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A PROPOSAL FOR A RECREATIONAL AND EDUCATIONAL RESERVE ON THE MANAWATU SAND COUNTRY

J. Ogden*

CONTENTS

* Present address: Dept. of Biogeography & Geomorphology, Research School of Pacific Studies, Australian National University, Box 4 P.O., Canberra, A.C.T. 2600, Australia.
Formerly at: Dept. of Botany and Zoology, Massey University, Palmerston North, New Zealand.

1. Introduction

This proposal is intended to stress my view that a representative portion of the coastal sand dune ecosystem of the Manawatu should be preserved. I believe the area suggested to be exceptionally suitable in many respects, but it is not the only possibility which should be considered. The important point is that an area large enough to be truly representative and also resistant to land-use changes in the surrounding area should be set aside. [I have been encouraged to make this proposal by many others, both professional ecologists and members of the general public, concerned at the gradual disappearance of one of the characteristic land forms and wildlife habitats of the Manawatu Plain.]

The Manawatu sand country extends from Paekakariki north for 120 miles to Patea and is up to 12 miles wide with an area of 210,000 acres. Most of this area is now either farmed, or under pine plantations. 'This land surface has been formed since the end of the last glaciation (c. 10,000 years ago) by the combination of a rising coast-line and the landward movement of the sand dunes being formed along the coast. The process of landward migration of the dunes has not always been at a uniform rate, so that it is possible to divide the area up into four different 'phases' which are of different ages and can be recognised on the ground by their different soils. Virtually all the natural forest and scrub vegetation has disappeared from the older 'phases', which are now productive farm lands, but the more recently formed dunes nearer the coast still possess areas of sand hills, plains and peaty swamps which give a good indication of the pre-European vegetation and of the early conditions in the genesis of the soils of the farmed areas nearby. (See Cowie, 1963; 1968).

As the city of Palmerston North and its adjacent boroughs grow in size, recreational pressure on the adjacent coast will increase. At present the open dune area, extending inland for a mile or more behind the beach provides recreation for a relatively small number of persons. Walkers, naturalists and professional ecologists visit the area and schools and universities run educational field excursions to it. In the vicinity of Himatangi Beach and Tangimoana townships 'Beach Buggy' driving is rapidly increasing in popularity. However, most visitors to the area do not penetrate the dunes proper, but simply walk along the beach and climb onto the fore-dune. From the latter vantage point there is a magnificent view along the sweeping line of breakers, south to Kapiti Island and north to Mount Egmont. Looking inland from the same dune crest the rolling dune system forms an irregular pattern of light and shadow, constantly changing as the wind ripples the Marram grass and the clouds drift across the sky. In the distance are the green Tararua ranges, and from some places the snowy summit of Ruapehu is visible. The aesthetic qualities of this coast-line, although subjective and not easily definable, are of prime importance in the case I present for the preservation of a representative portion of the sand dune ecosystem. If such a reserve is created, then the aesthetic experience is also preserved for future generations to enjoy.

2. The Proposed Area

The proposed area covers about 1500 acres to the west of Pukepuke Wildfowl Management Reserve. The latter is an area of dune lake and swamp managed for scientific research into the ecology and productivity fo ducks and other water-birds by the New Zealand Wildlife Service (Dept. of Internal Affairs), and is one of the few remaining small remnants of a type of ecosystem formerly much more widespread in the sand country (see Appendix 2). The large size of the proposed area is in agreement with Esler's recommendations (Appendix 3). Fig. 1 gives the general location of the area, about half way between the townships of Himatangi Beach and Tangimoana, while Fig. 2 gives the boundaries, fence lines, etc., in greater detail. The scientific benefit of the contiguity with the Pukepuke Reserve is that a complete cross section of the Waitarere Phase dunes, and their overlap with the older Motuiti Phase dunes would be included in the total area. This means that virtually all the habitats present in the Sand Country would be represented, and moreover the buried peats of the overlap zone would be preserved for study. As the Pukepuke Reserve is already well administered, with a scientific officer usually in residence and visitor accommodation available, the management and supervision problems might not be so great as they would otherwise be.

The northern boundary of the suggested area would follow the Pukepuke outlet drain, and include it. So far as the author is aware no other Whitebait stream on this stretch of coast is protected in this way. Because Pukepuke is a M.O.W. 'representative catchment', detailed weather and water-level recording instruments are already installed in the area, so that inclusion of the drain would give greater security to hydrological research and more flexibility in the management of the swamp/dune system as a natural unit. The southern boundary of the proposed area is more arbitrary and might be varied depending on land tenure, etc., in the area. The important point is that a sufficiently large area of the mobile dune system, designated 'Forest Service Plantation Area' in Fig. 2 be reserved.

Fig. 3 illustrates the great diversity of habitats in the area at present and may be contrasted with the forest monocultures on formerly very similar areas to the north (Fig. 4).

3. Land Usage and Management of the Proposed Reserve

The area as a whole can be divided into four sections:

(1) the Pukepuke Reserve;
(2) the Eastern Section;
(3) the South West Corner;
(4) the North West Corner.

These sections will be briefly described and discussed separately.

(1) The Pukepuke Reserve.

This area is currently administered as a Wildfowl Management Reserve by the Wildlife Service of the Department of Internal Affairs. No change in its status or management is suggested.

(2) The Eastern Section.

This is the fenced area adjacent to Pukepuke comprising Blocks 59,60 and 61 and a part of R.A. Wilson's property (see Fig. 2). Most of this area has had Marram planted in the past, and the flats have been sown with exotic grasses and clover. The dunes carry Lupins, and there are some areas of Pine plantation. Currently the area carries stock, and it is suggested that its management would continue substantially unchanged if the area became a reserve. Some control would have to be exerted over stocking rates, fertiliser application, pine planting, etc., but there is no a priori reason why grazed and managed plantation areas should not be included within the reserve.

In this way the present diversity would be preserved.

(3) The South West Corner.

This area is a complex of sand dunes and flats, with Marram grass and Lupins predominating. There are some areas of unstable shifting sand. Part of the area is described in detail in Esler (1970). This is the most accessible area to the general public being reached by a walk of less than a mile along the beach from Himatangi township. Controlled recreational usage could occur here, although care would be needed to ensure the stability of the foredune and to prevent encroachment of mobile sand onto areas outside the reserve.

(4) The North West Corner.

