

# POSSIBILITIES AND PROBLEMS FOR NATURE CONSERVATION IN A CLOSELY SETTLED AREA

B. P. J. MOLLOY

*Botany Division,  
Department of Scientific and Industrial Research, Christchurch*

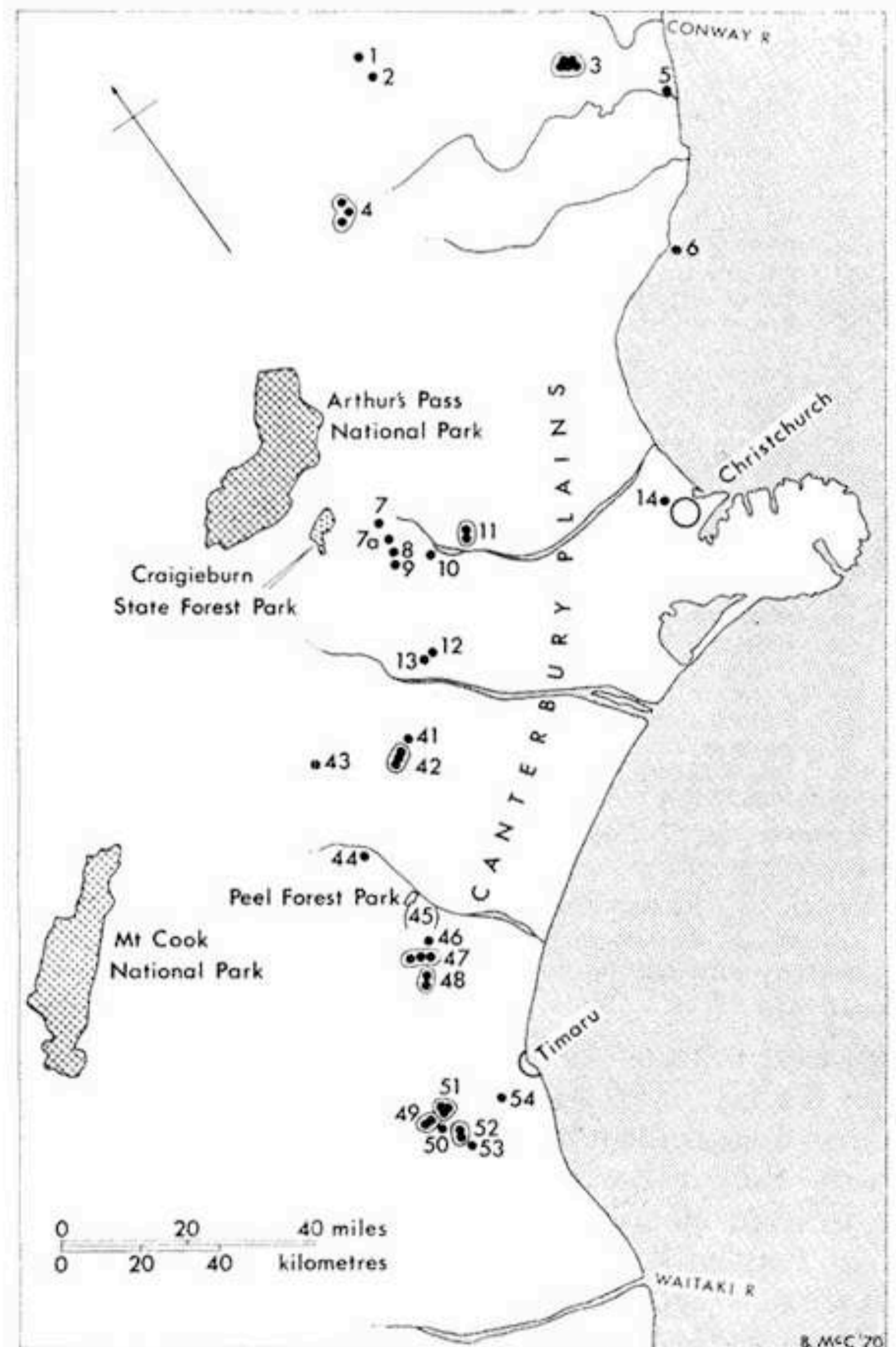
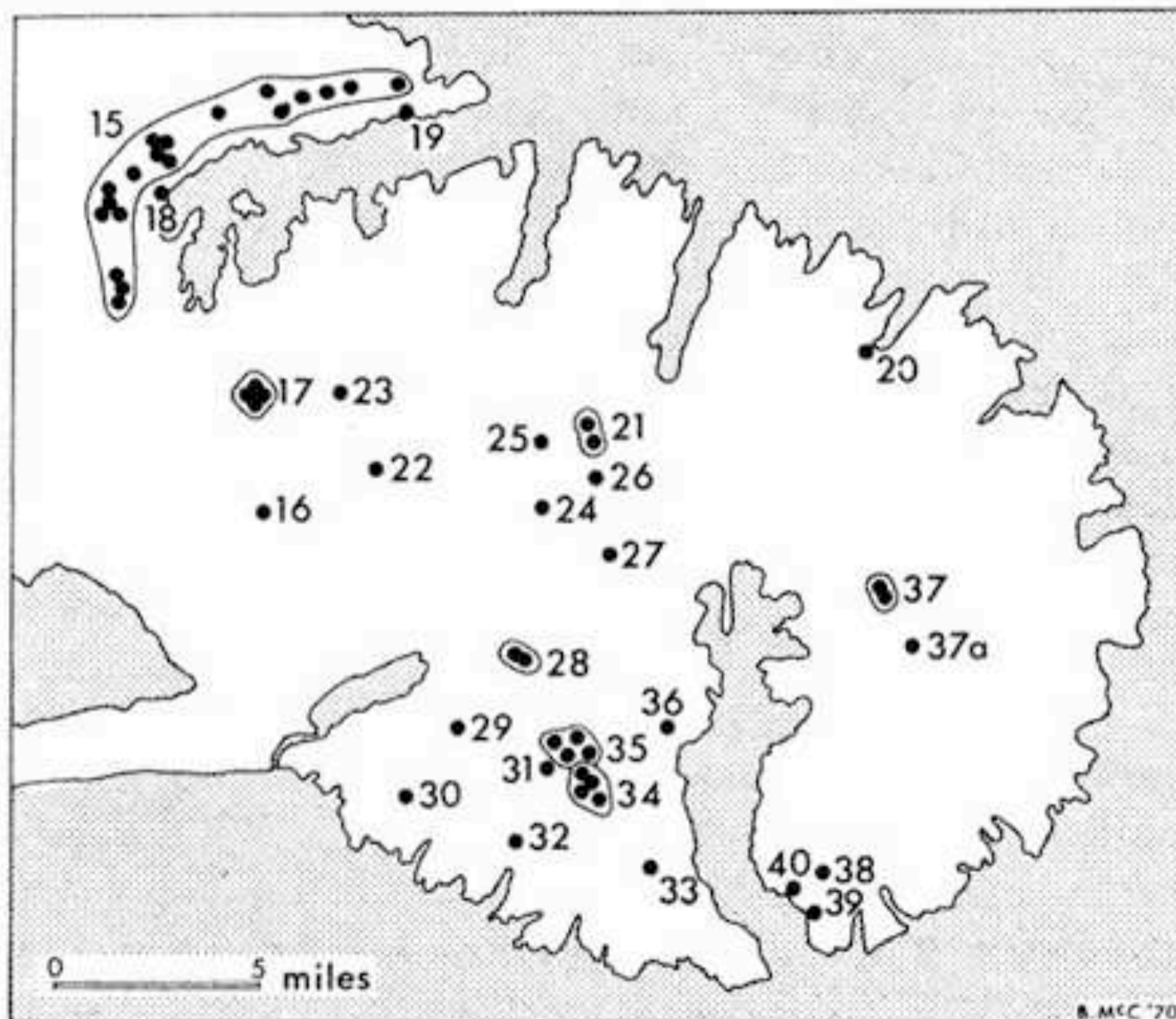
**SUMMARY:** The distribution of parks and reserves in the Canterbury Land District is outlined, and attention is drawn to the predominance of forest and mountain vegetation within the present network of nature conservation.

