THE HISTORICAL ECOLOGY OF THE
INDIGENOUS FOREST OF THE
TARANAKI UPLAND

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Summary

The hill country of Taranaki and the hardwood/podocarp forest of the region are described broadly. Regeneration of the principal species is discussed. A pronounced lack of podocarp advance growth is considered to be neither a result of linear succession nor a phase in a successional cycle but is attributed to the effect of recent climatic variation. In the main the forest is, however, a climatic-climax association developed since the final cold period of the Pleistocene.

INTRODUCTION

Some 700,000 acres of indigenous forest stands on the old, dissected upland between the lower reaches of the Awakino and Wanganui Rivers, which enter the sea on the west coast of the North Island some 100 miles apart. It lies westward of, and, due to land clearing, separate from the well-known forests of West Taupo and Tongariro National Park. By far the greater part is contained within the Taranaki Land District.

Though it is one of the largest remnants of the original North Island forest cover, this tract has received no more than passing mention in botanical literature. The failure to investigate must have been due largely to the undeniable difficulties, indeed hazards, of travel through a dense, inhospitable, trackless forest growing on steep and very broken country.

Even foresters have hitherto not been required to give much attention to the Taranaki region. Sawmilling never has been, and never will be, undertaken on a large scale. The timber resource is small and scattered and consists of low volume stands. The greater part of the forest has an important protective function but there are no pressing erosion problems. Moreover, hardly one third of the land is vested in a forest authority.

However, a primary survey of the entire forest, begun in 1952, has just been completed. Sufficient evidence has been gathered to make possible a preliminary ecological analysis—that is the purpose of this article. Any theory propounded may have little practical significance in the region itself but as a contribution to solution of the basic ecological problems of the North Island forests as a whole it might conceivably aid the formulation of sound principles of silviculture in areas where sustained yield management of indigenous timbers is to be attempted.
Following descriptions of the environment and the forest types the ecological dynamics will be discussed and an explanation of the various problems that arise will be offered.

GEOLOGY AND TOPOGRAPHY

The Taranaki Upland is a great block of very gently inclined beds of massive sandstones and unconsolidated mudstones. In the late Pliocene the land surface was reduced to a peneplain. Since then earth movements have brought about a progressive uplift and consequent dissection has reached a stage where few remnants of the old surface remain. A general tilting to the south-west gives a gradual fall in the height of ridges from 2,500 ft. in the east to 500 ft. near the coast or adjacent to the circum-Mount Egmont lowland. The largest original rivers easily maintained grade so that the present almost maturely-dissected landscape is traversed by a series of south-flowing, deeply-entrenched rivers with inherited meanders. These are the Wanganui, with the tributary Ohura and Tangarakau, and the Waitotara and Patea. A secondary drainage system in the north-western sector includes the Waitara, Tongaporutu and Mohakatino Rivers and the lower reaches of the Mokau and Awakino.

During a pause in uplift a number of wide inland valleys were formed, these being now 5-700 ft. above sea-level (e.g., Ohura Valley). However, a final rejuvenation of the landscape has resulted in the rugged terrain characteristic of most of the country still carrying forest. Typically, there is an intricate series of long, sharp-crested, accordant ridges and narrow, deep valleys. Streams often rise on almost sheer faces of exposed “papa” then flow in crevasse-like, saw-cut gorges. Many of the larger, however, are aggraded in their lower reaches. As the sandstones are very resistant to lateral corrosion many valleys are lined with sandstone cliffs. In sharp contrast are the occasional slightly-inclined benches or dip slopes, varying from a few to hundreds of acres in extent. These are formed by the sliding, on a spectacular scale, of blocks of sandstone over underlying mudstone.

It will be evident that only a few areas of forest stand on “easy” country. The largest occurs on some 15,000 acres of remnant peneplain (Waitaanga “plateau”), which is the source of the Tangarakau and Mohakatino Rivers. Another remnant, long and narrow, forms the crest of the Matemateaonga Range which divides the head-waters of the Patea and Waitotara Rivers and the upper Waitotara from the middle Wanganui. Dip slopes still forested are most extensive in the environs of the lower Mokau. Very few stream or river flats have not been cleared.

CLIMATE AND SOILS

Annual rainfall is generally between 50 and 80 inches, rather more over the highest ground. Winter and spring are very wet and cool to mild; summer and autumn are wet and warm to very warm. Moisture
is, then, always adequate though there are winter and late spring rainfall maxima. Much of the rain comes with the passing of warm fronts and often is heavy and prolonged. Frosts are fairly frequent during the winter but snow is rare—five or so light snowfalls may occur on the Matemateaonga Range each year.