Roughly from Sandy No. 1 Trig. to the Pukepuke drain, bounded on the East by the fenced Eastern Section and on the West by the beach. This section should be preserved in its present state as an Educational and Scientific Area. It contains several dune units of the type described by Esler (1969) and Cowie (1968) and its dune flat vegetation is relatively little modified (Appendix 1). Figs. 6 to 10 illustrate parts of the area. In order to maintain the diversity of this unstable area some limited disturbance by people (and possibly stock) would be desirable.

In the overall management of the area under discussion certain basic principles would need to be recognised. (1) The area is inevitably subject to change, both in its topography and vegetation, so that any attempt to maintain the status quo exactly as at present would be doomed to failure. The objective must be to maintain essentially the same mosaic of habitat types, but not necessarily in the same places as at present. (2) The vegetation and the topography are closely related (see Fig. 9), and both are controlled ultimately by the level of the water-table. Successful management therefore involves a thorough understanding of the hydrology of the system (see Esler, 1969, and McHarg, 1969, p.7-17). (3) With different land-use requirements in the area - established wild-fowl reserve, grazing land, plantations, recreational areas and foreshore, educational and scientific interest, etc. - it is clearly necessary that conflicts be resolved for the good of the overall management of the whole system. It is suggested that a small committee comprising representatives of the main interested parties, and under the guidance of a professional ecologist might be the best way of arriving at management decisions.

4. Studies for which the proposed area is uniquely suitable

The following list is not exhaustive, and reflects mainly my own interests. The topics I suggest are outlined only very briefly.

(a) Vegetation in relation to water-table.

Refer to Esler (1969). This could include also the respective roles of native and introduced plants in dune formation and stabilisation. The history of dune stabilisation in the part of the area now used for grazing is depicted in Figs. 11 and 12 and in Appendix 1. Vegetation studies in the area could be carried out at all levels from primary school upwards; a leaflet illustrating the main plant species present in the area (Appendix 4) greatly assists such educational exercises. A thorough understanding of the control of the vegetation by the ground water-table would have considerable implications for the water supply and disposal problems posed by the expansion of the coastal resorts.

(b) The Geomorphology and History of the Manawatu Coast.

The mode and rate of the formation of the 'dune units' described by Cowie (1968) is not fully understood. The history of phases of dune instability, sea level fluctuation and hydrological changes could be investigated by analyses of some of the buried soils and peats present in the area. The origin of the 'raised beach' present behind the foredune along much of this coast is not known, but studies on it have already been carried out by Massey University students and should be quickly expanded as the shell deposits are being rapidly destroyed by human trampling and vehicles (see Appendix 5).

(c) The process of soil formation.

The soils in the area are all of essentially the same age and origin, so that differences in soil profile development, nutrient turnover rates, etc., in the grazed and forested areas, as compared with those areas still in a more or less natural state could lead to a much fuller understanding of the process of soil development in the sand country in general. This type of research has great application, and is of particular interest to Dr. Cowie (pers. comm.).

(d) Maori history.

Archaeological sites with Moa bone deposits are known from nearby areas on the Motuiti phase dunes (see McFadyen,) and more recent shell middens and small fire places are abundant in the proposed area (Fig. 8). Old literature (Downes, 1909; Wilson, 1959) suggests that a Maori Pa was present on the shores of the formerly much larger Lake Pukepuke (see Fig. 2) and there was certainly a Pa and an Eel fishery at nearby Lake Kaikokapu. Although no traces of these formerly important habitation sites are known on the present surface, it is quite likely that they remain buried below the Waitarere phase sand dunes. The area currently receives some small usage by Maoris for the harvesting of Pingao.

(e) Ecotypic differentiation of (plant) species on extreme substrates.

Many of the species present in the sand plain vegetation appear to be ecotypic derivatives of more widespread coastal and montane species. The sand plains and the adjacent estuaries make an interesting comparison for the student of plant evolution but so far no detailed studies have been undertaken (see Ogden, 1974).

(f) General.

The educational value of the sand dunes and their enclosed flats as a simple ecosystem, in which the interactions of soil, climate, vegetation and man's activities can be readily demonstrated, must be strongly emphasised. The area near Himatangi is already used for this purpose by Massey University and several other local organisations. In addition, dune systems in general, and the Manawatu in particular, provide excellent situations for the study of ecological succession, a concept essential for the successful management of any natural area. Finally I stress that the topics I have suggested are but a few of the possibilites. Others, such as ecology of native and introduced birds and mammals, currently in progress at Pukepuke Reserve, could well be extended into the proposed reserve area.

5. List of References

Carnahan, J.A. (1957) Botany of the Manawatu sand country. Proceedings of the New Zealand Ecological Society, 5 : 17-18.

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McHarg, I.L. (1969) 'Sea and Survival' in Design with Nature. Natural History Press, pp.viii, 197.

Ogden, J. (1974) Observations on two coastal ecotypes of Selliera radicans Cav. (Goodeniaceae) growing in the Manawatu District of New Zealand. Unpublished manuscript.

Wilson, R.A. (1959) Fifty years' farming on sand country. Keeling and Mundy, Palmerston North.

APPENDIX 1

A brief survey of the vegetation of the proposed reserve area

1. Historical.

The area to the north-west of the Pukepuke Reserve is now mostly covered in vegetation, with Marram and Lupins on the dunes and a mixture of small native herbs and introduced pasture plants on the flats. Old maps of Pukepuke lagoon clearly demonstrate that drifting sands were still advancing over the swamp vegetation in the 1930's and it is probably about this time that the first attempts at dune stabilisation using Marram Grass were attempted (Wilson, 1959). Aerial photographs (10 chains/inch) taken in 1942 show that at that time much of the area to the west of Pukepuke was still drifting sands. An analysis of aerial photographs taken since that time is summarised in Figs. 11 and 12 and Tables 1, 2, 3. The area analysed is marked on Fig. 5 and is approximately 333 acres in extent.

In 1942, 54% of the area was open sand, but since then this percentage has decreased, to 6% in 1968 (Table 1). This represents about 160 acres of new vegetation cover on the 333 acre plot. The rate of colonisation has not been constant during this period, and there is an indication that 'blow outs' of the existing vegetation have become more frequent since 1958 (Table 2). (In this respect it is relevant to record that further Marram planting occurred in the area in 1957 or shortly after and that rapid colonisation of some blow-outs occurred in the 1963-1968 period.) If the rate of colonisation is expressed in terms of the proportion of bare sand actually available for colonisation (Table 3) it appears that although the overall rate of colonisation on a per unit area basis has decreased, nevertheless the small patches of sand remaining are shrinking faster than the large expanses of earlier years.