Other natural communities in the land district are then described, and their potential as ecological or scientific reserves is reviewed. In this paper, emphasis is placed on some of the lesser-known communities that still survive in the closely settled environment of the Canterbury Plains. The problems associated with the acquisition and maintenance of reserves are briefly discussed.

## EXISTING PARKS AND RESERVES

Scenic and allied reserves in the Canterbury Land District are concentrated on Banks Peninsula and in the foothills, front ranges and intermontane areas of the Southern Alps. In addition, there are two National Parks (Mount Cook and Arthur's Pass), the new Craigieburn State Forest Park and Peel Forest Park (also listed here as Scenic Reserve No. 45), all in mountain districts (Figs. 1 and 2 and accompanying legend).

Most of these parks and reserves concern forest communities and associated scrub and grassland of sparsely populated upland areas. Of the 56 scenic and allied reserves, 51 include various forest communities, and of these more than half occur on Banks Peninsula. The distribution of parks and



FIGURES 1 and 2. National and Forest Parks and Scenic and allied reserves in the Canterbury Land District.

Number	Name	Brief Description
1	Lake Tennyson	Lake waters
2	Lake Guyon	Lake waters
3	Lottery Bush	Podocarp/Beech/Hardwoods
4	Lewis Pass	Beech/Tussock
5	Waiau River Mouth	Podocarp/Hardwoods
6*	Motunau Island	Island/Wildlife
7	Lake Grasmere	Beech
7a	Craigieburn	Beech/Tussock
8	Cave Stream	Limestone cave
9*	Castle Hill	Limestone flora
10†	Kowai Bush	Beech/Hardwoods
11	View Hill	Podocarp/Beech/Hardwoods
12	Hoods Bush	Beech
13†	Hoods Bush	Beech
14	Riccarton Bush	Podocarp/Hardwoods
15	Summit Road	Podocarp/Hardwoods/Tussock
16	Kaituna Valley	Podocarp/Hardwoods
17	Sign of the Packhorse	Podocarp/Hardwoods/Tussock
18	Governors Bay	Hardwoods
19	Buckleys Bay	Coastal Hardwoods
20	Little Akaloa	Coastal Hardwoods
21	Purau Track	Podocarp/Hardwoods
22	Kaituna Spur	Podocarp/Hardwoods/Tussock
23	Herbert Peak	Podocarp/Hardwoods/Tussock
24	Morice Settlement	Podocarp/Hardwoods
25	Mt. Fitzgerald	Podocarp/Hardwoods/Tussock
26	Mt. Sinclair	Podocarp/Hardwoods/Tussock
27	Mortgomery Park	Podocarp/Hardwoods
28	Okuti Valley	Hardwoods
29	Te Oka	Podocarp/Hardwoods
30	Magnet Bay	Podocarp/Hardwoods
31	Devils Gate	Podocarp/Hardwoods/Tussock
32	Peraki Bay	Podocarp/Hardwoods
33	Long Bay	Podocarp/Hardwoods
34	Carews Peak	Podocarp/Hardwoods
35	Paraki Saddle	Podocarp/Hardwoods/Tussock
36	Wainui	Podocarp/Hardwoods
37	Otepatotu	Podocarp/Hardwoods
37a	Ellan Gowan	Podocarp/Hardwoods
38*	Armstrong	Podocarp/Beech/Hardwoods/ Tussock
39*	Dan Rogers Creek	Coastal Hardwoods/nikau
40†	Palm Gully	Coastal Hardwoods/nikau
41	Alford	Podocarp/Beech/Hardwoods
42	Shaplin Falls	Beech
43*	Lake Heron and Maori Lakes	Lake waters
44	Raules Gully	Podocarp/Hardwoods
45	Peel Forest	Podocarp/Beech/Hardwoods/ Tussock
46	Orari Gorge	Podocarp/Hardwoods
47	Waihi Gorge	Podocarp/Hardwoods
48	Hae Hae Te Moana	Hardwoods
49	Tasman Smith	Hardwoods
50	Pareora River	Podocarp/Hardwoods/Tussock
51	Pareora	Hardwoods
52	Matata	Podocarp/Hardwoods
53	Mt. Nimrod	Podocarp/Hardwoods
54	Claremont	Podocarp/Hardwoods

\* Reserve for the preservation of flora and fauna.

