MAVORA

Development of a Planning Process for Reconciliation of Interests in Wilderness

K.F. O'Connor • G.W. Batchelor • J.J. Davison

TGMLI

Lincoln Papers in Resource Management No. 4

Tussock Grasslands and Mountain Lands Institute, Lincoln College

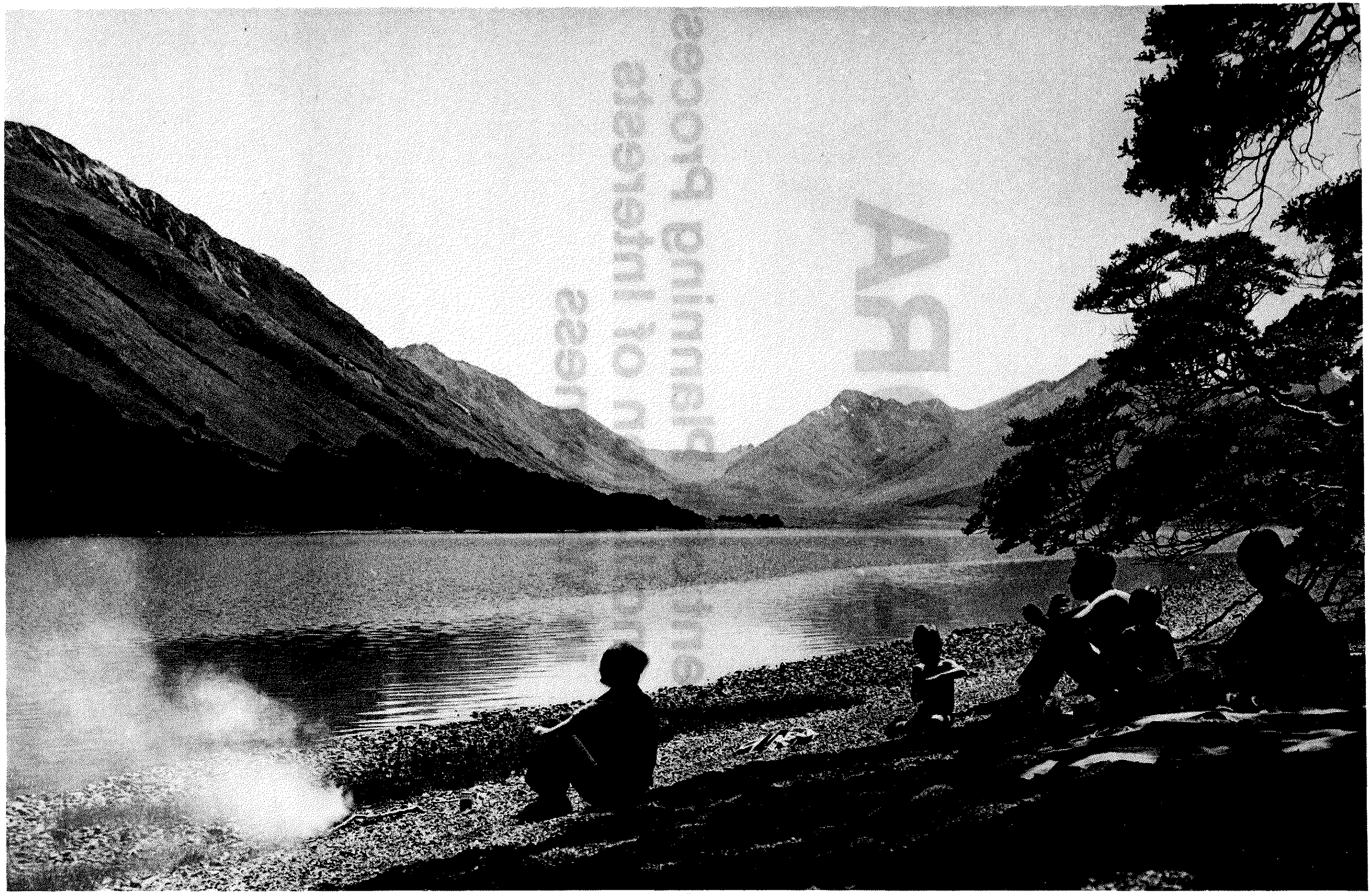
Published by Centre for Resource Management

ISBN 0-908584-75-X

ISSN 0111-1809

MAVORA

Development of a Planning Process for Reconciliation of Interests in Wilderness



Mavora: where mankind and mountains may be reconciled (1).

MAVORA

Development of a Planning Process for Reconciliation of Interests in Wilderness

K.F. O'Connor, G.W. Batchelor and
Jenny J. Davison

Lincoln Papers in Resource Management No. 4

Published by Centre for Resource Management

for

Tussock Grasslands and Mountain Lands Institute
Lincoln College, New Zealand, September 1982

PREFACE

The present work is subtitled "Development of a Planning Process for Reconciliation of Interests in Wilderness. This title introduces three important elements. First, it is a particular kind of study. Second, it is oriented to reconciling conflicting interests. Third, it deals with wild land in public ownership.

We have attempted to do much more than present a report involving inventory and assessment of resources and recommendations of a package of resource uses. Certainly from the beginning this project has had as its main purpose the formulation of a multi-objective use plan, producing a recommended use planning outline for the Mavora Lakes area. It was with this aim that a proposal was submitted to the Director General of Lands to secure financial support for the project. It was consistent with this stated purpose that the Department of Lands and Survey financially supported the original field work and collation of information with a view to assisting its own decisions on land management for the areas of its responsibility.

It became evident as the first draft of recommended use planning outline was being prepared in 1976, that there were profound conflicts between different possible uses of the area and there also appeared to be major differences of attitude between different national and local government agencies. Any recommendations that we might make to the agencies involved concerning resource uses for the future would have lacked cogency if they did nothing to resolve such conflicts or differences. Study of new approaches to resource management and to land evaluation in particular became essential. Whereas most New Zealand land planning studies hitherto had emphasised land inventory and capability assessment, we found that the required recommendations themselves demanded foundations in the socio-economic as well as in the physical or ecological sphere.

Diligent use of the now bountiful international literature on land evaluation and resource management and planning allowed us to understand the kinds of approach that were necessary to integrate socio-economic with physical and ecological considerations. Methods had been developed in other countries for integrated resource planning and management, as conflict resolution among land use interests is now commonly called. Most of these methods were found to be based on resource inventory and interpretation procedures which would have required far more expenditure of money and manpower than we had available, more indeed than we believed the Mavora area could at present justify. We found that we had to develop new operational procedures to suit our mountain wilderness problem. Our objective in this respect became the development of resource evaluation and use planning procedures which would allow the major directions of use to be rationally decided, at the same time identifying the supplementary studies likely to be necessary for consequential decisions.

One of the important geographic features of New Zealand is that it is predominantly hilly and mountainous. It is a remarkable accomplishment that this complex terrain should have been so well inventoried in terms of topography, geology, soils and land units by the Department of Lands and Survey, Geological Survey of the Department of Scientific and Industrial Research, Soil Bureau of the Department of Scientific and Industrial Research, and Water and Soil Division of the Ministry of Works and Development respectively.

Use suitability assessments, however, must consider the resource at a dimension appropriate to each use for which suitability is being independently estimated. Among the potential uses of the Mavora are pastoralism with its extensive ranging of livestock, wildlife conservation with extensive ranging of birds, recreation with the important elements of landscape viewing and wilderness and nature experience, and water production and management from extensive catchments. Each of these uses warrants resource evaluation at dimensions far larger than the bounds of the individually mapped land unit components. Furthermore, design of such uses in harmony with mountain nature requires that planning must take account of the systematic unities in landscape, as well as of the differences between its components.

These considerations of dimension and of system unity suggested that we should incorporate the land systems concepts of Christian (1958). We believe that these concepts contribute materially to the discernment of order in the midst of variety represented by resource inventory. They also allowed us to prepare economically a planning outline suitable for primary decision making.

It has already been suggested that land systems may have great value as a base for primary land use decisions in a wider range of situations in New Zealand where integration of uses is sought (O'Connor 1978, Mathieson 1976). We affirm the more traditional view that use capability for individual uses should be assessed for individual land units as the need arises for second-order decisions on actual practice.

The socio-economic information incorporated in this study may not always suffice for the second-order decisions that will be necessary to implement the use recommendations arising from the primary assessment. We consider, however, that sufficient kinds of socio-economic information have been integrated in the planning process outlined here, for local, regional and central government personnel to accept the primary evaluation we have made. If they disagree with us in assessments or weighting of social interests, then it will be easy for them to insert new values and examine the consequences in the planning process. If new recommendations would arise from alteration of assessed values or weightings then it may be prudent to assess socio-economic conditions more carefully. We believe that they should find it a relatively straightforward exercise to gather the further detail if it be required. We believe that the constant clarification of values and the recurrent confrontation of values with facts which are at the heart of resource management (Davidoff and Reiner 1961, Kaplan 1958, O'Connor 1978) will be made more productive and less burdensome because the planning process which we have developed provides a methodic context for these activities.

This study took longer to complete than its complexity and scope warranted. The study has been through three major phases, each of which has had its own character and reflects the state of the art for the authors at the time. The first phase of work involved the collation and interpretation of resource data. It led to a set of recommendations which were grounded as much on the intuitions of the authors as on the resource facts collated. As indicated earlier, such a basis would not have been cogent for resolving the conflicts between resource uses and between resource management agencies. The second phase of work involved a structuring of the planning process in which representatives of such resource management agencies and interest groups could be positively consulted. From this phase a draft report emerged which was submitted for comment to the sponsors. The third phase has involved the senior author in the revision of the presentation of the planning process and findings into their present form. Interruptions occurred between each phase, first from the departure of the second author to resume a teaching career and the more urgent demands on the other authors of the preparation for and compilation of proceedings from the 1977 Conference on the Conservation of High Mountain Resources and their involvement in studies of nationwide recreation use of mountain lands, and finally for the senior author from the recurrent tasks of a University Institute post. These delays have been turned to profit. As a teacher in resource management programmes I have used the "Mavora Planning Process" for nearly four years at Lincoln College so that students could subject it to their own critical analysis and test its worth in a wide range of land evaluation and planning exercises.

As indicated immediately above, an earlier draft of this report was submitted for comment to the Department of Lands and Survey which funded the original investigations, as well as to some other parties. As an outcome of student experience and in consequence of comments received, I have carried out extensive revisions of the presentation without substantially altering the findings of the study. This revision was made because comments from critics of the draft report and from students using the methods developed in it indicated that the real value of the report lay in the process and methods developed and that failure to understand them would lead to continuing dispute about the findings and recommendations.

We believe that wise decisions must be grounded in a sequential procedure for confrontation of physical and ecological fact and function of the real world with the needs and values of an equally real and complex society. We do not deny that such considerations have influenced decisions in similar matters up to the present. We claim, however, that unless such considerations are seen to be taken in an open, clear and orderly process, our society will never be confident of its political decisions and seldom be able to identify and profit from its mistakes. For this reason we believe that our study may have value far beyond the margins of the wild but serene Mavora, in the wider field of resource management in New Zealand at large.

Kevin F. O'Connor

Professor of Range Management
Fellow, Tussock Grasslands & Mountain Lands Institute
Joint Centre for Environmental Sciences
Lincoln College, January 1982

The authors of this work:

Kevin O'Connor, B.Agr.Sc., B.A., Ph.D., F.N.Z.I.A.S., is Professor of Range Management in the Joint Centre for Environmental Sciences at Lincoln College. From 1969 to March 1981 he was also Director of the Tussock Grasslands and Mountain Lands Institute. Following university qualifications in agricultural sciences, economics and philosophy he worked from 1956 to 1969 in grassland research, especially in the South Island tussock grasslands, initially as Liaison Officer for Tussock Grasslands Research in the Department of Agriculture and then as Officer-in-Charge of the Lincoln Regional Station of Grasslands Division of Department of Scientific and Industrial Research. At Lincoln College, in addition to grassland and mountain research, he was responsible for the advanced teaching programme leading to the post-graduate Diploma in Natural Resources from its inception until its integration in 1979 in the work of the Joint Centre for Environmental Sciences. His special teaching responsibility continues to be in Land Classification and Utilisation. He has been responsible for guiding this Mavora study and for the assembly, revision and final presentation of the whole as well as the primary composition of Chapters 6, 7, 9, 10, 11, 12, 13.

Graham Batchelor, B.Sc., Dip.Surv., Dip.Nat.Res., came to Lincoln College after completing university training in surveying and physics at the University of Otago and some years' field experience in Southland and school-teaching in the North Island. He completed the field studies for the first five chapters of this study as the project requirements for the Diploma in Natural Resources in 1976 and collected much of the further material required for the larger study. For the past few years he has been teaching science in a Canterbury Post-Primary School.

Jenny Davison, B.A., Dip.N.Z.L.S., Dip.Nat.Res., after qualifying in history and library science has led a varied career in New Zealand, North America and South America involving secretarial work, mountaineering, park and community service. She completed her Diploma in Natural Resources with a project tracing the history of recreation in the Lake Ohau district. For the next few years she worked with the Tussock Grasslands and Mountain Lands Institute in the field of recreation and natural resources and is now in related work in the Department of Lands and Survey. Her contribution to this study has been the primary revision of the earlier chapters and the compilation of Chapter 8, following interviews with leaders of all the organisations involved.

ACKNOWLEDGEMENTS

The following individuals gave freely of their time for personal interviews, discussion and correspondence or otherwise volunteered information and opinions. The authors wish to thank them sincerely for their co-operation and acknowledge their debt to them for information and stimulus derived from such contact. The authors assume full responsibility for any errors of fact which may reside in this study and for all the opinions and judgments expressed therein.

K.A. Ackley, Senior Lecturer in Natural Resources, Lincoln College.

R. Barrowclough, Federated Mountain Clubs of New Zealand, Mount Aspiring National Park Board.

J. Bathgate, New Zealand Forest Service, Invercargill.

J. Brent, Department of Lands and Survey, Invercargill.

A. Brookes, Kingswell High School, Invercargill.

D. Brown and other members of the Landrover Club, Dunedin.

W. Brown, Mavora Farm Settlement.

J. Bruce, Soil Bureau, Dept of Scientific and Industrial Research, Gore.

M. Burke, Mount Aspiring National Park.

L.J. Coughlan, Wildlife Division, Department of Internal Affairs, Dunedin.

E.J. Davies, then Department of Lands and Survey, Dunedin, now Christchurch.

A. Hall, Wildlife Service, Queenstown.

D. Harroway, Centre Hill Farm Settlement.

J.P. Harty, Department of Lands and Survey, Invercargill.

J.A. Hayward, then Tussock Grasslands and Mountain Lands Institute, now Joint Centre for Environmental Sciences.

A.D. Horn, then Southland Catchment Board, Invercargill, now Waitaki Catchment Commission, Kurow.

J. Irwin, New Zealand Oceanographic Institute.

H.A. Jacobs, Fiordland National Park.

P.N. Johnston, Botany Division, Department of Scientific and Industrial Research, Dunedin.

D. Johnstone, Planning Consultant for Wallace County Council.

W.G. Keay, John McGlashan College, Dunedin.

M. Kershaw, New Zealand Forest Service, Invercargill.

W. Lee, Botany Department, University of Otago.

P.W. Lenihan, Southland Catchment Board.

E.I.R. McCartney, Wallace County Council.

N.A. McMillan, Southland Catchment Board, Invercargill.

R.F. McMinn, Department of Lands and Survey, Invercargill.

C. Main, New Zealand Forest Service, Invercargill.

A.F. Mark, Botany Department, University of Otago.

D. Marshall, Department of Lands and Survey, Invercargill.

R. Mathieson, Department of Lands and Survey, Wellington.

G.A. Mead, Southland Youth Adventure Trust, Invercargill.

R. J. Metherall, Elfin Bay Station.

C. Meurk, Botany Department, University of Otago.

W.L. Miller, Department of Lands and Survey, Dunedin.

L.F. Molloy, Federated Mountain Clubs of New Zealand.

J. Neilson, Wildlife Service, Dunedin.

R. Nilsson, Wildlife Service, Dunedin.

N. O'Byrne, Soil Bureau, Gore.

Professor Parker, visiting at University of Canterbury.

B. Pinney, Mossburn.

W.A. Robertson, Department of Lands and Survey, Wellington.

M. Small, Wildlife Service, Queenstown.

J. Soams, Department of Lands and Survey, Invercargill.

L. Spence, Wallace County Council.

V. Stout, Zoology Department, University of Canterbury.

R.R. Sutton, Southland Acclimatisation Society

I. Turnbull, New Zealand Geological Survey, Dunedin.

R. Usmar, then New Zealand Forest Service, Invercargill.

P. Wilding, Wallace County Council.

Organisations replying to our written requests were as follows:

Dunedin Canoe Club
Federated Farmers of New Zealand, Southland
Girl Guides, Fiordland District
Hokonui Tramping Club, Gore
Invercargill Conservation Committee
New Zealand Deerstalkers' Association, Invercargill
New Zealand Horse Society, Southland Area
Otago Mountaineering and Tramping Club
Southland Environmental Action Group
Southland Power Boat Association
Southland Tramping Club
Southland Youth Adventure Trust
Y.M.C.A., Invercargill

Their assistance is appreciated.

Grateful acknowledgement is made for the assistance of the Director General of the Department of Lands and Survey in making available a grant to support the field research and compilation work of Mr G.W. Batchelor and in making available the services of Miss Jenny Davison for the furtherance of this work. Thanks are also expressed for the criticisms of staff of the Department of Lands and Survey and other persons of the draft report of this study. This assistance is in no way to be interpreted as an endorsement or approval of the findings or recommendations contained therein.

Miss P.V. Prendergast provided the line drawings for the figures and Mr B. Pinney provided photographs for the plates. Tussock Grasslands and Mountain Lands Institute typists typed the manuscript. To these people and to Mr Brian Robertson and Ms. E. R. Short, for editorial and publishing services in the Tussock Grasslands and Mountainlands Institute, the authors are especially grateful.

CONTENTS

List of Tables

List of Figures

APPENDICES

CHAPTER ONE
Introductory Outline

1.1 THE MAVORA AS A RESOURCE USE PLANNING PROBLEM

The Mavora Lakes area has been a subject of regional interest and some controversy for a number of years. Geographically, the Mavora is intermediate between an acknowledged zone of preservation and a zone of land development. Historically it represents a zone of interaction between different agency interests, notably those of the New Zealand Forest Service and those of both the nature conservation and pastoral administration and development arms of the Department of Lands and Survey. Extensive pastoralism as private enterprise has yielded ground in the district to pastoral development and farm settlement. The limits to this process have tended to be set by progressive experience on the land available for farm settlement. A working plan had been drafted for the adjacent Snowdon Forest. More active management planning for lands administered separately by these two major central government agencies served to bring into sharper contrast any differences between such development proposals if they remained ineffectively co-ordinated. Meanwhile the long-valued fishery resource of the Mavora Lakes and the Mararoa River has itself commanded greater attention because of increased use by anglers and the improved road access to the area which has itself increased boating and other shoreline recreation. While discharge from the lakes in the Mararoa River is being directed down-stream into Manapouri for power production, some thought has been given to using it in part to augment the summer low flows of the Oreti to Invercargill.

Different communities of interest show varying degrees of support and aversion for the different kinds of resource use outlined above. Decisions are needed to determine the optimal use of resources before any further development which may irreversibly change the resources and their character.

1.2 THE AIMS OF THE STUDY

The primary aim of this study was to produce a recommended use planning outline that would reconcile these aspirations where possible and make an assessment of research and detailed survey that would be needed for effective implementation.

As an instrument for this primary aim, it became necessary to develop and test processes of

(i) assessing land resources and water resources in principally qualitative terms,

(ii) of evaluating such resources in terms of use suitability for a range of uses,

(iii) of identifying and assessing social interests in such uses,

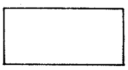
(iv) identifying alternative opportunities for their satisfaction, and

(v) of integrating such evaluations and assessments with the enunciated goals and objectives of government and community organizations in as compatible a way as possible.

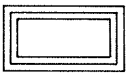
1.3 THE PLANNING PROCESS DEVELOPED

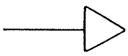
The planning process developed to attempt resolution of the acknowledged problems to attain the primary aim is outlined in the accompanying flow diagram (p.3).

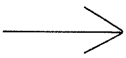
 indicates a process

 indicates a statement of knowledge in which the subjective element is minimal

 indicates an assessment or judgement in which the subjective element is important

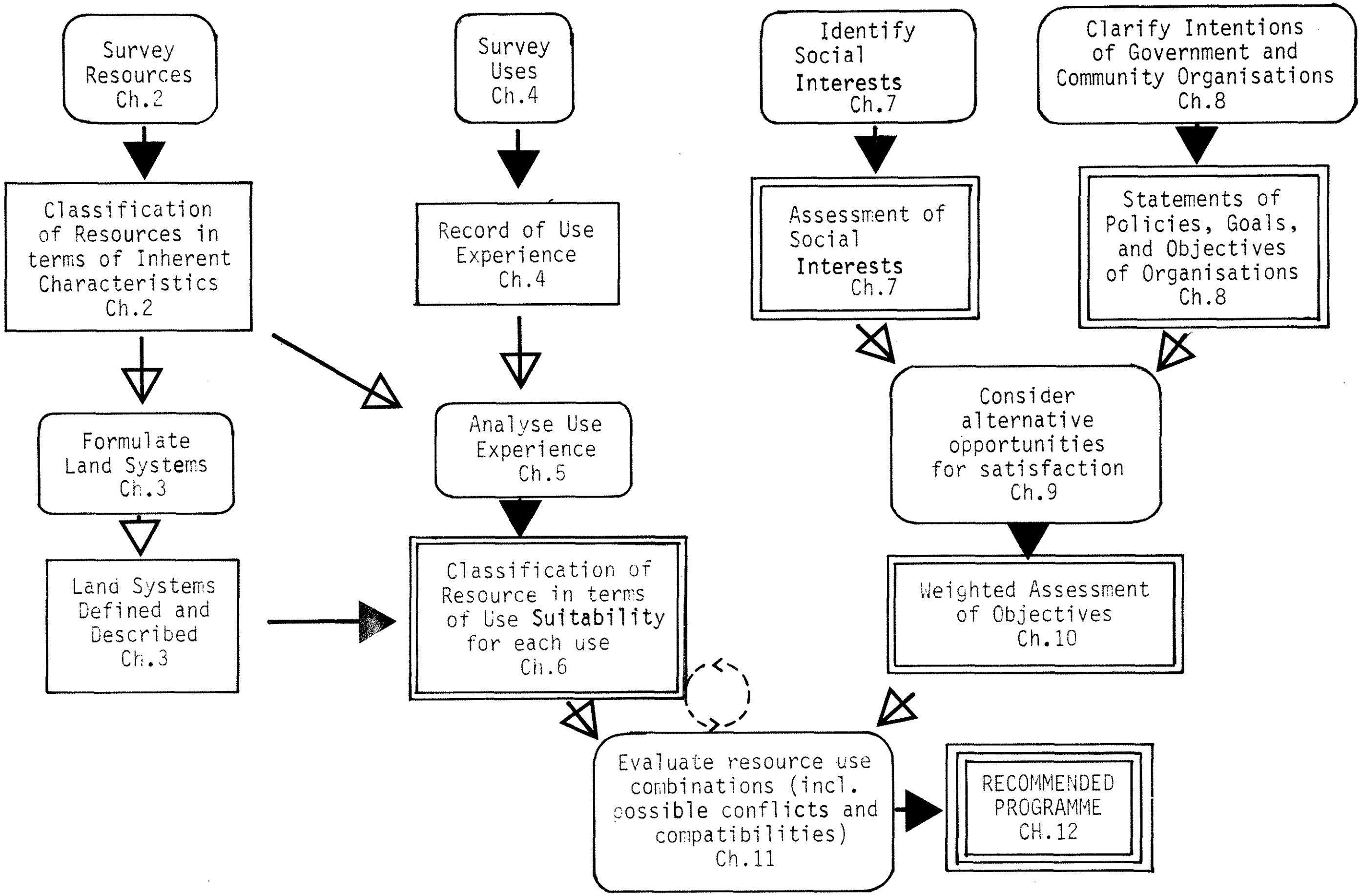
 indicates a recommended course of action

 indicates output

 indicates input

 indicates feedback of information and reformulation of resource uses

THE PLANNING PROCESS - MAVORA STUDY



The components of the process are further explained:

Survey and Classification of Resources in Terms of Inherent Characteristics:
The inherent characteristics of the environment which are considered are: location, geology, geomorphology, topography, climate, soils, vegetation, water bodies and wildlife (Chapter 2).

Formulation, Definition and Description of Land Systems:
Terrestrial information is organised as land systems (Chapter 3).

Uses Surveyed and Analysed: These are nature conservation, forestry, grazing, recreation and downstream water uses (Chapters 4 and 5).

Use Suitability for each use is assessed from use experience of the resources identified or from use experience of similar resources. This results in the theoretical range of choice of alternative uses (Chapter 6).

Estimation of Social Needs and Desires for each of a number of uses is made with consideration of the inherent worth of each and the evidence of demand for each (Chapter 7).

Intentions are identified as a clarification of the projected use objectives of the different resource controlling bodies and resource using bodies and persons. These are crystallised as interpretative statements of Policies, Goals and Objectives of these organisations (Chapter 8). The hierarchy of policies, goals and objectives as defined below under Recommended Programme is central to the planning process.

Alternative Opportunities for satisfaction of social needs and desires are appraised by considering other local or regional resources and their uses or potential uses for the purposes considered (Chapter 9).

Weighted Assessment of Objectives involving judgements on the relative worth of different objectives. Each objective is weighted either positively or negatively, according to the alternative opportunities for satisfaction of needs, and the significance to society of who benefits and how do they benefit from the proposed objectives (Chapter 10).

Resource Use Combinations are evaluated, identifying compatibilities and conflicts between different uses of the same or related resources (Chapter 11).

Recommended Programme of the practical and socially optimal uses is presented (Chapter 12).

Hierarchy of Policy, Goals and Objectives:
Each step down the hierarchy indicates what is recommended (or accepted) in order to fulfil the step above. Thus:

> A policy is a statement of guiding philosophy, a broad statement of an explicit purpose which reflects societal values.
>
> A goal states the policy suggesting measurable criteria or quantification. (The policy values are accepted.) It is concise enough to act as a directive in designing objectives.
>
> An objective is a specific activity capable of both attainment and measurement, bringing the policy into effect.

Objectives may be broken down into tasks which implement the objectives. They are specific, routine, of shorter duration, but aimed at adhering to the same objective.

Objectives and goals are separated from the policy statement because:

(i) there are nearly always alternative (compatible or conflicting) ways to pursue a policy or goal;

(ii) they relate to distinct steps of the planning process, for policies and goals are related to ends, objectives and tasks to means;

(iii) they help clarify the difference between and define the roles of those who make policy and those who implement it.

1.4 LIMITATIONS OF THE STUDY

This study was a pilot study. The detail of environment over the entire study region has not been described. Instead, the report summarises the Mavora region, organising information on resources in a land systems approach. It is as concerned with clarifying the process of reaching recommendations as with the recommendations themselves. Interpretation of the use suitability of resources of this environment is not easy. Expert advice on specific uses has been sought and used wherever it was known to be available. Where further research is needed, this is noted. Where other activities than research are needed from governmental agencies or community organizations, these are noted. Such a study as this would be best carried out in the framework of a thorough regional plan for the whole northwest Southland region. Some features of this greater regional context are presented.

1.5 PREVIOUS STUDIES IN THE MAVORA REGION

Studies written on resources of the study region have been consulted. Two land use capability surveys have been completed - one by Dunbar *et al* (1966) and a more recent one by the Southland Catchment Board (unpublished). The Department of Lands and Survey produced a draft management plan for the region at the same time as this study was being carried out (Department of Lands and Survey Management Study Team, 1975). The New Zealand Forest Service has a draft working plan for the Snowdon State Forest (Snowdon State Forest Working Plan, 1975). Several geological studies of aspects of the region were available for perusal. Scattered information only was available on vegetation, wildlife, climate and water resources. Land Resource Inventory Worksheets for the region have more recently been published (Hunter 1977, 1978).

1.6 FIELD WORK

Environmental information was gathered during two weeks of February, 1976. This involved visits to Dunedin, Invercargill and the Mavora Lakes. Mr N. O'Byrne, Soil Bureau, Gore, gave considerable assistance for three days on a reconnaissance soil survey of some sections of the region.

Information on recreation, pastoral and forestry uses was gained during a 10-day visit to the region surrounding the study area, including a visit to Elfin Bay Station and Fiordland and Aspiring National Parks. Lands and Survey personnel and New Zealand Forest Service personnel made themselves available in the field to assist the study.

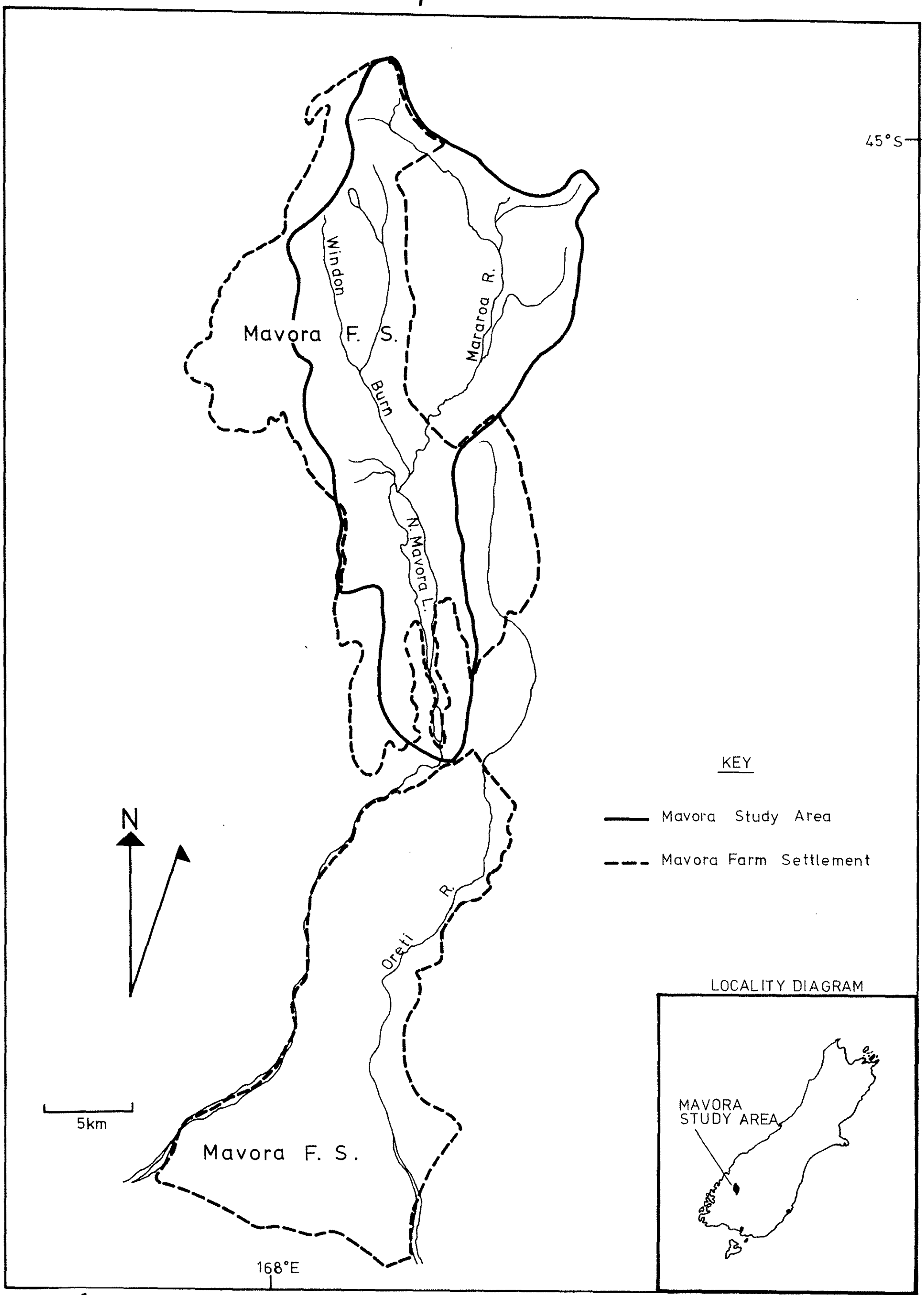
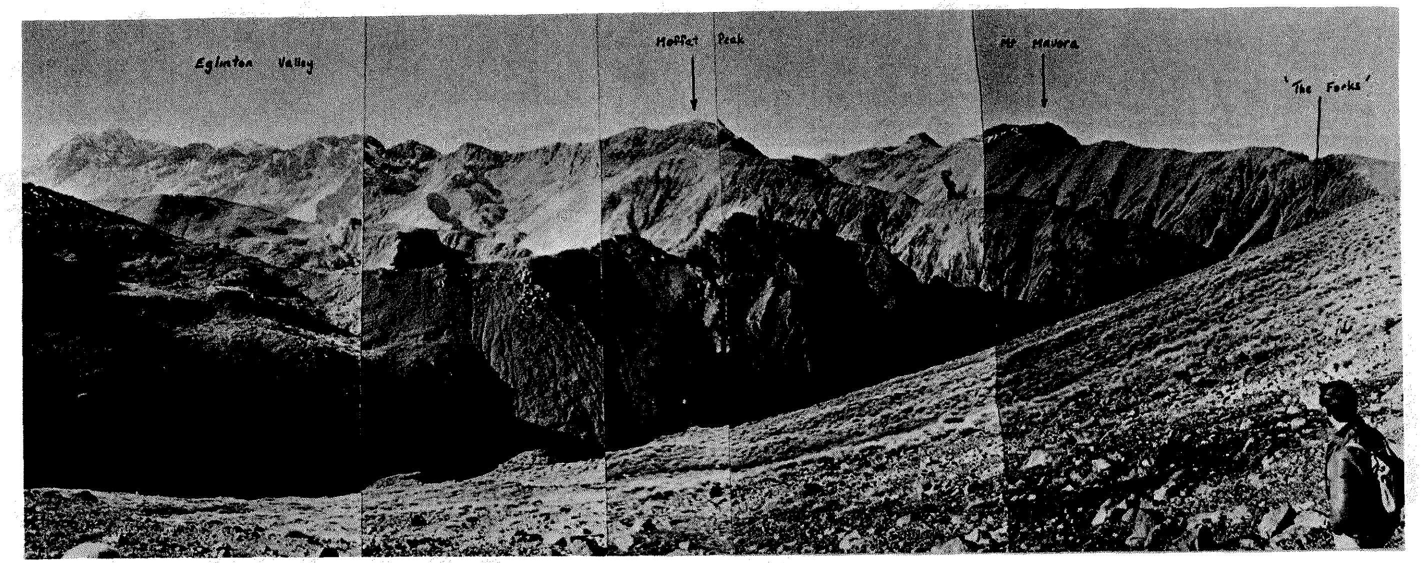


FIGURE 1: LOCATIONS AND BOUNDARIES OF THE MAVORA STUDY AREA AND UPPER MAVORA FARM SETTLEMENT

1.7 THE STUDY AREA

The study was prompted by land use planning problems associated with the Upper Mavora Farm Settlement and greatest attention was given to that area in initial study. However, because activities within one part of a catchment may have a major impact on other parts, it was considered desirable to extend the study to that part of the Mararoa Catchment north of the entrance road to the Mavora Lakes. These boundaries are illustrated in Figure 1.

The study area lies within the Te Anau-Mavora district of north-west Southland, and many relationships exist between the study area and the greater Southland region, e.g., regional recreation needs and downstream water uses. Centrally located between the important tourist and recreational centres of Queenstown, Te Anau-Manapouri and Milford Sound, the Mavora could play a significant role in national recreation planning, especially as part of the National Walkway System.



Panoramic view from a saddle in the Livingstone Mountains looking into the heads of the Windon Burn. (Courtesy of Southland Catchment Board) (2)

Panoramic view to the west from terraces in the Upper Mavora Valley taken in late April 1969. (Courtesy of Southland Catchment Board) (3).

CHAPTER TWO
Inherent Characteristics of the Mavora Environment

The aim of this chapter is to record, assess and interpret the resources of the Mavora environment in terms of those characteristics which are inherent in the environment itself.

2.1 LOCATION AND ACCESS

The Mavora Lakes lie in the glacial Mararoa Valley at more than 600 m above sea level, almost surrounded by high mountains, in Wallace County, northwest Southland, at latitude 45^{o} to 46^{o}. Although passes north to the Greenstone Valley and east to the Von River and the Upper Oreti Valley do not exceed 1,000 metres in altitude, the great trough of Lake Wakatipu further to the north and east has tended to inhibit access to the Mavora from these directions. For the first century of European settlement in New Zealand, this remote valley lacked road access even through its opening to the south. The lakes themselves are more than 30 kilometres from the main highway from Lumsden to Te Anau and are 140 kilometres by road from Invercargill, the main centre of population in Southland. From the end of the rough access road at the south end of North Mavora Lake, a track negotiable by four-wheel drive vehicles skirts the eastern shore of this lake and continues up the Upper Mararoa Valley. Access on foot is possible from the Eglinton Valley in the north-west, from the north via the Greenstone and the east from the Von (Figure 2).

The area of the catchment above and including the Mavora Lakes is approximately 44,000 hectares. The extremities are defined by national grid co-ordinates on NZMS 1 S131 (Eglinton) and NZMS 1 S141 (Mavora).

North	120 770
West	050 590
South	150 320
East	240 660

The relationship of the Mavora Lakes study area to South Island population centres is shown in Figure 2. Location in the greater Southland region, access and place names referred to in the report are illustrated in Figure 3.

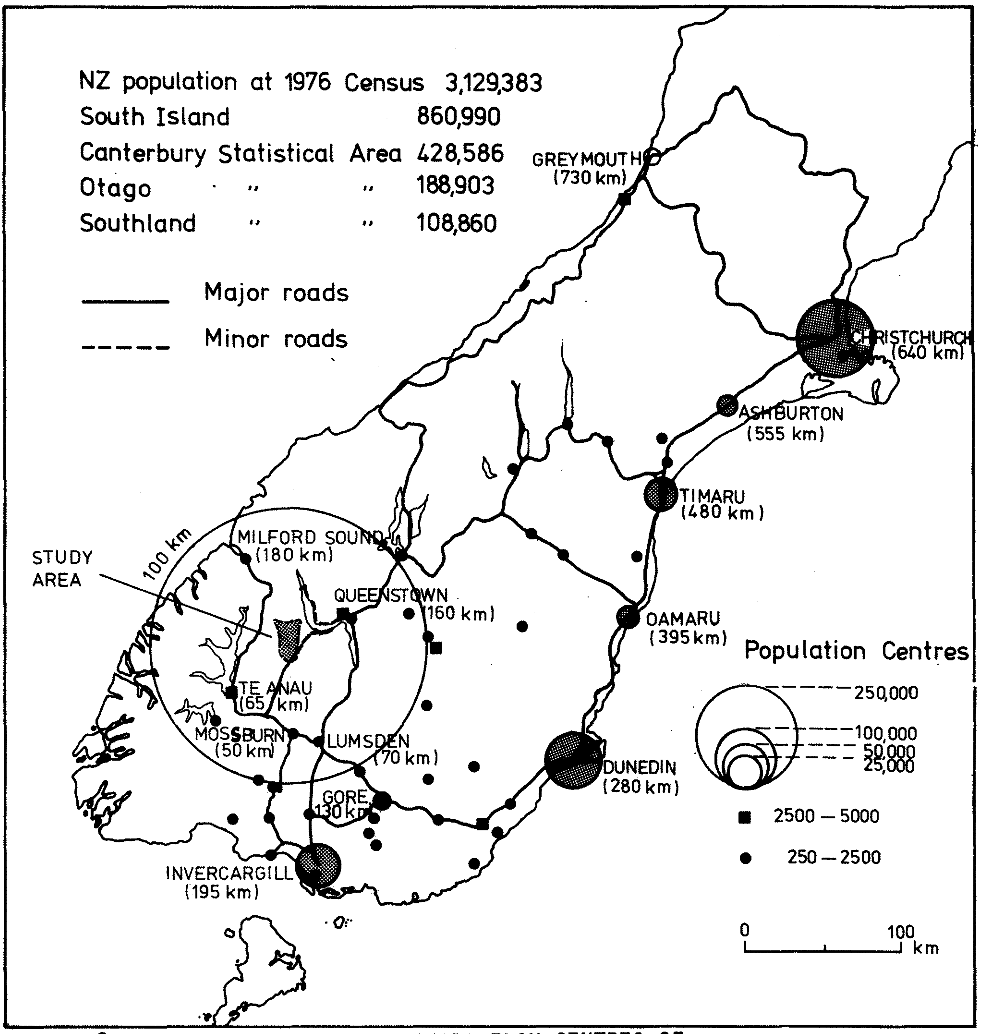


FIGURE 2: DIRECT AND ROAD DISTANCES FROM CENTRES OF POPULATION IN THE SOUTH ISLAND

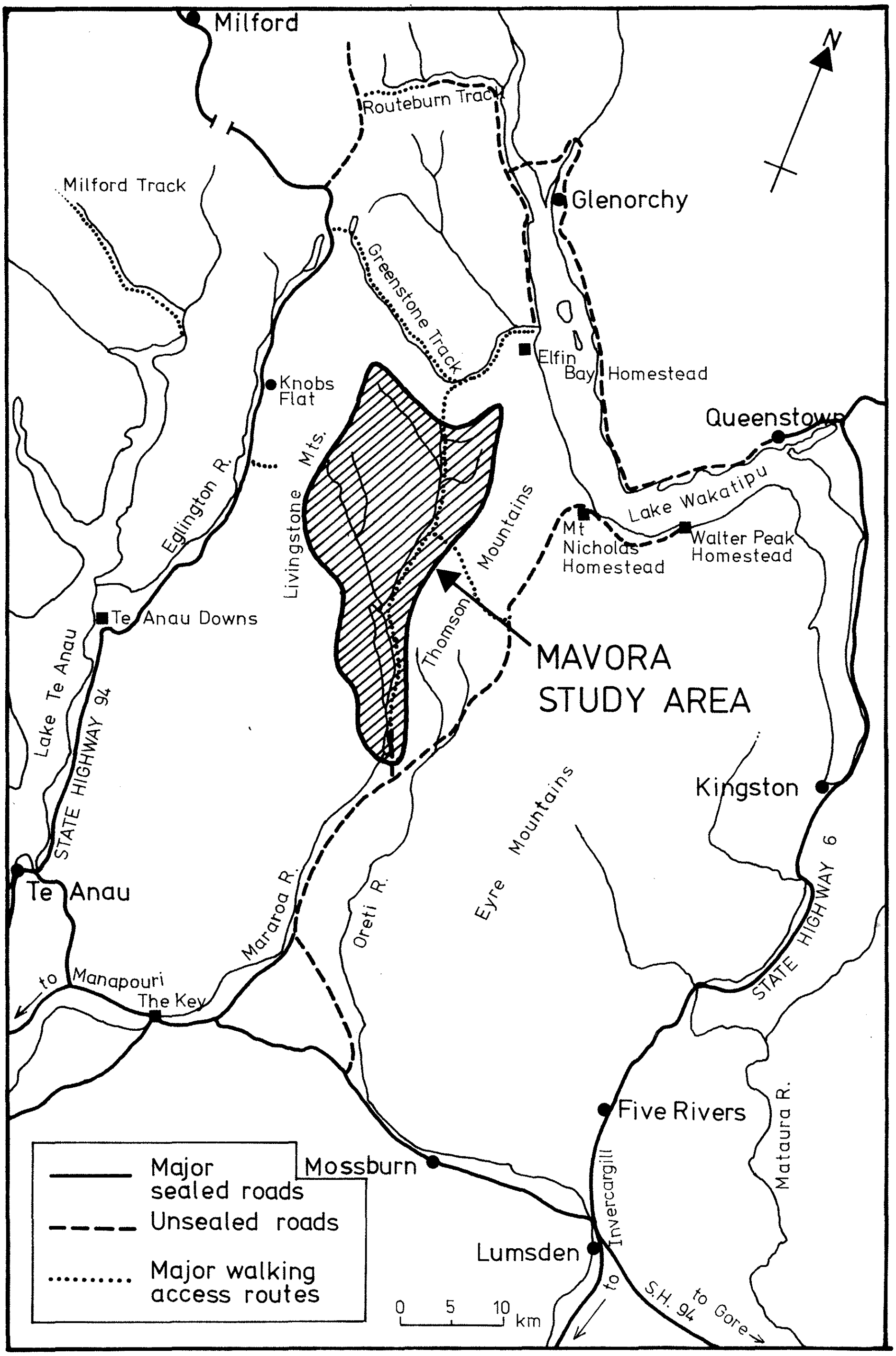


FIGURE 3: LOCATIONS AND ACCESS SURROUNDING THE MAVORA STUDY AREA

2.2 GEOLOGY AND GEOMORPHOLOGY

2.2.1 Outline of Geologic History

An outline of the major geological processes involved in the history of the area is derived from Wood (1962), Craw (1974) and Turnbull (1974).