Table 1. Relative proportion of bare sand and vegetation in the study area.

Date	Bare sand	Vegetation
1942	54	46
1958	22	78
1968	6	94

Table 2. Rates of colonisation acres/year.

Period	Years	Gross colonisation	Blow outs	Net colonisation
1942-58	16	7.7	0.3	7.4
1958-68	10	6.0	0.6	5.4

Table 3. Rates of colonisation of the bare sand available for colonisation, expressed as percentages.

Date interval	Amount of available bare sand actually colonised during the time interval	Colonisation of bare sand available on a per annum basis
1942-58	58%	3.6%
1958-68	74%	7.4%

2. The present vegetation of the area.

General accounts of the vegetation can be found in Carnahan (1957) and in the important papers by Esler already quoted (Esler 1969, 1970). The proposed reserve area was visited in May 1972 with Dr. Cowie and the following notes made.

(i) Dune unit 'A' Figs. 5, 6 and 7, and ground photos Figs. 8 and 9. The landward end of the dune unit is composed of a sheet of mobile sand, and there is clear evidence of erosion of the lateral dunes. Despite this, small Marram dunes are forming along the inner flanks of the unit. The central portion is mainly occupied by Juncus spp. and Leptocarpus simplex with only small areas of the more typical sand flat association of small native herbs towards the seaward end. The following native species were recorded, but the list is certainly incomplete.

Graphalium luteo-album (forming zones around hollows)

Carex pumila (colonising seaward end flats)

Juncus spp.

Senecio lautus

Leptocarpus simplex

Selliera radicans (round leaved form)

Scirpus

Lobelia anceps

Coprosma acerosa

Cassinia leptophylla

Epilobrium billarderiarum

Spinifex hirsutus

Desmoschoenus spiralis

In addition the following species (excluding pasture grasses) were recorded:

Senecio ? elegans

Trifolium spp.

Medicago spp.

Ammophila arenaria

Leontodon hispidus

Lagurus ovatus

A careful search should be made in the area for:

Limosella lineata

Ranunculus acaulis

Eleocharis neo-zelandica

as these plants are present in the flats described by Esler (1969) and are rare in New Zealand. The foredune in the area is in good condition and is formed by Spinifex on its seaward slope, with Marram, Pingao, Coprosma and Cassinia on its landward flank and in the small jumble of dunes to its immediate rear. In the hollow behind the foredune are gravel and shell deposits, with pieces of pumice and larva. Similar deposits to the North also have small shell middens and fire sites. The seaward end of Dune Unit A is apparently wetter than the landward end and has areas of Carex pumila and Selliera radicans and their associates.

The dune unit to the immediate North of the one described is apparently older, with a cover of Cassinia, Coprosma and Pimelia arenaria bushes among the Marram. The flat is colonised by Toe Toe, Flax and Lupins with the occasional young Pine and Cabbage Tree (Cordyline australis). Leptocarpus is however still frequent, linking the vegetation to that of the flat already briefly described.

(ii) Dune unit 'B' (Fig. 10). Good Pingao dunes can be seen in this area, but the unit is dominated by Leptocarpus and introduced grasses are common. It is apparent from Fig. 10 that various vegetation zones can be recognised within the unit, the denser vegetation apparently occurring at the (?wetter) seaward end. Temporary pools are present in the area, and show an interesting vegetation zonation. The only especially interesting species seen in the traverse of this unit was Gunnera arenaria, although the small patch observed appeared to be dead. This large flat is particularly suitable for studies of the sort outlined in part 4 (a) of this proposal.

APPENDIX 2

Summary of a paper presented at the 21st Annual Conference of the New Zealand Ecological Society, 25th August 1972

On the origins and decline of the coastal swamp ecosystems of the Manawatu

J. Ogden

The swamps and shallow lakes lying along the boundary of the Motuiti and Waitarere sand dune phases in the Manawatu were probably first formed between 900 and 1200 AD, during the extension of the Motuiti phase. Removal of sand down to the mean summer water table by the wind created shallow pools, which were enlarged and deepened by a rise in the local water table, probably resulting from coastal progradation and occurring about 1600 AD. A period of relative stability until about 1850 allowed the development of communities of swamp plants in former open water areas, but sufficient water remained to support large numbers of ducks. The presence of a Maori Eel fishery at Kaikokapu and a Pa at Pukepuke suggests that food was abundant in the area. Between 1850 and 1900, bullocks grazing the Spinifex foredune set the Waitarere dune phase in motion. Many of the former swamps and lakes were buried by drifting sand. At Pukepuke there is evidence of local drifting even as late as the 1930s, and in some areas to the south the process continues today. Drainage changes, and the extension of the Raupo beds since 1942, have also profoundly effected the local ecology. Superimposed upon these changes are those due to the invasion of the area by exotic plants and animals since European times.

Other Papers presented were:

Caithness, T.A. Introduction to the Pukepuke Lagoon Wildlife Project (summary available).

Caithness, T.A., & Pengelly, W.J. The waterfowl and their use of Pukepuke Lagoon (see Proc. N.Z. Ecol.Soc. (1973) 20, 1-6).

Castle, P.H.J. The role of eels in the ecology of Pukepuke Lagoon (summary available).

Fordham, R.A. Use by Pukeko of pasture adjoining Pukepuke Lagoon (summary available).

Gibbs, G. Plankton cycles and some comments on succession in the Pukepuke Lagoon system (see Proc. N.Z.Ecol.Soc. (1973) 20, 13-20).

Lavers, R.B. A preliminary account of a study on a ferret population at Pukepuke Lagoon (see Proc. N.Z.Ecol.Soc. (1973) 20, 7-12).

Ogden, J. Energy flow in Typha stands (summary available).

Page, C. A brief account of the Pukepuke hydrological basin research work being carried out by the hydrological division of Ministry of Works.

Ritchie, I. Dune chronosequence and history of the Manawatu coastal vegetation over 10,000 years.