Soils are immature silt loams, universally mulls. Typically, a few inches of friable red-brown or black topsoil overlies a yellow-brown loam which rapidly becomes nutty, compact, and tenacious, and more clayey or sandy with depth. The only marked variation is the occasional presence of a thin leached horizon and an orange-coloured subsoil under hard beech. Weathering rock is usually only one or two feet below the surface. On stream flats soils are, of course, much deeper. Even then, however, neither podsolisation nor gleying is more than incipient. There are a few small areas of immature podsol (grey-brown loams) where Maioa or Egmont andesitic ash has accumulated and been retained as a soil constituent. The ash showers occurred in the remote past (approximately 40,000 years ago); traces of any disruptive effect on the forest have long since disappeared.

FOREST SPECIES

The podocarps are rimu (Dacrydium cupressinum), miro (Podocarpus ferrugineus), Hall's totara (P. hallii), kahikatea (P. dacrydioides), tanekaha (Phyllocladus trichomanoides), and matai (Podocarpus spicatus), which occur in small groups or singly in dense stands of hardwood. A softwood stocking higher than six trees per acre is exceptional and very limited—generally it is nearer half that figure. Rimu and miro are the most common. Hall's totara is almost confined to ridge tops and kahikatea to riparian flats. Tanekaha is distributed sparsely at low altitudes north of latitude 39 deg. S, while matai is present only on the most fertile valley soils.

Tawa (Beilschmiedia tawa) and kamahi (Weinmannia racemosa) are the principal hardwoods, occurring abundantly in admixture over most of the region. Tawa is usually the dominant but it is the more sensitive and, therefore, poorly developed or absent on the driest, wettest, or most exposed sites. It is then that quintinias (Q. serrata and Q. acutifolia), elsewhere shrubs, appear as small trees; they are, though, restricted to the northern half of the forest. Hinau (Elaeocarpus dentatus), rewarewa (Knightia excelsa), and pukatea (Laurelia novae-zelandiae) are seldom numerous but are widespread within their usual limits of site tolerance. The last-named rarely occurs above 1,200 ft. Maires (Olea Cunninghamii, O. lanceolata, and O. montana) are fairly common on the best alluvial silts, rare elsewhere. Kohekohe (Dysoxylum spectabile) is abundant on the coast and persists as an occasional small tree or shrub up to ten miles inland. A few other hardwoods are either very local, e.g., mangeao (Litsaea calicaris), puriri (Vitex lucens), pōkaka (Elaeocarpus hookeriex), or else seldom attain tree size, e.g., toro (Suttonia salicina).
Northern rata (*Metrosideros robusta*) is an important physiognomic dominant. Combines on rimu, pukatea, and occasionally other species are common everywhere except in some sheltered valleys at low altitudes.

In the north, hard beech (*Nothofagus truncata*) occupies much of the rugged sandstone country, forming almost pure stands. Very rarely black beech (*N. solandri*) is present. However, south of latitude 39 deg. S. it rather abruptly quite replaces hard beech, which in turn becomes very sparse and probably does not occur further south than the vicinity of Whangamomona. Silver beech (*N. menziesii*) is confined, as far as is known, to the catchment of the Waitaanga stream, in the headwaters of the Tangarakau River.

In podocarp/hardwood forest there is, generally, a high stocking of tawa and/or kamahi poles, with profuse scrub hardwoods, tree ferns, shrubs, supplejack (*Rhipogonum scandens*), epiphytes, and ground ferns. Even under hard and black beech, though the shrub tier may be relatively open, the ground cover is frequently very dense. Goats, cattle, and pigs have destroyed undergrowth in places, but there are extensive unaffected areas.

**FOREST TYPES**

The following type descriptions are based on data recorded by the National Forest Survey (Thomson, 1946). The northern half of the forest was sampled systematically by the Survey, while some random sampling and reconnaissances were carried out in the south.

The figures in parentheses after the names of trees are the average number over 12 ins. d.b.h. per acre. Poles are regarded as trees between 4 and 12 ins. d.b.h.

**Waitaanga Type**

This is the best class of forest, on rolling to moderately steep terrain, 1,300 to 1,600 ft. above sea-level, at the head of the Tangarakau and Mohakatino rivers.

Large rimu (3) and rata (1½) emerge from a dense canopy of tawa (22) and kamahi (18), with miro (24) and hinau (2) scattered throughout. Hall's totara and rewarewa are present on a few ridges. On flats beside the rivers there is a variation. Rimu and miro tend to occur in denser groups (6-12). Rata is still present but tawa is restricted and kamahi correspondingly more prominent. Occasional kahikatea, Hall's totara and maire, and rare matai appear. There are, more especially along the Mohakatino, frequent small areas occupied solely by kamahi and quintinia poles.