† Private scenic reserve.

(Based on information supplied by the Christchurch offices of the New Zealand Department of Lands and Survey and the New Zealand Forest Service.

reserves reflects the pattern of forest survival during the last 1000 years when much of the Canterbury Land District was deforested, largely by early Polynesian fires, and to a lesser extent by European fires and felling (Molloy 1968). The fact that such a large number of these survivors has been successfully reserved is a permanent tribute to the efforts and foresight of conservationists, both past and present.

On the other hand, it could be argued that this apparent preoccupation with forest and upland

vegetation has been at the expense of other, lowland communities, perhaps less aesthetic in appearance, but surely no less important ecologically. For example, with the exception of Riccarton Bush — Scenic Reserve No. 14 — there is a notable lack of reserves in the closely settled environment of the Canterbury Plains (Fig. 1). This region, together with the Culverden Basin and other similar landforms in eastern Canterbury, approaches 2½ million acres in area and forms a significant ecological zone. Superficially, it presents a picture of continuous farmland and urban areas devoid of native communities. However, it will be shown that this picture is more apparent than real, that there are, in fact, many native communities that still survive on the Canterbury Plains, and that positive steps are now being taken to preserve at least some representative areas.

#### PRELIMINARY SURVEYS

Initial surveys by the writer and others over the past 12 months have revealed many surviving native communities with uncultivated soils scattered throughout the Canterbury Plains. Most of these communities are little known and of surprising floristic and ecological diversity, though modified by burning and grazing to a greater or lesser extent. As several of these relics are in imminent danger of being eliminated by rural and urban development, urgent action is required to preserve and/or at least document the most valuable examples.

A thorough survey of the Plains' indigenous communities is a first requirement, and in this respect a useful baseline is the soil pattern. Figure 3 and its legend show the relative areas and different kinds of soils found on the Canterbury Plains and similar regions of interest in this survey. This map is a simplification of a more complex soil pattern, especially regarding the age, depth and degree of drainage of the solum. Nevertheless, it has proved very useful in helping to select representative sites and major variants with special features. Of the environmental variables affecting community dynamics on the Canterbury Plains, the soil is apparently the deciding factor in many instances. The ultimate aim, therefore, is to preserve a selection of surviving natural communities which represent a fair cross-section of the soil types present. The distribution of the following examples in relation to major soils is shown in Figure 3.

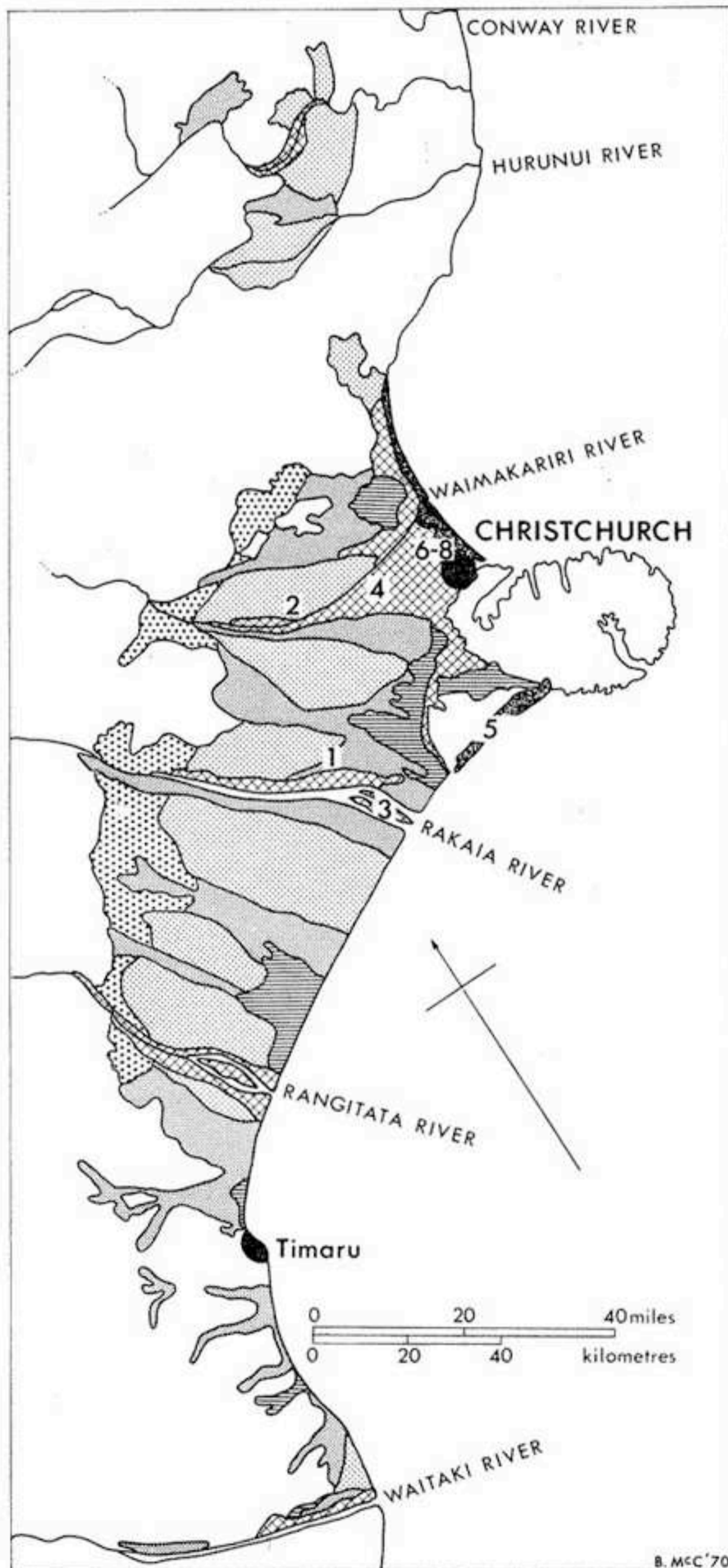
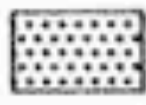







FIGURE 3. Soils of the Canterbury Plains and similar landforms in eastern Canterbury.