In the Permian there was sedimentation of "greywackes" of the Caples group and faintly schistose sandstones, siltstones and argillites of the Routeburn formation. Of the same age apparently are the igneous and volcanic formations, the Red Mountain ultramafics and the Livingstone volcanics. Folding caused the development in the west of the Key Summit geosyncline with marine sedimentation within it (Tapara formation) and the Red Rock geosyncline to the east.

In the Jurassic, strata were uplifted to be eroded in the Cretaceous and early Tertiary to a surface of low relief. During the Tertiary there was some marine and terrestrial sedimentation followed by massive uplift with faulting and folding to form the mountain ranges during the late Tertiary and early Pleistocene. Intense glaciation with successive advances in the Pleistocene has been followed by fluviation in the Holocene.

2.2.2 Structure and Faulting

The major structural features are the two synclines, the Key Summit syncline of the Livingstone Mountains in the west and the Red Rock syncline of the Thomson Mountains in the east. A simplified east-west cross-section is shown in Figure 4. These two synclines run approximately parallel in a north-south direction, being separated by the Livingstone Fault to the west of the Mavora Lakes. This fault is of regional significance and stands out generally as a very prominent vertical scarp. Deformation of rock increases towards the fault indicating considerable movement (Craw 1974). The region as a whole is intensely folded and complexly faulted. The Thomson Mountains are dominated by "north-trending sub-horizontal folds in bedding with vertical to steeply east dipping axial planes" cut by several large northeast trending faults, e.g. the Trench Burn Fault, Gilbert Fault and Kenada Fault (Turnbull 1974).

2.2.3 Lithology

Detailed lithology is shown in the key to Figures 4 and 5.

Tall tussock grassland on dissected colluvial surfaces in the Upper Windon, Livingstone Mountains on the left (4).

View down the Windon Stream showing its progressive incision into the terraces and fans of the U-shaped valley (Thomson land system) (5).

(1) Within the Red Rock Syncline:

(a) The Caples Group of partly schistose sedimentary rocks of mainly greywacke and sandstone pass up conformably to the

(b) Routeburn Formation of faintly schistose sedimentary rock of mainly greywacke and sandstone.

(2) Within the Key Summit Syncline:

(a) Red Mountain Ultramafic, an igneous formation of predominantly ultrabasic rock of serpentine and dolerite, overlain by

(b) Livingstone Volcanics, a basic volcanic formation.

(c) The Tapara Formation, marine sediments which are basic and calcareous, derived from volcanic terrain, lie in the fold of the Syncline.

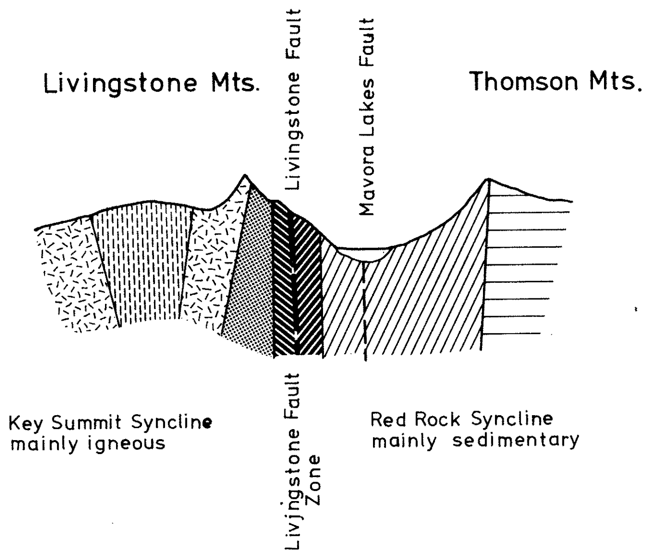
(3) Rocks of the Livingstone Fault Zone are shattered and deformed owing to stress and movement of the fault. They are schistose greywacke and sandstone to the east and spilites, sedimentary inclusions and doleritic inclusions to the west.

(4) The Mavora Formation, consisting of outwash gravels, moraine, fan and talus deposits of the Pleistocene glaciation are found on valley floors.

(5) Alluvial Deposits of a recent nature are found near present streams.

2.2.4 Glaciation

Successive ice advances and retreats modified the landscape to its present landforms - hummocky moraines, bouldery and poorly drained, ice-worn spurs, structurally controlled benches, hanging valleys, cirques and U-shaped deposits are mapped in Figure 6. Glacial advances and their resultant landscape features are illustrated in Figure 7. The advances, all of the Hawera series, Pleistocene Epoch, are from oldest to youngest: Mavora, Trench Burn and Pass Burn (Turnbull, 1974).



KEY SUMMIT SYNCLINE

Lithology	Formation	Group	Age	Era
Sedimentary - argillite, sandstone	Tapara Formation	Maitai Group	Triassic to Permian	Paleozoic
Volcanic - spilite, keratophyne, albite, dolerite, gabbro, pyroxine, epidiorite and some breccia, greywacke, argillite.	Livingstone Volcanics	Te Anau Super-group		
Igneous - periodotite, Serpentinite, pyroxenite, gabbro, dolerite.	Red Mt Ultramafics			
ROCK OF RED ROCK SYNCLINE				
Sedimentary - faintly shistose greywacke, sandstone, argillite, siltstone, conglomerate chert.	Routeburn Formation			
Sedimentary - partly shistose greywacke, sandstone, argillite, siltstone, conglomerate, chert.		Caples Group	Permian to Carboniferous	
ROCK OF LIVINGSTONE FAULT ZONE				
Deformed rocks - spilites, sedimentary inclusion, doleritic inclusion.	Livingstone Melange		Permian?	
Metamorphic - deformed schistose greywacke, sandstone, siltstone, conglomerate, red and green chert, pillow lava.	Westburn Formation	Haast Schist Zone	Permian?	

FIGURE 4: GENERALISED CROSS-SECTION OF LITHOLOGY

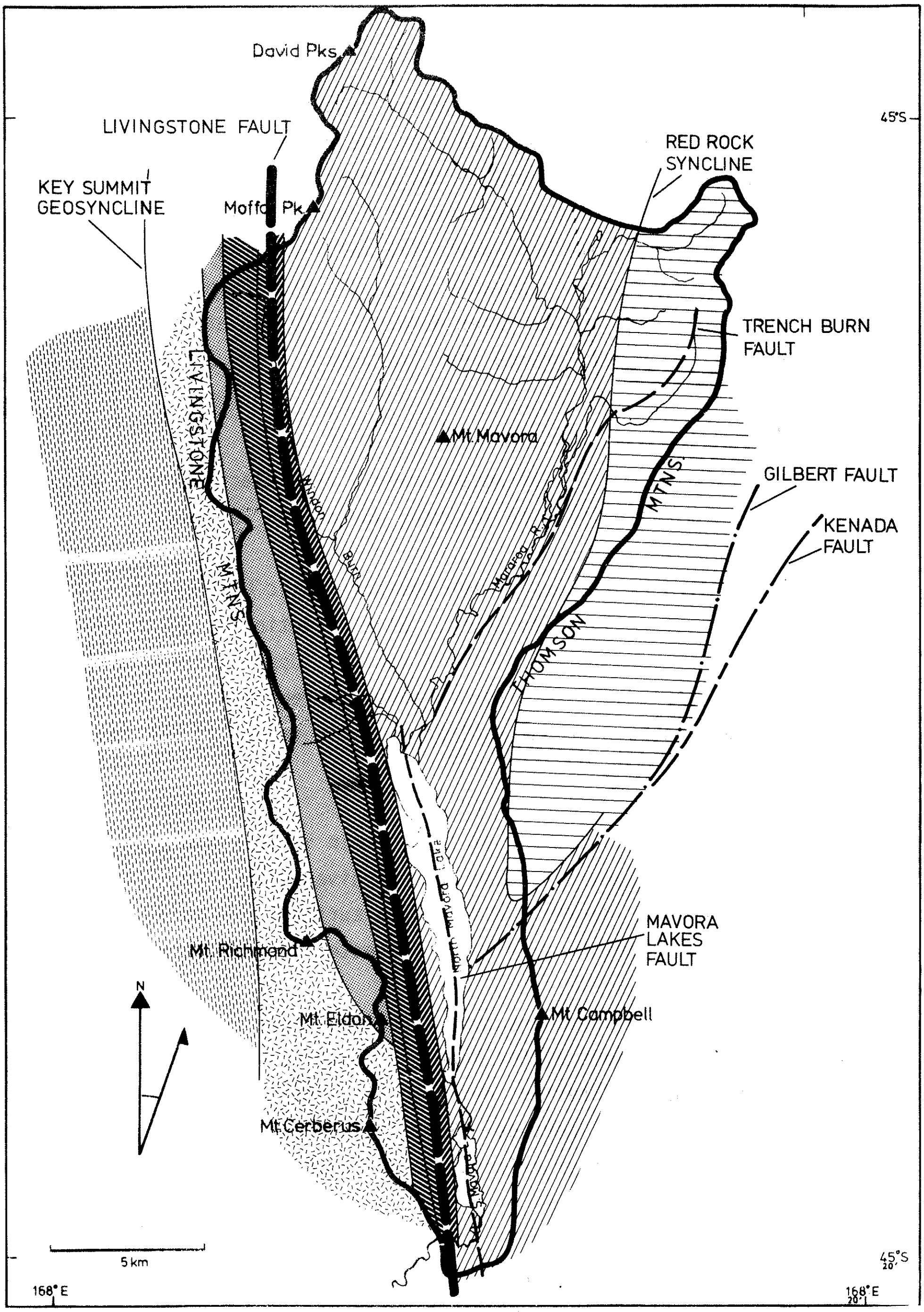


FIGURE 5: GEOLOGY - LITHOLOGY

In general, ice flowed from the Greenstone catchment over the Passburn Saddle and down the Mararoa to the junction with the Windon Glacier. The combined iceflow continued southwards between the Livingstone and Thomson Mountains. Behind the terminal moraines of successive advances, lakes such as the Mavoras were formed, but these have been partially infilled by deltas of both the main stream and tributary mountain streams (e.g. the West Burn, Kerries Hut deltas at North Mavora, The Ponds in the Upper Mararoa). During at least one advance, ice flowed from the Upper Mararoa into the Von.

2.2.5 Landforms, Relief and Topography

Land forms in the Mavora region result mainly from glacial and fluvial activity following the massive uplift and faulting during the Tertiary.

The mountain ranges rise steeply from characteristic U-shaped glacial valleys generally tending from North to South. Glacial action on these mountains has produced ice-worn spurs in the northern sector. Upper reaches of tributary valleys have been eroded into cirques, many now remaining as hanging valleys above the steep facetted trough wall of the main valley of the Upper Mararoa and the Windon.

Fluvial action on morainic material in the main valleys has produced small areas of outwash, but many of these have received tributary stream deposits of fans and steep cones. Morainic and outwash surfaces are more extensive in the Upper Mararoa, but there they are much dissected by minor streams.

Colluvial deposits are prominent throughout the upper portions of the study region, including the foot of the Thomson Mountains where the Caples greywackes, susceptible to frost-shattering, built up thick talus deposits on many slopes during successive glacial periods. Specific features of landforms and drainage patterns are used with other criteria to differentiate the region into land systems.

Relief is very strongly developed throughout the region, from the valley floor to the summit of the adjacent mountains being of the order of 1,000 metres.

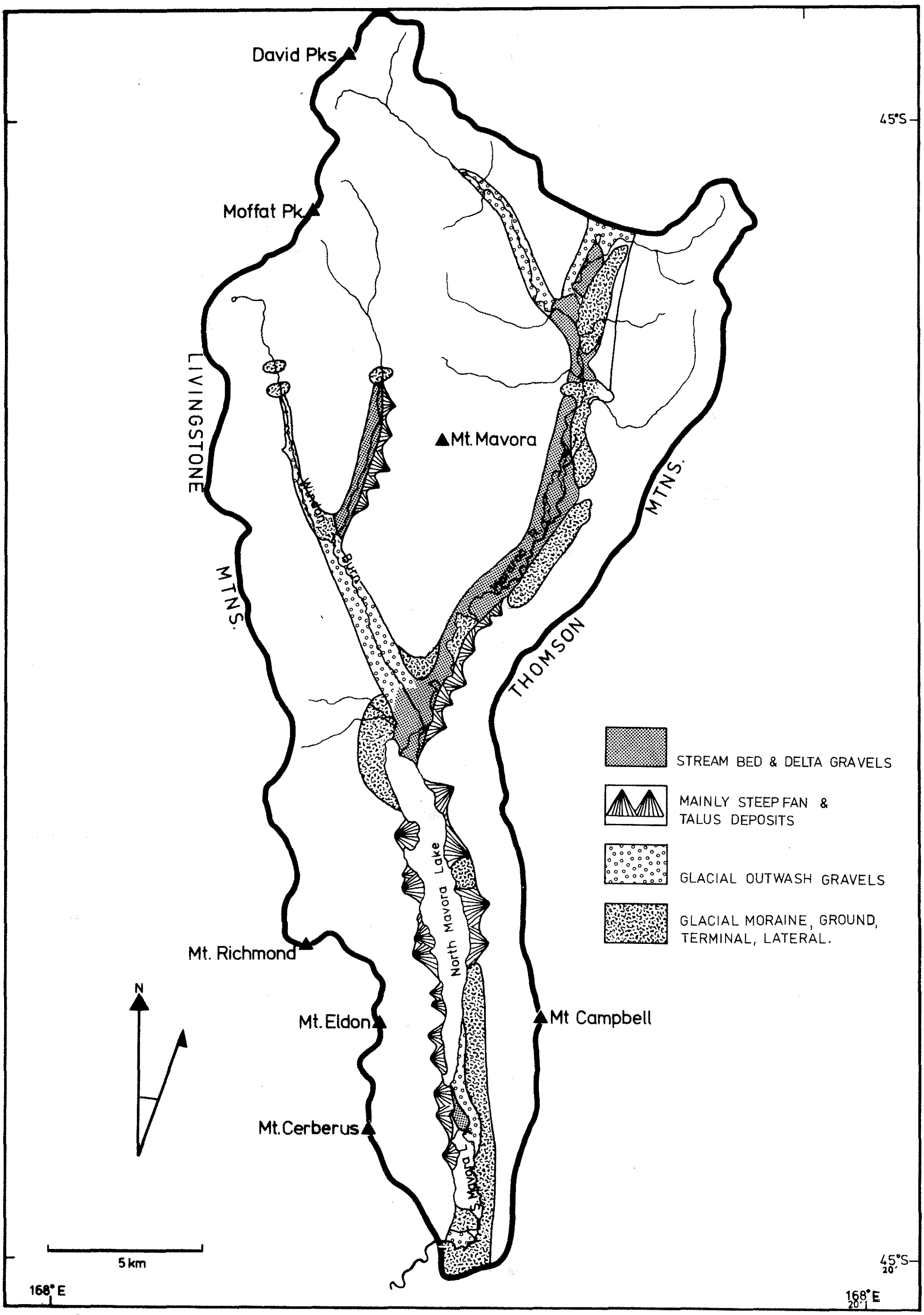


FIGURE 6: GEOLOGY - QUATERNARY DEPOSITS

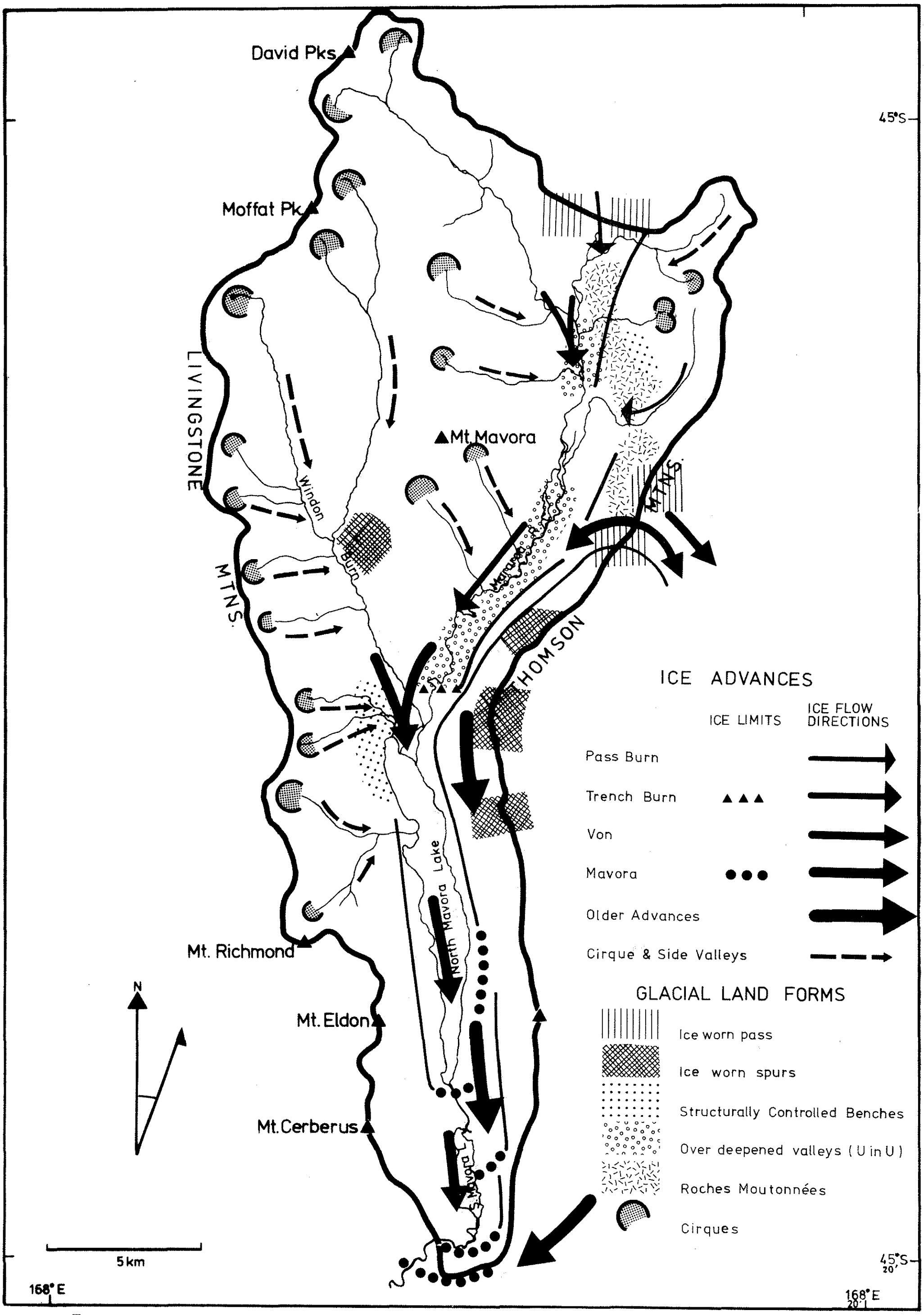
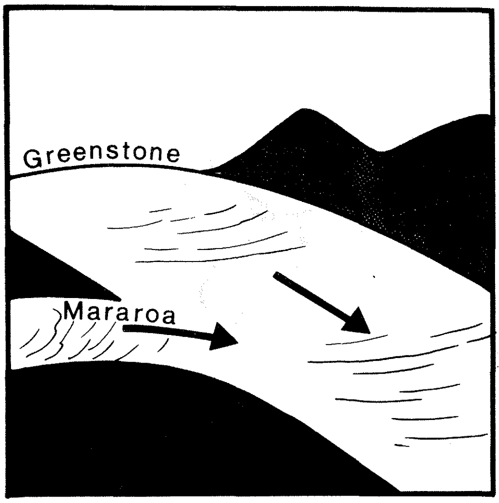
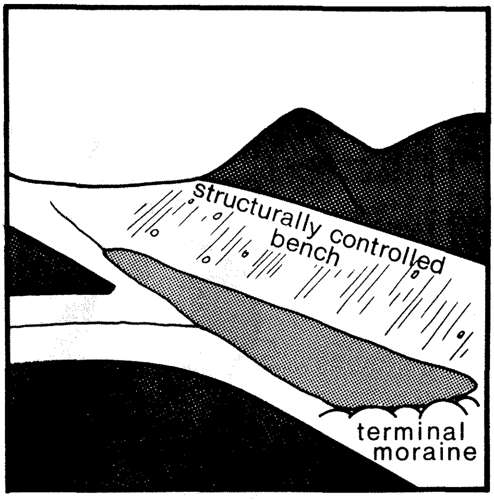


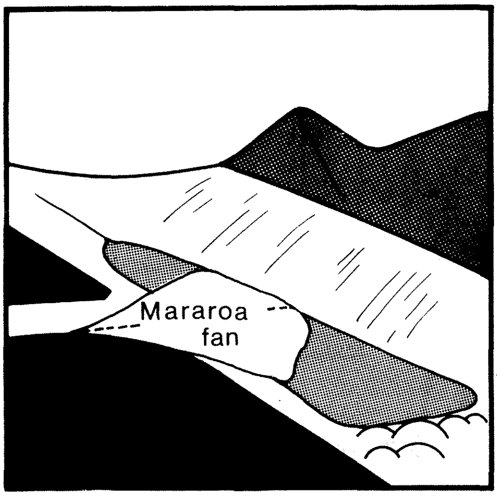
FIGURE 7: GEOLOGY - GLACIAL DEPOSITS AND LAND FORMS



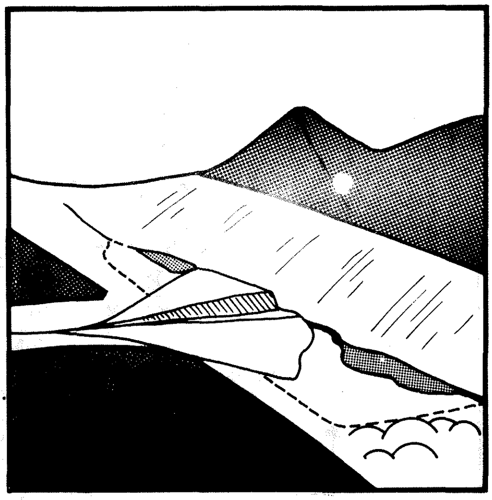
1. Major glacier from Greenstone



2. Glacial retreat – terminal moraine dammed lake



3. Fan built up over lake



4. Infilling followed by stream down cutting and draining of previous lake

FIGURE 3: AN INTERPRETATION, AFTER TURNBULL (1974) OF GLACIAL AND NON-GLACIAL EVENTS IN THE UPPER MARAROA VALLEY

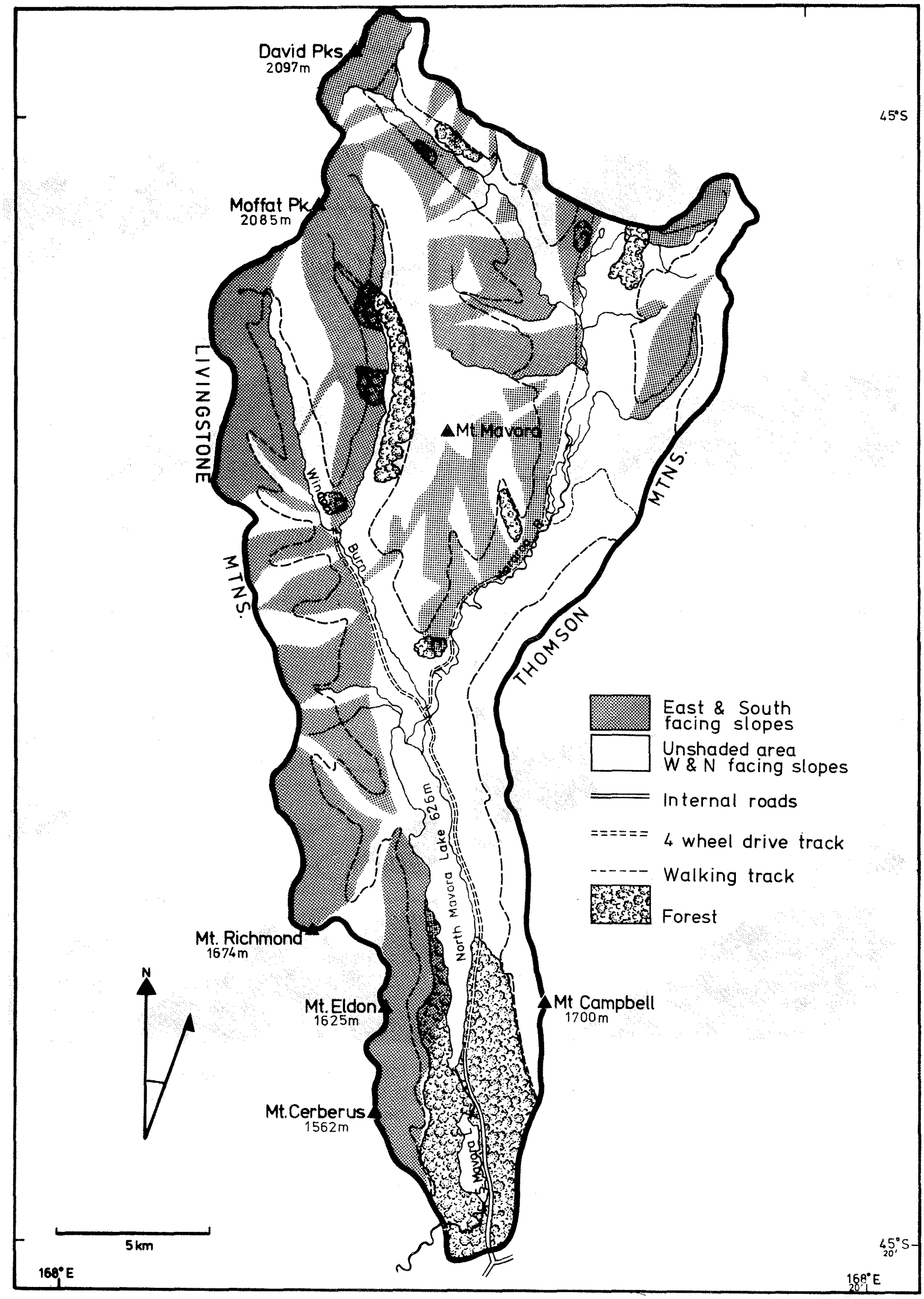


FIGURE 9: RELIEF AND ASPECT

Topography is generally steep. No detailed slope analysis has been carried out but it is estimated that only five percent of the catchment is under a 7^{o} slope and that approximately 80 percent is steeper than 15^{o}. Of the steeplands, much of the terrain is deeply dissected and is, therefore, very steep or precipitous. Figure 9 illustrates relief with particular emphasis on aspect differences.

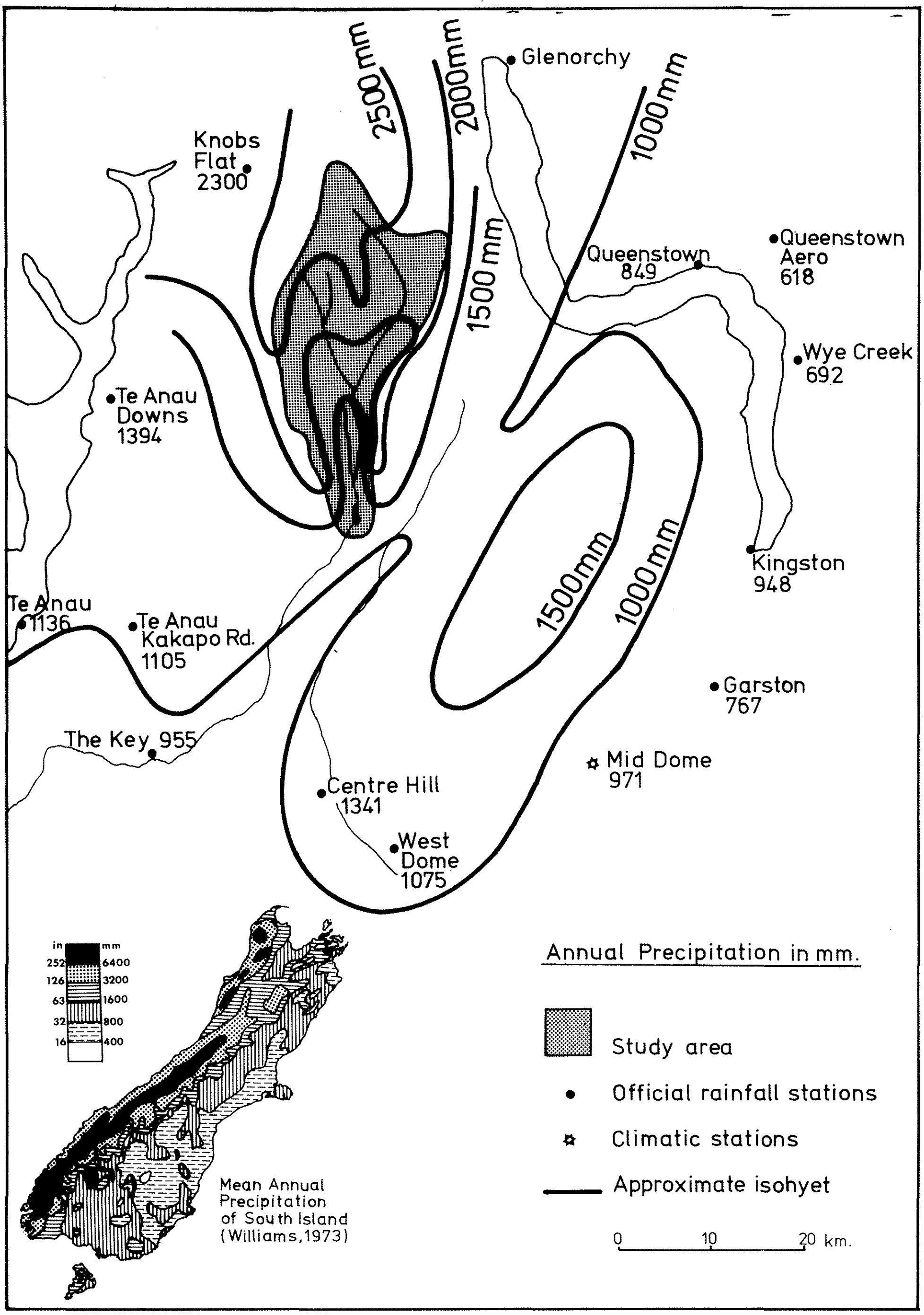


FIGURE 10: ANNUAL PRECIPITATION

2.3 CLIMATE

2.3.1 General Features

Although climate has changed considerably during geologic time, notably the warming to a possible optimum 3,000 to 5,000 years ago following the end of the Ice Age (15,000 years ago), a gradient from high precipitation in the west to low in the east has probably persisted throughout this period. This is supported by the evidence of larger glacial valleys in Fiordland to the west and the relative paucity of glacial valleys in Central Otago to the east where solifluction surfaces abound.

For the Mavora region itself there is a dearth of meteorological information, but a qualitative description can be given in which it is possible to interpolate quantitative values from adjacent regions.

There is a transition in Southland from a coastal climate in the south to a subcontinental climate in the north. Frosts at almost any season of the year, snow at high altitudes at any time of the year and violent northwest storms are all hazards of the greater Te Anau-Mavora region. Droughts can seriously affect the lowlands of this region, but the land to the north and west is generally cooler and wetter than that from the Mavora Lakes southward.

The position of the Mavora study area in the general pattern of climatic elements for the South Island as a whole is illustrated in the figures which accompany this outline of elements of climate (Figures 10-14).

2.3.2 Precipitation

The region lies in a transition zone between the high rainfalls of Fiordland and the low rainfall areas of Central Otago to the east. Within the study region itself the greatest variation occurs from north to south and from high altitudes to low. Annual precipitation is shown in Figure 10 by estimated isohyets. Official rainfall stations are situated beyond the perimeter of the study area and interpolation between these has taken into account the variations in terrain. An approximation of the increasing rainfall gradient on the valley floor from south to north is indicated by the following estimates:

South Mavora Lake	1,000 - 1,200 mm	(40-50 ins)
Head of North Mavora Lake	1,200 - 1,600 mm	(50-60 ins)
Head of Mararoa River	2,000 - 3,000 mm	(80 - 120 ins)

Monthly rainfall normals for official rainfall stations are shown in Appendix 1. Knobbs Flat probably most closely resembles the seasonal regime of the upper valley sectors, while Te Anau Downs is considered representative of the Mavora Lakes sector. The seasonal march of precipitation for these two stations is illustrated in Figure 11. Generally low precipitation occurs in February and during winter. Highest precipitation occurs in early spring months and in April.

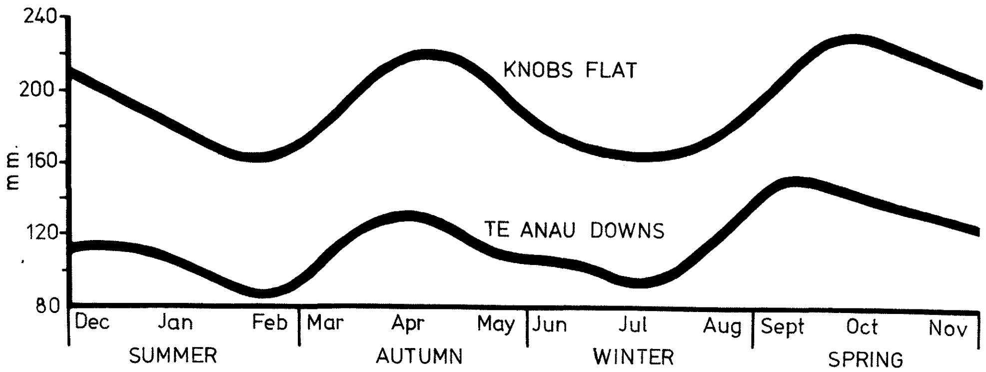


FIGURE 11: SEASONAL PRECIPITATION NORMALS AT KNOBS FLAT AND TE ANAU DOWNS

Estimates of precipitation are of limited value, not only because of the necessity of interpolation in mountainous terrain but also because of indications of high seasonal variability. Reports from local residents to the south suggest that one in three summers are droughty. Snow is a dominating influence in winter in particular, especially at higher levels. The mountains tend to be snow-covered for most of the winter. Flats in the valley are covered at least once a year. Occasionally snow is recorded to a depth of 0.5 m with the maximum reading at 1.2 m in 1939 (Department of Lands and Survey Management Plan study team, 1975).

2.3.3 Temperature

Extreme temperatures show marked contrast from summer to winter in the lowland sectors of this subcontinental environment but the warm summer period is comparatively short. This is indicated in Figure 12 where this region is within the zone of longest frost season in New Zealand. Figure 13 presents the monthly march of temperatures for the nearest climatologic stations. As the Mavora study area is at a higher altitude than these stations, it is probable that the rise in temperatures in the spring is slower and their decline in autumn is faster than those illustrated. Within the study region there are topographic differences in thermal regimes. On the evidence of vegetation cover and snow cover, the following thermal zones are qualitatively described:

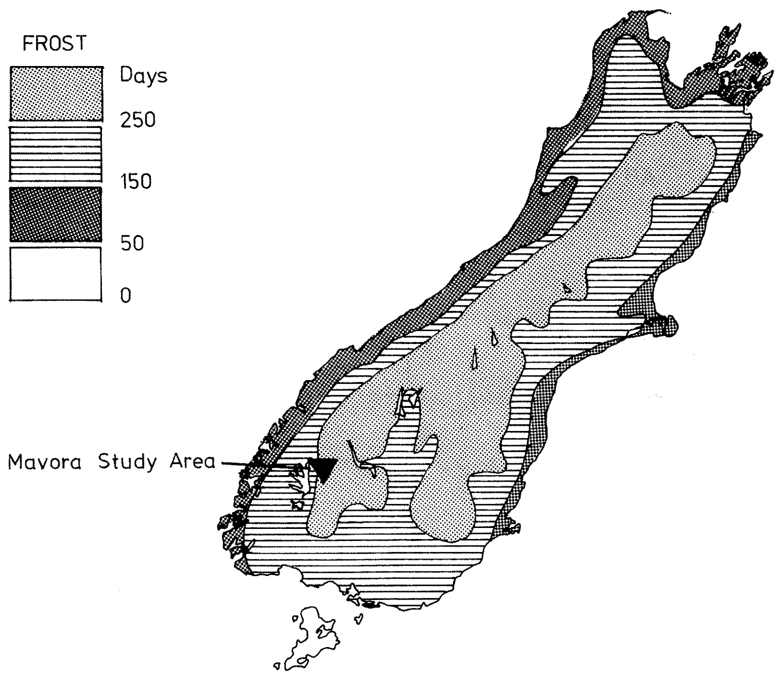


FIGURE 12: FROST SEASON

High altitude	Very cold winter (with snow lying). Cool to cold summer.
Shaded slope	Cold to very cold winter. Mild to cool summer.
Sunny slopes	Cold winter. Mild summer.
Valley floors	Cold winter (with severe frost extending into early summer). Mild summer.

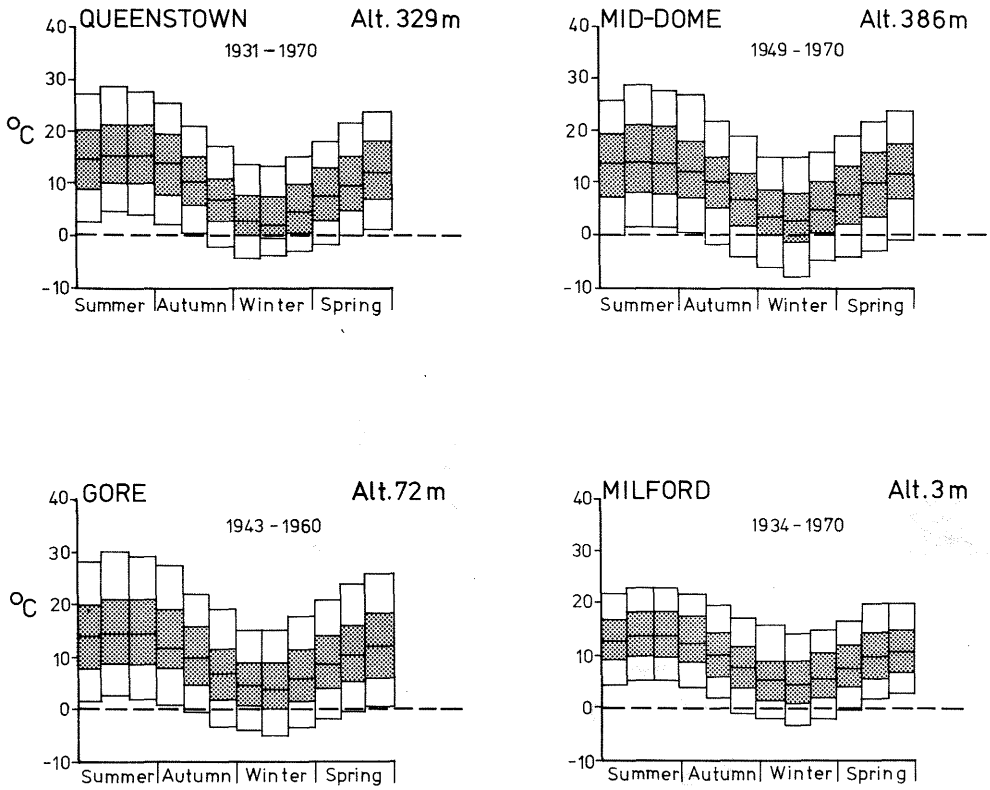


FIGURE 13: MONTHLY TEMPERATURE AT NEARBY CLIMATOLOGICAL STATIONS

2.3.4 Sunshine

No records are available from within the study region, but it is shown within one of the least sunny zones of New Zealand in Figure 14. Sunshine is greatly affected by the steep topography as well as by low angle of sun and the prevailing cloudiness. Some areas of valley bottoms and shady slopes in winter may receive direct sunshine for only three hours on bright clear days.