[DEP]ARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH
Botany Division Substation
PLANT DISEASES DIVISION

61 199
61 934
864 785
"Plantlab"

Postal address:
Private Bag
AUCKLAND

APPENDIX 3

Reference

24 August 1971

Mr J.D. Cowie
Soil Bureau
D.S.I.R.
Private Bag
PALMERSTON NORTH

Dear Des,

It seems to me too that there should be a sand country reserve in the Manawatu but I did nothing more than think about it. I note a few relevant points for your guidance.

1. In the Himatangi Beach area there are communities of native plants still very much as they would have been in pre-pakeha times. These are mostly on the fore dune and wet sand plains. These were not described by Cockayne or any other botanist until my papers appeared. I have not seen similar vegetation elsewhere but am hopeful of finding the same patterns north of Kaitaia. Many of the same plants occur on Farewell Spit but the land forms are different.

2. Persistence of these communities is due to bad farming. These are communities which can persist only where there is instability. Grazing with cattle has provided these conditions - rabbits may have helped. Marram is only locally prominent, spinifex being dominant on the fore dune and apparently replacing marram. Inland a few chains where spinifex does not thrive marram is more plentiful. Pingao is abundant in patches. Lupin and tall fescue are confined to stable areas but would spread further and oust nearly all native plants if stabilisation was encouraged. I fear that pampas will eventually spread over much of the less stable sand country.

3. The major problem in creating a reserve is to maintain instability without affecting adjoining properties. This dictates some of the requirements that possible land for a reserve must meet.

a. The reserve must be large (minimum of 1 sq. mile) with a supply of sand from the coast and a deposition area on the landward side so that there would be no encroachment onto farmland.

b. The reserve must be elongated with sides running approximately WNW - ESE. I suggest dimensions of about 2 miles x ½ mile.

4. The most suitable place seems to be south of Himatangi Beach between Himatangi Beach Rd and the stream draining Koputara lakes. There are several different properties in the area.

Property	Owner/occupier	Valuation at 1.11.66 (dollars)
1. 623 ac Pt Lot 1 DP 12793 Pt 1 DP 12976 Val Roll No. 1429/1	Himatangi Beach Co (D.H. Roche)	U.V. 1210 I.V. 300
2. 895 ac Val. Roll No.1429/1	B.P. Lomas, Himatangi RD Foxton	U.V. 1965 I.V. 735
3. 236 ac Lot 1 DP 16819	L.A. Sexton, Oroua Downs, R.D. Foxton	U.V. 4100 I.V. 13000
4. 345 ac Secs 382 & 383 Val Roll No. 1429/17	Owned by Maoris Occupied by B.E. Sexton	U.V. 390 I.V. 300
5. 100 ac Lot 1 DP 18813 Val Roll No. 1429/9	J.D. Willis, 8 Alan St. Palmerston North	U.V. 475 I.V. 880 + trees
6. 3549 ac Pt 3 DP 9897 Lots 2 & 3 DP 13356 Val Roll No. 1429/10	B.E. Sexton, Himatangi R.D. Foxton	U.V. 9175 I.V. 24725 + trees

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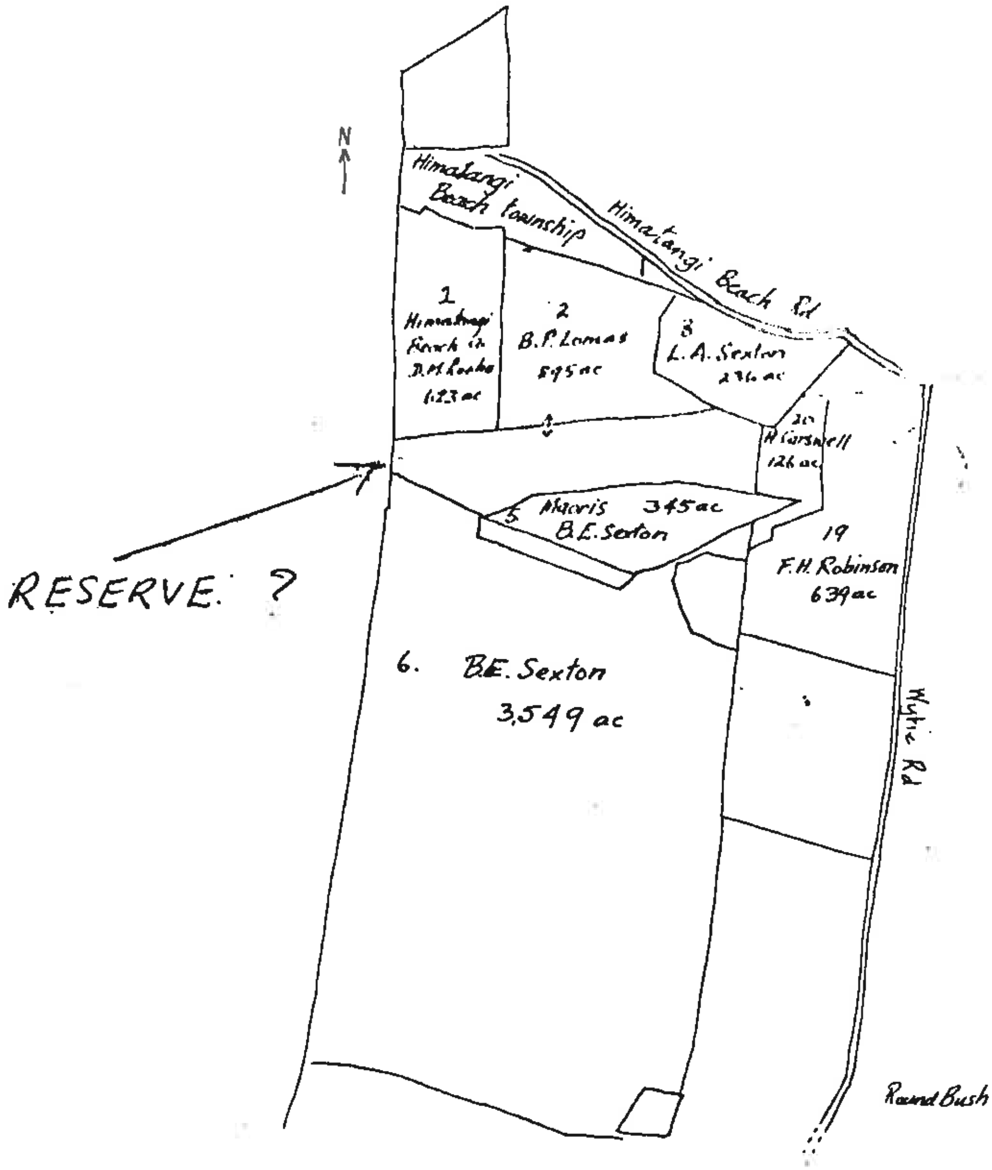
If you could have a reserve set aside it would have to be managed quite differently from any other reserve in N.M. The main difficulty that I forsee is to keep out exotic plants which might suppress the natives. I'm doubtful if this could be done indefinitely. Left as it is the native communities would persist into next century but if NZFS takes over all could be lost in 10 years. Perhaps you could achieve as much by pushing for its reservation as an open area for recreation. Nobody would like to see a solid belt of trees from Tangimoana to Foxton Beach but this could happen. Palmerston North city should see that it doesn't happen.