-  Humid yellow-grey earths and associated yellow-brown soils of the fans and high terraces
-  Subhumid yellow-grey earths and associated yellow-brown soils of the fans and high terraces
-  "Older" recent soils of the fan margins and low terraces
-  Recent soils of the lowland fringe
-  Gley, gley recent, saline gley recent and organic soils of the lowland fringe
-  Yellow-brown sands of the coastal fringe

Based on 'Soil Map of the South Island, New Zealand,' (N. Z. Soil Bur. Bull. 26(1), 1968)

#### NEW AND POTENTIAL RESERVES

##### Example 1: Bankside

Twelve months ago the first potential site was examined on the north bank of the Rakaia River, and about four miles due east of Bankside on the Main South Road. Here, about 200 feet above sea level, and within an hour's drive of Christchurch, was a block of undeveloped plainsland several hundred acres in extent, and representing soils — Eyre/Paparua complex — which cover 240,000 acres on the Canterbury Plains. Prior to recent subdivision and cultivation, the local vegetation consisted of a mosaic of fescue-tussock grassland (*Festuca novae-zelandiae*), danthonia grassland (*Notodanthonia clavata*) with scattered shrubs of matagouri (*Discaria toumatou*), and large clumps of kanuka scrub (*Leptospermum ericoides*) which seems to be the climax vegetation on this soil complex (Fig. 4).

Although hitherto modified by burning and grazing, special features of this area are its undisturbed soils and the surprising number and diversity of plant species. In the fescue-tussock grassland, for instance, 55 predominantly native species have been recorded. This figure compares very favourably with the mean value of 45 species encountered by Connor (1964, 1965) in fescue-tussock grasslands of intermontane areas in Canterbury. No comparable collection of native communities is



FIGURE 4. *Bankside* — examples of the *kanuka* and *danthonia* communities.

[Photo C. J. Miles, D.S.I.R.]

known to survive on Eyre-Paparua soils in other parts of the land district. About seven acres at Bankside have been bought by the Crown and set aside as a scientific reserve. This reserve is described in greater detail elsewhere (Molloy 1970).

#### *Example 2: Eyrewell*

Five hundred feet higher on the Canterbury Plains on the north bank of the Waimakariri River, and between the Eyrewell State Forest and Burnt Hill, lies a large but diminishing area of undeveloped Lismore soils—the largest single soil complex on the Plains, covering about 500,000 acres. This area contains the last surviving stands

of kanuka thicket and associated grassland which extended on a broad front from the foothills to the coast, a distance of some 25–30 miles, 120 years ago.

The natural vegetation in this area differs in many ways from that at Bankside, although certain floristic and structural similarities are retained. The outstanding feature is the kanuka thicket, with its closed canopy of slender plants about 15–20 feet tall, and a discontinuous understory of mingimingi (*Cyathodes juniperina*) ranging in fruit colour from white to deep red. The groundlayer is dominated by the cosmopolitan temperate moss, *Hypnum cupressiforme*, which covers the inter-



FIGURE 5. Eyrewell—tall kanuka thicket and short-tussock grassland.

[Photo C. J. Miles, D.S.I.R.]

vening soil surface with a spongy carpet up to five inches thick. Herbaceous plants—except the tuberous orchids—and other woody species are rare under the dense kanuka, which again seems to be the natural climax on these soils. However, their numbers and variety increase in natural clearings (Fig. 5) and on disturbed margins. Notable in this respect are the short tussocks (*Festuca novae-zelandiae*, and *Poa laevis* “S.I.”—silver tussock), manuka (*Leptospermum scoparium*), and *Coprosma intertexta* and *Pomaderris phyllicifolia* var. *ericifolia*—two shrubs which are rarely found today in Canterbury. A representative area of about six acres has been purchased by the Crown and set aside as a scientific reserve.

### Example 3: Great Island

Youthful soils are a feature of the Canterbury Plains. Many occupy the braided channels and recent floodplains of major rivers and are now so well covered with adventive trees, shrubs and herbaceous plants, that natural communities are difficult to find. However, on Great Island, between the Main South Road and the coast in the Rakaia River, is a large area of riparian woodland (*sensu* Hopkins 1970) on Selwyn-Waimakariri soils which must be unique to Canterbury. Dense pure stands of slender kanuka up to 35–40 feet tall merge with mixed stands of kanuka, common kowhai (*Sophora microphylla*), matipo (*Pittosporum tenuifolium*), cabbage-tree (*Cordyline australis*), several shrubs



FIGURE 6. *Great Island — riparian woodland of kanuka, matipo and cabbage tree.*

[Photo C. J. Miles. D.S.I.R.]

including *Coriaria arborea* and one or two lianes (Fig. 6). On the woodland floor, many native ferns, grasses and other herbs occur, especially along the margins of deep channels that are periodically flushed with flood waters. Birdlife in this woodland is prolific.

Here also is a kind of kowhai steppe woodland (*sensu* Beard 1967) albeit induced, containing the largest single collection of the common kowhai in the Canterbury Land District (Fig. 7). Upstream the island narrows to a tall natural dune system covered in kanuka, kowhai, cabbage tree and other species and then finally spreads out into a large stony floodplain now abandoned by the Rakaia River. These young Selwyn soils support fine

examples of typical riverbed vegetation dominated by matagouri thickets and danthonia grassland (*Notodanthonia clavata*, *N. maculata*), but including many other species such as *Poa maniototo*, *Carmichaelia monroi*, *Olearia virgata*, *Raoulia australis*, *Dichondra brevifolia* and an undescribed species of *Cotula*. A large and representative portion of Great Island has recently been set aside as a reserve by the landowners, the North Canterbury Catchment Board.

