burning or heavy browsing prevented regeneration until after the date of mustering off, when for a short period, before the arrival of deer and the build-up of stragglers into wild merino flocks, regeneration of beech was possible. These basins are noteworthy also in that some hundreds of acres of steep and partly eroded slopes are now dominated by sprawling colonies of *Celmisia incana* which appear to have replaced *Danthonia flavescentis* tussock and probably to some extent beech forest.

COOK'S HORN BASIN. The processes of erosion and regeneration have been investigated most closely in a tributary basin near the head of the Tutaekuri River, which possesses most of the characteristics of Area 3; vestiges of original forest, forest regeneration following fire, some of the original tussock cover, induced manuka scrub, wind-blown pumice scars, screes, and rock falls.

The Cook's Horn Basin is roughly circular, measures about a mile across, and ranges from 4,600 to 2,000ft in altitude.

In 1937 the vegetation was surveyed and a quadrat was pegged out in regenerating pole beech. At that date the main features were the absence of regeneration under the forest canopy, the evidence of heavy pig and deer populations, and the unexpected discovery that none of the three main scree systems was delivering spoil to the waterways, but that they were separated from them by belts of stabilized rock fragments already in process of being recolonized by vegetation.

Since that date the recolonization of screes has proceeded at a slow rate from the bottom, and a fourth scree appears to be reaching stability; the animal population has decreased sharply following the erection of a tramping hut in 1936; the spread of beech into manuka scrub has become conspicuous and regeneration within the forest has become dense. The latter has been closely associated with the opening of the canopy, and particularly with the destructive effect of snowfall and icing on pole timber. This destruction was first observed in the winter of 1936 in a narrow belt of pole timber, snapped or bent, and beech regeneration was first noticed along this belt. A similar narrow belt was formed about 1943, since when no certain evidence of snow break has been recorded here, though an even more spectacular snow break occurred in the neighbouring Kiwi Saddle area in the winter of 1956.

Generally the picture is one of a rapid recolonization by beech and at higher altitudes a slower recolonization of bare slopes and screes by scrub and other alpine plants, but three or four active gutters in the pumice slopes suggest early stages in the development of fresh scree systems. One extensive face of shattered rock from the highest part of the circumference is still much affected by frost action and contributes large quantities of spoil to the main watercourse.

A recheck of the beech quadrat in 1954 shows that while in 17 years the basal area of timber has remained constant, 42 per cent. of the trees have died. (A tally of visible stumps and dead trees in 1937 gave a similar rate of mortality over, say, the 20 preceding years.) Apart from a slight tendency for the smaller trees to be eliminated, no pattern of mortality can be obtained. The opening of the canopy has commenced but is less advanced than elsewhere, and the floor is still substantially bare. Limited patches of beech seedlings, dating from about 1950, have made their appearance, and a variety of under shrubs were recorded in 1954. The mast year of 1955 has had little effect.

KIWI SADDLE. Snow break in pole timber at a recent date has already been mentioned. On the ridge running north of this saddle to Castle Camp at the head of the Tutaekuri, mountain beech forest formerly extending to about the highest timber line, where it apparently consisted of gnarled, over-mature trees, has been burnt and replaced by a luxuriant cover of *Poa caespitosa* tussock. This succession has not been observed elsewhere.

MANSON COUNTRY. This isolated ridge also has been extensively burnt and is still grazed. Exposed crests up to 4,500ft in altitude are in many places eroded and bare of vegetation, while considerable areas of forest have been replaced partly by tussock, partly by *Celmisia spectabilis*. Introduced grasses are common below 4,000ft, in basins, and *Leptospermum* scrub or second-growth *Nothofagus* forest on the slopes.

HOGGET BLOCK. This tussock plateau to the west of the Manson has affinities rather with the Ngamatea Plateau beyond the Taruarau River than with any portion of the Kaweka Range, and is included here merely for convenience. In spite of a long period of grazing and evidence of burning, it is still dominated by *Danthonia rigida*. Several volcanic plateau species, such as *Cyathodes colensoi*, *Coprosma petrei*, and *Carmichaelia orbiculata*, extend on to it from the Ngamatea Plateau.

Area 4. Southern Kaweka

The Blowhard Plateau, together with the foothills lying to the north of it and the broken country to the west of it between the Kaweka and Ruahine Ranges, are at the present day a uniform area of manuka scrub with scattered islands of forest, only two of which, the Black Birch and Boyd's Bush, are of any considerable extent.

Most of the manuka scrub is fire induced; the earliest description (Colenso, 1851, 1852) speaks of *Pteridium* fern land, with subalpine scrub and open ground on the more exposed ridges.