I wish you luck.

Kind regards

Alan

A.E. Esler

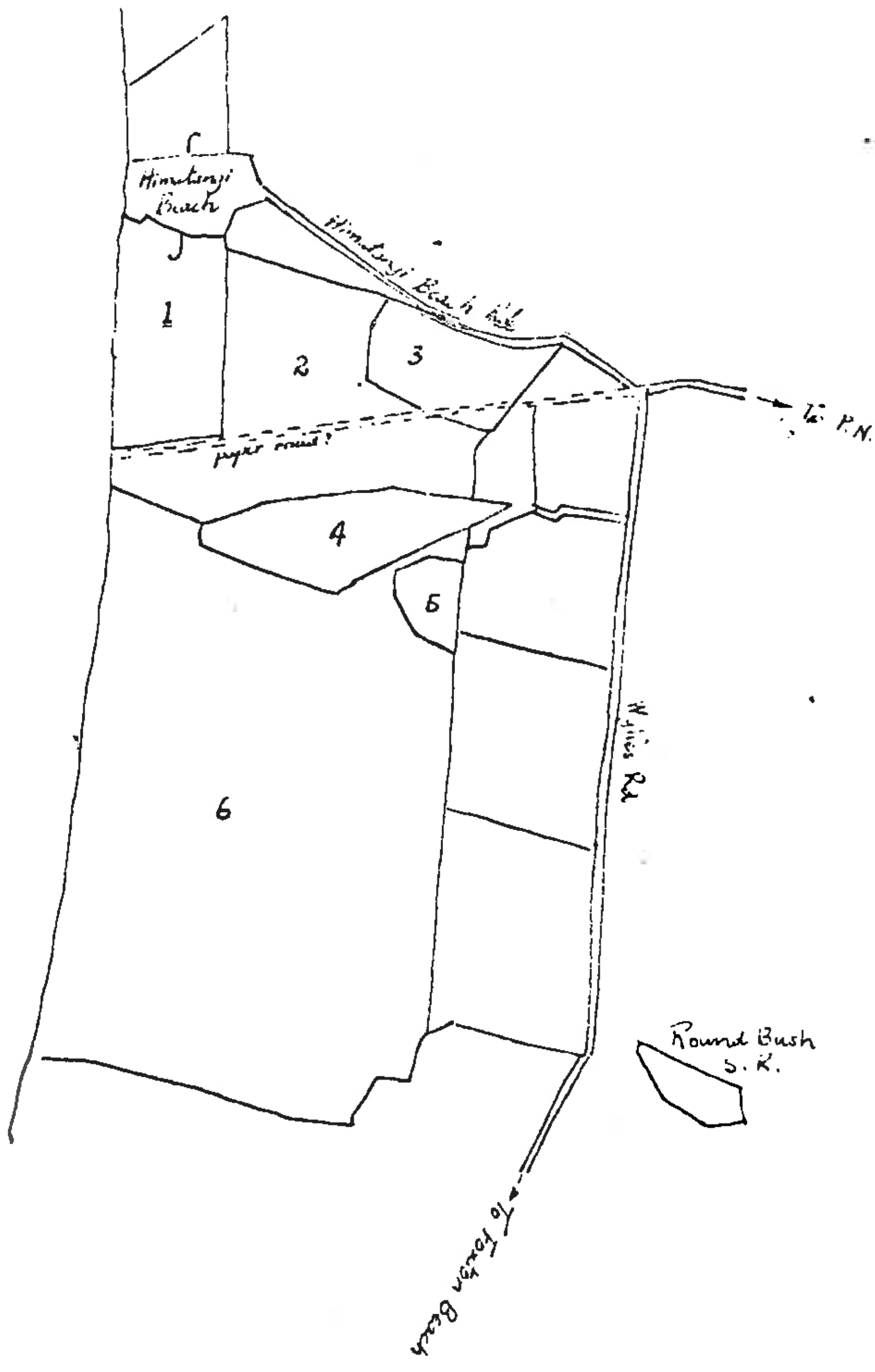


1 in = 1 mile

Criteria for reserve

1. Continued instability
2. Young sand plains with Limosella, Ranunculus acaulis, Eleocharis n.g., Carex pumila etc { These are rare in NZ }
3. Older sand plains with Leptocarpus + toetoe
4. A good area of Desmoschoenus
5. Minimum of exotics particularly tree lupin & tall fescue
6. Good fore dune

A.E.
30.7.72


Himatangi Bush
Himatangi Beach Rd
1
2
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6
paper road?
To P.N.
Round Bush
S.R.
To Foxton Beach

1 in = 1 mile

APPENDIX 5

Notes on the 'raised beach' in the Himatangi-Tangimoana region of the Manawatu Coast

Superficial shell and pebble deposits occur in the hollows, 'blow outs' and sand plains immediately behind the fore-dune down the whole of this stretch of coast. They are most extensive south of the Rangitikei River, where they are associated with pebble beds. South of Himatangi pebbles are rare and shells predominate. Where pebbles are present they are mostly about two or three inches in their maximum dimension, and are well rounded. Most of them are greywacke, although volcanic rocks and pumice are not uncommon. Decomposing driftwood and iron concretions also occur, and items of litter obviously left by Europeans, such as cartridge cases.

The shell deposits are sometimes composed predominantly of species which are no longer frequent in the present day strand-line deposits (e.g. Amphidesma subtriangulosum). More frequently they are composed of species present on the modern beach but in different proportions. There appears to be a tendency for the largest individuals of any particular species to be present on the raised beach. In some areas (e.g. just south of both Tangimoana and Himatangi Beaches) there are obvious 'middens' usually only a few yards across, composed predominantly of Amphidesma and ~~Mactra~~ Longimactra shells, and often associated with small heaps of fire reddened and fractured stones. Most of the areas have been extensively damaged by vehicles during the war years, and more recently by beach buggies.