#### *Example 4: Halkett*

Youthful soils of the Canterbury Plains differ from each other in many respects. At Halkett, for example, on the edge of the vast floodplain of the



FIGURE 7. *Great Island* — kowhai steppe woodland with scattered clumps of kanuka.

[Photo C. J. Miles, D.S.I.R.]

Waimakariri River, is a youthful ecosystem peculiar to this region. A very open steppe woodland of the common kowhai is given added variety by the dwarf kowhai (*Sophora prostrata*) and hybrids between these two (Figs. 8, 9). Other trees and shrubs are also found, including matagouri, kanuka, *Hymenanthera alpina* and cabbage tree.

The undulating surface, which is characteristic of the area, is dominated by the ubiquitous danthonia (*Notodanthonia clavata*) and two small native twitches, *Zoysia minima* and *Pyrrhanthera exigua*; but there are numerous other species including: *Aciphylla subflabellata*, *Carmichaelia corrugata*, *Cheilanthes sieberi*, *Poa lindsayi*, *Tillaea*



FIGURE 8. *Halkett* — kowhai open steppe woodland with *Sophora microphylla* and *S. prostrata* (centre foreground).

[Photo C. J. Miles, D.S.I.R.]

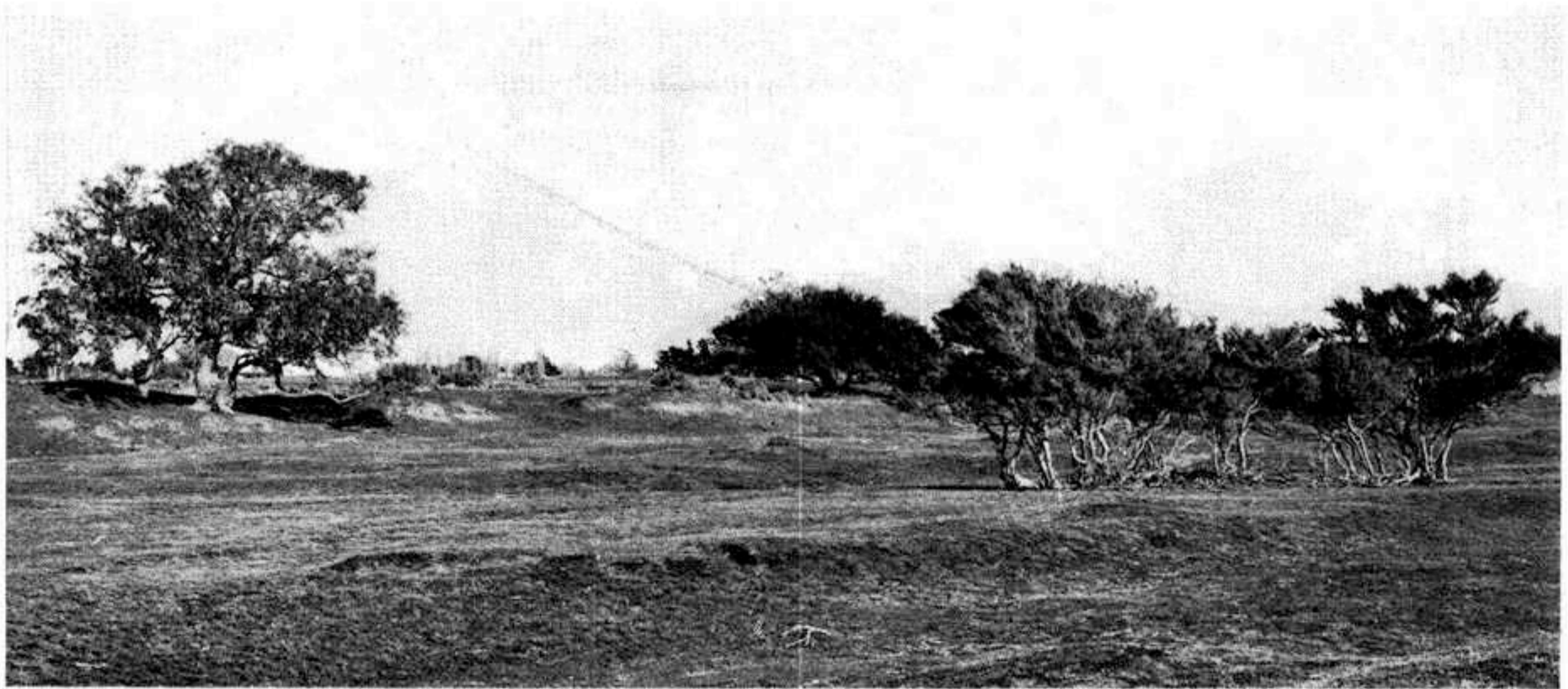


FIGURE 9. *Halkett*—*kowhai* open steppe woodland with *kanuka* (right) and *Sophora microphylla* × *prostrata* (centre background).

[Photo C. J. Miles, D.S.I.R.]

*sieberiana*, *Raoulia monroi* and the tuberous orchids *Pterostylis mutica*, *Prasophyllum colensoi*, *Microtis unifolia* and *Thelymitra longifolia*. Also worth mentioning are the artificial water races which carry a rich native flora on their margins and represent man-made replicas of natural channels that have disappeared with land development. Approximately 40 acres of this ecosystem have also been set aside as a reserve by the landowners, the North Canterbury Catchment Board.

#### *Example 5: Kaitorete Spit*

Undisturbed coastal sand country is a diminishing natural resource north of Christchurch (Mason 1968); but south of Christchurch on Kaitorete Spit, separating Lakes Ellesmere and Forsyth from the Pacific Ocean, is a primitive coastline which is unique in its geological, pedological, botanical and archeological features. Along the coast, beginning at the widest northern end of the spit, dark, scrub-covered, shingle beach ridges give way to a narrow dune system about 15 miles long and dominated throughout by the golden pingao (*Desmoschoenus spiralis*) (Fig. 10). Other native plants such as *Dodonaea viscosa* and *Muehlenbeckia astonii* reach their known southern limits on these dunes. Here also is found *Carmichaelia appressa* (a plant restricted to the area), gnarled masses of ngaio (*Myoporum laetum*) (Fig. 11), and well over 50

other native species. In natural blow-outs in the dune system there are numerous mounds of burnt stones and charcoals—the remains of ancient Maori ovens. Coastal wildlife is plentiful and supplements the freshwater wildlife on the lake side of the spit.

