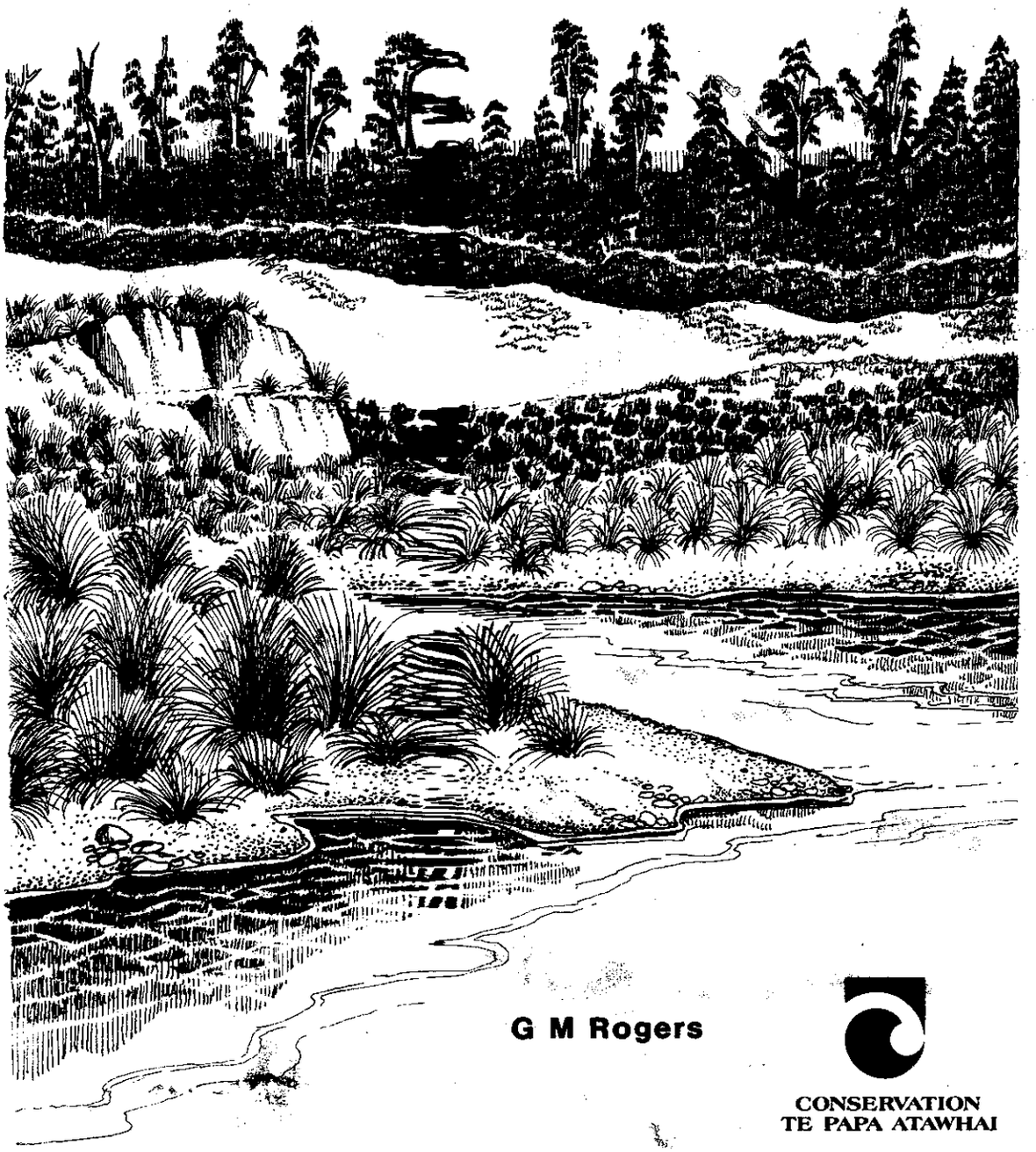
Moawhango Ecological Region

Survey Report For The

Protected Natural Areas Programme



G M Rogers

CONSERVATION
TE PAPA ATAWHAI

MOAWHANGO ECOLOGICAL REGION

SURVEY REPORT FOR THE

PROTECTED NATURAL AREAS PROGRAMME

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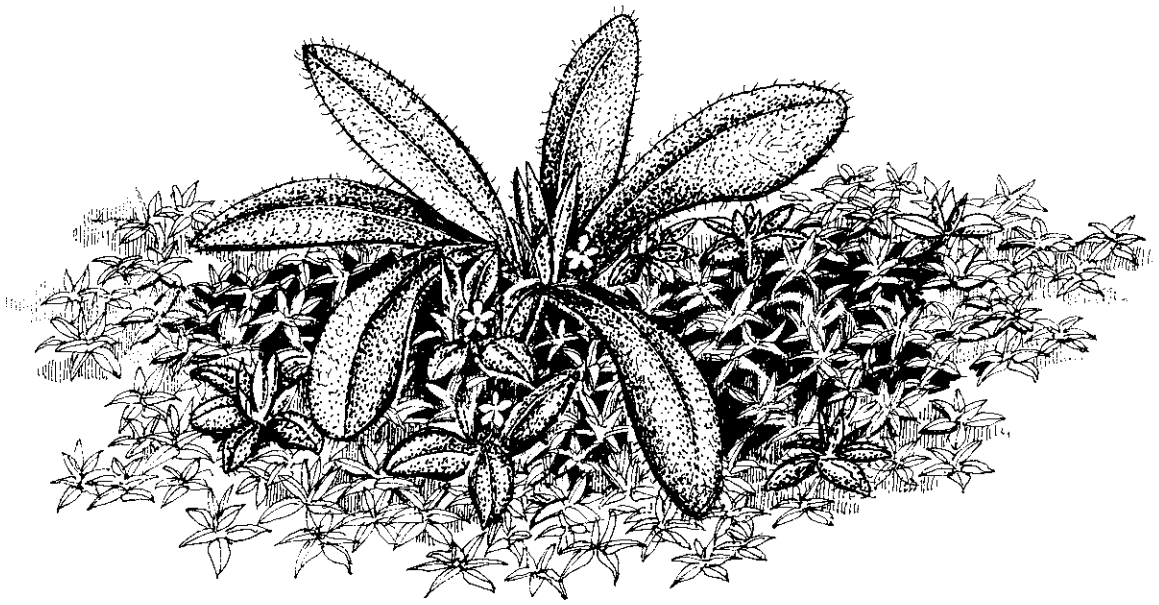

Illustration above: *Myosotis* sp. unnamed (*M. pygmaea* var. *glauca*) surrounded by *Raoulia tenuicaulis*. The only North Island locality for this forget-me-not is in RAP2 in the Moawhango River headwaters. The species is then disjunct to Castle Hill, Canterbury and then to Central Otago.

Cover Illustration: Some of the essential geographical elements of Moawhango Ecological Region: shallowly incised streams in limestone-capped plateaux; red tussock grassland, inaka shrubland, mountain toatoa scrub, and fire-modified kaikawaka stands.

Artist: Steve Burgess, Rotorua

FOREWORD

This report is one of the Protected Natural Areas (PNA) Programme series of reports which describe recommended areas for protection (RAPs) within ecological districts and regions. The Moawhango Ecological Region PNA report has been prepared by Dr Geoffrey Rogers of Landcare Research New Zealand Ltd, under contract to the Department of Conservation, and funded jointly by the Department's Science and Research Division and Wanganui, Tongariro/Taupo and Hawkes Bay Conservancies.

Much of the field work was carried out as part of Dr Rogers' Ph. D. studies between 1984 and 1987, and subsequently by Dr Rogers with staff of the DOC and volunteers.

Moawhango Ecological Region (ER) is mostly plateau and rolling hill country which lies between the North Island's rugged Kaimanawa and Ruahine Ranges. The landscapes are often dramatic, and human impacts are not immediately apparent over quite large parts. Although native red tussock is its most distinctive natural feature, the region possesses great diversity. Its landforms include broad plateaux and dry and wet floored basins, and the rivers flow in spectacular gorges in greywacke, limestone or softer sediments, or between broad flat terraces. Peat, pumice, tephras, gravels and silt are just a few of the surface materials. The tussock grasslands enclose forest remnants of many types (beeches, kaikawaka, podocarp and broad-leaved species are variously dominant), native shrublands, and wetlands with tall reeds and short turf plants. At higher altitudes there are montane herbfields. Moawhango ER has an unusually large number of plant species which are nationally threatened, rare, or local, or which have unusual distributions.

Moawhango ER is quite unlike any other part of the North Island. Some people feel that it is most similar to parts of Central Otago. Indeed, the scientific studies on which this PNA report was founded, point to numerous "connections" between inland Otago and the Moawhango country. Another aspect of the Moawhango ER which this report highlights is that much of the vegetation cover, even in areas still dominated by native tussocks, shrubs, trees and wetland plants, is the result of human disturbance. An understanding of how these "natural" landscapes have changed with time - and will continue to change - is crucial to the future management of the land if the region's natural qualities are to be conserved.

This report identifies nine key areas (RAPs) which, if protected and managed with conservation as the primary goal, will represent the full range of natural features which today give Moawhango ER its unique character.

It must be noted, however, that outside of the nine RAPs there is still much land which is in a natural or semi-natural state. As in the South Island high country, managers in the Moawhango region can do much to conserve the region's expansive wilderness qualities by sustainable management of all natural areas.

The nine RAPs are the starting point for the implementation phase of the PNA Programme. This will involve discussion and consultation, particularly with the landholders involved. The Department of Conservation has a strong commitment to pursue the objectives of the PNA Programme. Three of the nine RAPs and a small part of a fourth one are on lands controlled by the Department of Defence. The challenge will be to reach agreement on a level of protection which also allows the land to continue to be used for army training or other defence purposes.

A Recommended Area for Protection is as much a recommendation to the Department of Conservation as from it. Changes in recommendations may occur following the consultation process, or after consideration of other values that the RAP and its surroundings may possess. The Department will then endeavour to negotiate the proposals resulting from this process with the landholders concerned, to achieve an appropriate form of protection for each area.

This survey report contains a great deal of information on the ecological values and history of the Moawhango Ecological Region. It is a substantial reference work as well as a guide to conservation priorities. It will be of wide interest to landholders, conservation managers from the Department of Conservation and other agencies, iwi, scientists, conservation groups and the general public.

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30 June 1993

TABLE OF CONTENTS PAGE

ABSTRACT 1

INTRODUCTION 2

METHODOLOGY 3

ECOLOGICAL CHARACTER OF MOAWHANGO REGION 3

Location 3
Climate 3
Landforms 3
Soils 8
Special Geological and Geomorphological Features 9
Vegetation 9
Flora 15
Threatened and Local Plants 15
Biogeographically Special Plants 18
Wildlife 19
Human Prehistory 20
History of Ecological Survey 21

RESULTS
Land Systems 21
Bioclimatic Zones 21
Ecological Units 21
Ecological District Boundary 23
Tenure, and Regional Government 23
Tongariro Power Project 23

EXISTING PROTECTED NATURAL AREAS 24
PNA1 Hihitahi Forest Sanctuary 25
PNA2 Ruahine Forest Park 26
PNA3 Batley Private Protected Land 28
PNA4 Motumatai Department of Conservation Lease 29

RECOMMENDED AREAS FOR PROTECTION 31
Evaluation 31
Priorities for Protection 31
RAP1 Aorangi-Awarua 35
RAP2 Ngawakaakauae 41
RAP3 Ngamatea East Swamp 45
RAP4 Tikitiki 49
RAP5 Te Rei 53
RAP6 Owhaoko 56
RAP7 Pleasants Bush 59
RAP8 Three Kings 61

BOUNDARY CHANGE RECOMMENDATIONS 64
RAP9 Irirangi Wetlands 64

FINAL COMMENTS 65

ACKNOWLEDGEMENTS 66
REFERENCES 67

APPENDICES

Appendix 1: Plant species with distributional limits in Moawhango Ecological Region 73
Appendix 2: Checklist of native vascular plant species in Moawhango Ecological Region 76
Appendix 3: Endangered, threatened, vulnerable, and local species in Moawhango Ecological Region 84
Appendix 4: Checklist of vertebrate wildlife species in Moawhango Ecological Region (bird names after Turbott 1990) 85
Appendix 5: Description of physiography of land systems of Moawhango Ecological Region 87
Appendix 6: Checklist of ecological units in Moawhango Ecological Region 88
Appendix 7: Recommended Areas for Protection and land system representation 92
Appendix 8: Ranking of Recommended Areas for Protection 93
Appendix 9: Common and scientific plant names 94
Appendix 10: Checklist of adventive vascular plants in semi-natural and natural areas of Moawhango Ecological Region 96
Appendix 11: Glossary of scientific terms 98

FIGURES

Figure 1: Location of Moawhango Ecological Region 4
Figure 2: Land systems of Moawhango Ecological Region 22
Figure 3: Moawhango Ecological Region and location of Recommended Areas for Protection 33
Figure 4: RAP1, Aorangi-Awarua 34
Figure 5: RAP 2, Ngawakaakauae 40
Figure 6: RAP 3, Ngamatea East Swamp 44
Figure 7: RAP 4, Tikitiki 48
Figure 8: RAP 5, Te Rei 52
Figure 9: RAP 6, Owhaoko 56
Figure 10: RAP 7, Pleasants Bush 58
Figure 11: RAP 8, Three Kings 62

ABSTRACT

Moawhango Ecological Region is a highly distinctive montane-subalpine region of the central North Island, characterised by undulating and plateau topography and extensive red tussock grasslands and mixed shrublands. The Region comprises two geographic areas with contrasting geology, landforms, soils, climate, and forest types. Greywacke peneplain remnants in the north have summer-dry climates and deep andesitic tephra soils with interbedded Taupo Pumice. Soft marine sediment plateaux in the south experience equably humid climates, and Taupo Pumice is absent from the shallower tephra soils. The plateau and peneplain landforms of Moawhango are in stark contrast to the dissected volcanic and greywacke mountainscapes of surrounding ecological districts. A large proportion of the Region retains natural or semi-natural vegetation, albeit, much of it fire-induced. A mosaic of fragmented beech forests on the greywacke country and kaikawaka forests on the soft sediment plateaux are surrounded by the last extensive seral tussock grasslands remaining in the North Island. Most tussock grasslands give way to shrublands within 30-65 years in the absence of burning. In addition, there is a scattering of non-forest sites which have been without forest for millenia, the result of cold-air inversion and poor-drainage. These sites support unusual habitats for a biogeographically special flora. Mostly small herbaceous species, these plants are part of the strong floristic and landscape relationships between the Region and the South Island.

Only a small proportion of the Region's ecological diversity is formally protected in reserves, and these are mostly around its border. There are many opportunities to improve protection of natural areas in Moawhango Ecological Region, because the land is generally of low farming productivity, and large areas are in crown tenure. The chance to protect intact sequences of native vegetation still remains.

INTRODUCTION

The Protected Natural Areas Programme was set up to identify and to protect examples of the full range of indigenous biological and landscape features in New Zealand, and thereby maintain the distinctive character of the country (Technical Advisory Group, PNA Programme 1986). The programme was convened in 1983 in response to the objective expressed in Section 3 (1) (b) of the Reserves Act 1977 which identified the need for

> "... the preservation of representative samples of all classes of natural ecosystems and landscapes which in their aggregate gave New Zealand its own recognisable character."

New Zealand has been divided into 268 ecological districts, which are grouped into 85 ecological regions (McEwen 1987). An ecological district has geology, topography, soils, climate, and biology, plus the broad cultural pattern, interacting to produce a characteristic landscape and range of biological communities (Technical Advisory Group, PNA Programme 1986; Myers *et al.* 1987). The ecological character of Moawhango Ecological Region is so distinct from surrounding regions that it was defined as a separate ecological region; i.e., Moawhango Ecological Region comprises a single ecological district (McEwen 1987).

Moawhango Ecological Region was prioritised for a PNA report by Wanganui, Tongariro-Taupo, and Hawke's Bay Conservancies of the Department of Conservation because of its highly distinctive ecological and landscape character, the paucity of protected natural areas, the fragmented state of natural resource and scientific information, and the rapid conversion of tussock grassland to improved pasture in recent years.

Because of the breadth of existing knowledge, the task of reporting was seen by the Department as mainly collation of existing information and formulation of priority areas for protection. Extensive field survey was deemed unnecessary, but complementary reconnaissance of small, poorly understood areas was undertaken. The report describes the ecological character of the district, focusing on the origins of the landforms and the vegetation patterns before and after human impact. In selecting recommended areas for protection (RAPs), no judgement has been made on the likelihood of future trends in secondary vegetation; rather, the present ecological character and landscape pattern were the basis for reserves recommendations. Protection proposals notwithstanding, in the absence of fire there will be dramatic changes over time in landscape character, as native shrubs and trees spread through the secondary grasslands. This process is well underway at present in some areas.

The general Moawhango region was informally labelled as the Inland Patea by early Europeans after the first visits by missionaries Richard Taylor from Wanganui and William Colenso from Hawke's Bay. The 'Inland' epithet differentiated the district from coastal Patea of south Taranaki. Land tenure is noteworthy for areas in multiple Maori ownership, a large military holding at Waiouru, and large freeholded sheep and cattle stations.

METHODOLOGY

The Protected Natural Areas Programme Guidebook of Myers *et al.* (1987) was used as a prescription for the project, except that no detailed field reconnaissance or intensive field sampling with numerical classification of vegetation was undertaken. Detailed survey was considered unnecessary because of existing ecological knowledge of virtually the whole Region, accumulated in connection with a doctorate study (Rogers 1987) on the landscape history of the region. This study also reviewed the state of previous knowledge of the natural history of Moawhango Ecological Region. Only small additional field survey was necessary to complete a comprehensive coverage of the Region. Aerial photographs and topographical maps (NZMS 260 1:50 000) were an aid in the derivation of land systems, ecological units, and RAPs. A geomorphological or landform classification was modified after Whitehouse *et al.* (1990). Vegetation cover classes used in this report follow Atkinson (1985), with the addition of tussock grassland and shrub-tussock grassland cover classes.

ECOLOGICAL CHARACTER OF MOAWHANGO ECOLOGICAL REGION

LOCATION

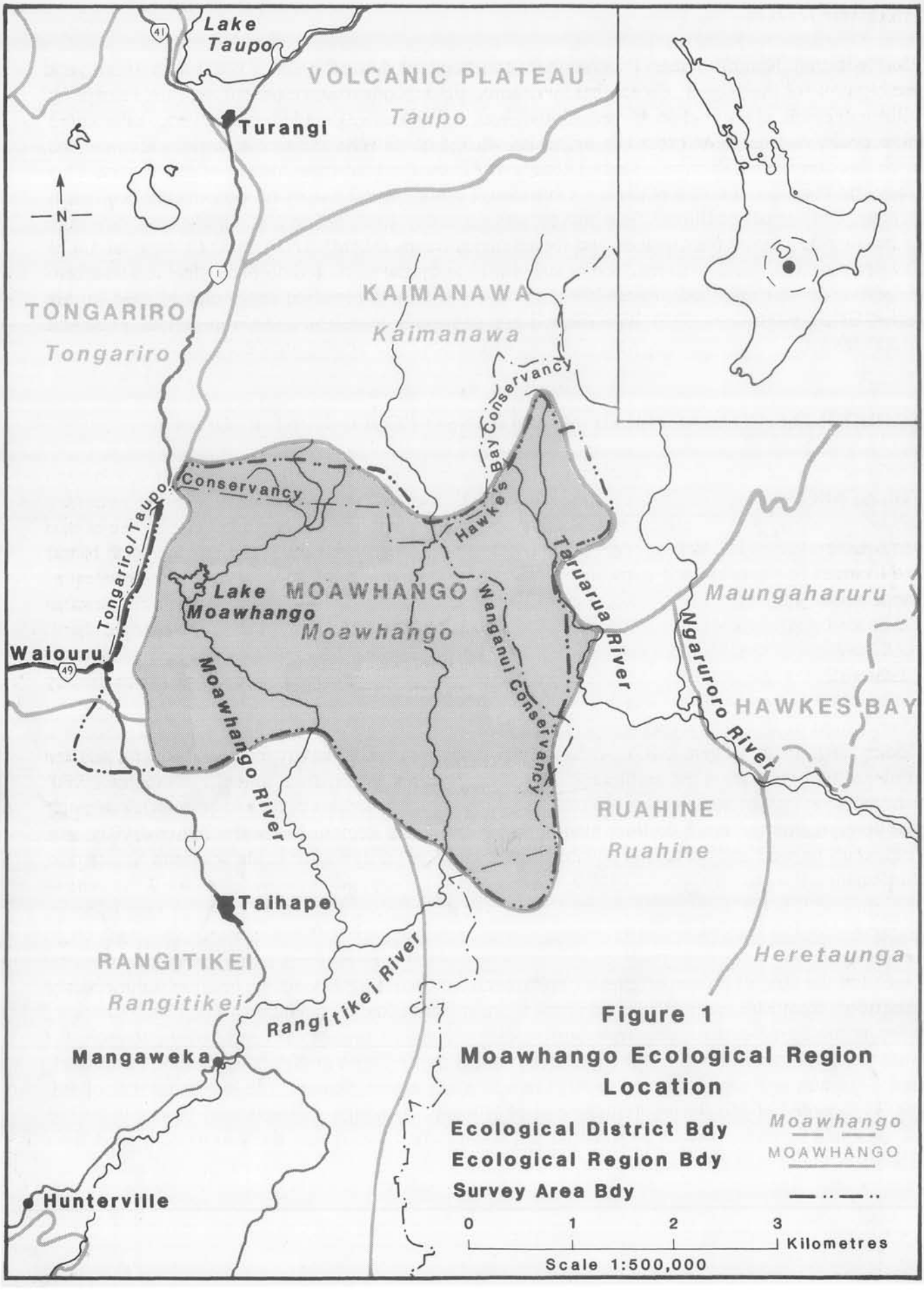
Moawhango Ecological Region is encircled by the Tongariro volcanoes in the west, by North Island axial ranges in the north and east, and by the slump topography of Rangitikei Ecological Region in the south (Fig. 1).

CLIMATE

Moawhango experiences a cool-temperate, rain-shadow climate with moderate seasonal variations (Elder 1962, 1965, Rogers 1987). Although the winds are predominantly from the westerly quarter (Elder 1965), wind from the northeast is important. Weather patterns are strongly influenced by the orographic effects of surrounding mountains, which intercept both westerly and easterly airstreams, and precipitation therefore declines toward the centre of the Region. Marked summer-dryness is a feature in the west and north, but equable humid climates predominate in the southeast adjacent to the Ruahine Range.

Rainfall

Not all of the rainfall is from orographic spillover from encircling mountains, because southwesterly rain fronts from Manawatu-Wanganui districts are uninterrupted by mountains. There are, however, steep rainfall gradients running from surrounding mountains toward the centre of the Region, for instance 2083 mm at Boyd's Hut (Ngaruroro River) to 1092 mm at Ngamatea Station homestead, and 1731 mm at Ruahine Corner to 1013 mm at Mangaohane Station. The lowest rainfall of 890 mm is recorded at Moawhango village east of Hihitahi. Although summers may be dry in the lee of mountain barriers, periods of potential soil water deficit throughout the year as computed from Thornthwaite (1948) are insignificant.


Lake Taupo
VOLCANIC PLATEAU
Taupo
Turangi
N
TONGARIRO
Tongariro
KAIMANAWA
Kaimanawa
Hawke's Bay Conservancy
Tongariro/Taupo Conservancy
Lake Moawhango
MOAWHANGO
Moawhango
Waiouru
Moawhango River
Wanganui Conservancy
Taruarua River
Maungaharuru
Ngaruroro River
HAWKES BAY
RUAHINE
Ruahine
Taihape
RANGITIKEI
Rangitikei
Rangitikei River
Heretaunga
Mangaweka
Hunterville
Figure 1
Moawhango Ecological Region Location
Ecological District Bdy
Ecological Region Bdy
Survey Area Bdy
Moawhango
MOAWHANGO
0 1 2 3 Kilometres
Scale 1:500,000

Wind

Most wind is from the western sector, and contributions from the south are minimal. East and northeast winds have a 21 % frequency/annum, yet easterly rain is only important in extreme eastern districts. West and northwest winds blow on 35 % of days. In the characteristically windy New Zealand climate, an unusually high 23.5 % of days at Waiouru are calm.

Temperature

Waiouru Military Camp provides the only temperature statistics. Summers are warm with contrasting cold winters. Average summer-month temperatures are 12-14°C. Between June and August average screen daily minimum temperatures approach freezing, and average daily means are 4°C. Temperature values for Waiouru are considered a conservative representation for the district in view of its relatively low altitude. Frosts occur on an average of 97 days/year.

LANDFORMS

The landforms of Moawhango Ecological Region rate as its most distinctive and diagnostic natural feature. Most striking are the remnants of greywacke peneplains in the far north dating to at least the late Tertiary, and montane block plateaux of younger marine sediments throughout the central and southern districts. Although low relief characterises the plateau surfaces, the individual blocks are separated by deeply-incised and wide river valleys. Tectonic uplift in the Kaikoura Orogeny of the surrounding mountains, the Kaimanawa, Kaweka, and Ruahine Ranges, has similarly elevated the Moawhango region to upper montane elevations. Greywacke rocks and surfaces are called 'hard' rock landforms because the rocks are hardened or metamorphosed, and the marine sediments of sandstone, siltstone, mudstone, and limestone are referred to as 'soft' rock landforms because they have not been metamorphosed.

Geological and geomorphological studies of Moawhango Ecological Region are few, with detailed work undertaken only in the northwest and southeast peripheral sectors. Initially, Grindley (1960) mapped the northern sector at 1:250 000, and Gregg (1960) described the age and lithology of marine sediments of the Rangitikei land system. Sporli and Barter (1973) and Sporli (1987) have mapped pre-Quaternary peneplain remnants on the Torlesse greywackes of the southern Kaimanawa Mountains, and these landforms extend southward to Moawhango Ecological Region. Remnants of this ancient greywacke erosion surface also dominate the Rangitikei and Owhaoko land systems. It is possible that the erosion surface dates to the Cretaceous (65-135 ma) (Sporli 1987) and would represent by far the oldest landforms in the North Island, and may be contemporaneous with the Cenozoic surface of Central Otago preserved as a series of block mountains and intermontane basins.

The Moawhango peneplain appears as a series of broad convex ridges and spurs and intervening concave basins. The basins are represented best in the Moawhango River headwaters in the Ngawakaakauae and Moawhango West catchments. Other basins are The Bowery, Awapatu, Argo, and Big Valley. These antecedent basins were valleys formed on the old generation greywacke peneplain. In geographic scale and extreme of summer dryness, the basins do not compare with the largest intermontane examples of Central Otago, but in topography and native flora the Moawhango systems have many similarities. The basin floors are the largest, cold-air inversion, non-forest sites in the North Island, and are by far the most ecologically diverse.

West of the Kaweka Range lies the greywacke Owhaoko plateau, where the erosion surface is sub-horizontal and has been downdropped in relation to the surrounding mountain country. The Ngamatea plateau is basically a downdropped horizontal peneplain of greywacke also, overlain by soft marine sediments.

Sometime in the late Miocene-early Pliocene, the fossil greywacke surface was partially submerged at the edge of a lower North Island marine transgression. The marine transgression replaned contact points on the underlying greywacke peneplain and deposited various thicknesses of overlying sandstone, siltstone, mudstone, and limestone sediments. On Ngamatea plateau, a series of low emergent ridges trending northeast separated a series of interfingering shallow sediment basins, such as that now occupied by Ngamatea East Swamp. A series of estuarine embayments, reminiscent of the present Marlborough Sounds, bordered emergent greywacke land of the Kaimanawa-Kaweka area to the north (R. Black, Hawke's Bay Regional Council pers. comm. 1986). The Ngamatea and Owhaoko plateaux existed as the northern shoreline for the late Tertiary sea that engulfed the lower North Island. Estuarine lake sediments also cap the summit of the Three Kings Range at T20/593955, outcropping on an Argo Road cutting. In essence, northern Moawhango Ecological Region formed a local northern shoreline for the sea that covered much of the lower North Island in the mid-Tertiary. There is no evidence that the sea covered the area of the present Kaimanawa Mountains, or that soft marine sediments were deposited in that area. In Moawhango, Tertiary sediments cap the greywacke erosion surface, and their horizontal regularity shows that there was virtually no fault dislocation of the peneplain during uplift later in the Kaikoura Orogeny (R. Black pers. comm.). The Tertiary sediments are almost 300 m thick in the centre and southwest of the Region, but they rapidly wedge-out northeastward toward the Kaimanawas. Where the Tertiary marine sediments were deposited comparatively thinly over the southern Kaimanawa Mountains, they have been largely eroded away since exposure with uplift in the Kaikoura Orogeny.

Many deeply-incised river gorges and hanging valleys in the upper Moawhango River region east of State Highway 1 are superimposed on the old-generation greywacke surface. These gorges often bisect the longitudinal axis of the ranges at right-angles, e.g., Mt Azim Gorge across the northern Three Kings Range. These are spectacular geomorphological features, up to 400 m deep, and result from the drainage pattern established in the overlying marine sediments being superimposed on, or inherited by, the underlying greywacke surface.

Kingma (1962) mapped the regional geology, and Browne (1978) has mapped the Tertiary sequence of the Mangaohane plateau at 'Blue Slip' in the Ikawatea Stream catchment, where the marine sediments abut the Ruahine Range greywackes. At Potae (U21 816681), south of Ruahine Corner, the uppermost limestone strata are tilted vertically from dislocation by the emergent Ruahine Range. Beu *et al.* (1981) believe uplift of the Ruahine Range commenced less than 1 million years ago.

The Mangaohane and Hihitahi surfaces are composed of a series of south and southwest-dipping plateau blocks separated by parallel faults. Displacement of the plateau surface as coherent blocks provides a stepped repetition of terrain. Reporoa Bog and Makirikiri Tarns occupy depressions on two of these block surfaces. Prominent escarpments on the Tertiary surface result from weaker underlying siltstone eroding away below erosion resistant, capping limestone. Durable limestone blocks litter escarpment slopes from backslope erosion in cold Pleistocene climates. Back-wearing of scarps instead of down-wearing of sediments is characteristic of bare rock surfaces in cold climates.

On Ohutu Ridge and south of Reporoa Bog on the Mangaohane plateau, the basement greywacke surface outcrops as a ridge and series of knolls above the softer sedimentary plateau. Pedestal remnants of marine sediments at Te Rakaunuiakura and Aorangi suggest many metres of marine sediment was stripped from the Mangaohane plateau during the Pleistocene. Erosion-resistant, limestone lenses form the surface of the plateau, following stripping of softer overlying siltstones and sandstones. There is geomorphological and plant biogeographic evidence that at least parts of Moawhango Ecological Region remained above the sea in the late Tertiary (Rogers 1989b).

The predominant soil parent material is Holocene andesitic ash derived from the Tongariro volcanoes as cold, air-fall, incremental showers. Topping (1973, 1974) mapped the proximal sequence of ash showers around the Tongariro volcanic ringplain and these can be more or less traced as thin lenses in Moawhango Ecological Region. The ash sequence is 3-4 m deep in the west, thinning to 2-3 m on the Mangaohane plateau. Several of the ashes have distinct and diagnostic appearances: Ngauruhoe Ash (present day-2500 yr BP) is uppermost with a dark grey sandy texture; underlying Taupo Pumice (1850 yr BP) is cream-white and has a coarse-textured pumiceous appearance; and deep Papakai Tephra (2500-9800 yr BP) is red-brown, deeply weathered, and of a silty texture. Mangamate Tephras (*c.* 10 000-9800 yr BP) appear as several red-brown lapillis beneath more deeply-weathered Papakai Tephra. Papakai and Mangamate Tephras are often referred to as the upper Tongariro Ashes. The ash sequence mantles the primary bedrock landforms and smooths the microtopography.

Two pre-Holocene ash units outcrop in embankments in the Region and have obviously survived stripping during the late Otiran glacial advance. Milne (1973) reported the multi-banded Kawakawa Tephra (21 500 ka) in the floor of the Rangitikei valley at NZMS 713781 in the Mangaohane road cutting. A further outcrop occurs at NZMS U21 781775 on Mangaohane Station, indicating vegetation occurred to at least 1000 m altitude during the peak of the last Glaciation. Otiran loess composed of andesitic ashes from the Tongariro volcanoes underlies Holocene ashes in an Argo Road cutting on the floor of the Moawhango River valley at NZMS T21 519898.

Both the Moawhango and Ngamatea land systems were inundated by the Taupo Pumice pyroclastic flow. Valley and basin-floor deposits are < 10 m deep and preserved as intact riparian terraces fringing lower valley slopes, but hillslope deposits are much thinner veneers of often redistributed pumice. The pumice flow extended south further in low relief areas than in upland areas. In the west, the southernmost point for the flow down the Rangipo depression was the Irirangi Swamp, while in the adjacent uplands, the flow ceased 15 km north at the Kaimanawa Trig on the Three Kings Range. On Ngamatea plateau, the flow stopped at the Taihape-Napier Road, but extended almost to Moawhango Village down the Moawhango River.

Several rhyolitic tephras from the Taupo and Okataina Volcanic Centres and andesitic tephras from the Tongariro volcanoes appear as narrow ash horizons in peat bogs. This ash chronology is useful for studies of landscape history as derived from peat morphology and pollen analysis for the Holocene period (Rogers & McGlone 1989; Froggatt & Rogers 1990) . Up to 5 m of peat have accumulated in basin peat bogs of the Three Kings Range and in Reporoa Bog in the last 12 000 years, and up to 1 m of peat in blanket or capping peats of the Three Kings Range. Climate deterioration toward increased seasonality and wetter winters about 6000 years ago led to the formation of blanket peats on mountain summits (Rogers & McGlone 1989).