Only remnants of this type remain outside this district, but sufficient to indicate that in the more fertile inland valleys the riparian variant was usual, with matai and maire usually more frequent than at Waitaanga and with tanekaha occasionally present in the north.

Most of the rimu are from 500 to 700 years old. Study of annual rings of stumps in logged forest has shown that diameter is a reliable
indicator of age, within the type. Rimu under 30 ins. d.b.h., about 25 per cent. of the total, are 200 to 300 years old. The main generation is just approaching senescence—about one in eight is moribund, and there are occasional dead or fallen trees.

**Waitaanga Silver Beech Type**

This type is now practically all logged. It occurred along the sluggish, meandering Waitaanga Stream (head of the Tangarakau River) in swamp depressions separated by hummocks of drier ground. Silver beech was abundant, with kamahi, under occasional to frequent rimu and kahikatea. All age classes of beech were well represented but thrifty trees were rare. Early decay and stagnation was the rule.

In the vicinity, single old silver beech standards are sparsely scattered in the podocarp-hardwood type. Rare groups of small, stunted trees occur on the few atypically steep and narrow spurs overlooking the valley.

**Mokau (Dip Slope) Type**

The extensive dip slopes of the lower Mokau catchment have been formed at levels between 800 and 1,300 ft. above sea-level. They are backed by sandstone ridges, fronted by gorges and seamed with numerous streamlets. Drainage of the mudstone base is, however, usually only fair.

Rimu (1½) and rata (1) are again the physiognomic dominants, but here the former are all over 30 ins. d.b.h., with one in four standing trees dead. Decadence of rimu is, indeed, the outstanding feature of the type—comparatively recently the average stocking was equal to that at Waitaanga but much of the crop is now lying on the ground. The occasional associate kahikatea are likewise senile. Other podocarps are rare, with matai absent altogether. Clumps of tawa (15) and kamahi (10), with hinuau (2) and rewarewa (1), alternate with groves of large mahoe (*Melicytus ramiflorus*), fuchsia (*F. excorticata*), pigeonwood (*Hedycarya arborea*), and tree ferns. Pukatea (2½) occurs consistently in the dampest situations.

The marked overmaturity of rimu and kahikatea is normal wherever pockets of this type occur elsewhere in the region. Windthrow of old tawa also is fairly common.

**Hutiwai (Riparian) Type**

Just as some valleys are occupied by a variant of the Waitaanga riparian association those in the north-western sector contain forest which may be regarded as a development of the Mokau type. The “type locality” is the Hutiwai Valley; the stream is a tributary of the Tongaporutu River.

The main tier is comprised of predominantly large, mature to overmature kahikatea (2½) and relatively large, rather decadent pukatea (6). Rata (combines on pukatea) is occasional and rimu rather rare. Kahikatea are frequently windthrown. Tawa (12), kamahi (8), and
hinau (1) become still more restricted, while scrub hardwoods and tree ferns are even more aggressive.

Panirau (Dry Ridge) Type

This association occurs on dry, usually narrow, ridges. It is a characteristic of the very steep, broken terrain of the Panirau Valley (tributary to the Mokau) but is extensive in many other localities, too.

Short-boled, and usually small or medium diameter, Hall’s totara (2½) and miro (1½) occur regularly. Rimu, small and slender, are very sparse, while tanekaha is occasionally present at the lowest altitudes. Kamahi (12), rewarewa (4), hinau (3), and quintinia (2) are the main hardwoods. Small tawa occur wherever site conditions are more favourable than usual. Rata combines with the occasional large, defective Hall’s totara and there are small terrestrial rata (probably Metrosideros umbellata) in a few places.

Coastal Type

A distinctive type forms a narrow belt, three or four miles wide at most, in the north west, on broken country exposed to the sea breezes.

Podocarps are sparse indeed, the only large trees being rata, which are often dead or dying. Tawa (7), kohekohe (6), hinau (2), pukatea (1), nikau (Rhopalostylus sapida), and tree ferns fill the gullies. A wind-battered kamahi/rewarewa association is typical of most ridges, hard beech being dominant on the remainder.

The paucity of podocarps cannot be due solely to the environment. Sporadic fires and exploitation have occurred here not only from the first days of European settlement but since at least the 18th century when a very large Maori population occupied the Tongaporutu-Awakino coastal terrace.