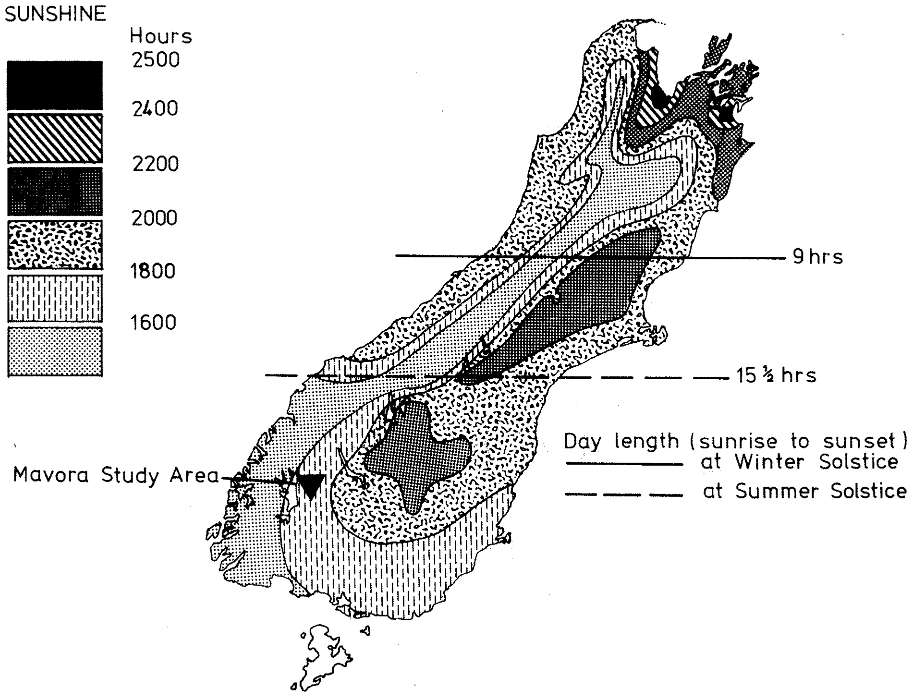
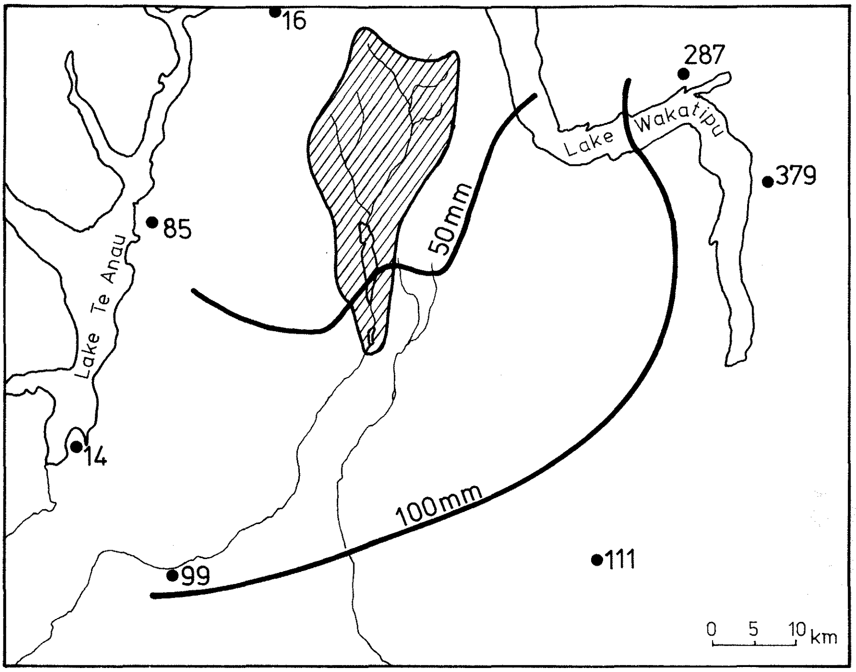


FIGURE 14: ZONES OF SUNSHINE DURATION IN SOUTH ISLAND, NEW ZEALAND

2.3.5 Wind

Strong nor'wester winds funnel down the valley, especially in spring, and may be of prime importance as an erosion agent on frost-lifted or cultivated surfaces. Southwest winds can bring sleet and snow in winter and spring, and occasional summer rainstorms.

FIGURE 15: ANNUAL WATER DEFICIENCY MAP



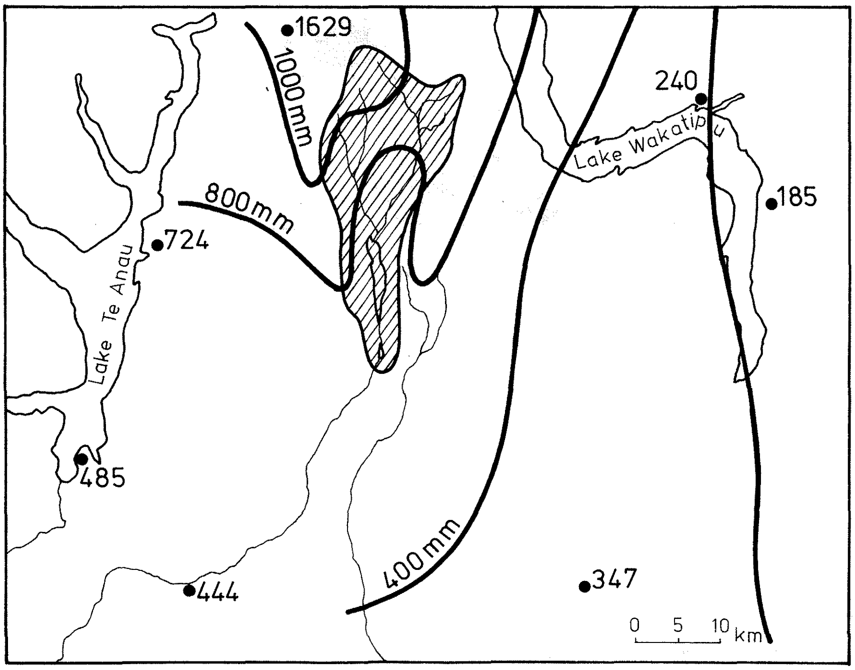


FIGURE 16: ANNUAL WATER SURPLUS MAP

2.3.6 Water Balance

Daily water balances showing water deficiency and surplus runoff were calculated for the rainfall stations by the New Zealand Meteorological Service from daily rainfall and potential evapotranspiration data, as outlined by Coulter (1973). Potential evapotranspiration was calculated by the Penman equation at Gore, Queenstown or Queenstown Airport and used in calculations for the other locations. This extrapolation cannot be given great confidence for the higher rainfall areas but it is the only possible compromise in view of the lack of long-term thermal data for the region. Soil moisture storage capacity is assumed to be 75 mm and actual evapotranspiration is estimated to approximate to potential evapotranspiration until all soil moisture is used. On this basis, calculated annual water deficiency and annual water surplus are shown for the region in Figures 15 and 16 respectively.

Tables of precipitation, potential evapotranspiration, water deficiency, number of days dryness, runoff and number of days runoff at the various rainfall stations are shown in Appendix 1. Figure 17 shows the seasonal changes in water balance for Te Anau Downs and Knobs Flat. Seasonal values for Knobs Flat and Te Anau Downs give the closest available approximations to the head of Windon Burn and Mararoa, and the Mavora Lakes area respectively. At the head of the valleys a very slight water deficiency may occur for two or three days in January and February. Usually very little runoff occurs in this late summer period. Calculated surplus for runoff shows a rise in autumn and a maximum in early spring, with a marked decline in early winter. The lower area around the lakes has generally a drier water balance. Late summer shows nil runoff with water deficit for 27 days over summer rising to a peak in February. Runoff follows a similar pattern to that further up the valley but is greatly reduced.

2.3.7 Climatic Summary

Figure 18 presents a summary of climatic information in a map of climatic zones of the study area on the basis of precipitation and seasonal temperature regimes.

FIGURE 17: Seasonal water balance at Te Anau (approximating Lakes area) and Knobs Flat (approximating head of Windon Burn and Mararoa River).

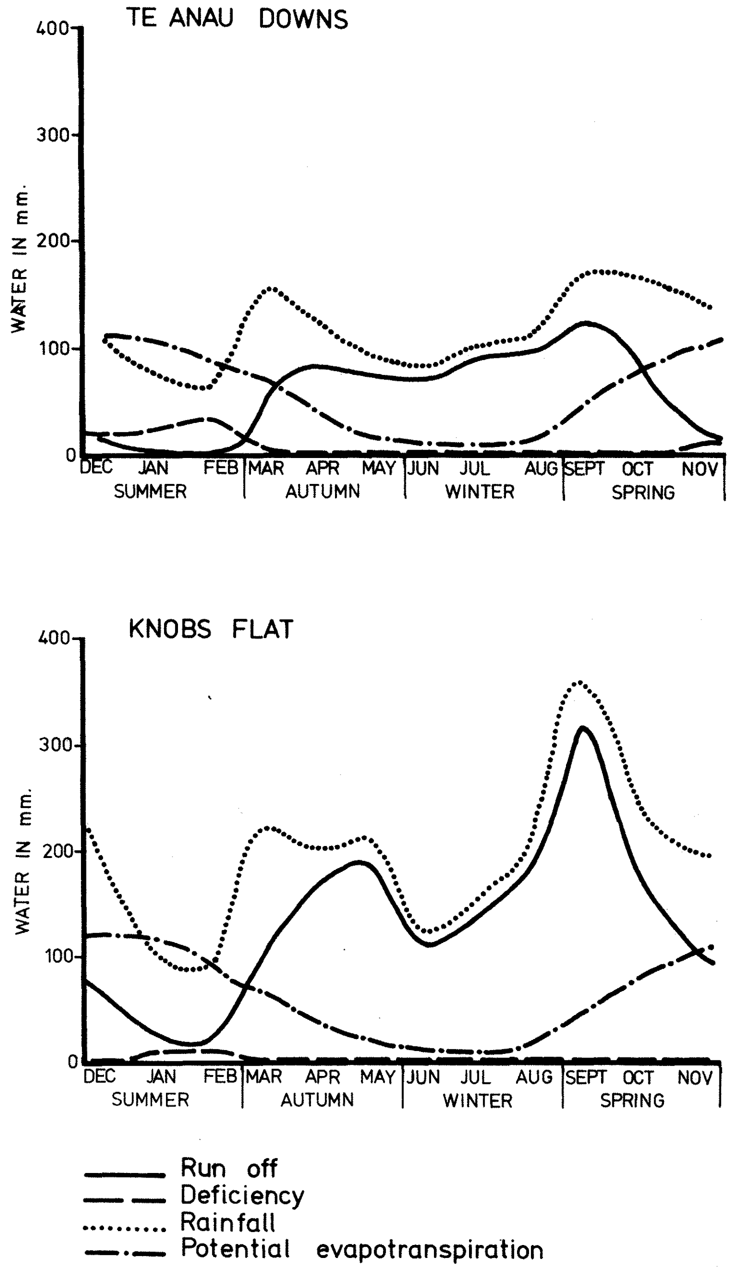


FIGURE 17: SEASONAL WATER BALANCE AT TE ANAU (APPROXIMATING LAKES AREA) AND KNOBS FLAT (APPROXIMATING HEAD OF WINDON BURN AND MARAROA RIVER).

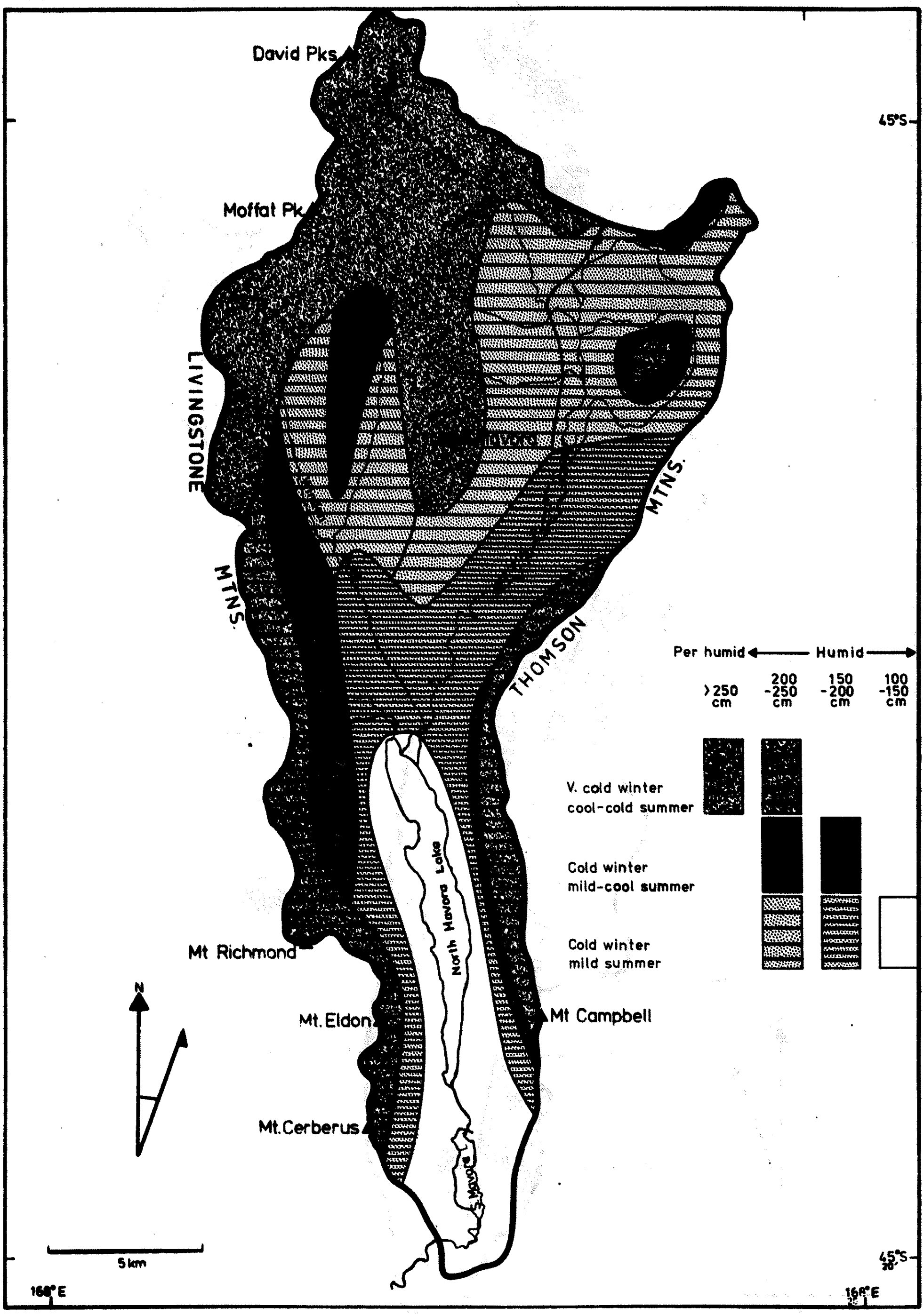


FIGURE 18: CLIMATIC ZONES

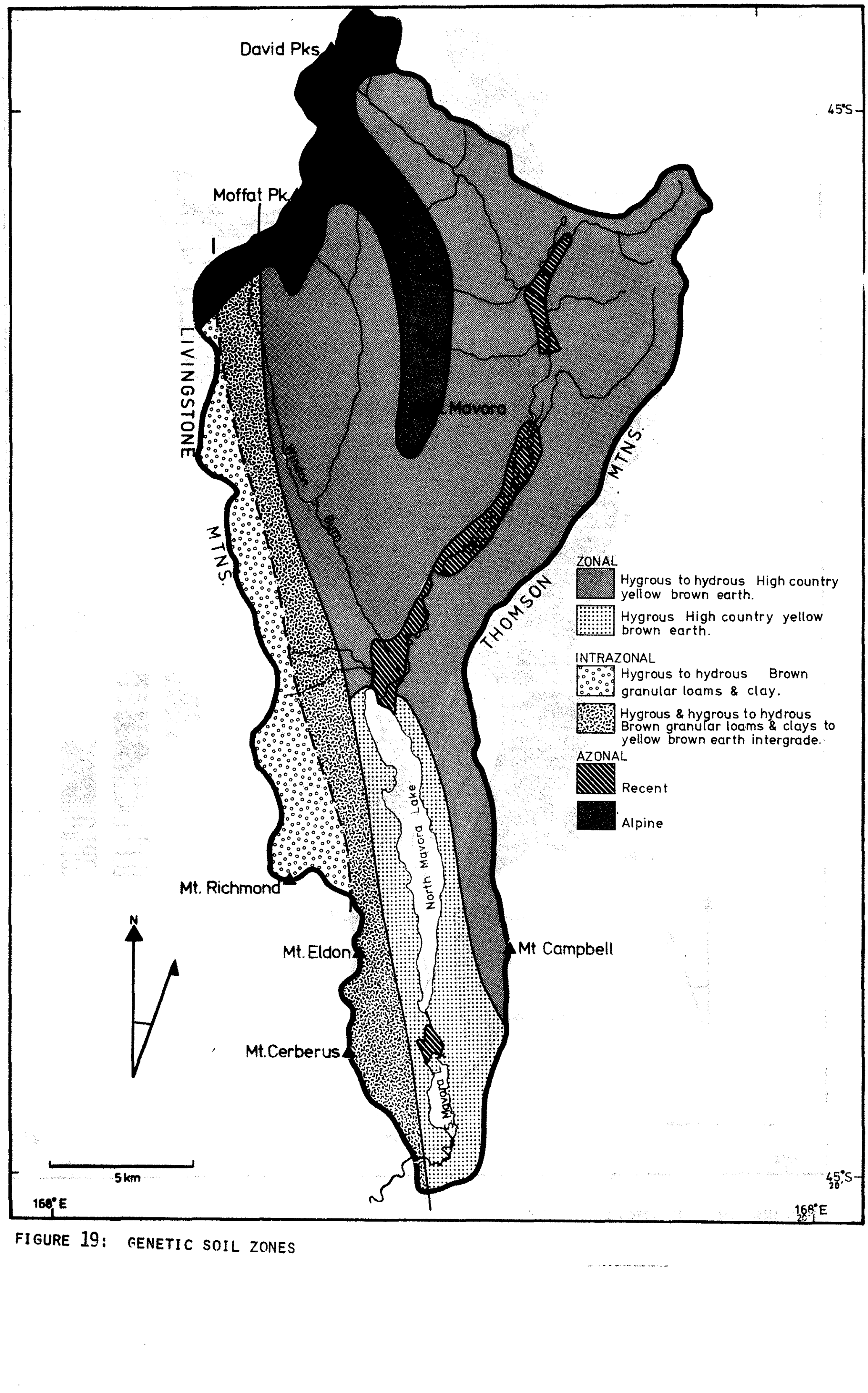


FIGURE 19: GENETIC SOIL ZONES

2.4 SOILS AND EROSION

2.4.1 Introduction

The General Survey of the Soils of the South Island (Soil Bureau, 1968) describes and maps the soils of the Mavora study area on a scale of four miles to one inch. The mapping unit used is the soil set, a group of soils with like profile or from like assemblages of profiles occurring together on a particular landscape. Figure 19 shows a pattern of genetic groups of soils interpreted from the General Survey of Soils of the South Island (1968).

In conjunction with the present study, Soil Bureau, D.S.I.R., has been preparing a preliminary description of the soil/landscape relationships, dividing the soil sets on fans, moraines, flood plains and terraces into associations. Sets are retained for the steeplands. The series is a grouping of soil types with similar modal profiles, temperature and moisture regimes and similar parent materials (Taylor and Pohlen, 1962). Where provisional renaming has been introduced, this study has adopted the soil association,as the variability between and within landscape units is too great to be contained within a single series. A soil association is a compound mapping unit comprised of two or more soil types or series. For the most part, the pattern can be resolved on ordinary detailed maps.

2.4.2 Description of Soils

West of the Livingstone Fault the ultramafic igneous rocks give rise to intra-zonal soils, the brown granular loams and clays, and intergrades to yellow-brown earths. These occur in the Eldon, West Burn and Livingstone Land Systems (see Figure 22 for delineation of land systems). To the east, in Thomson, Sugar Loaf, Livingstone (Mararoa Subsystem) Land Systems, normal silicious parent material of greywacke and sandstone give rise to zonal soils, high-country yellow-brown earths and related soils. Recent soils occur on alluvium of river flats and youthful fans. Other azonal soils are the alpine soils formed generally on steep slopes at high altitudes. Some soil profile summary descriptions are included in Appendix 2. The relationship of soils to landscape units in Land System Analysis is set out in Table 1.

TABLE 1: The Genetic Soil Groups, Soil Sets and Tentative Soil Associations in Relation to Topography, Characteristic Soil Moisture Class and Zonal Characters.

Zone, Including Annual Precipitation		Genetic Soil Group	Characteristic Soil Moisture Class	Topography of Landscape Units						
				River Flats and Young Fans	Old Fans	Moraine	Terraced Outwash	Colluvial Lower Slope	Lower Hillslope	Upper Hillslope
Zonal On normal siliceous parent material	>150 cm	High-country yellow-brown earth.	Hygrous to Hydrous	)	* Craigieburn	* Cass	* Cass Craigieburn	* Cass Cass Hill	** Waikaia Steepland	** Kaikoura Steepland
	<150 cm		Hygrous	)	* (Eldon)	* (Mavora)	* (Windon)	* (Shirkers)	** (Livingstone Steepland)	**
Intrazonal On igneous and volcanic parent material	>150 cm	Brown granular loams and clay.	Hygrous to Hydrous	-	-	-	-	-	-	Windley Steepland
		Brown granular loams and clay to yellow-brown earth intergrade		-	-	-	-	-	**	Takitimu Steepland
	<150 cm		Hygrous	-	-	-	-	-	Eglinton Steepland	**
Azonal Weakly developed profiles	>100 cm	Recent	Hygrous to Hydrous	Tasman	-	-	-	-	-	-
	>200 cm	Alpine	Hygrous and Hydrous	-	-	-	-	-	-	Alpine

Notes: All soil associations (*) are unnamed. Existing soil sets are named as in General Survey of Soils of the South Island. Tentative new soil sets on steeplands are shown by **. Tentative names for one of these and for soil associations in the hygrous high-country yellow-brown earth group are shown in parentheses. A dash signifies a null class in the Mavora region.

2.4.21 Zonal Soils

2.4.211 Hygrous High-Country Yellow-Brown Earths

These are weakly-weathered and strongly leached soils formed on largely greywacke rock, alluvium and colluvium, moraine and loess. They have a thin solum with very friable to loose dark brown loamy crumb structured topsoils and friable yellowish to brownish-yellow crumb to granular structured subsoil. They have low natural nutrient status. Named soils are:

On Fans - Eldon Association

These are moderately young yellow-brown earths and vary from shallow and stony at the apex of a fan or on young fans to silt loams, some wet with pale subsoils on the toes of fans. This association has been identified within areas previously included within the Craigieburn soil set.

On Hummocky Moraine - Mavora Association

These vary from silt loams to stony and shallow loams on moraine and gravel of the hummocks to heavy silt loams in depressions. These soils have been included within the Cass soil set.

On Terraced Outwash - Windon Association

The profile is similar to Mavora in general character with main differences being related to depth to gravels and degree of drainage. Such soils have been included within the Cass or Craigieburn sets.

On Colluvial Lower Slopes - Shirkers Association

These are wetter, heavier silt loams and stony silt loams. Drainage is somewhat impeded by the damming effect of lateral moraine. These soils have been included in the Cass or Cass Hill soil sets.

On Lower Hill Slopes - Livingstone Steepland Set

These are generally well drained soils, often silt loams, weakly structured. They vary considerably in horizon depth and in stoniness. Such soils have been previously included in the Waikaia Steepland set.

On Upper Hill Slopes - Hitherto Kaikoura Steepland Set

Silt loams generally with crumb or nutty structure, varying greatly in depth and stoniness and showing considerable variation in degree of profile development because of drift regime renewal.

2.4.212 Hygrous to Hydrous High-Country Yellow-Brown Earths

Soil associations and steepland soil sets of this moisture class in the high-country yellow-brown earth genetic soil group have been schematically included in Table 1 but have not been summarily described. Belonging to the upper parts of the Mararoa catchment in a zone of higher precipitation, these soils generally show increased platiness, more intense leaching and a trend towards podsolization in comparison with their counterparts in the zone with less than 150 cm precipitation.

2.4.22 Intrazonal Soils

2.4.221 Hygrous to Hydrous Brown Granular Loams and Clays

These are formed on basic and ultra-basic rock rich in magnesium, serpentine and dunite. They are very low in natural nutrients and release toxic magnesium and chromium compounds with weathering. Both topsoil and subsoil have clay loam textures.

On Steeplands - Windley Steepland Set

Windley soils have dark grey-brown granular stony clay loam topsoil above yellow-brown stony clay loam subsoils. They show many inter-grades to skeletal soils.

2.4.222 Hygrous to Hydrous Brown Granular Loams and Clays to Yellow-Brown Earths Intergrade

These soils are derived from basic rock, largely basic sandstone, conglomerate and alluvium derived from them. The soils are mostly shallow and skeletal and strongly leached. Topsoils are very dark brown peat to peaty loams with dark brown granular to crumb structured silt loam subsoils, often stony. They have low natural fertility.

On Steep Lower Hillslopes - Eglinton Steepland Set

Peaty surface layer generally covers brown stony silt loam with nutty or granular structure over bright yellowish brown heavy silt loam with blocky structure.

On Very Steep Upper Hillslopes - Takitimu Steepland Set

Blackish peaty loams overlay very dark grey-brown silt loams with grit and rock fragments over brown-yellow gritty silt loam. They vary greatly in depth and profile development.

2.4.23 Azonal Soils

Recent Soils on Alluvium - Tasman Association

These soils have very little profile development with only small development on rapidly accumulating sites and have distinct A C profiles on slowly accumulating sites furthest from the rivers. Textures tend to be the same as the parent material and are predominantly sandy.

2.4.3 Erosion

The area has been subject to active geological erosion not only because of the harsh physical environment but also because of the widespread faulting and associated crush zones. Acceleration of erosion has occurred since human occupation but it is difficult to discern with confidence how much of the active erosion on the Thomson and Livingstone Mountains is geological and how much is attributable to Polynesian or European activities. Pastoralists' fires and subsequent grazing have clearly depleted mountain vegetation and allowed the extension of erosion by soil, frost and subsequent wind action and soil wash. Gullies have extended from higher altitude areas upward into depleted zones and have enlarged downward through beech forest and short tussock grassland induced from tall tussock and beech forest. Dunbar *et al* (1966) presented an erosion map for the Mararoa Catchment in which the non-forested hill lands and steeplands of the Mavora study area were classified for the most part as having more than 40 percent exposure to erosion. This assessment was explained in Dunbar *et al* (1966) in Appendix II as the "extent or erosion recorded as an index based on the extent of visible erosion and the amount of bare ground exposed to erosion". For the hill slopes, the types of erosion identified were "mainly high altitudes subject to scree, gully, sheet and wind erosion in various combinations". They also noted that "a high incidence of natural or geological erosion was also recorded wherever it was present". A portion of their erosion map, for the Mavora, is presented in Figure 20.

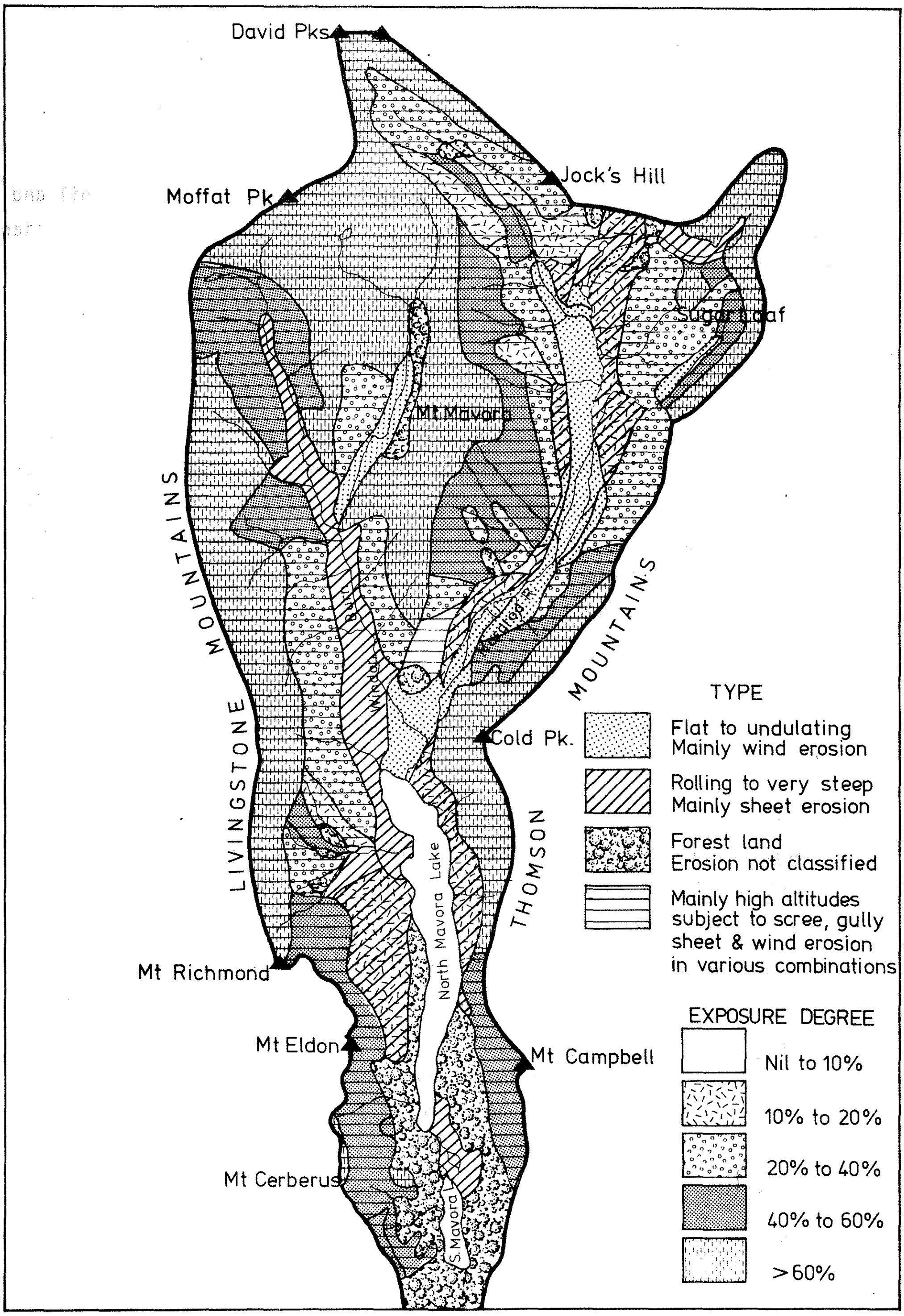


FIGURE 20: EROSION

2.5 VEGETATION

2.5.1 Introduction

Most of the catchment is in native vegetation which has adapted to soil and climate conditions since the last glaciation and the fires of the Polynesian period, especially destructive of forest. Fires and grazing of European settlement reduced forest and tall-tussock grassland further and introduced adventive species, especially to valley floors and lower slopes. Nowhere are these introductions physiognomic dominants.

Typically, short-tussock grasslands and red tussock grasslands on valley floors give way to snow tussock and subalpine scrub at higher altitudes interspersed with screes. Vegetation eventually runs out in rocky alpine barrens. Beech forest dominates in the south around the South Mavora Lake and skirts the shores of a portion of the North Mavora Lake. Pockets further up the valley indicate how beech forest once dominated on most of the lower slopes.

2.5.2 Vegetation Classification

The general distribution of vegetation is mapped in Figure 21 in the following physiognomic classes:

(1) Alpine Barren - bare rock, often snow covered.

(2) Screes and Fellfields - extending from alpine barren through snow tussock and even to valley floor.

(3) Short-Tussock Grassland - mainly fescue tussock (*Festuca novae zelandiae*) with abundant adventive grasses and other herbs and patches of matagouri scrub (*Discaria toumatu*).

(4) Tall-Tussock Grassland -
  - (a) Snow tussock on ultramafic rock, principally *Chionochloa macra*.
  - (b) Snow tussock (*Chionochloa* spp.)
  - (c) Red tussock (*Chionochloa rubra*).

(5) Subalpine Scrub - *Dracophyllum* spp., *Cassinia* spp., *Hebe* spp.

(6) Evergreen Forest - *Nothofagus* spp.

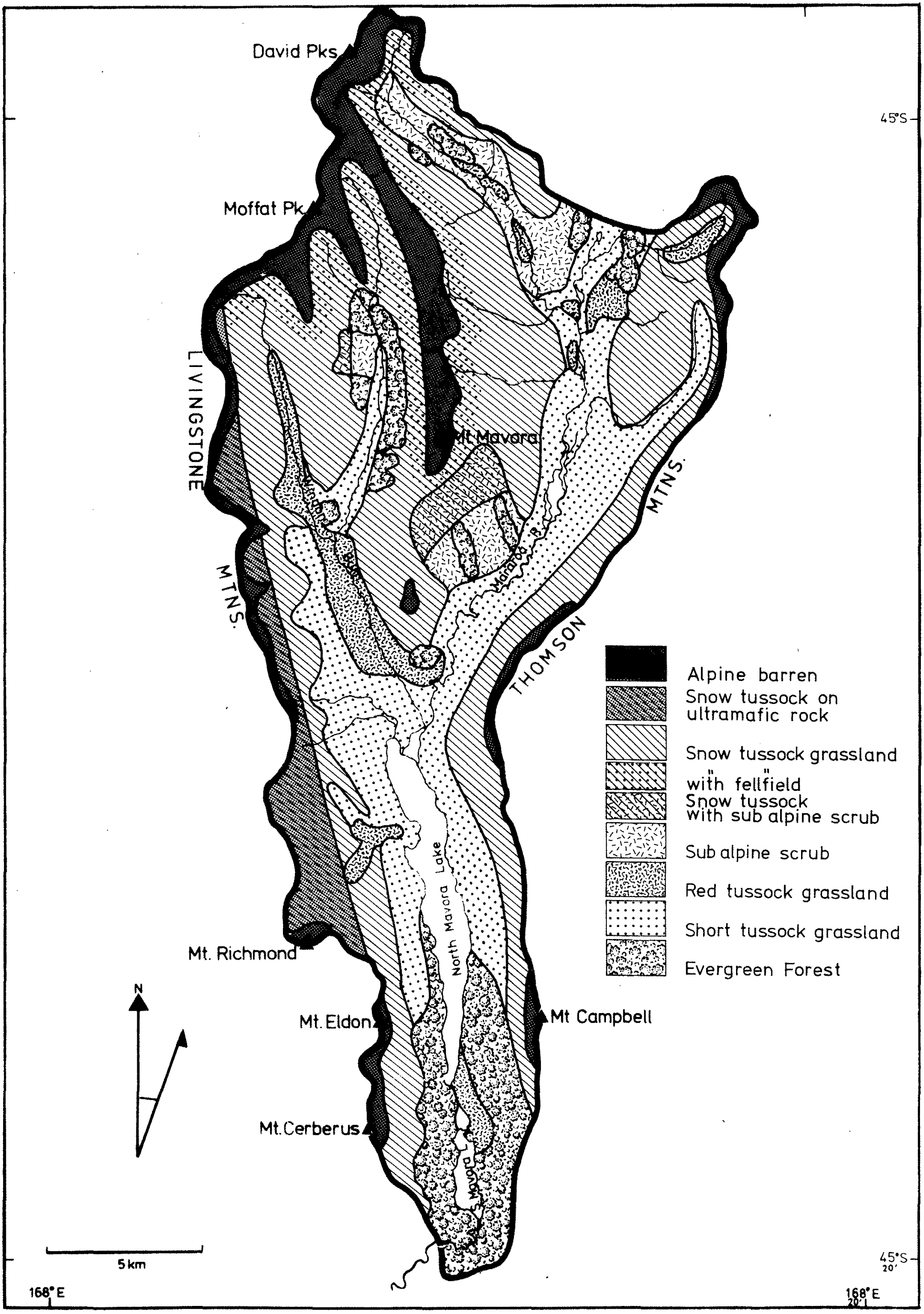


FIGURE 21: VEGETATION

2.5.3 Distribution and Composition of Vegetation

2.5.31 Tussock Grassland and Scrubland

Notes on composition and distribution of these formations are compiled mainly from Dunbar *et al* (1966), together with a Southland Catchment Board's unpublished land capability inventory (Southland Catchment Board, 1969), aerial photographs and limited field observation. Aerial photographs have been used as far as possible to separate the alpine barrens and fell fields from the tall-tussock grasslands.

2.5.311 On Valley Floors:

(1) River Flats, Moraines and Moraine Outwash Terraces

In areas of good drainage on river flats and on the hummocks of the moraines, fescue tussocks dominate with intertussock swards of browntop (*Agrostis tenuis*), Yorkshire fog (*Holcus lanatus*) and white clover *(Trifolium repens)* with occasional silver tussock (*Poa laevis*) and stunted matagouri. For wetter areas, terrace and moraine hollows, red tussock dominates with fescue, the main associated grass and occasional *Cassinia* sp. and *Dracophyllum* spp.

(2) Fans

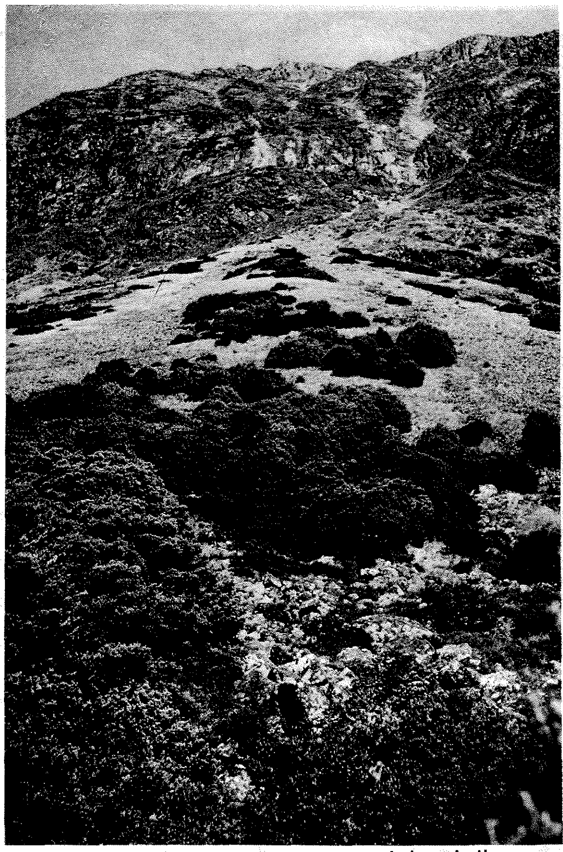
Silver tussock and fescue tussock dominate with some matagouri.

2.5.312 On Slopes

(1) Sunny Slopes (North and West Facing)

Fescue tussock dominates on lower slopes with thick matagouri on some steep slopes, up to 880 m, both yielding at about 940 m to snow tussock (*Chionochloa rigida*) in association with fescue tussock, blue tussock (*Poa colensoi*), *Gaultheria depressa* and turpentine bush (*Dracophyllum* spp.).

Major low-growing species are: *Cyathodes fraseri, Deyeuxia forsteri, Raoulia subsericea, Luzula campestris* and *Anisotome* spp. Other species that commonly occur are *Notodanthonia setifolia, Hypochaeris radicata, Celmisia gracilenta, Wahlenbergia albomarginata* and species of *Pimelea* and *Blechnum*. Mountain totara (*Podocarpus nivalis*) enters the association at 1,200 m.



Depleted subalpine scrub on an exposed slope in the upper east branch of the Windon (Mararoa subsystem) (6).

Dense subalpine scrub in the rocky riparian zone in the upper reaches of the Windon Stream (east branch)(7).

Characteristic Chionochloa–Celmisia association of the subalpine grasslands in the Mararoa subsystem (8).

Red tussock (Chionochloa rubra) characteristic of wetter sites on terraces in the Windon Burn, growing above fescue tussock (Festuca novae zelandiae) and fog (Holcus lanatus) associates (9).

(2) Shady Slopes (South and East Facing, Cold, Wet, Exposed Slopes). Snow tussock associated with subalpine scrub extends as low as 850 m, below which the short-tussock grassland dominates. With snow tussock, the subalpine scrub *Cassinia* frequently dominates drier ridges, and *Hebe odora* the moister situations associated with *Dracophyllum uniflorum*, *Coprosma* spp., *Lycopodium* spp., *Cyathodes empetrifolia*, *Deyeuxia avenoides*, *Gaultheria rupestris*, *Pentachondra pumila*.

Most snow tussock is *Chionochloa rigida*, especially in the low alpine zone extending down as far as the forest. At higher altitudes, *C. macra* sometimes occurs. In the wetter areas of the Windon Burn and Mararoa, *C. flavescens* replaces *C. rigida* in the lower alpine zone with *C. pallens* replacing *C. macra* at higher altitudes. *C. crassiuscula* replaces both when very wet or in avalanche chutes (Lee and Meurk, 1975).

2.5.313 On Ultramafic Rock (of West Burn and Livingstone Land System)

The ultramafic rock releases weathering products toxic to some plants and this, together with the high altitude, 1,200 m to 1,400 m, results in a very limited vegetation range of about 10 species. *C. macra* is the tussock dominant.

Developed soil profiles on the ultramafic rock are very rare. Soil material may be trapped by isolated plants. There are non-ultramafic intrusions into the ultramafic body and here small flushed areas occur with dramatic increase in number of species, similar to those on the nearby greywacke.

2.5.32 Forests

Forests occur on moraine, fans and slopes. The short description here follows the pattern of Dunbar *et al* (1966).

The forests are mainly mountain beech (*Nothofagus solandri* var. *cliffortioides*) but some silver (*N. menziesii*) and red beech (*N. fusca*) and hybrids occur in the Snowdon Forest extending westwards from Mavora.