The height of the deposits above the present high water mark is not known, but it cannot be more than a few feet, and is quite possibly less than one foot. In places there is evidence of burial by the extending foredune, and in other places previously buried shell deposits are being re-exposed.

In February 1969 a comparative study was made of the shell deposits on the raised beach and on the adjacent modern beach about half a mile south of Himatangi Beach Township. Samples were collected by the use of .25 m^2 quadrats placed at random within shell patches on the two areas. Sixteen quadrats were taken on the raised beach and twelve on the modern strand line. All whole shells present at the surface were collected from each quadrat and bagged separately. (In subsequent years further samples were taken, but because these simply confirmed the 1969 results they are not discussed here.) The results are presented in Table 1. No attempt was made to collect all species present on the two beaches as it was felt that only the most abundant shells were certainly of local origin. Triangle Shell (Spisula aequilateralis) was the predominant shell on both areas and all valves of this species were measured from angle to angle (i.e. the longest straight line measurement possible on the shell). These measurements are presented as a frequency histogram in Fig. 1.

Table 1. Relative proportions* of the shells of different Molluscs on the raised and modern beaches south of Himatangi in 1969.

Total numbers are based on 16x.25m^2 quadrats for the raised beach and 12x.25m^2 quadrats for the modern beach. Percentages in parentheses.

Species	Modern Beach No.	Modern Beach %	Raised Beach No.	Raised Beach %
Spisula aequilateralis	1276	(96.7)	231	(78.8)
~~Matra discors~~ Longimactra elongata	25	(1.9)	26	(8.9)
Amphidesma subtriangulosum	10	(0.8)	32	(10.9)
Others(1)	8	(0.6)	4	(1.4)
Totals	1319	(100.0)	293	(100.0)

(1) Chione stuchburyi; Dosinia anus; ?Maoricolpus sp; Baryspira ? australis; Pecten novaezelandiae; a Mussel and an Oyster.
Also collected on subsequent occasions from both beaches: Alcithoe arabica; Struthiolaria papulosa; Xenophalium pyrum and Amphidesma ventricosum.

* Note that the count refers to single valves; as the vast majority of molluscs in the table are bivalves this does not effect the comparison.

Interpretation of Results

It is reasonable to assume that the shell deposits on the raised beach are older than those of the present strand line. It may not be reasonable to assume that the shell deposits on the two beaches represent similar sortings - by the action of the sea - from the living mollusc communities. That is, the process of deposition on the raised beach may have differed from the present process of deposition. The raised beach may represent an accumulation of shells over a long time span (in contrast to the sample taken from the modern strand-line), or alternatively may represent a single deposition from a catastrophic storm or tectonic event. Because the raised beach deposits are older, they will have suffered greater changes in species

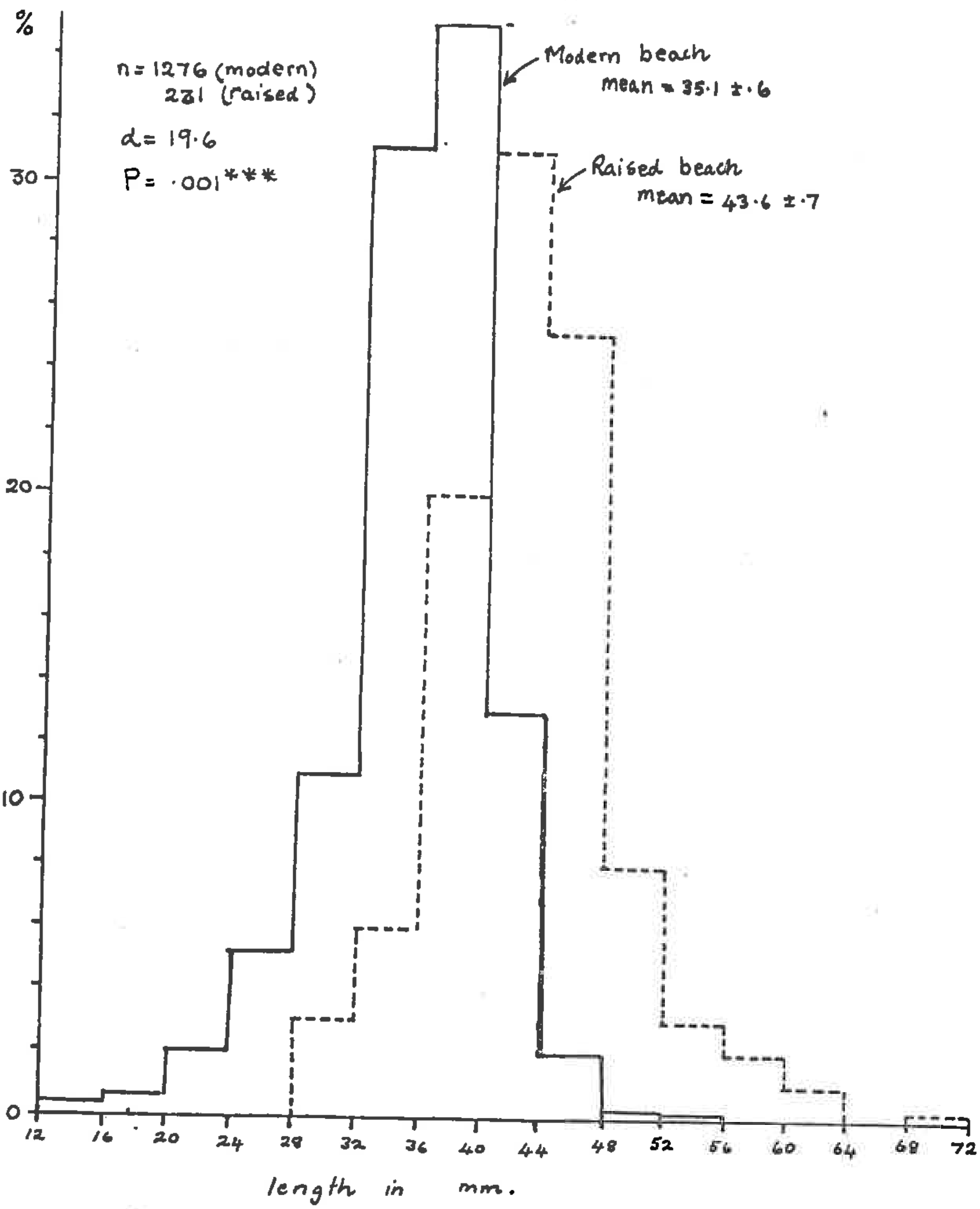


FIG 1. Frequency distribution of *Spisula aequilateralis* shells on the modern and raised beaches on the Manawatu coast.