SOILS

Campbell (1979) mapped the soils of the district. Soils of volcanic ash are differentiated principally on the particular ashes present and their relative thicknesses. In the west and north, Upper Tongariro Ash, rhyolitic Taupo Pumice and andesitic Ngauruhoe Ash dominate. In the south and east, Upper Tongariro andesitic ash is the main mineral constituent of upper horizons. Campbell also categorised the district soils on degree of horizon development within the individual ash layers. In general, soils developed on central North Island air-fall tephra are not strongly weathered, a product of moderate rainfall and the youthful soil parent materials. Campbell classified four broad soil groups according to the soil parent material and stratigraphy:

1. Volcanic ash deposits - Kaimanawa, Kaweka, Ngauruhoe, Manukaiapu, Waimarino, Waiouru, Taruarau, and Ngamatea soils.

2. Volcanic ash and peat - Murimotu soils.

3. Volcanic ash overlying Cenozoic (soft marine) sediments or greywacke - Waihua, Otupae, Irirangi, Timahanga, Titapu, Moawhango and Ohakune soils.

4. Greywacke - Rimutaka and Renata soils.

Many subalpine soils have very severe to severe or moderate soil limitations for use. Soils above 800m experience cold winters, and consequent low soil temperatures are significant limitations. The soils formed mostly from Taupo Ash (Pumice) and those under high rainfall are likely to be strongly leached and nutrient deficient. The soils formed from the younger Ngauruhoe Ash are weakly weathered, have weakly developed structures and, as a result, are very susceptible to wind and sheet erosion. The soils on the older ash deposits (upper Tongariro Ashes) have well developed profiles, and, where altitude and rainfall are lower (Irirangi and Moawhango soils), there are few limitations for use. At higher altitudes and under higher rainfall (Titapu and Otupae soils) there are severe limitations of erosion risk and low soil temperatures.

No organic soils are mapped in the Reporoa Bog area nor in the vicinity of the Makirikiri Tarns, although extensive organic (peat) soils do occur in both these localities. Thin ironpans are commonly found within soil profiles at textural boundaries where iron compounds tend to precipitate out owing to changes in permeability and porosity.

The texture of volcanic ash soils is predominantly sandy or silty and, although a substantial part of the clay fraction is allophane, the proportion of clay is generally low. In the north, soils developed from younger Taupo Pumice and Ngauruhoe Ash are less weathered, with weakly developed structure and are susceptible to wind erosion and summer moisture deficits. Taupo Pumice soils are also well drained.

SPECIAL GEOLOGICAL AND GEOMORPHOLOGICAL FEATURES

Several noteworthy physical features of the landscape have no formal recognition or protection. Important profiles of sequences of tephra showers, superimposed river gorges, and peat bogs used in studies of landscape history are included in the list.

1. An exposure of Kawakawa Tephra (22 590 +/-230 yr BP) in a road cutting at U21 711782 (see also Milne 1973).

2. A high altitude exposure of Kawakawa Tephra in a track cutting on Mangaohane Station at U21 784771 (see also Rogers 1987).

3. Reporoa Bog included in RAP 1, is important for 4 m of peat accumulation since 11 000 yr BP, and the preservation of 7 tephra horizons (Froggatt and Rogers 1990). Pollen curves were prepared from peat cores for the derivation of a post-glacial vegetation history (Rogers and McGlone 1989).

4. Three Kings Range summit peat bogs (RAP 8); 5 m of peat accumulated since 11 000 yr BP, with the preservation of six tephra horizons (Froggatt and Rogers 1990). Pollen curves were prepared for the derivation of a post-glacial vegetation history (Rogers and McGlone 1989).

5. Mt Azim gorge, the most spectacular superimposed river gorge in Moawhango Ecological district developed in the old generation greywacke peneplain.

VEGETATION

Introduction

Considerable native vegetation remains in the district, despite the disappearance of 75 000 ha of shrubland and tussock grassland because of conversion to improved pasture between the Second World War and 1984 (Rogers unpublished Forest Research Institute Report 1991a, Rogers in press). Secondary vegetation predominates in the Region, and old-growth forests are only important in wetter and high altitude peripheral areas. Native vegetation has virtually disappeared from a large upper montane central region of soft sediment plateaux previously covered in mixed podocarp-upper montane conifer forest, stretching from Hihitahi in the west, to Otupae and Pukeokahu in the east. Two broad geological zones had beech forest on undulating greywacke landforms in the north, and upland conifer forest (kaikawaka, Hall's totara, pink pine, and mountain toatoa) on soft marine sediment plateaux mainly in the south (Rogers & McGlone 1989).

Forest

A full understanding of earlier ecological sequences of forest in prehuman times is compromised by the fragmented patterns remaining after deforestation.

Podocarp/hardwood

Old-growth forest on lower montane soft sediment landforms is a diverse podocarp/hardwood association dominated by matai, kahikatea, totara, and rimu, with black maire, lacebark, titoki, putaputaweta, hinau, tarata, and fivefinger also important. Kowhai, ribbonwood, and lacebark are important along riparian cliffs and water courses. This community is best preserved in riparian and hillslope forests of the lower Moawhango River from its confluence with Aorangi Stream southwards. *Pseudopanax ferox* occurs in only three broad North Island localities, one of which consists of only four trees in degraded riparian forest above the Moawhango River at T21 578728.

Beech

Black beech forests with emergent rimu and abundant broadleaf occur altitudinally above podocarp/broadleaved forest on cold steep sandstone sites (much of the rimu has been selectively logged). The best stands are in Tikirere Stream of Motukawa Station, lowermost Te Rei bush (RAP 5), Pokopoko Stream catchment on Mangaohane Station, and on mid slopes of western Aorangi (RAP 1).

Above black beech on the northern greywacke landforms, mixed beech forest occurs. The number of beech species declines eastward from the Defence land to the upper Taruarau River catchment, and also increases southward through the Defence land. Red, silver, and mountain beech are prominant in the Defence land (RAP 7), decline to red and mountain beech at Tikitiki Bush (RAP 4) on the western Ngamatea plateau, and only mountain beech occurs at Otutu Bush adjoining the Kaweka forests. The north-south gradient in the Defence land has mountain beech only in the north, with red, silver, and mountain at Pleasants Bush midway south, and red and mountain at Westlawn (silver beech reaches its southern limit in Moawhango Ecological Region at Westlawn where approximately five trees exist). Although most beech forests occupy greywacke landforms, several exist on plateau margins such as Tikitiki Bush (RAP 4), Te Rei Bush (RAP 5), and around the southern margin of Mangaohane plateau (RAP 1). Beech forests on the Moawhango land system are only abundant on dissected terrain of the Moawhango River catchment between the Moawhango reservoir and the Mt Azim gorge. Forest fires were concentrated along spur and ridge summits, along valley floors, and on northern aspects, leaving forest on south-aspect, mid-valley slopes.

Upland conifer

Above black beech on soft sediment plateaux, kaikawaka dominates, with Hall's totara in the drier west and with mountain toatoa and pink pine in the humid east. Broadleaf and putaputaweta are important lower canopy species throughout, and the understorey consists of first wineberry, then horopito, and finally *Coprosma* sp. (t) (Eagle 1982), *Myrsine divaricata*, and *Rubus cissoides* in an ascending altitudinal sequence from 900-1320 m.

Possums and deer have depleted these forests of numerous lower canopy and understorey species including ribbonwood, mountain fivefinger, *Coprosma tenuifolia*, broadleaf, *Fuchsia excorticata*, hen and chicken fern, and *Astelia* spp. These kaikawaka forests covered most of the Mounganui, Kauakeke, Erewhon, southern Ohinewairua, Ngamatea, Otupae, and Mangaohane plateaux, an area of 300 sq. km. Hihitahi and the Waiokotore-Ohutu Ridge forests are the only substantial remnants. Small remnants within tussock grassland and along plateau margins are scattered throughout the Region, particularly about Auahitotara, the Otupae Range, and Mangaohane plateau. Dieback or sudden decline of kaikawaka and Hall's totara old-growth stands since 1950 is evident at Hihitahi and in the headwaters of Ohutu Stream east of Aorangi. There is no regeneration of kaikawaka and Hall's totara in affected stands and, given the density of shrubs in the understorey and their probable inhibitory effect on conifer recruitment, tall conifer forest is being replaced by broadleaved scrub and low forest.

Secondary Vegetation

Widespread secondary vegetation accompanied forest clearance by early Maori fires, and in area dominates natural and semi-natural landscapes today. The two physiographic zones have widely contrasting secondary shrubs, but the same tussock grasses. Burning depletes the shrubs and selects, at least initially, for tussock grasses.

Red tussock dominates all secondary tussock grasslands, but is most competitive in humid climates and on moist soils. On thin soils in the summer-dry northern region, red tussock is rapidly depleted by burning and grazing and is replaced by hard tussock, patotara, various mosses, lichens, and adventive grasses. Silver tussock was once important on higher-fertility, frequently disturbed areas, but it has been much reduced by grazing because of its palatibility to farm stock. Even degraded hard tussocks will disappear with prolonged grazing and frequent burning to be replaced by a mouse-ear hawkweed sward. Bristle tussock only appears on disturbed sites or eroding areas and is not common. Blue tussock is a minor inter-tussock species of many grasslands, and it has suffered severe depletion by feral horse and stock grazing. Mid-ribbed snow tussock has not expanded beyond its originally restricted alpine sites within the Region, and today is found only on the summits of greywacke ranges in the northern Moawhango land system, e.g., the Te Puta o te hake Range. Mid-ribbed snow tussock may shortly disappear from the Region because of feral horse grazing (Rogers 1991). *Deschampsia caespitosa*, a tall grass of flush zones and eutrophic wetlands, has also virtually disappeared from the Region because of past stock grazing. Only one or two plants remain, on the Makirikiri Tarn depression of Mangaohane plateau.

Successionally, a red tussock grassland persists for less than 30 years in the absence of burning on the northern greywacke part of the Region (Rogers & Leathwick in press). There, the invasive shrubs are monoao, manuka, and kanuka, in that successional replacement sequence. Monoao extends south to the northern boundary of Hihitahi forest in the west and to the northern Otupae Range in the east. On steep escarpment slopes of elevated fertility, mountain flax is selected ahead of tussock grasses and shrubs by burning. The flax is invaded by manuka in the absence of burning. At high altitudes on the northern greywacke landforms a low shrubland of subalpine and alpine species has developed from past burning comprising monoao, *Dracophyllum recurvum*, *Brachyglottis bidwillii*, pygmy pine, and scattered red tussock.

On the floor of cold-air inversion basins and valleys monoao is the main shrub; manuka and kanuka, having less frost-tolerance, are restricted to above an inverted shrub-line some way above the basin floor on surrounding hillslopes. On hillslopes, manuka and kanuka form extensive shrubland and scrub, often in a dynamic steady-state because of the absence of a seed source for *Nothofagus*. Kanuka appears discontinuously in these communities, in a pattern inexplicable in terms of environmental factors; historical factors may partly explain kanuka's distribution.

On the southern soft sediment plateaux, a red tussock grassland persists for approximately 55-65 years and is invaded by inaka above 1220 m and manuka below. Manuka is eventually replaced by black and red beech trees and podocarp and broadleaved tree species. Inaka is a successional host to mountain toatoa and, in close proximity to a seed source, kaikawaka. *Coprosma* sp. (t) (Eagle 1982) and broadleaf also invade inaka shrubland. However, inaka may persist as a shrubland and scrub for up to 200 years in the absence of a seed source for invasive trees.

Extensive areas of the western Defence land from the Moawhango reservoir south to Waiouru have been stripped of tussock grasses and shrubs by burning, grazing by farm animals, and military training. As a grossly-modified ecosystem of mostly adventive grasses, the area will show a very slow regenerative response of tussock grasses and shrubs to the removal of these disturbances. On some basin and valley floors subject to unsustainable grazing and burning pressure (e.g., Awapatu Stream in the Defence land), a degradational sequence of vegetation change has proceeded from red tussock to hard tussock to *Hieracium pilosella*, adventive grasses, mosses, and patotara (Rogers 1991b).

Natural Non-forest Sites

Non-forest sites within previously extensively forested landscapes were the refuges for and liberation sites of virtually all the species of secondary vegetation of the Region, and the habitat of a number of plants with special distributions. Sites inimical to forest result from cold-air drainage, elevated watertables, and frequent geomorphic disturbance. The Moawhango has extensive frost-inversion basins and valleys, wetlands, and cliffs. Fire has modified all the non-forest sites except for three largely unmodified basins within kaikawaka and red beech forests at the southern limits of the Mangaohane plateau south of Te Rakaunuiakura (aerial photographs show the sites and access is off the Potae to Waiokotore track). These sites lie in Ruahine Forest Park. Dominant vegetation on these small bogs is mountain toatoa/inaka-bog pine scrub with infrequent *Pittosporum turneri*, *Olearia virgata*, and *Hebe odora*. Red tussock is rare and confined to the poorest-drainage sites along streams.

Ombrogenous (blanket or capping) peat bogs, e.g., Three Kings Range, and topogenous (basin) peat bogs, e.g., Ngamatea (West) Swamp and Ngamatea (East) Swamp, provide extensive oligotrophic wetland habitat for non-forest plants. Peat bog vegetation is dominated by wire rush, umbrella fern, and red tussock, but shrubs tolerant of waterlogged-soils and low fertility, e.g. *Hebe odora, Dracophyllum longifolium*, and *Olearia virgata*, were important before frequent human fires.

Flush zones, seepages, stream banks and levees, that mostly occur within frosty basins and wetlands, support many plants with special distributions in New Zealand (Macmillan 1991, Rogers 1988, 1989b, 1989c, 1991b, 1992). Most special plants are small shrubs, herbs, and grasses that are still confined to their highly specialised habitats despite recent opportunities to expand into surrounding open areas when forest has been removed by burning. The sites of highest special plant diversity are intermontane frosty basins of the Moawhango River headwater (RAP 2), and Reporoa Bog and Makirikiri Tarns (RAP 1). Explanations for this special plant biodiversity centre on the narrow ecological tolerances of these plants being catered for by special habitats mostly restricted to Moawhango Ecological Region in the North Island. Distributionally, the plants fall into several categories (Rogers 1989) (Appendix 1): local endemics; species occurring only in Moawhango Ecological Region in the North Island, but also occurring in the South Island; and species with southern limits to their North Island distributions. Many of the species are discussed in more detail under the section 'Biogeographically special plants', and also in the descriptions of RAPs 1 and 2.

Influence of Vulcanism on Vegetation

The pyroclastic flow of Taupo Pumice (1850 yr BP) was the only eruption from the Taupo and Tongariro Volcanic Centres to extensively destroy vegetation in Moawhango Ecological Region in the last 2000 years. Many areas of the Moawhango River headwaters and the Ngamatea plateau were engulfed, with the deepest pumice deposition on low-lying topography. Although much vegetation was inundated by the incandescent ash-cloud, there is evidence that forest recolonised most of the affected region (Rogers in press). Deep deposits of pumice on basin and valley floors were substantially eroded away, probably rapidly, by river transport of the buoyant pumice. Redistributed pumice in the Moawhango River basins has banked-up around the entrance to river gorges where the rivers exit the basins. The sub-plinian eruptions from the Tongariro volcanoes destroyed vegetation only on the upper slopes of the volcanic cones. Although individual eruptions deposited cold air-fall lapilli and smaller sand-sized ash over the Moawhango district, the showers did not destroy vegetation and, at worst, stripped foliage from trees only in the western districts closest to the volcanoes. Each incremental ash shower would have produced a soil fertility boost for *in situ* plant communities.

Prehuman Vegetation

The nature of prehuman landscapes was addressed in Rogers (1987, in press) and Rogers and McGlone (1989). Whereas open vegetation of shrubland and tussock grassland now dominates the Region, in prehuman times the D istrict was mostly forested. The patterns of forest types can be partly deduced from exisiting forests and are described above. The exceptions to ubiquitous forest were the intermontane basins of the upper Moawhango River, the wide valleys of the Rangitikei and Taruarau Rivers, and numerous peat bogs, all supporting open vegetation. Non-forest vegetation on basin and valley floors was scrub and shrubland consisting of various mixes of mountain toatoa, bog pine, inaka, monoao, *Olearia virgata*, *Hebe parviflora* var. *arborea*, and *Cassinia vauvilliersii*, depending on soil drainage, frost intensity, and summer aridity. Manuka and kanuka were excluded by intense frosts. Because of the superior stature of shrubs, tussock grasses on these sites were probably restricted to open understoreys of shrubland, along water courses and, with umbrella fern and wire rush, on oligotrophic peat bogs. Where forest has been cleared from catchment slopes surrounding non-forest valleys and basins, the present frost-determined lower limit of manuka probably marks the position of the original inverted treeline.

There is sub-fossil evidence in peat bogs of limited prehuman deforestation in the rain-shadow region of the Moawhango River headwaters. Lightning-strike fires and forest clearance led to some secondary grassland *c.* 3000 yr BP (Rogers & McGlone 1989), but the extent of grassland is difficult to estimate from pollen records. This was a North Island equivalent of the deforestation process underway in south Canterbury and Otago *c.* 2500 yr BP (McGlone 1973, 1983).

Cultural Influence on Vegetation

The timing and geographical extent of Maori forest clearance are well understood in Moawhango Ecological Region (Rogers 1987). A single conflagration deforested the western district south to Hihitahi *c.* 570 yr BP. A single fire *c.* 430 yr BP deforested the eastern district probably extending over the Ngamatea, Otupae, and Mangaohane plateaux. Subsequent burning of secondary vegetation on the deforested landscapes added little to the removal of forest.

Recurrent burning by prehistoric Maori of the secondary vegetation that replaced the forest induced 165 500 ha of seral tussock grassland. Manuka appeared commonly in grasslands with the spread of sheep farming by Europeans in the mid-late 19th century, and probably resulted from late 19th century Maori forsaking their prehistoric burning practices and from animal disturbance fostering the spread of shrubs.

Some 56 600 ha or 34 % of the tussock grasslands in 1840 remain today, of which only 1900 ha are protected. The incentives provided by Land Development Encouragement Loans in the 1970s and early 80s contributed most to the transformation to improved pasture of 75 000 ha since 1940. Conversion occurred mostly on plateaux east of the Rangitikei River, but ceased with the removal of the subsidies in 1985. The bulk or 44 850 ha (79 %) of the tussock now occurs in the Ministry of Defence holding at Waiouru, with 7700 ha on Ngamatea and Owhaoko, and 4100 ha on Mangaohane plateau.

Spread of heather, monoao, manuka, and kanuka through red tussock grasslands in the west and north is now dramatically changing their status. In the absence of burning, the effective lifespan of undisturbed summer-dry grasslands is less than 30 years in the north and 55-65 years in the south (Rogers & Leathwick in press). Rates of shrub invasion also vary with topography, distance from seed source, and drainage. In the absence of burning, all seral Moawhango grasslands will be invaded by shrubs, so widespread are the woody species seed sources. Even the frosty basins and valleys and wetlands, now mostly in tussock grassland will be invaded by shrubs, because most have had their steady-state shrubs and low trees removed by human burning. However, the habitats of special plants such as flush zones, gravel levees, and seasonally wet depressions will remain free of erect shrubs.

Grazing by farm stock and feral horses has acted continuously, and burning intermittently, in modifying the northern rainshadow grasslands of Moawhango Ecological Region since the 1880s. Pastoral rangelands have shifted progressively from tall tussock to short tussock particularly on sheltered basin floors and warm plateaux favoured by stock. Several species may have largely disappeared including the highly palatable and probably originally widespread grass *Elymus rectisetus* (*Agropyrum scabrum*) which disappeared early from tussock grasslands with the release of stock.

Recurrent burning of tussock in the last 3 decades for shrub suppression, fodder improvement, control of *Pinus contorta*, and accidental fires from Army artillery practice has induced adventive grass swards and *Hieracium* herbfield, and progressively eliminated tussocks. Deliberate burning of degraded tussock grassland clearly has no merit in suppressing the spread of native shrubs and maintaining tussock cover as rangeland for stock.

FLORA

Appendix 2 lists the native plants found in the Region. Plant names follow Allan (1961), Moore and Edgar (1970), Healey and Edgar (1980), Connor and Edgar (1987) and Webb *et al.* (1988). Given the comparatively high altitude, an inland location, the extent of cultural modification, and the lack of coastal, lowland, and alpine bioclimatic zones, Moawhango Ecological Region has a particularly diverse indigenous flora of approximately 750 species (Appendix 2). The significance of this figure is apparent when compared with the flora of Central Otago at 910, a region of considerably greater geographic and ecological variation and extent.

Botanical exploration has been quite thorough since the Second World War, noteworthy for the efforts of A.P. Druce, N.L. Elder, C.C. Ogle, and the Wellington Botanical Society (see History of ecological survey). Field survey has concentrated on habitat diversity to economise effort. In particular, non-forest sites have received considerable attention. Assuming that the diverse secondary vegetation was derived from the restricted non-forest sites following deforestation (Rogers in press), these habitats in pre-human times probably supported diverse floras in small areas. Some species loss was probably an inevitable consequence of human modification of these sensitive sites, but inundation of the Moawhango River headwaters and Ngamatea plateau by deep Taupo Pumice probably caused the greatest loss of biodiversity in the low-lying sites in the north.

THREATENED AND LOCAL PLANTS

Twenty-one species included in the latest checklists of threatened and local plants (Wilson and Given 1989, Cameron *et al.* 1993) are recorded in the region (Appendix 3). An annotated list of noteworthy species follows:

Extinct:

Logania depressa: Collected only once by William Colenso in 1847 (Colenso 1884) from the upper Moawhango River catchment. Given Colenso's most likely route, the collection site was presumably in the western area of the Defence land.

Endangered:

Acaena rorida: This Makirikiri Tarns endemic is confined mainly to damp channels of ephemeral streams feeding the Makirikiri basin. Two populations occur on the western margin of the basin on the floor of limestone ravines feeding headwater streams of Waiokotore Stream. The species is being reduced in cover by Yorkshire fog (*Holcus lanatus*) and *Hieracium pilosella* invading numerous sites. It also hybridises with *Acaena novae-zelandiae*, and this may threaten its long-term survival.

Amphibromus fluitans: Occurs in one montane tarn fed by the Kaimaikuku Stream in the lower Awapatu valley of the Waiouru Defence land. The tarn is subject to fluctuating water levels, severe feral horse damage, and is designated as a low-impact area by the military. The tarn margin is also the only North Island site for a small population of *Gnaphalium ensifer*.

Pterostylis micromega: Several individuals have been seen on peat bogs of the Defence land and Ngamatea plateau.

Vulnerable:

Alepis flavida: Originally recorded from the Region, but now probably extinct through possum browsing.

Deschampsia caespitosa: Recorded from Ngamatea (West) Swamp where it appears to be in no danger from stock grazing; from the Moawhango River headwaters where it is believed to have been recently eliminated by feral horse grazing (pers. obs.); and from Mangaohane plateau, where it is very rare (possibly recently eliminated) because of stock grazing.

Myosotis sp. ("Volcanic Plateau")(aff. *M. pygmaea*): This species occupies wet depressions and damp channels in ephemeral streams in non-forest sites. Two sites are known: a small population in the upper basin of the Moawhango River headwaters (not the Moawhango West River); and at Makirikiri Tarns.

Peraxilla tetrapetala: Originally recorded from the Region, but approaching extinction through possum browsing. One recent record is from the saddle between the Ikawetea and Mangatera Rivers, immediately southeast of Potae (J. Barkla pers. comm. 1993).

Prasophyllum sp. unnamed (aff. *P. patens*): recorded from Lake Horotea in the Taruarau River headwaters. A large population has recently been uncovered in Irirangi Swamp on the southwest corner of the Region, west of Hihitahi (C.C. Ogle Department of Conservation pers. comm.).

Ranunculus recens var. *recens*: This is possibly a Moawhango Ecological Region endemic. Approximately four populations occur in the Moawhango West River basin and there is one record from east of Ngamatea (East) Swamp on the Ngamatea plateau.

Rare:

Ourisia modesta: Only one population (perhaps one plant) is recorded from the outlet stream of a natural forest clearing immediately northeast of Ruahine Corner Hut on the Mangaohane plateau. The record is in Ruahine Forest Park.

Pittosporum turneri: Moawhango Ecological Region is a stronghold for this central North Island endemic, with approximately 25 isolated populations occurring around Ohutu Ridge and the Mangaohane plateau within old-growth kaikawaka forest, on natural non-forest clearings, along reconstituted forest margins, and in secondary shrubland. All except one plant, which has semi-adult foliage, have juvenile divaricating architecture and juvenile foliage.

Ranunculus ternatifolius: Recorded from Reporoa Bog, one of only two North Island sites (the other is from Erua State Forest Sanctuary, west of Mt Hauhungatahi).

Tupeia antarctica: Has been recorded from the Region, but probably now extinct, because of possum browse.

Indeterminate and insufficiently known:

Libertia peregrinans: Previously recorded from the upper Hautapu Stream below the northwest corner of Hihitahi, but recent searching has failed to relocate the species.

Myosotis sp. unnamed (*M. pygmaea* var. *glauca*): Confined to levees and riparian sites in two intermontane basins of the Moawhango River headwaters.

Pimelea aridula: Several varieties or subspecies are recorded in central North Island, with one confined to greywacke gorges in the middle reaches of the Moawhango River immediately east of Waiouru.

Local:

Pleurosorus rutifolius: Recorded from greywacke gorges in the Ikawatea River south of Pohokura before the Ikawatea joins the Taruarau River. The record is in reality just on the boundary between Moawhango and Ruahine Ecological Regions.

Pseudopanax ferox: Only two adult, one semi-adult, and one juvenile plant are known from highly modified river terrace forest (Druce 1982) on a terrace above the Moawhango River 7 km below Moawhango village. The lack of juveniles presumably results from understorey modification and continuing stock grazing. This occurrence could be just south of the Region boundary and, therefore, may be in Rangitikei Ecological District.

Tetrachondra hamiltonii: This species is quite extensive on the southern Mangaohane plateau, its only North Island locality. Deforestation and subsequent depletion of the tussock grasslands probably led to local population growth for the species, because it is widespread in moist intertussock herbfields.

Cardamine sp. (*C. debilis* agg. "Reporoa Bog slender var."): Known only from Reporoa Bog in the North Island.

BIOGEOGRAPHICALLY SPECIAL PLANTS:

A very large number of plant species (72) have significant biogeographic limits in Moawhango Ecological Region (Appendix 1). The great majority are plants of special microhabitats (Rogers 1989b) within larger non-forest sites formed from cold-air inversion and high watertables. There are two endemic species (Group 1 Appendix 1), the bidibidi, *Acaena rorida,* which is confined to the Mangaohane plateau, and the probably extinct *Logania depressa*, a low-growing shrub originally recorded in the vicinity of the Defence land at Waiouru. For such a small geographic area, Moawhango Ecological Region also contains a large number of species that occur only there in the North Island and are then disjunct to the South Island (Group 3 Appendix 1). These species mostly occur in two areas of the Region. Nine species occur only in the Defence land at Waiouru and mostly in the intermontane basins of the Moawhango River headwaters. Noteworthy species in this area are, *Acaena inermis*, *Agrostis imbecilla*, *Carex berggrenii*, *Carex petriei*, *Gnaphalium ensifer*, *Koelaria* sp. (*K. novozelandica* agg.), *Luzula* sp. (*L. rufa* var. *albicomans*), *Myosotis* sp. (*M. pygmaea* var. *glauca*), and *Nertera* sp. (aff. *N. balfouriana*). Another six species are confined to the Mangaohane plateau in the North Island, that is, *Cardamine* sp. (*C. debilis* agg. Reporoa Bog slender var.), *Elymus laevis*, *Euphrasia disperma*, *Myosotis tenericaulis*, *Ourisia modesta*, and *Tetrachondra hamiltonii*. *Ranunculus recens* var. *recens* is also in Group 3, but it occurs in the northern Defence land and on Ngamatea plateau. *Uncinia strictissima*, another Group 3 species, is now known from only two plants on Ngamatea plateau after the disappearance of a previous population, probably through habitat destruction, on the northwest boundary of Hihitahi forest. Several of these Group 3 species show dramatic disjunctions: the closest recorded South Island sites for several species are: *Ourisia modesta*, Gouland Downs, northwest Nelson; *Tetrachondra hamiltonii* and *Luzula decipiens*, Matiri Plateau, northwest Nelson; *Euphrasia disperma*, Denniston Plateau, northwest Westland; and *Myosotis* "glauca", Nevis valley Central Otago. Two other species occur only in one other North Island location outside Moawhango Ecological Region: *Ranunculus ternatifolius* occurs at Reporoa Bog and at Erua Scientific Reserve west of Mt Hauhungatahi; and *Carex uncifolia* is recorded from a bog between Mt Hauhungatahi and Mt Ruapehu. The only known Moawhango population of *C. uncifolia* was recently lost through road construction in The Bowery in the Moawhango River headwaters

Most of the 72 plants have distributional limits in the Moawhango River headwaters or on the Mangaohane plateau. The microhabitats, in particular, flush zones, l_vees, stream banks, and periodically inundated hollows, often coincide with the original positions of the inverted treelines surrounding the non-forest sites. The rarity of most species reflects the paucity of specialist microhabitats, which in turn reflects the topographical rarity of natural non-forest depressions. Alpine species are not important in this group, reflecting the paucity of genuine alpine habitat within the Region.

WILDLIFE

Kiwi, blue duck, falcon, banded dotterel, and kaka are threatened bird species that occur in Moawhango Ecological Region (after Bell 1986) (Appendix 3). Kiwi have been recorded in Hihitahi State Forest Sanctuary in 1983 (unpublished New Zealand Forest Service Report 1984). There are also unconfirmed reports of kiwi from Ohutu Ridge and on the track from Ruahine Corner to Potae (S. Bolton pers. comm. 1993). There is also an unconfirmed report of kokako from Hihitahi (unpublished New Zealand Forest Service Report 1984). Blue duck have been recorded in the Otokoro Stream and Moawhango River around the exit of Mt Azim gorge in the Defence land. Blue duck are also recorded in the Mangatera Stream and tributaries (Department of Conservation blue duck database). Banded dotterel nest in the basins of the upper Moawhango River, and about Ngamatea East Swamp. Falcon are frequently seen through most of the Region, and kaka have been seen at Westlawn on the southern Three Kings Range and west of Mt Aorangi.

The central North Island endemic skink, *Leiolopisma microlepis* is currently known from Motutaiko Island, Lake Taupo, and from four sites in Moawhango E.D (Whitaker 1991; Hutchinson 1992). Other lizards for the Region are shown in Appendix 4 (after Pickard & Towns 1988).

Many of the widespread feral animals of forested uplands in New Zealand are recorded in the Region (Appendix 4). Red deer occur in all forested areas in moderate numbers. Populations were high at Hihitahi until five years ago, but are now low because of increased recreational hunting. Sika deer are also recorded throughout the Region: they are the commonest deer species in the north, and migration and population growth southward through the Ruahine Range is evident (pers. obs.).

Approximately 1500 (1992) feral horses range throughout 65 000 ha of the northwest sector in the southern Kaimanawa Mountains. Their deleterious environmental impacts on biogeographically special plants and their habitats, and grasslands on basin floors and plateaux are described by Rogers (1991). Since protection under the Wildlife Act in 1981, the horses have reproduced at an annual rate of 16.7% with a doubling of the population every 3.84 years. The protection boundary roughly coincides with State Highway 1 in the west, the tramping access corridor to the Rangitikei River from the SH 1 in the north, the Rangitikei River in the east, and private sheep stations south of Waiouru in the south. The Department of Conservation has prepared a management plan which includes options for limiting horse numbers.

Although goats are present in low numbers in parts of the Ruahine Range and scenic reserves east of Taihape, there are no known populations in the Moawhango. Feral pigs were abundant in all Moawhango tussock grasslands in the late 19th century, but only one small population now survives in the Ohutu Stream catchment west of Aorangi.

Information on invertebrates has not been actively sought for this report. However, the invertebrate fauna is likely to be diverse and to contain local and biogeographically significant species. This is indicated by brief surveys made of native land snails on Mt Aorangi by G.R. Parrish (Department of Conservation Whangarei) and by B. Abernathy (1990) in which about 25 species were found. Three small samples of litter (totalling less than 2 litres) from Hihitahi 1993 contained 161 native snails, comprising 13 species of which four were not in the earlier Aorangi collections.

A large land snail, *Powelliphanta marchanti*, which is nationally rare, is found on escarpment slopes of soft marine sediments, particularly on the Mangaohane plateau, and on the northern fringes of the Region in beech forest on greywacke headwaters of Rangitikei River and Aorangi Stream). Another land snail, *Rhytida* (*Wainuia*) *urnula* is known from the Mangaohane plateau (pers. obs.).

HUMAN PREHISTORY

The earliest prehistoric Maori tribe, the Ngati Hotu, were displaced westward across the Moawhango River in the early 1500s by the arrival of Ngati Tama (Anon 1987). Both tribes lived relatively peacefully as neighbours until about 1645, when the Ngati Whiti tribe, led by Whitikaupeka from Hawke's Bay, migrated to the area. Together, Ngati Tama and Ngati Whiti displaced Ngati Hotu from the Inland Patea. The dominant Maori tribes of the district in the latter prehistoric period were the Ngati Whiti and Ngati Tama, settled on the river terrace land between the Rangitikei and Moawhango Rivers. Both the dominant tribes have ancestral links with the Ngati Kahungunu of Hawke's Bay. Prehistoric Maori settlement was concentrated at Te Awarua Pa situated above the Rangitikei River (NZMS 260 U21 704664), and at Matuku (NZMS 260 T21 625676) on the Moawhango River. These kainga were visited by the early missionary explorers Richard Taylor from Wanganui in 1845 and William Colenso from Hawke's Bay in 1847. With European arrival, the kainga were rapidly abandoned. Little evidence of settlement remains at Matuku and Te Awarua, or at the spectacular headland pa Kiripana (NZMS 260 T21 587694) above the Moawhango River, but four sites of historic and archaeological interest are listed in the Rangitikei District Scheme:

1. Giant cabbage trees described by Colenso at Ngatarua (Site 26).
2. Colenso Memorial (Site 27).
3. Partly completed Maori canoe and tree stump (Site 25).
4. Matuku Pa (Site 17).

Waiu Pa (NZMS 260 T20 505857) is a historic Maori gunfighters pa dating from the Maori Land Court period of *c.* 1880 (R.A.L. Batley pers. comm.). It probably marked a territorial boundary between iwi of Moawhango/Taihape and Karioi/Ohakune (Ngati Rangipo) districts. There is another unprotected site of Maori earthworks 150 m to the east of Waiu Pa. A joint move is underway by the Department of Conservation and the New Zealand Army to further document and protect this site.