General Podocarp/Hardwood Type

The most extensive association—the typical forest of the hill country, developed on steep slopes (25 to 45 deg.) and in narrow, dank, valley bottoms. Included in the type are some stands on broad ridges and more gentle slopes between 1,600 and 2,000 ft. altitude, where podocarp stocking is being reduced through death and wind-throw of senile trees.

There are infrequent large rimu and rata, and smaller miro and Hall’s totara—on the average rather less than one of each per acre. Large, old kahikatea occasionally occur in gully heads. The numbers of tawa (17) and kamahi (14) remain quite high, while hinau, rewarewa, and pukatea are scattered throughout. Scrub hardwoods are dense in the innumerable small gullies.

Matemateaonga (Higher Altitude) Type

Along the crest of the Matemateaonga Range, between 2,000 and 2,500 ft. above sea-level, are frequent stretches of level or undulating ground. On these occurs almost purely hardwood forest dominated by rata and kamahi.
The rata (3) are large to very large trees, frequently dying or badly broken by wind. Remains of rimu hosts can be seen occasionally. Abundant kamahi (22) closes the canopy. Many of these are very large and sprawling and evidently took root on prostrate logs. There are, however, many young trees of terrestrial origin. Over-mature hinu are scattered throughout, and there is a sprinkling of mature tawa on hillocks. No standing maire have been seen but occasional remains of logs have been seen on the forest floor. A few miro are present but rimu are very rare and invariably moribund. Scrub hardwoods and tree ferns are numerous, particularly so on the damp flats where exceptionally large mahoe and fuchsia compete with kamahi for dominance.

Where ridges steepen and narrow the forest closely resembles the Panirau type (Hall's totara/miro/kamahi), differing mainly in the absence of rewarewa, quintinias and rimu, and the presence of toro and pepperwoods (*Pseudowintera axillaris* and *P. colorata*) rather than xerophilous shrubs.

The eastern arc of the range has yet to be reconnoitred. The texture of the forest canopy in aerial photographs is identical with that of the known sector but it is thought possible that silver beech may be present.

**Whitianga (Secondary) Type**

About 200 years ago several thousand acres of forest on hilly country north of the Whitianga Valley, between Tahora and the Tangarakau River, were partially destroyed by fire. Since then, pole stands have developed along most ridges while remnants of the virgin forest remain in saddles and in the valleys. Much of the area is only moderately steep and most of the original association was the Wai-taanga type. The altitude is between 500 and 1,000 ft.

Generally, the sere has reached a stage where scattered rimu (3) and miro (1), 12-20 ins. d.b.h. and 60 to 70 ft. tall, emerge from a dense tawa canopy at 50 ft. The podocarps have deep, spreading crowns while the few tawa, hinu, and rewarewa of equal size are likewise forked, short-boled trees. Moribund kamahi and stumps of kamahi are scattered throughout. In the main tier tawa poles are very abundant (180 per acre); other species are rewarewa (50), hinu (20), local maire (10), occasional rimu, miro, and kamahi, and rare, very local, kahikatea.

**Hard and Black Beech Types**

These associations are confined to the most rugged terrain. Distribution is, therefore, in accordance with the general pattern of dissection of the old upland—the most extensive areas of beech are peripheral and neither species occurs higher than about 1,500 ft. In the hinterland, the stands are discontinuous but consistently occur as narrow bands along razorback ridges or fringing cliff tops, and as small pockets on sharp spurs and peaks. Frequently with height there is
a slight improvement in site conditions and beech-dominated forest is supplanted by the Panirau type. In some localities, indeed, the types appear to be alternatives, as it were. "Beech ridges" are a feature of most of the river valleys except that of the Waitara. In that large catchment there is but one isolated stand (black beech), covering hardly 40 acres. Neither species is ever present in gullies or along stream banks.

In the hard beech type there is an average of 20 beech stems per acre, most under 30 ins. d.b.h. Very occasionally indeed black beech or hard x black hybrids are present. Small Hall’s totara, miro, tanekaha, and rimu occur sparsely in that order of frequency. Associated hardwoods are likewise small and though relatively more common are by no means abundant. The most usual are kamahi (4), tawa (3), rewarewa (1), and quintinia (1).

Apart from the difference in beech species, the black beech type is nearly identical. Hard beech and/or hybrids occur singly or in very small groups in widely-separate localities. Tanekaha and quintinia are present only near the northern limits.

The two types are contiguous in the Tangarakau Gorge. Where the gorge runs westward hard beech occupies the precipitous spurs and bluffs above the river but black beech pockets are here relatively common, notably at the upper limits of beech stands. As the river turns sharply south black beech at once becomes predominant.