and size class composition due to breakage and weathering than the modern beach. In this way the raised beach should show relative enrichment with the more sturdy shell species and with larger (and stronger) individuals. This is seen to be the case; not only is *Mactra ? discors* much commoner on the raised beach (Table 1) but also the size class distribution of *Spisula aequilateralis* (Fig. 1) shows a significantly greater mean and modal length. The relative abundance of *Amphidesma subtriangulosum* on the raised beach can perhaps be explained by Maori activity. Small middens composed almost entirely of *Amphidesma subtriangulosum* are present not far away at the same level as the raised beach.

Although some over-representation by larger shells on the raised beach is to be expected the trend is much too marked to be due entirely to the greater breakage of small shells. Moreover the size frequency distribution is approximately normal on both areas, not markedly positively skewed on the raised beach as might be expected if that population were equivalent to a modern beach population which had lost the smaller sizes classes by differential breakage. (It does however show a slight positive skew.) On the raised beach 3.3% of the Triangle Shells were greater than 56 mm in length; using this ratio the expected number of shells of the same size in the modern beach sample of 1276 shells would be 42. In fact no shells greater than 56 mm occurred in that sample. Similarly, the expected number of shells greater than 44 mm on the modern beach is 501, but only 29 occurred. I conclude that the Triangle Shells on the raised beach are significantly larger than those on the modern beach, and that this difference is too great to be entirely accounted for by the breakage of smaller shells on the raised beach since its formation. Other attempts to derive the raised beach population from the modern beach by some kind of differential sorting (e.g. wave action, wind) also founder on the absence of larger shells in the modern beach sample, and on the magnitude of the mean size difference. However it is quite likely that both the size class frequency distribution of Triangle Shells and the species composition of the strand line deposits show seasonal variation, which has effectively been included in the raised beach but not in the modern beach samples. Alternatively if the raised beach is the product of a single storm or tectonic uplift in the past then this could have occurred at a different season from that in which the modern beach samples were taken. The seasonal variation of the modern beach shell deposits in the area is not known, but a study of them would throw more light on the origins of the raised beach.

Finally, the possibility remains that the raised beach deposits are a wave-sorted sample of the mollusc communities living off-shore at the time of their deposition, in much the same way as the present strand line and upper beach shell deposits are a sorted sample of the present off-shore communities. If this is the case, and assuming no changes in tidal behaviour influencing shell transport and deposition, then it follows that the species composition and size class distribution of the off-shore mollusc community in this area have changed since the formation of the raised beach. This change has been an increase in Spisula aequilateralis at the expense of ~~Maetra ? discors~~ Longimactra elongata and Amphidesma subtriangulosum, associated with a decrease in the mean size of Spisula aequilateralis individuals. Despite the uncertainly attached to this conclusion it does appear to be a reasonable explanation of both pieces of information. The cause of the purported change is not known. The well documented changes in coastal vegetation (Cowie, 1963; Wilson, 1959) and forest clearance in the Rangitikei and Manawatu catchments - particularly high country erosion - in the last century may well have increased the silt load of these rivers. Increased silt deposition off-shore could directly influence the relative proportions of species in communities of 'suspension feeders' such as Spisula, ~~Maetra~~ Longimactra and Amphidesma. Increased turbidity might also influence phytoplankton productivity, thus indirectly reducing the food supply available to the molluscs.

LEGENDS TO FIGURES

Fig. 1. Part of Sheet N.Z.M.S.1. N148. Showing location of proposed reserve (red). The green area is Pukepuke Wildfowl Management Reserve.

Fig. 2. Detailed Map of Proposed Reserve boundaries (Topographical Plan of Tangimoana Development Area. Oct. 1964, E. Tupon).

Fig. 3. Oblique aerial colour photograph showing location oi Pukepuke Lagoon and part of the proposed reserve. Note the diversity of wildlife habitats in the area; swamp, lake, dune, shore, estuary, farmland and plantation.