The Moawhango subtribes collected mottled petrel (*Pterodroma inexpectata*) from Aorangi (RAP 1), and old burrows have been found by R.A. Wilson and others (R.A.L. Batley pers. comm.). A number of trans-provincial Maori routes crossed the Mangaohane plateau as depicted on early surveyors maps: one left Te Awarua Pa, passed up the Mangatera River, on to Potae, and across to the Ruahine Range; another followed the forest margin from Aorangi to Ruahine Corner and on to Potae (Anon 1895), while a third went from Te Papa a Tarinuku (The Narrows) on the Rangitikei River across the Mangaohane plateau to Pohokura and Kuripapango (Anon 1886). A further track, known as Te Puta o te haki (Elder 1962) crossed Defence land north of Waiouru running from the Rangipo desert to Owhaoko (Ngamatea), and a northern Moawhango range bears this epithet. Batley (1956) recorded the use of totara bark from near The Narrows on the Rangitikei River by late prehistoric Maori to construct food-storage containers.

HISTORY OF ECOLOGICAL SURVEY

Aston (1914) is the first documented record of botanical survey in the district, with a visit to Ruahine Range and Reporoa Bog. Norm Elder of the New Zealand Forest Survey commenced a period of central North Island mountain survey in 1941, including the Moawhango, culminating in the publication of three substantial papers (Elder 1959, 1962, 1965). A.P. Druce of Botany Division, DSIR, also commenced his intensive ecological survey of the district in 1941, the next 50 years marked by numerous unpublished reports on the flora. Various members of the Wellington Botanical Society contributed to these surveys. W. (Bill) Harris, a palynologist with Botany Division, DSIR, cored Reporoa Bog for palynological investigation in 1951 (pers. comm. to A.P. Druce). Ecological survey continues with the work of the author and C.C. Ogle (1988).

RESULTS

LAND SYSTEMS

To ensure that RAPs are representative of the whole Moawhango Ecological Region, the ecological district was divided into four areas with apparently uniform geophysical attributes: landforms, geology, soils, altitude, and climate. These four land systems are termed Moawhango, Rangitikei, Owhaoko, and Mangaohane (Fig. 2 and Appendix 5).

BIOCLIMATIC ZONES

Bioclimatic zones are in accordance with PNA Programme methodology (Myers *et al.* 1987), based on the rationale of Muerk (1984), and with zone boundaries based on indicator plant species and altitudinal vegetation zonation. Only two zones are recognised.

Montane (500-900 m): a zone characterised by podocarp/broadleaved forest on warm aspects and rimu/black beech forest on cold aspects. Red beech forest is important on upper montane sites in equably wet and moderately fertile environments. Deforested sites have kanuka, manuka, red tussock, and hard tussock.

Subalpine (900-1480 m): a zone characterised by kaikawaka, Hall's totara, and pink pine forest on soft rock landforms, and mountain beech with less red beech on hard rock landforms. The treeline in the wetter kaikawaka forest districts is 1440 m, and in the drier mountain beech zone it is 1470-1500 m. Secondary vegetation is mainly monoao and red tussock south to Hihitahi and Otupae, but inaka and red tussock dominate south of this.

ECOLOGICAL UNITS

The ecological unit concept, describing a unique combination of vegetation type and landform, formed the basis for analysing the ecological diversity of the district. Imbalances between the total ecological diversity of the district and representation of ecological units in the existing reserves network, formed the basis for derivation of RAPs. In addition, several ecological units appear in more than one RAP: this is an insurance against future vegetation destruction: it recognises the functional relationships between contiguous habitats and ecosystems; and it buffers reserves against exogenous disturbances.

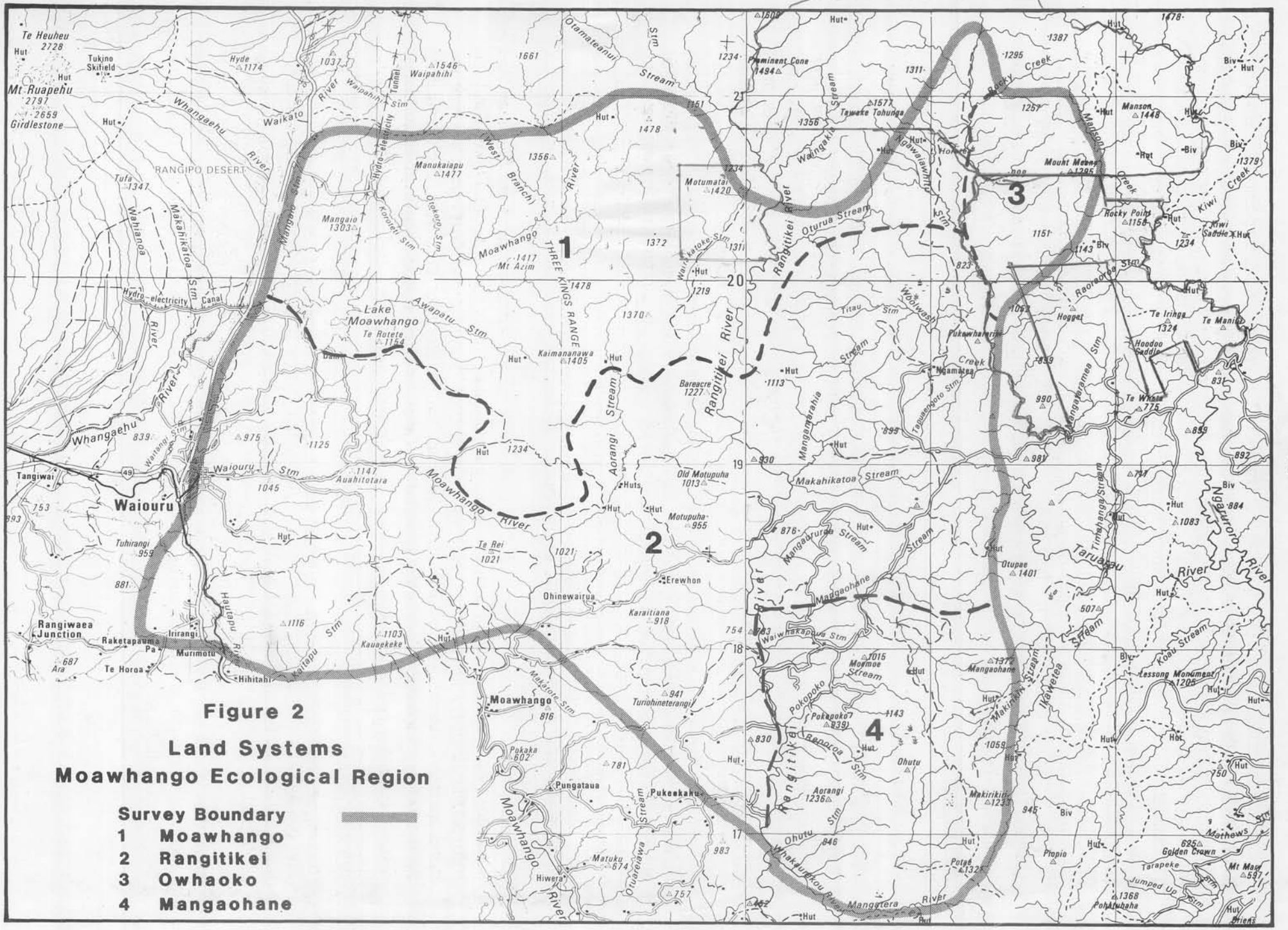


Figure 2
Land Systems
Moawhango Ecological Region
Survey Boundary
1 Moawhango
2 Rangitikei
3 Owhaoko
4 Mangaohane

Appendix 6 summarises this diversity, amounting to 142 ecological units. Landform classes were based on a primary division of basement rocks into hard rock (greywacke) and soft rock (marine sediments) surfaces. Appendix 6 also shows the ecological units already protected and units represented in RAPs.

ECOLOGICAL REGION BOUNDARY

The ecological region and district boundaries only broadly follow those in McEwen (1987), and several adjustments were made for the purposes of the survey. The survey boundary includes an area southwest of Waiouru about Irirangi Swamp which, on landform and vegetation criteria, fits in Moawhango Ecological Region and not Rangitikei Ecological Region.

TENURE, AND REGIONAL GOVERNMENT

Tenure is mainly large freehold pastoral runs, including Ngamatea, Otupae, Mangaohane, Ohinewairua, Mounganui, Motukawa, Erewhon, Springvale, Blackhill, and Oruamatua. There are several blocks of multiple-ownership Maori land, namely the Aorangi-Awarua Block bordering the Ruahine Range, parts of Ngamatea East Swamp, the Motumatai and Pinnacles area in the southern Kaimanawa Mountains, and large areas of Ngati Tuwharetoa land in the Taruarau River catchment, and the entire Owhaoko land system. The 65 000 ha Defence land at Waiouru is a substantial Crown holding, along with a small part of the Ruahine Conservation Park. The Irirangi area is largely private tenure, but it has a small military reserve (HMNZS 'Irirangi').

The Manawatu-Wanganui Regional Council administer regional government on land draining west into the Rangitikei River, and the Hawke's Bay Regional Council administer land draining east into the Ngaruroro River. Ngamatea Station is bisected by the regional council boundary.

TONGARIRO POWER PROJECT

The main physical impact of the Tongariro Power project, constructed during the 1970s on the Moawhango River, was the creation of a large reservoir, extending from near the Desert Road up to the outlet of Pleasants Bush gorge. One terrestrial ecosystem impacted by the project was riparian gravel terraces, that are now periodically flooded above the reservoir because of the fluctuating water level and, below the reservoir, artificially exposed and desiccated. The only record of a special plant from the affected stretch of river is *Acaena inermis* in the gorge below the reservoir, and that population is healthy.

Following stocking with trout, the reservoir is now a popular site for trout anglers. Because of the wide fluctuations in water level (15 m), the unconsolidated littoral zone is now a large source of loess in dry windy weather. The littoral zone, which remains unvegetated, also erodes with wave action, stormwater runoff, and wind ablation.

EXISTING PROTECTED NATURAL AREAS

There are approximately 7344 ha in the protected area network in a total ecological district area of 146 250 ha, representing 5.02 % of the land area. Kelly (1980) has proposed that 10% of the original area of each landscape or habitat class to be an adequate representation in protected natural areas. The existing reserves and protected areas fall well short of this desirable level of representativeness for the original landscape classes, kaikawaka forest, beech forest, mixed shrubland on hillslopes, tussock grassland on hillslopes, tussock-shrubland on basin and valley floors, and topogenous and ombrogenous peat bogs.

The district has four protected natural areas (Fig. 3, p. 33): the Batley Private Protected Land in the southern Kaimanawa Mountains; the Hihitahi FS (Forest Sanctuary) south of Waiouru; a small part of the Ruahine Conservation Park in the northwest Ruahine Range; and the Department of Conservation leases (from Maori owners) the Oruamatua-Kaimanawa Block 1T at Motumatai in the southern Kaimanawa Mountains, a block contiguous with the Batley Private Protected Land. The latter area only has protection at the will of the Maori owners to lease the block and the Department of Conservation's commitment as leasees. Moawhango Ecological Region is shown as having no PNAs in Timmins & King (1984) because Hihitahi FS is recorded in Rangitikei Ecological Region, Ruahine Conservation Park in Ruahine Ecological Region, and the Batley reserve in the Kaimanawa Conservation Park. Although the mountains surrounding Moawhango Ecological Region are adequately protected, the intervening sedimentary plateau and greywacke peneplain district received little attention for nature conservation protection. The limited number of reserves also reflects the small amount of crown holdings, and extensive and large individual freehold tenure.

PNA 1 HIHITAHI FOREST SANCTUARY

Area	2170 ha
Altitude	800-1100 m
Grid reference centre	NZMS 260 T21 463806
Land system	Rangitikei
Bioclimatic zone	upper montane

Ecological units

- red beech on soft rock plateau;
- matai-totara-rimu-kahikatea/broadleaved species forest on soft rock hillslope, plateau, and escarpment slope;
- mountain toatoa forest on soft rock hillslope, and plateau;
- kaikawaka-Hall's totara forest on soft rock hillslope, plateau,escarpment slope, valley floor, and gorge;
- inaka shrubland on soft rock hillslope, plateau, and escarpment slope;
- monoao/red tussock/hard tussock shrub-tussock grassland.

The Sanctuary contains the only protected remnant of kaikawaka-Hall's totara forest which was an extensive community on sedimentary plateaux in the Rangitikei land system in prehuman times. A further 14 small remnants of this summer-dry climate forest occur in the southern Defence land about Auahitotara, west of Waiouru. Hihitahi is the most representative remnant of this conifer forest in the district because of its extent, altitudinal range, comparative intactness, and community diversity. The only public access is afforded via a Right of Way from S.H. 1 on the western boundary. Two small stands of red beech, each less than 1 ha, occur at NZMS 260 T21 458824 and T21 465807. (These stands feature in an analysis of the community interactions between beech and conifer forest in Moawhango Ecological Region (Rogers 1989a).) Monospecific stands of ribbonwood extend to their highest altitudes nationally (1038 m) near Hihitahi Trig. Stands of ribbonwood occupy higher fertility depressions in the ash-mantled plateau. There is cause for concern because almost all stands are damaged by deer and possum browsing and recruitment is virtually absent. Below 900 m mixed podocarp/broadleaved forest with scattered kaikawaka and Hall's totara occurs. This altitudinal zone is occupied by red beech-mountain beech elsewhere in Moawhango Ecological Region, e.g. Te Rei Bush immediately to the east on Mounganui Station. The ages of peripheral stands of kaikawaka have been used to determine a history of Polynesian burning (Rogers 1987), emphasising the scientific importance of the reserve.

Kiwi and kokako have been recorded from the Sanctuary in recent years (unpublished New Zealand Forest Service report 1984), and a kaka was seen in June 1993 (W Simmons and H Dorrian pers. comm.).

Deer numbers were very high through to the early 1980s, but with an increase in private hunting activity in the last decade, numbers have declined dramatically (pers. obs.). Areas of kaikawaka-Hall's totara forest on steep-slopes display advanced dieback symptoms, with few emergent live trees remaining above an induced community of low-broadleaved trees (mainly wineberry and horopito) and divaricating shrubs. Although limited regeneration of shade-tolerant Hall's totara occurs, kaikawaka regeneration is absent. Landcare Research is investigating reasons for the dieback and the dynamics of the replacement shrub-hardwood community in relation to the long-term viability of tall forest. Deer numbers in the Sanctuary are monitored by the Wanganui Conservancy of the Department of Conservation. Because the Sanctuary is completely surrounded by private farmland, ring-fencing was prioritised by the Department of Conservation and is nearing completion except in the northwest corner.

On the north, west, and east boundary a narrow strip of red tussock grassland, less than 100 m wide, separates the forest from the fenceline. Secondary shrubs are invading the grassland, and forest will eventually recolonise the marginal strip of secondary vegetation. There are virtually no opportunities to expand the Sanctuary because of surrounding improved pasture.

PNA 2 RUAHINE FOREST PARK

Area	approximately 3480 ha
Altitude	400-1346 m
Grid reference centre	NZMS 260 U21 780680
Land system	Mangaohane
Bioclimatic zone	upper montane

Ecological units

- mountain beech forest on soft rock hillslope, plateau, and escarpment slope;
- red beech forest on soft rock hillslope, plateau, escarpment slope, valley floor, and gorge;
- rimu/black beech forest on soft rock hillslope, and escarpment slope;
- matai-totara-rimu-kahikatea/broadleaved species forest on soft rock hillslope, plateau, and escarpment slope;
- matai-kahikatea/black beech forest on soft rock hillslope, and plateau;
- black beech on soft rock hillslope;
- mountain toatoa forest on soft rock hillslope, plateau, escarpment slope, and valley floor;
- mountain toatoa/inaka forest on soft rock hillslope, escarpment slope, and valley floor;
- kaikawaka-pink pine forest on soft rock hillslope, plateau, escarpment slope, valley floor, and gorge;
- kaikawaka-pink pine forest on hard rock ridge;
- tupare forest on hard rock ridge, and knoll;
- inaka shrubland on soft rock hillslope, plateau, and escarpment slope;
- inaka/red tussock/hard tussock shrub tussock grassland on soft rock hillslope, plateau, and escarpment slope;
- red tussock/hard tussock grassland on soft rock hillslope, plateau, escarpment slope, and valley floor.

The extensively forested portions of the southern Mangaohane plateau and Ohutu Ridge are included in Ruahine Forest Park, excluding the downfaulted marine sediment block at Lake Colenso. Landforms are dominated by marine sediment plateaux, one steeply-dipping from Ohutu Ridge south-westward to the Whakaurekou River, and the other, a horizontal block from Ohutu Ridge to Potae. Ohutu Ridge is a broadly convex greywacke unit with thinly-capping marine sediment outcrops on the western margin. The Waiokotore Stream has a spectacular fall through a series of cataracts from Te Rakaunuiakura to the Mangatera River. Te Rakaunuiakura is a special landform, featuring a high pedestal remnant of siltstone buttressed with a limestone rimrock.

Intact altitudinal sequences of forest spanning 930 m extend from Lake Colenso to Potae and from the Rangitikei River to Ohutu Ridge at Titapu. Nowhere else in the Region are such extensive unbroken altitudinal sequences of forest protected. Anon (1987) summarised the nature conservation values of the Aorangi-Awarua Block which is contiguous with Ruahine Forest Park. Blue duck, kaka, and falcon, all threatened bird species (Bell 1986), were recorded from comparable landscapes in the adjacent Aorangi-Awarua Block. *Powelliphanta marchanti*, a nationally rare large land snail is known from around Potae, and also from the Ohutu Stream catchment and about Aorangi (RAP 1).

The altitudinal sequence of forest types from the Rangitikei River to Ohutu Ridge has been classified by J.L. Nicholls (Forest Research Institute, Rotorua). A sequence south of Ohutu Stream is as follows. A small area of dense podocarp-hardwood forest (PHa) and medium dense podocarp-hardwood forest (PHb) grades upward into black beech dominated podocarp-hardwood-beech forest. The podocarps are mostly matai, kahikatea, and rimu, with scattered totara and miro. Red beech forest (Ba) is next in the altitudinal sequence, which transitions gradually into red beech with scattered kaikawaka and Hall's totara (PHBd). The treeline forest is a conifer forest (PHc) of kaikawaka, mountain toatoa, pink pine, and broadleaf. Scrub-low forest caps Ohutu Ridge consisting of tupare, pink pine, mountain toatoa, broadleaf, and *Coprosma* sp. ('t') (Eagle 1982). Similar sequences, without the lowest altitude dense and medium dense podocarp-hardwood communities, extend from Lake Colenso to Ohutu Ridge and Ruahine Corner on the southern extremity of Mangaohane plateau. Red beech and mountain beech are slowly expanding their coverage on the southern Mangaohane plateau at the expense of the kaikawaka stands (Rogers 1989a). Range expansion of beech occurs by both marginal spread and the establishment of outlier stands of beech within the kaikawaka forest. Population growth of beech has been underway for at least the last 6000 years (Rogers & McGlone 1989), and it appears beech is very slowly spreading onto the plateau.

The Ruahine Forest Park also contains 160 ha of intact red tussock grassland from Ruahine Corner to Makirirkiri Trig and across to the toe-slope of Te Rakaunuiakura. Inaka is slowly invading the red tussock (G.M. Rogers 1990, unpublished FRI contract report; G.M. Rogers 1991a, unpublished FRI contract report), at a rate that transforms tussock grassland to shrubland within 55-65 years. Rates of shrub invasion are fostered by steep topography. The last substantial tussock grassland fire at Ruahine Corner was in the summer of 1946-1947.

The pattern and ages of secondary woody vegetation separating the tussock grassland from the old-growth kaikawaka forest at Ruahine Corner were useful for determining the history of prehistoric Maori burning on the plateau (Rogers 1987). The plateau was cleared of forest in a conflagration *c.* 430 years ago, and subsequent burning of secondary vegetation selected tussocks ahead of woody plants. Three natural non-forest clearings within old-growth kaikawaka forest add to the scientific value of vegetation at Ruahine Corner. Two of the clearings have not been burnt in human times, indicating the likely future composition of vegetation on Makirikiri Tarns and Reporoa Bog in the long-term absence of fire. Old-growth vegetation will be dominated by mountain toatoa, bog pine, inaka, and *Olearia virgata*, and not tussocks.

Populations of *Pittosporum turneri*, a rare tree (Department of Conservation Threatened Species Database) of central North Island forest margins occur on these clearings (Rogers 1988). A cohort of 7 pole-sized saplings is found on the 'horse paddock', 300 m northeast of Ruahine Corner; a low tree, with foliage and architecture transitioning from juvenile to adult, occurs on one of two clearings between Ruahine Corner and Potae; and two saplings are on the forest margin south of the airstrip at Ruahine Corner. Another biogeographically significant plant on a clearing at Ruahine Corner is *Ourisia modesta*, known from only one site, its only North Island occurrence. *Tetrachondra hamiltonii*, another species restricted to the Mangaohane plateau in the North Island, mostly occurs in herbfields in RAP outside the Park. The only locality for *Myosotis spathulata* in the Region is on a limestone outcrops at Potae. Limestone talus on the summit of Te Rakaunuiakura supports *Senecio glaucophyllus* ssp. *toa*, a taxon of restricted occurrence on central North Island mountains.

PNA 3 BATLEY PRIVATE PROTECTED LAND

Area	899 ha
Altitude	800-1230 m
Grid reference centre	NZMS 260 T20 682075
Land system	Moawhango
Bioclimatic zone	upper montane

Ecological units

- mountain beech forest on hard rock hillslope, colluvial toe slope, ridge top, valley floor, and gorge;
- kanuka/manuka scrub on hard rock hillslope, colluvial toeslope, and valley floor;
- manuka shrubland on hard rock hillslope, and colluvial toeslope;
- manuka/monoao shrubland on hard rock hillslope, colluvial toeslope, spur top, and valley floor;
- monoao/red tussock/hard tussock shrub tussock grassland on hard rock hillslope, and colluvial toeslope;
- red tussock/hard tussock grassland on hard rock hillslope, colluvial toeslope, and ridge top.

The Batley PPL spans different landforms to those of the Motumatai DoC lease, but the vegetation is substantially similar. A large proportion of the block occupies the catchment of Alexandra Creek, an upper montane basin representing part of the Tertiary peneplain, but subsequently dissected by stream downcutting from uplift in the Kaikoura Orogeny. The landforms of Alexandra basin are dominated by a sequence of three consequent river terraces and rises dating three phases of uplift interspersed with quiescent phases.

The pattern of mountain beech, surrounded by secondary kanuka/manuka scrub, and red tussock grassland was a pattern induced primarily in Polynesian times with the last phase of burning in early European times. Kanuka/manuka scrub flanking the Rangitikei River was burnt in the 1983 Ohinewairua fire, but is now regenerating. Alexandra basin has been protected from late European burning, resulting in widespread advanced succession to mountain beech forest. The greywacke landforms and the comparatively intact vegetation contribute to the outstanding landscape value of the block.

An ecological assessment of the block was completed by McQueen (1972).

PNA 4 MOTUMATAI DEPARTMENT OF CONSERVATION LEASE

Area	1295 ha
Altitude	880-1420 m
Grid reference centre	NZMS 260 T20 683049
Land system	Moawhango
Bioclimatic zone	upper montane

Ecological units

- mountain beech forest on hard rock hillslope, colluvial toeslope, ridge top, valley floor, and gorge;
- kanuka/manuka scrub on hard rock hillslope, colluvial toeslope, valley floor, knoll, and gorge;
- manuka shrubland on hard rock hillslope, colluvial toeslope, and gorge;
- monoao/red tussock/hard tussock shrub-tussock grassland on hard rock hillslope, colluvial toeslope, and valley floor;
- red tussock/hard tussock grassland on spur top, valley floor, knoll, basin floor, and gorge.

This protected area has a low security of protection (Maori lease), but opportunities for land development are constrained by the long-term predominant land use of the surrounding Defence land. Landforms consist of the broadly convex Motumatai ridge (1420 m), and the broadly concave Big Valley, drained by Pinnacle Creek. Part of the greywacke peneplain is atypically dissected on the Pinnacle ridge by downcutting of the Rangitikei River. The Big Valley is clearly an old generation landform feature, but with later modification through folding and uplift in the Kaikoura Orogeny. Less than 5 % of the protected area remains in the original mountain beech forest. The remainder is manuka and monoao shrubland, and red tussock grassland. Riparian cliff communities along the Rangitikei River support *Asplenium trichomanes*, rare in central North Island and *Epilobium astonii* a central North Island endemic.

The block supports large numbers of Kaimanawa feral horses (Rogers 1991) that have heavily degraded tussock grassland on valley floors, parts of the summit of Motumatai ridge, and grasslands bordering isolated forest stands. Conversion of tussock grassland to adventive grassland also accompanied stock grazing in the Big Valley by animals of Ohinewairua Station, but this ceased in 1989. The floor of the Big Valley is a cold-air inversion, natural non-forest site, but little of the original shrubland community remains after a long history of human burning and animal grazing. An inverted shrub-line of frost-damaged manuka above the valley floor roughly coincides with the original mountain beech inverted treeline. Contiguous with the Motumatai PPL, the block is a significant nature conservation asset, because of old generation landforms, its wilderness quality, and diverse native vegetation.

Historical features are the abundant early historic Maori place-names recorded by R.A.L. Batley (pers. comm.); the mineshaft in the Big Valley that was reputedly driven for goldmining in the early 20th century (J. Hally pers. comm.); and the remains of the pack-track in Big Valley, used for musterers and rabbiters access to the Tawake Tohunga Range and Golden Hills on Ngamatea Station.

Because of the uncertain tenure of this block and the quality of the natural environment, a thorough evaluation for possible RAP status should accompany any future moves toward a change in tenure.

RECOMMENDED AREAS FOR PROTECTION

EVALUATION

One hundred and forty-two ecological units were identified (Appendix 6), of which 76 (54 %) are represented in existing PNAs. In broad terms, the following groups of ecological units are adequately covered by the existing network:

1. Mountain beech forest on hard rock landforms
2. Red beech forest on soft rock landforms
3. Kaikawaka-Hall's totara forest on soft rock landforms
4. Kaikawaka-pink pine forest on soft rock landforms
5. Kaikawaka-pink pine forest on hard rock landforms
6. Tupare forest on soft rock landforms.

No secondary vegetation or natural non-forest ecosystems have secure futures, nor do the podocarp forests and mixed beech associations. Most of the biogeographically special plants and habitats also lie outside the reserves network.

PRIORITIES FOR PROTECTION

A set of seven, somewhat overlapping, criteria are applied for the selection of RAPs (see METHODOLOGY chapter of Myers *et al.* 1987):

1. Naturalness - in areas of high natural values the vegetation reflects the original prehuman condition (*i.e.* prior to approximately A.D. 800).

2. Representativeness - an assessment of how well the RAP shows the overall characteristics of the ecological district or land system. An attempt was made to represent each ecological unit in at least one RAP (except ecological units of low natural value).

3. Diversity - areas of high diversity encompass a wide range of natural features (*e.g.* a range of land systems, ecological units, soils, landforms, vegetation communities, animal species and bioclimatic zones).

4. Special features - biotic and abiotic features of significance in the area (*e.g.* threatened plants/animals or species of limited distributions, wildlife habitats of importance, spectacular or unusual landform features, geological reference or type localities).

5. Cultural influences - the extent and impact of human disturbances (*e.g.* buildings, fences, roads, introduced animals, burning, drainage).

6. Other values - include aesthetic, spiritual and landscape values; educational use; economic value; recreational/amenity values; scientific use and off-site significance.

7. Management issues - factors that have a current or potential adverse effect on a RAP's naturalness. Management issues are described briefly, but discussion of management techniques is beyond the scope of this report.

Additional criteria used in the selection of RAPs are:

1. Boundaries often follow catchment boundaries, thereby often capturing the diversity of an area, as well as sometimes providing a buffer from outside disturbances (*e.g.* fire and grazing animals).

2. Areas of lower conservation value are sometimes added to the more natural part of a RAP in order to increase the diversity of an area.

3. Representation of the same ecological unit in more than one RAP is an insurance against future loss.

4. Large size which provides increased ecological viability; functional links between ecological units and vegetation patterns along environmental gradients can also be preserved.

Guidelines have also been developed and applied for wetlands:

1. The minimum size of a RAP is the whole wetland. This enhances viability (*i.e.* the ability of an area to maintain itself in the long term, without special management effort). A RAP boundary that encompasses an entire wetland generally will minimise the effects of adjacent development.

2. Nationally, wetlands are greatly modified and under-represented in protected natural areas. They are recognised as priority areas for protection (Commission for the Environment 1986).

3. Moawhango Ecological Region wetlands are unique in terms of landform setting, age of peat accumulation, and vegetation composition.

4. Soils in a protected wetland are benchmarks that can be compared to soils under nearby developed areas to monitor changes to profile morphology and chemical properties.

The representation of RAPs in the four land systems appears in Appendix 7. A priority ranking of RAPs is presented (Appendix 8) as a guide for nature conservation action. RAP Category 1 is the highest priority, where incremental damage to biota is present or where threats from development for improved pasture or deleterious military use are iminent. Category 2 applies to RAPs where development potential is still present, but probably of lower probability. In most instances, the RAPs are under no immediate threat of substantial vegetation destruction.

However, in many instances incremental degradation occurs from domestic stock grazing, feral horse impact, Army training activity, and periodic wildfire. Changes in farming profitability and central Government attitudes to land development subsidies are the greatest threat to RAPs outside the Defence land at Waiouru. Some measure of protection is accorded RAPs 2, 5, and 7, because Army impacts are deliberately reduced in these areas, and predominant land uses accord with nature conservation interests. In contrast, feral horse grazing is antagonistic to rare flora preservation in RAPs 2 and 7.

The New Zealand Army recently fostered the preparation of a Land Use Impact Study (Rogers 1992) by public agencies with scientific and land use advocacy roles on Ministry of Defence land at Waiouru. This environmental impact study encourages a balance between land development and environmental protection. Two zones designated low impact (RAP 2 and part RAP 7) were established in 1974 for the welfare of biogeographically special plants. Present land use practices and feral horse impact are still leading to habitat deterioration. The greatest threat to nature conservation values on Defence land are engineering developments such as roads, quarries, and satellite camps, burning, and feral horse damage. The extension of Argo Road beyond the Stowman Range is a real possibility, dependent upon development planning by senior personnel and funding availability.

RAPs 1-8 (Fig. 3) cover 15 689 ha. Existing PNAs have a combined area of approximately 7850 ha, and in combination with the 8 RAPs some 23 500 ha or 16.1 % of the Region would, ideally, have a protection status. RAP9 (Irirangi Wetlands) has not been included in these data; the total area of wetlands around Irirangi is about 470 ha.