2.5.321 Forest Margins

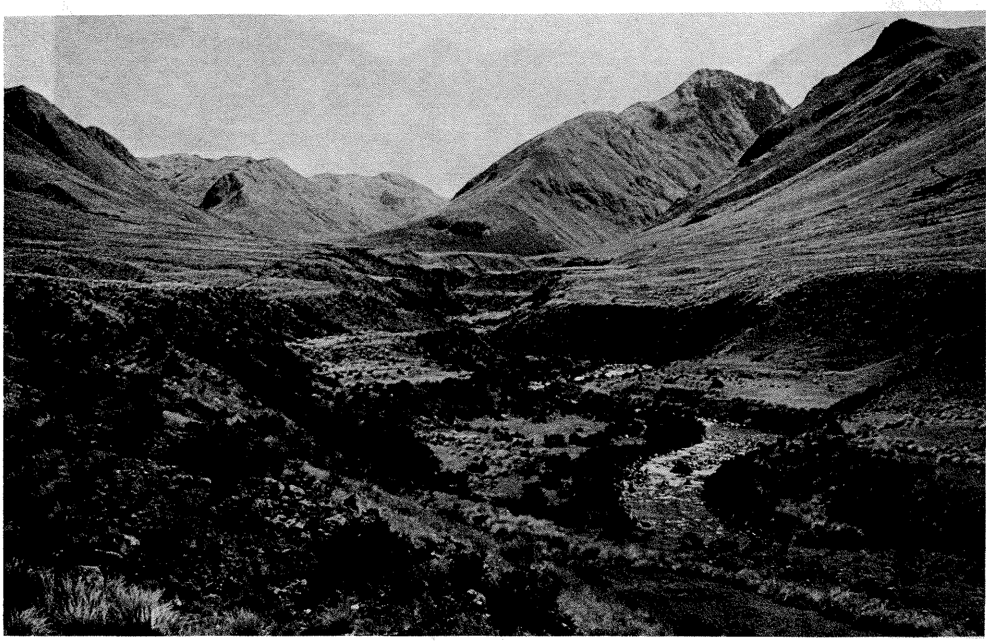
The upper margins seem fairly stable but with some damage from screes above. The upper timberline is, however, artificially depressed in many places below a natural level at about 1,000 m. These lowered timberlines may have been caused by fire. The lower margin is often marked by a belt of vigorous beech regeneration. Rabbits, domestic animals and deer may have affected the forest margin in the past by suppression of this marginal regeneration.

2.5.322 Interiors

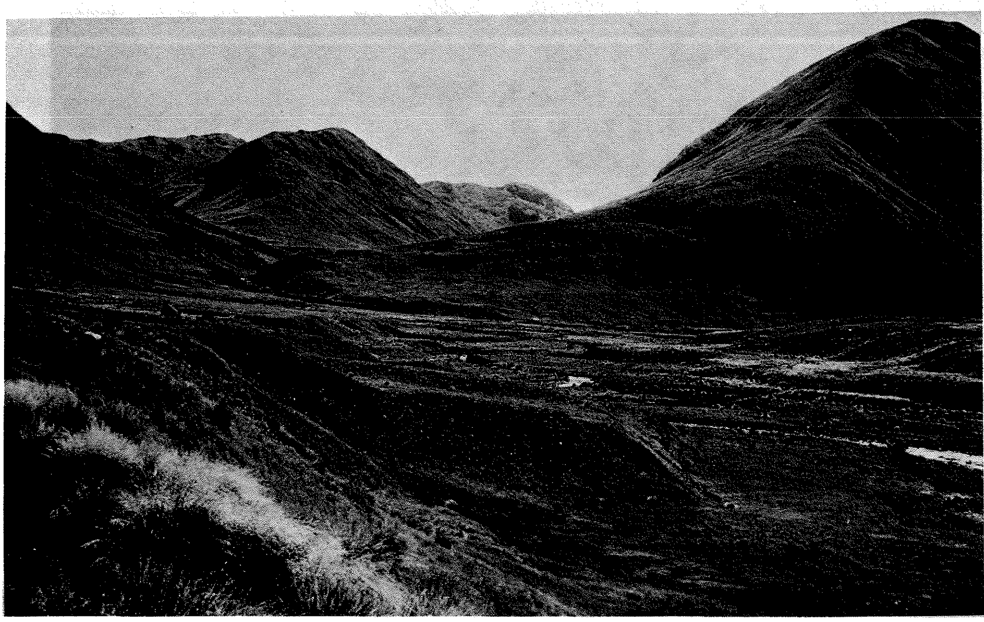
Typically there is no second tier of minor species but a well-developed upper canopy. Understorey species are few - *Griselinia littoralis, Neopanax colensoi* and *Coprosma parviflora*. In places, especially in the Windon Burn, the surface scree has cut into the bush. At damp sites pockets of *Asplenium bulbiferum, Polystichum vestitum* and *Blechnum discolor* may occur. Regenerating beech seedlings are erratic and higher altitude trees are scraggy and short boled with little regeneration evident. Many stands are mature, e.g. Shirkers Bush on the southern slopes of Mount Mavora is mainly mountain beech with many unhealthy and dying trees. Here and elsewhere in the Mavora, beech forest may show evidence of patches of even-age stands associated with larger areas of mature beech forest.

2.5.4 Weeds

Ragwort *(Senecio jacobea)*, a noxious weed, is spreading in the grasslands of the Upper Mararoa valley. Its occurrence extends to 700 m (about 150 m above the lakes) but may go further if allowed to seed freely. Briar (*Rosa eglanteria*) is found in some of the small gullies, especially on fans and moraines. Native plants that are problems for grazing purposes are matagouri, bracken and tutu. *Hieracium pilosella*, which has achieved recent notoriety as a weed of pastoral land, has been reported in the Mavora district.



Matagouri (Discaria toumatu) and associated montane shrub species mark the scarp slopes of terraces in the middle reaches of the Windon Burn (10).



Modified tussock grassland on the terraces and flood plain of the Windon Burn, near the Forks Hut. Shady slopes are characterised by patches of remnant bush and scrub. (11)

North Mavora Lake in stormy mood (12).

Tranquility at the south shore of North Mavora Lake. Snowdon forest in the background (13).

2.6 WATER BODIES

2.6.1 Rivers

The Upper Mararoa River and Windon Burn flow from the north-east and north-west of the catchment respectively, join and enter the Mavora Lakes, the discharge of which continues as the Mararoa River to the Waiau River. There it is intercepted by a weir and backflows up the old course of the Waiau to Lake Manapouri which now discharges through a hydro-electric plant to Doubtful Sound on the Fiordland coast. The Oreti River initially flows parallel to the Mararoa in a valley immediately east of Lake Mavora and continues generally southward through Southland to the sea not far from Invercargill.

Stream flow data for the Mararoa are sparse; the only available records being 45 km downstream from Mavora Lakes at Mount York between 1963 and 1967 (M.W.D., 1975). On the assumption that the Mararoa Catchment contributes 40 percent of the Mt York hydrograph, the mean flow of the Mararoa below Mavora Lakes is calculated at 13 cumecs.

Estimates of lake volumes and turnover times are 38×10^7 cu m and 4×10^7 cu m and 11 months and one month for North and South Mavora Lakes respectively. Estimates are summarised in Table 2, the bases of the estimates being presented in Appendix 3.

TABLE 2: Estimates of Mararoa Stream flow and North and South Mavora Lakes volumes.

Mararoa River Stream Flow		
Average flow	13 cumecs)	1.4×10^8 cu m/yr *
Low flow	9.2 cumecs)	
Flood flow	280 cumecs)	
North Mavora Lake Volume		38×10^7 cu m
South Mavora Lake Volume		4×10^7 cu m

* Southland Catchment Board, 1975; Dunbar *et al*, 1966.

Although the headwaters of the Mararoa probably yield more water than neighbouring valleys, the storage of the Mavora Lakes reduces flood peaks and maintains low flows below the lakes. The maintenance of low flow was illustrated on one occasion by the Southland Catchment Board when the low flow in the Mararoa fell to 9.2 cumecs and the low flow in the Oreti fell to 1.2 cumecs. Flood peaks of 280 cumecs at Mavora Lakes outlet have been estimated by Dunbar *et al* (1966). This value is lower than those in adjacent rivers, but such lake discharge remains higher for longer periods. River flows within the study area, not having such storage above the lakes, are probably more flashy. Although flooding has been a problem in the Lower Mararoa and in the Whitestone River, floods do not present a major problem in the Upper Mararoa but they may temporarily affect access.

Despite buffering effects of these lakes in the Mararoa system, the limited records of the streamflow for the Mararoa at Mt York indicate considerable variation in mean daily discharge from month to month in the period from April 1963 to July 1967 (Table 3). Although May, June, September and November have had higher than average discharges, there is no consistency in such seasonal patterns. As part of this study, a preliminary examination was made of the possible relationship between monthly discharge at Mt York and recorded precipitation or calculated water balance at localities reasonably close to the Mararoa Catchment. Table 4 presents the correlation coefficients between monthly values for varying numbers of months for which calculations were possible. Simple regressions indicate that some 20 percent of the variations in monthly discharge at Mt York can be accounted for by taking into account the estimated water available for runoff at either Queenstown, Te Anau or Mid Dome. Somewhat less explanatory power is ascribable to the simple monthly precipitation records for these stations. Stepwise multiple regression shows that 43 percent of variation in monthly discharge is accounted for by taking into account the monthly precipitations at Queenstown and Te Anau. For a shorter period for which

TABLE 3: Monthly mean daily discharge of Mararoa River at Mt York, April 1963 - June 1967 (litres per second).

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.
1963				164	298	273	152	312	618	355	522	155
1964	334	110	255	193	565	252	263	443	523	385	517	542
1965	381	233	283	158	440	624	405	210	377	492	531	191
1966	369	203	126	382	207	388	256	210	156	163	179	245
1967	470	355	340	491	757	648						

Te Anau Downs monthly precipitations were available, a similar percentage of variation in monthly discharge was accounted for simply by taking the monthly precipitation at Te Anau Downs into reckoning (Z = 3734 + 175 ± 57 Y5). No significant improvement was obtained by including further precipitation stations. These, it may be noted from Table 4, are closely correlated with monthly precipitation with Te Anau Downs.

TABLE 4: Correlations between monthly measured precipitations and calculated water surpluses for selected stations and monthly mean daily discharge of Mararoa River at Mt York.

		Y1	Y2	Y3	Y4	Y5	X1	X2	X3	Z
Precipitation										
Mid Dome	Y1	.	.590	.562	.632	.873	.456	-	-	.421
Te Anau	Y2		.	.748	.808	.860	-	.692	-	.315
Queenstown	Y3			.	.828	.923	-	-	.437	.408
Knobs Flat	Y4				.	.938	-	-	-	-
Te Anau Downs	Y5					.	-	-	-	-
Water Surplus										
Mid Dome	X1						.	.634	.616	.438
Te Anau	X2							.	.642	.421
Queenstown	X3								.	.445
River Flow										
Mararoa	Z									.

It is tentatively concluded that Mararoa River flow is highly variable even monthly and is substantially dependent on rainfall, especially in the upper part of its catchment. It is also suggested that examination of longer term rainfall records correlated with precipitation in the catchment, e.g. Queenstown, might provide some indication of the likely range of monthly discharge from the Mararoa at Mount York.

TABLE 5: Comparison of some southern lakes.

		Oligotrophic							Meso-eutrophic
		Small Southern Lakes				Large Southern Lakes			Small Southern Lake
		(1) South Mavora	(1) North Mavora	(2) Fergus	(2) Gunn	Te Anau	Manapouri	Wakatipu	Hayes
Morphometry									
Max. depth (m)		45	100	30	100	276[3]	444[3]	378[3]	33[3]
Length (km)		3.0	11.8	4.5	5.7	53.0[4]	19.5[4]	83.0[4]	3.1[4]
Max. width		0.7	1.5	0.5	1.5	9.6	9.6	4.8	0.9[4]
Altitude (m)		612	625	500	450	211	181	309	329[4]
Area (km^2)		1.2	10.8	0.4	1.67	342.0	145.0	291.0	2.6
Watershed		Beech forest and tussock grassland	Tussock grassland	Beech forest		Beech forest, fernland and tussock grassland		Tussock grassland and forest remnants	Developed farm land
Physical									
Temperature (°C.)		Surface Bottom							
Summer		15.8 8.8	14.2 7.6	14.7	13.2 6.9	17.75-9.2		16.0 -8.75	18.35-8.2
Winter		9.8 8.9	10.1 8.1	9.8 9.5	Feb.-May	8.0 -8.0		8.75-8.75	5.75-5.6
Summer		Weakly stratified		Homothermous		Weakly stratified			Stratified
O_2 Conc. at bottom (% Sat.)	S	66%	70%	90.5 83.5	89.6 75.3	82%	82%	-	40-100%
	W	71%	62%	83.4 81.5	83.1 83.3				13- 20%
					High				Low
Visibility Secchi Disc (m)	S	8.0	9.0	6.5	8	8.5-11.3	6-10	7.7-18.0	6.0
	W	8.5	7.58	8.9	5.5				
		Surface Bottom	Surface Bottom	Surface Bottom	Surface Bottom				
pH	S	6.9 6.55	7.0 6.5	7.1 6.8	6.7 6.8			7.05	7.1-8.0
	W	6.95 6.7	6.75 6.45	7.2 6.9	6.8 6.4	6.7	6.5		7.5
Conductivity (m S/cm at 25°C.)	S	3.4	3.4 3.3	6.4 5.4	41 48	3.5-3.6	6.2		-
	W	3.15 3.3	3.1 3.3	57 58	41 45	3.2			
					Low				
Alkalinity as $CaCO_3$ (g/m^3) 25°C.	S	13.85 14.0	13.5 14.0	0.42 0.43	0.31 0.34	12.0	11.0	-	-
	W	14.1 14.85	13.5 14.5	0.43 0.43	0.31 0.34	10.5	10.0		
				(meq HCO_3/1)					
Chemical mg/1									
Silica (as SiO_2)				4	6	3[5]	4[5]	2.5[5]	(5)
Total Phosphorus				0.15	0.007				
Soluble Phosphorus				<0.002	<0.002	Trace			0.3-1.3
Nitrate-Nitrogen				0.05	0.05	Nil			
Nitrite-Nitrogen				<0.001	<0.001	Nil			-
Ammoniacal Nitrogen				<0.005	<0.005	0.003	0.003	0.004	0.005-0.149
Albuminoid Nitrogen				<0.005	<0.05	0.045	0.031	0.014	0.084-0.142
Total organic N				0.64	0.13				

Compiled from:
(1) Stout, 1976 (pers. comm.)
(2) Green, 1973
(3) Jolly and Brown, 1975
(4) Irwin, J., 1975
(5) Jolly, 1968

2.6.2 Limnology

The Mavora Lakes can be classified morphometrically as sub-rectangular elongate, in glacial oversteepened valleys enclosed by moraine (after Irwin, 1975).

They are relatively oligotrophic, weakly thermally stratified in summer and probably low in chemical content and production (Stout, 1976). They can, therefore, be considered as warm monomictic, i.e. stratified lakes in summer with full circulation in winter at temperatures above 4^{o}C (Jolly and Irwin, 1975).

Stout (1976) summarises their surrounding and local vegetation conditions as follows:

> "Lake Mavora North: Mostly surrounded by tussock grassland, shingle shore, with most rooted aquatic vegetation on the west side. Maximum depth recorded, 100 m.
>
> Lake Mavora South: Mostly surrounded by native forest. Some rooted aquatic vegetation and algal growth on the bottom. Maximum depth recorded, 45 m."

Data available for the Mavora Lakes are presented in comparison with other southern lakes in Table 5. Lakes Fergus and Gunn are oligotrophic but with forest watersheds and are similar in size to the Mavora Lakes. The oligotrophic large southern lakes, Te Anau, Manapouri and Wakatipu, are much deeper, but in part have similar watersheds. Lake Hayes is a small eutrophying lake with a semi-intensive pastoral watershed. These comparative lake conditions are discussed in more detail with a view to possible risks of alteration of the character of the Mavora Lakes.

The Mavora Lakes chemically and thermally would appear to behave similarly to Lake Gunn and the large southern lakes, having considerably less nutrients and temperature stratification, and greater visibility and saturated dissolved oxygen concentration in the bottom waters than Lake Hayes. Lake Fergus, being shallower and more susceptible to mixing than the Mavoras, is homothermous, i.e. it does not stratify.

2.6.21 Temperature

In summer a lake may divide into two regions: the surface waters (epilimnion) become warm while the bottom waters (hypolimnion) remain cool with a narrow band of water between the two where the water cools rapidly with depth (thermocline). In a stratified lake, mixing does not take place because cooler bottom waters are more dense than the warmer surface waters. This, in effect, divides the lake both thermally and chemically. When the surface temperature approaches that of the bottom water in late autumn, stratification breaks down and all water may freely mix.

Stratification is weak in the Mavora Lakes because of the deep mixing effects of strong winds in the warming period of spring and early summer, especially as the lakes are of an elongated shape with the long axis lying along the path of the prevailing winds. Stratification is also of a magnitude similar to large southern lakes. The depth of the thermocline is in proportion to the maximum depth about one-third of the depth from the surface. The South Mavora Lake shows warmer bottom waters in summer than the North Mavora Lake, mainly owing to its shallower depth and greater susceptibility to mixing. In contrast, Lake Fergus, of slightly shallow depth, does not stratify (homothermous). Lake Hayes, of similar depth to Lake Fergus but eutrophic, has more pronounced stratification, persisting to some degree even in winter.

2.6.22 Visibility and Light Penetration

Both Mavora Lakes are very clear, as measured by Secchi disc by Stout (1976), and compare with other oligotrophic southern lakes, having considerably higher clarity than Lake Hayes.

Although light penetration readings have not been done in the Mavora Lakes, Green (1973) shows that in Lakes Gunn and Fergus, of similar depth but lower visibility, light penetration occurs to the bottom in summer and is "significantly reduced at a depth of 40 m in Lake Gunn and was only just measurable at the bottom of Lake Fergus" in winter.

High transparency indicates a low phyto-plankton concentration and low lake productivity, together with a general lack of silt, particulate organic matter and humic material. Somewhat lower visibility readings in Lakes Gunn and Fergus than in the Mavora Lakes may be due to humic colouring from a forest catchment, while the lower value for Lake Hayes probably indicates high phyto-plankton concentration.

2.6.23 pH, Alkalinity and Conductivity

pH and alkalinity are close to neutral or very slightly acid and are similar to other southern lakes except Hayes, which is probably alkaline during algal blooms. The low conductivity indicates a low concentration of ions.

2.6.24 Dissolved Oxygen

Oxygen supply is abundant at all levels in the lakes at all times. The South Mavora Lake shows a small drop in oxygen supply during summer stratification.

2.6.25 Nutrients

Although no values on the phosphorus and nitrogen content are available, the oligotrophic character shown by the low conductivity, high visibility indicating low productivity and the concentration of oxygen in the bottom waters despite some stratification all join with the knowledge of lakes with similar relatively unmodified catchments in indicating that phosphorus and nitrogen have very low concentrations and are limiting to production at least during summer.

2.6.26 Productivity

Primary production and thus productivity increases until an essential factor becomes limiting. In such oligotrophic lakes, phosphorus and nitrogen are probably limiting in summer with light penetration limiting in winter (Stout, 1976).

Productivity, oxygen saturation, nutrient supply, thermal properties and light penetration are, therefore, interrelated. During summer, in conditions of stratification, most production occurs in the warm well-illuminated surface waters, with any dead organic material falling to the bottom to decay. The bottom waters have a fixed supply of dissolved oxygen until the turnover, i.e. when mixing starts. A balance exists between the process that generates oxygen, photosynthesis assisted by good illumination, and those that use oxygen, i.e. respiration and decay. If water visibility declines through a variety of causes, including increased density of living organisms, then decaying matter may reduce the level of oxygen in the bottom waters as photosynthesis is itself reduced with diminishing light penetration.

During early winter when mixing occurs, nutrients from the bottom waters may cause a flush of growth in surface waters that continues throughout winter at a slower rate until stratification once again occurs.

Seasonal bioproduction variations are probably small at Mavora because of a low nutrient supply, weak stratification, low productivity and very clear water. In comparison, Lake Hayes, with increased nutrient supply, allegedly from surrounding farm land but possibly from other causes as well, probably has considerable variations shown at times by moderately high plankton production (Jolly, 1968).

2.7 WILDLIFE

2.7.1 Birds

Mavora's wildlife has regional significance (Nilsson, 1975) for the preservation of endangered or threatened bird species.

About one-third of New Zealand's native birds are endangered in some way; for example, bush felling activities may be reducing suitable habitat for some of them. Of those listed as endangered, kaka, robin and yellow-crowned parakeet are plentiful at Mavora Lakes.

Some other threatened species are found there. Crested grebe is found occasionally on the south lake. It is locally rare and vulnerable to recreational pressure. Being a diving animal and having a floating nest, it can be easily disturbed by power boats.

Diversity of species is high. The Mavora region is in a fringe area between a wet climate to the west and a dry climate to the east. Some plant species from the wetter region as well as those from the drier region exist together in association. This, and the high diversity of site conditions such as running and still water, swamp, forest and tussock grassland, and variation in topography, support a high diversity of species. Appendix 4 presents a bird check list. The great diversity of species and the relatively easy access to different habitats make for valuable bird watching opportunities but with concomitant risks of wildlife disturbance.

2.7.2 Fish

Sutton (1975) supplied the following information concerning the Mavora brown trout fishery:

> "Brown trout, plus various small native fishes, are present in Lakes Mavora and the Mararoa River and its tributaries. A few Rainbow trout have been recorded in South Lake Mavora and the lower Mararoa River but these are considered to be odd venturesome individuals.
>
> "Brown trout in these waters are abundant and of excellent size and fighting quality. The average size of trout rivals that of almost all other fisheries in the district. The fishery is self-supporting in that adequate spawning gravels are available in the rivers and streams. The quality of angling is of a very high order, especially dry fly angling both in the lakes and the river.

> "Angling pressure was formerly light due to difficulty of access. Since access has been made easy, angling pressure has increased enormously. To date there are no indications that there is any deterioration in trout stocks due to angling pressure."

2.7.3 Mammals

No full census of wild mammals has been carried out in the Mavora but some information has been gleaned from Dunbar *et al* (1966) and from New Zealand Forest Service Draft Working Plan for the Snowdon State Forest (1975).

Red deer were liberated in the vicinity of Lake Manapouri early this century and probably merged with introductions made further to the east to colonise the whole of the Mararoa Catchment within three or four decades. Although recreational hunting has existed in recent decades, it was only with helicopter hunting during the 1960s that population control became effective. Fallow deer from the Caples and Von Valleys occasionally appear in the Mararoa watershed and chamois have in recent years arrived in low numbers in the Livingstone Mountains.

Small mammals in the Mavora include low densities of opossum in the beech forest and forest-grassland margin, hares which are abundant from valley floor to the alpine grassland and rabbits which are now sparse after having once been at plague densities.

Feral animals include goats as well as pigs to the west, but densities are at present apparently fairly low. Feral sheep and cattle have apparently been eliminated.

CHAPTER THREE
Land Systems of Mavora

The land systems approach is a method to describe the environment and its dynamics by considering, after the manner of Christian and Stewart (1968):

(a) independent factors - climate, geology, topography;

(b) dependent factors - soil and vegetation;

(c) dependent attributes - erosion, problems of utility and potential productivity.

More traditional approaches in New Zealand are Land Use Capability Surveys (Water and Soil Division, N.Z. Ministry of Works, 1971), and Soil Surveys (Taylor and Pohlen, 1962).

There are two land system mapping units considered (Gibbons and Downes, 1964):

1. <u>Land Unit</u>

   Land units are areas where characteristic patterns of a number of land components are present. A land component is the smallest, most detailed unit of mapping where climate, parent material, topography and vegetation are uniform within limits significant for a particular type of land use. Land units also occur in patterns because the independent variables of climate, parent material and topography are few and one or more is usually constant over large areas with other environmental factors depending on them.

   Land units have less uniform characteristics than the land component but are adequate for a reconnaissance survey as in this study. Land units are identified by field and air photo interpretation and are approximately equivalent units to soil series, associations and complex in New Zealand Soil Surveys.

2. <u>Land System</u>

   Land systems are large areas made up of a limited number of related land units based on features considered to be important for land use. A land system must have at least one independent variable constant. Several sub-systems may be within a land system based on differences in independent factors, e.g. rock types.

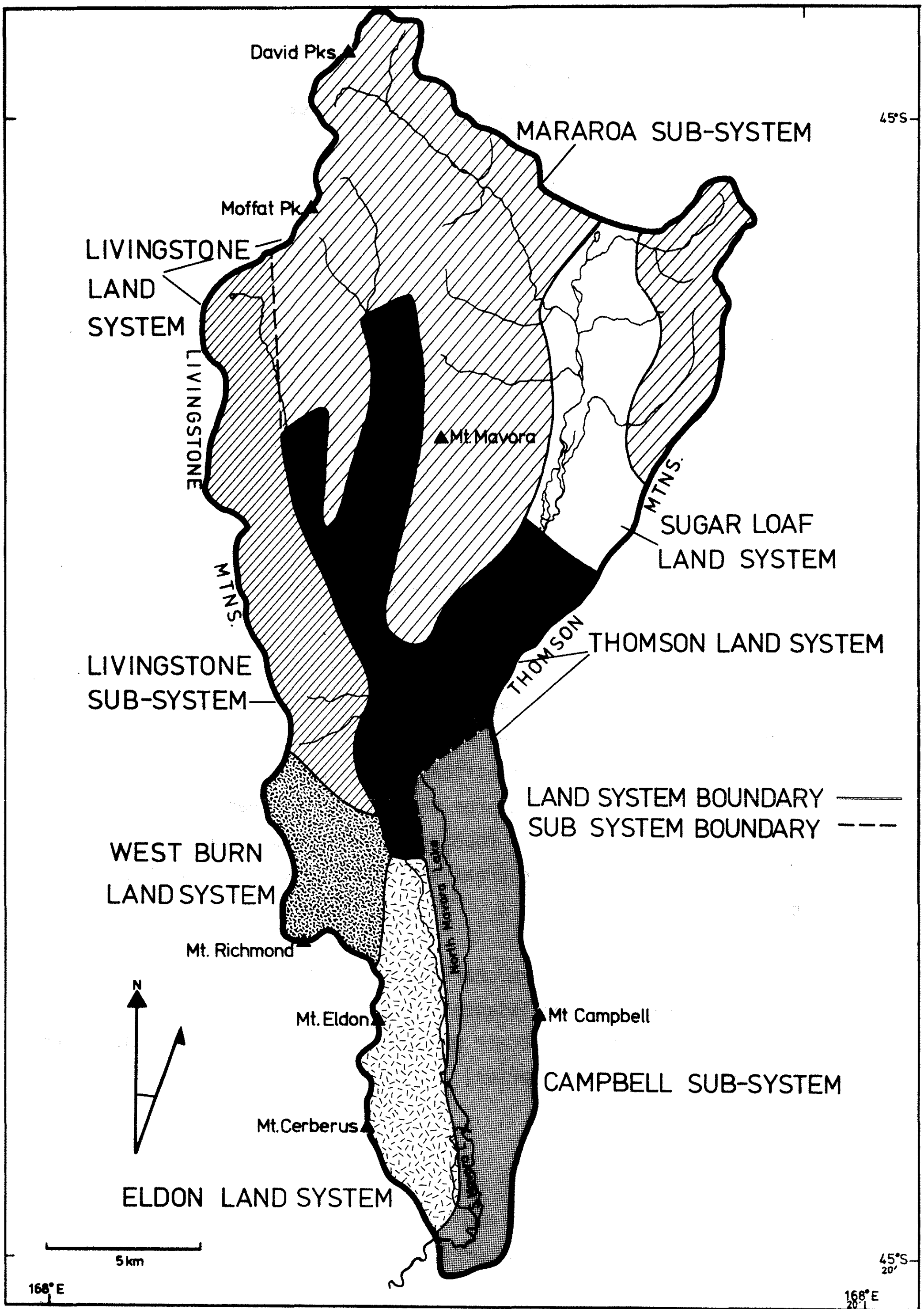
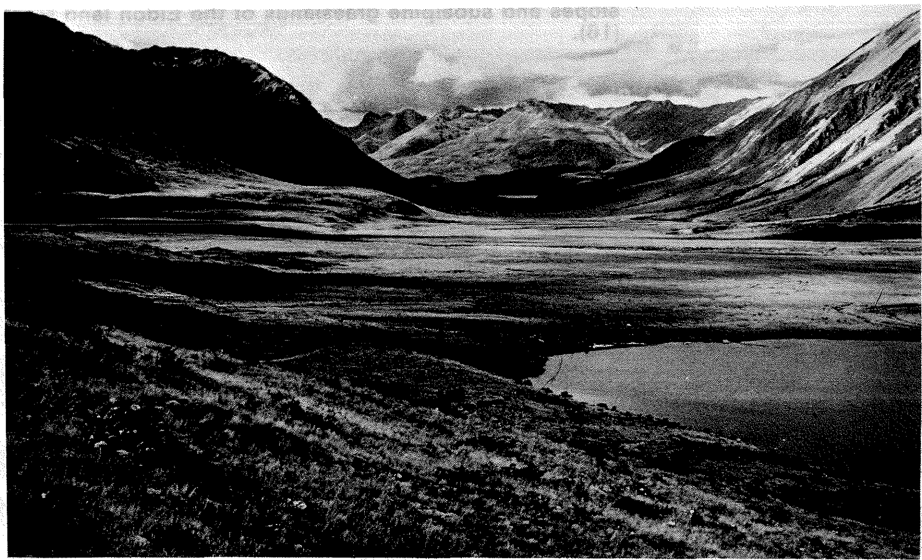
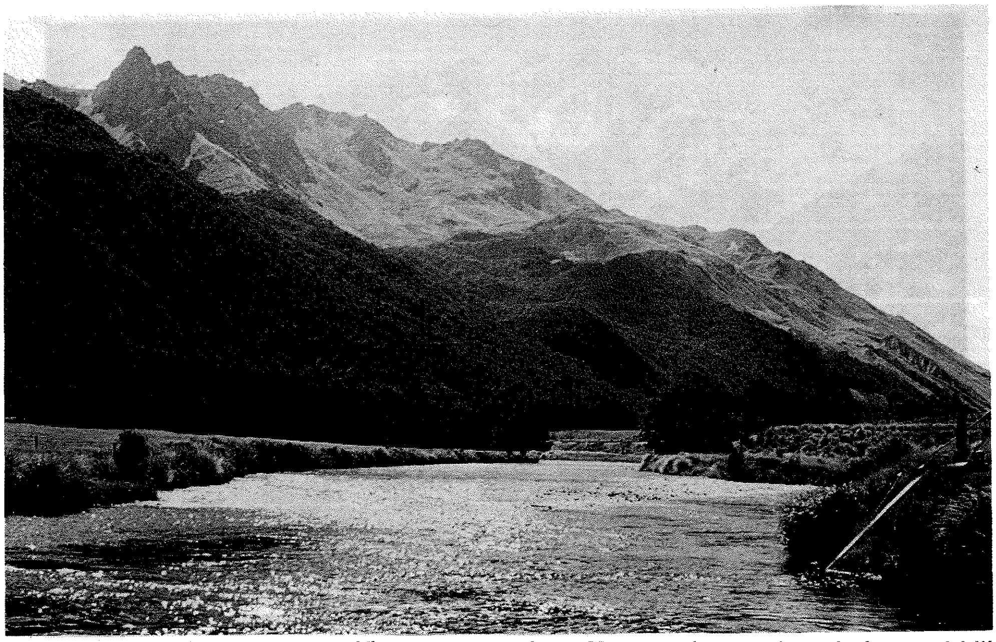


FIGURE 22: LAND SYSTEMS

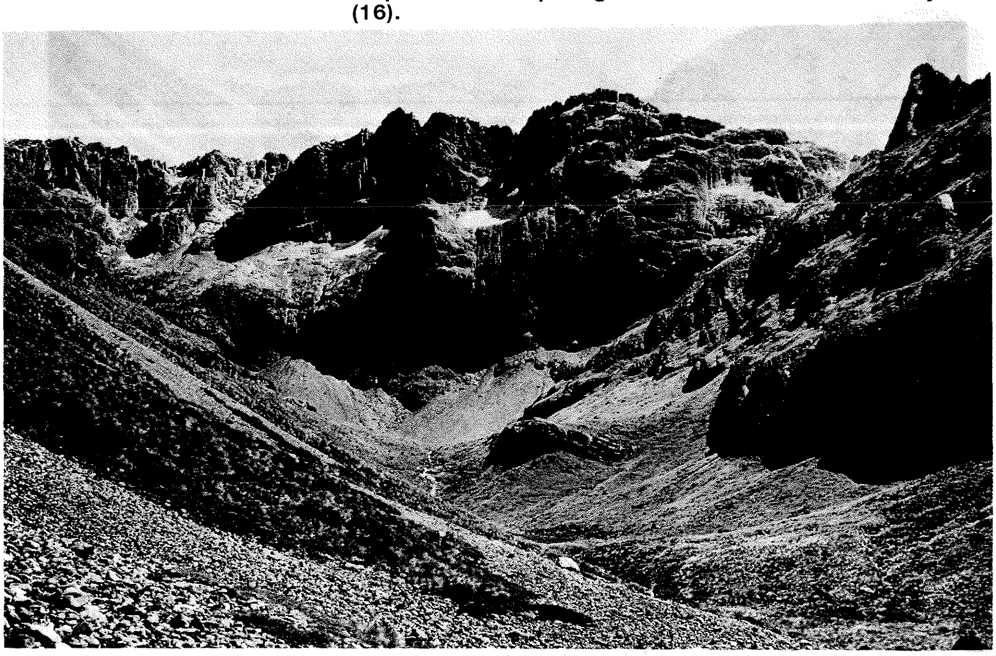
Depleted and eroded slopes of the Campbell subsystem with active fan deposits through mountain beech forest (14).



View up the Upper Mararoa Valley from above the north-west corner of North Mavora Lake. The principle land units of the Thomson subsystem identified in Fig.24 are illustrated from left to right of this picture, across the lower part of this valley: Unit 6 (colluvial foot slope) above unit 5 (ice shorn bench) with unit 4 (out-wash terraces) extending across valley to unit 1 (river flat) and up through unit 2 (cones and fans) to units 7 and 8 (sunny hill slopes) on the Thomson mountains (15).



View upstream from Mararoa river to densely forested hill slopes and subalpine grasslands of the Eldon land system (16).



Precipitous bluffs and steep colluvial deposits, supporting scree vegetation as in foreground or in tussock grassland and herbfield communities. Upper reach of the East Branch of the Windon, Mararoa subsystem (17).

The Mavora study area is presented as five land systems based on differences in geomorphologic pattern. For example, the Sugar Loaf Land System is a broad U-shaped valley resulting from glacial scouring and moraine deposit, while the Eldon Land System's main features are the dendritic streams and gullies within a fault crush zone. Two land systems, Thomson and Livingstone, are divided into sub-systems on drainage density in the former and rock type in the latter.

Block diagrams and tables show relationships between variables. They are symbolic and do not necessarily show the whole land system but demonstrate how assemblages of land units fit together within the land system. Vegetation is summarised physiognomically only in these tables although there are important floristic differences besides the physiognomic dominant. Wildlife elements are not included in the tables. Forest birds and water and water margin birds are the principal wildlife elements and their habitats are respectively the lower altitude forest and forest margins and water body and water margins.

Key to Figures 23-29

Key to Figures 23-29

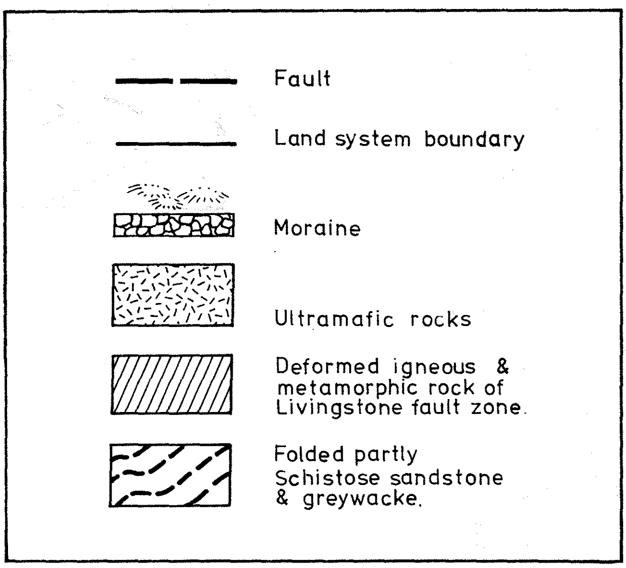


FIGURE 23: Thomson Land System

Floors and sunny, west and north-facing slopes of a narrow U-shaped main upper glaciofulvial valley

(a) Campbell Sub-System

Forested and tussock sunny face of the Thomson Mountains adjacent to the Mavora Lakes. High drainage density.

Geology:	Sedimentary rock of Permian age; partly schistose, Caples greywacke, sandstone, mudstone, impure chert, breccia.
Geomorphology:	Glacial action plained face - now dissected by structurally controlled streams with a high drainage density following N.E. tending faults that split greywacke folds. Screes lie over much of the upper surface with fans built up over moraine on foot slopes.
Altitude:	700 - 2,000 m
Climate:	Average annual rainfall 1,200 - 2,000 mm. High winds. Cold with frost and snow in winter, cool to mild in summer.

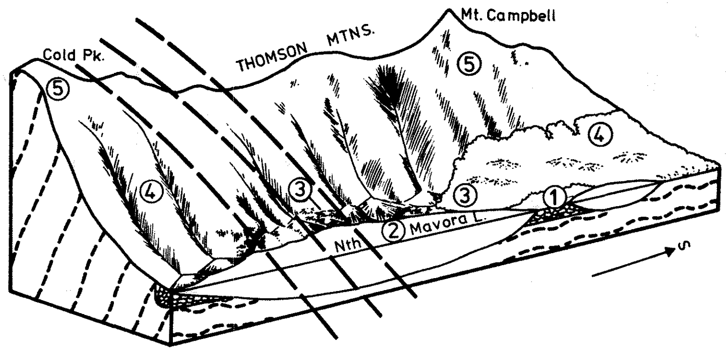


FIGURE 23: CAMPBELL SUB-SYSTEM

Unit	Area	Climate		Land Form	Soil and Erosion	Vegetation
		Summer	Winter			
1	Very small	Mild Humid 100-150 cm	Cold Snow at times	River flat and Young Fans. Flat areas around streams. Poor drainage at entrance to lakes.	Tasman: Hygrous, recent alluvial, variable textured/ sand to silt loam/ soil. Very little structure. Shallow but deeper in places and further away from river. Slight wind erosion. Flooding in lower areas.	Short-tussock grassland (fescue tussock).
2	Small	Mild Humid 100-150 cm	Cold Snow at times	Old Fans: Gently sloping and overlying moraine, some protrude into lakes as deltas.	Eldon: Hygrous, young alluvial high-country yellow-brown earth. Silt loams but stony in places. Derived from greywacke gravels of Land Units 4 and 5. Slight wind erosion.	Short-tussock grassland. (Silver and fescue tussock, scrub land and matagouri).
3	Medium	Mild Humid 100-150 cm	Cold Snow at times	Hummocky Moraine: Undulating surface around lake edge.	Mavora: Developed on bouldery glacial moraine. Older and finer textured than 2 but has gravels and boulders. Hygrous, high-country yellow-brown earth. Wet in hollows but not gleyed.	1. Humps - short-tussock grassland. Hollows - tall-tussock grassland. 2. Evergreen forest (beech, mainly mountain beech).
4	Large	Mild to cool Humid 150-200 cm	Cold Snow lies for periods	Lower Hill Slope: Steep, 700-1,000 m altitude, Dissected by streams. Scree from Unit 5 overlies surface in places.	Livingstone Steepland: Older, more finer textured hygrous and hydrous high-country yellow-brown earth. Fairly severe wind and sheet erosion.	1. Short/tall-tussock grassland association (fescue and snow tussock). 2. Evergreen forest (mountain beech).
5	Large	Cold to cool Humid 200-250 cm	Very cold Cool Snow lies all Winter	Upper Hill Slope: Very steep, 1,000 - 2,000 m altitude. Large scree slopes at head of streams.	Kaikoura Steepland: Higher wetter version of Unit 4, much bare ground and scree. Severe to extreme wind, sheet, scree and gully erosion.	1. Tall-tussock grassland, (snow tussock), herb and fell-field, rock, scree.

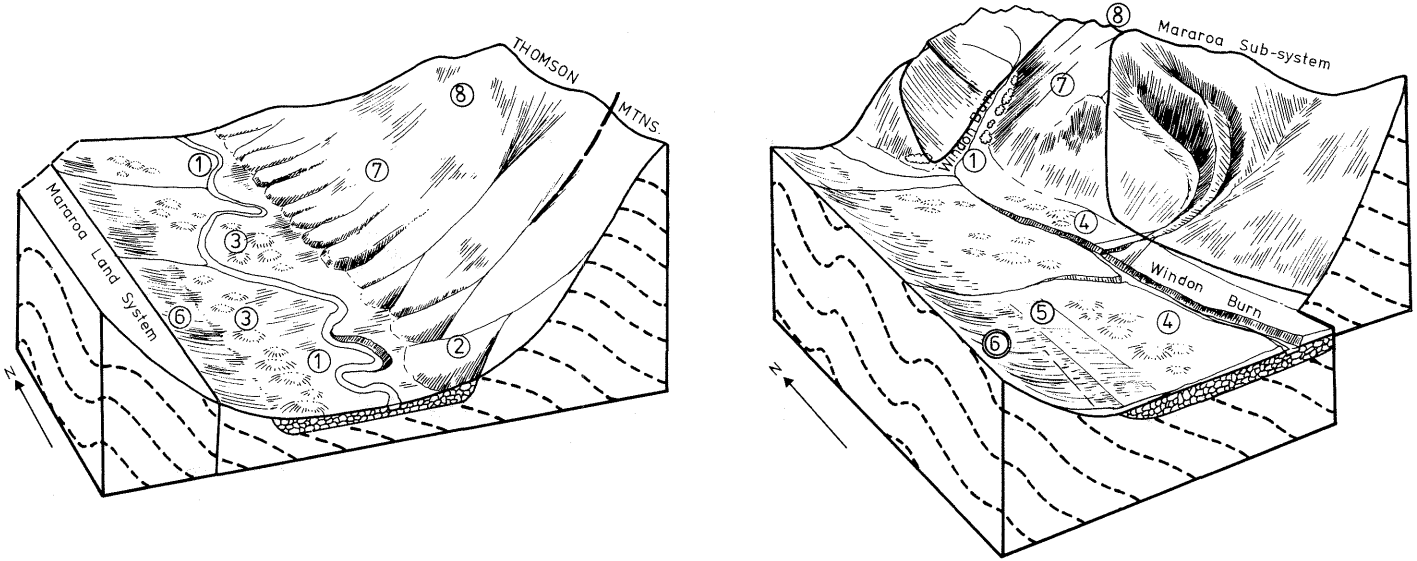
FIGURE 24: Thomson Land System

(b) Thomson Subsystem

Tussock grassland on valley floors and sunny faces with low drainage density of the Windon Burn and Mararoa River.

Geology:	Sedimentary rock of Permian age, partly schistose, Caples greywacke, sandstone, mudstone, chert, breccia.
Geomorphology:	Glaciers carved straight, narrow U-shaped valley. Parallel ridges and mainly shallow gullies occur from fluvial action on sunny faces of intensely folded greywacke and sandstone. Occasionally a stream follows a fault. Drainage density is low with streams flowing in gullies, mainly during rainy periods. Gullies end in fans and high-angled cones. Valley floor has two types of drainage: 1. Entrenched channel of Windon Burn in outwash terraces. 2. Meander pattern of the Mararoa.
Altitude:	700 - 2,000 m
Climate:	As for Campbell Subsystem, except upper reaches probably receive more precipitation.