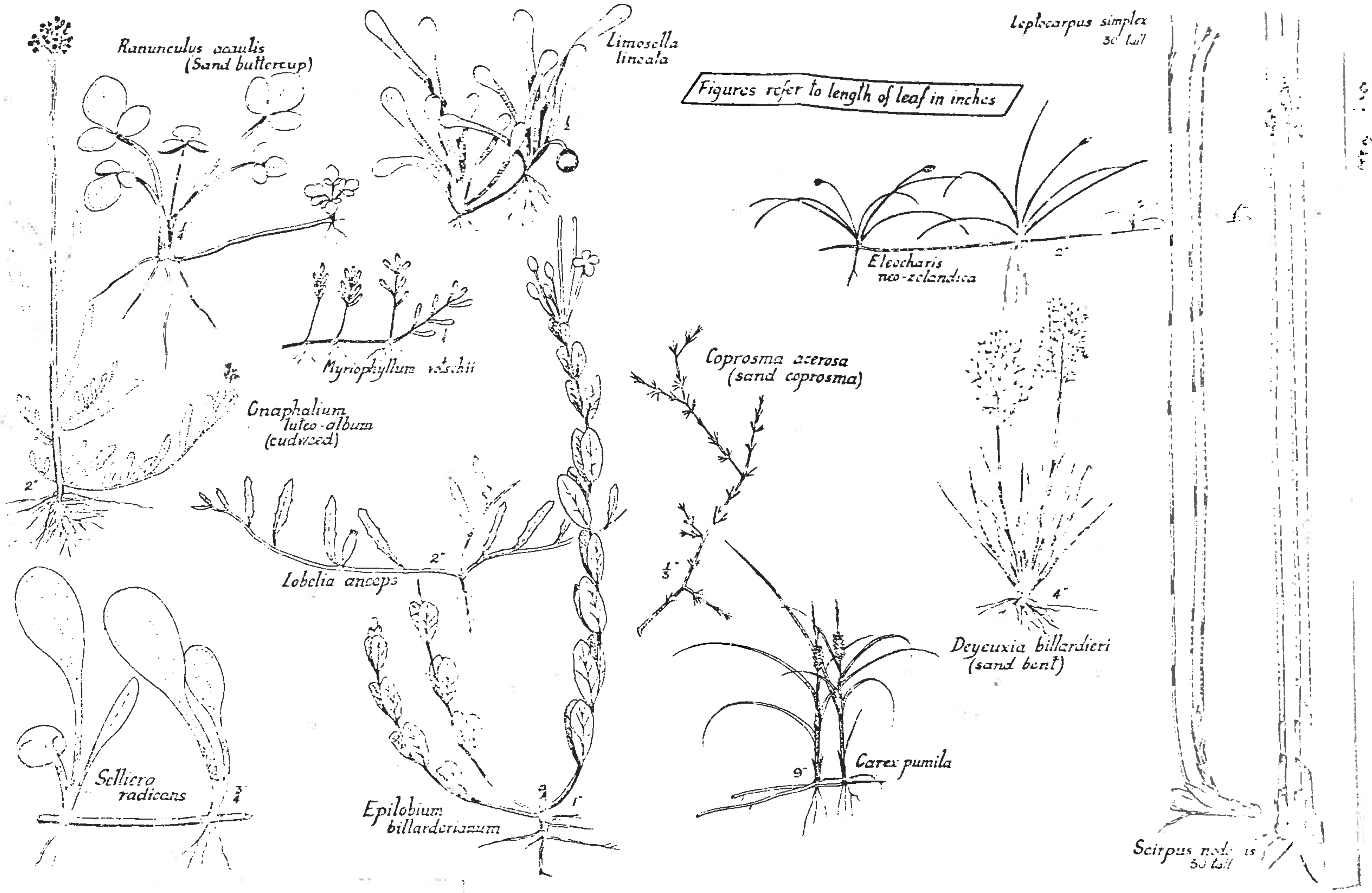
Fig. 4. Oblique aerial colour photograph showing the lack of ecological diversity in the Pine plantations on similar dunes to the north of the Rangitikei estuary.

Fig. 5 Aerial photograph showing part of the proposed reserve to the west of Pukepuke Wildfowl Management Reserve. Most of the area is currently grazed. Note bare sand areas on left hand side of photograph, scale = 10 chains/inch. (This photo shows the area in which the sand colonisation studies described in Appendix 1 were carried out).

Fig. 6. Overall colour aerial showing most of the proposed reserve area. Dune units marked 'A' and 'B' are shown in greater detail in Figs. 7,8,9 and 10.

Fig. 7. Small eroding dune unit 'A' typical of the Waitarere phase dunes. Shell middens are circled.

Fig. 8. Ground level photograph taken in dune unit 'A' looking seawards. Maori shell middens circled. 1, Foredune. 2, Sand Plain. 3, Embryo Dunes. 4, Lateral Dune. 5, Transverse Sand Apron.

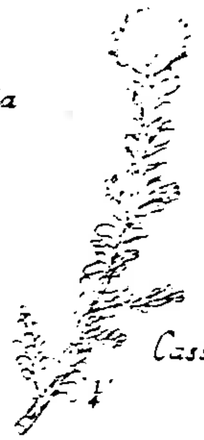


Ranunculus acaulis (Sand buttercup)
Limosella lineata
Figures refer to length of leaf in inches
Leptocarpus simplex 30" tall
Eleocharis neo-zelandica
Myriophyllum votschii
Coprosma acerosa (sand coprosma)
Gnaphalium luteo-album (cudweed)
Lobelia anceps
Deyeuxia billardieri (sand bent)
Selliera radicans
Epilobium billardierianum
Carex pumila
Scirpus nodosus 30" tall

Lup nus arboreus (tree lupin)

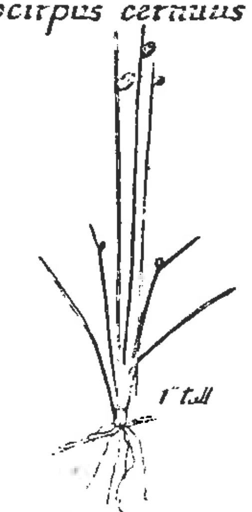
P... arenaria (sand p melea)

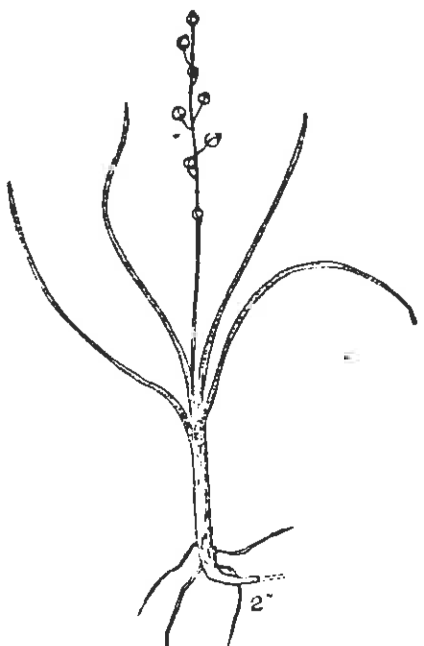
Lagurus ovatus (harestail)



Cassinia leptophylla

Scirpus cernuus



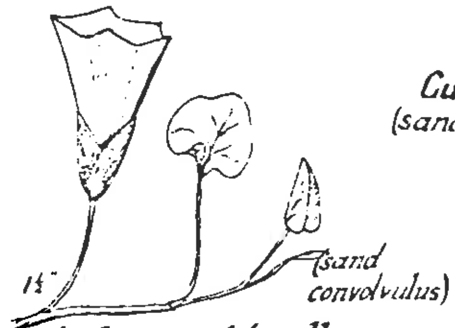


Triglochin striatum

Lilaeopsis orbicularis

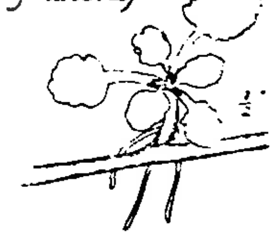
Prepared by

A. E. Esler Nov. 1968



Calystegia soldanella

Gunnera arenaria (sand gunnera)



SAND PLANTS