PODOCARP SUCCESSION

The stocking of pole and sapling podocarps is insufficient to ensure complete replacement of the present failing stands, except for miro, Hall’s totara, and tanekaha in limited areas. The lack of rimu, kahikatea, and matai advance growth, and regeneration is particularly obvious. Poles of these are so rare that Forest Survey sampling of the virgin forest “picked up” a rimu only once—and kahikatea and matai never.

Generally miro and Hall’s totara poles and saplings are fairly frequent. Poles are on the average equal in number to the mature trees but occurrence is actually more sporadic. In the associations of the dry ridges the poles of these two species are twice as numerous as trees over 12 in. d.b.h. However growth is slow there and many of the larger poles are actually mature trees. In the main Mate-mateaonga type, on the other hand, no poles and only rare saplings of either have been seen. Where it occurs on ridges tanekaha is well-represented in the pole and sapling phases but no regeneration has been seen in the luxuriant stream-flat forests.

HARDWOOD SUCCESSION

The disproportion in numbers of senile and young trees is as great with several of the hardwoods as it is with rimu and kahikatea. Fully two-thirds of the hinau, pukatea, and maihe, large and small, are
much decayed. About 50 per cent. of rewarewa are completely sound—the difference is probably due to the relative abundance of that tree on dry ridges. The stocking of poles and saplings of all these species is adequate only locally and there seems to be a tendency toward more limited ranges. Thus, hinau advance growth is more confined to ridges and lower altitudes than are the parent trees, maire more to alluvial flats, while pukatea poles and saplings are often absent at higher levels. Rewarewa again provides the exception—in the general type regeneration is far more widespread and frequent than that of hinau.

Though large, over-mature, dying, and windthrown tawa and kamahi are by no means uncommon, poles, saplings, and seedlings of both are normally abundant. Naturally, kamahi poles are particularly dense where the environment does not favour tawa. Quintinia seldom attains the same status as kamahi but is equally aggressive in its sphere. So, too, is kohekohe, on the coast. There is no decline in the activity of northern rata—rather the reverse. Where rimu has all but disappeared as on the Matemateaonga Range, it is seizing on other trees, e.g., tawa and hinau. Both hard and black beech often occupy very exposed situations and have a short life. Nevertheless, on the whole they regenerate lustily and there is no sign of their losing ground, except where either is swamping out relic pockets of the other. Silver beech easily holds its own in the Waiaanga swamp. However, old trees scattered in the podocarp/hardwood forest in the vicinity are not accompanied by any younger age-class save very occasional seedlings.

**INDUCED SUCCESSION**

There is no natural forest edge. Before the advent of the Polynesians the original tract continued practically to the coast and merged with the forests of surrounding districts. Permanent Maori clearings were limited to a coastal strip, the largest inland valleys and pa sites along navigable rivers and the main land routes. Contemporary fires sometimes spread afar—the type at Whitianga is an example, not unique. However, most induced associations of equivalent age have been obliterated or re-modified after European settlement. Small stands of pole podocarps which have been preserved in places on valley farmlands are believed to have originated in pre-European times. Areas of forest burnt some sixty years ago and not further cleared, and of abandoned hill pasture very rapidly reverting to forest are quite extensive. At Waiaanga there are about 10,000 acres of forest which have been logged, mostly since 1940, but only very small similarly exploited areas elsewhere.

So far there has been no systematic study of these more recently-induced associations. Certainly, on the formerly-burnt hill country podocarp regeneration is scant. Rewarewa, kamahi, and the beeches are clearly the most aggressive re-colonisers. However, rimu regenera-
tion is strikingly abundant in open spaces in the oldest areas of logged or burnt forest on the Waitaanga flats. Although no statistics are available to support the contention, it is thought highly probable that the establishment of the young rimu has been helped considerably by cattle browsing hardwoods and consolidating the soil. Small pole and sapling kahikatea, miro, and Hall's totara also occur in local abundance on the margins of remnant lowland forest under similar conditions.

ECOLOGICAL PROBLEMS

It will be evident that the major species of the Taranaki hill country forest are tawa, kamahi, hard beech, and black beech. If numerical rather than physiognomic dominance be used as the criterion of subdivision, then there are but four main sub-associations, namely tawa/kamahi, kamahi, hard beech, and black beech forest. These sub-associations are apparently distinct topographic-climax groups which together constitute a climatic-climax forest. Succession of each species is a straightforward and continuous process. Two much smaller sub-associations, silver beech/kamahi and tawa/kohekohe, may also be included in this category. The podocarps, with the dependent rata, and the other hardwoods are, except under very exceptional circumstances, much fewer in number. This is obviously due to their various narrower limits of site tolerance or competitive faculty—these are well-known and need not be described here.