FIGURE 24: THOMSON SUB-SYSTEM



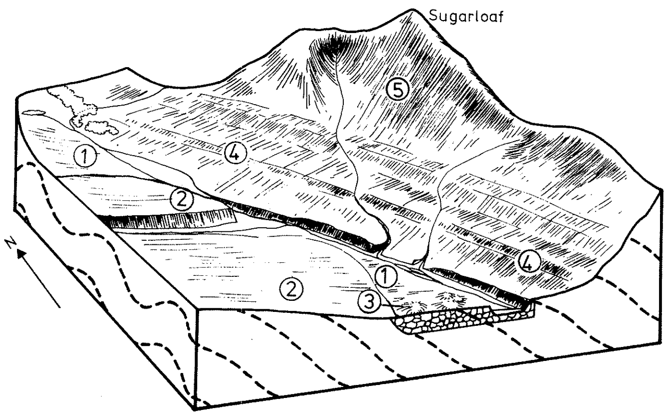
Unit	Area	Climate: Summer	Climate: Winter	Land Form	Soil and Erosion	Vegetation
1	Medium	Mild	Cold Snow at times	River Flat: Flat alluvial areas around streams extending into deltas into lake. Poor drainage in very low lying areas.	Tasman: Recent alluvial variable textured but mainly coarse soil. Very little structure. Shallow mainly but deeper on low terraces further away from river. Slight wind erosion. Flooding in lower areas.	Short-tussock grassland and scrubland. (Fescue tussock and matagouri).
		Humid 150-200 cm				
2	Small	Mild	Cold Snow at times	Fans, Low Terrace and Cones: Gently to strongly sloping. Overlying moraine and valley alluvium. Built up by gully streams.	Eldon: Young alluvial high-country yellow brown earth. Medium textured but stony in places. Derived from greywacke gravels and silts of Units 8 and 7. Scree on steep cones. Slight wind erosion.	Short-tussock grassland and scrubland. (Silver and fescue tussock and matagouri).
		Humid 150-200 cm				
3	Medium	Mild	Cold Snow at times	Hummocky Moraine: Undulating surface of mostly greywacke boulders and rubble dumped by retreating glacier. Sometimes overlying ice cut benches.	Mavora: Older and finer texture than 2, but with much gravel and boulders. Wet in hollows but not gleyed. Slight wind erosion.	1. Humps - short-tussock grassland. 2. Hollows - tall-tussock grassland (Red tussock).
		Humid 150-200 cm				
4	Medium	Mild	Cold Snow at times	Outwash Terraces: Glacial deposits have been terraced by water action. Thin layer of alluvium or loess in places with large boulders protruding. Flat to gently undulating.	Windon: Similar to Land Unit 3 but better drained with less hollows. Slight-moderate wind erosion.	As for Land Unit 3. (Sides of terrace and gullies often in matagouri).
		Humid 150-200 cm				
5	Medium	Mild	Cold Snow at times	Ice-Shorn Bench: Rolling, ice-shorn structurally controlled bench with roches moutonnes and mamillated surface of moraine.	Unnamed hill variant of Mavora. Actually very similar to Mavora, but less hollows with poor drainage because of slope. Moderate sheet erosion.	Short-tussock grassland. (fescue-tussock)
		Humid 150-200 cm				
6	Small	Mild to Cool	Cold Snow at times	Colluvial Foot Slope: Strongly sloping concave. Shaded, damp slope extending parallel to hillslope.	Shirkers: Fine textured soil (heavy silt loam), drainage poor but not gleyed. Slight to moderate wind erosion.	1. Tall and short-tussock association (Red and fescue tussock). 2. Small patch of evergreen forest - mountain beech (Shirkers Bush).
		Humid 150-200 cm				
7	Large	Mild	Cold Snow at times	Lower Sunny Hill Slope: Glacial carved, very steep slope. 700-1,000 m altitude. Parallel ridges and gullies in intensely folded greywacke and sandstone. Some gullies follow faults. Low drainage.	Livingstone Steepland: Older, medium-fine textured high-country yellow-brown earth. Severe wind, sheet and gully erosion. Scree from Land Unit 8.	1. Tall/short tussock grassland association (snow and fescue tussock). 2. Evergreen forest in parts - scree breaking through from Land Unit 8
		Humid 150-250 cm				
8	Large	Cold to cool	Very cold Snow lies all winter	Upper Sunny Hill Slope: Glacial carved very steep slope, 1,000 - 3,000 m altitude. Large scree slopes in faulted and folded greywacke and sandstone.	KaikouraSteepland: Higher version of 7. Mostly bare ground and scree. Extreme wind, sheet scree erosion.	Tall-tussock grassland (snow tussock), herb and fell-fields, rock, scree.
		Humid -Perhumid 200-250 cm				

FIGURE 25: Sugar Loaf Land System

Tussocky morainic floors and ice-sculptured sunny faces of the main upper glacial valley.

Geology:	Sedimentary rock of slightly to party schistose greywacke and sandstone with intense folding and some faulting.
Geomorphology:	A broad U-shaped valley with ice-shorn structurally controlled benches scattered with moraine resulted from the erosive forces of a large external glacier from the Greenstone and passing down the Mararoa and North branch of the Von (Pass Burn and Trench Burn advance). Terminal moraine with hummocky surface and numerous tarns dammed at lake in the valley after glacial recession. Alluvium was deposited on the bottoms of this lake and a large fan developed, from a supply of sediment from the Mararoa River from the north-west, forming two lakes which have since been in part infilled. Alluvial areas of poor drainage and small ponds resulted when the lakes partly drained through down cutting as sediment supply diminished.
Altitude:	800-2,000 m.
Climate:	Approximate annual rainfall 2,000 - 2,500 mm. High winds. Cold with frost and snow in winter, mild summer.

FIGURE 25: SUGAR LOAF LAND SYSTEM



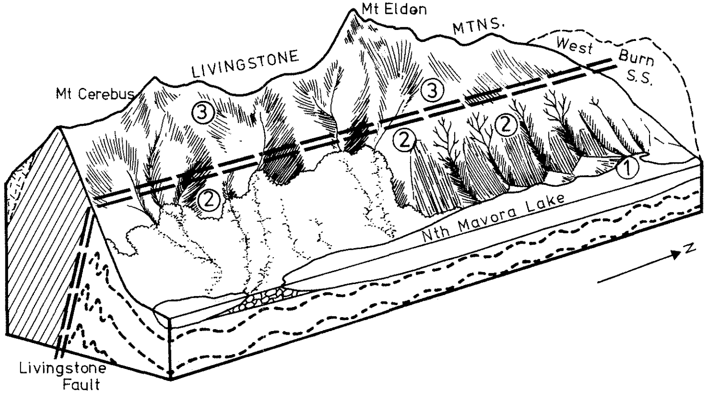
Unit	Area	Climate Summer	Climate Winter	Land Form	Soil and Erosion	Vegetation
1	Small	Mild	Cold Snow at times	River Flat and Terrace. Areas around streams and alluvial areas of past lake with poor drainage.	Tasman: Recent alluvial, variable textured by mainly coarse soil. Very little structure. Shallow and stony, but deeper and finer textured at old lake site. Slight wind erosion. Flooding in lower areas.	Short-tussock grassland (fescue tussock).
		Humid 200-250 cm				
2	Very small	Mild	Cold Snow at times	Fans: Gently sloping.	Eldon: Young, alluvial soil. Medium textured yellow-brown earth, stony in places. Derived from greywacke gravels and silts. Slight wind erosion.	Short-tussock grassland (fescue tussock.
		Humid 200-250 cm				
3	Medium	Mild	Cold Snow at times	Hummock Moraine: Undulating surface with lumps and hollows containing tarns.	Mavora: Older and finer texture than Land Unit 2 but with much gravel and boulders. Wet in hollows, but not gleyed. Slight wind erosion.	Hummocks: Short-tussock grassland (fescue tussock) Hollows: Tall-tussock grassland (red tussock).
		Humid 200-250 cm				
4	Large	Mild	Cold Snow at times	Ice Shorn Bench: Rolling to steeply sloping, 800-1000m ice shorn structurally controlled bench with roches mountonees and mamillated surface of moraine.	Unnamed hill variants of Mavora. Probably very similar to Mavora(Unit 3) but less hollows with poor drainage because of slope. Moderate sheet erosion.	Tall tussock grassland. Lower wetter regions - red tussock. Upper drier areas - snow tussock. Some evergreen forest (mountain beech).
		Humid 200-250 cm				
5	Medium	Cool to cold	Very cold Snow	Upper Hillslope: Very steep, 1,000 - 2,000 m altitude. Scree slopes dominant.	Kaikoura Steepland: High altitude high country yellow brown earth. Severe sheet, scree gully, wind erosion.	Tall tussock grassland and scree (snow tussock).
		Humid - Perhumid >250 cm				

FIGURE 26: Eldon Land System

Tussocky shady face above beech forest on the U-shaped lower main glacial valley, influenced by shattered zone of Livingstone Fault.

Geology:	Rocks are deformed and shattered from movement of Livingstone Fault. East of fault: Metamorhpic semischist and greywacke; shattered schistose sandstone, siltstone, red and green chert. West of fault: Igneous and metamorphic; spilites, dolerite, sedimentary inclusion.
Geomorphology:	Oversteepened valley side was cut by glacial action. Fluvial action developed a dendritic drainage pattern in shattered fault zone region. Fans formed at bottom of gullies.
Altitude:	700 - 2,000 m
Climate:	As for Thomson Land System, but colder and moister due to shady aspect.

FIGURE 26: ELDON LAND SYSTEM



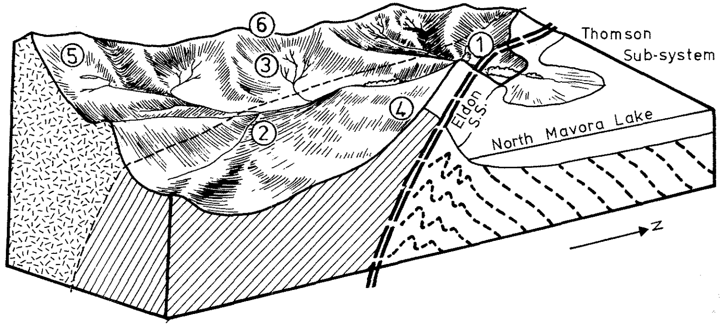
Unit	Area	Climate		Land Form	Soil and Erosion	Vegetation
		Summer	Winter			
1	Small	Mild Humid 100-150 cm	Cold	Fan or Cone: Gently to strongly sloping. Protruding into lake.	Eldon: Young alluvial soil, medium-textured but stony in places. Derived mainly from semi-schist greywacke gravels of Land Unit 2 but some igneous gravels from Land Unit 3. Slight wind erosion.	Short-tussock and scrub (silver and fescue tussock, matagouri).
2	Large	Mild to cool Humid 150-200 cm	Cold Snow at times	Lower Hillslope: Shady steep to very steep slopes incised by gullies and streams with dendritic drainage pattern on shattered fault zone rock, 500-1,000 m.	Livingstone Steepland: Older medium-fine textured high-country yellow brown earth. Differs from Thomson Land Unit 7 in having more chert and igneous derivatives from Land Unit 3. Moderate sheet and gully erosion.	1. Short/tall-tussock (fescue lower altitude grading to snow tussock at higher altitude). 2. Evergreen forest (mountain beech).
3	Large	Cool to cold Humid 200-250 cm	Very cold Snow	Upper Hill Slope: Very steep with bluffs >1,000 m. Mainly scree slopes with some gullies of Land Unit 2 intruding.	Takitimu Steepland: Stony loams of brown granular loam to yellow brown earth intergrade. Severe to extreme sheet, gully and scree erosion.	Tall-tussocks (snow tussock) and herbfield, bare rock, scree.

FIGURE 27: West Burn Land System

Tussocky and scree glacial tributary, spilling out to a large delta, west side of North Mavora Lake.

Geology:	1. Igneous (Red Mountain ultramafic - olivine serpentine) rocks to the west 2. Deformed, faulted igneous (spilite, dolorite) and metamorphic rock adjoining Livingstone Fault.
Geomorphology:	A north-south over-steepened U-shaped side valley was formed by glacial action along faults and line of deformed, weaker rocks, finally breaking through part of Livingstone Range to join with main valley glacier. Existing streams are structurally controlled with a trellis drainage pattern following initial glacial valley bottoms. Side streams from the west branch in a dendritic pattern from more uniform igneous ultramafic rocks.
Altitude:	700 - 2,000 m
Climate:	As for Thomson Land System, but colder and moister, being a narrow and deep valley and in a shady aspect.

FIGURE 27: WEST BURN LAND SYSTEM



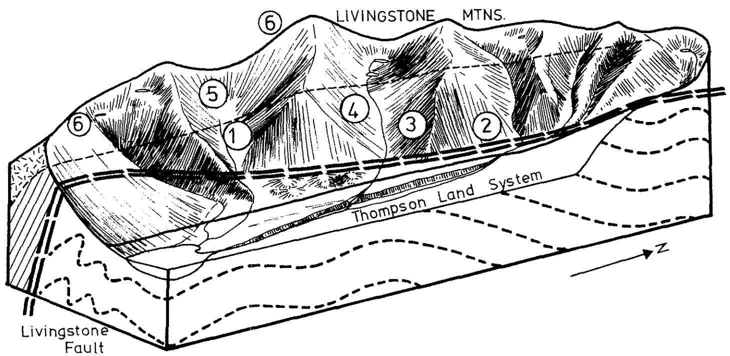
Unit	Area	Climate		Land Form	Soil and Erosion	Vegetation
		Summer	Winter			
1	Small	Mild to cool	Cold	Valley Floor and Lower slopes on deformed igneous and metamorphic rocks (see geology above), rolling to very steep.	Unclassified Alluvial Grading to Eglinton Steepland: Stoney loam of lower altitude than 2. Yellow brown earth to brown granular loam intergrade. Slight-medium wind and sheet erosion.	1. Tall/short-tussock grassland (red and fescue tussock). 2. Patches of beech forest
		Humid 150-200 cm				
2	Medium	Mild	Cold Snow lies	Sunny Hill Slope on deformed igneous and metamorphic rocks. Very steep altitude < 1,100 m. Scree.	Takitimu Steepland: Stoney loam. Yellow brown earth to brown granular loams intergrade. Fairly severe scree, sheet and gully erosion.	Short/tall-tussock grassland (fescue and snow tussock).
		Humid 150-200 cm				
3	Large	Cold	Very cold Snow lies much of winter	Shady Hill Slope on Igneous ultra-mafic rocks. Steep-very steep. Altitude 600 - 2,000 m. Extensive scree.	Windley Steepland: Stony loams. Brown granular loams and clays. Severe*. Extreme scree, sheet and gully erosion.	Tall-tussock grassland (snow tussock). Stunted growth owing to toxic effect from weathering products of ultrama-fic rock.
		Humid 200-250 cm				
4	Large	Mild to warm	Cold Snow for periods	Sunny Hill Slope above land Unit 2	Takitimu Steepland. Severe sheet scree.	Tall-tussock grassland (snow tussock) and herbfield.
		Humid 200-250 cm				
5	Large	Cool	Very cold Snow	Cirque and upper valley above land Unit 3	Windley Steepland: Stoney loams. Brown granular loams and clays. Extreme, sheet and scree erosion.	Stunted and sparse tall tussock (snow tussock). Much bare ground.
		Humid 200-250 cm				
6	Medium	Cool to cold Snow at times	Very cold Snow	Alpine ridge above land Unit 5	Windley Steepland and an Alpine Steepland: much rock, scree. Extreme, sheet and scree.	Fellfield, rock, scree.
		Humid 200-250 cm				

FIGURE 28: Livingstone Land System

(a) Livingstone Sub System

Geology:	1. Igneous ultramafic rocks (Red Mountain ultramafics of Serpentine and Olivine) extend in a N.S. belt. 2. Deformed igneous (spilites, dolerite) and metamorphic rock adjoins the Livingstone Fault.
Geomorphology:	As for Mararoa Sub System.
Altitude:	1,000 - 2,500 m
Climate:	As for Mararoa Sub System.

FIGURE 28: LIVINGSTONE SUB-SYSTEM



Unit	Area	Climate: Summer	Climate: Winter	Land Form	Soil and Erosion	Vegetation
1	Small	Mild Humid 200-250 cm	Cold	Valley floor and Lower slopes.	Unclassified alluvial to Eglinton steepland. Brown granular loams and clay to yellow brown earth intergrade. Slight sheet, wind, flooding in lower areas.	Tall/short tussock grassland (snow tussock/fescue tussock and red tussock in valley).
2	Medium	Mild to cool Humid 200-250 cm	Cold Snow	Truncated Spurs and Facetted Trough Walls.	Eglinton Steepland on lower slope. Takitimu on upper slope. Medium-severe sheet scree erosion.	Tall/short tussock grassland (snow tussock and fescue tussock).
3	Medium	Mild to cool Humid 200-250 cm	Cold Snow for conside-rable periods	Shady Hill Slopes: very steep with small slip scars or screes.	Takitimu Steepland: As for Eglinton, but at higher altitude. Fairly severe, scree erosion.	Tall-tussock grassland (snow tussock herbfield).
4	Large	Mild Humid 200-250 cm	Cold Snow for periods	Sunny Hill Slopes: Very steep with screes.	Takitimu Steepland: Severe sheet scree erosion.	Tall-tussock grassland (snow tussock) and herbfield.
5	Large	Cool Perhumid > 250 cm	Very cold Snow	Cirque and upper valleys: Precipitous bluffs and tarn basins.	Windley Steepland: Stoney loams. Brown granular loams and clays. Extreme sheet, scree.	Stunted tall-tussock (snow tussock) and much bare ground.
6	Large	Cool to cold Snow at times Perhumid > 250 cm	Very cold Snow	Alpine ridge: Precipitous bluffs with ice and snow lying nearly all year in places.	Windley Steepland to Alpine Steepland: much have rock, scree. Extreme sheet, scree.	Fellfield, rock, scree.

FIGURE 29: Livingstone Land System

Short, side valleys of glacial origin; alpine areas and cold, east and south facing slopes of the main glaciofluvial valley.

(b) Mararoa Sub System

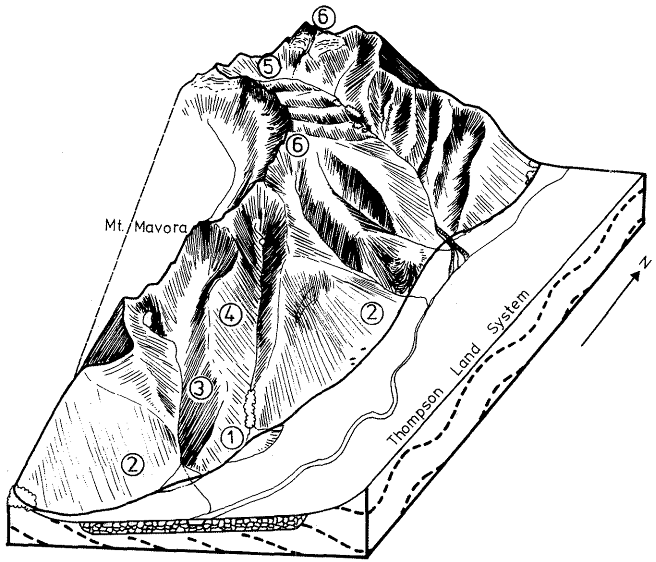
Geology: Sedimentary, partly schistose: greywacke, sandstone, mudstone, chert, breccia. Intensely folded and faulted.

Geomorphology: Hanging U-shaped glacial valleys and Y-shaped valleys developed by short glaciers leaving steep faces and cirques at their head, within which tarns have formed. The shady slopes being facetted; trough walls or truncated spurs, resulted from main valley glaciers.

Altitude: 1,000 - 2,000 m

Climate: Colder and wetter than other systems. Snow lying in winter at lower altitudes and nearly all year at higher altitudes.

FIGURE 29: MARAROA SUB-SYSTEM



Unit	Area	Climate		Land Form	Soil and Erosion	Vegetation
		Summer	Winter			
1	Small	Mild Humid 200-250 cm	Cold	Valley Floor and Lower Slopes: Rolling to steep.	Unclassified alluvial grading to Livingstone Steepland: Slight wind and sheet erosion. Flooding in lower areas.	1. Tall-tussock, short high altitude scrub (snow tussock) 2. Evergreen forest (mountain beech).
2	Large	Mild to cool Humid 150-250 cm	Cold Snow for some of winter	Facetted Trough Walls, Truncated Spurs: Shady hillslope spurs being cut by main glacier system. Steep - very steep.	Livingstone Steepland: Wetter version. Old medium-fine textured high-country yellow brown earth.	Tall-tussock grassland (narrow leaved snow tussock) with short high altitude scrub.
3	Medium	Mild to cool Humid 200-250 cm	Very cold Snow for considerable periods	Shady Hillslope: Very steep with small slip scars or screes.	As above. Fairly severe wind and sheet erosion.	Tall-tussock grassland and short high altitude scrubland and herb fields (narrow-leaved snow tussock and broad leaved snow tussock).
4	Medium	Mild Humid 200-250 cm	Cold	Sunny Hillslope: Very steep with screes.	As above. Severe wind, sheet, erosion scree.	Tall-tussock grassland and high altitude scrub.
5	Medium	Cool Perhumid 250 cm	Very cold Snow	Cirque: Precipitous bluff and tarn basins.	Kaikoura Steepland: Higher version of Unit 4. Severe wind, sheet and scree erosion.	Herb field and tall-tussock grassland in tarn basins (mid rib snow tussock).
6	Large	Cool to cold Snow at times Perhumid 250 cm	Very cold Snow	Alpine Ridge: Precipitous bluffs with ice and snow lying nearly all year in places.	Alpine Steepland: Much bare ground, rock, scree. Extreme wind, sheet and gully scree erosion.	Fellfield, rock, scree.

CHAPTER FOUR
Resource Uses: Historic and Current

4.1 HISTORIC ASPECTS

4.1.1 The Polynesian Period

Since the glacial age (15,000 years ago) climate in the South Island gradually became warmer, possibly culminating in a climatic optimum 3,000 to 5,000 years ago with climate warmer than it is at present. Plants colonised during the warming period, and about the time of optimum climate, scrub and grassland flourished above the timberline and forest was widespread below. With a return to cooler conditions the environment for plant growth would have become a little harsher.

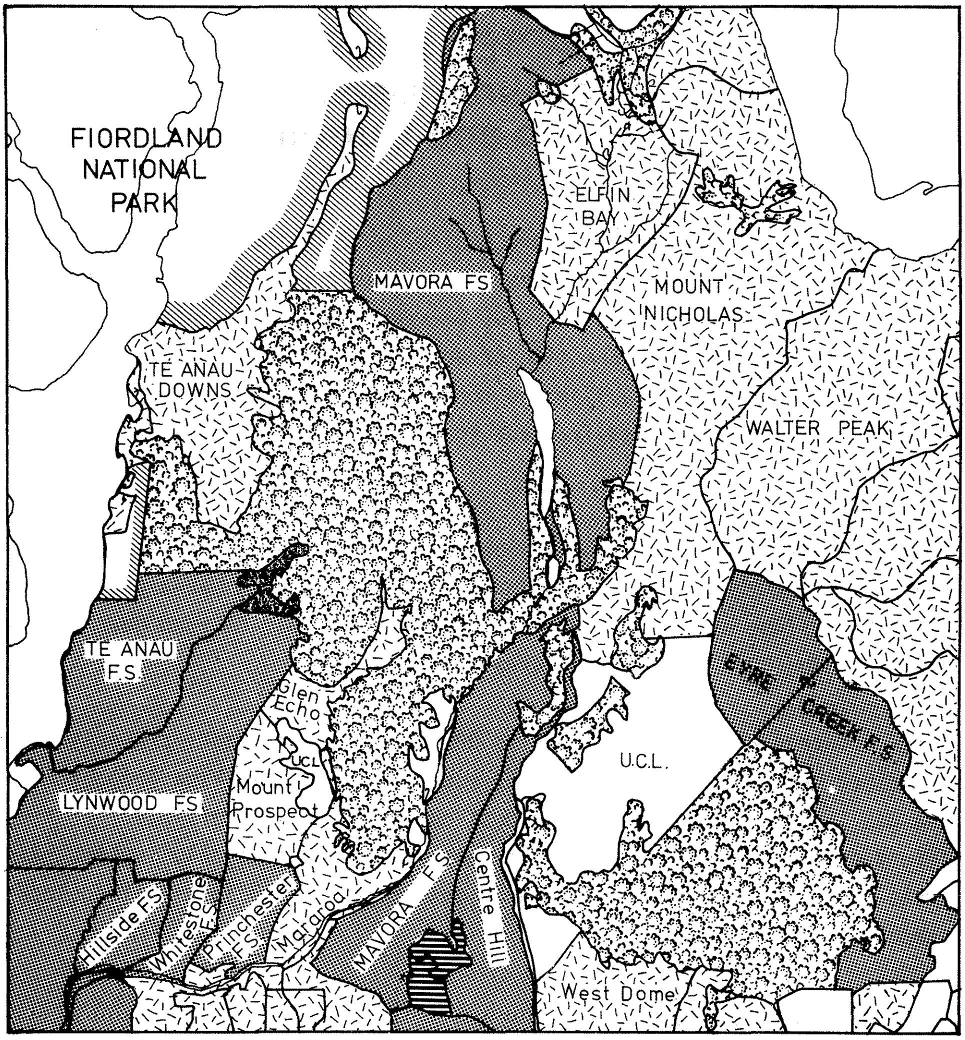
Into this environment came Polynesian hunters and travellers perhaps a thousand years ago. At that time, the beech forest of the Mavora Lakes probably extended along both sides of the North Mavora Lake and possibly clothed part of the slopes of the Windon Burn and Upper Mararoa River valley.

Fires occurred widely as far back as 900 to 1,000 years ago, probably causing a sustained period of soil erosion and scree development. Fire brought about changes in vegetation that were almost complete and irreversible. Of the burnt forest perhaps less than 10 percent regenerated and that only in high rainfall areas and shaded gullies, the balance developing mainly into tall-tussock grasslands.

4.1.2 The European Period

The catchment has been treated as pastoral country since it was taken up under pastoral licence during the 1850s. Some boundary changes occurred up to 1900. There had been very little land development, extensive sheep grazing being the major use and cattle playing a minor part. Settlers were required to graze one sheep to three acres before application for licence was granted. However, after licences were granted the stocking rate sometimes soared, occasioning overstocking. The effect of grazing and attendant burning practice was to aggravate the erosion cycle initiated by Polynesian fires.

Extensive burning, release of rabbits in 1850 and of deer in 1900 eventually led to declining sheep numbers until about the 1930s when the decline was arrested (Dunbar *et al*, 1966).



GOVERNMENT TENURE

Farm Development Blocks (all partly developed)

Proposed Reserve

UCL Unalienated Crown Land

State Forest

National Park Boundary

LEASEHOLD

Pastoral Run or Past. Occupation Licence

FREEHOLD

Takaro Properties Ltd.

FIGURE 30: LAND TENURE OF THE MAVORA STUDY AREA AND ADJACENT AREAS OF MAVORA FARM SETTLEMENT

Prior to 1930 the study area, as part of Burwood Station, carried Merino sheep. Romney rams were later put over Merino ewes, developing a flock of Romney Halfbreds with some Merino characteristics. A change to cattle-dominant grazing followed a period with a shortage of labour. For example, the head of the Mararoa carried 12,000 dry sheep in 1939-40 but changed to 3,000 sheep plus seasonal use by 1,600 cattle in 1946.

As part of this pastoral use there was little cultural improvement. The only oversowing recorded was of seed spread from horseback in 1962. Twenty bags of grass seed were spread in the vicinity of West Burn. A musterer's hut had been built and maintained on the eastern shore of the North Mavora Lake.

Hunting use on the open country increased in the 1950s, and there was some increase in popularity of recreational fishing as local access was improved and as the district generally benefited from highway improvement. Some half dozen cottages or huts were built between or alongside the lakes.

Burwood Station pastoral operations extended over a much wider area than the present study area. It was one of the last properties to be acquired by the Government in the extensive land settlement programme in northwest Southland which has been carried out actively since the 1950s.

4.2 CURRENT USES OF RESOURCES

4.2.1 Tenure

Mavora study area has three main components. The New Zealand Forest Service controls virtually all significant forest areas, being part of the Snowdon State Forest, sections of Wakatipu State Forest to the north and of Eyre State Forest to the south east; the Department of Lands and Survey controls the Mavora Farm Settlement comprising the bulk of the study area; Elfin Bay Station occupies the Upper Mararoa Valley as an extension of a pastoral lease administered by the Department of Lands and Survey. Tenure is illustrated for the Mavora study area and adjacent lands in Figure 30.

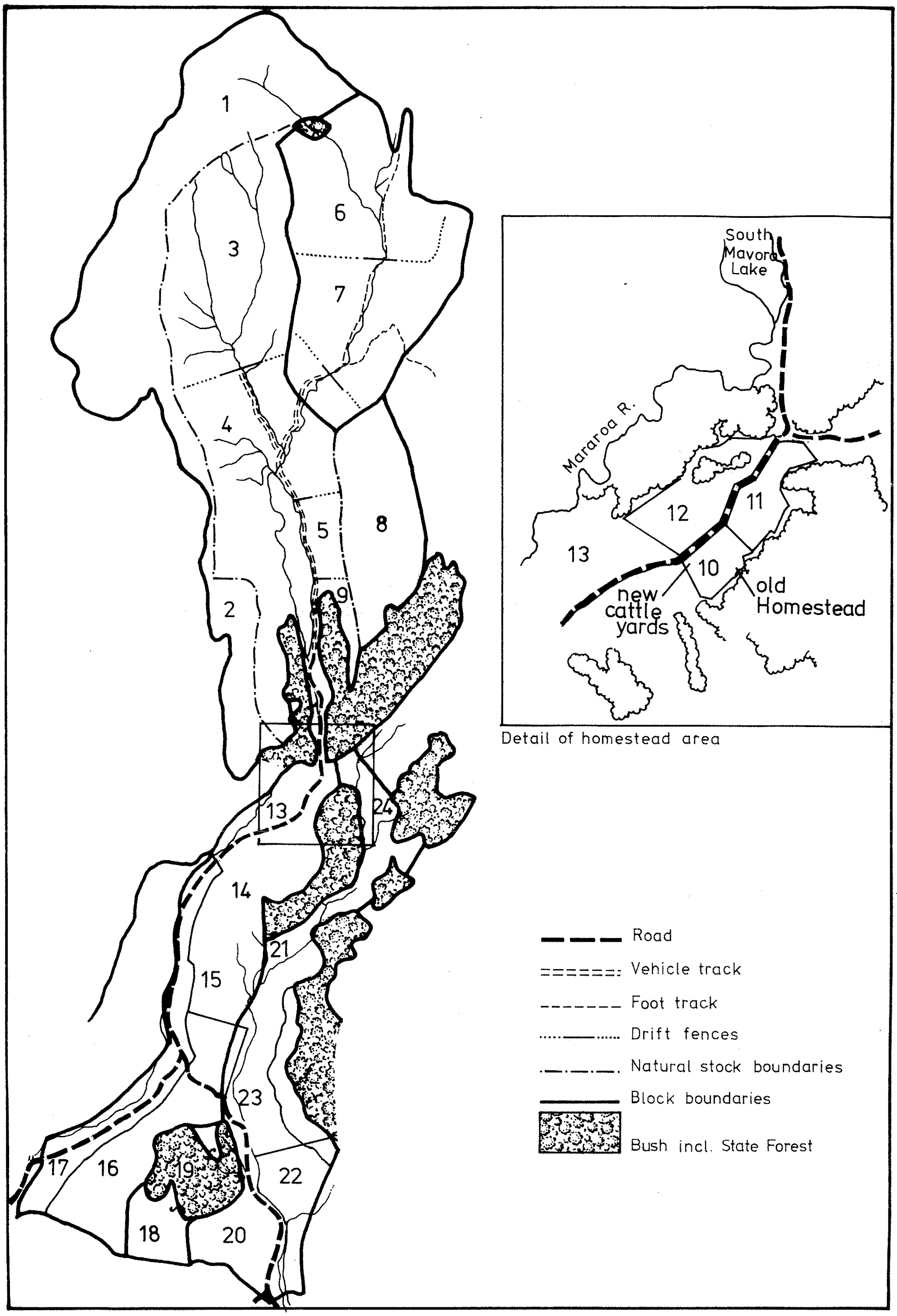


FIGURE 31: RECENT STATE OF LAND DEVELOPMENT IN MAVORA STUDY AREA AND ADJACENT AREAS OF MAVORA FARM SETTLEMENT

LAND DEVELOPMENT AND PASTORAL UTILIZATION

(Key to Figure 31)

MAVORA FARM SETTLEMENT

Mavora Sub-block:

1,2,8	Unimproved grassland - not stocked
3,4,5	Unimproved grassland Summer grazing (Dec-Feb) 200 heifers Winter grazing (May-Aug) 1,100 cows
9	Unimproved grassland - not stocked regularly
10,11,12,13	Unimproved grassland, seasonal grazing
14,15	Unimproved grassland with little grazing
16	Approximately 14 80 ha blocks, good pasture (oversown)
17	Approximately 1,000 ha progressively fenced but including riparian land

Centre-Hill Sub-block:

20	Approximately 5 80 ha blocks, fair pasture (oversown), and 90-100 cultivated 8-15 ha blocks
21	Unimproved grassland
22,24	Watershed protection, unimproved grassland, not stocked
23	Watershed protection, unimproved grassland, some stocking for weed control

PROPOSED RESERVES

18	Red tussock
19	Burwood Bush

ELFIN BAY

6,7	Unimproved grassland, winter and spring grazing (June-Dec) 500 cows

4.2.2 Grazing

In 1966 the Crown purchased Burwood Station. The run of which the study area was part became known as Mavora Farm Settlement. This purchase was carried out as part of Land Settlement policy whereby land suitable for pastoral development was acquired, developed to a suitable stage and subdivided for settlement by hitherto landless farmers.

Nearly 2,350 hectares of river flats and adjacent slopes in the Upper Mararoa were partitioned from the Mavora Farm Settlement and leased for grazing as an additional area to the Elfin Bay run on Lake Wakatipu. This was done to provide the Elfin Bay run with a better balanced resource for a sound economic unit. Despite the difficulties of access from Elfin Bay, 500 cows are wintered successfully from June to December in two blocks in the Upper Mararoa. Very few losses are generally experienced, but control of stock grazing has been difficult because of the paucity of fencing.

The balance of the Mavora study area was retained in the Farm Settlement and it was used for short term summer grazing. On one occasion there were 19,500 ewes on the area but the average number was 15,000 for the months of February and March. This practice was not persisted with because of:

(a) lack of controlled dispersion of sheep because of inadequate fencing;
(b) occasional high losses of stock;
(c) large labour requirements which impaired performance of other necessary work.

Present practice is to stock the Mavora area with 200 heifers from December to the end of February and with 1,100 cows from May to mid-August. This grazing use is complementary with the utilisation of the improved pastures on the developed land at lower altitude to the south. The present state of development of this land in the Oreti and Mararoa Valleys is indicated in Figure 31. The undeveloped country in the Upper Mararoa provides relief in the summer and also furnishes very cheap wintering for the cattle. The Department of Lands and Survey has drafted policy for the Upper Mararoa in which it states that grazing is "an important part of the overall (farm) concept, to protect the values of the area, provided it is compatible with an acceptable level of public use ..." (Lands and Survey Management Plan Team, 1975). The extreme limits of pastoral use in the Windon and Upper Mararoa are indicated as natural boundaries.

4.2.3 Forestry

The Snowdon Forest is a protection and recreation forest. Current development of a Working Plan for this forest includes the tentative zoning of the forest skirting the lakes on the east as an amenity area. There is no timber extraction at present contemplated in the eastern part of the Snowdon Forest. The remainder of the forest is treated principally as protection forest, although it is also used for hunting and tramping. The New Zealand Forest Service is responsible for noxious animal control in the Snowdon Forest, but departmental operations have not been necessary in recent years, thanks to private hunting and especially helicopters on commercial recovery. The forest is covered under the Southland Conservancy Fire Plan.

4.2.4 Recreation

Recreational use of the area has shown accelerated increase in the last decade. Picnicking and camping are of prime interest because of public demand and because of their conspicuous character in comparison with tramping and hunting. Much of the camping is associated with angling in lakes and rivers and some of it with boating, for which South Mavora Lake is especially favoured. Campers, caravans and boats have become a common sight in the last five or six years. Large school camping groups have also been frequent in recent summers. Fireplaces, benches and toilet facilities have been installed in the areas of apparent principal demand. Some swimming is associated with picnicking and camping, but low water temperatures, even in summer, make this recreation not very attractive. Winter uses have included skating on smaller ponds and cross-country skiing. Access by 4-wheel drive vehicles and trail bikes beyond the south end of North Mavora is not encouraged.

From having been the principal recreation use of a few decades ago, hunting has now declined in numbers relative to other recreational uses. For the Snowdon Forest as a whole, the volume of current hunting use is indicated by more than a hundred permits covering a total of more than two hundred persons annually. Tramping has increased in the area generally. Tracks and signs have facilitated tramping in the Snowdon Forest. Tramping use of the Upper Mararoa is principally from Elfin Bay. It is locally estimated that less than 15 percent of Elfin Bay visitors (who number more than 500 annually) make use of the Upper Mararoa, the majority of trampers preferring the Greenstone Track. From Forest Service observations it has been estimated that there has been about a seven-fold increase in recreational use of the Mavora area in a three-year period, in part at least attributable to improved road access to it.

CHAPTER FIVE
Analysis of Use Experience

To arrive at an assessment of use capability, it is essential in the view of such authorities as the U.S. National Resources Planning Board (1941) to analyse use experience with the same or similar resources. This analysis is first done with factors affecting stability and productivity and is then followed with an empirical assessment of local use experience.

In many situations controlled scientific information is not available. Instead, the observations and opinions of persons familiar with a particular use of resources have been used, where available. The approach taken in this analysis is to consider, first, the factors affecting terrain stability, and second, the factors affecting primary productivity on which all historic and present uses in some measure depend.

5.1 STABILITY

Sound resource management policy requires that any yield must be permanently sustainable, that is, there should not be any persistent resource depletion. This, in turn, implies that the ecosystems of the region should remain naturally stable or should be assured of cultural stability.

Soil in the very long-term may be considered a renewable resource, but since the conditions for soil formation in the future cannot be assured for many of the harsher climatic zones, soil is best regarded as non-renewable. Stability is estimated with regard to a series of environmental factors (U.S. Department of Agriculture, 1961).

5.1.1 Stability Against Water

This depends on several factors. Stability of aggregates in the surface layer of the soil is manifest in resistance to dispersion when wetted. Most soils have similar topsoil with very weakly developed structure. Ease of saturation and water-holding capacity affect infiltration. Restricted permeability and reduced water-holding capacity will increase surface runoff and the chance of erosion. No data on soil infiltration capacity are available, but in keeping with the observed low bulk densities of topsoils under tall-tussock (Williams *et al*, 1978) and the high infiltration rates observed by Hayward (1977) in

TABLE 6: Assessment of stability against water of typical land units.

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Land form	River flats	Fans	Moraine terrace outwash	Hummocky moraine	Steep land	Very steep land
Soils	Tasman	Eldon	Windon	Mavora	Livingston	Kaikoura
Ease of dispersal of aggregates	Very high	High			Very high	
Infiltration capacity	Very high	High	High	High on hummocks. Moderate in hollows.	High	
Waterholding capacity	Very low but moderate in deeper phases	Low	Low to moderate	Low to moderate	Moderate	Low
Climate	Moderate to high precipitation but little evidence of high intensity rainfall. Generally low temperatures.				Higher rainfall and snowfall and generally lower temperatures.	
Slope	Flat	Gently sloping	Undulating	Hummocky rolling	Steep	Very steep
Vegetation	Good cover in general.				Depleted	
Stability against water	Moderate flooding in wetter places	Moderate			Low	Very low

Canterbury studies, the soils are inferred to be of generally high infiltration capacity. Heavy treading loads by humans, livestock or deer, especially in trails through forest areas, would be expected to reduce surface infiltration.

Slope has varied influence on stability, interacting with vegetation's stabilising factors.

Vegetation cover protects soil against raindrop impact and against needle ice. Roots of vegetation, especially the interlocking roots of trees and shrubs, stabilise saturated soils against mass movements. Loss of vegetation both above and below ground surface has probably been the most important destabilising factor in past use. Climatic factors have not been sufficiently closely recorded for such features as rainfall intensity and freeze-thawing frequency to estimate hazard to stability. The assessment of inherent stability against water of typical soils is set out in Table 6. These assessments are more confidently applied to the zonal rather than the intrazonal soils (p. 32).

5.1.2 Stability Against Wind

This depends on the interaction of several factors. Fine primary particles may be aggregated but for most soils aggregation is weak. Coarse primary particles such as sand and gravel do not blow as readily as silts except where they have less protection from vegetation, allowing saltation to develop. Wind velocity and turbulence affect the stability of soils, especially as dry soil particles are easily blown away when lifted from the ground surface by soil frost.

Vegetation cover counteracts wind erosion by raising roughness height and by insulating soils against soil frost. Patchy vegetation may increase turbulence close to the ground.

All soils are very prone to wind erosion except gravelly and sandy phases of Tasman series on Unit 1. The silt component of the Tasmans, however, may be subject to wind erosion, and even the sandy phases may be subject to saltation if dry and denuded of vegetation for long stretches. An assessment of susceptibility to wind erosion is given in Table 7.

TABLE 7: Assessment of stability against wind erosion of typical land units.

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Land form	River flats	Fans	Moraine terrace outwash	Hummocky moraine	Steep land	Very steep land
Soils	Tasman	Eldon	Windon	Mavora	Livingston	Kaikoura
Topsoil texture (size of particles)	Often sandy soil	Silt loam				
Wind	High winds and turbulence at frequent intervals.					
Frost	Many frosts in winter and spring causing "frost lift" of depleted ground.					
Vegetation	Mainly good				Fair to good	Poor
Stability against wind (with veg. cover)	Medium-high with good vegetation cover.					
Stability against wind (without veg.)	Moderate	Poor to fair with poor vegetation cover.				

5.2 PLANT GROWTH OR PRIMARY PRODUCTIVITY

All growth, whether of grass or trees, seems much slower to start in the spring than in the lower country to the south. Climate and soil conditions indicate that natural plant growth would probably be rather low and it would not be likely that cultured plant yield would be high, even at high levels of culture.