The chief problem, and one that has so far proved insoluble, is to account for any such pre-European vegetation pattern. The prevalence of *Pteridium* fern and the pattern of forest islands suggest a succession following destruction of forest, but no evidence of this is forthcoming, while the Blowhard soils indicate that tussock grass or scrub has been the dominant cover there over a long period.

Most of the area lies between 2,000ft and 3,000ft, and the common element in the forest islands is the presence of podocarps as scattered trees or pockets in beech forest, usually mountain beech but occasionally red beech being dominant.

One small island, the Blowhard Bush, is exceptional in being podocarp-broadleaf forest, but early station diaries mention several additional islands of podocarps which were utilized or perhaps burnt at an early date, most of the locations being now lost. The former State Forest 23, an 800-acre strip in the Ngaruroro valley, may fall into this category as there is one early account of matai forest in that locality of which no trace is now visible.

Most of the lost islands are reported as matai (*Podocarpus spicatus*), but at the present day the most common species are the thin-bark totara (*P. hallii*) and rimu (*Dacrydium cupressinum*) with occasional matai and kahikatea (*Podocarpus*

dacrydioides). Miro (*P. ferrugineus*) is infrequent. Maire (*Olea lanceolata*) occurs in association with podocarp forest, and there is even one record of the lowland-forest liane *Rhipogonum*.

BEECH FOREST. In the smaller islands of forest, mountain beech is generally dominant though well below its usual altitudinal range, but some red beech is frequently present. In the large forest areas there is a well developed red-beech zone. There is a tendency for forest to extend into the surrounding manuka scrub, which tendency is particularly marked on the McIntosh Plateau, where scattered saplings, mainly of red beech and totara, appear above the scrub over a wide area. The isolation of the plateau probably accounts for this, as it has escaped the scrub fires which have repeatedly swept the Blowhard, though there also the tendency for beech to advance into scrub has been observed.

SCRUB LAND. The dominant vegetation is manuka scrub, gnarled and stunted in exposed positions, tall and dense in shelter, growing on several feet of pumice soil which has been blown or washed out into frequent scars on which little or no vegetation has become established. These scars appear to have developed as a result of grazing and burning and to be still extending, to judge from the rate of exposure of roots and the undercutting of adjacent hummocks.

A considerable proportion of kanuka (*Leptospermum ericoides*) which may be as high as 50 per cent. is of significance in view of its resistance to manuka blight, which has recently (1956) been identified in the area.

A 1946 fire made a clean burn over a considerable proportion of the Blowhard. This was followed by the dominance of bracken fern, even where it had been suppressed by manuka, and ten years later fern still tends to dominate, though manuka is coming through it. Quadrats have been established both in this 1946 fern and in the adjacent manuka scrub, to study the stages of reversion in the immediate future and probably the effect of manuka blight at a later date.

Where manuka scrub is established and not too dense there is a considerable undergrowth, with *Olearia furfuracea* and a number of heaths prominent. The *Olearia* appears to be able to dominate manuka on shady faces but to remain stunted in exposed situations.

TUSsock. Though tussock is not mentioned in early accounts, there is a certain amount of *Danthonia rigida* and *Festuca novae-zelandiae*, and a little *Poa caespitosa* scattered over the area today, and they were probably a more important element in the 1870's and 1880's, when large numbers of sheep were grazed on the Blowhard, Black Birch, and McIntosh.

At the present day two areas of *Danthonia rigida* tussock exist, one of a few acres in a hollow on the Blowhard, the other a much larger natural clearing in beech forest (Littles Clearing) on the flat summit of the Black Birch Range. Only half the clearing is in tussock; the lower half, which 33 years ago was a spectacular *Celmisia* meadow, is now dominated by manuka scrub. These appear to be successions following burning, and succeeded each other in a comparatively brief period.

River-bank Communities

NGARURORO-TARUARAU CONFLUENCE. A strikingly distinct lowland community occurs in a restricted area of river terrace and cliff at the Ngaruroro-Taruarau confluence, altitude 860ft. On the terraces *Myoporum laetum* is dominant, with *Alectryon excelsum* and *Leptospermum ericoides* common. Lianes are abundant, mainly *Tetrapathaea tetrandra*, with *Mühlenbeckia australis* and *Parsonsia heterophylla* present also, and there is a close but somewhat xerophytic undergrowth consisting of *Coprosma rigida*, *Teucrium parviflorum*, *Urtica ferox* and some *Rubus squarrosus*. *Clematis afoliata* occurs in the vicinity though it has not been recorded in this particular community.

On the adjacent cliffs *Dodonaea viscosa*, *Hebe parviflora* (the prostrate rupestral form), *Rubus squarrosus*, *Angelica rosaefolia* and a tomentose *Senecio* (intermediate between *S. banksii* and *S. colensoi*) form a distinct community. Though 30 miles inland and separated from the coastal hills by the Heretaunga Plain, these communities have a distinct affinity with coastal forest.