When we think of potential reserves on the Canterbury Plains we usually think in terms of modest acreages, but this strip of natural coastline, covering about 1300 acres and owned by the Crown, surely warrants special consideration. In my opinion, every effort should be made to preserve the entire 1300 acres in its present state.

#### *Example 6: New Brighton*

One hundred years ago W. T. L. Travers (1868) wrote of flax: “Those who have had any opportunity of travelling over these islands, cannot fail to have been struck with the extensive distribution of the *Phormium tenax*. In almost every locality, whether on the mountain side or in the river bed, in the narrow valley or on the broad plain, we see it growing more or less abundantly. In many places, thousands of acres continuously are covered with it; and it would not be too much to say that *within a few miles of Christchurch alone, it occurs in great abundance, growing with more than average luxuriance.*”\*

\* Author's italics.



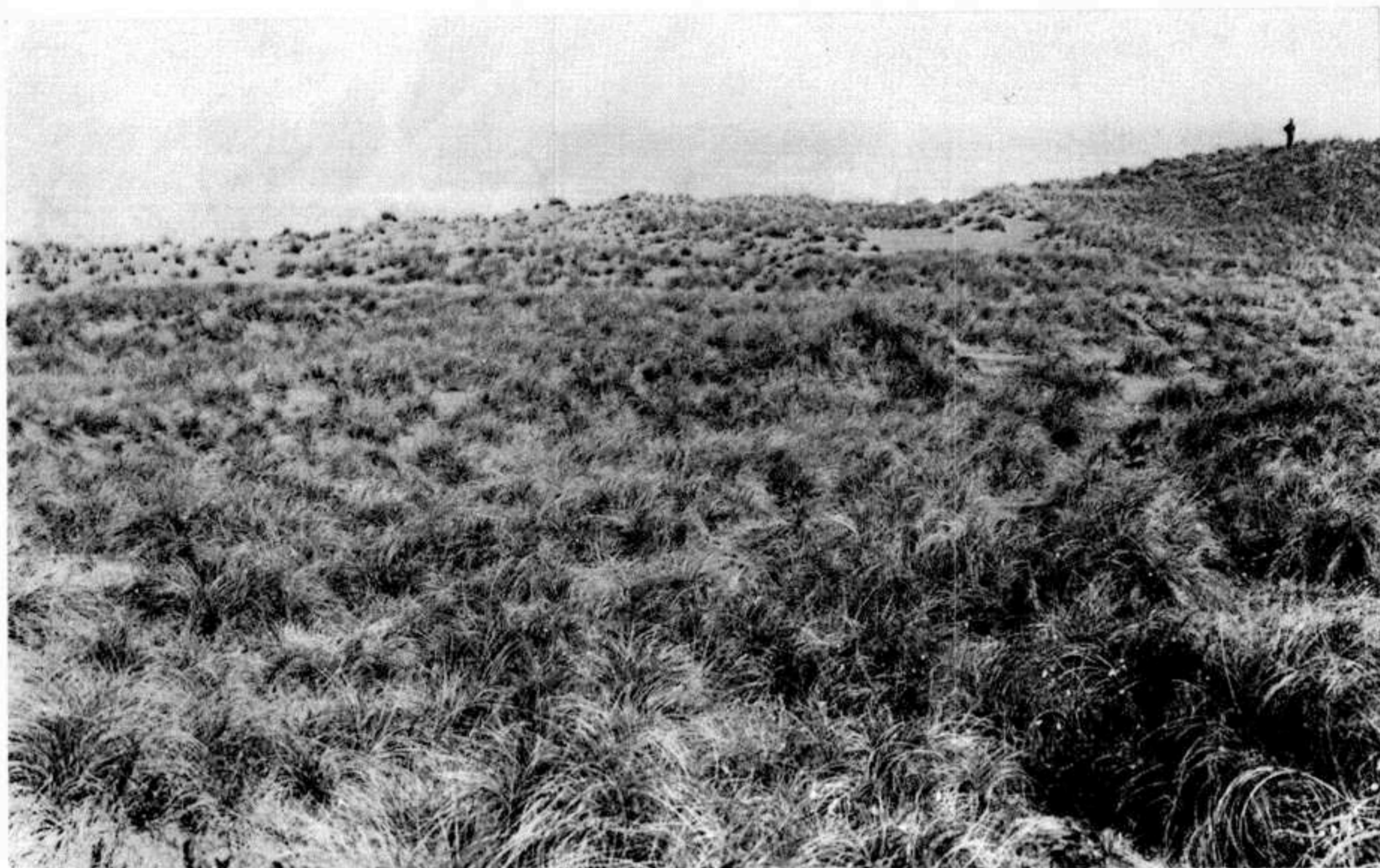


FIGURE 10. *Kaitorete Spit* — part of the extensive dune system covered with pingao and the adventive grass, *Lagurus ovatus*. [Photo C. J. Miles, D.S.I.R.]



FIGURE 11. *Kaitorete Spit* — typical, windshorn ngaio on coarse sands with pingao in the background. [Photo C. J. Miles, D.S.I.R.]



FIGURE 12. *New Brighton* — northern end of flax swamp which lies directly opposite the former residence of Dr L. Cockayne.

[Photo C. J. Miles, D.S.I.R.]

At New Brighton, inside the “urban fence”, and between the Avon River and New Brighton Road, is the last surviving stand of flax swampland in Christchurch, covering about eight acres. Flax (*Phormium tenax*) dominates the northern end (Fig. 12) which lies directly opposite the former residence and experimental gardens of Dr L. Cockayne. The southern end is subject to tidal influence allowing estuarine plants such as *Plagianthus divaricatus*, *Leptocarpus similis*, *Cotula coronopifolia*, *Salicornia australis*, *Scirpus americanus* and many others to enter the community. The central part is dominated by raupo (*Typha orientalis*) and niggerhead (*Carex secta*), and typically includes such native species as *Hierochloa redolens* “silver”, *Baumea rubiginosa* (*Cladium glomeratum*), *Coprosma propinqua*, *Blechnum capense*, *Hebe salicifolia* and *Cordyline australis*. Pukeko (*Porphyrio porphyrio*), duck (*Anas* spp.) and kingfisher (*Halcyon sancta*) are some of the birds which nest in this community.