Many uses, including grazing, forestry and recreation, are dependent on plant growth. Features of the environment that are relevant to plant growth and therefore to land use include the independent factors - climate, parent material, topography and time, and the dependent factors - soils and vegetation, plus dependent attributes such as nutrient status, water-holding capacity and stability (Figure 32).

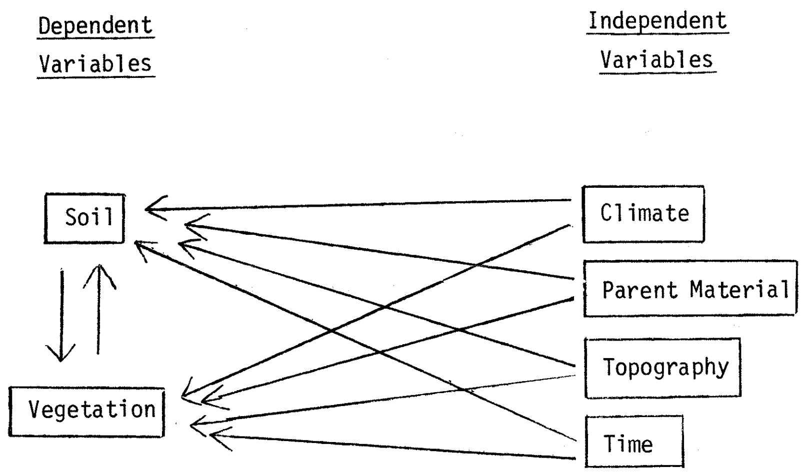


FIGURE 32: DEPENDENT AND INDEPENDENT VARIABLES IN PLANT GROWTH

5.2.1 Climate

The Mavora climate is unfavourable to growth for all types of commercially used vegetation. There is a short growing season owing to low temperatures in winter with long snow lie and some severe frosts extending into spring and early summer. One summer in three experiences drought. Strong north-west gales down the valley make for damaging conditions for trees. The low sunshine regimes and the likelihood of frequent wintry storms even in summer make the region unreliable for high levels of grassland or crop production.

5.2.2 Soils

The size and physical characteristics of the particles of which soils are composed and the way in which these particles are arranged are among the most important properties of soil in that they influence many other soil characteristics and attributes.

Soils with a clay component may develop an aggregated structure in which coarse particles are joined with the fine into crumbs, nuts and blocks. Soils such as those at Mavora, deficient in clay owing to weak weathering and somewhat deficient in organic materials, do not readily form strong aggregate. The fine fraction is diluted generally with a substantial proportion of weakly weathered rock fragments. These factors tend to reduce the water-holding capacity of soil.

The ability of soil to provide a continuing supply of water to plants varies with water-holding capacity, soil surface and local climate.

Soil surfaces protected with a plant cover can absorb water more rapidly than bare surfaces. Raindrop impact tends to seal pores, whereas vegetation keeps them open. Nevertheless, there seems little likelihood that soil surface conditions in Mavora limit water infiltration.

A cool, moist climate has a low evapotranspiration rate allowing water to remain in the soil for long periods, while a warm, dry and windy climate allows rapid evaporation. Plant cover retards evaporation by keeping the air near the soil saturated with moisture and slowing down wind movements.

Soil water availability is assessed for various land units as shown in Tables 8 and 9, presenting assessments of factors affecting grass growth and tree growth respectively.

Plant roots must have access to soil oxygen. Mavora soils are generally well drained except on some moraines (Unit 4) where ponding occurs in the hollows. Bog plants can adapt to these conditions, but it is estimated that in wetter hollows and on the alluvial flats, water tables may sometimes be too close to the surface to maintain satisfactory health of most tree crops.

Soil fertility depends on the presence of nutrients and their availability in a soluble form. No chemical analysis is available on Mavora soils, but the General Soil Survey of the South Island (Soil Bureau, 1968) has carried out analyses on the soil sets in other localities. Although not particularly useful because sets vary somewhat from place to place, these analyses indicate generally low fertility.

Some generalisations can be made from the weathering and leaching states of various units. Units 1 and 2 on the river flats and fans are accumulating and are relatively young, weakly weathered and weakly leached; thus their nutrient status is relatively higher than the older surfaces of Units 3, 4, 5 and 6. Higher precipitation tends to aggravate the effects of soil age. Soils on moraines and lower slopes are expected to respond to moderate topdressing. Although there are differences between units, compared to other New Zealand soils all soils are weakly weathered owing to cold conditions and moderately leached thanks to moderate to high rainfall.

5.2.3 Grass Growth

Grass production is assessed summarily in Table 8. A grading is given from the analysis of environmental factors described in 5.2.

The best units are those on river flats and fans (Units 1 and 2), followed closely by moraine terraces and moraine (Units 3 and 4). Steepland is graded fair to poor depending on altitude. Growth is at its best in spring; winter is too cold for growth, while some summers may be too dry. On the river flats (Unit 1) where the water table is high, and on the hummocky moraine (Unit 4) where moisture gathers in the hollows, summer dryness is not a problem. In such circumstances some early autumn growth is assured. Where summer drought occurs autumn growth is not expected, as relief from drought is usually accompanied by severe fall in temperature.

TABLE 8: Assessment of factors affecting pasture grass growth on typical land units.

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Land form	River flats	Fans	Moraine terrace outwash	Hummocky moraine	Steep land	Steep land
Soils	Tasman	Eldon	Windon	Mavora	Livingston	Kaikoura
Depth	Deep enough for grass roots				Some areas have topsoil stripped	Many areas have topsoil stripped
Water availability for grass	Good but dry in summer			Good remains in hollows in summer	Good except occasionally dry in summer	
Drainage	Very high	High	High-moderate	Moderate on hummocks, low in hollows	High	
Aeration	Very high	High	High-moderate	Moderate on hummocks, low in hollows	High	
Natural nutrient status (topsoils)	Moderate-low	Low	Low-very low	Low-very low	Low	
Response to fertiliser	Very good	Very good	Good. Higher P retention than Units 1 and 2.	Good. Higher P retention than Units 1 and 2.	Good-fair (response is slow where topsoil is removed.	
Thermal regime	Varies: hot in summer, very cold in winter, frost extends into spring and early summer.					
Light regime	Fair to moderate				Poor on shady slopes, moderate on sunny slopes.	
Grass growth	Moderate - spring-autumn		Moderate to fair except winter	Moderate to fair except winter	Poor spring and summer	Very poor spring and summer

TABLE 9: Assessment of factors affecting tree growth and establishment on typical land units.

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Land form	River flats	Fans	Moraine terrace outwash	Hummocky moraine	Steep land	Very steep land
Soils	Tasman	Elden	Windon	Mavora	Livingston	Kaikoura
Depth	Variable, locally deep	Moderate	Shallow-moderate	Deeper in hollows	With topsoil Moderate Topsoil gone Shallow	Bare rock -
Water availability in summer	Good in deep places and where water-table moderately high	Moderate	Moderate. Low in shallow places.	Moderate on hummocks. Good in hollows.	Low	Very low
Natural nutrients	Moderate	Moderate to low	Very low			
Drainage	Very high	High	High-moderate	Moderate on hummocks. Low in hollows.	High except in winter. Soil soggy.	
Climate	Short growing season (see grass growth). High winds likely to cause windthrow.					Most areas beyond climatic limit of trees
Tree growth	Moderate. Good in deeper areas.	Moderate	Moderate. Poor in shallow soil areas.	Poor, although water is available, drainage is poor	Poor	Very poor
Tree establishment	Poor except for deep places and where water-table is not too high.	Poor-moderate		Moderate. Most hollows good for some species.	Poor	Very poor

5.2.4 Tree Growth

Soil fertility of the surface layer may be of less importance for tree growth than for grass growth because tree crops can accumulate and recycle much of their nutrient requirement through litter fall, and extensive and deep rooting may enable them to tap water and nutrients to considerable depth.

Trees are much more affected by physical conditions that limit root range such as hard pans near the surface, gley horizons, poor aeration or seasonal waterlogging.

Rainfall amounts and periodicity are important in obtaining the maximum potential of soils. Trees may grow well throughout late spring-summer and early autumn, especially where deep porous soils contain reservoirs of soil moisture and nutrients, and where roots can reach these deeper layers.

Establishment of trees may be difficult because of low fertility, low water-holding capacity in the topsoil, windy conditions and frequent summer drought.

Techniques designed to overcome establishment problems include:

(1) Suppression of grasses by spraying so that the tree is released from competition.

(2) Rip line planting.

(3) Fertilising when planting.

Chavasse (n.d.) recommends *Pinus radiata* only for fast short-term shelter except in more favoured sites of inland Southland. Being at least 700 m above sea level, the Mavora region offers a poor environment for these species. Slower growing trees such as *Pinus nigra, Pinus ponderosa, Pseudotsuga taxifolia* and *Populus nigra* var. *italica* are probably more suited to the harsh conditions. Mountain beech (*Nothofagus solandri* var. *cliffortioides*) growing around the lakes on moraine and steep slopes has proven ability to grow in the area. Red beech (*Nothofagus fusca*) which is being invaded by mountain beech on the flatter soils near the lakes offers a possibility for harvesting and regeneration.

Appendix 5 shows a list of trees that may be suitable.

5.3 WATER PRODUCTION UNITS

Lakes vary with age, depth, size and conditions of their watersheds.

The two types of lake depend finally on the levels of dissolved nutrients. Oligotrophic lakes are clear, cold lakes of mountain regions. They usually have rocky bottoms and lie within infertile watersheds. The level of life that can be supported is low because of the lack of dissolved nutrients, although the low water temperatures result in a high degree of oxygenation.

Eutrophic lakes are often warmer, shallower and may have muddy bottoms, centred usually in watersheds with mature soils and abundant nutrient supply. Nutrients and warm water allow abundant plant growth. There can be seasonal problems when cold winter temperatures inhibit photosynthesis causing a decay of plant life and oxygen depletion.

The North Mavora Lake is more oligotrophic in nature than the South Lake, which is incipiently eutrophic (Stout, 1976). Feed supply will be greater in the South Lake. Both lakes are more mature and support much more abundant flora and fauna than other southern lakes (Purey-Cust, 1975).

Oligotrophic lakes are ideal for brown and rainbow trout, although only few rainbow are found. Trout often reach a large size in such conditions, but because of overall limitation in their food supply, seldom become abundant (Dasmann, 1972).

Table 10 summarises the properties and inferred production of the water units.

5.4 EMPIRICAL EVALUATION OF USE EXPERIENCE

The only resource use which has been experienced for a sustained period over virtually the whole study area has been "extensive grazing". As was noted in the previous chapter, there have been problems of stock losses but the most significant lesson from pastoral experience has been the deterioration of higher altitude grasslands, indicating their unsuitability for this kind of low intensity pastoral culture, as reviewed from South Island wide experience (O'Connor, 1962). The decline of pastoral quality on the sunny lower slopes is also consistent with pastoral experience elsewhere in the South Island and

TABLE 10: Assessment of Typical Water Units.

	North Lake	South Lake	Upper Mararoa River
Type	Oligotrophic (both lakes are more eutrophic than other Southern lakes)	Incipient eutrophic	
Dimensions:			
Shoreline - type	Beaches (sand and gravel)	Some beaches - usually small banks - 10' high	Banks and beaches
- length	Long	Short	
- vegetation	Beech trees	Beech trees and tussock grassland	
Area	Medium-small by Southern Lakes standards	Small	
Depth	Deep (100 m)	Relatively shallow (50 m)	Very shallow
Water Movement	Still but subject to wind	Still	Running gently - turbulent in short reaches and in floods
Quality T^o	Cold	Cold but warmer than North	Cold
Pathogens	Some naturally but more may be due to cattle access to waterways		
Visible pollutants	None	None	None
Nutrient level	Low	Greater than North	Low
Colour	Clear	More muddy or turbid	Clear, except in flood
Dissolved O_2	High	Decrease in lower half in summer	High
Plant Growth	Moderate	Greater than North	Moderate
Fish	Large brown trout	Greater numbers of brown trout	Large brown trout; fish feed and spawn at river inlets to lakes

suggests that sustained yield is likely to be obtained from such terrain only through careful grazing management or from the investment of capital in pasture improvement by fencing, legume oversowing and topdressing. On shadier lower slopes and on the hummocky moraines and outwash there is little evidence of loss of stability, but the quality of pasturage provided in the unimproved range does not indicate a high suitability for pastoral use without substantial investment. The fans which are in grassland and the alluvial lands in the valley floor have provided satisfactory pasturage, but a cautionary note must be expressed concerning cattle use of this water margin terrain.

There is no evidence within the study area of "intensive grazing use". Nor is there local experience of timber production from afforestation. Such uses would seem moderately well suited on the evidence of sites similar to the low and mid-altitude terrain of the Mavora where risk of inundation or localised erosion is not apparent.

Protection of land-slopes as catchment areas has been well served by both forest and tall-tussock grassland and shrubland, provided animal control has been reasonably effective. The provision for native birdlife by forest protection and the previous minimal management of wetlands has demonstrated the high suitability of these zones for biological conservation. Collections of rare and endangered plant species in the adjacent Eyre Mountains (Given, 1976) suggests the significance of the locality for further exploration and reservation for this purpose, as well as for conservation of native fauna.

The continuing recreational experience of a "semi-wilderness" or "natural area" kind during recent decades suggests substantial suitability for this sector of recreational use. Increase in boating use and of such activities as picnicking following improvement of access, suggests that such uses are found to be suited in some degree by the water body and water margin areas, but the possibility exists that such uses may be militating against satisfaction from wilderness type recreation uses and against the value of the area for biological conservation.

It should be noted that generally this empirical evaluation of use experience has been for each historic or current use in its own right with little or no regard to the compatabilities or conflicts which might exist between such uses. Likewise, the empirical evaluation so far presented has dealt with uses as affected by considerations of soil stability and primary productivity. Land uses such as pastoralism are directly influenced by climate, especially by the risk of snow losses. All resource uses, including recreation, are affected by location and access. Severe sheep losses have occurred in the past as the outcome of unusually heavy snowfalls. Although there are many sectors of the Upper Mararoa, especially of the Thomson Land System, which are suited to summer sheep grazing, they are better suited to fine-wool range sheep which are not now readily available from winter range at either the southern terminal or at Elfin Bay. Any sheep used on summer range in the Upper Mararoa have to trek or be trucked considerable distances to such range, some of it through forested country. Such problems have not been so serious for cattle grazing. As indicated in Figure 31, the Elfin Bay portion of the Upper Mararoa and the central and Windon Valley sectors of the Mavora Farm Settlement portion have been used profitably for cattle grazing from June to December and from May to August respectively. Such uses have been complementary with seasonal use of other terrain.

Access has affected recreational use in the past and affects some uses even now. Tramping parties do not have a convenient and interesting circuit involving the Upper Mararoa Valley and Mavora Lakes and return to starting point. Whether such a starting point is Elfin Bay on Lake Wakatipu or the Burwood-Mavora area, transport connections are not easy. The improvement in local roading in the Farm Settlement area has greatly improved access as far as the southern end of the North Mavora Lake. Access for angling elsewhere on North Mavora Lake has generally required a boat or four-wheel drive vehicle. The existence of such limited track access alongside North Mavora Lake and some kilometres up the Windon and Upper Mararoa Valleys has not only facilitated hunting and angling but has also no doubt prompted exploratory driving and trail-bike riding for pleasure.

CHAPTER SIX
Land Evaluation

6.1 AN EXPOSITION OF ALTERNATIVE PROCEDURES

When there is an increase in competition for land among different uses or among different groups of people, whether official or private, the land administering agency has to make decisions about land use in the public interest. It is a difficult problem to discern the public interest in such matters. An essential element in such discernment is land evaluation, in the broad sense. The evaluation of land is now a world-wide problem aggravated by two kinds of cultural phenomena.

On the one hand, cultural lag often means that public agencies have to approach the problem with administrative powers determined by earlier legislation which itself reflects the values of an earlier period. An example in New Zealand is our own Land Act 1948 as amended, which prescribed land classification in ways applied to current mountain land use conditions only with some apparent violence to elementary principles of logic. These are further indications that our water and soil conservation legislation may in other ways also suffer from cultural lag. The recent enactment of revised Reserves legislation has served to reduce cultural lag in another important sector.

On the other hand there is widespread variation in environmental perception, not only in the lay public but also in the professional sector. Nowhere is this more apparent than in the means of estimation of value for use (Wendelken and Hannan 1974, Lister 1976). Some professionals are concerned principally with assessment of the profitability of land use enterprises. At the other extreme are others concerned principally with environmental limitations or hazards to such uses. Between such extremes there is much confusion of values and of terms to express them.

At the same time as the present study, one of us was involved, with the support of Soil Bureau DSIR and the National Commission for UNESCO, in a review of methodology of land evaluation on a world-wide scale. It became evident from this review that the variable and at times ambiguous use of terms was as common in other parts of the world. For example, "potential" is sometimes used in the sense of a potential or possible land use, sometimes it is used in the sense of maximum productivity obtainable in a particular use, and sometimes it is used to represent the difference between present levels of productivity and possible future levels of productivity. Within these primary meanings there is often considerable variation in the assumption for removal of limitations.

In the face of these difficulties, we found it necessary for the present study to go back to the fundamental reasons and motives underlying land evaluation, to review the currently available procedures in New Zealand and then patiently to develop a systematic new procedure for application to the Mavora.

6.1.1 Reasons for Land Evaluation

In a review for an Expert Consultation on Land Evaluation in the Netherlands in October 1972, Brinkman and Smyth (1973) stated:

> "A sound land evaluation should contribute answers to the following questions:
>
> (a) How is the land currently used and managed, and what will happen in the future if present use practices remain unchanged?
> (b) What other uses of the land are possible under the relevant social and economic conditions?
> (c) Which of these uses of the land offer possibilities of sustained productivity and/or services, and environmental quality?
> (d) What limitations and/or adverse effects are associated with each alternative?
> (e) What recurring inputs are necessary to minimise limitations and adverse effects?
> (f) What are the benefits of each use?
>
> If major changes (change in land use or change in management system) are envisaged, the following questions also have to be answered:
>
> (g) What changes in the condition of the land are necessary? How are they to be effectuated?
> (h) What are the major non-recurrent inputs necessary to implement these changes?
> (i) What recurrent inputs will be necessary once the major changes have been made?
> (j) What is the nature and magnitude of benefits to be derived from all of these inputs?"

Perhaps naively, Wendelken and Hannan (1974) posed the New Zealand problem summarily: "The simple, essential question to be answered is: *What is the national land use plan for areas where commitments have not yet been fully made but which have been disturbed or altered from a natural condition and have potential for development and production not yet realised?"* They went on later to add a supplementary question: *"What proportion of the existing largely undisturbed native vegetation may be required in the future: (a) to add to the productive area of New Zealand in the years ahead; (b) to be preserved in its natural state?"*

6.1.2 Principal Evaluation Procedures Available in New Zealand

These questions are recognized to underlie the various procedures of land evaluation which have been developed in different organizations in different parts of the world in recent decades. The system most familiar to New Zealanders is the I-VIII Classification of Land Use Capability as produced for the Soil Conservation and Rivers Control Council (Water and Soil Division, MOW 1971). Although widely applied for soil conservation and catchment control purposes where limitations are the most influential factors, this system of land classification has also been developed to a limited degree to assess potential land use for agricultural, pastoral and production forestry purposes as well as for catchment protection roles (Howard 1976).

Soil interpretation systems have also been developed in New Zealand, e.g. Leamy (1963), Gibbs (1968), Jackson (1973), Griffith (1975). The emphasis in these classifications has been on suitability for particular uses. Like the general land use capability classification used in the soil conservation movement, these classifications have been strongly influenced by physical limitations. The different significance of physical limitations of different kinds for different uses has been noted by Cutler (1977), in his recent exposition of soil interpretation. The estimates of production, actual and potential, of the extended legend of the General Soil Surveys of New Zealand (DSIR Soil Bureau 1954, 1968) and the productivity ratings and assessments of district and detailed soil surveys counterbalance the aforesaid emphases on limitations. Leamy (1975) and Cutler (1977) have indicated the importance of survey and interpretation of soils in land resource assessment, especially for the purpose of resolving competition among different kinds of uses. Productivity has not yet been used, however, in any fully coherent and comprehensive land evaluation system in New Zealand, in the sense outlined by Brinkman and Smyth (1973) and Bennema (1975). An attempt has been made (O'Connor, 1962) to estimate the suitability of mountain soil sets for pastoral use by assessing their stability and productivity at different levels of pastoral culture. Such an assessment, although incorporating the essential element of productive benefit in relation to inputs, as well as the limitation of instability, failed to provide for simultaneous evaluation of and integration with other uses either concurrently on the same land or in competition.

6.1.3 Difficulties of Existing Procedures

None of the above procedures of soil or land evaluation is explicitly appropriate to the range of uses which are possible under the social and economic conditions relevant to the Mavora study area. Furthermore all are based on the concept of assessing limitations or suitability for particular uses of distinct land units. However, the practical uses to be considered may need to extend over larger areas of many different kinds of such land units. Indeed, many uses, especially but not solely in recreation, may be affected by the relationship between units or by the assemblage of land units in a landscape more than they are determined by the individual units themselves. Some uses such as those involving wildlife and those concerned with water management or use of water bodies may be especially influenced by the boundary conditions between resource units.

Correction of all these deficiencies by the assessment of production responses to inputs for each of the uses warranting consideration for each area of homogeneous land is virtually impossible for such terrain as Mavora represents. In the Mavora study area there are 80 unit areas, almost all unique, according to the Land Resource Inventory Worksheets. These are reproduced in Figure 33 (after Hunter, 1977, 1978). To identify the inventory code for each unit area an extended key is provided. Following the extended legend for the South Island, these unit areas can be assembled into Land Use Capability Units as illustrated in Figure 34. There are 18 different capability units embraced in nine capability subclasses. Reduced in this way, the number of assessments of individual use suitability to be made is no longer impracticable, so long as the number of uses remains small. Certainly, assessments of limitations and of soil conservation measures needed for particular uses are feasible at the scale described. What would be lacking still is information on the response in "produce" in various forms to different levels of inputs or culture, an essential element of suitability assessment (Brinkman and Smyth, 1973).

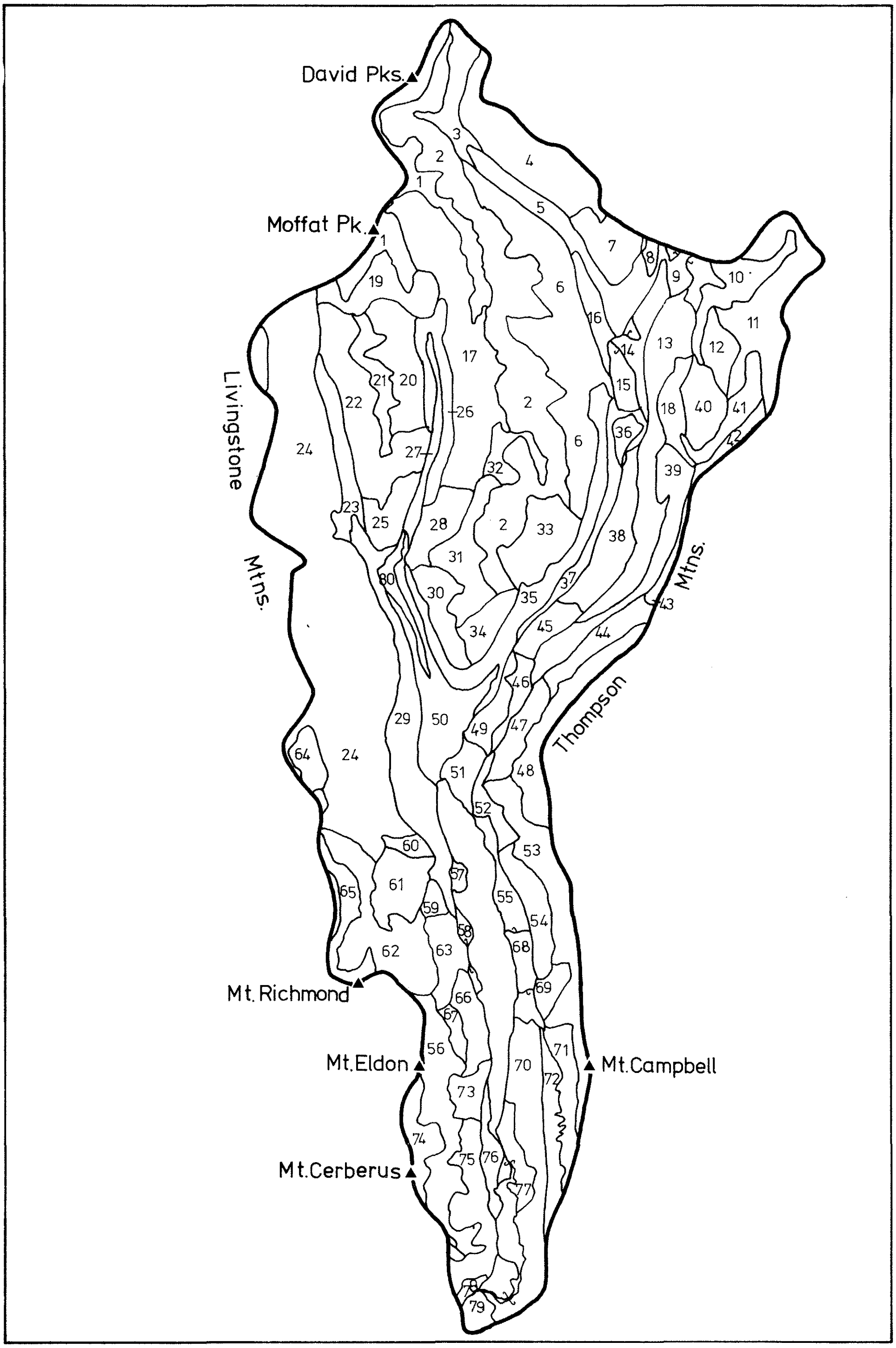


FIGURE 33: UNIT AREAS OF NEW ZEALAND LAND RESOURCE INVENTORY FOR MAVORA STUDY AREA (AFTER HUNTER, 1977, 1978)

KEY TO INVENTORY CODE

Layout of the code is as follows:

$$\frac{\text{Rock Type . Soil Unit . Slope}}{\text{Erosion degree and type . Vegetation}}$$

SOILS

Upland - High Country Yellow-Brown Earth

52	Craigieburn Soils
53	Cass Soils
53H	Cass Hill Soils
55b	Puketeraki Soils
55bH	Puketeraki Hill Soils
57	Kaikoura Steepland Soils
57c	Fairlight Steepland Soils
57f	Waikaia Steepland Soils

Brown Granular Loams and Clays

79a	Windley Steepland Soils

Brown Granular Loams and Clays to Yellow-Brown Earth Intergrade

80a	Glenelg Soils
82a	Eglinton Steepland Soils
82b	Takitimu Steepland Soils

Gley Recent Soils

90d	Dobson Soils

Recent Soils

99	Tasman Soils

Alpine Steepland Soils etc.

100	Alpine Steepland Soils
B R	Bare Rock

SLOPE

A	0-3°	E	21-25°
B	4-8°	F	26-35°
C	9-15°	G	>35°
D	16-20°		

EROSION

Degree of Erosion		Types of Erosion	
0	neglible	Sc	scree
1	slight	G	gully
2	moderate	Sh	sheet
3	severe	daF	debris avalanche
4	very severe	W	wind
5	extreme	D	deposition
		Sb	streambank
		sSl	soil slip

ROCK TYPES

Gw	- greywacke
Al	- uncemented gravel
In	- intrusives, ancient volcanics
Um	- ultramafite
(Al)	- significant in patches

VEGETATION

(Upper-case letter indicates type of vegetation comprises >40% of unit area, lower-case letter <40%)

Grassland

P2	Low producing or native grassland
P3	Short tussock associations (mainly silver and hard)
P4	Snow tussock associations
P5	Red tussock associations

Scrub

M3	Dracophyllum
M5	Sub-alpine scrub associations
M6	Mixed native scrub associations
M11	Matagouri

Forest

N4	Beech

KEY TO LAND RESOURCE INVENTORY UNITS IN MAVORA STUDY AREA

Unit Area	Inventory Code	Capability assessment	Unit Area	Inventory Code	Capability assessment
1	Gw · 100+BR · G 3Sc · ——	VIIIe 11	21	Gw · 57+BR · F 5Sc · p4	VIIIe 9
2	Gw · 57+BR · F 4ScG · p4	VIIIe 9	22	Gw · 57 · F 4ScG · p4m5	VIIIe 9
3	Al/Gw · 55bH · E+D 2Sc · P4	VIIe 21	23	Al · 53 · D 1ShScW · P4,5	VIIc 4
4	Gw · 57 · F+G 4ScG · p4m5	VIIIe 9	24	In+Um · 82b+79a · F 4ScShG · p4	VIIIe 9
5	Al · 53H · D 1Sh · M6p3,4	VIe 29	25	Gw · 57+53H · F+E 2Sh · P3m6	VIIe 26
6	Gw · 57+BR · F 3ShScdaF · P4	VIIe 26	26	Gw · 57f · F 3ScSh · N4	VIIIe 8
7	Gw · 57 · F 2ScG · P4	VIIe 26	27	Al · 99 · B 2DW · P2,3	VIs 11
8	Al · 53 · D+C 1Sh · N4	VIe 27	28	Gw · 57+BR · G+F 5Sc · p4	VIIIe 9
9	Al · 53 · C 2WSh · M6p3	VIs 12	29	Al/Gw · 53H · D+E 1ShW · P3,5m11	VIe 29
10	Gw · 57 · F 3ShSc · P4	VIIIe 9	30	Gw · 57f · F 2ScSh · P4,3	VIIe 23
11	Gw · 57 · F 5Sc · p4	VIIIe 9	31	Gw · 57 · F 5Sc · p4	VIIIe 9
12	Gw · 57 · F 4ScSh · p4	VIIIe 9	32	Gw · BR+100 · G 3Sc ——	VIIIe 11
13	Al/Gw · 53 · C+E 1Wsh · P3,5m11	VIe 27	33	Gw · 57+57f · F 4ScdaF · m5	VIIIe 9
14	Al · 99 · A 2DSb P3	VIs 11	34	Gw · 57 · F 3SdaF · P4	VIIIe 9
15	Al · 52 · A+B 1WSh · P3m6	IVe 16	35	Al/Gw · 53H · D+E 1Sh · P3,5m11	VIe 29
16	Al · 53 · C 1Sh · P3,5	VIe 27	36	Al · 53 · B 1W P3	VIs 12
17	Gw · 57 · F 4ScdaF · p4	VIIIe 9	37	Al · 53 · C+E 1ShW · P3,5	VIe 27
18	Gw · 57c · F 3Sh · P4	VIIe 23	38	Al · 99 · A 3D · P3	VIs 11+ VIIs 3
19	Gw · 57 · F+G 5ScG · p4m5	VIIIe 9	39	(Al)/Gw · 57c · E+F 2ShW · P3,4	VIe 29
20	Gw · 57 · F 3ShScdaF · P4	VIIIe 9	40	(Al)/Gw · 53H · E+D 2ShW · P4	VIIe 17

Unit Area	Inventory Code	Capability assessment
41	Gw · 57 · F 3Sh · P4	VIIe 26
42	(Al)/Gw · 57c · F+E 2ShW · P4	VIIe 23
43	Gw · 57c · F+D 1ShW · P4	VIIe 17
44	Gw · 57c · F 4ShSc · p4	VIIe 9
45	Al · 90d+99 · A 1Sb · P2,5,3	Vw 2
46	Al · 53+99 · B+E 1DSh · P3m11	VIs 12
47	Gw · 57+57c · F+G 4ScGSh · P3,4	VIIIe 9
48	Gw · 57 · F 5Sc · p4	VIIIe 9
49	Al · 99 · A 1Sb · P2,5,3	VIs 11+ IVe 8
50	Al · 53 · B+C 1ShW · P3,5m11	VIs 12
51	Al · 99 · A 2SbDW · P2,3m11	VIs 11+ IVs 12
52	Al/Gw · 57c · E+F 1Sh · P3,2m11	VIe 29
53	Gw · 57 · F 4ScSh · p4	VIIIe 9
54	Gw · 57f · F 2ShSc · P3,4	VIIe 23
55	Al · 53 · C+D 1WSh · P3m11	VIe 27
56	In+Um · 82b+79a · F 3ShSc · p4mS	VIIIe 9
57	Al · 99 · B 1WD · P3m11	IVs 12
58	Al · 53 · C/D 1Sh · P3m11	VIe 27
59	Gw+Um · 57f+79a G 3ShScG · P3,4m11	VIIIe 8
60	Um+In · 79a · F 2ShSc · P4	VIIIe 8
61	Um+In · 79a · F 3ShG · P4,3m4	VIIIe 8
62	In · 79a+82b+BR · F+G 3ScSh · P4	VIIIe 9
63	Gw · 57f · G 4ShScG · p3,4m4	VIIIe 8
64	Al · 55b · C 2ShSc P4,3	VIIc 4
65	In+Um · 82b+79a · F 4ScShG · p4	VIIIe 9
66	Gw · 57f · F 3GScSh · P3m4,11	VIIe 23
67	In+Um · 79a · G 5ScSh · p4	VIIIe 8
68	Al · 53 · C 1Sh · P3m11	IVe 16
69	Gw · 57 · F 3ShdaF · P4m3	VIIIe 8
70	Al · 53 · B+C 1Sh · N4	VIs 12
71	Gw · 57+BR · G+F 3ScG · p4m5	VIIIe 9
72	Gw · 57f · G 2ShG · N4	VIIIe 8
73	Gw · 57f · F 1Sh · N4	VIIe 23
74	Um · 82a · E 4ShSc · p4	VIIIe 9
75	Gw · 57f · F/G 1s$1Sh · N4	VIIIe 8
76	Al · 53 · C 1Sh · N4	VIs 12
77	Al · 53 · B+C 1W · P3,5	VIs 12
78	In · 82a+79a · E+F 1Sh · N4	VIIe 23
79	Al · 80a · B θ · N4	IVs 4
80	Al · 99 · A θ · P3,5	VIs 11

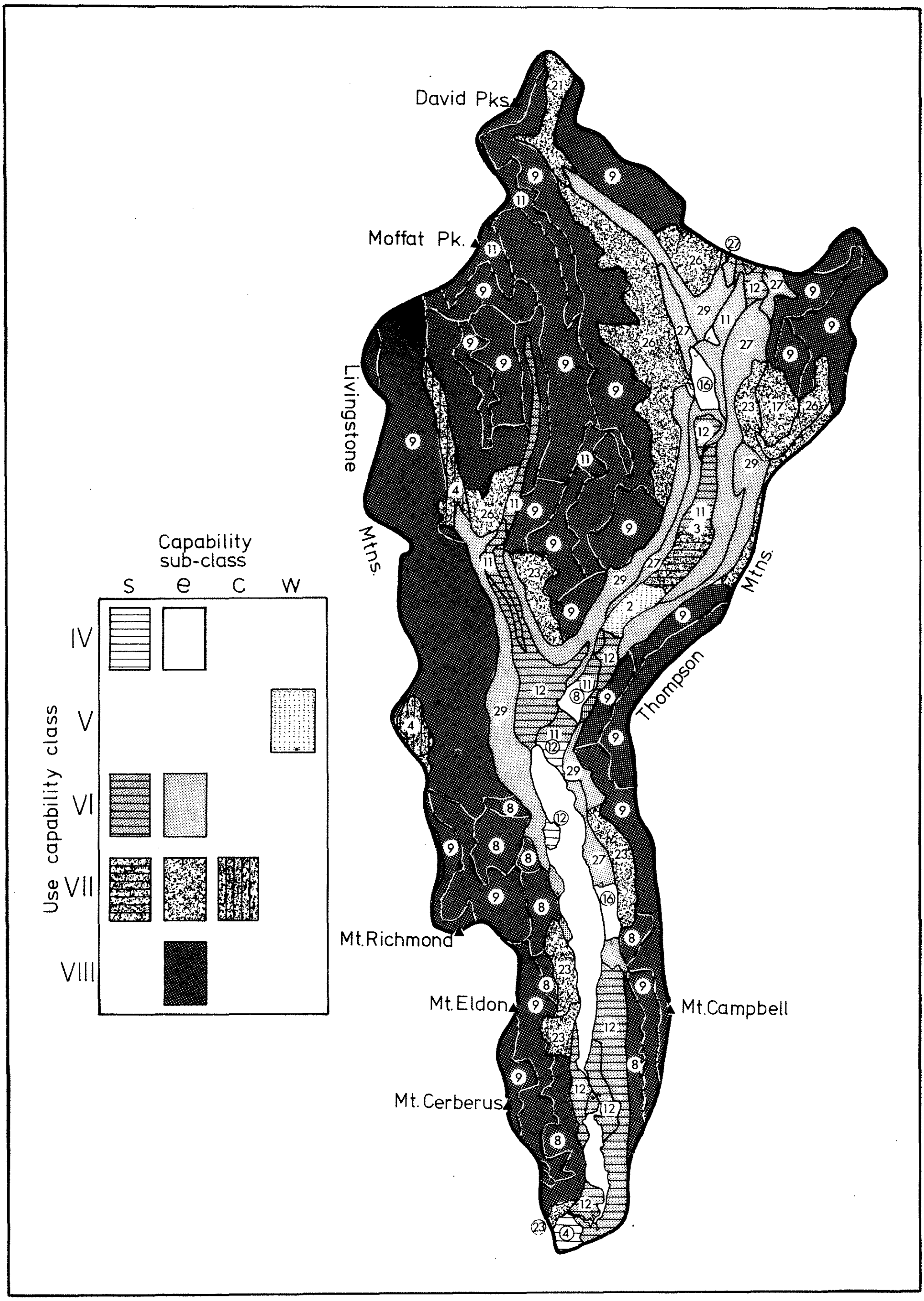


FIGURE 34: CAPABILITY CLASSES, SUB-CLASSES AND UNITS OF MAVORA STUDY AREA

Furthermore, the scale of land evaluation for some of the uses would remain inappropriate, as noted at the beginning of this section. Despite these deficiencies, the now existing land resource inventory units and their assembly in land capability units provide a useful cartographic summary. As will be shown, they provide a useful check on the "land system multiple use evaluation" developed in this study.

6.2 SUMMARY OF LAND SYSTEM EVALUATION PROCEDURE ADOPTED

Brinkman and Smyth (1973) presented the previously unpublished concepts of K.J. Beek concerning the actual or potential land use purpose for which land is to be evaluated. They proposed that such relevant use possibilities (termed "land utilisation types") should be identified as development alternatives early in the land evaluation process.

Within the theoretical range of choice of uses for the Mavora are pastoral agriculture, forestry, water management especially for downstream uses, conservation of vegetation and wildlife, many types of recreation including recreational enjoyment of fish, wildlife, water bodies and terrain and holiday settlement. For each of these uses a series of alternatives are considered, each defining a land utilisation type appropriate to this intensity of survey and evaluation. Each of these alternatives is assessed as suitable, conditionally suitable or unsuitable for each land system or subsystem. Land suitability (Brinkman and Smyth, 1973) is "the fitness of a given tract of land for a defined use. Differences in the degree of suitability are determined by the relationship, actual or anticipated, between benefits and required inputs associated with the use of the tract in question." These assessments are here made independently for each land utilisation type considered. The question of compatibility of concurrent uses is considered in a later chapter.

6.3 LAND UTILISATION TYPES CONSIDERED

Bennema (1975), following the practice of Brinkman and Smyth (1973), notes that utilisation types are of two kinds, those related to the land under present conditions leading to actual suitability classification, and those for which major improvements are necessary, leading to potential suitability classification. He emphasises that present uses of the land should not be ignored as an alternative in any programme. For the qualitative character and extensive scale of the Mavora evaluation, there seems little reason why such "present" land utilisation types should not be considered in the same evaluation, even though for many alternatives considered, the exercise is one of potential suitability classification. The alternatives considered are summarised below. Each of these summary statements specifies a "land utilisation type" which can be assessed in general terms for its "suitability" according to the procedure developed by Beek (1978).

6.3.1 Pastoral Alternatives

6.3.11 Pastoral - Intensive Self-Contained (PISC)

Oversowing and topdressing of stable river flats, terraces, moraines, fans and lower hill slopes, appropriate boundary and intensive subdivision fencing, stock-water supplies, vehicle track making, tree shelter, cultivation of haymeadows and supplementary cropland, including field drainage where necessary; erection of yards, farm buildings, homesteads; purchase and breeding of suitable sheep and/or deer and/or cattle to ensure intensive grazing management on all oversown and topdressed land and periodic utilisation of higher hillslopes by sheep or cattle.

6.3.12 Pastoral Semi-Intensive Accessory (PSIA)

Oversowing and topdressing of some terraces, moraines, fans and lower hill slopes, appropriate boundary fencing with minimal track improvement and subdivision fencing; some provision of live shelter, erection of yards and service huts; development of off-site base farm to furnish sheep or cattle for seasonal grazing in the Mavora (possibly supplementary to permanent deer), regularly in winters and in drier than average summers and autumns, with yearly alternating use of sub-divided blocks. (Deer grazing would be year-round if the deer option were followed.)

6.3.13 Pastoral - Extensive Regular Accessory (PERA)

Local strategic areas of topdressing and oversowing, some use of drift fences but no subdivision fencing; some use of sheep to assist ragwort control but generally grazing confined to cattle in winter and in summer, provided from off-site base farm. (This has been the pastoral alternative for part of the Mavora currently favoured by the land-administering agency for the Farm Settlement).

6.3.14 Pastoral - Extensive Irregular Use (PEIU)

No topdressing or oversowing, no additions of fencing of any kind, grazing use by cattle only and then only at the convenience of off-site enterprises, e.g. in severe summer drought or for wintering after serious autumn drought.

6.3.2 Forestry Alternatives

6.3.21 Forestry - Commercial Production/Protection (FCPP)

Extensive block planting of long-rotation silvicultured conifer forests (with/without amenity planting) on accessible moraines, terraces, fans and lower and mid slopes; rotational clear-felling and replanting; selective logging and silvicultural regeneration of appropriate beech forest; some road improvement and erection of service huts, fire protection facilities; protection/production planting of mid to higher slopes.

6.3.22 Farm Forestry (adjunct to 6.3.11 or 6.3.12) (FFA)

Local planting of adapted conifer species on moraines, terraces, fans and lower hill slopes; silviculture of plantations only, with or without amenity planting.