Thus far, there is no problem. However, the current failure of rimu, kahikatea, and matai succession (and the suspected partial failure of the other less numerous species) remains to be explained. Moreover, understanding of this forest is not complete unless the former differences in the ranges of hard and black beech and the presence of the silver beech "outlier" can be accounted for.

INADEQUATE THEORIES

Faced with the problem of the vanishing rimu in North Island rimu/tawa forests, Cockayne suggested that the climax of a linear succession was near at hand. He stated (Cockayne, 1928): "Tawa forest may, I think, be considered the final stage in the series of succession forming taxad forest, that is to say, that wherever it occurs one may conclude that forest rich in taxads previously occupied the ground. In support of this view, all degrees of intermediate stages exist between rimu and rimu-tawa forest."

In opposition to this view, it is pointed out that within the virgin forest of this region (and it is a large one) only two stages exist—mature rimu/tawa and over-mature rimu/tawa. Nor is there any evidence whatsoever that rimu, or other podocarps, were in the past any more abundant than they now are or very recently have been. Nowhere do soils show signs of the pronounced podsolisation that heavy podocarp stands might be expected to cause. No ancient matai
or totara logs are to be found in the undergrowth. Tawa are universally rather short-boled, heavily crowned trees—there are no stands which would appear to have been “drawn up” under dense podocarps. And old, coalesced rata combines are, on the whole, rather less frequent than rimu. It can only be concluded that the previous rimu generation was numerically no larger than the present.

Stumps of podocarps at Waitanganga reveal that they all grew slowly, extremely so in the first 200 years of life. Besides this, even the oldest trees tend to occur in small groups. These facts, viewed in the light of those above, strongly suggest that at least as far back as 1,000 years ago podocarps became established only under canopy breaks and were sorely pressed by hardwood competition until their crowns broke into the full light.

Furthermore, forest richest in podocarps is forest where kamahi dominates the main tier—and tawa is not succeeding kamahi on such sites.

Alternative hypotheses to Cockayne’s are the cyclic theory and its elaboration, the mosaic-cyclic theory. According to the first, light demanding and shade-tolerant species of mixed forest on neutral ground, i.e., where topographic or edaphic climax are not to be expected, regularly succeed one another as dominants. Each cycle consists of several phases. Theoretically-probable phases for a North Island podocarp-hardwood forest have been described by Cameron (1954). Aubréville advanced the idea that after a lapse of time cyclically-regenerating forest might well become resolved into a complex mosaic of sub-associations at different stages of the cycle. As put by Richards (1952): “On this theory, an extensive area of mixed forest may be regarded as a mosaic, each unit of the patch-work being a different combination of different species. On any one small area different combinations will succeed one another more or less cyclically.”

It is hard to see any mosaic pattern (in the above sense) in the Taranaki forest. Occasionally one may get the impression that over a small area there is a preponderance of younger hardwoods, such as tawa, kamahi, or hard beech, compared with a preponderance of older trees in an adjacent area, but clear-cut instances are rare. The very occasional pockets of pole hardwoods are usually obviously the results of local severe wind-damage or soil erosion. Those species which regenerate satisfactorily do so most freely where parent trees are most numerous. Nor is there any evidence of an overall cycle. What may be termed the “permanent background” species—tawa, kamahi, hard and black beech—regenerate where opportunity offers, achieve maturity according to the favorability of the local factors, and are ultimately replaced by the same or another species of the particular sub-association more or less according to the laws of chance.

If the gradual elimination of rimu be a phase of a cycle on a grand scale in space and time, when is the next rimu generation to
appear? Where elimination is well-nigh complete, on the Matemate-aonga Range, all stages of regeneration are competely lacking. Neither rimu nor kahikatea are taking advantage of the "open" kamahi/quintinia pockets on the Mohakatino flats.

CLIMATIC CHANGES AND VARIATIONS

The theories discarded have one thing in common. It is assumed that a forest is in equilibrium with its environment, dynamics being governed by internal causes, by the subtle interactions of the components. Perhaps, then, this forest is influenced to a certain degree by a comparatively recent change in an external ecological factor. Here the only possibility is that there has been a change in climate. To view the subject in the right perspective it is desirable to return as far back in time as there is sufficiently accurate knowledge of climatic changes. In this instance the close of the Pleistocene Period is a suitable starting point.