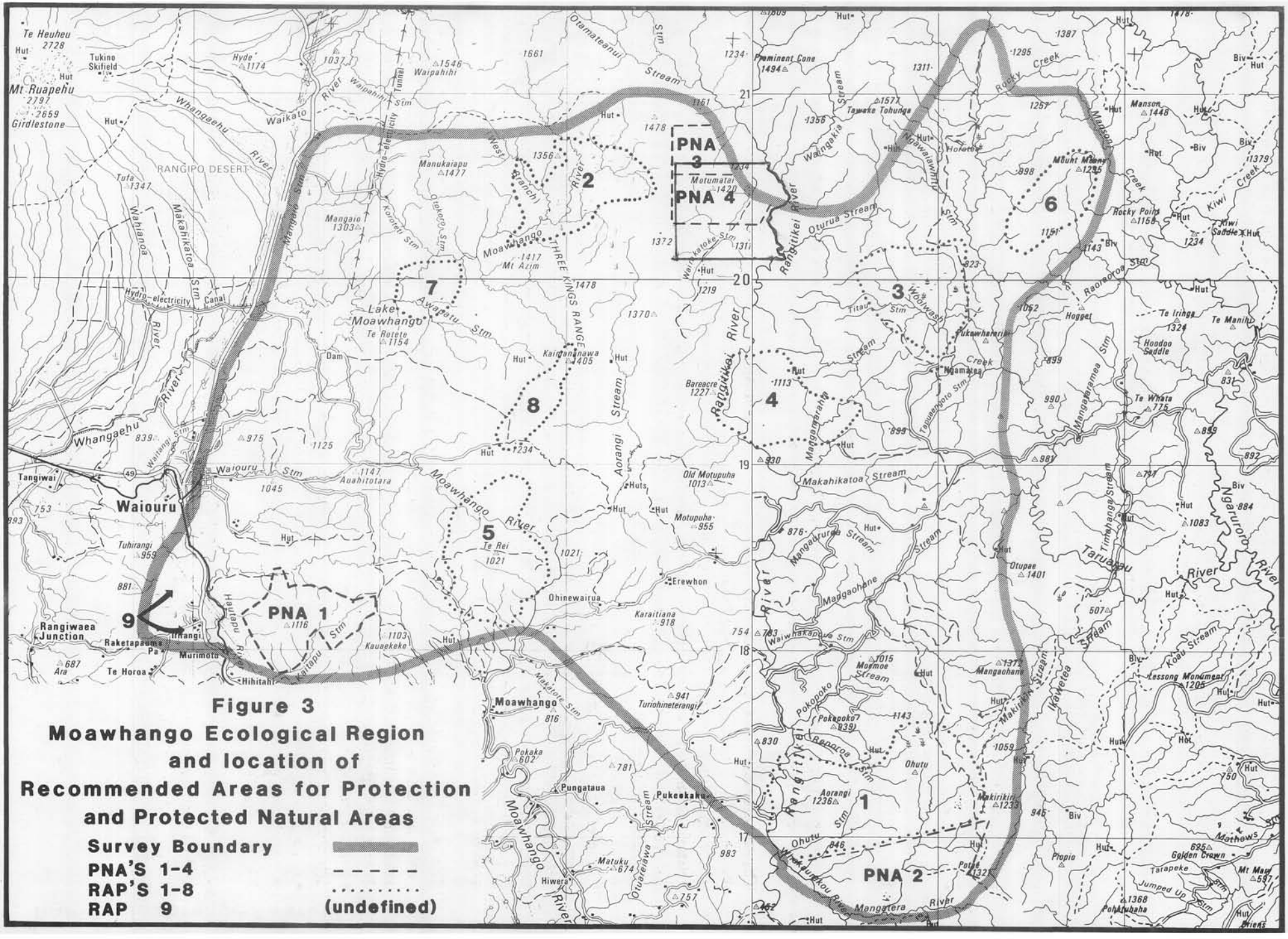
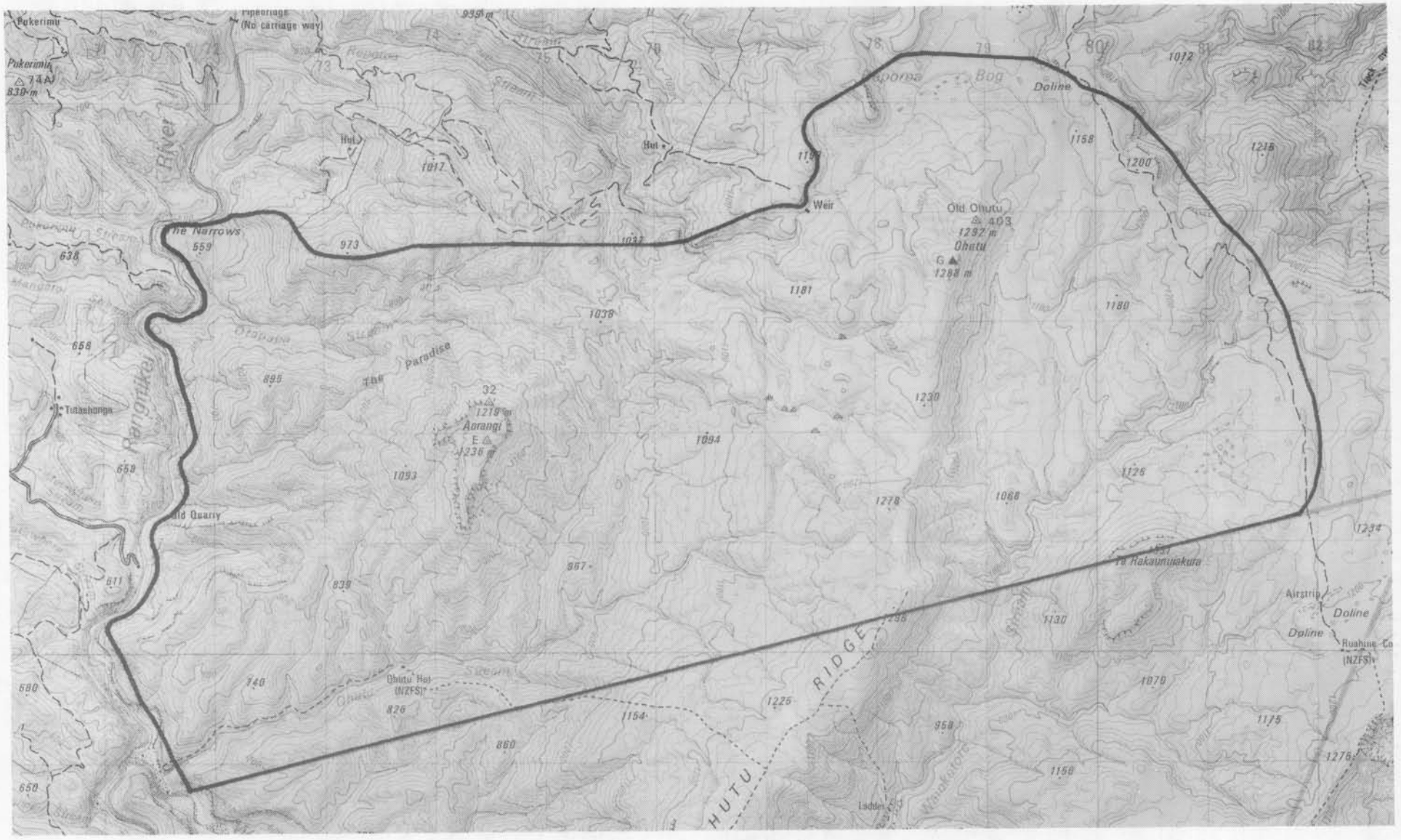


Figure 3
Moawhango Ecological Region and location of Recommended Areas for Protection and Protected Natural Areas

Survey Boundary	———
PNA'S 1-4	– – – – –
RAP'S 1-8	. . . . .
RAP 9	**(undefined)**

RAP 1 Aorangi-Awarua



1 0 1 2 3 4 5 kilometres

GR Centre: U21 768 721

Area: 4400 Ha

RAP 1 AORANGI-AWARUA

Land system:	Mangaohane
Area:	4400 ha
Altitude:	500-1330 m

Ecological units:

- red beech forest on soft rock hillslope, plateau, and escarpment slope.
- rimu/black beech forest on soft rock hillslope, plateau, and escarpment slope.
- matai-kahikatea forest on soft rock hillslope, plateau, escarpment slope, gorge.
- matai-totara-rimu-kahikatea/broadleaved species forest on soft rock hillslope, plateau, escarpment slope.
- matai-kahikatea/black beech forest on soft rock hillslope, plateau, escarpment slope, gorge.
- black beech forest on soft rock hillslope, valley floor.
- mountain toatoa forest on soft rock hillslope, plateau, escarpment slope, valley floor.
- mountain toatoa/inaka forest on soft rock hillslope, escarpment slope, valley floor.
- kaikawaka/pink pine forest on soft rock hillslope, plateau, escarpment slope, valley floor, gorge.
- kaikawaka/pink pine forest on hard rock ridge top.
- inaka shrubland on soft rock hillslope, plateau, escarpment slope, valley floor, gorge.
- manuka shrubland on soft rock hillslope, plateau, escarpment slope, valley floor, gorge.
- inaka/red tussock/hard tussock shrub-tussock grassland on soft rock hillslope, plateau, escarpment slope, valley floor, basin floor.
- tangle-fern-wire rush sedgeland on soft rock topogenous bog.
- sphagnum mossland tarns on soft rock basin.

Landform

Landforms and geology are mainly soft sediment plateaux with erosion resistant limestone at the surface in most cases. The surface of Mangaohane plateau is broken into several blocks tilted to the southwest by a parallel series of normal fault scarps running northeast-southwest. The tilted blocks create a stepped repetition of strata across the surface of Mangaohane plateau from the Ikawatea Stream to the Rangitikei River (Browne 1978). Ohutu Ridge forms the uplift scarp of a major block. The westernmost block dips steeply down to the Rangitikei River between The Narrows (Te Papa a Tarinuku) and the Whakaurekou River confluence. Browne (1978) described the late Pliocene-early Pleistocene stratigraphy of soft sediments of the Mangaohane plateau on Blue Slip, a large scarp on the eastern edge of the plateau midway along the track from Ruahine Corner to Potae.

Dolines or sink-holes appear in the capping limestone on the southeast corner of Mangaohane plateau about Ruahine Corner. Speleological examination of one of these solution-weathering features revealed one 900 m-long cave system between the Ruahine Corner airstrip and Ruahine Corner Hut.

Broadly-shallow depressions on two plateau blocks have given rise to extensive topogenous bogs (Reporoa and Makirikiri) with up to 5 m of peat (Froggatt & Rogers 1990). The distal remnants of several rhyolitic and andesitic ash showers from the Okataina, Taupo, and Tongariro Volcanic Centres appear as thin lens of ash interbedded in the peat. Both bogs have a mosaic of tarns supported by elevated walls of peat up to 1 m above the surrounding bog surface.

Makirikiri also has periodically inundated depressions fed by seasonal runoff from adjoining catchment slopes and by water ponding in depressions in high rainfall periods. This depression has entirely different hydrology to the peat-enclosed tarns. There is circumstantial evidence in the peat that the shape and position of the tarns alters through time.

Many fault scarps and valley midslopes are littered with large limestone blocks. The limestone blocks are collapsed cantilevers of the erosion-resistent capping limestone which have been undercut after the soft underlying sandstone and siltstone was preferentially eroded-away in cold-climate phases of the Pleistocene. At Potae the capping limestone has been deflected into vertical blocks by uplift of the bordering Ruahine greywackes. The soft marine sediments rapidly thin out eastwards against the Ruahine Range. Outcrops of the greywacke basement upon which the soft sediments were deposited are evident along Ohutu Ridge from Titapu to Reporoa Bog.

Aorangi and Te Rakaunuiakura are large pedestal remnants of limestone and mudstone elevated above surrounding topography by fault displacement.

The drainage network in the east is dominated by Waiokotore Stream, a shallowly-incised system on the plateau that drains south into the Mangatera River. The more deeply-incised upper reaches of Ohutu Stream dominate the west by draining the western catchment of Ohutu Ridge. Most of Reporoa Bog drains south into Reporoa Stream with a small portion draining north into Pokopoko Stream. A spectacular riverine feature occurs at The Narrows (U21 715739) where the Rangitikei River flows through a <5 m wide channel within flanking sandstone banks.

Vegetation

Forest

In broad terms, unbroken altitudinal sequences of forest dominate the southwest, and undulating tussock grassland and shrubland the northeast. An altitudinal range of 540-1300 m produces diverse forest types from the Rangitikei River to Ohutu Ridge. At lower altitudes, medium dense podocarp and podocarp-hardwood forests occur on less steep topography. These two forests are separated out on fertility and disturbance gradients. Rimu and kahikatea dominate these stands, though, matai, miro, and totara are common. A wide diversity of lower canopy and understorey tree species exist including black and white maire, ribbonwood, tarata, and rewarewa. These diverse podocarp-hardwood forests reflect high fertility soils developed on the siltstone and mudstone substrate. This typically lowland-lower montane community extends to unusually high altitudes of 900 m around Aorangi where high fertility soils compensate against decreasing temperatures with altitude. Steeper and more unstable gully or stream slopes support shrubs and low hardwood trees such as mahoe and kaikamako as a reflection of frequent landslide disturbance and thin soils.

On mid-altitude sites, black beech dominates with occasional rimu, miro, and Hall's totara, a forest community developed on lower fertility sandstone plateau remnants. In Ohutu Stream catchment, red beech and black beech predominate at mid altitudes. Above the beech, throughout the headwaters of Ohutu Stream, kaikawaka occurs with lower canopy mountain toatoa and broadleaf and, near the summit of Ohutu Ridge, pink pine. Finally, straddling Ohutu Ridge a low forest of pink pine, tupare, kaikawaka, and *Coprosma* sp. (t) (Eagle 1982) exists. Conspicuous collapse or dieback of kaikawaka trees and their replacement with horopito shrubs has occurred in lower altitude stands east of Aorangi. Sudden collapse of kaikawaka and Hall's totara trees is also widespread at Hihitahi.

Secondary Vegetation

The remainder of the RAP is in secondary vegetation following deforestation by early Maori burning and removal of shrubs from Reporoa Bog and Makirikiri Tarns. Only one island in a tarn at Makirikiri Tarns preserves the pre-fire shrubland vegetation of bog pine and inaka. Red tussock grasslands of the Mangaohane plateau are quite distinctive from those elsewhere in the district. These grasslands occupy the higher-altitude plateaux of the northwest Ruahine Range with their thinner ash mantle and frequently exposed limestone, and are not exposed to summer-dry climates of western and northern grasslands. Increased southerly and easterly precipitation and high cloud cover produce equably moist climates in the northwest Ruahine Range.

Inaka is the principal shrub and mountain toatoa the most common tree invading the red tussock grasslands in contrast to monoao, manuka, and kanuka elsewhere in the Region. Extensive seral grasslands do not occur within the bordering Ruahine Conservation Park.

Special plants

The RAP also supports many biogeographically special plants, the majority low herbs of natural non-forest sites, principally Reporoa Bog and Makirikiri Tarns. One species, *Acaena rorida*, a bidibidi, is endemic to the RAP in the upper reaches of Waiokotore Stream about the Makirikiri plateau (Macmillan 1991). Its habitat is periodically inundated wet depressions and floors of limestone ravines about Makirikiri Tarns. *Cardamine* sp. unnamed (*C. debilis* agg.; "slender var." of Allan 1961) (Reporoa Bog), *Elymus laevis* (Reporoa Bog), *Euphrasia disperma* (Reporoa Bog and Makirikiri Tarns), *Myosotis tenericaulis* (Reporoa Bog), *Ranunculus ternatifolius* (Reporoa Bog and Makirikiri plateau), and *Tetrachondra hamiltonii* (Makirikiri plateau) are largely restricted to the RAP in the North Island. Many species have southern limits to their North Island distributions within the RAP for instance *Anaphalis* sp. unnamed (aff. *A. keriensis*), *Bulbinella hookeri, Carex rubicunda, Drosera pygmaea, Galium* sp. unnamed (aff. *G. perpusillum*) (Makirikiri Tarns), *Hypericum* sp. unnamed (aff. *H. japonicum*) (Makirikiri Tarns), *Pittosporum turneri,* and *Senecio glaucophyllus* ssp. *toa. Galium.* sp. unnamed (aff. *G. perpusillum*) occurs only on the edge of the periodically inundated, elongated depression at Makirikiri Tarns and at Kaweka Lakes in the North Island (recent searches for the *Galium* at Makirikiri have been unsuccessful).

Fossil wood of *Lagarostrobus colensoi* (silver pine) in Reporoa Bog indicates that the species had its southern North Island limit in the RAP in the past; *L. colensoi* now reaches its southern limit at Tikitiki Bush (RAP 4). *P. turneri* in the northwest Ruahine Range is scattered along the red tussock-kaikawaka forest margin and on several poorly-drained clearings within the forest of the Mangaohane plateau. The largest population occurs in the RAP within riparian inaka scrub in the Waiokotore valley (U21 793790). *Senecio glaucophyllus* ssp. *toa* occurs on limestone talus on the northern summit extremity of Te Rakaunuiakura.

Druce (1973a, 1973b, 1973d, 1979) provides comprehensive species lists for the RAP and adjacent areas.

Selection criteria

The RAP comprises the bulk of the Mangaohane plateau or the Awarua-Aorangi Block currently under negotiation for covenanting as Private Protected Land. Beyond the strictly plant biogeographical reason for reservation, which is compelling in itself, other important values add impetus for a large RAP covering much of the southern Mangaohane plateau. The single tenure of the land and the present absence of agricultural and exotic forestry land use potential are bonuses. Landscape amenity values are also catered for in the RAP, including plateau vistas of extensive red tussock grasslands and inaka shrublands abutting kaikawaka forest. Anon (1987) thoroughly outlined the wide range of natural and heritage conservation values of the Aorangi-Awarua Block. The unbroken altitudinal sequence of forests between the Rangitikei River and Ohutu Ridge is unique. Apart from minor fire damage and quarry development on the truncated spurs and gullies fronting the Rangitikei River, the 850 m sequence of forest is intact and unmodified by logging. In addition, substantial podocarp-hardwood forests which once characterised Moawhango Ecological Region lower montane forests occur now only in the Aorangi-Awarua Block. Modified pockets of this association at Hihitahi differ in climate, geology, landforms, and consequent vegetation composition.

Reporoa Bog and Makirikiri Tarns have outstanding scientific, ecosystem, floristic, and landscape conservation values. Up to 5 m of peat has accumulated in Reporoa Bog in the last 12 000 years (Froggatt & Rogers 1990) and the stratigraphy and fossil pollen provide a valuable vegetation history of the region (Rogers & McGlone 1989). The two basins support one endemic plant species, 6 species restricted there in the North Island, and many other species of rare national occurrence or with southern limits to their North Island or national distributions. This special biogeography indicates unusual environmental conditions and/or earth history for the plateau (Rogers 1990). Reporoa Bog also has high floristic biodiversity with 171 native species (Druce 1973b), a total even more significant considering the almost complete removal of earlier woody vegetation by 450 years of burning.

Parakeets, North Island kaka, and blue duck are recorded from the western vicinity of the RAP, and falcon are present throughout the Mangaohane plateau. Fernbird occur throughout inaka shrubland in the Waiokotore valley at the base of Ohutu Ridge. North Island brown kiwi have recently been reported from Ohutu Ridge and on the Ruahine Corner to Potae track (S. Bolton Department of Conservation pers. comm. 1993). There are also large colonies of *Powelliphanta marchanti* on many moist escarpment slopes where the soft sediments elevate soil fertility. These populations occur throughout the open vegetation of red tussock grassland and inaka shrubland and the kaikawaka forests.

Notes

Most of the RAP has been the subject of protracted negotiations between the Department of Conservation and Board representatives of the Aorangi-Awarua Trust for formal protection through a conservation covenant.

Aorangi has historical significance for Ngati Whiti and Ngati Tama people (Anon 1987) relating to legends and the past collection of mottled petrels from the summit.

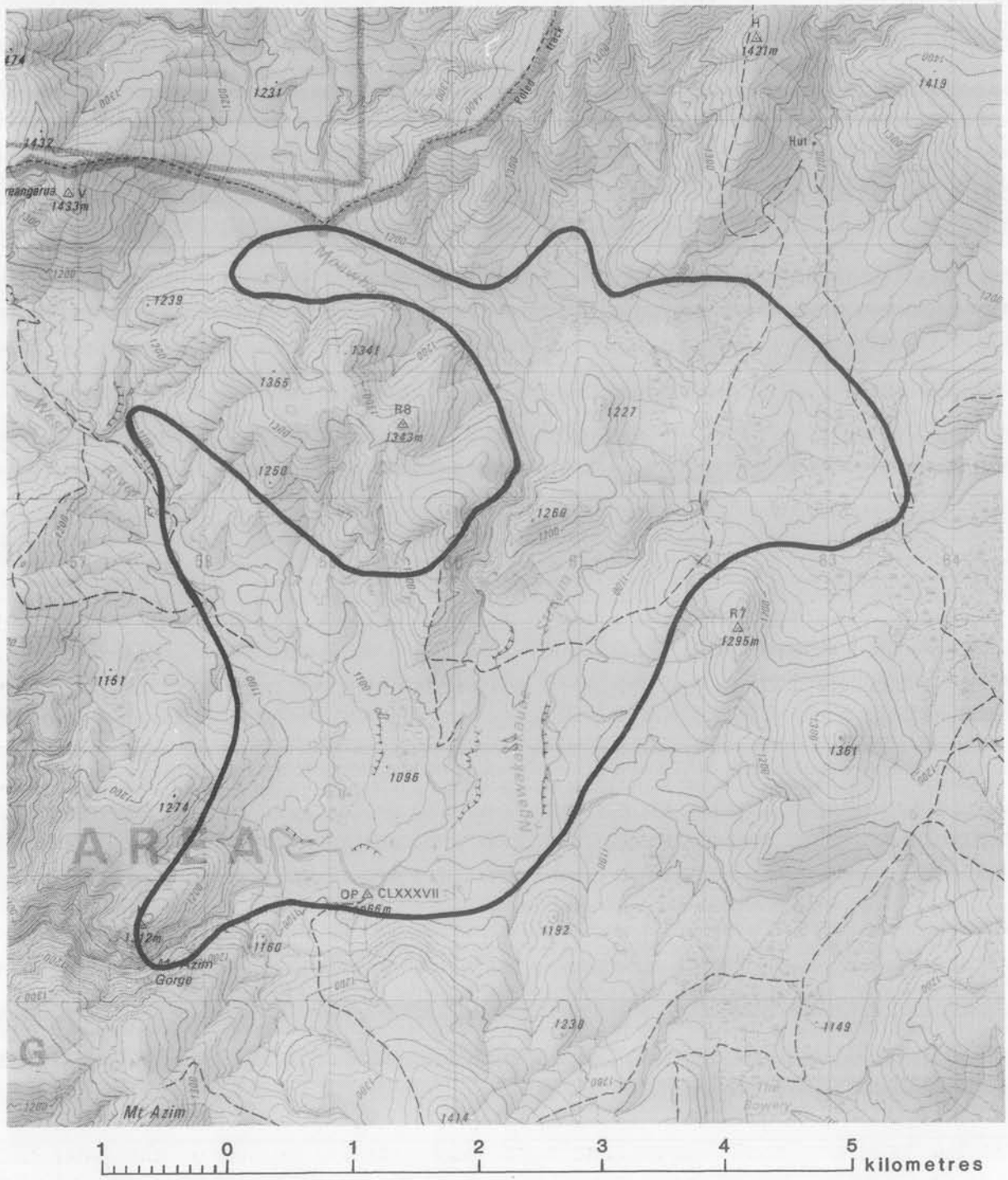
Reporoa Bog provides water supply to numerous farms northeast of Taihape via a reticulation network that has its source at a small weir in the head of Reporoa Stream. The weir and its empoundment have no detrimental influence on the hydrology of the bog because the empoundment is confined to the stream outlet.

Interspecific competition between *Acaena rorida* and the aggressive hawkweed *Hieracium pilosella* is being monitored in a series of permanent photopoints about the Makirikiri plateau. *Hieracium* appears to be invading the prostrate herbfield habitat of *A. rorida*, particularly where past cattle grazing has disturbed the vegetation. *A. rorida* is also threatened by hybridism with the introduced bidibidi, *Acaena novae-zelandiae*.

Ohutu Stream contains an unusually high diversity of invertebrate fauna (Collier and Wakelin 1990), probably reflecting the high fertility status of the stream ecosystem and the total absence of freshwater fishes.

Reporoa Bog is a wetland of national significance, and is included on the WERI (Wetlands of Ecological and Representative Importance) database administered by the Science and Research Division, Department of Conservation.

RAP 2 Ngawakaakauae



GR Centre: T20 597 046

Area: 1795 Ha

RAP 2 NGAWAKAAKAUAE

Land system: Moawhango
Area: 1795 ha
Altitude: 1060-1200 m

Ecological units:

- mountain beech forest on hard rock gorges.
- monoao/red tussock/hard tussock shrub-tussock grassland on hard rock hillslope, colluvial toeslope, valley floor.
- monoao/red tussock/hard tussock shrub-tussock grassland on soft rock hillslope, valley floor, basin floor.
- red tussock/hard tussock grassland on hard rock hillslope, colluvial toeslope, valley floor, basin floor.
- red tussock/hard tussock grassland on soft rock hillslope, colluvial toeslope, valley floor, basin floor.
- flush zone herbfield on soft rock hillslope, basin floor.
- tangle fern-wire rush sedgeland on soft rock topogenous bog.

Landform

Structurally, the basin is a down-warped part of the Cenozoic greywacke peneplain dominating the Moawhango land system. The rivers draining the wide and shallow basin enter and exit via striking superimposed gorges in enveloping ridges, incised up to 300 m deep in the greywacke basement. Three rivers draining the upper Moawhango region converge at the Mt Azim gorge after meandering across the basin floor. Soft marine sediments were deposited in the depression during the late Tertiary marine transgression of the lower North Island. Essentially, the region formed part of the paleoshoreline that marked the northern limit of the marine transgression. In contrast to the higher-altitude parts of the Kaimanawas, the greywacke peneplain here was less dislocated by tectonic uplift in the Kaikoura Orogeny and by fault dislocation.

Capping both the floor of the basin and the enveloping ridges are thin layers of marine sediments, which show that sediments once filled the entire basin. Thin sub-bituminous coal seams can be seen in the banks of the Ngawakaakauae Stream. More recently, the basin was infilled with 3-4 m of rhyolitic pumice from the Taupo Pumice eruption 1850 years ago. Much thinner pumice deposits mantled the upper catchment slopes. After the eruption, a pumice dam at the entrance to Mt Azim gorge caused water-saturated pumice to fill the basin. Eventually, the pumice dam burst, carrying much of the pumice away. A concentric strand line of pumice just above the floor of the basin marks the maximum level. Oligotrophic bogs formed on the pumice on the basin floor. Water-sorted pumice has produced arid blockfields, particularly where the rivers enter the superimposed river gorges, and these support scattered shrubland of *Hebe tetragona*, *Racomitrium lanuginosum*, and *Coprosma petriei*. Older oligotrophic peat bogs, predating the Taupo Pumice eruption, occur on river terraces in the lower reaches of the Moawhango West River.

Although extensive hillslopes are integral landform components of the catchment, only some are included in the RAP because mountain beech covered hillslopes are adequately represented in other PNAs and RAPs.

Vegetation

Open vegetation

Because the RAP is largely topographically restricted to the area of frost inversion, a natural non-forest environment, the vegetation is relatively uniform. Shrub-tussock grassland of monoao and red tussock dominates the basin floor and lower hillslopes. The vegetation is almost entirely secondary, resulting from repeated prehistoric Maori and early European fires. There was limited deforestation of the hillslopes before the period of human burning, which probably commenced with lightning-strike fires approximately 3500 years ago. Even today, accidental Army fires modify the vegetation, for instance in 1989 when approximately 100 ha of the adjacent Bowery basin (between Stowman and Three Kings Ranges) was burnt. A more diverse range of shrubs than just monoao would dominate the basin floor in the long-term absence of burning, e.g., bog pine, mountain toatoa, *Hebe parviflora* var. *arborea*, and *Cassinia leptophylla*. Tussocks would correspondingly reduce in abundance. The RAP represents the best example of intact shrub-tussock grassland on a basin floor or intermontane basin with high long-term viability at a landscape scale in the district.

Special habitats

However, within the apparent physiognomic homogeneity, there is wide vegetation diversity at a finer scale, particularly in the diverse habitats of the biogeographically special plants. Arid gravel levees have less than 1 % vegetation cover of *Raoulia* spp., *Pimelea prostrata*, and *Racomitrium lanuginosum* but, nevertheless, support many unusual plants including *Myosotis* sp. unnamed (*M. pygmaea* var. *glauca*) and *Luzula* sp. unnamed (*L. rufa* var. *albicomans*). Higher-fertility herbfields dominated by *Selliera microphylla, Juncus novae-zelandiae*, and *Carex berggrenii* are maintained on terrace flush zones fed by spring-water seepage from thin marine sediments about the basin floor. The elevated fertility and saturated conditions exclude taller-stature open vegetation such as *Empodisma minor*, *Schoenus pauciflorus*, taller *Juncus* spp., and tussock grasses. These terrace flush zones display wide edaphic variation at increasing distances from the water and nutrient sources. Periodically inundated, but summer-dry herbfields of *Racomitrium lanuginosum*, lichens, *Carex breviculmis*, *Oreomyrrhis* sp. (unnamed) and *Leucopogon fraseri* support special species such as *Ranunculus recens* var. and *Agrostis imbecilla*. Periodically inundated channels and hollows in tussock grassland also exclude tall grasses, sedges, and rushes, providing conditions for small herbs that have a capacity to survive underwater for extended periods. Prostrate or mat herbfields on summer-dry pavements, where competition from tussock grasses is eliminated, support several special herbs and grasses. Several mesotrophic ox-bows of the three main drainage arteries add considerable ecosystem diversity to the basin floor.

Druce (1973c, 1985, 1986) provide species lists for the RAP and adjacent areas.

Selection criteria

The RAP covers the major intermontane basin in the North Island where landscape history has provided refugia for a number of plant species recorded only there in the North Island, and that were probably more widespread in the late Tertiary. The diversity of biogeographically special plants and their habitats reflects the unusual combination of primary physical factors regulating the environment namely, the undulating greywacke landforms, the remnant marine sediment strata, frost inversion at high altitude, and a summer-dry climate. No other PNA or RAP has a closely similar mix of physical and biological natural features. The upper part of the superimposed Mt Azim gorge is included for landform representativeness, as is the upper Moawhango River gorge. The Bowery basin is not included, because it does not support the diversity of special plants associated with marine sediment remnants of the basins to the north, and it partly duplicates conditions within the RAP (G.M. Rogers 1989c, unpublished FRI contract report). The Bowery basin did, however, contain one known plant of *Carex uncifolia*, one of only two North Island records, but the plant was recently lost to road construction.

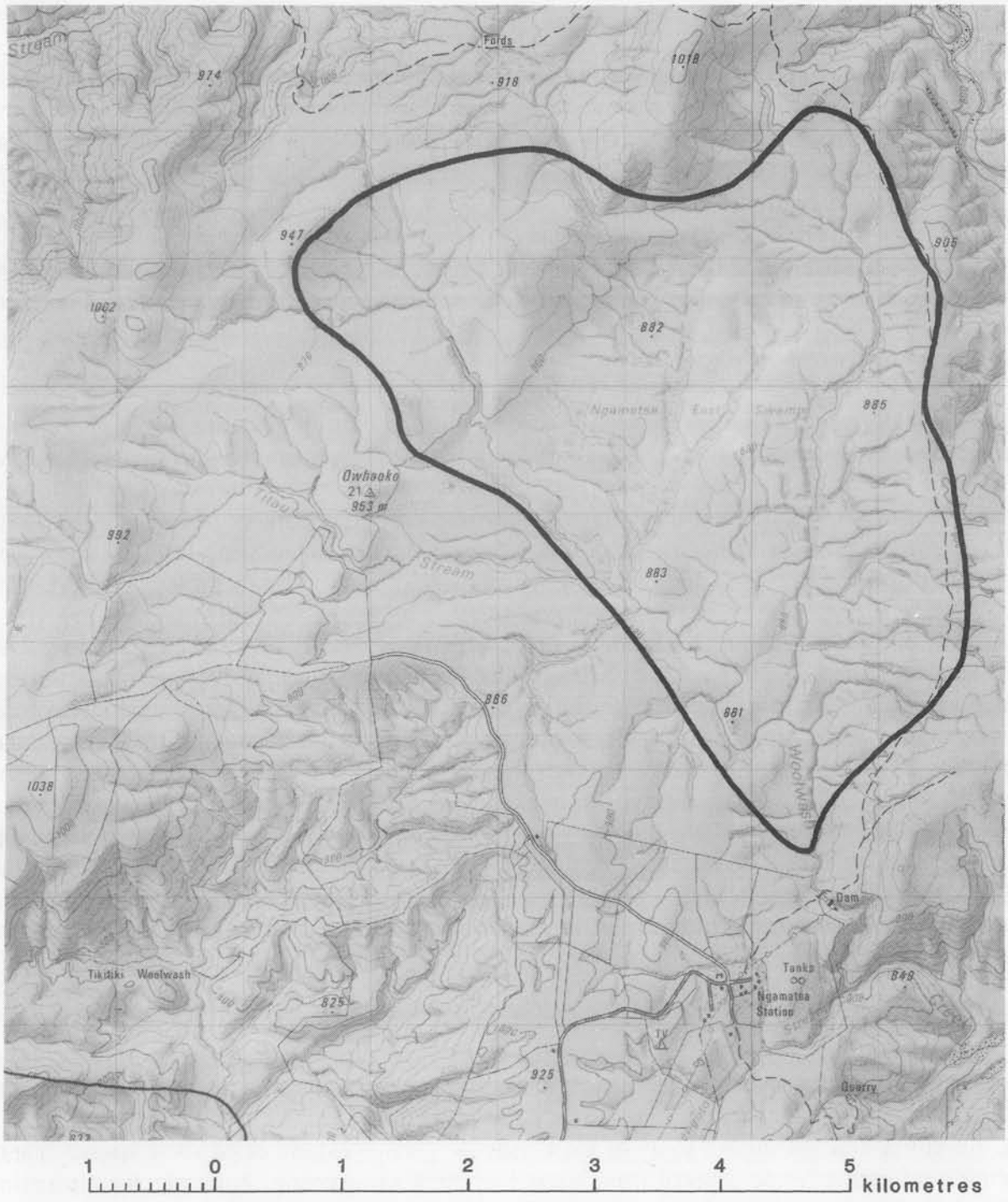
Plants substantially or completely restricted to the RAP in the North Island are *Carex berggrenii*, *Agrostis imbecilla*, *Acaena inermis*, *Luzula* sp. (*L. rufa* var. *albicomans*), *Koeleria* sp. (*K. novozelandica* agg.), and *Myosotis* sp. (*M. pygmaea* var. *glauca*). Other noteworthy species of very restricted distribution in the North Island are *Pittosporum anomalum*, *Carex petriei*, and *Myosotis* sp. (aff. *M. pygmaea*). Several other species have southern limits to their North Island distributions in the RAP (Rogers 1989b).

Notes

This proposal extends the unofficial recognition by the Army of the special floristic features of the Moawhango West basin floor, designated as a zone of restricted vehicle movement and a "non impact area". A major Army access road (Argo Road) extends from Waiouru to just south of the RAP on the bordering Stowman Range. Plans to extend the road through the Ngawakaakauae basin to the Desert Road were shelved recently because of engineering costs and conflicting environmental values. Improved funding levels in the future and/or a policy redirection could, however, see the road extended through the RAP to link up with S.H.1. Although the special plants have survived considerable human fire modification of their habitats, modern tussock grassland fires are accompanied by a proliferation of weeds exploiting community disturbance. Heather, in particular, would severely compromise the habitat viability of many special plants with establishment and population growth in the basin.

The RAP falls within the zone of protection for the Kaimanawa feral horses under the Wildlife Act 1953. Aerial surveys of the horses have shown recent population increases for the herd of 20 %/ annum. An environmental impact study of the horses (Rogers 1991) indicated some special plants and habitats suffered adverse damage from horse trampling and grazing. A management plan for the horse environment, recently prepared by the Department of Conservation, recommends control on the number of horses in the northern part of their range, a zone that includes the RAP.

RAP 3 Ngamatea East Swamp



GR Centre: U20 797 999

Area: 1763 Ha

RAP 3 NGAMATEA EAST SWAMP

Land system: Rangitikei
Area: 1763 ha
Altitude: 880 m

Ecological units

- kanuka forest on soft rock hillslope.
- kanuka forest on hard rock hillslope.
- kanuka/manuka scrub on soft rock hillslope.
- manuka/monoao shrubland on soft rock hillslope and basin floor.
- monoao/red tussock/hard tussock shrub-tussock grassland on soft rock hillslope and basin floor.
- monoao/*Pimelea* gravelfield on pumice-covered soft rock basin floor.
- sedgeland on seepage channels on soft rock basin floor.

Landform

Ngamatea plateau is a wide depression within the Cenozoic greywacke peneplain of the southern Kaimanawa Mountains. Although low greywacke ridges surround the shallow depression that Ngamatea East Swamp occupies, the depression floor is infilled with marine sediments derived from the late Tertiary period. The Ngamatea plateau, and Taruarau River headwaters immediately to the north, form a local northern limit for marine sediments that cover much of lower North Island. The entire plateau was uplifted without dislocation in the Kaikoura Orogeny. Whereas the basement marine sediments are soft siltstones and sandstones, the uppermost geology is two-three metre deep terraces of Taupo Pumice (1850 yr BP) from the pyroclastic flow that entered the plateau via the Golden Hills depression to the north. Water-sorting of the pumice produced arid blockfields on the surface. A dendritic drainage network of wide channels up to 100 m wide developed in the pumice-infilled basin after the eruption, and stream flow is sluggish because of gentle gradients and dense wetland vegetation. Streams have cut down through the pumice and now flow on a marine sediment or greywacke basement. Thinner veneers of pumice cover the low relief catchment slopes. The swamp hydrology is largely unaffected by damming of Woolwash Stream at its low point and outlet from the basin.