A similar community a mile downstream may be mentioned, though being on the Ruahine bank it is outside the area. This has the same components with the addition of *Sophora tetralix* and *Macropiper excelsum*, also colonies of *Hebe colensoi* (the Taruarau form) and *Myosotis eximia*.

TARUARAU BRIDGE. On cliffs in the vicinity of the bridge a colony occurs of the most widely distributed form of the glaucous *Hebe colensoi*.

KURIPAPANGO. A toothed form of *Hebe colensoi* with a limited distribution occurs on the Ngaruroro River cliffs in the vicinity of the bridge.

TUTAEKURI-DONALD CONFLUENCE. *Helichrysum depressum*, of which there is only one previous North Island record, forms an extensive colony on river shingle.

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NOTES ON PHOTOGRAPHS

PHOTO 1. Mohaka Valley: From Mangatainoka confluence upstream showing part of the *Leptospermum* scrub pattern in main valley which is presumed to be a pre-European fire pattern. The scarp (high right) leads to Te Matai (4,085ft), and the face of the scarp has been stocked from Lochinver station. The upper forest here is dominated by *Nothofagus menziesii*, the lower forest by *N. fusca* with pockets of podocarps. On the Kaweka (left hand) side *N. menziesii* and podocarps are limited to the river terraces of the Mangatainoka valley. Over-mature *N. fusca* forest mentioned in the text appears on the extreme left.

PHOTO 2. Ngaruroro Valley: Looking upstream (north) to Manson country. Apart from centre of forest gully in right foreground practically the whole area visible has been affected by fire in European times. The spurs in the centre of the photograph are in the area gazetted State Forest No. 23 in 1900, probably then a matai relic.

PHOTO 3. Cook's Horn Basin: Burnt logs were visible across these upper slopes as recently as 1930 and on the bare spur at extreme right. The scree (right) is still in running shingle for the top 700ft, but about 100 yards of stabilized fragments at the foot have been colonized by *Celmisia*, now reverting to scrub. The rock faces in the centre are unstable and subject to frost action, delivering large quantities of rock fragments to the watercourse. Vegetation is beginning to appear on the left-hand scree. Beyond this two channels 6-12ft deep in pumice soil are possibly developing into fresh screes.

PHOTO 4. Snow Break: Kiwi Saddle, 3,870ft. After a heavy snowstorm in July, 1956, several acres of regenerated mountain beech (70 years old) were affected by snow break, most trees being snapped off below the crowns, a considerable number uprooted or bent into

hoops. Similar effects have been observed in pole stands both here and at the lower elevations in the Cook's Horn Basin in two other winters in the past 20 years.

PHOTO 5. *Pumice Gullying*, Studholme's Saddle, 4,500ft. *Danthonia flavescens* on pumice soil. This area was considered to be the best grazing on the range prior to 1905. About that date it was heavily infested with rabbits and became the site of one of a chain of rabbiters' huts.

PHOTO 6. *Frost Terrace Margin*: Crest of range near Kaweka Trig, 5,500ft. The main vegetation is *Dracophyllum recurvum*, associated with *Celmisia incana* and a considerable number of smaller species of the same sprawling habit. The vegetation on the rock surface in the left foreground is a scree plant *Parahebe spathulata* which has been observed in the vicinity surviving on frost furrows. Pumice hummocks are visible in the *Danthonia flavescens* meadow in the background.

PHOTO 7. *Black Birch Range*. On the scarp of the Kaweka Fault (foreground) burnt logs occur up to 4,500ft, and clumps of trees survive in the gullies. Little's Clearing (*Danthonia rigida* bog) is prominent (upper left) on the flat top of the Black Birch Range, the near slope of the clearing now dominated by *Leptospermum* scrub was 30 years ago *Celmisia* meadow, presumably induced by a combination of fire and grazing. The belt of forest visible is *Nothofagus cliffortioides* on the crest and *N. fusca* on the slopes, mainly unaffected by fire. A relic of heavy podocarp forest, Balls Clearing (2,000ft) is visible in the background immediately behind Little's Clearing (3,600ft).

PHOTO 8. *Ngaawapurua* (3,500ft). *Danthonia rigida* tussock, heavily burned to left of stream, forest margin of *Nothofagus cliffortioides* affected by burning and showing marked browse line, exception at right where it has apparently been protected from fire by stream. Here *Danthonia-Aristotelia fruticosa* along stream merges into *Dracophyllum subulatum-Dacrydium bidwillii* scrub and this to *Phyllocladus alpinus* hedge along forest margin. *Nothofagus menziesii* is frequent to dominant behind the outer margin. *N. fusca* is absent.

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