It is the opinion of geologists that the great climatic changes that affected the polar and temperate zones in the Pleistocene were synchronous in both hemispheres. This is borne out by the latest investigations in New Zealand (Brothers, 1954, Cotton and Te Punga, 1955; Fleming, 1953), though precise correlation has not been possible because of various local complications. Willett (1950) has drawn a generalised picture of the likely limits of glaciation and depressions of snow lines and vegetation zones in this country. Following the geologists, one stands on reasonably firm ground in postulating that only about 15,000 years ago forest on the Taranaki Upland was just beginning to recover from the effects of a long period of cold climate and that mean temperature at sea-level was equivalent to that normal at 1,500 ft. or so today.

A vast accumulation of evidence from a variety of sources has established the fact that since the last glacial phase climate in the higher and middle latitudes of the northern hemisphere has not been constant. The several cycles now recognised lasted over periods from several hundred to one or two thousand years. Though differences in warmth and wetness were sufficient to bring about pronounced changes in regional vegetation and definitely affect the course of human history they are best referred to as climatic variations, or fluctuations, rather than changes, in order to avoid confusion with the more drastic pulsations of the Pleistocene (Brooks 1949; Good, 1947).

In New Zealand it is only lately that the possibility of recent variations has received attention and here the fields of enquiry are intrinsically fewer and more narrow. So far, however, research workers, supported by findings in South America, have concluded that it is likely that there has been a series of climatic cycles corresponding to those in the north (Cranwell, 1938; Harris, 1950 and 1951; Raeside, 1948). If this be so, then the last glaciation in New Zealand
was followed by an increasingly milder climate which culminated in a period, c.5,000-500 B.C., when conditions were more genial than they are today. Since then it has been generally cooler but there was an important warm phase, from approximately A.D. 200 to 1,200 in the South Island, which has been followed by a return to a rather more severe climate.

By accepting the probability of that last variation, Holloway (1954) was able to give the first satisfactory elucidation of the very involved forest distribution and succession patterns in the South Island. He gave several reasons why the effects of climatic variation would be less obvious in the North Island. Nevertheless, McKelvey (1953) was able to explain seeming anomalies in the process of forest colonisation after recent volcanicity in the Central North Island only by adopting the same hypothesis.

The forests of West Taupo, with which McKelvey dealt specifically, are mainly 2,000 ft. above sea-level. Those of the Taranaki Upland are mainly below that. The rainfall is nowhere near critically low for forest growth while the great majority of the trees stand well within the limits of their modern geographic ranges. So the latest climatic fluctuation could not be expected to have wrought spectacular changes in this region. Nevertheless, if the ecological problems be approached with a sequence of relatively recent climate change and subsequent variations (in line with those elsewhere) accepted as a fact, bearing in mind the qualifications just mentioned, it is considered that resolution becomes fairly simple.

A WORKING HYPOTHESIS

To picture the forest as it was 15,000 years ago necessarily involves some conjecture. However, if the deduction of climatic conditions then prevailing be valid one may presume that very few of the species now present would be absent altogether.

Silver beech forest must have been widespread on the Waitaanga “plateau” but even then was only a surviving fragment of very extensive stands which existed in earlier stages of the Pleistocene. (Silver beech pollen has been found in Pleistocene peaty lignite beds right on the Wanganui coast.) With the gradual amelioration of climate silver beech became relegated to the poorer sites. It has not responded to any late reversal of the trend since this has been insufficiently pronounced to rejuvenate a species now so drastically out of place and, moreover, severely handicapped in competition for seed dispersal. Riparian migration of beeches has never been possible in Taranaki. The niches at Waitaanga occupied by silver would, in the present climate, be very suitable sites for black beech, but topographic barriers have prevented its entry.

It is obvious from the occurrence of widely scattered pockets of black and hard beech that they have been in the Taranaki region for an extremely long time and that at some remote period distribution
was more continuous. Both can stand cooler temperatures than those experienced there today. Black beech is the more adaptable to cold and wet but is almost equally tolerant of heat and dry conditions; the district is at present a natural overlapping ground for these species. With climatic changes one would tend to supplant the other and vice versa. Since here neither can migrate save by seed being windblown from ridge to ridge across intervening gullies any such readjustment would be very slow generally, though doubtless comparatively rapid in any one particular stand. It seems that a northward surge of black beech took place during a long, cold phase until hard beech was almost eliminated in the south and black had dispossessed it at higher levels in the north. With climate growing warmer, black then lost much of the ground won in the north, but once the major climatic change was complete the relationship of these beeches became virtually static. This serves to emphasise once more that minor climatic oscillations are only slightly effective at low altitudes so far north as Taranaki.