This swamp is Crown land, classified as a recreation reserve, and controlled and managed by the

Christchurch City Council. In my view it should be re-classified to protect its plants, soils and wildlife, and perhaps even re-named the “Cockayne Reserve”.

#### *Example 7: Avon Mouth*

At the mouth of the Avon River where it enters the Avon-Heathcote Estuary, and bordered on both sides by the “urban fence”, is an extensive area of estuarine vegetation, tidal mud flats and islands which are difficult to find in other parts of Canterbury. Straddling the bridge shown in Figure 13 is an area of some 40 acres of Crown land representing the best of this ecosystem. Large tracts of *Plagianthus divaricatus*, *Leptocarpus similis*, *Juncus maritimus* and many other native salt marsh plants alternate with clean sand beaches and tidal muds which are particularly rich in animal life (cf. Morgans 1968). The bird population is abundant, including, in addition to gulls and other coastal birds, both overseas and local migratory waders.



FIGURE 13. *Avon mouth* — typical estuarine vegetation and tidal flats.

[Photo C. J. Miles, D.S.I.R.]

This area has recently been classified as a recreation reserve controlled and managed by the Christchurch City Council. Future plans include the replacement of the existing bridge with a longer more extensive structure and the reclamation of some of this estuary for recreational facilities. The future of this particular area seems predictable, but it is to be hoped that some parts will be retained in their present state in the course of urban development.

#### *Example 8: Harewood*

Beyond the "urban fence", on freehold land classified by the Christchurch Regional Planning Authority as a "proposed, special rural area", lie several hundred acres of undeveloped Selwyn soils of the Waimakariri River floodplain. The prevailing steppe-like grassland of this area differs floristically from that found on similar soils at Great Island and Halkett where *Notodanthonia clavata* is dominant. At Harewood, large areas are dominated by *N. caespitosa* and *Agropyron scabrum* "rough". Other plants restricted to Harewood in this comparison are *Convolvulus verecundus*, *Coprosma brunnea*, *C. petriei*, *Carex resectans*, *Hypoxis pusilla*, *Geranium retrorsum* and a member of the

*Clematis marata-quadribracteolata* complex. In addition, several species found at Great Island or Halkett do not occur at Harewood. Substantial differences in the frequency of species common to all three regions provide further contrasts.

This interesting area (Fig. 14) lies next to the Harewood Golf Club and the Christchurch International Airport, and the future extensions planned by both enterprises will eliminate most of the present native vegetation. It is important therefore to at least document the area and perhaps rescue some of the rarer species for transplantation to other similar communities.

#### PROBLEMS OF ACQUISITION AND MAINTENANCE

The examples of native communities discussed above represent a portion of the primitive environment of the Canterbury Plains. They are not the only ones, nor is it claimed that they all reflect a true cross-section of their respective soils. Some, in fact, may only be variants with certain special features. The important point is that such communities still survive in the closely settled environment of the Canterbury Plains. The fact that four of these areas have been successfully reserved within the last 12 months should demonstrate that