Vegetation

Pumice blockfields composed of water-sorted pumice are inhospitable to plant growth, because of summer drought, low fertility, frost heave, and wind ablation of the unconsolidated pumice. European burning has also been frequent, most recently 15 and 25 years ago (P. Mahoney pers. comm.). This burning followed earlier prehistoric Maori deforestation of the plateau forests of kaikawaka, Hall's totara, mountain beech and red beech (Rogers 1987). A diverse shrubland would have covered the swamp in prehuman times. Today, catchment slopes of the swamp are entirely in secondary vegetation or improved pasture.

Hawkins Hill bordering the swamp in the north supports extensive kanuka forest, and kanuka/manuka scrub, and hard tussock grassland. Eastern catchment slopes are dominated by red tussock grassland with invasive monoao and manuka. The position of the original inverted treeline of mountain beech surrounding the depression is discernible at the junction between manuka above on the colluvial toeslopes and hillslopes and monoao in the depression. Improved pasture forms the southern and western boundaries of the swamp. Pasture conversion has destroyed wetland vegetation on the southwest corner of the swamp. Runoff from the pasture affects the drainage channel communities, but not the terraces of Taupo Pumice.

Rather uniform vegetation communities cover the pumice terraces, but complex interactions in the gradients of watertable, pumice particle size, and fire disturbance produce wide variations in total cover. The driest terraces mainly have *Coprosma petriei* and *Raoulia* sp at less than 5 % total vegetation cover. Mesic terraces of pumice support sparse vegetation (< 10 %) on small hummocks dominated by monoao and red tussock, along with *Pimelea prostrata*, *Cassinia leptophylla*, *Racomitrium lanuginosum*, and *Celmisia glandulosa*. Wet depressions on the terraces support *Lepidosperma australe*, *Selliera microphylla*, *Gonocarpus aggregatus*, *Deyeuxia quadriseta*, wirerush, and *Centella uniflora*. Monoao shrubland would dominate the terraces after *c.* 50 years without burning; a return to a diverse shrubland of manuka, *Cassinia leptophylla*, bog pine, mountain toatoa, and *Hebe* spp. would be a longer-term process.

Diverse plant communities in the drainage channels reflect a gradient of increasing water depth downstream. *Olearia virgata* is important at the heads of stream channels. Wide stream channels with sluggish waterflows have diverse sedgeland communities of *Carex secta*, *Juncus gregiflorus*, *Sphagnum* sp., *Eleocharis gracilis*, *E. sphacelata*, *Baumea* spp., *Carex gaudichaudiana*, *Schoenus pauciflorus*, *Epilobium pallidiflorum*, *Epilobium chionanthum*, and wirerush. *Deschampsia caespitosa*, which is a grass with a vulnerable conservation status because of stock grazing, occurs in the channels. *Centrolepis ciliata* cushion mounds are common and are surrounded by *Baumea* spp., *L. australe*, and *Triglochin striata*.

Two biogeographically special plants are recorded from the swamp: the only two North Island plants currently known of *Uncinia strictissima* are on Ngamatea plateau, with one from the eastern margin of the swamp, and the other from the Mangamarahia Stream headwaters, east of Tikitiki Bush; *Ranunculus recens* var. (probably an endemic variety to Moawhango Ecological Region) is recorded from a stream bank on the eastern margin. The only other site for this taxon is in the Moawhango River headwaters (RAP 2).

Druce (1972b, 1985, 1986) provide species lists for the RAP and adjacent areas.

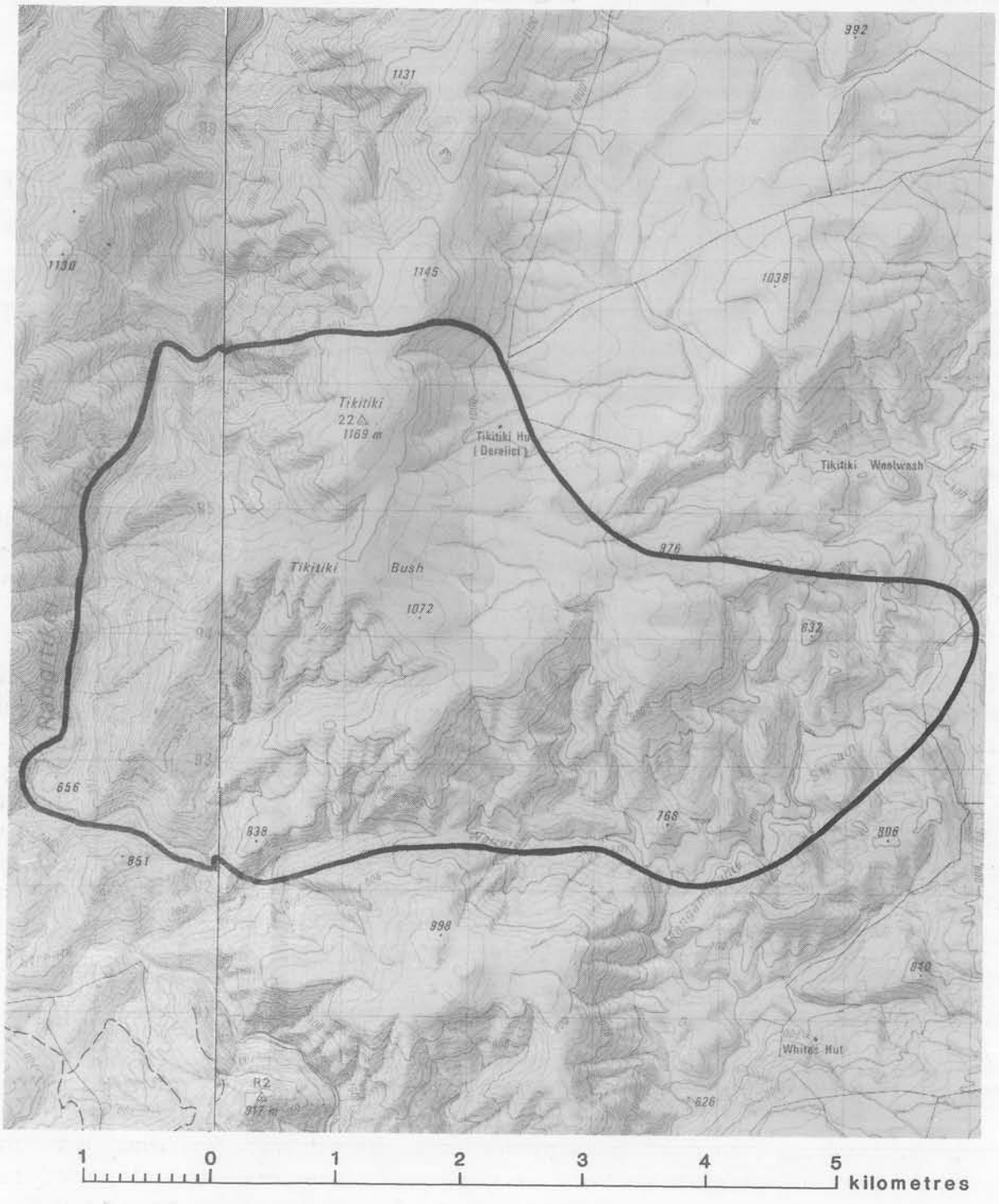
Selection criteria

Ngamatea East swamp has unique landform, vegetation, and biogeographic attributes conferring high conservation status. The combination of arid pumice terraces on soft rock basin landforms and a dendritic drainage network of wide seepage channels does not occur elsewhere. Despite frequent fire disturbance, low-level damming of the outlet, and encroachment of improved pasture on one boundary, the hydrology and plant biodiversity of the swamp are probably largely intact. Vegetation cover on the terraces is partly depleted by past burning, and the cover of ablation pavements correspondingly increased, but channel vegetation is probably mostly unmodified. The swamp is buffered in the east and north by natural landscapes that may not be developed for improved pasture. Reporoa Bog, Ngamatea West Swamp, and Irirangi swamp differ from Ngamatea East Swamp in landforms, plant community composition, and in matters of plant biogeography.

Notes

Land tenure is a combination of multiple Maori ownership and Ngamatea Station ownership. *Pinus contorta* regularly establishes in the swamp from seed sources west of the Rangitikei River in the Defence land, and this control is presently undertaken by the Department of Conservation, Hawke's Bay, and by the Manawatu-Wanganui Regional Council. Approximately 250 *P. contorta* saplings were cut from the swamp in the latest sweep in January 1993 (R. Apatu, Ngamatea Station, pers. comm. 1993). Banded dotterel inhabit the basin and nest on the western margin (also in RAP 2). The swamp was also a celebrated eel fishery for prehistoric Maori. A resource survey on the upper Ngaruroro catchment was completed by Eyles (1969).

RAP 4 Tikitiki



GR Centre: U20 716 944

Area: 2188 Ha

RAP 4 TIKITIKI

Land system: Rangitikei, Moawhango
Area: 2188 ha
Altitude: 650-1170 m

Ecological units

- red beech-mountain beech forest on soft rock hillslope, plateau, escarpment slope, valley floor.
- red beech-mountain beech forest on hard rock hillslope, ridge top.
- kanuka/manuka scrub on soft rock hillslope, plateau, escarpment slope, valley floor.
- manuka shrubland on soft rock hillslope, plateau, escarpment slope, valley floor.
- monoao/red tussock/hard tussock shrub-tussock grassland on hard rock hillslope, ridge top, colluvial toeslope.
- red tussock/hard tussock grassland on soft rock plateau, valley floor.

Landform

The RAP covers both steep greywacke hillslopes, ridge tops, and toeslopes, and soft sediment plateaux. In the west, a deeply-incised Rangitikei River has produced steeply erodable greywacke slopes about the river gorge. With the destruction of forest by burning on the river valley slopes, the mantling andesitic ash was stripped to expose the underlying greywacke bedrock.

R. Black (Hawke's Bay Regional Council pers. comm. 1988) believes Ngamatea plateau represents a remarkably intact remnant of a late Miocene estuarine landscape that has been uplifted without fault or fold dislocation of the original paleoshoreline. Thin remnants of estuarine marine sediments, including limestones, laid down on the greywacke peneplain are stratigraphically intact throughout the Ngamatea plateau. Marine sediments thin out as a cap on the western greywacke ridge of the RAP. Thicker marine sediments fill the basin floor in the Mangamarahie Stream. Finally, deep deposits of Taupo Pumice with incised stream valleys remain as arid infertile terraces in the Mangamarahie catchment. Thinner (<1.0 m) deposits of Taupo Pumice mantle the uppermost plateau surfaces.

Vegetation

Vegetation consists of the extensive red and mountain beech stand of Tikitiki Bush and small beech outliers within kanuka scrub of the Mangamarahie catchment, and widespread secondary communities of red tussock, monoao, manuka, and kanuka. Kanuka/manuka scrub-low forest and tussock grassland are topographically separated by cold-air drainage gradients, with tussock grassland sharply defined where cold-air ponds. Rates of successional change from red tussock grassland to monoao, manuka, and then kanuka on hillslopes are rapid, spanning <30 years (Rogers & Leathwick in press). Secondary vegetation is sparse on the deforested hillslopes of the Rangitikei River because of past burning and soil-stripping.

Beech Forest

In Tikitiki Bush, mountain beech and red beech are spatially sorted along a disturbance gradient. Because of its faster regeneration response to burning and windthrow, mountain beech predominates in peripheral stands, whereas, red beech with its superior stature and conservative regeneration capacity dominates central areas. Rare trees of Hall's totara occur within the red beech-mountain beech stands. The forest straddles the geological and landform transition from steep greywacke hillslopes of the Rangitikei River in the west to the soft sediment plateaux of Ngamatea Station in the east.

The spread of beech from isolated stands is dependent on secondary vegetation change advancing beyond red tussock-monoao shrub-tussock grassland to manuka-kanuka scrub. Beech re-occupation of previously deforested steep greywacke hillslopes where the andesitic ash has been stripped will be slow in the absence of a regolith.

Bog Forest

A small bog occurs on the southeast margin of Tikitiki Bush. The bog extends as an enclave into the forest, and here the depauperate remains of a silver pine-kaikawaka forest occur. Only two saplings of living kaikawaka and approximately 15 small trees of silver pine remain from the previous silver pine-kaikawaka forest. Kaikawaka has also been affected by a dieback event sometime since the 1950s, an event widespread in kaikawaka stands of Moawhango and Ruahine Ecological Regions, but the main damage to the stand resulted from burning, logging, and stock grazing. Where the bog extends beyond the forest, red tussock dominates after repeated past burning of secondary vegetation. Spread of beech trees from Tikitiki Bush and surrounding forest pockets through secondary shrublands will eventually see the red tussock bog completely enclosed by beech forest.

The eastern and northern margin of Tikitiki Bush was fire-modified in *c.* 1850 (Elder 1963) and again in February 1983 in the Ohinewairua fire that burnt in a north-easterly direction from near Bare Acre (T20 671952) west of Tikitiki Bush to Otutu Bush and Mt Meany (RAP 6) on the Owhaoko Block on the western margin of the Kaweka Range. Only the steep faces of the Rangitikei River in the west, and the northern margin of Tikitiki Bush were burnt in the 1983 fire. Immediately after the fire, fire-breaks were bulldozed across the RAP and down into Wairere Stream on the eastern boundary of the red tussock bog.

Secondary Vegetation

The Mangamarahie catchment in the east has a sequence of kanuka/manuka scrub and low forest on soft rock and Taupo Pumice hillslopes, along with a narrow network of cold-air inversion or non-forest valleys. Small islands of beech within the kanuka/manuka are expanding through the scrub nurse. The valley floor supports monoao, red tussock, and hard tussock in different proportions; it is highly unlikely manuka or kanuka will ever invade the tussock covered valley floor judging from the frost-damaged inverted line of manuka 5-10 m above the floor.

Druce (1972b, 1985, 1986) provide species lists for the RAP and adjacent areas.

Selection Criteria

Tikitiki Bush exists as the only forest remnant on the elevated Ngamatea plateau following two phases of forest destruction in the last 2000 years: 1) extensive deforestation by the pyroclastic flow of the Taupo Pumice eruption (1850 yr BP), and 2) further forest clearance 600-400 years ago by early Maori fires (Rogers 1987).

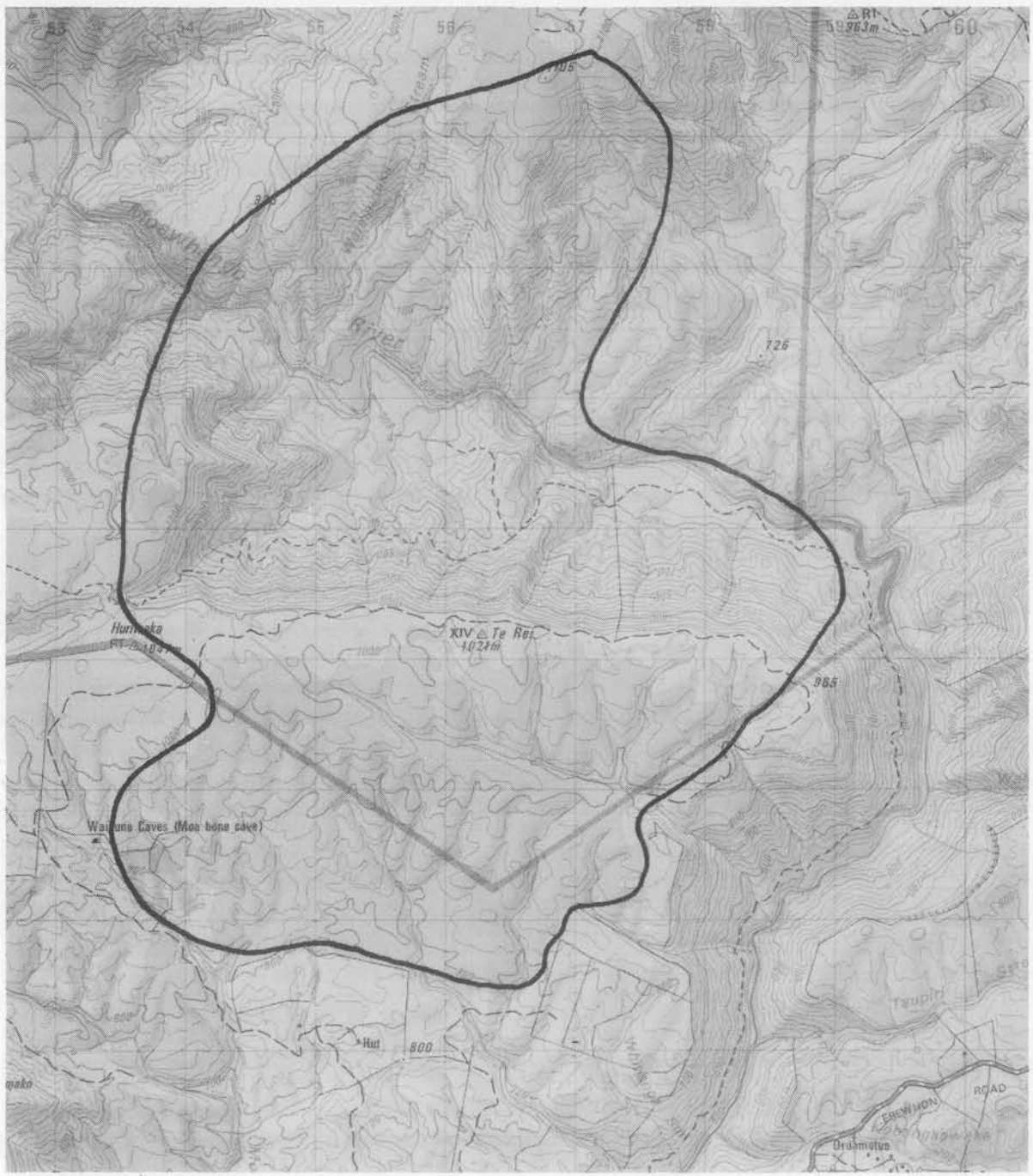
The poorly-drained depression with red tussock grassland bordering the southeast corner of Tikitiki Bush is the only bog record for silver pine in Moawhango Ecological Region (two silver pine trees occur in a kaikawaka forest remnant at Auahitotara and two trees are known from eastern Hihitahi). Originally covered in low open silver pine-kaikawaka forest interspersed with pokaka, manuka, and *Olearia virgata* var., the bog does not contain noteworthy non-forest plants. Silver pine reaches its southern limit in the North Island on the bog after prehuman stands further south on bogs of Otupae Station and at Reporoa Bog were destroyed by early Maori fires. *Korthalsella clavata* has one of only three North Island records from the bog (the other two are from the edge of Rangataua Forest, southern Ruapehu, and from Mataroa, west of Taihape). One of only two recent North Island records of *Uncinia strictissima* (pers. obs.) comes from a cold-air inversion valley in the Mangamarahia Stream headwaters at the eastern extent of the RAP (U20 751933).

The RAP also includes important riverine and river-cliff communities bordering the Rangitikei River. *Asplenium trichomanes*, *Epilobium astonii*, and *Hebe colensoi* are important plants associated with the greywacke cliffs bordering the river.

Notes

Red beech stands on the eastern margin were used for the extraction of fence batte ns in early European farming times and unused piles of batterns litter the forest understorey today. Additionally, silver pine has been extracted from Tikitiki Bush for support piles for early station buildings (V. Conchie, Hawke's Bay Regional Council, pers. comm. 1984). Most of the open vegetation of the RAP does not appear to be under immediate threat of land conversion, but, a further phase of improved pasture development could conceivably target the red tussock grassland and kanuka scrub-low forest in the east of the RAP. Cattle are grazed periodically in the Tikitiki block. The red beech and mountain beech stands of Tikitiki Bush are not fully representative of the forests that covered Ngamatea plateau in pre-Taupo eruption times. Charcoal derived from forests engulfed in the Taupo Pumice eruption revealed extensive kaikawaka stands with beech mainly confined to plateau margins (Rogers 1987) as the Tikitiki beech stands are today. But no relictual kaikawaka stands exist on Ngamatea plateau.

RAP 5 Te Rei



GR Centre: T21 561 862

Area: 2613 Ha

RAP 5 TE REI

Land system: Rangitikei
Area: 2613 ha
Altitude: 520-1020 m

Ecological units

- mountain beech forest on hard rock gorge.
- mountain beech forest on soft rock hillslope, plateau, escarpment slope.
- red beech-mountain beech forest on soft rock hillslope, plateau.
- rimu/red beech-mountain beech forest on soft rock hillslope, plateau.
- kowhai-putaputaweta-*Hoheria* forest on hard rock gorge.
- *Hoheria*-lancewood/mountain flax forest on hard rock gorge.
- manuka shrubland on hard rock hillslope, colluvial toeslope, valley floor, gorge.
- manuka shrubland on soft rock hillslope, plateau, escarpment slope, valley floor.
- mountain flax tussockland on soft rock hillslope, escarpment slope.

Landform

Landforms are mainly a conspicuous soft rock, block plateau bordered by a deeply incised Moawhango River. The Te Rei plateau tilts gently to the south, conforming to the tilting pattern of elevated plateaux in the southwestern Rangitikei land system namely, Hihitahi, Kauaekeke, and Pukemako. The plateau is terminated in the north by a spectacular 520 m high escarpment formed by incision of the Moawhango River in the soft marine sandstones. Remnants of elevated alluvial terraces appear on the northern slopes of the Moawhango River valley, and erosion-resistant tors of sandstone dot these surfaces. The RAP extends across the Moawhango River valley to the rounded greywacke landforms of the Three Kings Range at Westlawn. The Moawhango River enters the large valley between Te Rei and Westlawn via a superimposed gorge in the underlying greywacke basement. The contact region between soft marine sediments and the underlying much older greywacke surface is clear along the course of the Moawhango River.

Vegetation

The RAP has extensive red beech-mountain beech forest with scattered emergent rimu on the Te Rei plateau. The forest is all old-growth and some marginal retreat on the northern boundary resulted from early 20th century burns. On the other hand, the isolated mountain beech stand at Huriwaka on the western margin of the RAP is almost entirely secondary, judging from the age range of trees (Rogers 1987), suggesting regeneration after a late Polynesian era fire. Small stands of non-beech forest of lacebark, lancewood, kowhai, and putaputaweta occupy soft sediment escarpment slopes. On greywacke gorges kowhai dominates on uppermost thinner soils and mountain beech dominates as riparian forest on colluvial toeslopes lower-down. Mountain flax and manuka occupy escarpment slopes below Te Rei bush, and manuka is extensive on the Moawhango River valley floor. The early stages in the spread of mountain beech through nurse manuka is evident on the valley floor and escarpment slopes below Westlawn bush.

Druce (1985) provides a species list for the RAP and adjacent areas.

Selection criteria

Rimu/red beech-mountain beech forest on soft rock landforms is restricted to this RAP. Other important criteria are the extensive advanced succession to native forest in the Moawhango valley, the spectacular landform features, and the potential altitudinal range of forest when the large Moawhango valley fully succeeds to forest. The rimu/red beech-mountain beech forest on a soft rock plateau is in sharp contrast with kaikawaka-Hall's totara forest at similar altitudes, climate, and landforms at Hihitahi. With rehabilitation of forest in the valley, the RAP offers potential for an extensive representative landscape of beech forest on soft rock landforms, unrepresented elsewhere in Moawhango Ecological Region. *Olearia cheesemanii*, a cliff habitat species, has one record in the Moawhango in the Moawhango River gorge at the western end of the RAP. *O. cheesemanii* has an unusual distribution from Ohinemuri Gorge near Waihi, Lake Waikaremoana, the Moawhango, Otaki Gorge, and around Westport.

Notes

This sector in the Defence land receives only light military training impact; stock from adjacent Mounganui sheep station graze the area. A grazing lease from the NZ Army to Mounganui Station over Zone 33 will now have stock confined to the deeply-incised Moawhango River valley by a fenceline extending along the western escarpment rim of the Moawhango valley to Huriwaka Bush and along the northern margin of Te Rei Bush. Light stock grazing is not expected to disrupt successional changes in the manuka-kanuka communities or the spread of beech trees through nurse shrubland and scrub in the valley. Feral horses infrequently graze the Moawhango valley, but often graze the strip of secondary vegetation between Te Rei Bush and the Moawhango valley escarpment rimrock.

RAP 6 OWHAOKO

Land system: Owhaoko
Area: 1130 ha
Altitude: 980-1295 m

Ecological Units

- mountain beech forest on hard rock hillslope, colluvial toeslope, knoll, valley floor.
- kanuka forest on hard rock hillslope , ridge top, knoll, and colluvial toeslope.
- kanuka/manuka scrub on hard rock hillslope, colluvial toeslope, knoll, and valley floor.
- manuka shrubland on hard rock hillslope, colluvial toeslope, spur top, knoll, valley floor.
- monoao/*Dracophyllum recurvum* shrubland on hard rock knoll and ridge top.
- red tussock/hard tussock grassland on hard rock hillslope, colluvial toeslope, spur top, knoll, valley floor.

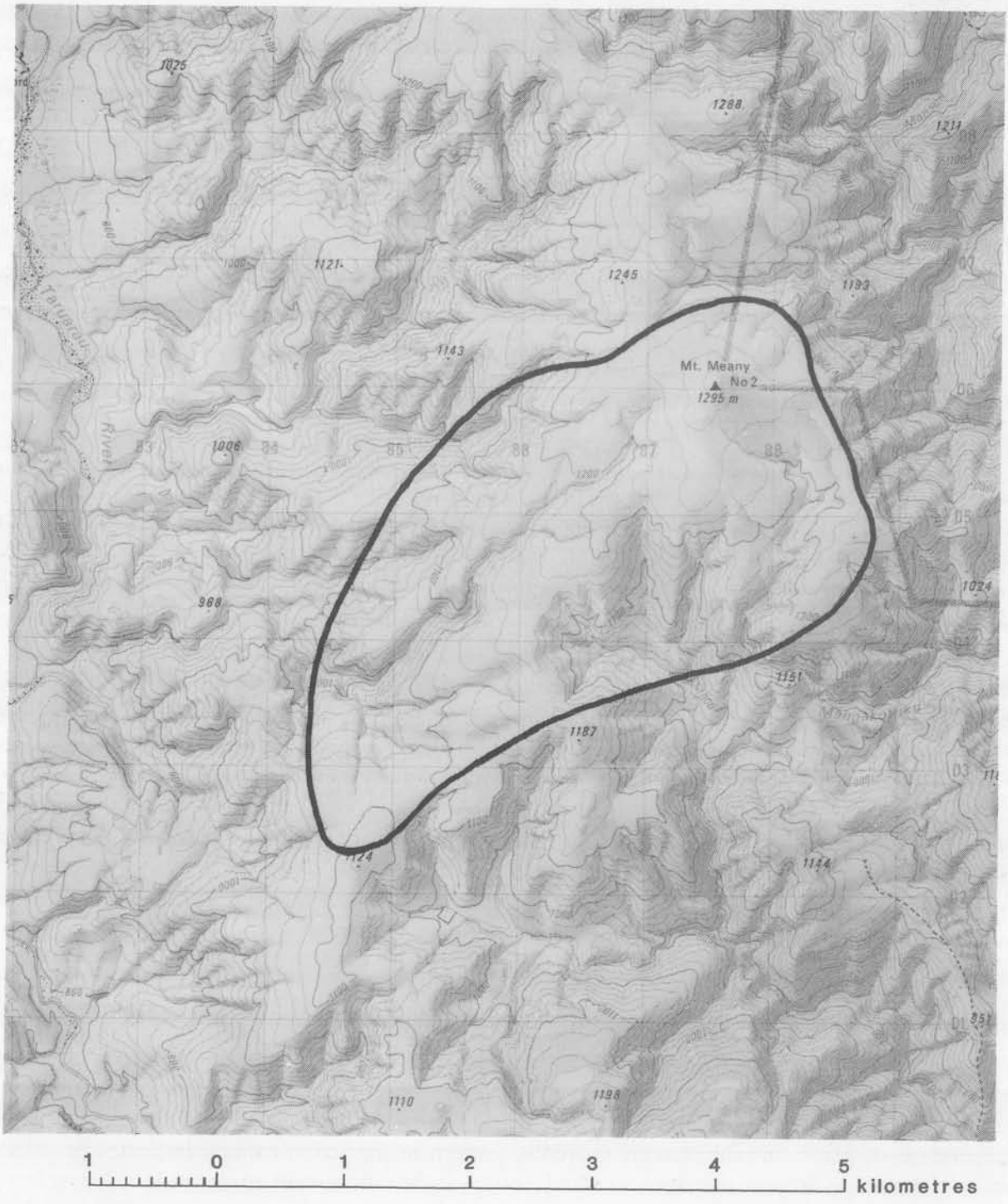
Landform

A large greywacke peneplain tilted down to the west dominates the entire Owhaoko land system and also the RAP. The Owhaoko land system is the eastern extremity of the undulating greywacke landforms of northern Moawhango Ecological Region where they abut the dissected, high relief landforms of the Kaweka Range. The Owhaoko block formed the eastern boundary of a shallow Miocene basin (10-12 million years ago) with subsequent re-emergence from the sea through tectonic uplift (R. Black Hawke's Bay Regional Council, pers. comm. 1986). The tilted block has near horizontal summit surfaces at its easternmost and highest extent about Mt Meany (1295 m). The tilted block is dissected by incised streams, that arise as shallowly-incised seepages on the summit surface and then progressively deepen in draining westward down the dip-slope to the Taruarau River. Holocene andesitic ash, with more recent blocky Taupo Pumice, overlies the greywacke bedrock and forms the main soil parent material. Erosion scars in the greywacke bedrock on steeper gully faces result from removal of previous manuka cover by intense fires and consequent stripping of the cover beds of ash. The RAP straddles the headwaters of the Mangakotuku and Raoraoroa Streams, tributaries of the Ngaruroro River, and unnamed tributaries of the Taruarau River.

Vegetation

The entire RAP supported monotypic mountain beech forest in prehuman times, but the legacy of past burning is now a diverse range of secondary vegetation and only isolated forest pockets. The summer-dry beech forest is species poor and subject to frequent windthrow and snow-break disturbance. A patch or synchronous mortality pattern in the forest canopy indicates predisposing site and stand-age factors that lead to stand collapse and subsequent regeneration. Therefore, the mortality patterns are a key to the population dynamics of these forests. Some of the stands show evidence of recent marginal expansion (before the February 1993 Ohinewairua fire), perhaps coinciding with a hiatus in burning after European farming commenced in the 1880s. However, many of these young marginal stands were burnt in the February 1993 fire (described in RAP 4).

RAP 6 Owhaoko



GR Centre: U20 887 050

Area: 1130 Ha

Truncated forest margins and forest pockets mainly in sheltered gullies are strong evidence in the Owhaoko land system of vegetation patterns determined and maintained by fire. Low intensity fires in bordering secondary vegetation commonly advance 10-50 m into a forest understorey, burning only dry decaying wood and litter, with little damage to living trees. Low kanuka forest and kanuka/manuka scrub were common on hillslopes before the 1993 fire, but were dramatically reduced to small areas on humid eastern aspects after the fire. Regeneration of kanuka and manuka is now well underway. On rounded summit surfaces a prostrate shrubland of *Celmisia spectabilis*, *Dracophyllum recurvum*, monoao, *Hebe tetragona*, and pygmy pine on skeletal soils derived from greywacke and Taupo Pumice is common. *Racomitrium lanuginosum, Hebe venustula*, and *Coprosma cheesemanii* are also important. This community is superficially alpine in appearance, but owes its origin to frequent burning and dry substrates. Regional treelines are at 1440 m well above the highest point of 1295 m. This prostrate shrubland will eventually be invaded by manuka, and perhaps kanuka, in the absence of burning. In turn, manuka and kanuka will act as a nurse for beech reoccupation of these deforested sites, again, in the long-term absence of burning. Kanuka is less important in secondary vegetation at the highest altitudes of the RAP, because it is at or near the altitudinal limit for the species.

Red tussock grassland dominates most other secondary vegetation, particularly on gently-sloping surfaces with intact ash substrates. Extensive mats of *Celmisia spectabilis* on summit plateaux testify to the replacement by this species of previous red tussock, hard tussock, and shrubs through frequent past burning. *C. spectabilis* is perhaps even more fire-resistant than the tussock grasses.