Fifteen thousand years back, kamahi would have survived everywhere, albeit as a scrub hardwood at higher altitudes. Probably, outside the comparatively small area of silver beech, the highest ground was covered by a kamahi/quintinia/toro/scrub hardwood type, with Hall’s totara/rata/kamahi forest universal lower down and off the black beech/hard beech ridges. Rimu, miro, kahikatea, tawa, hinau, maire, and rewarewa (and perhaps even tanekaha, matai, and pukatea) would have persisted at altitudes below 500 ft.; some of them, indeed, slightly higher. Trees such as kohekohe probably were displaced northward along the coast but it should be remembered that during a glacial phase sea level may fall by as much as 300 ft. With the onset of the relatively long span of the post-Pleistocene climatic optimum, redistribution would result in forest types basically the equivalent of those of today. Bird-distributed species migrate with quite astonishing speed, as is demonstrable in the successional circum-Taupo forests at the present time. Podocarps were never much more numerous than they are now but they grew with greater vigour and therefore re-establishment was successful even where hardwoods were most abundant.

For a few thousand years there may have been broad cyclic-regeneration in the most mixed forest, a podocarp/light-demanding hardwoods phase alternating with tawa or tawa/kohekohe dominant phases. This seems rather likely because of the general even age of the most recently established podocarps. A mosaic pattern never developed simply because the forest as now constituted never enjoyed a sufficiently long stable existence. It may have been during the period of podocarp aggression that hard and black beech were replaced by Hall’s totara/miro/kamahi stands on some ridge stretches. If greater warmth were accompanied by increased effective precipitation this would be understandable. Beech mast years would become fewer and
the balance of ridge-top conditions in marginal cases would be tilted against the beeches.

Rather later than in the South Island, and to a lesser degree, climate at length deteriorated. By about A.D. 1650 the cumulative effects were sufficient to suppress advance growth of rimu, kahikatea, and matai everywhere in the region. The first and hardest hit area was, naturally, the forest over 2,000 ft. on the Matemateonga Range. There, rimu has been virtually eliminated: If the trend continues a similar result seems probable at lower levels; as at Waitaanga, even on the best sites the standing podocarps approach senescence and there has been no effective regeneration in virgin forest for some 300 years. On the dip slopes, even though most of these are lower than the Waitaanga "plateau", the process is slightly more advanced due to more rapid growth and greater liability to decay on those wetter soils.

The hardier Hall's totara and miro, though somewhat affected where hardwood competition is strongest, almost maintain the status quo in the dry ridge types. Tanekaha also remains secure in a more limited but similar niche. Suspected current limitations in regeneration of hinu, maire, and pukatea can be ascribed only to the climatic variation. Certainly there has been an obvious decline of the two former on the Matemateaonga Range, precisely where the greatest effect would be expected.

One point may need elaboration. It might well be asked why tawa is not affected while rimu is, since the former occurs no further south in New Zealand than Marlborough Land District while rimu is common throughout the country. Changing climate, however, affects different species in different ways. In Taranaki, mature tawa do suffer from weather extremes of various kinds, especially from late frosts, but sheltered younger trees, thriving under a closed canopy, remain in abundance to fill any gaps. Mature rimu, on the other hand, are not nearly so sensitive though sometimes damaged by gales. These trees are not succumbing to inimical climate so much as simply dying from old age. It is in the stage between seedling and pole that the species now fails. In the particular environment of the Taranaki forest that stage has always been a critical one for rimu, where a change for the worse in climate would have immediate and, in time, very far-reaching effects.

The Whitianga type illustrates how relatively slight the overall impact of the climatic variation has been. After fire the forest is simply re-developing into something very like what it was previously. It must be remembered, though, that the secondary succession began some 200 years ago and that the type occurs at low altitude. More important, the rimu became established in a seral association, free from the intense competition of climax hardwood forest. Nowadays it regenerates only under the most favourable circumstances imaginable, after even more drastic alteration of environment.
NICHOLLS—INDIGENOUS FOREST

CONCLUSIONS

The forest of the Taranaki Upland is primarily an association of a few hardwoods. Grouping of these is largely dependent on topographically controlled factors, but overall they have been in equilibrium with the general environment since adjustment to the last secular climate change about 15,000 years ago. Scattered among these basic species is a variety of less adaptable hardwoods and several podocarps. Some of these have been permanently limited to special sites. Others have been more or less universally distributed but are now to varying degrees adversely affected by a recent, locally slight, climatic variation.

Finally, the point is stressed that these conclusions have been reached after only a primary survey of this forest. The hypothesis adopted seems the best explanation of the salient facts established so far. If it merely indicates points which need further clarification and thus stimulates more intensive research it will have served adequately.

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