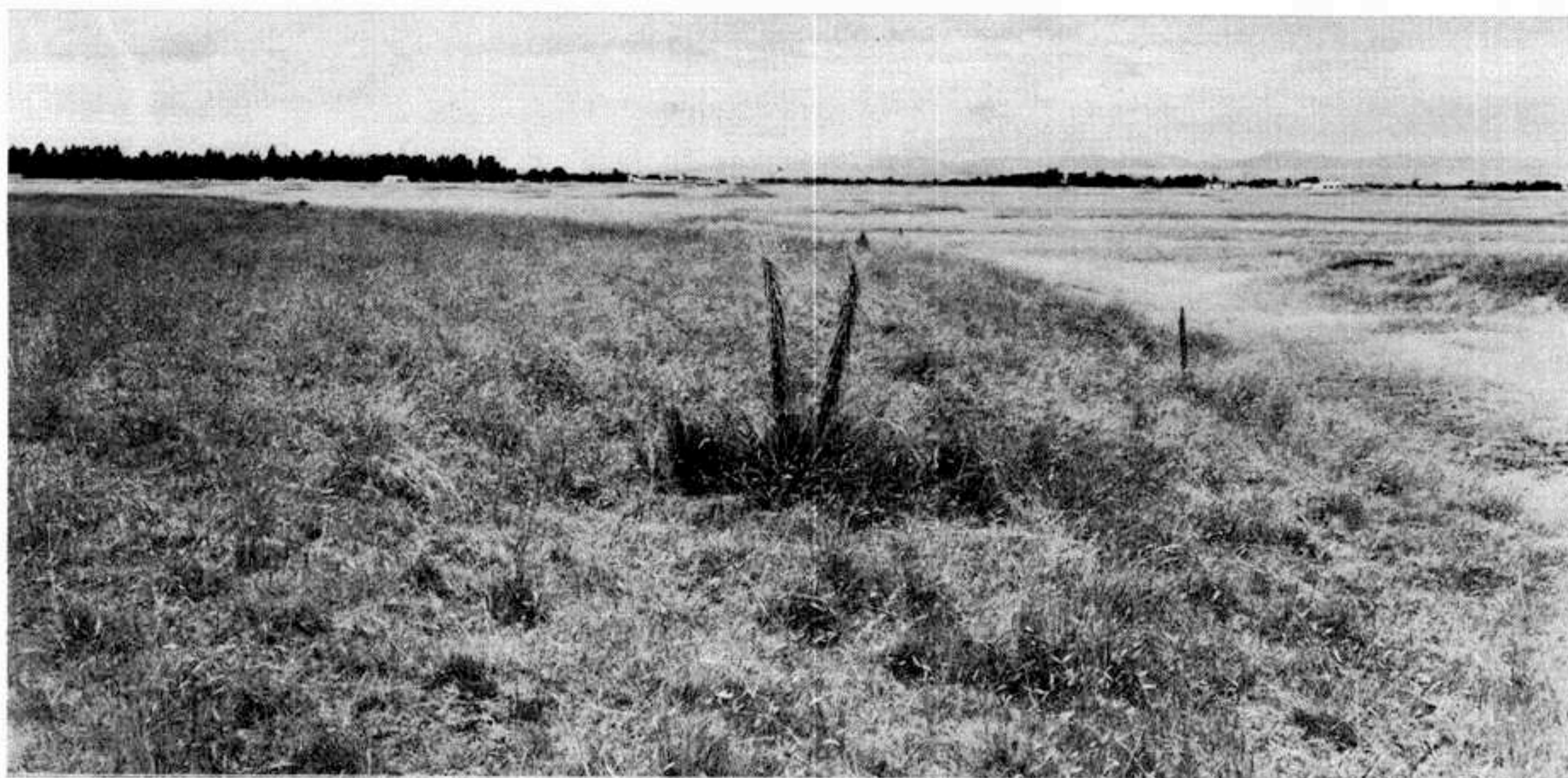


FIGURE 14. *Harewood* — *danthonia* grassland with female heads of *Aciphylla subflabellata* in the foreground and the Christchurch International Airport in the background.

[Photo C. J. Miles, D.S.I.R.]

New Zealand has the legal and administrative structure necessary for this purpose. In my experience the acquisition of such reserves does not pose any major problems, provided that the surveys, proposals, inspections and reports, are thoughtfully prepared and put through the appropriate channels.

The main problem, as I see it, concerns their future control and management. Can we, for example, devise a management programme for communities which have survived, and have sometimes been moulded, by 120 years of periodic grazing and burning? Experience overseas with reserves of similar vegetation indicates that immediate problems are brought about by the cessation of grazing (Wells 1969), and that some form of controlled grazing, cutting or even burning, may be essential to preserve some species and communities. Additional problems will include the possible drift of artificial fertilisers and pesticides and transfer of unwanted seeds and nutrients by livestock used for controlled grazing — not to forget the routine control of noxious weeds and pests.

Equally important will be the control of an increasing scientific and educational demand which these reserves must attract by virtue of their relic status and value as permanent reference sites, and

their accessibility. Although these reserves could serve several purposes, most will probably become scientific and educational reserves, the need for which has already been stressed (Atkinson 1961). It is suggested, therefore, that where possible these reserves should be owned and controlled by the Crown, and that a committee on which scientists are adequately represented is best suited to fulfil the role of their future management.

The potential of relic native communities on the Canterbury Plains is impressive. Many are little known, peculiar to the Plains, and almost totally undescribed. Much of what was thought by early writers to have disappeared completely still survives; and there will be many new and interesting records among the survivors. The one disturbing feature is the sudden impetus to develop "native" land which has been idle for the last 120 years. A check list of the Plains' indigenous relics is thus essential, followed by prompt action on the most urgent cases, and finally, a systematic documentation of all surviving natural ecosystems.

Such action may not be suitable or necessary for general application, but it would be encouraging if ecologists were attempting similar programmes in closely settled regions elsewhere.

## ACKNOWLEDGMENTS

Helpful discussion and co-operation with the following is duly acknowledged: Officers of the New Zealand Department of Lands and Survey, the New Zealand Forest Service, and the Christchurch Regional Planning Authority; Mr L. W. McCaskill; Mr A. C. Norton, North Canterbury Catchment Board; Mr H. G. Gilpin, Director of Parks and Reserves, Christchurch City Council; Mr A. R. Jamieson, Airport Manager, Christchurch International Airport; and many local farmers.

I also wish to thank Mr W. R. Sykes and Dr N. T. Moar for helpful criticism of this paper, and Mr C. J. Miles for photography. Figures 1-3 were drawn by Mrs B. McCulloch.

## REFERENCES

- ATKINSON, I. A. E. 1961. Conservation of New Zealand soils and vegetation for scientific and educational purposes. *Science Review* 19: 65-73.
- BEARD, J. S. 1967. Some vegetation types of tropical Australia in relation to those of Africa and America. *Journal of Ecology* 55: 271-290.
- CONNOR, H. E. 1964. Tussock grassland communities in the Mackenzie Basin, South Island, New Zealand. *New Zealand Journal of Botany* 2: 325-351.
- CONNOR, H. E. 1965. Tussock grasslands in the middle Rakaia Valley, Canterbury, New Zealand. *New Zealand Journal of Botany* 3: 261-276.
- HOPKINS, B. 1970. Fringing woodland—A note on a term in a publication of Kershaw. *Vegetatio* 20: 396-397.
- MASON, R. 1968. The vegetation of the coast. In *The natural history of Canterbury*. G. A. Knox, Ed. A. H. and A. W. Reed, Wellington.
- MOLLOY, B. P. J. 1968. Recent history of the vegetation. In *The natural history of Canterbury*. G. A. Knox, Ed. A. H. and A. W. Reed, Wellington.
- MOLLOY, B. P. J. 1970. Bankside—A new scientific reserve on the Canterbury Plains. *Proceedings of the New Zealand Ecological Society* 17: 47-51.
- MORGANS, J. F. C. 1968. The biology of the Avon-Heathcote Estuary. In *The natural history of Canterbury*. G. A. Knox, Ed. A. H. and A. W. Reed, Wellington.
- NEW ZEALAND SOIL BUREAU. 1968. Soil map of the South Island, New Zealand. In *Soils of New Zealand. Part 1. New Zealand Soil Bureau Bulletin*: 26 (1).
- TRAVERS, W. T. L. 1868. On the utilization of the *Phormium tenax*. *Transactions of the New Zealand Institute* 1: 114-119.
- WELLS, T. C. E. 1969. Botanical aspects of conservation management of chalk grasslands. *Biological Conservation* 2: 36-44.