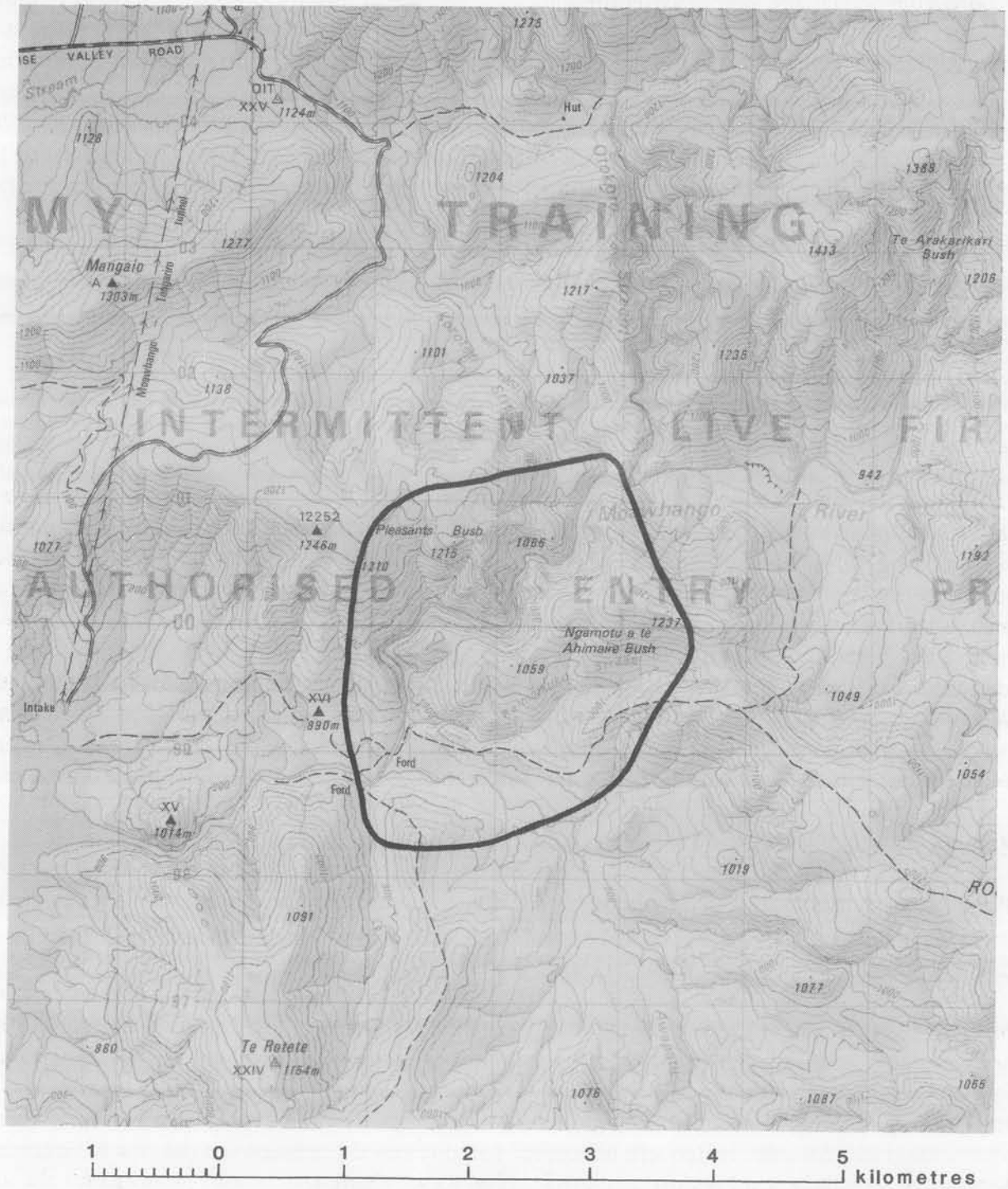
Selection Criteria

This RAP is the sole representative of the Owhaoko land system. The near horizontal nature of the extensive greywacke peneplain throughout the southern Kaimanawa mountains (Sporli 1987) dating to pre-Kaikoura orogeny times is best represented in the Owhaoko land system. The RAP includes the largest isolated remnant of mountain beech forest on the Owhaoko land system with a representative mix of all secondary vegetation on the variety of greywacke landforms. The RAP does not include the lower altitude parts of the land system because ecological units there are fully represented in other PNAs and RAPs. *Carex buchananii*, a local sedge in the North Island, occurs on the summit ridge of the RAP about Mt Meany.

Notes

All of the Owhaoko land system is owned by Ngati Tuwharetoa interests, based at Taupo, but the RAP includes a small portion of the westernmost Kaweka Conservation Park. *Pinus contorta* requires infrequent removal from the block. The seed source for the infestation exists to the west in the Army holding, west of the Rangitikei River, and from scattered saplings and small trees on Ngamatea (East) Swamp. Infrequent helicopter-based removal operations in the past have contained population growth beyond widely scattered saplings and young trees.

RAP 7 Pleasants Bush



GR Centre: T20 522 999

Area: 675 Ha

RAP 7 PLEASANTS BUSH

Land system:	Moawhango
Area:	675 ha
Altitude:	860-1246 m

Ecological Units

- mountain beech-red beech-silver beech forest on hard rock hillslope, ridge top, valley floor, gorge.
- kanuka/manuka scrub on hard rock hillslope, colluvial toeslope, valley floor.
- manuka shrubland on hard rock hillslope, colluvial toeslope, valley floor, gorge.
- red tussock/hard tussock grassland on hard rock basin floor.
- various herbs on periodically inundated tarn.
- various herbs on flush zone on hard rock terrace.

Landform

Landforms are steeply dissected greywacke hill country, with small peneplain remnants preserved on rounded ridge tops and in valley floors. Remnants of elevated terraces occur on valley midslopes and drainage from these to valley floors is via incised second generation gorges. The dominating landform feature is the deeply incised Moawhango River gorge where the river exits onto the more undulating marine sediment surfaces of basin floors. Kaimaikuku Stream catchment is a second generation valley in a greywacke ridge draining-out in its lower reaches onto an elevated hard rock terrace in the Awapatu basin. A periodically inundated tarn or seasonal wetland associated with the stream has developed on outwash alluvial sands on the terrace. The tarn is fed by floodwater overflow from Kaimaikuku Stream, and drainage is by subterranean seepage only. The tarn is hydrologically special for its seasonally fluctuating water levels and apparently high fertility.

Vegetation

Pleasants Bush and Ngamotu a te Ahimaire Bush are the central beech forest remnants of the RAP, on southeast aspects of the Moawhango River gorge and Kaimaikuku Stream respectively. Red, silver, and mountain beech occur in approximately equal proportions in Pleasants Bush, but mountain beech dominates Ngamotu a te Ahimaire Bush. Mountain beech dominates fringing secondary stands to both these remnants. Forest clearance by wildfire has predominantly affected both ridge top and valley floor, as it has throughout all the Moawhango land system. Consequently, forest was preferentially preserved on steep valley midslopes, on humid south and southeast facing aspects.

Secondary vegetation on hillslopes is mostly manuka and kanuka providing a nurse for the spread of beech. Given the intense heat generated by manuka and kanuka fires, past burning of these communities has induced ablation pavements in andesitic ash soils overlying the greywacke. Bare greywacke pavements are the endpoint of this erosion process. Monoao, red tussock, and manuka occur in different proportions about the deforested faces of the Moawhango River gorge and the Awapatu Stream catchment.

A tall, dense red tussock grassland occupies fertile and moist alluvial debris about the tarn on the Kaimaikuku terrace. The seasonal wetland on the terrace supports mats of *Carex rubicunda*, *Selliera microphylla*, and *Triglochin striata* on the littoral zone with occasional *Amphibromus fluitans*, *Lachnogrostis striata*, and *L.* sp. (aff. *L. filiformis*). The more or less permanently wet areas of the shallow tarn are covered in *Potamogeton cheesemanii* and *Eleocharis acuta.* Several small hollows in the floor of the Awapatu Stream are dominated by *Lilaeopsis ruthiana*, but Yorkshire fog and various clovers are invading after horse trampling.

Druce (1985, 1986) provides species lists for the RAP and adjacent areas.

Selection criteria

Two significant ecological units that do not appear in PNAs are catered for in the RAP. Mountain beech-red beech-silver beech forest on hard rock landforms are not represented elsewhere in the district. Silver beech in the Kaimanawa Mountains reaches a substantial southern limit in Pleasants Bush (four trees remain in forest at Westlawn 10 km to the south). The species reappears 45 km to the south in only four small stands in the central Ruahine Range.

No other periodically inundated tarn on alluvial sandy-silts is known from the Moawhango Ecological Region. The ecological viability of the tarn is a delicate balance between periodic water inundation and alluvial sedimentation. Seasonal fluctuations in water level and elevated fertility from the fresh greywacke alluvium act to suppress competition from tall sedges, rushes, and grasses (Ogle 1991), providing edaphic conditions suitable for low-growing herbs. The only North Island record for the herb *Gnaphalium ensifer* and the presence of the nationally endangered grass *Amphibromus fluitans* (Appendix 3) attest to the uniqueness of the habitat.

In general terms, the RAP is representative of beech forest covered steep greywacke hillslopes about the Moawhango River gorge, characteristic of the more tectonically dissected parts of the southern Kaimanawa Mountains. Deforestation by wildfire of the undulating landforms of the Moawhango land system was moderated by the dissected relief of the deeply-incised river gorges. This topography contrasts with the broad convexity and concavity of greywacke peneplain surfaces in the Moawhango River headwaters immediately to the east and included in RAP 2. The lowermost portion of the Awapatu Stream catchment is included, with several small flush zones flowing down the riser of hard rock terraces in the basin floor. Intense trampling by feral horses has, however, modified these wetlands.

Notes

The Kaimaikuku Stream tarn has a measure of protection from Army training activities as a zone of low impacts with restricted vehicle movements permissible only. A military road along Rogers Spur has been mooted, linking Three King's Range with the Moawhango Reservoir. This would impact upon the Kaimaikuku catchment and consequently threaten the tarn, because the tarn is close to the axis of the spur, the logical alignment of the road. Considerable earthworks in the vicinity of the tarn would be required for a satisfactory roading grade up the spur. Because of the elevated fertility, trampling by feral horses severely damages the tarn and littoral vegetation.

Blue duck have been reported in the last six months from the Otokoro Stream (S. Reynolds, N.Z. Army pers. comm., 1993) on the eastern boundary of the RAP.

RAP 8 THREE KINGS

Land system: Moawhango
Area: 1125 ha
Altitude: 1200-1240 m

Ecological units

- mountain beech forest on hard rock hillslope, ridge top.
- manuka shrubland on hard rock hillslope, colluvial toeslope, spur top, knoll, valley floor.
- monoao/red tussock/hard tussock shrub-tussock grassland on hard rock hillslope, ridge top, knoll.
- tangle fern-wire rush sedgeland on soft rock topogenous bog.
- tangle fern-wire rush sedgeland on hard rock ombrogenous bog.

Landform

This RAP covers the rounded ridge top of the Three Kings Range, a peneplain remnant at the southern limits of hard rock landforms in the Kaimanawa Mountains. Scattered greywacke tors on the summit ridge indicate very slow vertical downwearing as the dominant erosion process rather than backwearing on hillslopes. Terraces of soft rock overlie the rounded ridge on the flanks of the summit and conspicuous rim rocks of limestone on the outside of the terraces delineate these features. Basin or topogenous peat bogs, up to 5 m deep and 11 000 years old (Froggatt & Rogers 1990; Rogers & McGlone 1989) are developed on the soft rock terraces. Blanket or ombrogenous peat bogs, less than 1.5 m deep cap the rounded greywacke ridge and these mostly date from 6000 years ago. Several rhyolitic tephras from the Taupo and Okataina Volcanic Centres are preserved in both peat systems (Froggatt & Rogers 1990) enabling accurate dating of landscape history processes. Andesitic tephras from the Tongariro volcanoes are also interbedded in the peats. Greywacke tors dot the summit surface, from Westlawn to the Kaimanawa Trig at 1405 m.

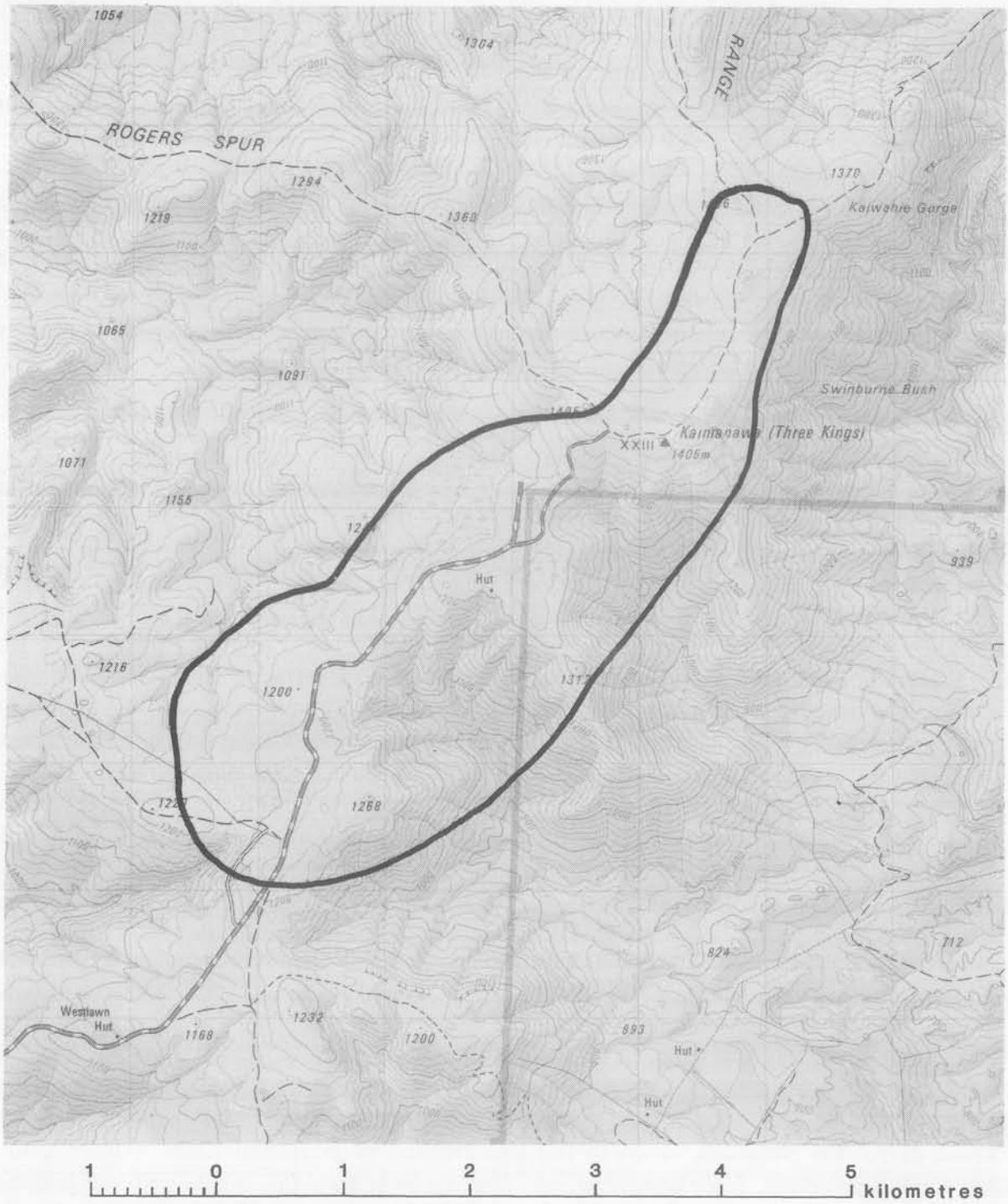
Vegetation

Most of the mountain beech forest covering the Three Kings Range was removed by early Maori burning leaving extensive red tussock-hard tussock grasslands. The area was farmed and burnt up to *c.* 1939, and intermittent burning from accidental Army fires continues to the present. Each fire acts to suppress successional monoao and retards the recolonisation of mountain beech. Scattered isolated mountain beech trees at 1365 m southwest of the Kaimanawa Trig probably occurred about the original treeline, but, there are no remains of a low forest of mountain toatoa that would have occurred above the mountain beech to the true treeline in prehuman times. Alpine shrubs of *Dracophyllum recurvum*, *Hebe tetragona*, and *Brachyglottis bidwillii*, mixed with red tussock and monoao, now constitute a subalpine shrubland occupying sites vacated by mountain beech and mountain toatoa forest.

Tangle fern-wire rush sedgeland, along with much red tussock, occupies both peat bog systems, but in prehuman times bog pine and mountain toatoa would have been important judging from subfossil wood buried in the peats.

Druce (1985, 1986) provide species lists for the RAP and adjacent areas.

RAP 8 Three Kings



GR Centre: T20 586 939

Area: 1125 Ha

Selection criteria

The topogenous and ombrogenous peats impart high conservation and scientific value to the RAP. The two peat systems occur along the Butts No 2 ridge (T 20 512063) to the head of the Moawhango West River and along the Motumatai Range, but they are best represented along the Three Kings Range. Ombrogenous peats also occur in the Kaimanawa Ecological Region, but on different landforms and in a different climate regime. A record of the effects of vulcanism, climate change, and burning on vegetation during the last 11 000 years was obtained from the Three Kings Range peats (Rogers & McGlone 1989). Both topogenous and ombrogenous peats are included because they are entirely different ecosystems, and they respond differently to climate changes. Tors are a special and rare feature of greywacke topography in the North Island because of the high rates of tectonic dislocation along the axial ranges that prevent development of these features associated with slow erosional downwearing. The RAP also offers potential for a reconstitution of the original treeline forests of mountain toatoa in the long-term absence of burning.

Notes

Argo Road, constructed by Army engineers in the late 1980s, bisects the RAP and detracts from natural landscape values. A quarry three km northeast of Westlawn Hut, adjacent to Argo Road has further degraded the naturalness of the landforms. A prohibition on the use of off-road vehicles across the peat surfaces for military training would be an important land use recommendation.

BOUNDARY CHANGE RECOMMENDATIONS

Minor boundary changes extending Moawhango Ecological Region at the expense of Ruahine and Kaweka Ecological Regions were completed in the review of McEwen (1987). Figure 1 shows both the Region boundary from McEwen (1987) and the boundary used in this survey. The latter therefore indicates recommended boundary changes for the next review of the Ecological Regions and Districts maps.

RAP 9: IRIRANGI WETLANDS

A lobate extension of the southwest boundary of Moawhango Ecological Region at the expense of Rangitikei Ecological Region is now recommended to include Irirangi Swamp which has strong geophysical and vegetation affinities with Ngamatea (West) Swamp south of Waiouru (Fig. 1).

Irirangi Swamp occupies a shallow depression in montane plateau landforms of soft sediments similar to those of Ngamatea (West) Swamp. Beyond the swamp in the west and south, landforms abruptly change to the dissected 'slump' topography of Rangitikei Ecological Region with diverse podocarp-broadleaved forest covering the high fertility marine sediments. Irirangi Swamp has two topographical components, a larger northern unit, and a slightly lower-altitude and smaller southern unit.

A plant species list and description of some vegetation types has been compiled by C.C. Ogle and J Barkla (1992) of the Department of Conservation, Wanganui. A simplified outline of the main vegetation types they identified on the basin floor follows:

1. Wirerush rushland with scattered red tussock.
2. *Baumea rubiginosa* sedgeland.
3. *Baumea huttonii* sedgeland.
4. Umbrella fern/wirerush fern-sedgeland.
5. Monoao/wirerush scrub.
6. Manuka/*Baumea rubiginosa*/*Juncus articulatus* scrub.
7. *Olearia virgata* scrub (on southern arm of Irirangi Swamp).
8. Swamp flax/wirerush-umbrella fern flax rushland.

The *Baumea* dominated sedgelands and other minor reed-dominated vegetation types on oligotrophic peat bogs are not represented in protected areas or RAPs in Moawhango Ecological District. Low hills in the north and west support manuka scrub. Several sheltered arms of the swamp support mixed shrubland and scrub, dominated by *Olearia virgata* and manuka, with less *Coprosma tenuifolia* and *Cordyline australis*, vegetation not represented on Ngamatea (West) Swamp. Forest vegetation on the southern catchment slopes is similar to lower-altitude plateau forests of Hihitahi Forest Sanctuary namely, Hall's totara-kaikawaka with scattered rimu over mixed shrub hardwoods of putaputaweta, lacebark, horopito, wineberry, and *Coprosma* sp. (t) (Eagle 1982).

Irirangi Swamp is floristically important for the recent discovery of probably the largest known population of *Prasophyllum* sp. (aff. *P. patens*), an orchid with a nationally 'vulnerable' status (C.C. Ogle, Department of Conservation, pers. comm. 1992).

The dissimilarities in topography and reed vegetation Irirangi Swamp has with Moawhango Ecological Region suggest that the area be prioritised by the Conservancy as an additional RAP to those in this report. However, a detailed proposal for the protection of a representative part or parts of the Irirangi wetlands has yet to be formulated, and boundaries for an Irirangi RAP are not shown in this PNA Programme survey report on Moawhango ER.

FINAL COMMENTS

Moawhango Ecological Region is poorly served with roads, and it supports only one small town (Waiouru). The Region has no parks or protected areas popular to outdoor recreationalists, except deer stalkers, and has no popular thoroughfares to surrounding protected areas. Consequently the Region is little recognised or appreciated by the general public. This low level of public familiarity belies the wealth of natural assets embodied in the Region, and the potential for land to be protected and managed to raise the district's natural history profile.

This report deals with vegetation - its dynamics and instability, its responses to human disturbance, and the degree to which it can be classed as natural and intact. It examines ecological processes, and how landscapes develop over geological time. The future design, implementation, and management of PNAs will need to draw upon this ecological perspective of change, and must recognise the antiquity of some landform surfaces and attendant ecosystems.

These landscapes show ecosystem and plant community variety at different scales. Forested plateaux and hill country are inherently uniform ecosystems over large areas within altitudinal bands, but there is community and ecosystem diversity at small-scales in many non-forest sites and in secondary landscapes. To maintain secondary landscapes for high community diversity may involve frequent fire disturbance, even though such management would be antagonistic to the development of more stable communities. The community diversity of landscapes subjected to a pattern of small fires, for instance the Defence land, offers higher diversity than areas with infrequent large-scale fires, e.g., the Taruarau River catchment.

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REFERENCES

Abernathy, B. 1990: Preliminary analysis of the small landsnail fauna of the Aorangi-Awarua Block. Report to the Rangitikei District Council Planning Hearing on application by Reeves Contractors to log the Aorangi-Awarua Block.

Allan, H.H. 1961. Flora of New Zealand, Vol. 1. Government Printer, Wellington. 1085p.

Anon. 1886: Survey map 832.41bj/1886/3779, Te Awarua Block. Scale indeterminate. Wellington, Alexander Turnbull Library.

Anon. 1895: Survey map 832.41gbbd/ca. 1895/389, Part of the Oruamatua Kaimanawa Block. Scale 1:31680. Wellington, Alexander Turnbull Library.

Anon. 1987: Aorangi-Awarua Resource Report. Prepared for the Regional Manager, Department of Conservation, Wanganui.

Aston, B.C. 1914: Art. VII-Plant habitats hitherto unrecorded. *Transactions of the New Zealand Institute 47*: 67-70.

Atkinson, I.A.E. 1985: Derivation of vegetation mapping units for an ecological survey of Tongariro National Park, North Island, New Zealand. *New Zealand journal of botany 23*: 361-378.

Batley, R.A.L. 1956: Some practical aspects of dendrochronology in New Zealand. *Journal of the Polynesian Society 65*: 232-244.

Bell, B.D. 1986: The conservation status of New Zealand wildlife. Occasional publication No. 12. New Zealand Wildlife Service. Department of Internal Affairs, Wellington.

Beu, A.G.; Browne, G.H.; Grant-Taylor, T.L. 1981: New *Clamys delicata* localities in the central North Island and uplift of the Ruahine Range. *New Zealand Journal of Geology and Geophysics 24*: 127-132.

Browne G.H. 1978: Wanganui strata of the Mangaohane plateau, northern Ruahine Range, Taihape. *Tane 24*: 199-210.

Brownsey, P.J.; Given, D.R.; Lovis, J.D. 1985: A revised classification of New Zealand pteridophytes with a synonymic checklist of species. *New Zealand Journal of Botany 323*: 431-489.

Brownsey, P.J.; Smith-Dodsworth, J.C. 1989: New Zealand ferns and allied plants. Auckland, David Bateman. 168p.

Cameron, E.K.; de Lange, P.J.; Given, D.R.; Johnson, P.N.; Ogle, C.C. 1993: New Zealand threatened and local plant lists 1993. New Zealand Botanical Society Newsletter Supplement 1.

Campbell, I.B. 1979: Soils of Rangitikei County, North Island, New Zealand. New Zealand Soil Bureau Report 38. Wellington, DSIR.

Cheeseman, T.F. 1925: Manual of the New Zealand flora. 2nd ed. Government Printer, Wellington.

Colenso, W. 1884: In Memoriam. An account of visits to and crossings over the Ruahine Range. Daily Telegraph, Napier.

Collier, K.; Wakelin, M. 1990: Invertebrate fauna and ecological value of Ohutu Stream, Ruahine Ranges. Internal Report No. 81. Science and Research Division, Department of Conservation, Wellington. 7p.

Commission for the Environment 1986: New Zealand wetlands management policy. Wellington, Commission for the Environment. 8p.

Connor, H.E.; Edgar, E. 1987. Name changes in the indigenous New Zealand flora, 1960-1986 and nomina nova IV, 1983-1986. *New Zealand Journal of Botany 25*: 115-170.

Cotton, C.A. 1926: Geomorphology. Revised 7th edition 1958. Wellington, Whitcombe and Tombs.

Christian, C.S. 1957: The concept of land systems and land units. *Proceedings of the Nineth Pacific Science Congress 20*: 74-81.

Druce, A.P. 1972a: Indigenous higher plants in the vicinity of Taihape. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P. 1972b: Higher plants (lycopods, ferns, gymnosperms, flowering plants) of Ngamatea Swamp, Tikitiki Bush, Lake Horotea, and upper Taruarau valley, southern Kaimanawa Mountains. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P. 1973a: Vascular plants of limestone plateau, N.W. Ruahine Range. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P. 1973b: Vascular plants of Reporoa Bog, N.W. Ruahine Range. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P. 1973c: Indigenous higher plants (lycopods, ferns, gymnosperms, flowering plants) of Hautapu and Moawhango catchments, and adjacent areas, S.W. Kaimanawa Mountains. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P. 1973d: Indigenous higher plants (lycopods, ferns, gymnosperms, flowering plants) of Aorangi (Mt), N.W. Ruahine Range. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P. 1975: Indigenous higher plants in the vicinity of Ikawatea Gorge, N. Ruahine Range. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P. 1978: Indigenous higher plants in the vicinity of Mataroa, N.W. of Taihape. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P. 1979: Indigenous vascular plants of Ruahine Range. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P. 1982: Indigenous higher plants (lycopods, ferns, gymnosperms, flowering plants) of Moawhango valley between Moawhango and Taoroa Junction, east of Taihape. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P. 1985: Indigenous higher plants (lycopods, ferns, gymnosperms, flowering plants) of Moawhango greywacke gorges, S.W. Kaimanawa Mountains. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P. 1986: Indigenous higher plants (lycopods, ferns, gymnosperms, flowering plants) of Kaimanawa Mountains and adjacent areas. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P.; Ogle, C.C. 1988: Indigenous higher plants (lycopods, ferns, gymnosperms, flowering plants) of Ngaurukehu Scientific Reserve, Hautapu valley, N. W. of Taihape. Revised 1991. Botany Institute, DSIR Land Resources, Lower Hutt.

Druce, A.P.; Williams, P.A.; Heine, J.C. 1987: Vegetation and flora of Tertiary calcareous rocks in the mountains of western Nelson, New Zealand. *New Zealand Journal of Botany 25*: 41-78.

Druce, A.P.; Williams, P.A. 1989: Vegetation and flora of the Ben More-Chalk Range area of southern Marlborough, South Island, New Zealand. New Zealand Journal of Botany 27: 167-199.

Elder, N.L. 1959: Vegetation of the Kaweka Range. *Transactions of the Royal Society of New Zealand 87*: 9-26.

Elder, N.L. 1962: Vegetation of the Kaimanawa Range. *Transactions of the Royal Society of New Zealand, Botany 2*: 1-37.

Elder, N.L. 1965: Vegetation of the Ruahine Range: an introduction. *Transactions of the Royal Society, Botany 3*: 13-66.

Eagle, A. 1982. Eagle's trees and shrubs of New Zealand. Second Series. Collins, Auckland. 311p.

Eyles, G.O. 1969 (unpublished): Land use capability survey of the upper Ngaruroro catchment, North Island, New Zealand. Napier, Ministry of Works.

Froggatt, P.C.; Rogers, G.M. 1990: Tephrostratigraphy of high altitude peat bogs along the axial ranges, North Island, New Zealand. *New Zealand journal of geology and geophysics 33*: 111-124.

Gregg, D.R. 1960: The Geology of Tongariro Subdivision. New Zealand Geological Survey, Bulletin No. 40. Wellington, Department of Scientific and Industrial Research.

Grindley, G.W. 1960: Sheet 8, Taupo (Ist Ed.), Geological Map of New Zealand 1:250 000. Wellington, Department of Scientific and Industrial Research.

Healy, A.J.; Edgar, E. 1980: Flora of New Zealand, Vol. III. Government Printer, Wellington. 220p.

Hutchinson, W.M. 1992 (unpublished): A survey for *Leiolopisma microlepis* in western Hawke's Bay, 9-13 March 1992. Department of Conservation, Wanganui.

Ingham, C.E. 1969: Tongariro Power Development, Geophysical Surveys, Part (3). Seismic investigations of Moawhango dam site and Paradise Valley. Wellington, Geophysics Division, Department of Scientific and Industrial Research Report 56.

Kingma, J.T. 1962: Sheet 11. Dannevirke (Ist ed.) Geological map of New Zealand. 1:250 000. Wellington, Department of Scientific and Industrial Research.

McEwen, M. (ed.) 1987: Ecological Regions and Districts of New Zealand - with four 1:500 000 maps of New Zealand. New Zealand Biological Resources Publication No. 5. Wellington, Department of Conservation. 4 parts.

McGlone, M.S. 1973: Pollen analysis. *In*: Leslie, D.M. *ed.* Relict periglacial landforms at Clark's Junction, Otago. *New Zealand journal of geology and geophysics 16*: 575-585.

McGlone, M.S. 1983: Polynesian deforestation of New Zealand: A preliminary synthesis. *Archaeology in Oceania 18*: 11-25.

Macmillan, B.H. 1991: *Acaena rorida* and *Acaena tesca* (Rosaceae) - two new species from New Zealand. *New Zealand journal of botany 29*: 131-138.

McQueen, D.R. 1972 (unpublished): The ecology of the Motumatai block (proposed Private Scenic Reserve). Wellington, Victoria University of Wellington Botany Department.

Milne, J.D.G. 1973 (unpublished): Upper Quaternary geology of the upper Rangitikei drainage basin, North Island, New Zealand. Ph.D. Thesis, Victoria University of Wellington.

Moore, L.B.; Edgar, E. 1976: Flora of New Zealand, Vol. II. Government Printer, Wellington. 354p.

Muerk, C.D. 1984: Bioclimatic zones for the Antipodes - and beyond? *New Zealand journal of ecology 7*: 175-182.

Myers, S.C.; Park, G.N.; Overmars, F.B. 1987: A guidebook for the rapid ecological survey of natural areas. New Zealand Protected Natural Areas Programme. New Zealand Biological Resources Centre Publication 6. Department of Conservation, Wellington.

Ogle, C.C. 1991: When is dryland wetland? Forest and Bird, August 1991: 46-49.

Ogle, C. C.; Barkla, J. (unpubl.) 1992. Vascular plants of Ngamatea and Irirangi Swamps, Waiouru, Wanganui Plant List No. 41, Department of Conservation, Wanganui. 9p.

Ogle, C.C.; Clerke, P. (unpubl.) 1988: Conservation of botanical and wildlife values of Ngamatea Swamp, Waiouru. Science and Research Internal report No. 37. Wellington, Science and Research Directorate, Department of Conservation. 10p.

Pickard, C.R.; Towns, D.R. 1988: Atlas of the amphibians and reptiles of New Zealand. Conservation Sciences Publication no. 1. Science and Research Directorate, Department of Conservation.

Pritchard, G.C. 1957: Experimental taxonomic studies on species of *Cardamine* Linn in New Zealand. *Transaction of the Royal Society of New Zealand 85*: 75-89.

Rogers, G.M. 1987 (unpublished): Landscape history of Moawhango Ecological Region. Ph.D. Thesis, Victoria University of Wellington.

Rogers, G.M. 1988: Parentless *Pittosporum turneri*. *Wellington Botanical Society Bulletin 44*: 26-36.

Rogers, G.M. 1989a: Beech and conifer community interactions in Moawhango Ecological Region, North Island, New Zealand. *New Zealand journal of ecology 12*: 47-62.

Rogers, G.M. 1989b: The nature of the lower North Island floristic gap. *New Zealand journal of botany 27*: 221-241.

Rogers, G.M. 1989c: Appraisal of the place of wild horses in the Kaimanawa Mountains. Forest Research Institute Contract Report (unpubl.) 31 p.

Rogers, G.M. 1990: Conservation status and future of North Island tussock grasslands. Forest Research Institute Contract Report FWE 90/34 (unpubl.) 15 p.

Rogers, G.M. 1991a: Rates of shrub invasion of North Island tussock grasslands. Forest Research Institute Contract Report FWE 91/33 (unpubl.) 22 p.

Rogers, G.M. 1991b: Kaimanawa feral horses and their environmental impacts. *New Zealand journal of ecology 15*: 49-64.

Rogers, G.M. in press: North Island seral tussock grasslands. 1. Origins and land use history. *New Zealand journal of botany*.

Rogers, G.M. (ed) 1992: Land use impact study of Ministry of Defence lands at Waiouru. Unpublished report for the New Zealand Army by the Manawatu-Wanganui Regional Council, the Department of Conservation, and the Forest Research Institute.

Rogers, G.M.; Leathwick, J.R. in press: North Island seral tussock grasslands. 2. Autogenic succession. Change of tussock grassland to shrubland. *New Zealand journal of botany*.

Rogers, G.M.; McGlone, M.S. 1989: A vegetation history of the southern-central uplands of the North Island. *Journal of the Royal Society of New Zealand 19*: 229-248.

Smith, E. Percy. 1871: Personal diaries of early survey triangulation of central North Island. Alexander Turnbull Library, Wellington.

Sporli, K.B. 1987: Airphoto lineaments and fracturing in the axial ranges of the North Island, New Zealand. *Journal of the Royal Society of New Zealand 17*: 139-156.

Sporli, K.B.; Barter, T.P. 1973: Geological reconnaisance in the Torlesse Super-group of the Kaimanawa Ranges along the lower reaches of the Waipakihi River, North Island, New Zealand. *Journal of the Royal Society of New Zealand 3*: 363-380.

Stevens, G.; McGlone, M.S.; McCulloch, B. 1988: *Prehistoric New Zealand.* Auckland, Heinemann Reed. 128 p.

Technical Advisory Group, PNA Programme 1986: The New Zealand Protected Natural Areas Programme: A scientific focus. Kelly, G.C.; Park, G.N. (eds.) *New Zealand Biological Resources Centre Publication No. 4.* DSIR Science Information Publishing Centre, Wellington.

Thornthwaite, C.W. 1948: An approach towards a rational classification of climate. *Geographical review 38*: 55-94.