6.3.3 Water Management Alternatives (WMD)

The only possible range of feasible alternatives to be considered would be for influencing the low flow, flood regimes or total yield in the Lower Mararoa, with a view either to management within the Mavora-Waiau-Manapouri water system or for partial diversion to the Oreti water system. (Of such alternatives the only one that could be pursued in its own right without major engineering investment within the two-Mavoras' water system itself is retirement of the whole catchment from grazing, with a view to reverting towards a "more natural hydrologic regime". It should be noted that because of the lake ponding effects it is doubtful whether this "retirement" would have any appreciable influence on low flows or on flood discharges.) There are water management implications within the Mavora-Upper Mavora system in alternatives in Nature Conservation, Wildlife Management and Recreation. These are considered in the appropriate scenarios for such uses.

6.3.4 Nature Conservation Alternatives

6.3.41 Wildlife Conservation to Maximum (WCX)

Closed game area status to continue, prohibiting game bird hunting as well as protecting all other birds protected under the Wildlife Act 1953; protecting all forest, forest margin, water body and water margin habitats from all wild and domestic animal influence; creating new habitats, especially by pond construction, planting of feed trees; trout fishery management by habitat protection and predator control.

6.3.42 Wildlife Conservation to Moderate Level (WCM)

Closed game area status to continue but with no special efforts to maintain or improve wildlife habitat.

6.3.43 Vegetation Conservation to Maximum (VCX)

Constitution of appropriate reserve status under Reserves Act for the maximum area available; management plan development and exclusion of all incompatible uses including all grazing by mammals; maximum protection of forest areas available under the Forest Act; alternatively, establishment of the whole area as a special area for biological conservation, excluding visitor use except under permit and meeting "strict natural area" or "managed natural area" criteria of IUCN (Dasmann, 1973).

6.3.44 Vegetation Conservation to Moderate Level (VCM)

Surveying, selection and designation of appropriate representative areas as Reserves under the Reserves Act and as Ecological Areas under the Forest Act; preparation of management plans to meet "strict natural area" or "managed natural area" criteria of IUCN (Dasmann, 1973).

6.3.5 Recreation Alternatives

6.3.51 Recreation - Wilderness-Dependent (RWD)

Limiting recreational use in character and intensity to allow only low rates of quickly reversible change in the natural environment and to ensure maintenance of wilderness experience (Hendee, Starkey and Lucas, 1978,cf. Molloy, 1976); such an objective would exclude virtually all current recreation activities except back-packing, tramping and related incidental relaxations and exertions; density of trampers would itself have to be low to maintain wilderness experience and, in the strict sense, tracks and any other facilitation would be excluded.

6.3.52 Recreation - Natural-Area-Dependent (RNAD)

Facilitating but limiting recreational use in character and intensity to allow only low rates of reversible change in the natural environment (except locally, as at tracks and campsites) and to maintain generally the essential experience of environmental naturalness (awareness of the humanly-unmodified); minimum development for on-foot recreation (Robertson, 1972); all forms of on-foot recreation: tramping, cross-country skiing, fishing, hunting, back-pack camping and related pursuits would be acceptable up to levels consistent with objectives stated; horse-riding and canoeing possibly would also be acceptable at low intensities; public safety would be considered in provision and mapping of tracks, huts, bridges, suitable spacing of huts, provision for emergencies, minimal critical signposting (Molloy, 1976).

6.3.53 Recreation - Open-Space-Dependent (ROSD)

Facilitating but limiting recreational use in character and intensity to accept and maintain open vista landscape, little-modified by man or sparsely settled; provision and maintenance of tracks or walkways, huts, campsites, bridges, live or built shelter; all forms of foot-borne recreation and horse-trekking, canoeing and quiet boating. (It should be noted that recreational activities here involved include all forms included in Recreation - Natural-Area-Dependent. The difference between the two land utilisation types is in the way the environment is managed and accordingly in the kind of environmental experience involved in the recreation.)

6.3.54 Recreation - Resource Based but Resource Modifying (RRBM)

Facilitating up to acceptable levels of environmental change to be defined, all forms of resource-based recreation compatible with one another; picnicking and motor-camping, boating, skating, skiing, horse riding, foot-borne recreations, driving for pleasure, use of off-road vehicles, provision of fireplaces, campsites, sanitary facilities, safety measures and shelter. (It will be noted that definition of different acceptable levels of environmental modification or impact makes for quite different land utilisation sub-types.)

6.3.55 Recreation - Vacation Building Development (RVBD)

Erection of accommodation lodges, cabins, cottages or "second homes" for sustained or periodic recreational or retirement use; possible future provision of tourist facilities including commercial restaurants, shops, fuel supplies and intermediate or user-oriented recreation. (It will be noted that definition of building types and purposes, e.g. cottages vs lodges, can lead to different land utilisation sub-types.)

6.3.6 Wild Animal Management Alternatives

Apart from the extremes of wild animal extermination (such as would be involved in alternatives 6.3.43 and in 6.3.3 as outlined above) and deer-farming (such as was included as a possible component of alternatives 6.3.11 and 6.3.12), there are other wild animal management alternatives, not unconnected with recreation alternatives or with nature conservation alternatives.

6.3.61 Wild Animal - Strict Population Control (WASPC)

Monitoring and control of deer and chamois populations by licensed helicopter hunting and capture and by foot hunting, whether by official or private hunters.

6.3.62 Wild Animal - Recreational Hunting Management (WARHM)

Exclusion of commercial forms of population control, except when clearly essential to regain control; promotion of and reliance on recreational foot-hunters, ensuring perpetuation of a hunting resource within acceptable levels of environmental modification.

6.4 SUITABILITY ASSESSMENTS

Eighteen land utilisation types identified in the preceding sections have been assessed for suitability for each of the Land Systems of the Mavora. The assessments are presented in summary in Table 11. It is emphasised that these assessments are not for all land units within each land system but for each land system as a whole. In essence, each land system is judged for its capacity to accommodate enterprises of the land utilisation types described.

TABLE 11

Suitability Assessments (see text) for Land Use Alternatives in Land Systems of the Mavora Study Area

Land Utilization Types (see text)	Land Systems						
	Campbell	Thomson	Sugar Loaf	Mararoa	Livingstone	West Burn	Eldon
Pastoral							
PISC	2.3	2.2	2.2	3.1	3.2	3.2	3.2
PSIA	2.2	2.1	2.1	3.1	3.1	3.2	3.2
PERA	1.3	1.2	1.2	3.1	3.1	3.2	3.2
PEIU	2.3	2.2	2.2	3.1	3.1	3.2	3.2
Forestry							
FCP	1.3	2.3	2.3	3.1	3.1	3.2	3.2
FFA	1.2	2.2	2.2	3.1	3.1	3.1	3.1
Water Management							
WMD	2.3	2.3	2.3	3.1	3.1	3.2	3.2
Nature Conservation							
WCX	1.1	1.1	1.1	1.3	1.3	1.3	1.1
WCM	1.1	1.1	1.1	1.2	1.2	1.2	1.1
VCX	1.3	1.3	1.3	1.2	1.2	1.2	1.2
VCM	1.2	1.2	1.2	2.1	2.1	2.1	1.1
Recreation							
RWD	3.1	3.1	3.1	2.2	2.2	1.2	2.2
RNAD	1.2	1.2	1.2	1.1	1.1	1.1	1.1
ROSD	1.1	1.1	1.1	1.2	1.2	1.2	1.2
RRBM	1.2	2.2	2.2	3.1	3.1	2.2	2.2
RVBD	1.2	2.3	2.3	3.2	3.2	3.2	2.3
Wild Animal Management							
WASPC	1.3	1.3	1.2	1.2	1.2	1.2	1.2
WAHMR	3.1	3.1	3.1	2.3	2.3	2.3	2.2

Key to Suitability Assessments:

	Suitable	Conditionally Suitable	Unsuitable
Highly	1.1	2.1	3.1
Moderately	1.2	2.2	3.2
Marginally	1.3	2.3	

6.4.1 Assessment Classes

6.4.11 Orders of Suitability

Following Brinkman and Smyth (1973), first classification is according to the following definitions, adapted here for the land system dimension:

Order 1. Suitable land: Land on which sustainable use for the defined purpose in the defined manner is expected to yield benefits that will justify required recurrent inputs without unacceptable risk to land or water resources within the land system or in adjacent areas.

Order 2. Conditionally suitable land: Land having characteristics which, in general, render it unsuitable for sustainable use in the defined manner but which, subject to conditions of management which are not specified in the general definition of the use, could be rendered suitable.

Order 3. Unsuitable land: Land having characteristics which appear to preclude its sustainable use for the defined purpose in the defined manner or which would create production, upkeep and/or conservation problems, requiring a level of recurrent inputs unacceptable at the time of the interpretation.

6.4.12 Degrees of Suitability - Classes of Order 1

Class 1.1 Highly suitable: Land having no significant limitations to sustained accommodation of the defined use or only minor limitations that will not significantly reduce production benefits and/or will not raise recurrent and minor capital inputs for production and/or conservation above a readily acceptable level.

Class 1.2 Moderately suitable: Land having limitations which in aggregate are moderately severe for sustainable accommodation of the defined use and which will reduce production benefits and/or increase required recurrent and minor capital inputs for production and/or conservation to the extent that the overall advantages to be gained from the use will be much less than expected on Class 1.1 land although remaining positive.

Class 1.3 Marginally suitable: Land having limitations which in aggregate are severe for sustained accommodation of the defined use and will so reduce production benefits and/or so increase required inputs that such expenditure would be only marginally justified.

6.4.13 Degrees of Conditional Suitability - Classes of Order 2

It will be apparent from the definition of Order 2 that classes of conditional suitability for a use of defined purpose and manner would become classes of suitability, were the land utilisation type more critically defined. Accordingly the classes of Order 2 can be defined with relation to Order 1.

Class 2.1 Land having characteristics which, in general, preclude sustainable accommodation of the defined use but which, subject to special conditions defined at the sub-class level, would be equivalent to land of Class 1.1.

Class 2.2 Land having characteristics which in general preclude sustainable accommodation of the defined use but which, subject to special conditions defined at the sub-class level, would be equivalent to land of Class 1.2.

Class 2.3 Land having characteristics which in general preclude sustainable accommodation of the defined use but which, subject to special conditions defined at the sub-class level, would be equivalent to the land of Class 1.3.

6.4.14 Degrees of Unsuitability - Classes of Order 3

Class 3.1 Presently unsuitable: Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at presently acceptable cost and which are so severe as to preclude successful sustained use of the land in the defined manner.

Class 3.2 Unsuitable: Land having limitations which appear so severe as to preclude any possibility of successful sustainable use of the land in the defined manner.

6.4.2 Reasons for the Pastoral Assessments

6.4.21 Assessment for Intensive Self-Contained Pastoral Enterprises (PISC)

The limitations that affect enterprises of this type as defined are not erosion risks of Class VIII land, because the use presumes the necessary fencing and the improvement of the pastorally suited country. The inherent limitations then emerge as climate, area location and distribution of suitably responsive land. All land systems are affected by comparatively short pasture growing season and by snow risk. The Eldon, West Burn and Livingstone Land Systems are clearly unsuitable: so is the Mararoa System, as defined earlier, at present state of knowledge, technology and economics. The Sugar Loaf, Campbell and Thomson Land Systems could prove suitable in deer farm enterprises if appropriate fencing against escape and protection from poaching could be developed, as well as road access. However, the Campbell sub-system lacks any extensive area of cultivable land that might well be necessary for winter feed. Accordingly it is conditionally marginally suitable. The Sugar Loaf and Thomson Land Systems have much more extensive potentially cultivable land. As a possible deer enterprise the Thomson system in particular has serious problems of security against escape and poaching.

An intensive pastoral enterprise based on sheep or cattle in the Thomson and Sugar Loaf Land Systems must at the present time be assessed as conditional because vehicle access conditions are unspecified. Conditional assessments must also follow from the estimated risk of lake enrichment from the use as defined. Even if these conditions were satisfied, the limitation persists that intensive pastoral enterprise in any part of the Mavora is most severely affected by the climatic limitations on pasture growth and by the probably substantial deficiencies of plant nutrients in all except the younger fan and flood plain soils.

6.4.22 Assessment for Semi-Intensive Accessory Pastoral Enterprises (PSIA)

The inherent limitations affecting such accessory pastoral enterprises are of the same kind as those affecting the intensive self-contained pastoral use but they are less severe in their influence on the Campbell, Thomson and Sugar Loaf Land Systems, because the sufficient area, seasonal climate and soil fertility criteria need not be so influential. These systems must remain conditionally suitable for this alternative because of the access situation, the estimated risk of lake enrichment and the possible loss problems associated with deer farming. The conditionally highly suitable rating (2.1) for the Thomson and Sugar Loaf Systems illustrate the higher summer utility of river flats and the higher summer utility of oversown and topdressed grasslands in this higher rainfall area. Appropriate fencing may need to be berm fencing for water body protection. Clearly, the economic benefits from such accessory development would be as much determined by conditions at the "off-site base farm" to be developed for this kind of use. The Mararoa, Livingstone, West Burn and Eldon systems are clearly unsuitable, at least at present technology.

6.4.23 Assessment for Extensive Regular Accessory Pastoral Enterprises (PERA)

The Campbell subsystem is moderately suited, the Thomson and Sugar Loaf systems are highly suited. As noted previously, this type of utilisation is very similar to the current actual use except that strategic local topdressing has not been carried out. There seems little doubt about its suitability in both the Sugar Loaf system and the Thomson subsystem so far as the cattle benefits are concerned, either to the Elfin Bay or to the present Mavora Farm Settlement enterprise. There may be conflicts or incompatibilities with other uses. A caveat may need to be applied to intensity of this pastoral use. There is some likelihood that difficultly reversible damage to resources could occur from repeated heavy cattle use of such terrain, especially affecting tall tussock condition and water margin. The Mararoa and Livingstone subsystems are assessed as unsuitable because there is inadequate knowledge of the potential for pasture improvement or long term effects of cattle on resources in these situations. The West Burn and Eldon systems are considered generally unsuitable for improvement and unsuitable for use without improvement.

6.4.24 Assessment for Extensive Irregular Pastoral Use (PEIU)

These assessments are similar to those for Regular Accessory Pastoral use except that they are now conditional for the Campbell, Thomson and Sugar Loaf systems because of the uncertainty of animal behaviour with irregular use as well as the uncertainty of animal supply itself.

6.4.3 Reasons for Forestry Assessments

6.4.31 Assessment: Commercial Production Forestry with Production/Protection Planting (FCPP)

The Campbell subsystem is assessed as marginally suitable. Low site suitability for radiata pine makes commercial forestry prospects marginal and the economic prospects for other enterprises using such species as Douglas fir, even if likely to be more resistant to the endemic hazard of windthrow, do not seem clearly favourable. A similar assessment applies to the Thomson subsystem and to the Sugar Loaf system as well as to the once forested lower slopes of the moister Eldon system. It should be made clear that for substantial portions of most land systems, there seems little reason to expect poor growth from suitable provenances. Low margins causing marginal suitability seem more likely to arise from external factors.

This marginal suitability must be considered conditional for most land systems because of the uncertainties of access in the use as specified. It is conceivable that there might be additional benefits from production/protection forest planting, especially in soil conservation and water quality control. In view of the buffering role of the lakes themselves, any distant off-site benefit must remain questionable. Some benefits might accrue to other uses including some aspects of recreation, especially with amenity planting accompanying the commercial forestry, but these could be offset for other uses. The remaining land systems are accordingly classified at present technology, economics and knowledge as unsuitable.

6.4.32 Assessment for Farm Forestry Adjuncts (FFA)

This use is classified as moderately suitable on the Campbell System and as conditionally moderately suited on the Thomson and Sugar Loaf Systems. The difference resides in the uncertainty of economics of access to these further removed sites as well as to their slightly higher altitudes. No other land system is considered suitable for this use because, among other reasons, none other is considered suitable for the pastoral enterprise to which farm forestry would be an adjunct.

6.4.4 Reasons for Water Management Assessment (WMD)

The three drier land systems, Thomson, Campbell and Sugar Loaf, are considered conditionally marginally suitable for the use specified. The four wetter systems are considered unsuitable for this type of land utilisation. It is possible that there may be some downstream hydrologic influences of vegetation in the drier Thomson mountains but it is very unlikely that there are any measurable effects to be had from vegetation management in the wetter north and west. Quite apart from the buffering influence of the lakes themselves, there seems little justification in downstream river behaviour for the land utilisation alternative considered. (An entirely different situation exists in the Mararoa River system below the lakes which is not covered in this study.)

6.4.5 Reasons for Nature Conservation Assessments

6.4.51 Assessment of Wildlife Conservation to the Maximum (WCX)

All land systems including or bordering major water bodies and native forest were assessed as highly suitable for this type of land utilisation, in accordance with the high potential for biological conservation revealed in the checklist of birds and the high quality of the fishery. Other land systems are classed as marginally suitable for this purpose, since the expected benefits would be small, in relation to the cost necessary for maximum habitat protection.

6.4.52 Assessment of Wildlife Conservation to Moderate Level (WCM)

For all land systems including or bordering major water bodies and native forest, suitability for this use is high. For others it is moderate since the benefits would be achieved probably with smaller cost than WCX.

6.4.53 Assessment of Vegetation Conservation to Maximum (VCX)

For the three eastern systems, Campbell, Thomson and Sugar Loaf, the suitability is marginal, principally because the destruction of native vegetation that has already occurred is not likely to be reversed except in the very long term. For the northern and western systems the benefits may be greater because the tall-tussock and shrublands are in a better condition to recover in the higher moisture regimes.

6.4.54 Assessment for Vegetation Conservation to Moderate Level (VCM)

The Campbell, Thomson and Sugar Loaf systems are moderately suitable for this use. The Mararoa, Livingstone and West Burn systems are conditionally highly suited to a selective reserve policy, the conditional factor being dependent on whether important ecotones of tall-tussock species and their associated vegetation are to be established there. The Eldon system is considered highly suitable because of relatively species-rich beech forest. Reserves of Chionochloa on ultramafic rock are of potential special scientific interest but these may be best selected in the West Burn system. The generally higher degree of suitability for this selective use rather than the blanket conservation use (VCX) derives from the prospect of similar benefits for lower costs.

6.4.6 Reasons for Recreation Assessments

6.4.61 Assessment for Wilderness-Dependent Recreation (RWD)

The Campbell, Thomson and Sugar Loaf systems are unsuitable because their wilderness character and ability to supply a wilderness experience has already been lost by human influence on the landscape (Molloy, 1976). The Livingstone, Mavora and Eldon systems are classed as conditionally moderately suited, depending on whether Molloy's (1976) stringent criteria are applied or the somewhat greater emphasis on the "wilderness experience" is applied as by Hendee *et al* (1978). The West Burn system may provide wilderness enough in its upper units because of their partial orientation away from zones of human contact and influence. None of the systems could be classified as suitable for wilderness-dependent recreation if the size and length of access journey criteria suggested by Molloy (1976) were firmly applied. There is some suggestion (Hendee *et al*, 1978) that these criteria may not be fully applicable in highly complex and varied terrain.

6.4.62 Assessment for Natural-Area-Dependent Recreation (RNAD)

The western and northern land systems are highly suited to such use, especially with their residual forest areas and alpine units. The drier eastern systems have lower suitability for this utilisation type, because of the existing modification of vegetation.

6.4.63 Assessment for Open-Space-Dependent Recreation (ROSD)

The Campbell, Thomson and Sugar Loaf systems are all highly suitable in part because of their closeness to water bodies, in part because of the relatively small area of forests. The four wetter land systems which are better suited to Natural-Area-Dependent Recreation are less well suited to the Open-Space-Dependent class.

6.4.64 Assessment for Resource-Based Recreation which is Resource-Modifying (RRBM)

The Campbell System is moderately well suited to this use. The Thomson, Sugar Loaf, West Burn and Eldon systems are all conditionally moderately suited, the condition being influenced by access development. The Mararoa and Livingstone systems are unsuited.

6.4.65 Assessment for Vacation Building Development (RVBD)

The Campbell system is moderately suited to accommodate in some locations at least this type of use, with the caveat that South Mavora Lake at least may be rather vulnerable to organic or nutrient enrichment. The marginal suitability of the Thomson, Sugar Loaf and Eldon systems is conditional upon access development. The Mararoa, Livingstone and West Burn systems are all clearly unsuitable. Hayward and Boffa (1972) demonstrated in the Waimakariri how zones of greatest recreational significance could be identified, how sites could be assessed for their ability to absorb building development and how site suitability within such zones could be estimated. Such a process would have to be applied to the Campbell Land System if a decision were to be made in favour of such building development.

6.4.7 Reasons for Wild Animal Use Assessments

6.4.71 Assessment for Strict Population Control of Wild Animals (WASPC)

All systems are classified as marginally or moderately suitable, this being the trend of current practice of wild animal control under the New Zealand Forest Service. Benefits obtained are principally in venison recovery or in live deer capture. Difficultly quantifiable benefits are also obtained in vegetation recovery. If there were not the current economic regime of valuable returns from deer slaughter or capture, the benefits from the alternative would be less but would probably still be sufficient to justify continued strict control. The growing problem of opossum control may increase costs without commensurate increase in benefits.

6.4.72 Assessment for Herd Management for Recreation (WAHMR)

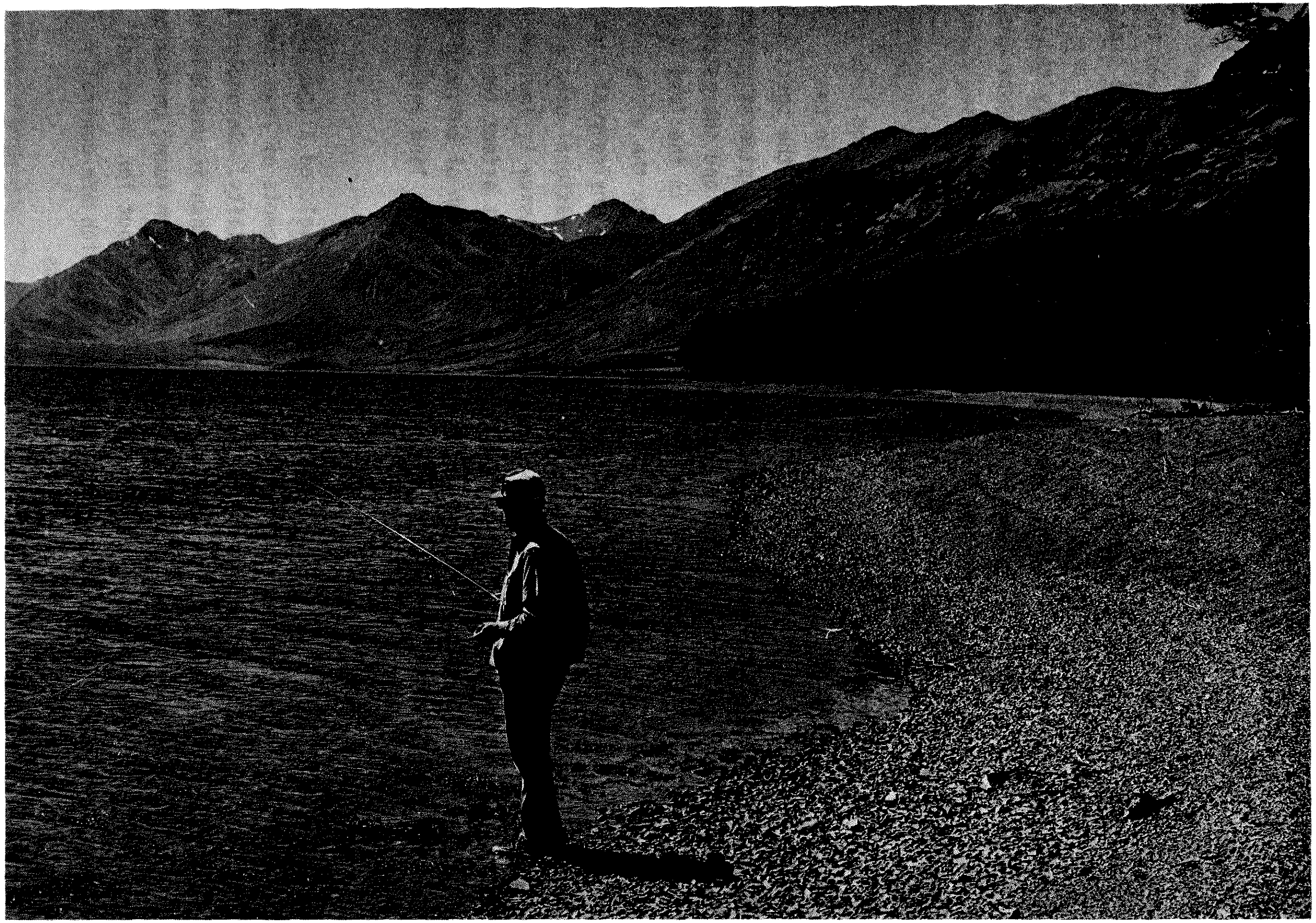
For the three eastern land systems, Campbell, Thomson and Sugar Loaf, this use is considered unsuitable because of the large areas of depleted mountainside that must be freed from wild grazing as part of its recovery process. An additional reason is the difficulty of ensuring strict population control in the Oreti headwaters if only recreational hunting pressure is to apply in the eastern Mararoa-Mavora country adjacent. Conditional marginal suitability is assessed for the northern and north-western systems West Burn, Livingstone and Mararoa, depending on the feasibility of such control in a zone adjacent to the Fiordland National Park. Conditional moderate suitability is assessed for the Eldon system because of its easier access on foot through the Snowdon Forest.

6.5 COMMENTARY

It will be evident from careful inspection of Table 11 and the reasons expounded for the assessments therein that there is a substantial subjective element in it. This is not contested. It was acknowledged at the outset that this was an interpretive classification. This land evaluation process has been devised to allow appraisals to be made in a reconnaissance. These appraisals can be translated into more quantitative assessments in further priority areas. All the assessments that are here reported have some quantitative basis but only the principal factors are mentioned in the summary of reasons. *If assessments are to be challenged and altered by new information or by the turn of events, such adjustments can be made without subverting the procedure outlined.*

It will also be evident that the limitations from land instability and from soil and climatic influences on plant productivity are taken account of in the assessments of the suitability of each land system to accommodate the specified land utilisation types. It should also be observed that this consideration has influenced both the specification of the land utilisation types and the assessments of suitability. The hazards of soil erosion as manifest in the land use capability subclasses IVe, VIe, VIIe and VIIIe are considered in the above way, as reference to Figure 34 will confirm. Other hazards to the environment such as the possible enrichment of the lake waters by nutrients from pastoral uses are also taken into account. The detailed consideration of this issue is included in Appendix 6. It should be noted that although this use does not affect the suitability of land per se for the use specified, the definition of suitable land in para 6.4.11 includes the concept of unacceptable risk to both land and water resources.

In summary, then, it can be recognized that the procedure developed allows the appraiser to take logical account of the general economic aspects of land uses as well as the physical limitations affecting land use capability. Secondly, it allows this kind of appraisal to be done in a broader scale than is possible if each relatively homogeneous area of land is to be considered in turn, on its own merits. Third, it allows positive appraisals to be carried out for important social uses, such as recreation and nature conservation, which are generally formally allocated only land residual to other requirements.



The Mavora Lakes constitute a brown trout fishery of great quality. Campbell subsystem in the background (18).

CHAPTER SEVEN
Social Interests in Land Use

7.1 THE ELEMENTS OF THE PHILOSOPHY, POLITICS AND ECONOMICS OF LAND USE

The last chapter has indicated how elementary qualitative or quantitative benefit/cost ratios may be incorporated into simple assessments of land suitability for an array of different uses. Not infrequently the plea is heard that the lands of this country should be used each for the purpose to which it is best suited. Such pleas may arise from awareness that some of our "best" soils are not being used for the purpose for which they are perhaps most valuable, e.g. intensive food production (e.g. Leamy, 1975). This may lead to concern that our lands, being under-utilised, will be wasted in other uses. As Wendelken and Hannan (1974) point out, sometimes this kind of concern spills over into a bias in favour of a particular kind of land use (e.g. farming rather than forestry), so long as the land is in some way suited to the use for which a bias is held. The logic of using land for the use to which it is best suited is in part at least based on the premise that the forces of nature will win in the end. Taken to its logical conclusion, this would have the land and its homeostatic properties not merely influencing, but dictating our life on it. Such a conclusion is rejected as absurd. Some other principle must be sought. Designing with nature suggests respect for nature, not abdication of the design role to nature herself. Any pattern of civilised land utilisation involves the assertion by mankind of needs and demands and the bending of the homeostatic properties of land itself to fulfil those needs and demands. Bending, rather than either fracturing or leaving unmodified, seems to be essential to our survival.

The present era of human history is marked by a profound questioning by some sectors of human society of the very character of civilisation, especially the sustainability of civilisation if it be in fact based on unsound notions of human ecology. The extremist views of an ultra-nature-preservationist position are sometimes allied with a reversion-to-nature movement. Such a position can be rejected as an absurdity for all human beings, all of the time. At the other extreme, the exploitative backlash reinforces its all too familiar arrogance towards nature with arguments and actions for economic development that do violence to the finite character of planetary resources. At the same time, this exploitative despotism over nature ridicules the intimate linkage between man and nature that has existed in all persisting human cultures on the earth and derides the ethic of stewardship of creation which has motivated some of the best elements of civilisation in both eastern and western societies. This grossly improvident and materialistic position is likewise to be rejected as an absurdity, for it places no value on human survival or on planetary survival.

Between these two extremes all human societies have to steer some middle course. Inspiration and leadership for each to find such a viable course has been provided by United Nations, through the Stockholm world conference on the human environment and the establishment of the United Nations Environmental Programme as well as through the development of natural resources programmes of UNESCO and other agencies of the United Nations family. More specifically, A World Conservation Strategy has recently been launched by the International Union for Conservation of Nature and Natural Resources (IUCN) which provides an intellectual perspective and practical guidance for concerted action needed at national and international levels for the rational management of the earth's resources. New Zealand has responded to this inspiration by proposing its own New Zealand Conservation Strategy (Nature Conservation Council, 1981).

In this proposal, an organized attempt has been made to provide a framework for integrating the concepts and policies of development and conservation. Development is there understood as

> "the modification of the biosphere and the application of human, financial, living and non-living resources to satisfy human needs and improve the quality of human life."

Conservation is defined as

> "the management of human use of the biosphere to yield the greatest sustainable benefits to present generations while maintaining potential to meet the needs and aspirations of future generations."

Both these definitions are unashamedly anthropocentric in character. In this lies their potential for integration or fusion. Both demand profound reappraisal of the nature of man and identification and characterization of human needs. We cannot be morally content to accept as a valid and legitimate demand any kind of human appetite or want without consideration of its implications for other kinds of human appetites or for the same kind among other people elsewhere or at some future time. Amoral liberalism in economics is untenable in a finite world.

Identification of needs and aspirations and assessment of the demands that arise from them are as necessary for the wise planning and administration of land use as are the assessments of the sustainable supply of "produce" from land of different kinds in different kinds of utilisation. As indicated in the introductory section of the previous chapter, we have enjoyed very commendable coverage of New Zealand in the survey of resources for the supply side of land economics issues. We have also considerable information on land productivity in various uses. Despite the widespread acknowledgement of the importance of economic factors in New Zealand life, we have shown, in general, a strange reluctance to formalise the demand side of land economics questions. Our reluctance to formalise demand extends into a reluctance to morally assess the relative worth of a potentially effective demand. We tend to disparage such assessment as "merely politics."

From its foundation more than two thousand years ago, economics has always been an integral part of politics. Its subordination to politics has been a recurrent characteristic, even in land use issues. Wendelken and Hannan (1974), Lister (1976) and Rockell (1976) each trace historical trends or recent instances in which politics, including institutional politics, have dominated market forces in the resolution of land use conflicts in New Zealand. Other examples could be found. Economists tend to the view that sustained interference with the forces of the market even in a "mixed economy" leads to the need for massive adjustment to market values at some later date. Sustained distortion of a "market economy" or a "mixed economy" serves to cultivate conditions in which pressures, often covertly exercised, affect political decisions more than do principles of sound economics understood in the wide sense.

There is a great volume of information in New Zealand on land needs for different purposes, but seldom is such information harnessed into a comprehensive assessment that would allow fundamental economic values and forces to be expressed. In general, we manifest rather narrow views on the scope of economics, tending to confine it to issues which are merely financial. Thus Baumgart (1976), in reviewing land use and the needs of society, suggested as a "briefly stated policy" on land use:

> "In the interests of New Zealand the long term goals for the management of our land should be to strike an optimum balance between economic and social (*sic*) benefits to be derived from natural resources. They should seek to

make the fullest contemporary use of natural resources without denying to subsequent generations their opportunity to share these resources in their time."

There is no mistaking Baumgart's meaning and there would be general concurrence with his proposed principles of policy, as is shown in the definitions of development and conservation cited from the New Zealand Conservation Strategy. Many professional economists, however, would bridle at the implied exclusion of social benefits from the scope of economics, although some economists are more wont than others to slip back into the market place of the financial tangibles. Welfare economics may have had a renaissance with Pigou, but it had its western foundation in Aristotle more than 2,000 years ago.

> "Economics has to do more with men than with the acquisition of inanimate things and more with human excellence than with the excellence of property which we call wealth." (Politics, Bk 1, Ch.13)

The calculation of comparative value for society of different kinds of land use is a difficult exercise for laymen. We tend to make our private or public choices by invoking factors which we think are special and personal to us. We often eschew the complex analyses and formulae of the economists, little realising that their very complexity often derives from the efforts of the professional economist to take account of the factors which we erroneously believe are special to ourselves.

Social welfare is wisely conceived as some kind of aggregate of net benefits to different individuals or groups with human needs and aspirations which vary widely from one to another. Different individuals and groups have not simply different wants. They also have unequal power and influence in the market. Accordingly, the market economy cannot be expected to bring about the ideal distribution of welfare. Choice of the mix of benefits in this aggregate of public interest is often by political intervention. Political intervention does not itself guarantee an ideal distribution of welfare. Special pleading and various personal interests can influence public choice. What is important for a democratic society is that the considerations which affect public choice should be explicit and open.

Such public choice can be represented in economic parlance just as can be demonstrated the interaction of supply and demand in the market model. A modern but straightforward approach to the economics of public choice has been well expressed by Whitby and Willis (1978):

> "For public activities, objectives may be combined together in a Social Welfare Function (SWF) which states the relationship between progress towards each of a society's objectives and its total welfare. Most readers .... will not have seen an actual SWF because they are essentially a theoretical construct relating to the processes which take place in a politician's mind. One of the controversies in welfare economics relates to the form of the SWF - the way in which the welfare of individuals is combined to give total welfare - but for this text we shall adopt a more pragmatic approach regarding it merely as a list of objectives.
>
> This conveniently allows us to separate the functions of economist and politician. The economist needs to know the list of variables which are included on the right hand side of the SWF, but he may leave the politician to combine the variables together. Of course, this distinction may prove difficult to sustain, because the politician may well ask for advice about the way in which the variables should be combined."

To pursue the goal of having future decisions about the Mavora, or similar resource areas, make some contribution to social welfare, we should, therefore, attempt to attain certain objectives. We should identify social interest arising from needs and desires for the "benefit" of different uses. We should clarify the objectives of different agencies and organizations for the public interest. We should assess the alternative opportunities for the fulfilment of human needs. We should take these into account in suggesting weightings that might be applied to different group benefits in decisions about the use of these Mavora resources.

7.2 THE IDENTIFICATION AND ASSESSMENT OF SOCIAL INTERESTS

No attempt is made to quantify the effective demand for uses themselves or for the produce of different uses. In Table 12 we identify and assess at local, regional, national and international levels the different social "appetites" for the kinds of use involved in the use suitability assessments. In the case of pastoral enterprises, the actual land user is considered separately from the user of the produce. In the case of forestry as well as farming, employment possibilities are considered as pastoral work and forestry work. For recreation, the user

TABLE 12: Assessments of Social Interest in Possible Uses of the Mavora and their Produce or Benefit.

Use	Source of Interest			
	Local	Regional	National	International
Pastoral Use				
Intensive user	Low	Medium	Medium	-
Seasonal user	High*	Low	Low	-
Deer user	High	High	High	-
Pastoral produce	Medium	High	High	Medium
Deer produce	High	High	High	High
Pastoral work	Medium	Medium	Medium	-
Forestry				
Forest produce	Medium	Medium	Medium	Low
Forest work	Medium	High	High	-
Nature Conservation				
Wildlife	High	High	High	High
Vegetation	Low	Medium*	Medium*	Low*
Landscape	High	High	High	High
Recreation				
Group A	Medium	High	High	Medium
Group B	Medium	High	High	High
Group C	High	High	High	High
Group D	Medium	High	High	Medium
Cottages (E)	Medium	High	High	Low
Group Lodges (F)	Low	High	Low*	Low*
Wild Animals				
Commercial	High	High	High	High
Recreational	High	High	High	High
Water Production				
Downstream uses	Low	High*	Medium*	-

* Assessment requires further research (see text).

and the beneficiary are considered identical. The assessments proper are subjective but they have the benefit of a large number of interviews, especially in the region.

7.2.1 Interests in Pastoral Uses

There is evidence of a continuing steady demand in Southland and New Zealand generally for an opportunity to take up farming in a land development project. Although there is continued local interest in maintaining or increasing area in intensive farming, effective local interest in new farms among existing local residents is assessed as low. Local interest is in fact in the promotion of farming. So far as seasonal use of forage resources is concerned, it is expected that demand for this grazing may remain high locally. Further research is indicated as necessary to determine whether farms established already or to be established in the Te Anau-Centre Hill district are likely to need such seasonal grazing supplements. If such a need is not highly probable, the need for seasonal use is likely to be confined to the holder of one or two base farms in the district, yet to be established, together with the run-holder of Elfin Bay to the north-east.

The interest in the "produce" of traditional pastoral use is medium locally, being of some potential significance to local transport and service interest. Regional economic significance in Southland and national significance are both assessed as high because of likely contribution to the earning of overseas income. Such produce would make a small contribution to meet world demand for wool and meat.

For the kind of pastoral land use involving deer-farming there seems to be at present little reduction in the high level of interest, nationally, regionally or locally. Likewise there is high demand for deer farming produce, locally, regionally and nationally in the form of young disease-free breeding stock, and internationally in the form of venison and other deer products. The national interest in such international trade remains high. The social interest in employment would not be substantial for the pastoral uses, apart from the land-holding role. It may, however, be important. Shepherding may be essential for summer grazing use of semi-improved or unimproved grasslands in the Mavora. Intensification of land use in traditional livestock or in deer would be of only minor local or regional significance in increasing employment levels. Although there are not many new jobs created per 1000 hectares by pastoral intensification, the present national and regional employment situation would suggest that the cumulative effect of such a policy of intensification might be very beneficial. The base of the expanding prosperity of the north-west Southland commercial sector is now as well grounded in pastoral farming as it is in tourism.

7.2.2 Interests in Forestry

Although there is currently a shortage of timber locally, requiring imports into the district, it is not expected that any Mavora afforestation programme would contribute greatly to local needs for timber in comparison with the radiata production expected from elsewhere in the locality and region. The quantity or kind of produce that could be expected from Mavora forestry cannot be estimated at the present time to be of high regional or national interest. It is, however, estimated that there could be high regional interest and high national interest in increased employment opportunities from forestry. It is questionable to what degree this interest would be focussed on areas such as the Mavora rather than areas with higher land suitability for production forestry.

7.2.3 Interests in Nature Conservation

There is abundant evidence of high local, regional, national and international interest in fish and wildlife conservation. For vegetation conservation there is not such clear evidence of local interest, but at wider dimensions interest may be affected by research that establishes the taxa and communities present and at risk in the area or else present in scientifically interesting situations such as at ecotones or species' limits. This suggests that, subject to the caveat of possible research outcome, there may be little interest in large scale vegetational reservation. On the other hand there is widespread evidence of local, regional, national and international interest in the conservation of natural landscape. For this interest the physiognomy of vegetation may be more important than its floristics. This almost certainly has implications for forestry and intensive pastoral farming (cf Hayward and O'Connor, 1981). The possibilities for landscape enhancement by such uses cannot be ignored.

7.2.4 Interests in Outdoor Recreation

In a major study recently published (Aukerman and Davison, 1980), mountain lands recreation is defined as "people using mountain lands in their leisure time to fulfil their human needs." As these authors point out, there is a great variety of such needs. We can discern in different people the need for solitude or for chosen companionship, the need for variety and exploration, the need to return to the recollected familiar, to something seeming timeless and unchanging in an ever-changing world, the need to meet a challenge and prove a skill, or the need to be enriched and satisfied with natural beauty, the need for relief from tension or the need to be emptied of self and immersed in the contemplation of a milieu of new proportions. As Aukerman and Davison indicate, we have very little quantitative information on the human needs of people seeking mountain recreation. We have some indication of their wants and their recreation behaviour, but "serving the wants of existing users without reference to needs may lead to self-perpetuating excess, luxury and diversion of resources from other potential users" (Aukerman and Davison, 1980).

For the purpose of this present assessment we make a classification of recreation into groups of activities which are determined by the behaviour of the user as well as the nature of the resource dependence, the nature of the resource impact and the interaction of the recreational activity with other recreation activities:

(A) Wilderness - dependent recreation, including some back-pack tramping, hunting and mountaineering. This corresponds with the land utilization type RWD (Section 6.3.51).

(B) Natural area and open space recreation which has only small or local environmental impact and high within-group compatibility, including back-pack tramping, foot-hunting, climbing, fishing, cross-country skiing and other on-foot activities. Horse-trekking and canoeing are included in this group as local "conditional" uses. In the main, this set corresponds with land utilization type RNAD (Section 6.3.52) and most of ROSD (Section 6.3.53).

(C) Outdoor activities of low or local environmental impact but demanding vehicular access to the site of the activity, including tent and trailer-camping, picnicking, nature study, sail boating and canoeing, fishing, swimming, ice-skating. In general, this set may be accessory to land utilization type ROSD (Section 6.3.53) but corresponds principally with local areas of RRBM (Section 6.3.54).

(D) Resource-based outdoor activities of substantial environmental impact and of generally low compatibility with group A, B or C activities, including power boating, water skiing, trail biking, 4-wheel driving, motorised hunting or touring, skiing (skifield). This corresponds with part of land utilization type RRBM (Section 6.3.54).

Regionally and nationally, interest in all four of these groups is assessed as high. The only one for which interest is assessed as high locally is group C, especially for family parties. Other groups of recreation activities are assessed as having medium local interest. International interest by visitors to New Zealand and especially to the Southern Lakes area is indicated to be high for groups B and C and medium for groups A and D. Several overseas visitors at Te Anau have expressed great satisfaction with the opportunity for quiet group C recreation activities at Mavora. The interest of international visitors in two or three day walks is likewise evident, corresponding to Natural-Area-Dependent and Open-Space-Dependent activities of Group B.