Timmins, S.; King, K. 1984: Register of protected natural areas in New Zealand. Department of Lands and Survey, Wellington.

Turbott, E.G. (convenor) 1990: Checklist of the birds of New Zealand and the Ross Dependency, Antarctica (3rd edition). Ornithological Society of New Zealand. 247p.

Ward, J.M. 1982: A key, synopsis, and concordance for *Raoulia. Mauri ora 10*: 11-19.

Webb, C.J.; Sykes, W.R.; Garnock-Jones, P.J. 1988: Flora of New Zealand, Vol. IV. Botany Division, Department of Scientific and Industrial Research, Christchurch. 1365p.

Whitaker, A.H. 1991 (unpublished): A survey for *Leiolopisma microlepis* in the Inland Patea district, upper Rangitikei River catchment, central North Island, with observations on other lizard species: 14-21 January 1991. Report prepared for the Department of Conservation, Wanganui.

Whitehouse, I.E.; Basher, L.R.; Tonkin, P.J. 1990: A landform classification for PNA surveys in eastern Southern Alps. DSIR Land Resources/Lincoln University Soil Science Department unpublished draft report. 32p.

Wilson, C.M.; Given, D.R. 1989: Threatened Plants of New Zealand. Wellington, DSIR Publishing. 151 p.

OTHER REFERENCES

Threatened plants database: unpublished DSIR Land Resources (Lincoln) computer database.

Wetlands of Ecological and Representative Importance (WERI): unpublished Department of Conservation (Head Office) computer database.

APPENDIX 1

Plant species with distributional limits in Moawhango Ecological Region

The southern limits and local abundance of plant species with distributional limits within Moawhango Ecological Region are shown (see also Rogers 1989). The biogeographic groups are:

1. Local endemic.
2. Southern limits of a central North Island endemic.
3. Species that occur only in Moawhango Ecological Region in the North Island and are then disjunct to the South Island.
4. More widespread species in the upper North Island that have southern North Island limits in Moawhango Ecological Region and are then disjunct to the South Island. Under the heading Locality, 'Moawhango' refers to the Moawhango River headwaters region.

Group	Species	Local abundance	Locality
1	*Acaena rorida*	rare	Mangaohane
	Logania depressa	extinct	probably Army country
2	*Carex astonii*	frequent	Mangaohane
	Craspedia sp. (i)#		
	Dracophyllum subulatum	abundant	Ngamatea
	Raoulia sp. (*R. australis* "north" of Ward, 1982)	rare	Ngamatea
	Hebe colensoi	frequent	River gorges and cliffs
	Anaphalis sp. (aff. *A. keriensis*)	frequent	
	Hypericum sp. (aff. *H. japonicum*)	rare	Mangaohane
	Prasophyllum sp. (aff. *P. patens*)	rare	Lake Horotea, Irirangi
	Ranunculus nivicola	frequent	Moawhango headwaters
	Acaena microphylla s.s.	abundant	Moawhango & Ngamatea
	Gentiana sp. (aff. *G. spenceri*)		
	Schoenus fluitans	frequent	Moawhango & Ngamatea
3	*Acaena inermis*	rare	Moawhango
	Agrostis imbecilla	rare	Moawhango
	Cardamine sp. (*C. debilis* agg. "Reporoa Bog slender var.)	rare	Reporoa Bog
	Carex berggrenii	very rare	Moawhango
	Carex petriei	very rare	Moawhango
	Elymus laevis (*Asperella laevis*)		
	Euphrasia disperma	rare	Mangaohane
	Gnaphalium ensifer	very rare	Moawhango
	Koelaria sp. (*K. novozelandica* agg.) [*K. kurtzii*]	very rare	Moawhango
	Luzula sp. (*L. rufa* var. *albicomans*)	very rare	Moawhango
	Myosotis tenericaulis	very rare	Reporoa Bog

	Myosotis sp. (*M. pygmaea* var. *glauca*)	very rare	Moawhango
	Nertera sp. (aff. *N. balfouriana*)	very rare	Moawhango
	Ourisia modesta	very rare	Mangaohane
	Ranunculus recens var.	very rare	Moawhango & Ngamatea
	Tetrachondra hamiltonii	locally abundant	Mangaohane
	Uncinia strictissima	very rare	Ngamatea, Hihitahi
4	*Bulbinella hookeri*	abundant	Mangaohane
	Carex rubicunda	frequent	several non-forest sites
	Carex uncifolia	possibly locally extinct	Moawhango
	Coprosma petriei	frequent	Moawhango & Ngamatea
	Deschampsia novae-zelandiae	frequent	Moawhango
	Deyeuxia sp. (*D. quadriseta* agg.)	frequent	Mangaohane
	Drosera pygmaea	rare	several non-forest sites
	Elymus tenuis	frequent	Moawhango
	Epilobium gracilipes	frequent	Mangaohane
	Epilobium hectori	rare	Moawhango
	Galium sp. (aff. *G. perpusillum*)	frequent	Mangaohane
	Gnaphalium sp. (aff. *G. paludosum*)	frequent	Mangaohane
	Hydrocotyle sulcata	frequent	Moawhango
	Isolepis fluitans	rare	Mangaohane, Irirangi
	Korthalsella clavata	very rare	Ngamatea
	Lachnagrostis sp. (unnamed)	rare	Irirangi
	Lagarostrobus colensoi	very rare	Ngamatea
	Lagenifera montana	rare	Moawhango
	Lagenifera pinnatifida	frequent	Mangaohane
	Luzula decipiens	rare	Mangaohane, Ngamatea
	Microtis oligantha	frequent	Mangaohane
	Myosotis sp. (*M. australis* agg.)	very rare	Moawhango
	Oreomyrrhis sp. (*O. colensoi* var. *delicatula*)	frequent	Moawhango
	Pernettya macrostigma	abundant	Moawhango
	Pimelea microphylla (*P. prostrata* in part)	frequent	Moawhango
	Pittosporum anomalum	very rare	Moawhango
	Plantago triandra s.s.	locally abundant	Mangaohane
	Pseudognaphalium sp. (*P. luteoalbum* agg.)	frequent	Mangaohane
	Pseudopanax ferox	very rare	Moawhango village (probably Rangitikei E.D.)
	Pterostylis humilis	rare	Moawhango
	Ranunculus ternatifolius	very rare	Reporoa Bog
	Ranunculus sp. (*R. lappaceus* var. *macrophyllus*)	frequent	Mangaohane
	Ranunculus simulans	rare	Mangaohane

Raoulia sp. (*R.* sp. K of Ward, 1982)	rare	Moawhango
Rytidosperma pumilum	rare	Moawhango
Rytidosperma tenue	rare	Moawhango
Selliera microphylla	locally abundant	Moawhango & Ngamatea
Senecio glaucophyllus (ssp. *toa* [ssp. raoulii])	very rare	Te Rakaunuiakura
Senecio sp. (*S. glaucophyllus* ssp. *discoideus*)	rare	Moawhango
Stackhousia minima	abundant	Mangaohane

refer Druce et al. (1987) and Druce and Williams (1989) for description

APPENDIX 2

Checklist of native vascular plant species in Moawhango Ecological Region (including RAP9, Irirangi, see text, p. 64).

The list was compiled from Druce (1972a,b; 1973a,b,c,d; 1975; 1978; 1979; 1982; 1985; 1986), Druce and Ogle (1988), Ogle and Barkla (1992) and personal communication with A.P. Druce, Landcare Research, Lower Hutt.

Nomenclature follows Allan (1961), Cheeseman (1925), Connor and Edgar (1987), Healy and Edgar (1980), Moore and Edgar (1976), Brownsey, Given, and Lovis (1985), Webb, Sykes, and Garnock-Jones (1988), unless otherwise indicated.

Abbreviations used:

aff. : affinities with
agg. : aggregate, comprising more than one species
cf. : compare with
s.l. : sensu lato, in the broad sense
sp. : species (singular)
spp. : species (plural)
ssp. : subspecies
s.s. : sensu stricto, in the narrow sense
var. : variety

1. GYMNOSPERMS

Dacrycarpus dacrydioides
Dacrydium cupressinum
Halocarpus bidwillii
Halocarpus biformis
Lagarostrobos colensoi
Lepidothamnus laxifolius
Libocedrus bidwillii
Phyllocladus alpinus agg.
Podocarpus hallii
Podocarpus nivalis
Podocarpus totara s.s.
Prumnopitys ferruginea
Prumnopitys taxifolia

2. TREES AND SHRUBS (Monocots)

Cordyline australis
Cordyline banksii
Cordyline indivisa

3. TREES AND SHRUBS (Dicots)

Alectryon excelsus var. *excelsus*
Alepis flavida
Alseuosmia pusilla
Aristotelia fruticosa var. *microphylla*
Aristotelia serrata
Brachyglottis bidwillii var. *bidwillii*
Brachyglottis repanda s.s.
Brachyglottis rotundifolia var. (described as *Senecio elaeagnifolius)*
Carmichaelia arborea var. (described as *C. odorata)*
Carmichaelia cunninghamii var. (described as *C. flagelliformis)*
Carmichaelia enysii var. *orbiculata*
Carpodetus serratus
Cassinia leptophylla var. (described as *C. vauvilliersii)*
Coprosma acerosa ssp. (unnamed)
Coprosma cheesemanii s.s.
Coprosma colensoi s.s.
Coprosma crassifolia
Coprosma depressa
Coprosma foetidissima
Coprosma grandifolia
Coprosma linariifolia
Coprosma lucida s.s.
Coprosma microcarpa
Coprosma perpusilla ssp. *perpusilla*
Coprosma petriei
Coprosma propinqua ssp. *propinqua*
Coprosma pseudocuneata ssp. *pseudocuneata*
Coprosma rhamnoides s.l.
Coprosma rigida
Coprosma robusta
Coprosma rotundifolia
Coprosma rubra

Coprosma rugosa ssp. *rugosa*
Coprosma sp. (unnamed; aff. *C. cheesemanii)*
Coprosma sp. (unnamed) (called *"C. parviflora* var. *dumosa"* in Flora of New Zealand Vol. 1, but incorrectly so).
Coprosma sp. (described as *C parviflora*), drupes usually unpigmented, occasionally purplish-red
Coprosma tenuifolia
Coprosma virescens
Coriaria arborea
Coriaria kingiana
Coriaria plumosa
Coriaria pteridoides
Corokia cotoneaster var. *cotoneaster*
Cyathodes dealbata
Cyathodes empetrifolia
Cyathodes juniperina agg.
Discaria toumatou
Dracophyllum longifolium var. (described as *D. filifolium)*
Dracophyllum recurvum
Dracophyllum subulatum
Elaeocarpus dentatus s.l.
Elaeocarpus hookerianus
Epacris alpina
Fuchsia excorticata
Gaultheria antipoda
Gaultheria colensoi
Gaultheria rupestris s.l.
Gaultheria sp. (described as *G. depressa* var. *novae-zelandiae)*
Griselinia littoralis
Hebe colensoi s.l.
Hebe macrocarpa var. (described as *H. corriganii)*
Hebe odora s.s.
Hebe stricta var. *stricta*
Hebe subalpina var. (described as *Hebe truncatula)*
Hebe tetragona var. *tetragona*
Hebe venustula
Hebe sp. (described as *Veronica arborea)*
Hebe sp. (described as *Veronica squalida)*
Hebe sp. (described as *H. stricta* var. *egmontiana* and as *H. stricta* var. *lata)*
Helichrysum aggregatum var. *aggregatum*
Hoheria angustifolia
Hoheria populnea var. *lanceolata*
Korthalsella clavata
Korthalsella lindsayi
Kunzea ericoides agg.
Leptospermum scoparium var.
Leucopogon fasciculatus var.
Leucopogon fraseri s.s.
Leucopogon suaveolens
Logania depressa
Lophomyrtus obcordata
Melicope simplex
Melicytus sp. (unnamed; aff. *M. alpinus)*
Melicytus lanceolatus s.l.
Melicytus micranthus s.l.
Melicytus ramiflorus ssp. *ramiflorus*
Myoporum laetum var. *laetum*
Myrsine australis
Myrsine divaricata s.s.
Myrsine nummularia
Myrsine salicina
Neomyrtus pedunculata
Nestegis cunninghamii
Nestegis lanceolata
Nothofagus fusca
Nothofagus menziesii
Nothofagus solandri
Olearia arborescens
Olearia cheesemanii
Olearia colensoi var. *colensoi*
Olearia furfuracea var.
Olearia ilicifolia
Olearia nummulariifolia var. *nummulariifolia*
Olearia rani var. *colorata*
Olearia solandri
Olearia virgata var. (unnamed)
Pennantia corymbosa
Pentachondra pumila
Peraxilla tetrapetala
Pernettya macrostigma
Pimelea aridula var. (unnamed)
Pimelea buxifolia
Pimelea longifolia var. *longifolia*
Pimelea microphylla
Pimelea prostrata
Pimelea suteri var. (described as *P. oreophila)*
Pittosporum anomalum
Pittosporum divaricatum s.l.
Pittosporum eugenioides
Pittosporum rigidum var. *rigidum*
Pittosporum tenuifolium s.l.
Pittosporum turneri
Plagianthus regius var. *regius*
Pseudopanax anomalus
Pseudopanax arboreus var. *arboreus*
Pseudopanax colensoi s.s.
Pseudopanax crassifolius

Pseudopanax edgerleyi
Pseudopanax ferox
Pseudopanax simplex s.l.
Pseudowintera colorata
Schefflera digitata
Solanum aviculare var. *aviculare*
Sophora microphylla
Sophora tetraptera
Streblus heterophyllus
Tupeia antarctica
Urtica ferox

5. LIANES (Dicots)

Calystegia tuguriorum
Clematis foetida
Clematis forsteri
Clematis paniculata
Clematis quadribracteolata
Metrosideros colensoi s.l.
Metrosideros diffusa
Muehlenbeckia australis
Muehlenbeckia axillaris
Muehlenbeckia complexa
Muehlenbeckia ephedroides
Parsonsia capsularis
Parsonsia heterophylla
Passiflora tetrandra
Rubus cissoides var. (unnamed)
Rubus schmidelioides var. *schmidelioides*

6. FERN ALLIES

Lycopodium australianum
Lycopodium fastigiatum
Lycopodium laterale s.l.
Lycopodium scariosum
Lycopodium varium s.l.
Lycopodium volubile

7. FERNS

Adiantum cunninghamii
Asplenium bulbiferum
Asplenium flabellifolium agg.
Asplenium flaccidum
Asplenium gracillimum
Asplenium hookerianum
Asplenium lyallii
Asplenium oblongifolium
Asplenium polyodon
Asplenium richardii
Asplenium terrestre ssp. *terrestre*
Asplenium sp. (unnamed; aff. *A. trichomanes)*
Azolla filiculoides
Blechnum sp. 1 in Brownsey *et al.* (1985)
Blechnum sp. 3 (*ibid*)
Blechnum sp. 2 (*ibid*)
Blechnum chambersii
Blechnum colensoi
Blechnum discolor
Blechnum fluviatile agg.
Blechnum membranaceum
Blechnum minus
Blechnum penna-marina
Blechnum procerum
Blechnum vulcanicum
Botrychium australe
Botrychium biforme
Cheilanthes humilis
Ctenopteris heterophylla
Cyathea colensoi
Cyathea smithii
Cystopteris tasmanica
Dicksonia fibrosa
Dicksonia lanata s.s.
Dicksonia squarrosa
Diplazium australe
Gleichenia dicarpa
Grammitis billardierei
Grammitis ciliata
Grammitis magellanica ssp. *nothofageti*
Grammitis patagonica
Grammitis poeppigiana
Histopteris incisa
Hymenophyllum bivalve
Hymenophyllum cupressiforme
Hymenophyllum demissum
Hymenophyllum dilatatum
Hymenophyllum flabellatum
Hymenophyllum malingii
Hymenophyllum multifidum
Hymenophyllum peltatum
Hymenophyllum pulcherrimum
Hymenophyllum rarum
Hymenophyllum rufescens
Hymenophyllum sanguinolentum agg.
Hymenophyllum villosum
Hypolepis ambigua
Hypolepis millefolium
Hypolepis rufobarbata
Lastreopsis glabella

Leptolepia novae-zelandiae
Leptopteris hymenophylloides
Leptopteris superba
Ophioglossum coriaceum agg.
Paesia scaberula
Pellaea rotundifolia
Phymatosorus pustulatus
Pleurosorus rutifolius
Pneumatopteris pennigera
Polystichum richardii
Polystichum silvaticum
Polystichum vestitum
Pteridium esculentum
Pteris tremula
Pyrrosia eleagnifolia
Rumohra adiantiformis
Schizaea australis
Sticherus cunninghamii
Trichomanes venosum

8. ORCHIDS

Aporostylis bifolia
Caladenia lyallii
Caladenia sp. (unnamed; aff. *C. carnea)*
Chiloglottis cornuta
Corybas macranthus
Corybas oblongus
Corybas rivularis s.s.
Corybas trilobus s.s.
Earina autumnalis
Earina mucronata s.s.
Gastrodia cunninghamii
Gastrodia minor
Microtis oligantha
Microtis parviflora
Microtis unifolia
Orthoceras novae-zeelandiae
Prasophyllum colensoi
Prasophyllum sp. (unnamed; aff. *P. patens*)
Pterostylis banksii
Pterostylis foliata
Pterostylis humilis
Pterostylis patens
Pterostylis tristis
Pterostylis venosa
Pterostylis sp. (unnamed)
Spiranthes novae-zelandiae
Thelymitra cyanea
Thelymitra decora
Thelymitra formosa
Thelymitra hatchii
Thelymitra longifolia

9. GRASSES

Anemanthele lessoniana
Agrostis dyeri s.s.
Agrostis imbecilla
Agrostis muscosa
Agrostis pallescens
Agrostis personata
Amphibromus fluitans
Anemanthele lessoniana
Chionochloa conspicua ssp. *cunninghamii*
Chionochloa pallens ssp. *pallens*
Chionochloa rubra ssp. *rubra*
Cortaderia fulvida
Deschampsia caespitosa var. *micrantha*
Deschampsia novae-zelandiae
Deschampsia tenella
Deyeuxia quadriseta agg.
Deyeuxia aucklandica
Deyeuxia avenoides s.l.
Dichelachne crinita
Echinopogon ovatus
Elymus laevis
Elymus multiflorus
Elymus narduroides
Elymus tenuis
Festuca multinodis
Festuca novae-zelandiae
Festuca sp. (unnamed; aff. *F. rubra)*
Hierochloe recurvata
Hierochloe redolens
Koeleria cheesemanii
Koeleria novozelandica agg.
Lachnagrostis filiformis s.s.
Lachnagrostis striata
Lachnagrostis lyallii s.s. (incl. *L. filiformis* var. *semiglabra*)
Lachnagrostis sp. (unnamed; aff. *L. filiformis)*
Lachnagrostis sp. (unnamed)
Microlaena avenacea
Microlaena polynoda
Microlaena stipoides
Poa anceps ssp. *anceps*
Poa breviglumis
Poa cita ssp. (unnamed)
Poa colensoi
Poa imbecilla
Poa matthewsii

Poa pusilla
Poa sp. (unnamed; aff. *P. novae-zelandiae)*
Rytidosperma australe
Rytidosperma buchananii
Rytidosperma clavatum
Rytidosperma gracile
Rytidosperma merum
Rytidosperma pulchrum
Rytidosperma pumilum
Rytidosperma setifolium
Rytidosperma unarede
Trisetum sp. (unnamed; aff. *T. antarcticum)*
Trisetum sp. (unnamed; aff. *T. antarcticum)*
Trisetum sp. (unnamed)
Zoysia minima

10. SEDGES

Baumea huttonii
Baumea rubiginosa
Baumea tenax
Baumea teretifolia
Carex berggrenii
Carex breviculmis
Carex buchananii
Carex colensoi
Carex comans
Carex coriacea
Carex diandra
Carex dipsacea var. (described as *C. tahoata)*
Carex dissita s.s.
Carex echinata var. (described as *C. stellulata* var. *australis)*
Carex flagellifera
Carex forsteri
Carex gaudichaudiana
Carex geminata
Carex inversa
Carex lambertiana
Carex maorica
Carex petriei
Carex raoulii
Carex rubicunda
Carex secta s.s.
Carex sinclairii
Carex solandri
Carex testacea s.s.
Carex uncifolia
Carex virgata
Carpha alpina s.s.
Eleocharis acuta
Eleocharis gracilis
Eleocharis sphacelata
Isolepis aucklandica
Isolepis caligenis
Isolepis crassiuscula
Isolepis distigmatosa
Isolepis fluitans
Isolepis habra
Isolepis pottsii
Isolepis inundata
Isolepis reticularis
Isolepis subtilissima
Lepidosperma australe
Machaerina sinclairii
Oreobolus pectinatus
Oreobolus strictus
Schoenus apogon s.l.
Schoenus concinnus
Schoenus fluitans
Schoenus maschalinus
Schoenus pauciflorus s.s.
Uncinia caespitosa
Uncinia clavata
Uncinia distans
Uncinia divaricata
Uncinia egmontiana
Uncinia ferruginea
Uncinia filiformis
Uncinia fuscovaginata var. *fuscovaginata*
Uncinia involuta
Uncinia laxiflora
Uncinia leptostachya
Uncinia longifructus
Uncinia rubra
Uncinia rupestris s.l.
Uncinia scabra
Uncinia silvestris s.l.
Uncinia strictissima
Uncinia uncinata
Uncinia viridis
Uncinia zotovii
Uncinia sp. (unnamed; called *"Uncinia affinis"* in Flora of New Zealand Vol. 2, but incorrectly so)
Uncinia sp. (unnamed; aff. *U. nervosa)*

11. RUSHES

Centrolepis ciliata
Centrolepis pallida
Empodisma minus

Juncus antarcticus
Juncus australis
Juncus distegus
Juncus gregiflorus
Juncus holoschoenus
Juncus novae-zelandiae
Juncus pallidus
Juncus pauciflorus
Juncus planifolius
Juncus pusillus
Juncus sarophorus
Luzula colensoi
Luzula decipiens
Luzula leptophylla
Luzula migrata
Luzula picta s.s.
Luzula subclavata
Luzula sp. (described as *L. picta* var. *limosa)*
Luzula sp. (described as *L. rufa* var. *albicomans)*

12. MONOCOTS OTHER THAN ORCHIDS, GRASSES, SEDGES,AND RUSHES

Arthropodium candidum
Astelia fragrans
Astelia grandis
Astelia solandri
Astelia sp. (unnamed; aff. *A. nervosa)*
Bulbinella hookeri
Collospermum microspermum
Dianella nigra
Herpolirion novae-zelandiae
Lemna sp. (called *"L. minor"* in Flora of New Zealand Vol. 2)
Libertia grandiflora
Libertia ixioides
Libertia peregrinans
Libertia pulchella
Luzuriaga parviflora
Phormium cookianum
Phormium tenax
Potamogeton cheesemanii
Potamogeton suboblongus
Triglochin striata
Typha orientalis
Wolffia australiana

13. COMPOSITE HERBS

Abrotanella caespitosa
Anaphalis keriensis s.s.
Anaphalis subrigida
Anaphalis sp. (unnamed; aff. *A. keriensis)*
Anaphalis sp. (described as *Xeranthemum bellidioides)*
Anaphalis sp. (unnamed; aff. *Xeranthemum bellidioides)*
Brachyglottis lagopus var. *lagopus*
Brachyscome radicata
Celmisia glandulosa var. *glandulosa*
Celmisia gracilenta agg.
Celmisia incana s.l.
Celmisia spectabilis ssp. *spectabilis*
Celmisia sp. (unnamed; called *"C. graminifolia"* in Flora of New Zealand Vol. 1 but incorrectly so)
Craspedia minor var. *minor*
Craspedia viscosa
Craspedia sp. (unnamed)
Craspedia sp. (unnamed)
Gnaphalium audax
Gnaphalium delicatum
Gnaphalium ensifer
Gnaphalium gymnocephalum
Gnaphalium involucratum
Gnaphalium limosum s.s.
Gnaphalium mackayi s.s.
Gnaphalium paludosum s.s.
Gnaphalium polylepis
Gnaphalium ruahinicum
Gnaphalium traversii
Gnaphalium sp. (unnamed; aff. *G. paludosum)*
Helichrysum filicaule
Lagenifera cuneata
Lagenifera montana
Lagenifera petiolata
Lagenifera pinnatifida
Lagenifera pumila
Lagenifera strangulata
Leptinella pusilla
Leptinella sp. (unnamed; aff. *L. squalida)*
Leucogenes leontopodium
Microseris scapigera
Pseudognaphalium sp. (unnamed aff. *P. luteoalbum)*
Pseudognaphalium sp. (unnamed aff. *P. luteoalbum)*
Raoulia albosericea
Raoulia glabra
Raoulia grandiflora var. *grandiflora*
Raoulia tenuicaulis s.l.
Raoulia sp. (unnamed; aff. *R. australis)*
Raoulia sp. (unnamed; aff. *R. monroi)*
Senecio glaucophyllus ssp. *toa*
Senecio glomeratus

Senecio minimus
Senecio quadridentatus
Senecio rufiglandulosus var. *rufiglandulosus*
Senecio wairauensis
Senecio sp. (described as *S. lautus* var. *discoideus)*
Taraxacum magellanicum
Vittadinia australis agg.

14. OTHERS (D)

Acaena rorida
Acaena anserinifolia
Acaena emittens
Acaena inermis
Acaena juvenca
Acaena microphylla
Acaena profundeincisa
Aciphylla colensoi var. *colensoi*
Aciphylla sp. (unnamed; aff. *A. squarrosa)*
Anisotome aromatica
Australina pusilla
Callitriche petriei ssp. *petriei*
Cardamine corymbosa agg.
Cardamine sp. ("Long Style" of Pritchard 1957)
Cardamine sp. ("Narrow Petal" of Pritchard 1957)
Cardamine sp. ("Glossy Leaf" of Pritchard 1957)
Cardamine sp. (described as *C. debilis* "slender var." in Flora of New Zealand Vol. 1)
Cardamine sp. ("Scree Race" of Pritchard 1957)
Cardamine sp. ("Tussock Race" of Pritchard 1957)
Centella uniflora
Colobanthus apetalus s.l.
Colobanthus strictus
Colobanthus sp. (unnamed; aff. *C. buchananii)*
Crassula sieberiana
Dactylanthus taylorii
Dichondra repens var.
Dichondra sp. (unnamed; *D. brevifolia)*
Drosera arcturi
Drosera binata
Drosera peltata ssp. *auriculata*
Drosera pygmaea
Drosera spathulata
Epilobium alsinoides s.s.
Epilobium astonii
Epilobium atriplicifolium s.s.
Epilobium billardiereanum s.s.
Epilobium brunnescens s.s.
Epilobium chionanthum
Epilobium chlorifolium
Epilobium cinereum
Epilobium cockayneanum
Epilobium glabellum s.s.
Epilobium gracilipes
Epilobium hectorii s.s.
Epilobium insulare
Epilobium komarovianum
Epilobium linnaeoides
Epilobium macropus
Epilobium melanocaulon
Epilobium microphyllum
Epilobium nerteroides
Epilobium nummulariifolium
Epilobium pallidiflorum
Epilobium pedunculare s.s.
Epilobium pernitens
Epilobium pubens
Epilobium pycnostachyum
Epilobium rotundifolium
Epilobium tenuipes s.s.
Epilobium sp. (described as *E. brunnescens var. minutiflorum)*
Euphrasia cuneata
Euphrasia disperma var. *disperma*
Euphrasia revoluta
Euphrasia zelandica var.
Forstera bidwillii s.l.
Forstera tenella
Galium perpusillum s.s.
Galium propinquum
Galium trilobum
Galium sp. (unnamed; aff. *G. perpusillum)*
Gentiana bellidifolia s.s.
Gentiana grisebachii s.s.
Gentiana montana s.l.
Gentiana sp. (unnamed; aff. *G. spenceri)*
Geranium microphyllum
Geranium potentilloides var. *potentilloides*
Geranium sessiliflorum var. *novae-zelandiae*
Geum leiospermum
Geum parviflorum agg.
Gingidia montana
Glossostigma elatinoides
Gonocarpus aggregatus
Gonocarpus micranthus ssp. *micranthus*
Gratiola sexdentata
Gunnera dentata var. *dentata*
Gunnera monoica
Gunnera prorepens
Haloragis erecta ssp. *erecta*
Hydrocotyle dissecta

Hydrocotyle elongata
Hydrocotyle heteromeria
Hydrocotyle hydrophila
Hydrocotyle microphylla
Hydrocotyle moschata
Hydrocotyle novae-zeelandiae s.s.
Hydrocotyle pterocarpa
Hydrocotyle sulcata
Hydrocotyle sp. (described as *H. novae-zelandiae* var. *montana*)
Hypericum japonicum
Hypericum sp. (unnamed; aff. *H. japonicum)*
Hypsela rivalis
Jovellana sinclairii
Kelleria dieffenbachii
Kelleria laxa
Lilaeopsis ruthiana
Limosella lineata
Linum monogynum var. *monogynum*
Liparophyllum gunnii
Mazus radicans s.s.
Mentha cunninghamii
Montia fontana s.s.
Myosotis eximia
Myosotis forsteri
Myosotis pygmaea s.s.
Myosotis spathulata s.l.
Myosotis tenericaulis
Myosotis venosa
Myosotis sp. (unnamed; aff. *M. pygmaea)*
Myosotis sp. (unnamed; aff. *M. australis)*
Myosotis sp. (described as *M. pygmaea* var. *drucei*)
Myosotis sp. (described as *M. pygmaea* var. *glauca)*
Myriophyllum pedunculatum ssp. *novae-zealandicum)*
Myriophyllum propinquum
Myriophyllum triphyllum
Neopaxia sp. (described as *Claytonia calycina)*
Nertera balfouriana
Nertera ciliata
Nertera depressa
Nertera scapanioides
Nertera setulosa
Nertera sp. (unnamed; aff. *N. balfouriana)*
Nertera sp. (unnamed; aff. *N. dichondrifolia)*
Oreomyrrhis colensoi s.s.
Oreomyrrhis ramosa
Oreomyrrhis sp. (described as *O. colensoi var. delicatula)*
Oreostylidium subulatum
Ourisia colensoi
Ourisia lactea ssp. *drucei*
Ourisia macrophylla ssp. *robusta*
Ourisia modesta
Ourisia vulcanica
Oxalis exilis
Oxalis magellanica agg.
Parahebe diffusa ssp. *diffusa*
Parahebe hookeriana
Parahebe spathulata
Parietaria debilis
Phyllachne colensoi s.l.
Plantago novae-zelandiae
Plantago raoulii var.
Plantago triandra s.s.
Plantago uniflora
Potentilla anserinoides
Pratia angulata agg.
Psychrophila novae-zealandiae
Ranunculus amphitrichus
Ranunculus cheesemanii var. (described as *R. carsei)*
Ranunculus glabrifolius
Ranunculus insignis
Ranunculus membranifolius
Ranunculus multiscapus s.s.
Ranunculus nivicola
Ranunculus recens var. (unnamed)
Ranunculus reflexus
Ranunculus royi
Ranunculus simulans
Ranunculus ternatifolius
Ranunculus sp. (described as *R. lappaceus var. macrophyllus)*
Rumex flexuosus
Scandia rosifolia agg.
Schizeilema colensoi
Schizeilema nitens
Schizeilema trifoliolatum
Scleranthus biflorus
Scleranthus uniflorus
Selliera microphylla
Stackhousia minima
Stellaria decipiens s.l.
Stellaria gracilenta
Tetrachondra hamiltonii
Urtica incisa
Utricularia novae-zelandiae
Viola cunninghamii
Viola filicaulis
Viola lyallii
Wahlenbergia albomarginata var. *pygmaea*
Wahlenbergia rupestris

APPENDIX

Endangered, threatened, vulnerable, and local species in Moawhango Ecological Region
Under the heading Locality, 'Moawhango' refers to the Moawhango River headwaters region.

WILDLIFE

Species	Common name	Category*
Equus caballus	feral horse	rare
Hymenolaimus malacorhynchos	blue duck	threatened
Falco novaeseelandiae	New Zealand falcon	threatened
Charadrius bicinctus bicinctus	banded dotterel	threatened
Nestor meridionalis septentrionalis	North Island kaka	threatened
Eudynamys taitensis	long-tailed cuckoo	rare
Leiolopisma microlepis	Taihape skink	indeterminate

PLANTS

Species	Local abundance	Category*	Locality
Logania depressa	unknown	extinct	Moawhango (endemic)**
Acaena rorida	rare	endangered	Mangaohane
Amphibromus fluitans	very rare	endangered	Moawhango
Pterostylis micromega	rare	endangered	Moawhango
Alepis flavida	unknown	vulnerable	unknown
Deschampsia caespitosa	very rare	vulnerable	Ngamatea and Mangaohane
Myosotis sp. "Volcanic Plateau" (aff. *M. pygmaea*)	rare	vulnerable	Moawhango and Mangaonane
Peraxilla tetrapetala	unknown	vulnerable	east of Potae
Pittosporum turneri	rare	vulnerable	Mangaohane
Prasophyllum sp. unnamed (aff. *P. patens*)	rare	vulnerable	Lake Horotea and Irirangi
Ranunculus recens var. *recens*	rare	vulnerable	Moawhango and Ngamatea
Ourisia modesta	very rare	rare	Mangaohane
Pittosporum turneri	rare	rare	Mangaohane
Ranunculus ternatifolius	very rare	rare	Reporoa Bog
Tupeia antarctica	unknown	rare	
Libertia peregrinans	possibly locally extinct	i & k***	Hihitahi
Myosotis sp. *(M. pygmaea* var. *glauca*)	rare	i & k	Moawhango
Pimelea aridula	rare	i & k	Moawhango & Ngamatea
Pleurosorus rutifolius	rare	local	Pohokura
Pseudopanax ferox	very rare	local	Moawhango village
Tetrachondra hamiltonii	locally abundant	local	Mangaohane
Cardamine sp. (*C. debilis* agg. "Reporoa Bog slender var.")	rare	local (endemic)	Reporoa Bog

* from Bell (1986) and Cameron *et al.* (1993)
** appears in Cameron *et al.* (1993) as taxonomically indeterminate
*** appears in Cameron *et al.* (1993) as indeterminate and insufficiently known

APPENDIX

Checklist of vertebrate wildlife species in Moawhango Ecological Region (bird names after Turbott 1990)

Birds

Australian magpie	*Gymnorhina tibicen*
blackbird	*Turdus merula merula*
California quail	*Callipepla californica brunnescens*
Canada goose	*Branta canadensis*
chaffinch	*Fringilla coelebs gengleri*
greenfinch	*Chloris chloris chloris*
goldfinch	*Carduelis carduelis britannica*
hedge sparrow, dunnock	*Prunella modularis occidentalis*
house sparrow	*Passer domesticus domesticus*
kahu, Australasian harrier	*Circus approximans gouldi*
kaka, North Island	*Nestor meridionalis septentrionalis*
kakariki, parakeet	*Cyanoramphus* spp.
karearea, New Zealand falcon	*Falco novaeseelandiae*
karoro, southern black-backed gull	*Larus dominicanus*
kawau, black shag	*Phalacrocorax carbo novaehollandiae*
kereru, New Zealand pigeon	*Hemiphaga novaeseelandiae novaeseelandiae*
koekoea, long-tailed cuckoo	*Eudynamys taitensis*
korimako, bellbird	*Anthornis melanura melanura*
kotare, New Zealand kingfisher	*Halcyon sancta vagans*
little shag	*Phalacrocorax melanoleucos brevirostris*
mallard	*Anas platyrhynchos platyrhynchos*
matuku, Australasian bittern	*Botaurus stellaris poiciloptilus*
North Island fantail	*Rhipidura fuliginosa placabilis*
North Island fernbird	*Bowdleria punctata vealeae*
North Island kaka	*Nestor meridionalis septentrionalis*
North Island rifleman	*Acanthisitta chloris granti*
parera, grey duck	*Anas superciliosa superciliosa*
pheasant	*Phasianus colchicus*
pied tit	*Petroica macrocephala toitoi*
pied stilt	*Himantopus himantopus leucocephalus*
pihoihoi, New Zealand pipit	*Anthus novaeseelandiae novaeseelandiae*
pipiwharauroa, shining cuckoo	*Chrysococcyx lucidus lucidus*
pohowera, banded dotterel	*Charadrius bicinctus bicinctus*
pukeko, swamp hen	*Porphyrio melanotus*
putangitangi, paradise shelduck	*Tadorna variegata*
redpoll	*Carduelis flammea cabaret*
riroriro, grey warbler	*Gerygone igata igata*
ruru, morepork	*Ninox novaeseelandiae novaeseelandiae*
skylark	*Alauda arvensis arvensis*
song thrush	*Turdus philomelos*

spur-winged plover	*Vanellus miles novaehollandiae*
starling	*Sturnus vulgaris vulgaris*
tauhou, silvereye	*Zosterops lateralis lateralis*
tui	*Prosthemadera novaeseelandiae*
welcome swallow	*Hirundo tahitica neoxena*
whio, blue duck	*Hymenolaimus malacorhynchos*
white-faced heron	*Ardea novaehollandiae*
whitehead	*Mohoua albicilla*
yellowhammer	*Emberiza citrinella caligosa*

Fish

brook char	*Salvelinus fontinalis*
brown trout	*Salmo trutta*
common bully	*Gobiomorphus cotidianus*
common river galaxias	*Galaxias vulgaris*
lamprey	*Geotria australis*
long-finned eel	*Anguilla dieffenbachii*
rainbow trout	*Salmo gairdnerii*

Introduced mammals

brush-tailed possum	*Trichosurus vulpecula*
cattle	*Bos taurus*
feral pig	*Sus scrofa*
hare	*Lepus europaeus*
hedgehog	*Erinaceus europaeus*
feral horse	*Equus caballis*
kiore (recorded in past)	*Ratus exulans*
mouse	*Mus musculus*
Norwegian rat (brown rat)	*Rattus norvegicus*
rabbit	*Oryctolagus cuniculus*
red deer	*Cervus elaphus*
sheep	*Ovis aries*
ship rat (black rat)	*Rattus rattus*
sika deer	*Cervus nippon*
stoat	*Mustella erminea*

Lizards

common gecko	*Hoplodactylus maculatus* "maxi"
small-scaled skink	*Leiolopisma microlepis*
3	*Leiolopisma nigriplantare polychroma*
	Leiolopisma nigriplantare maccanni
speckled skink	*Leiolopisma infrapunctatum*

SYSTEM	LANDFORMS	GEOLOGY	SOILS	ALTITUDE	CLIMATE	VEGETATION
MOAWHANGO	hard rock landforms: dissected horizontal peneplain as flat-topped convex ranges separated by wide concave basins and valleys with swales; moderate relief precipitous antecedent gorges	Kaimanawa greywacke - alternating argillite and sandstone with tuffs; Kaimanawa schist - central band of pelitic schist and conglomerate this overlying Tertiary remnants mantling post-glacial andesitic ashes and deep Taupo Pumice - infilled basins	Taruarau and Ngamatea soils derived from Ngauruhoe and Taupo ashes over Tongariro ash Kaimanawa, Kaweka, Waiouru, and Ngauruhoe soils derived from Ngauruhoe, Taupo and Tongariro ashes over greywacke	mostly upper montane-alpine: 900 m in intermontane basins to 1650 m peaks of the southern Kaimanawas	rainfall 1200-2200 mm/annum predominantly from west; summer-dry	red tussock - hard tussock grassland; monoao shrubland: manuka shrubland: kanuka scrub - low forest mountain beech forest
RANGITIKEI	soft rock landforms: gently-tilted plateaux separated by deep fault-aligned valleys steep escarpments capped with limestone rimrocks	Fossiliferous calcareous sandy siltstones with capping limestones thin late-glacial loess mantling post-glacial andesitic ash	Waiouru soils derived from Ngauruhoe ash over Taupo Pumice and Tongariro ash: Moawhango soils derived from Tongariro ash: Ngamatea soils derived from thin Taupo Pumice over Tongariro ash Mangamahu soils derived from soft sedimentary rock	500 m at Moawhango village to 1200 m on the Tikitiki ridge, Ngamatea	rainfall 900-1300 mm/annum predominantly from west; summer-dry	kaikawaka - Hall's totara forest; matai - totara/houhere forest; matai - Hall's totara/broadleaf forest; lowland ribbonwood forest
OWHAOKO	hard rock landforms: tilted peneplain with shallowly incised streams	Kaimanawa greywacke - alternating argillite and sandstone with tuffs thin mantling post-glacial andesitic and rhyolitic ash	Kaimanawa and Otupae soils derived from Ngauruhoe and Tongariro ash over grewacke Taruarau and Ngamatea soils derived from Ngauruhoe and Tongariro ash over greywacke	800 m in the Taruarau River valley to 1300 m at Meany	rainfall 1400-1800 mm/annum predominantly from northwest and east; summer-dry	red tussock - hard tussock grassland monoao shrubland; manuka shrubland; kanuka scrub remnant peripheral mountain beech forest
MANGAOHANE	both hard rock and soft rock landforms: gently-tilted fault-separated plateaux with bog-depressions and sinkholes: rounded knolls and ridges	Cocquina limestones, calcareous sandstones and siltstones with thin greywacke conglomerates mantling post-glacial andesitic ash	Titapu and Moawhango soils derived from Tongariro and Ngauruhoe ash over sedimentary rock Waiaruhe soils derived from sedimentary rock	700 m in the Pokopoko Stream valley to 1320 m at Potae	rainfall 1500-1800 mm/annum predominantly from east and southwest; equable distribution	red tussock grassland and inaka shrubland mountain toatoa forest; kaikawaka - pink pine/mountain toatoa forest; red beech - mountain beech forest; rimu/black beech forest/matai - totara - kahikatea - rimu forest

APPENDIX 5

APPENDIX 6

Checklist of ecological units in Moawhango Ecological Region

Bioclimatic Zones	Hydrologic element	Landscape unit	Vegetation structural class	Ecological Vegetation type	Unit Landform	PNA number	RAP number
montane-subalpine	terrestrial	hill country	forest	mountain beech	hard rock hillslope	3, 4	6, 8
					colluvial toeslope	3, 4	6
					ridge top	3, 4	8
					valley floor	3, 4	6
					knoll		6
					gorge	3, 4	2,5
montane-subalpine	terrestrial	hill country	forest	mountain beech	soft rock hillslope	2	5
					plateau	2	5
					escarpment slope	2	5
montane-subalpine	terrestrial	hill country	forest	red beech	soft rock hillslope	2	1
					plateau	1,2	1
					escarpment slope	2	1
					valley floor	2	
					gorge	2	
montane-subalpine	terrestrial	hill country	forest	mountain beech-red beech-silver beech	hard rock hillslope		7
					ridge top		7
					valley floor		7
					gorge		7
montane-subalpine	terrestrial	hill country	forest	red beech-mountain beech	hard rock hillslope		4
					ridge top		4
montane-subalpine	terrestrial	hill country	forest	red beech-mountain beech	soft rock hillslope		4, 5
					plateau		4, 5
					escarpment slope		4
					valley floor		4
montane	terrestrial	hill country	forest	rimu/red beech-mountain beech	soft rock hillslope		5
					plateau		5
montane	terrestrial	hill country	forest	rimu/black beech	soft rock hillslope	2	1
					plateau		1
					escarpment slope	2	1
montane	terrestrial	hill country	forest	matai-kahikatea	soft rock hillslope		1
					plateau		1
					escarpment slope		1
					gorge		1
montane	terrestrial	hill country	forest	matai-totara-rimu-kahikatea/broad-leaved species	soft rock hillslope	1,2	1
					plateau	1,2	1
					escarpment slope	1,2	1
montane	terrestrial	hill country	forest	matai-kahikatea/-black beech	soft rock hillslope	2	1
					plateau	2	1
					escarpment slope		1
					gorge		1

montane	terrestrial	hill country	forest	black beech	soft rock hillslope	2	1
					valley floor		1
montane-subalpine	terrestrial	hill country	forest	mountain toatoa	soft rock hillslope	1,2	1
					plateau	1	1
					escarpment slope	2	1
					valley floor	2	1
montane-subalpine	terrestrial	hill country	forest	mountain toatoa/inaka	soft rock hillslope	2	1
					escarpment slope	2	1
					valley floor	2	1
subalpine	terrestrial	hill country	forest	kaikawaka-Hall's totara	soft rock hillslope	1	
					plateau	1	
					escarpment slope	1	
					valley floor	1	
					gorge	1	
subalpine	terrestrial	hill country	forest	kaikawaka-pink pine	soft rock hillslope	2	1
					plateau	2	1
					escarpment slope	2	1
					valley floor	2	1
					gorge	2	1
subalpine	terrestrial	hill country	forest	kaikawaka-pink pine	hard rock ridge	2	1
montane	terrestrial	hill country	forest	kowhai-putaputa-weta-*Hoheria*	hard rock gorge		5
montane	terrestrial	hill country	forest	*Hoheria*-lance-wood/mountain flax	hard rock gorge		5
subalpine	terrestrial	hill country	forest	tupaare	hard rock ridge	2	
					knoll	2	
montane	terrestrial	hill country	forest	kanuka	hard rock hillslope		2,3,6
					colluvial toeslope		6
					ridge top		6
					knoll		6
montane	terrestrial	hill country	forest	kanuka	soft rock hillslope		2,3
montane	terrestrial	hill country	scrub	kanuka/manuka	hard rock hillslope	3,4	6,7
					colluvial toeslope	3,4	6
					ridge top		7
					valley floor	3,4	6,7
					knoll	4	6
					gorge	4	7
montane	terrestrial	hill country	scrub	kanuka/manuka	soft rock hillslope		2,3,4
					plateau		4
					escarpment slope		4
					valley floor		4
montane-subalpine	terrestrial	hill country	shrubland	inaka	soft rock hillslope	1,2	1
					plateau	1,2	1
					escarpment slope	1,2	1
					valley floor		1
					gorge		1

montane-subalpine	terrestrial	hill country	shrubland	manuka	hard rock hillslope	3,4	5,6,7,8
					colluvial toeslope	3,4	5,6,7,8
					spur top		6,8
					valley floor		5,6,7,8
					knoll		6,8
					gorge	4	5,7
montane-subalpine	terrestrial	hill country	shrubland	manuka	soft rock hillslope		1,4,5
					plateau		1,4,5
					escarpment slope		1,4,5
					valley floor		1,4,5
					gorge		1
montane-subalpine	terrestrial	hill country	shrubland	manuka/monoao	hard rock hillslope	3	
					colluvial toeslope	3	
					spur top	3	
					valley floor	3	
montane-subalpine	terrestrial	hill country	shrubland	manuka/monoao	soft rock hillslope		2,3
					basin floor		2,3
montane-subalpine	terrestrial	hill country	tussockland	mountain flax	soft rock hillslope		5
					escarpment slope		5
montane-subalpine	terrestrial	hill country	shrubland	monoao/*Draco-phyllum recurvum*	hard rock knoll		6
					ridge top		6
montane-subalpine	terrestrial	hill country	shrub-tussock grassland	monoao/red tussock/hard tussock	hard rock hillslope	3,4	2,4,8
					colluvial toeslope	3,4	2,4
					ridge top		4,8
					valley floor		2
					knoll	4	8
montane-subalpine	terrestrial	hill country	shrub-tussock grassland	monoao/red tussock/hard tussock	soft rock hillslope	1	2,3
					plateau	1	
					escarpment slope	1	
					valley floor		2
					basin floor		2,3
montane-subalpine	terrestrial	hill country	shrub-tussock -grassland	inaka/red tussock/hard tussock	soft rock hillslope	2	1
					plateau	2	1
					escarpment slope	2	1
					valley floor		1
					basin floor		1
montane-subalpine	terrestrial	hill country	tussock-grassland	red tussock/hard tussock	hard rock hillslope	3	2
					colluvial toeslope	3	2
					ridge top	3	2
					spur top	4	2,7
					valley floor	4	
					knoll	4	
					basin floor	4	
montane-subalpine	terrestrial	hill country	tussock-grassland	red tussock/hard tussock	soft rock hillslope	2	2
					colluvial toeslope	2	2
					plateau	2	4
					escarpment slope	2	
					valley floor		2,4
					basin floor		2

subalpine	terrestrial	hill country	herbfield	flushzone-Moawhango	soft rock hillslope	2
					basin floor	2
montane-subalpine	terrestrial	hill country	sedgeland	tangle-fern-wire rush	soft rock topogenous bog	1,2,8
montane-subalpine	terrestrial	hill country	sedgeland	tangle-fern-wire rush	hard rock ombrogenous bog	8
montane	lacustrine	hill country	herbfield	various herbs and forbs-Awapatu	periodically inundated tarn	7
montane	terrestrial	hill country	herbfield	various herbs and forbs-Awapatu	flushzone on hard rock terrace	7
montane	terrestrial	hill country	gravelfield	monoao/*Pimelea*	pumice-covered soft rock basin floor	2,3
montane	fluvial	hill country	sedgeland	sedges and rushes	seepage channels in soft rock basin floor	2,3
montane	fluvial	hill country	mossland	*Sphagnum*	tarns in soft rock basin	1

APPENDIX 7

Recommended Areas for Protection and land system representation in Moawhango Ecological Region

Recommended Area for Protection	Land System				Area (ha)
	Moawhango	Rangitikei	Owhaoko	Mangaohane	
Aorangi-Awarua (RAP1)				X	4400
Ngawakaakauae (RAP2)	X				1795
Ngamatea East Swamp (RAP3)		X			1763
Tikitiki (RAP4)	x	X			2188
Te Rei (RAP5)		X			2613
Owhaoko (RAP6)			X		1130
Pleasants Bush (RAP7)	X	x			675
Three Kings (RAP8)	X	x			1125
Irirangi (RAP9)		X			*
TOTAL (approx.)					**15689**

Key: X = land system a major component of RAP
x = land system a minor component of RAP
* = boundaries yet to be formalised (see text)

APPENDIX 8

Categories of priority for action on Recommended Areas for Protection in Moawhango Ecological Region

Category 1	Aorangi-Awarua	RAP 1
	Ngawakaakauae	RAP 2
	Ngamatea East Swamp	RAP 3
	Tikitiki	RAP 4
	Irirangi Wetlands	RAP 9
Category 2	Te Rei	RAP 5
	Owhaoko	RAP 6
	Pleasant Bush	RAP 7
	Three Kings	RAP 8

APPENDIX 9

Common and scientific plant names

black beech	*Nothofagus solandri* var. *solandri*
blackberry	*Rubus fruticosus*
black maire	*Nestegis cunninghamii*
blue tussock	*Poa colensoi*
bog pine	*Halocarpus bidwillii*
bracken	*Pteridium esculentum*
bristle tussock	*Rytidosperma setifolium*
broadleaf	*Griselinia littoralis*
broom	*Cytisus scoparius*
browntop	*Agrostis capillaris*
Californian thistle	*Cirsium arvense*
cocksfoot	*Dactylis glomerata*
fescue tussock	*Festuca novae-zelandiae*
fivefinger	*Pseudopanax arboreus*
gorse	*Ulex europaeus*
Hall's totara	*Podocarpus hallii*
harakeke, New Zealand flax	*Phormium tenax*
hard tussock	*Festuca novae-zelandiae*
harebell	*Wahlenbergia albomarginata*
hen and chicken fern	*Asplenium bulbiferum*
hinau	*Eleocarpus dentatus*
horoeka, lancewood	*Pseudopanax crassifolius*
horopito, pepperwood	*Pseudowintera colorata*
inaka	*Dracophyllum longifolium* var. (*D. filifolium*)
kahikatea	*Dacrycarpus dacrydioides*
kaikamako	*Pennantia corymbosa*
kanuka	*Kunzea ericoides*
kaikawaka	*Libocedrus bidwillii*
kohuhu	*Pittosporum tenuifolium*
kowhai	*Sophora microphylla*
lacebark	*Hoheria populnea* var.
lancewood	*Pseudopanax crassifolius*
makomako, wineberry	*Aristotelia serrata*
mahoe	*Melicytus ramiflorus*
manuka	*Leptospermum scoparium*
matai	*Prumnopitys taxifolia*
mid-ribbed snow tussock	*Chinochloa pallens*
miro	*Prumnopitys ferruginea*
mountain beech	*Nothofagus solandri var. cliffortioides*
mountain fivefinger	*Pseudopanax colensoi* var. *colensoi*
mountain flax	*Phormium cookianum*
mountain toatoa	*Phyllocladus alpinus*
patotara	*Leucopogon fraseri*
pink pine	*Halocarpus biformis*

pokaka	*Elaeocarpus hookerianus*
putaputaweta, marbleleaf	*Carpodetus serratus*
pygmy pine	*Lepidothamnus laxifolius*
red beech	*Nothofagus fusca*
red tussock	*Chionochloa rubra*
rewarewa	*Knightia excelsa*
ribbonwood	*Plagianthus regius*
rimu	*Dacrydium cupressinum*
silver beech	*Nothofagus menziesii*
silver tussock	*Poa cita*
snow totara	*Podocarpus nivalis*
sweet vernal	*Anthoxanthum odoratum*
tarata	*Pittosporum eugenioides*
ti kouka, cabbage tree	*Cordyline australis*
titoki	*Alectryon excelsus*
totara	*Podocarpus totara*
tupare	*Olearia colensoi*
umbrella fern	*Gleichenia dicarpa*
white maire	*Nestegis lanceolata*
wineberry	*Aristotelia serrata*
wire rush	*Empodisma minor*
Yorkshire fog	*Holcus lanatus*

APPENDIX 10

Checklist of adventive vascular plants in semi-natural and natural areas of Moawhango Ecological Region

Acaena agnipila	bidibidi
Achillea millefolium	yarrow
Agrostis capillaris	browntop
Aira caryophyllea	silvery hair grass
Anthoxanthum odoratum	sweet vernal
Arctium sp.	burdock
Arenaria serpyllifolia	sandwort
Bromus hordeaceus	soft brome
Callitriche stagnalis	starwort
Calluna vulgaris	ling (Scottish) heather
Capsella bursa-pastoris	shepherd's purse
Carduus tenuiflorus	winged thistle
Carex ovalis	
Cerastium fontanum ssp. *vulgare*	mouse-ear chickweed
Cirsium arvense	Californian thistle
Cirsium vulgare	Scotch thistle
Crepis capillaris	hawksbeard
Cynosurus cristatus	crested dogstail
Dactylis glomerata	cocksfoot
Epilobium ciliatum	
Erodium circutarium	storksbill
Festuca nigrescens	hair fescue
Festuca tenuifolia	sheep fescue
Geranium molle	
Glyceria declinata	floating sweetgrass
Gnaphalium coarctatum	
Gnaphalium sp.	
Hieracium pilosella	mouse ear hawkweed
Holcus lanatus	Yorkshire fog
Hypochoeris radicata	catsear
Hypericum humifusum	trailing St. John's wort
Isolepis setacea	
Juncus effusus	
Juncus articulatus	jointed rush
Lotus suaveolens	hairy birdsfoot trefoil
Leontodon taraxacoides	hawkbit
Leucanthemum vulgare	ox-eye daisy
Linum catharticum	purging flax
Lolium perenne	perennial ryegrass
Lotus pendunculatus	lotus
Mycelis muralis	wall lettuce
Myosotis laxa ssp. *caespitosa*	water forget-me-not
Pinus contorta	lodgepole pine
Plantago major	broad-leaved plantain
Poa annua	

Poa pratensis	Kentucky bluegrass
Poa trivialis	
Prunella vulgaris	selfheal
Ranunculus repens	buttercup
Rumex acetosella	sheep's sorrel
Salix cinerea	grey willow
Sagina procumbens	procumbent pearlwort
Senecio jacobaea	ragwort
Senecio sylvaticus	wood groundsel
Sonchus asper	prickly sow thistle
Stellaria media	chickweed
Taraxacum officinale	dandelion
Trifolium dubium	suckling clover
Trifolium pratense	red clover
Trifolium repens	white clover
Veronica serpyllifolia	
Verbascum thapsus	woolly mullein
Vulpia bromoides	vulpia hairgrass

APPENDIX 11

Glossary of scientific terms

Source reference: Myers *et al.* (1987)

adventive: arriving from outside; in contrast to native; for instance, a plant which grows in the wild but whose presence is directly or indirectly attributable to humans.

alluvium: rock or soil material that has been transported primarily by flowing water.

andesite: a dark coloured, fine-grained volcanic rock of intermediate composition *(i.e.* 52-65% SiO_2).

argillite: a hard, dark grey to black mudstone which, in New Zealand, is commonly associated with greywacke.

bioclimatic zone: One of the categories used in classifying natural ecosystems in the PNA Programme. It refers to the broad distribution of vegetational zones along altitudinal gradients where a particular climatic regime dictates the character of the natural ecosystem. There are eight classes of bioclimatic zone (coastal, semi-coastal, lowland, montane, subalpine, lower alpine, upper alpine, nival). For example - the upper limit of rimu may denote the upper limit of the lowlands bioclimatic zone.

biogeography: The study of the distribution in time and space of organisms.

Cenozoic: That period of geological time spanning the last 65 million years, i.e., the Tertiary and Quaternary epochs.

canopy: The layer or layers formed by the uppermost crown or their parts. The concept is applicable to any kind of vegetation. In forests it includes lianes and epiphytes.

colluvium: rock or soil material that has been transported downslope primarily by gravity.

communities: A collection of populations of animals and plants that occur naturally together in a common environment of any size.

conservation: the preservation and protection of natural and historic resources for the purpose of maintaining their intrinsic values, providing for their appreciation and recreational enjoyment by the public, and safeguarding the options of future generations *(Conservation Act 1987,* Section 2 (1)).

Cretaceous: the period 135-65 million years ago on the geological timescale.

deflation: reduction of a surface by wind erosion.

diversity: the range of natural physical and biotic components in an area (land systems, landforms, soils, plant and animal communities, ecological units and ecosystems).

ecological character: The distinguishing features of a particular place, definable in terms of biotic composition, climatic, edaphic and topographical information.

ecological district: A local part of New Zealand where geological, topographical, climatic and biological features and processes, including the broad cultural pattern, interrelate to produce a characteristic landscape and range of biological communities. New Zealand has been subdivided into 268 such districts. It represents the level for assessing the representativeness of major ecosystem types in the national network of Protected Natural Areas.

ecological region: A group of adjacent ecological districts with very closely related ecological characteristics, or, in some cases, a single very distinctive ecological district. New Zealand has been subdivided into 85 such regions.

ecological unit: the ecological unit is the linking, in tandem, of a natural community type (usually a vegetation type) and a physical environment type (usually a landform type) (Myers *et al.* 1987). For example, red beech forest on colluvial hillslope or red tussock grassland on valley floor. Other important attributes of the unit such as the bioclimatic zone (e.g., montane, coastal) may be added to the name. The concept of ecological units has been designed to give specific meaning to the Reserves Act 1977 phrase "all classes of natural ecosystems ...". Ecological units are used in the survey phase to determine the biological and physical composition of the Study Areas.

endemic: plant and animal species confined to New Zealand. It includes bird species that breed only in New Zealand, but which may disperse to other countries in the non-breeding season or as sub-adults (Bell 1986).

erosion pavement: a surface covering of stone, gravel or coarse soil particles that develops after wind, sheet or rill erosion removes the fine soil.

exotic: introduced from abroad.

forbs: herbs other than grasses

gorge: a relatively deep and narrow valley passage with steep, rocky sides, often with a cascading stream channel on the valley floor.

greywacke: a hard grey sandstone, which is the most abundant rock in New Zealand.

habitat: the part of the environment in which a plant or animal lives. An organism usually has adaptations which allow it to live in that particular part of the environment, and it may be more or less restricted to that habitat.

hanging valley: a side valley, not necessarily of glacial origin, whose mouth is noticeably higher than the floor of the main valley at the junction of the two.

"hard" rock: qualifier applied to hill and mountain slopes formed on consolidated , strongly indurated, unweathered rock. Rock surface cannot be indented with a geological hammer. In the Mowhango, greywackes and argillites are "hard" rocks.

Holocene: the period 10,000 years ago to the present day on the geological timescale. The Holocene Epoch covers the duration of the present interglacial (Selby 1982), and is characterised by a rise in temperature since the last glacial episode of the Pleistocene Epoch and an associated rapid rise in sea-level to its present level.

hydrologic class: One of 6 descriptive categories used in classifying the influence of water on the character of the biotic elements. If water is not a significant influence, a site is considered terrestrial. On sites where water is a major feature the characteristics of the soils and biota will be strongly influenced by the nature of the water body (e.g., palustrine, lacustrine, riverine, estuarine, marine).

terrestrial:	free water has an insignificant role in the ecological character of these areas.
palustrine:	a wetland community/environment characterised by emergent vegetation which may, or may not, have free standing water present.
lacustrine:	a lake community/environment lacking persistent emergent vegetation.
riverine:	a system of flowing freshwater.

indigenous: native to, and occurring naturally in New Zealand. All those features which in the aggregate originally gave New Zealand its own distinctive character. It is important at the regional, district and species level.

Kaikoura Orogeny: the second mountain building period in New Zealand, which began approximately ten million years ago and is continuing today. Over this period the present shape and topography of New Zealand has been formed.

landform: All the physical, recognisable, naturally formed features of land, having a characteristic shape, e.g. hill, valley, or alluvial fan. In the PNA Programme, classification of a landform emphasises its ecological significance rather than its geomorphological or geological significance.

landform definitions:

alluvial terrace: flat to gently sloping area of alluvium of variable height above river level. May be periodically flooded.

alluvium:	rock or soil material that has been transported primarily flowing water.
basin:	concave to flat area on hillside; site of water accumulation.
cliff:	very steeply sloping to vertical rock face at inland locations.
colluvial hillslope:	foot or hillslope with accumulated colluvium.
colluvium:	rock or soil material that has been transported primarily by gravity to foot of hillslope.
hillslope:	slope unit on which drainage lines are predominantly parallel.

landscape unit: distinct large scale physiographic units. See introductory section in report.

land systems: Christian (1957) defines a land system as..... "an area throughout which there is recurring pattern of topography, soils, and vegetation: a change in the pattern determines the boundary of a land system". For the purposes of this study, geology, soils, and topography were the criteria used to delineate land systems.

limestone: a chemical sedimentary rock which contains at least 50% of either calcite/aragonite ($CaCO_3$) or dolomite ($CaCO_3.MgCO_3$).

loess: buff to light-yellowish or yellowish-brown coloured, unstratified deposits of loosely arranged angular grains of silt deposited by the wind. Loess is wind-blown dust, of Quaternary age, carried from alluvial valleys and outwash plains.

metamorphosed: rocks that have had their cystalline structure altered by excessive pressure and heat in geological processes.

native: Not known to have been introduced by human agency.

natural area: A place characterised by indigenous species or ecosystems, or a place or landform not or scarcely modified from an indigenous condition. Some natural areas will be identified as suitable for evaluation of ecological quality and representativeness, and hence also be study areas. Some of these may be of sufficient quality to become Recommended Areas for Protection. In some instances one natural area may embrace more than one study area.

naturalness: an assessment of how closely the physical and biotic components of an area reflect the condition before human occupation (in New Zealand, approximately pre-AD 700).

nature conservation value: A value assessment for nature conservation purposes based on scientific criteria derived from ecological, and biogeographical theory (diversity, naturalness, rarity, etc.) and on the social value placed on those criteria.

ombrogenous peat: a blanket or capping peat that occurs on convex surfaces and dependant for developed entirely on rainfall and cool temperatures; c.f.topogenous peat.

orographic: the influence of mountains on weather patterns; as moisture-laden clouds rise over mountains, cooler temperatures cause condensation of water vapour and rain results.

Otiran glaciation: the period approximately 80,000 to 14,000 years ago in New Zealand, marked by three major episodes of relatively cold temperatures and associated glacial advances.

Pleistocene: the period 2,000,000 - 10,000 years ago on the geological timescale. The Pleistocene Period was characterised by marked fluctuations in climate which resulted in the occurrence of several episodes of mountain glaciation.

Protected Natural Area (PNA): a legally protected area, characterised by indigenous species or ecosystems, in which the principal purpose of management is retention of the indigenous state. The term may also be applied to areas legally protected for their soil, geological and/or landform values.

pyroclastic flows: a hot, erupted cloud of ash and gas which flows as a ground-hugging avalanche, and cools to form ignimbrite.

Quaternary: the period 2,000,000 years ago to the present day on the geological timescale.

Recommended Area for Protection (RAP): An area identified as priority for protection because it contains the best example or examples of its type or class of natural ecosystem and/or landscape in an ecological district.

A RAP is intended to be the basis for a proposal for a new protected natural area that would supplement the existing system of protected natural areas and make it more fully representative of New Zealand's ecological diversity. Seven selection criteria are used for identifying Recommended Areas for Protection in the PNA Programme: representativeness, diversity and pattern, rarity and special features, naturalness, long-term ecological viability, size and shape, buffering and surrounding landscape.

representative: The extent to which an area represents or exemplifies the components of the natural diversity of a larger reference area e.g. representation in reserves of the current natural diversity of an ecological district, or representation of the original natural landscape.

The identification and evaluation of the key representative natural areas in all Ecological Districts in the principal objective of the PNA Programme.

natural diversity: Natural diversity refers to the range of the natural physical and biotic components in the landscape including species, plant and animal communities, ecosystems, landforms, soil sequences, and dynamic systems and processes.

pattern: An ecological term describing the arrangement of species, communities and habitats according to spatial and environmental gradients.

rarity: A measure of the paucity of numbers of occurrences of elements of natural diversity (e.g. species, communities).

naturalness: Involves the assessment of the degree an area (e.g. vegetation ecosystem) has been free from the effects of human disturbance and intervention. It is also an assessment of the indigenous content of the area.

viability: The ability of an area's plant communities (or in some cases a particular species) to maintain themselves in the long term, in the absence of any special effort to perpetuate them. Regeneration and vigour of a particular species, and the size and stability of communities are important factors for evaluation.

buffering: Protection of an area (or a particular community) from outside modifying influences, given by natural features (catchment boundaries, rock barriers, surrounding vegetation) or, in some cases, fences or other artificial structures (Ward et al. 1987).

surrounding landscape: The land which surrounds and influences a particular natural area, and is influenced by the same set of physical parameters as the natural area.

site: An area of land surface for which a specific statement can be made of aspect, slope, exposure, ground water, underlying geological material and vegetation. The size of a site may vary quite widely depending on the degree of uniformity required for sampling.

regolith: soil, weathered rock and other unconsolidated rock material of whatever origin (Selby 1982).

representativeness: an assessment of how well an area (*e.g.* a RAP) shows the overall characteristics of a larger area (*e.g.* a land system or ecological district).

rhyolite: a light-brown to grey coloured, fine-grained volcanic rock of acid composition (*i.e.* more than 66% SiO_2).

riser: the steep slope below the edge of a terrace tread.

sandstone: a sedimentary rock composed of sand-sized particles.

siltstone: a sedimentary rock composed of silt-sized particles.

soil profile: a vertical section of soil through its organic and mineral horizons, extending into the parent material.

"soft" rock: qualifier applied to hill and mountain slopes formed on unconsolidated to moderately indurated, unweathered rock. Rock surface can be indented with a geological hammer. In the Mowhango, sandstones, siltstones, mudstones, and limestones are "soft" rocks.

study area: A tract of land with indigenous vegetation delineated as suitable for survey in rapid field inventory in order to identify the ecological patterns and the natural diversity of an ecological district.

It is an arbitrary unit, defined as appropriate to circumstances - it may be defined by the boundary of a remnant forest stand; a catchment; a legal title; or in largely undifferentiated environments by grid squares or other manageable, arbitrarily bound areas.

succession: The process of change in the appearance, composition and structure of a community, usually over a number of years. Change may be due to biotic factors, or state factors, or both.

terrace: a flat or gently sloping surface *(i.e.* the tread), generally composed of alluvial deposits, bounded on one side by a steeper descending slope (*i.e.* the riser) and, on the other, by a steeper ascending slope.

Tertiary: the period 65 to 2 million years ago on the geological timescale. The Tertiary period was marked initially by sea transgression until, about 25 million years ago, renewed uplift caused the seas to retreat.

topogenous peat: topogenous peats develop from poor drainage in concave depressions; c.f. ombrogenous, blanket, or capping peat.

tread: the flat or gently sloping broadly planar surface of a terrace. The tread marks the position of a former floodplain of a river or stream, now abandoned and left as a higher level as the river downcut through it.