Interest in built accommodation is assessed as low locally, high regionally, medium nationally and low internationally at the levels which might be expected at Mavora. Had there been road access to Mavora fifty years ago it might have had fishing lodges erected on its shore for overseas visitors and others, as did Wakatipu, Hawea and Wanaka. (It is doubtful whether high national interest would arise at present, when the limitations of sunshine are realized.) The growth in affluence and the independence of private motor transport have reduced the need for such accommodation away from major holiday centres such as Queenstown and Te Anau. A large appetite still exists for second homes and holiday cottages (Group E), both nationally and regionally, although there has been some evidence of a recession in effective demand. Locally there is probably still some latent demand for a hunting or fishing crib in an area such as Mavora, even though it has been the policy of the land administering agency to require the removal of such cribs when they lacked legal tenure.

The appetite which is more complex to determine is that for lodges and cabin complexes (Group F), especially for schools, adventure trusts and other groups. This appears to be high regionally but <u>for the Mavora</u> it is low locally, as well as nationally and internationally. It might be heightened nationally and internationally as a consequence of walkway designation, especially for the road-end area at the Mavora Lakes. The national interest in such facilities remains

Recreational access bridge across the Mararoa river provides for dispersal of both enjoyment and impact (19).

Proposed recreational development area in the Campbell subsystem, showing enjoyment (above) and impact (below) of off-road vehicle use. Even in a development area, safeguards must be designed to minimise environmental damage (20, 21).

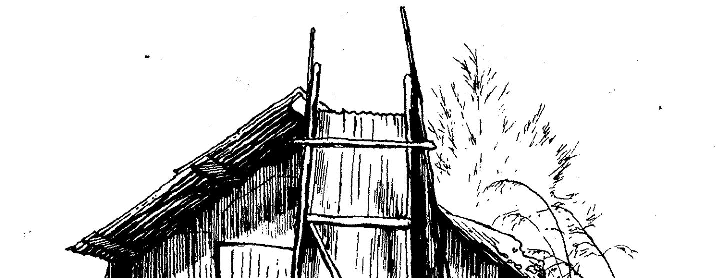
generally high, but there is no evidence that there is at present substantial interest from outside the region in such an area as the Mavora. In contrast, there might be wider interest in such a facility in the Greenstone.

7.2.5 Interests in Wild Animals

At all levels interest is high in both commercial hunting and in recreational hunting of wild animals. Whether such interest in commercial hunting will change as deer-farming becomes more firmly established remains to be seen. There seems little prospect of reduction in interest in recreational hunting. It should also be noted that there is a continued local, regional and national interest in effective control of wild animal populations for the sake of vegetation conservation and natural revegetation. Regionally and nationally, this interest has traditionally been expressed chiefly in official concerns for "water and soil values". Were recreational and commercial hunting to wane for any reason, this regional and national interest in animal control would still exist. It is doubtful if control at public expense could be readily justified as a priority for soil and water values, in comparison with other areas in the region, because of factors working against downstream or other offsite economic significance. Nevertheless, interest in animal control would still be justified for the preservation of scenery as traditionally valued.

7.2.6 Interests in Downstream Water

There is substantial interest regionally in downstream water regimes, especially in low flows, as indicated earlier, provided that diversions can be made to the Oreti system. There is a low local interest, not because of neglect of this resource but because it is recognized that water quality and flow regimes are more affected locally by influences below the lakes. The national interest is also involved in the possible Oreti augmentation with its potential for economic development in the region, but it is also involved because of the small contribution of the Mararoa at present to the Manapouri hydro-electric system.



CHAPTER EIGHT
Policies, Goals and Objectives of Government Agencies, Local Bodies and Community Organisations

Policies, goals and objectives as expounded on page 4 of this report have been identified for agencies and organisations which have important roles or influence in the Mavora. Representatives of each body were separately interviewed, their official documents of policy were studied and draft statements in the format presented were prepared for comment and discussion with the representatives concerned. Although every effort was made at this stage of the study to represent policy accurately and to the satisfaction of the party involved, these statements should not be considered as binding on any of the parties concerned.

It is emphasised that the policy of each organisation is related to the purpose for which it is constituted, whether this be administration of Acts of Parliament or the fulfilment of objects of the constitution appropriate to each. Nevertheless, it may be recognised that there is some convergence of policies among organisations on many important issues. When similar goals are identified there is often concordance in the objectives proposed as instrumental to these goals. Even where convergence is lacking, the possibility can be seen of reconciliation of potential conflicts by separation of such conflicting uses within the study area.

The value of this presentation is to allow the ready identification of those aspects in which there is agreement on goals and objectives and those about which there is divergence. It is also useful to identify the convergence between the assessed social interests at local and regional level and the stated objectives for local bodies, government agencies and community organisations.

It should be noted that the dimensions of concern or responsibility of many of the organisations represented are much wider than the Mavora. We have represented their policies, goals and objectives as they are relevant to the Mavora. For many organisations the immediate zone of responsibility extends beyond the boundaries of the Mavora study area, e.g. New Zealand Forest Service and Snowdon and Eyre Forests, Department of Lands and Survey and the Centre Hill and Mavora Farm Settlements. For the Fiordland and Aspiring Park Boards, the zone of responsibility does not include the Mavora proper even in part, but their zone of concern with it is as a present buffer area to a national park.

Policy statements are presented in summary form for each organisation in turn.

WALLACE COUNTY COUNCIL

Policy:		Protect in the public interest the Upper Mararoa and Windon Burn catchments for their scenic values. (Reserve for recreation and open spaces.)		Encourage wise land use and make better provision for the conservation, use and quality of natural water, and to promote its multiple use, as well as to promote soil conservation and prevent damage by flood and erosion (zoned for watershed conservation).
Goals:	1.	Active maximum recreational benefit and preservation of environmental quality.	2.	Achieve water and soil conservation.
Objectives:	1.1	No buildings will be permitted within 1000 metres of the lake edge of the Mavora Lakes.	2.1	Prohibit farming except where this would abrogate provisions of existing pastoral leases and pastoral occupation licences (underlying zoning of Rural B2).
	1.2	Power boats to be prohibited on South Mavora Lake and the Upper Mararoa River between the two lakes. Power boats will be permitted on the North Mavora Lakes subject to suitable controls.		

SOUTHLAND CATCHMENT BOARD

Policy:	Ensure efficiency in major uses of water resource consistent with maintenance of soil, river and stream stability and water quality standards, and have due regard to recreational needs and the safeguarding of scenic and natural features, fisheries and wildlife habitats.		
Goals:	1. Maintain land stability.	2. Augment and regulate downstream water supply for domestic, industrial, agricultural and hydro-electric purposes.	3. Maintain water quality for fisheries and appropriate recreations.
Objectives:	1.1 Achieve retirement from grazing by domestic and feral animals of all Class VIII land and, where appropriate, severely eroded (Class VII) land.	2.1 Reserve land for water management purposes. Exclude stock or allow limited grazing only to encourage recovery of native flora, especially snow tussock, for interception and water retention, particularly in respect to low flows.	3.1 See 1.2
	1.2 Berm fence or prohibit grazing to maintain river-bank stability, with the additional benefits of reduction of organic and inorganic pollution and protection of fisheries in maintaining water quality and spawning grounds.	2.2* Divert water from Mavora Lakes to the Oreti River for agriculture, domestic and industrial purposes, (1) at low summer flow when value for power generation is low, or (2) during flooding into a storage dam when flood water would otherwise be wasted over the Mararoa Weir.	
		2.3* Dam the Oreti River for storage in conjunction with 2.2.	

* These two objectives imply a prior objective of investigating their feasibility.

SOUTHLAND ACCLIMATISATION SOCIETY

Policy:	To preserve, conserve and manage wildlife and freshwater fisheries, especially the Mavora brown trout fishery and the birdlife of the Mavora area.	
Goals:	1. Ensure the developments and changes of land use that may directly or indirectly affect fisheries and wildlife, but more particularly their habitats, are compatible with the policy.	2. Maintain relative isolation, scenic beauty, wildlife and general tranquility as factors which add much to the quality and enjoyment of angling.
Objectives:	1.1 Oppose residential and restrict agricultural developments as detrimental to fisheries and wildlife.	2.1 Restrict the erection of buildings associated with camping, residential use or commercial development.
	1.2 Restrict the influence of cattle grazing in river valleys to maintain stream stability, fisheries and wildlife habitat.	2.2 Prohibit the use of power-driven boats on the south Mavora Lake and limit their use on the north Mavora Lake.
	1.3 Prevent introduction of predatory or incompatible species, e.g. domestic cats and dogs.	2.3 Maintain prohibition on shooting game birds.
		2.4 Maintain absolute protection of non-game birds.

FEDERATED FARMERS OF NEW ZEALAND (INC.), SOUTHLAND PROVINCIAL DISTRICT

Policy:	Encourage land settlement and fullest use of unoccupied land, creating farm units of such size as to ensure efficient farm production.		
Goals:	1. Ensure that areas in the Mavora which are suitable for grazing and other appropriate activities are fully utilised and on no account lost to farming.		2. Maximum environmental, recreational and water protection values (subject to Goal 1).
Objectives:	1.1 Develop and topdress 3,000 hectarés of Class VI land at the head of the North Mavora Lake for grazing.		2.1 Use grazing to prevent the area from becoming a fire hazard generally, and in particular to Mount Aspiring National Park and Snowdon State Forest.
	1.2 Provide road access to the top of the North Mavora Lake for the development process.		2.2 Use grazing, limited if necessary, to maintain existing native cover.
	1.3 Lease the above area for grazing when developed to private individual settlers in adjoining areas or as a run on special tenure.		2.3 Ensure that recreation activities carried out are appropriate to the mountain environment and not destructive of fragile ecological systems.
	1.4 Investigate potential as a breeding area for calves to supply to down country farmers for fattening.		2.4 In particular, develop and maintain the Mavora Lakes and their immediate environs for appropriate recreation activities.
	1.5 Assess other possible associated uses such as hydro-electricity production.		2.5 Ensure adequate protection of the bush and red tussock reserves as part of an integrated preservation and recreation plan for the wider Mavora region.

DEPARTMENT OF LANDS AND SURVEY

Policy:	Make use of existing natural resources while preserving environmental and visual qualities and at the same time having regard to productivity and potential productivity.		
Goals:	1. Preserve from use that which will destroy or diminish these environmental and visual qualities.	2. Continue grazing of open areas while maintaining and improving vegetation cover and environmental quality.	3. Encourage active and passive forms of outdoor recreation compatible with public enjoyment of these qualities.
Objectives:	1.1 Preserve any area or feature of natural significance by classification as a special area. 1.2 Prohibit facilities that can be located outside the area, e.g. farm buildings and holiday homes.	2.1 Manipulate grazing to maintain vegetation in a condition acceptable for fire protection, weed control and public recreation, with spot spraying of weeds as required.	3.1 Encourage recreational activities in harmony with the environment, such as picnicking, hiking, horse-riding, some types of boating, fishing and swimming, though recreational use of any area may be limited to a level within carrying capacity assessed by impact. 3.2 Discourage recreational activities not in harmony with the purpose of the area or lessening enjoyment of the area by others. 3.3 Provide basic picnic and toilet facilities in areas of concentrated public use or for public safety and health. 3.4 Establish access and internal roads sufficient only to avoid concentration of people at any one area and attain acceptable patterns of visitor distribution. Road standards should relate to recreation values of minimum development encouraging low speeds for safety.

NEW ZEALAND WALKWAY COMMISSION

Policy:		Provide public access by foot to the countryside for both physical recreation and enjoyment of natural and cultural environment.
Goals:	1.	Establish a system of walking tracks of varying degrees of difficulty and amenity to cater for a spectrum of user capacities, while respecting the rights of both public and private property holders.
Objectives:	1.1	Develop to Walkway standard the existing track beside the Mavora Lakes, along the upper Mararoa River and joining the Greenstone Track, as a Walkway, to route or track standard.

FIORDLAND AND MT ASPIRING NATIONAL PARKS

Policy:		To secure to the public the fullest proper use and enjoyment of the parks consistent with the preservation of its natural features and the protection and well-being of its native flora and fauna.
Goal:	1.	Support adequate buffer zones that will enhance the national parks' protection role through maintaining remoteness and accommodate recreation that might otherwise create undue pressure on national parks.
Objectives:	1.1	Oppose roading development such as the proposed Greenstone Valley road, as this would effectively destroy the Mavora/Greenstone buffer zone.
	1.2	Encourage proposals appropriate to maintaining the buffer area, e.g. support the Walkway proposal, management of the Mavora area for recreation and other uses consistent with maintaining environmental quality.

NEW ZEALAND FOREST SERVICE: SNOWDON STATE FOREST

Policy:	Satisfy as fully as possible recreational demands providing natural systems are protected, taking into consideration the total valley system including rivers and lakes, regardless of tenure.				
Goals:	1. Maintain the forest in a thrifty condition so that the widest possible range of forest use options is kept open.	2. Conservation of quantity and quality of soil, including minimising flooding, protection of down-stream values and maintaining a high quality water yield.	3. Protect indigenous fauna and their habitat.	4. Preserve scenic, aesthetic and historical values.	5. Satisfy compatible recreational demand and encourage family participation.
Objectives:	1.1 Maintain protection from fire. 1.2 Maintain animal census and control by recreational and other appropriate hunting.	2.1 Maintain forest consistent with Forest Protection* zones. 2.2 Establish and maintain survey of catchment condition.	3.1 Zone Ecological and Forest Sanctuary* areas. 3.2 Protect from grazing and browsing.	4.1 Zone Forest Sanctuary and Protection zones*. 4.2 Acquire all forest land for preservation.	5.1 Zone a narrow strip of land along the eastern shores of the Mavora Lakes as Amenity Zone* and confine development to this. 5.2 Zone if necessary this Mavora area in more detail, e.g. separate camping and picnicking. 5.3 Zone the lakes to separate or exclude non-compatible pursuits. 5.4 Provide limited basic facilities.

Zoning adopted by the New Zealand Forest Service includes: *Protection is a primary zone class in New Zealand State Forest Classification. Forest Sanctuary, Ecological and Amenity zones are among the 20 categories that may be imposed on the primary Protection, Production and Recreation zone classes.

FEDERATED MOUNTAIN CLUBS OF NEW ZEALAND

Policy:		Safeguard and promote the sound development of all mountain districts with the wisest long term use of the natural environment.
Goals:	1.	Prepare a recreation and conservation plan for New Zealand, zoning for a variety of dominant uses, i.e. catering for maximum of recreational uses while ensuring minimum overlap of conflicting uses and undesirable impact on the landscape.
Objectives:	1.1	Ensure that the draft plan is considered in planning for the Mavora Lakes area, i.e. the upper Windon Burn and most of the upper Mararoa as a Natural Area*, the immediate Mavora Lakes water shed as Open Space*, and the south Mavora Lake as a Recreation Area*.
	1.2	Investigate the potential of the Snowdon/Dunton Range for skiing.

* Definitions after Molloy (1976) as applied here are, in brief:

Natural Area: Natural landscapes and vegetation predominate with minimum development (huts, tracks and bridges) for foot recreation.

Open Space: Containing uninterrupted vistas and sufficiently large open areas to reduce man and his works to a small scale compared with the landscape. Appropriate open space areas include tussock, scrubland, wetland, etc., rather than forest. There may be a low level of man-modification.

Recreation Area: Generally a small area with appeal to the public at large, family groups, etc. Picnic sites, nature walks, shelters, ski tows and lodges and appropriate developments. It is desirable that recreation areas are reasonably close to urban centres.

CHAPTER NINE
Alternative Opportunities for the Satisfaction of Local Needs

9.1 PRINCIPLES AND THEIR APPLICATION

It is a sound principle of resource use planning to consider alternative opportunities which may exist for the satisfaction of human needs or social demands. Especially is this a valuable procedure where there are potentially conflicting demands for the use of the resource in question. It may be that for one demand there are no alternative means of supply. For other demands there may be such alternatives. If each use or benefit had otherwise equal weighting, the case could be strengthened for allocating the resource to that use which could not otherwise be practised. Such a procedure was developed more than a decade ago by Gibbons and associates in presenting a case for conservation of the Little Desert in Victoria, Australia. In like manner, an assessment of alternative opportunities for practising likely uses in the Mavora is therefore made. Greatest attention is given to the uses for which there is local and regional high demand. National and international interests generally have wider opportunities for alternative satisfaction. Some attention, however, would be given to such national and international interests when they belong to national or international visitors in the locality or if such interests had little or no alternative opportunity for satisfaction. For the local and regional area alternative opportunities are assessed therefore as nil, low, medium, or high.

9.2 ALTERNATIVE OPPORTUNITIES FOR PASTORAL USE

It is expected that more than 300 farm units will eventually be developed for settlement from the current land development programme of the Department of Lands and Survey in western Southland. Although there is substantial demand for such farm units as they become available, it must be conceded that real alternatives to the Mavora study area exist as sites for development toward intensive pastoral farms, even though many of these in the region are at present in private tenure as partly developed farming land or in pastoral leases. Alternative opportunities are assessed as high.

For deer-farming and deer produce, high opportunity also exists on existing farming properties in the Mossburn-Te Anau district as elsewhere in New Zealand.

What may not so readily be found is a suitable site for an intensive or semi-intensive deer farm if the Government were called upon to establish a nucleus disease-free or special breeding herd for the benefits of the industry. In this respect some consideration has been given to the possible sites for a wapiti breeding herd which could be isolated from cross breeding with the more common red deer populations. For such a special use the alternative opportunity seems low but it could be expanded by negotiation elsewhere.

For seasonal grazing use there is no satisfactory alternative available for the Elfin Bay run than the Upper Mararoa valley. For seasonal use in the vicinity of Mavora Lakes, where animals would come from the south, the only alternatives available, were such seasonal supplementary grazings found to be necessary, would be in the Upper Oreti or elsewhere within the present farm settlements. The Upper Oreti appears unsuitable for pastoralism because of erosion damage and erosion risk. Elsewhere within the farm settlements land could be reserved for seasonal use but only by foregoing its intensive development and settlement. Such lands might still suffer from summer drought, the very factor from which relief would be sought. It might be inferred, therefore, that there is a real and valid need for seasonal grazing for which there may be little or no alternative opportunity. For that conclusion to be sound and relevant, further research and investigation must demonstrate that there will be a regular or frequent need for such seasonal grazing both during and after the present land development phase. It would also be prudent to establish that alternative supplies of supplementary feed could not be economically provided by feed imports or irrigation. It would also need to be established that livestock could adapt to and use any semi-improved pasturage in the Mavora. Finally, it would be necessary to show that foregoing the full development of part of the remaining Mavora Farm Settlement and Centre Hill Farm Settlement and retaining such portions for seasonal use would not be a more feasible and beneficial alternative. In summary, alternative opportunities for seasonal pastoral use are assessed as medium, but conditional on further investigation.

9.3 ALTERNATIVE OPPORTUNITIES FOR FORESTRY

Production forestry opportunities are substantial in western Southland, both in state forests and on privately held farms or farms to be privately held following land settlement. As indicated earlier, the prospects for production forestry appear to be much more promising in the central and southern parts of Wallace County than in this northern extremity, the Mavora. Production/protection plantings have similar opportunity and may have much greater value in the Takitimus or in the Oreti headwaters related to the Eyre State Forest remnants. In summary, alternative opportunities for forestry use are assessed as high.

9.4 ALTERNATIVE OPPORTUNITIES FOR WATER PRODUCTION FOR DOWNSTREAM ABSTRACTION

So far as the management of the Lower Mavora is concerned it would appear both from Howard's (1973) discussion of the downstream implications of land development in this district and from the discussion in this study of use suitability (6.3.3) of the Mavora area for this purpose, that water regimes and quality can be better ensured by action below the Mavora Lakes than above them. So far as augmentation of low flows in the Oreti is concerned there is the possibility of benefit from Oreti catchment rehabilitation, but no feasible measure in the Upper Oreti could be expected in the short term to provide the gains in low flows likely to be projected by the proposed abstraction from the Mararoa. Thus alternative opportunities for augmenting downstream flows seem to be low but the relevance of this factor to catchment land use seems to be minimal, except for riparian land.

9.5 ALTERNATIVE OPPORTUNITIES FOR NATURE CONSERVATION

It may be argued that the Fiordland and Aspiring National Parks together provide abundant opportunity for nature conservation in the region. The fact that the Mavora extends into a less humid area than do these national parks suggests that there might be elements of the flora and possibly of the fauna of southern New Zealand which might be better served by reservation in the Mavora than in these two national parks. This would require further field research to determine.

Some particular vegetation conservation objectives call for comment in respect to alternative opportunities. There are probably few opportunities other than the Livingstone mountains for the conservation of southern representative tall tussock grasslands and other vegetations on ultramafic rock. In this respect, it may be of considerable genetic significance also to conserve representative areas of such vegetations growing on adjacent zonal soils. The second objective is the conservation of representative areas of lowland and upland Southland red tussock. A few years ago there seemed such an abundance of such associations, even though modified. At the present time there are few representative areas available for conservation.

Only as a result of the most strenuous campaigns by botanists have the land administering authorities been persuaded to reserve even modest areas in little modified condition. The third objective is conservation of wetlands and wetland communities in which northwestern Southland was once so rich. The Upper Mavora and the adjacent area of the Upper Upukeroa to the west are probably of acute significance for this objective.

In so far as several of the bird species of the Mavora are in varying degree threatened with extinction, it cannot be claimed that there is any valid alternative opportunity for their conservation so long as they remain threatened. The brown trout fishery of the Mavora which is claimed to provide angling of very high quality is not likely to be matched in the region. In general, therefore, the alternative opportunities locally and regionally for conserving natural systems such as are represented in the Mavora, are low.

9.6 ALTERNATIVE OPPORTUNITIES FOR RECREATION

Assessment of alternative opportunities for recreational activities of the several groups identified has been made by study of management plans being prepared for public lands in the region as well as by reference to the regional mountain land recreational resources identified by Smith *et al* (1980).

There are opportunities for genuine wilderness recreational experience, those of Group A (7.2.4), in sectors of the Fiordland National Park. There are opportunities for Natural-Area-Dependent recreation, the main part of Group B, also in the Fiordland National Park, in the Caples-Greenstone area, in Mt Aspiring National Park and in the more intact parts of the Eyre Forest. There are comparatively few other regional opportunities besides the Eyre and Takitimu mountains for such recreation, even of Open-Space-Dependent kind, especially opportunities readily accessible and suitable for family group participation. For this reason no doubt, the suggested Upper Mararoa-Mavora sector of the National Walkway has been recognized as fulfilling a vital local and regional need which could not otherwise be easily served. Group C recreation, the quieter kind of resource-based activities, requiring vehicle access but with only local impacts, has comparatively few alternative opportunities even in the Te Anau area. In the eastern part of the district, in the vicinity of Mossburn, there are few legally accessible opportunities and none that would rival the Mavora for quality. So far as the activities of Group D are concerned, Lake Te Anau district provides ample opportunity for some. It is possible that opportunities for four-wheel drive and other off-road vehicles could be devised in the Oreti or wider Five Rivers area.

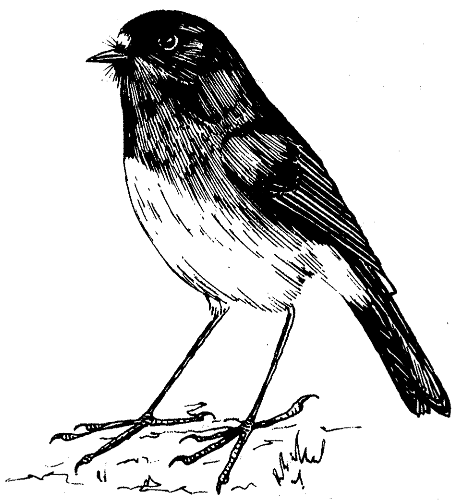
Alternative opportunities for dispersed cottages are now at a premium as in most parts of southern New Zealand, in keeping with the general trend of district planning schemes. There are, however, some signs of change in this situation, for clustered cottage opportunities are increasing. Alternative opportunities for lodge or cabin-complex accommodation (Group F) are limited in the locality proper, although there are such facilities in the Te Anau area and such places as the Borland Lodge have provided such a facility elsewhere in the northern part of the Southland region.

In summary then, alternative opportunities for satisfaction of recreation interests locally and regionally can be assessed as follows:

Group A (Wilderness-Dependent, RWD):	Medium
Group B_1(High for Natural-Area-Dependent, RNAD) Group B_2(Low for Open-Space-Dependent, ROSD) :	Medium
Group C (Vehicle-accessible, RRBM with little and localised environmental impact):	Low
Group D (Vehicle-accessible, RRBM, but substantially resource-modifying):	Medium - high
Group E Vacation Building (Cottages, etc.) Dispersed:	Low
" " " " Clustered:	High
Group F Vacation Building (Lodges, etc.):	Medium

9.7 ALTERNATIVE OPPORTUNITIES FOR WILD ANIMAL USES

It is becoming increasingly obvious that alternative opportunities of wild animal hunting or capturing are being steadily reduced by helicopter operation. So long as economic profitability of venison recovery or deer capture is sustained it can be expected that there will be continued reduction of the wild animal resource. Accordingly the opportunities for recreational foot-hunting will be further reduced (cf Simmons and Devlin 1981). It should also be observed that the two forms of wild animal use proposed for the Mavora, strict population control by all viable means, and herd management for recreational hunting, tend to be mutually exclusive. Furthermore, recreational hunting is unlikely under present regimes to remain practicably feasible if alternative opportunities for commercial hunting are elsewhere reduced to negligible levels. The control and possible elimination of such wild animals from Fiordland National Park, in accordance with policy, therefore can be expected greatly to reduce the alternative opportunities for commercial and recreational hunting. Even though other opportunities at present exist, current trends would suggest that alternative opportunities both in commercial and recreational hunting in the locality and region will fall to a low level. The potential implications of "helicopter poaching" recreational hunting areas are serious, just as they have been elsewhere in New Zealand. If commercial hunting remains economically viable and legitimate as an activity in the region it would be only by the most stringent policing that an area could be effectively dedicated for recreational hunting only.



CHAPTER TEN
Weighted Assessment of Possible Planning Objectives for the Mavora Area

10.1 THE PRINCIPLES OF WEIGHTINGS

In their exposition of a pragmatic and straightforward approach to social welfare functions, quoted in Chapter 7 of this study, Whitby and Willis (1978) expressed their preference to list several objectives, leaving to the politician the weighting of benefits to different groups or individuals that would come from pursuit of different planning objectives. They also foresaw that the economist or resource planner should be ready to suggest weightings that might be assigned to individual benefits. In an earlier edition of the same work (Whitby *et al*, 1974) the authors indicated how weightings assigned explicitly or implicitly to individual net benefits affected the sum of benefits which constitute social welfare:

$$\text{Social Welfare} = a_1B_1 + a_2B_2 + \ldots\ldots a_nB_n$$

where B_1, B_2, etc. are the net efficiency benefits accruing to each individual and a_1, a_2, etc. are the weights attached by society to an increase in the welfare of each individual. Political scientists and economists recognize that it is possible to discern such weightings from analysis of political decisions.

Our intention here is to suggest weightings that might be applied to a series of planning objectives, the promotion of each in turn of the land utilization types outlined in Chapter 6. We bear in mind the likely distribution of benefit to society from each one, gauged from the social interest assessed in Chapter 7, and the alternative opportunities for the satisfaction of needs assessed in Chapter 9. The suitability of the resources for each land utilization type is not included in these weightings. Only those land utilization types which appear suitable in some degree for the Mavora are considered as planning objectives.

It is clear that net benefits identified for different land utilization types and expressed in the suitability assessments (Table 11 in Chapter 6) are qualitative rather than quantitative. For this reason, there is no justification for expressing weightings for these benefits as specified values. Instead, weighting coefficients are proposed as <1, 1, >1, $>>1$, indicating less than 1, 1 or no weighting, more than 1, much more than 1 respectively. In some cases a weighting is expressed in parenthesis, indicating that it is conditional upon results of further investigations. In each case summary notes are provided, indicating reasons for the weightings proposed.

10.2 PROPOSED WEIGHTINGS

10.2.1 Pastoral Planning Objectives

10.2.11 Pastoral Intensive Self-contained (PISC)

Weighting <1. Low local interest. Alternative opportunities are available for the regional interest. Few potential user beneficiaries but potentially significant for more numerous "produce" beneficiaries, regionally and nationally.

10.2.12 Pastoral Semi-intensive Accessory (PSIA)

Weighting >1. Local interest is either confined to Elfin Bay runholder or subject to further examination of needs following development of other sectors of local Farm Settlements. Alternative opportunities are uncertain for this second group but are non-existent on Elfin Bay run for the same kind of terrain as in the Upper Mararoa. Potentially significant produce benefit, regionally and nationally, from the combined produce of this Mararoa use and development of base areas (e.g. Elfin Bay). Increased weighting is indicated for potential deer farming at this level.

10.2.13 Pastoral Extensive Regular Accessory (PERA)

Weighting 1. Local interest is dependent on continuation of present farming operations or on emergence of similar need in subsequent settled farming pattern, for which PERA would be of less net benefit to fewer beneficiaries than PSIA.The land use as specified involves strategic oversowing and topdressing but little fencing. Benefit/cost ratios would be at best moderate in such conditions. Alternative opportunities are uncertain.

10.2.14 Pastoral Extensive Irregular Use (PEIU)

Weighting <1. Local interest at present is very low and likely to be less than PSIA. There is little benefit beyond the locality. Alternative opportunities, like those for PSIA, remain uncertain. Sustainability without topdressing is doubtful and accordingly social benefits may be exceeded by social costs.

10.2.15 Pastoral Deer Farm Adjunct (PDFA)

Weighting >1. Potentially of some significance to deer farming industry. Alternative opportunities for specific purposes remain somewhat uncertain. It also warrants more thorough investigation for possibilities of integration with recreational hunting, especially if range condition improves with reduction in grazing.

10.2.2 Forestry Planning Objectives

10.2.21 Forestry Commercial Production/Protection (FCPP)

Weighting <1. Local interest currently low and alternative opportunities are high.

10.2.22 Farm Forestry Adjunct (FFA)

Weighting 1. Local interest currently low but would grow if there were development of PSIA and PDFA. Various benefits could be widely distributed, especially in locality and Southland region. Alternative opportunities are readily available for farm forestry in the district with superior opportunities elsewhere in the region.

10.2.3 Nature Conservation Planning Objectives

10.2.31 Wildlife Conservation to Maximum (WCX)

Weighting >1. Local, regional and national interests would benefit through enhancement of fishery and other recreational enjoyment of nature as well as from the conservation of possibly threatened biota. Alternative opportunities for many species are available. Few alternatives match quality of the brown trout fishery. This quality could be enhanced if full protection were given to spawning waters and natural feed supplies.

10.2.32 Wildlife Conservation to Moderate Level (WCM)

Weighting >1. Comments as for WCX.

10.2.33 Vegetation Conservation to Maximum (VCX)

Weighting 1. Recreation of Group B, dependent on Natural Area, would benefit somewhat. Interests in maximum conservation are moderate at present and further research would be necessary to justify any claim for larger or wider benefit. Alternative opportunities in precisely similar range of environment are low and may be nil for some specific objectives.

10.2.34 Vegetation Conservation to Moderate Level (VCM)

Weighting 1. The scientific benefits of a selective reservation policy are sufficient to validate this objective at present. Further research could lead to a higher weighting if relict or other important vegetation systems were discovered. Alternative opportunities in similar environments may be very limited.

10.2.4 Recreation Planning Objectives

10.2.41 Recreation - Wilderness-Dependent (RWD)

Weighting 1. Potential beneficiaries must be few because small area available would be able to provide strict wilderness values for only very few at a time. Alternative opportunities for wilderness recreation (Group A) exist in region.

10.2.42 Recreation - Natural-Area-Dependent (RNAD)

Weighting >1. Potential beneficiaries are more numerous than RWD, with high level of interest. Alternative opportunities are available in the region but are not readily accessible for the full range of Group B recreation activities that depend on Natural Area.

10.2.43 Recreation - Open-Space-Dependent (ROSD)

Weighting >>1. Potential beneficiaries are numerous, especially family groups, with generally high level of interest. Alternative opportunities are not abundant and are of generally lower quality and lower suitability for family groups seeking Group B activities suited to open space.

10.2.44 Recreation - Resource Based but Resource Modifying (RRBM)

10.2.441 For Activities of Group C

Weighting >>1. For these activities for which powered vehicles are necessary only to the point of recreation, there is high interest, especially among local residents and visitors to the locality. Beneficiaries are numerous and potentially more so. Alternative opportunities are not abundant and are of generally lower quality.

10.2.442 For Activities of Group D

Weighting <1. For these activities for which powered vehicles are necessary as an integral part of the recreational activity, there is generally high interest but it is not so marked among locals or international visitors. Beneficiaries are numerous. Alternative opportunities are medium and at present are available or could be made available elsewhere in the district or region. For some particular activities alternative opportunities are high in the district. Their overall discordance with the Mavora environmental character earns their poor weighting.

10.2.45 Recreation - Vacation Building Development (RVBD)

10.2.451 For Cottages, Cribs, Holiday Homes, etc. (Group E)

Weighting <1. Potential beneficiaries could not be numerous, despite the high interest regionally and nationally, because construction would soon alter the benefit to be the equivalent of having a building at, say, Te Anau or Manapouri. For isolated or dispersed cottages there are few comparable opportunities available but for holiday homes or cottages aggregated in mountain-lake settings there are increasingly abundant opportunities.

10.2.452 For Lodges and Cabin Complexes (Group F)

Weighting 1. High regional interest signifies potentially numerous beneficiaries. Further investigation might reveal further need and potential benefit in conjunction with the development of National Walkway. Alternative opportunities are available for lodges generally but perhaps of lower location quality. Alternatives would not be readily available if lodges or cabin complexes were necessary for a National Walkway through the Upper Mararoa-Mavora.

10.2.5 Wild Animal Planning Objectives

10.2.51 Strict Population Control (WASPC)

Weighting 1. Direct beneficiaries are few in number but locally and regionally significant. Indirect beneficiaries from strict population control would principally be the same as benefit from VCX. Alternative opportunities exist for deer capture and venison recovery which have been involved in effective control measures but such opportunities are steadily being reduced.

10.2.52 Herd Management for Recreation (WAHMR)

Weighting >1 (>>1). Direct beneficiaries are much more numerous, locally and regionally than for WASPC. Few alternative opportunities are available. Provided investigations showed that there would be no less vegetation conservation benefit than from WASPC and no aggravation of problems to adjacent areas, the conditional weighting (>>1) could apply.

10.2.6 Water Management Objective

10.2.61 Water Management for Downstream Uses (WMD)

Weighting 1. Regional beneficiaries are numerous but significance of upper catchment management to the possible downstream purpose requires research if it is to be determined.

CHAPTER ELEVEN
Combination of Resource Uses

11.1 MULTIPLE USE MANAGEMENT PRINCIPLES

Multiple objective planning such as this study has involved may or may not involve multiple use management. As O'Connor (1972) pointed out with regard to recreation in New Zealand mountains, it is unlikely that recreational use will ever be a single purpose use except on very small tracts. It was there pointed out from Clawson and Knetsch (1966) that the interweaving of different uses such as recreation, grazing and timber harvesting on different areas within such a body of land as a national forest can be interpreted as "multiple use management, on this scale and in this sense." Clawson and Knetsch also identified as a growing system of multiple use management the use of the one tract of land "for two or more purposes either at different times of the year or simultaneously." They went on:

> "Accomplishing this will require a thorough study and analysis of the resources and their potential and of the demand. The result will be the establishment of levels of use of the resources on various areas that represent optimum combinations of uses and not maximum production of any single use.
>
> "The economic rationale of multiple use is that the sum total of the values thus created is greater than the value from any single use - and enough greater to more than offset the added costs."

The Mavora study area is clearly amenable to multiple use management in the first sense for there are land systems and parts of land systems which are highly suited to one use while other systems or other parts of land systems are much better suited to other uses. For the second kind of multiple use management to be evaluated, that involving simultaneous or alternating use of the same terrain, some assessment must be made of the influence on some potential uses of assigning resources to another particular use. This assessment has been carried out for all land utilisation types considered in the foregoing chapters. Results are summarised below as the positive or negative effects of resource assignment to one use on the possible conduct of other uses on the same terrain or water body. If neither positive nor negative effects are identified then it is considered that effects would be indeterminate or negligible. Assessments are tabulated in Table 13.

11.2 INFLUENCES OF EACH RESOURCE USE ON OTHER USES OF THE SAME TERRAIN

11.2.1 Pastoral Influences

11.2.11 Pastoral Intensive Self-Contained (PISC)

Positive effects on deer-farming adjunct and farm forestry. Negative effects on commercial production/protection forestry, wildlife and vegetation conservation to maximum levels, all forms of recreational use (except boating), holiday building, and recreational hunting management of wild animals.

11.12.12 Pastoral Semi-Intensive Accessory (PSIA)

Positive effects on deer-farming adjunct and farm forestry. Negative effects on commercial production/protection forestry, wildlife and vegetation conservation to maximum, wilderness-dependent recreation (Group A) and natural-area-dependent recreation (part of Group B), resource-modifying recreation (Group C and Group D) except where water and shoreline-based, cottage building in general and recreational hunting management of wild animals.

11.2.13 Pastoral Extensive Regular Accessory (PERA)

Negative effects on commercial production/protection forestry, wildlife conservation to the maximum, vegetation conservation to maximum or moderate levels, recreation of Group A, part of Group B (natural-area-dependent) and Group C, recreational hunting management of wild animals.

11.2.14 Pastoral Extensive Irregular (PEIU)

Negative effects on commercial production/protection forestry, wildlife conservation to the maximum, vegetation conservation to maximum or moderate levels, recreation of Group A and part of Group B (natural-area-dependent).

11.2.15 Pastoral Deer-Farming Adjunct (PDFA). (Secondary use with PISC, PSIA)

Positive effects on intensive and semi-intensive pastoral farming as supplementary to them. Possibly some enhancement of open-space-dependent recreational experience of Group B. Negative effects on wildlife and vegetation conservation to the maximum and on recreation of Groups A, C and D.

11.2.2 Forestry Influences

11.2.21 Commercial Production/Protection Forestry (FCPP)

Possible positive effects on wild animal herd management for recreation. Negative effects on all pastoral uses, wildlife conservation to the maximum, on vegetation conservation and on recreation of Groups A and B.

11.2.22 Farm Forestry Adjunct (FFA)

Positive effects on intensive and semi-intensive farming including deer-farming, on wildlife conservation to moderate levels, Group C recreation and wild animal hunting. Negative effects on wildlife conservation to the maximum, on vegetation conservation and on wilderness and natural-area-dependent recreation (Group A and part Group B).

11.2.3 Nature Conservation Influences

11.2.31 Wildlife Conservation to Maximum (WCX)

Positive effects on vegetation conservation and on wilderness and natural-area-dependent recreation (Group A and part Group B). Negative effects on all pastoral and forestry uses, recreation of Groups C and D and herd management for recreational hunting.

11.2.32 Wildlife Conservation to Moderate Level (WCM)

Positive effects on all recreation activities of Groups A, B and C. Negative effects on extensive pastoralism and on commercial forestry and Group D recreation.

11.2.33 Vegetation Conservation to Maximum (VCX)

Positive effects on wildlife conservation and on recreation of Groups A and B. Negative effects on all pastoral and forestry activities and on Groups C and D recreation as well as recreational hunting management of wild animals.

11.2.34 Vegetation Conservation to Moderate Level (VCM)

Positive effects on wildlife conservation. Negative effects on extensive pastoralism, commercial forestry and some Group D recreation.

11.2.4 Recreation Influences

11.2.41 Wilderness Recreation (RWD - Group A)

Positive effects on nature conservation and herd management for recreational hunting. Negative effects on all pastoral and forestry uses, recreation of Groups C and D and all vacation construction.

11.2.42 Natural Area Recreation (RNAD - part Group B)

No positive effects necessarily follow. Negative effects on all pastoral and forestry uses, recreation of Groups A, C and D and all vacation building.

11.2.43 Open Space Recreation (ROSD - part Group B)

No positive effects necessarily follow. Negative effects on intensive pastoral farming and commercial forestry, recreation of Groups A and D and on cottage building.

11.2.44 Resource-Modifying Recreation (RRBM - Group C)

Negative effects on all forms of pastoralism and forestry and on maximum levels of nature conservation, recreation of Groups A, B and D and on cottage building.

11.2.45 Resource-Modifying Recreation (RRBM - Group D)

Negative effects on intensive and semi-intensive pastoralism and commercial forestry, nature conservation and recreation of Groups A, B and C.

11.2.46 Vacation Building Development - Cottages (RVBD - Group E)

Negative effects on nature conservation and on recreation of Groups A and B as well as on pastoral and forestry uses if dispersed on the same terrain.

11.2.47 Vacation Building Development - Lodges (RVBD - Group F)

Negative effects on maximum levels of nature conservation and on recreation of Groups A and B on the same terrain.

11.2.5 Wild Animal Control Influences

11.2.51 Strict Population Control (WASPC)

Major positive effects on nature conservation and general positive effects on all pastoral and forestry uses.

11.2.52 Herd Management for Recreation (WAHMR)

Positive effects on nature conservation to moderate levels. Negative effects on intensive and semi-intensive pastoralism.

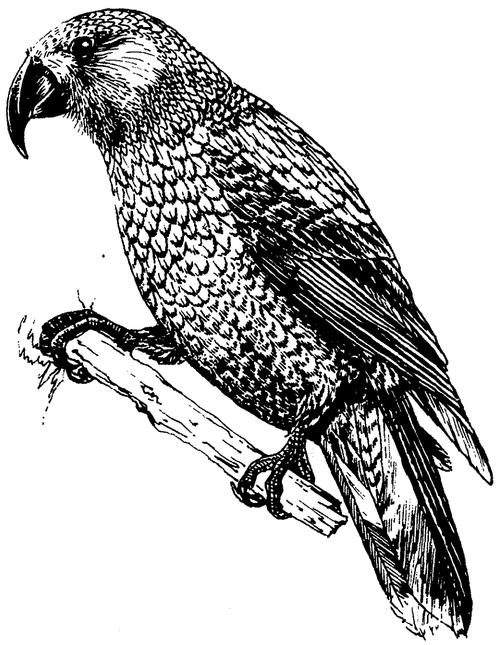


TABLE 13: INFLUENCE OF EACH USE ON EACH OTHER USE ON THE SAME TERRAIN.

Influenced uses	Influencing Uses																			
	PISC	PSIA	PERA	PEIU	PDFA	FCPP	FFA	WCX	WCM	VCX	VCM	RWD (A)	RNAD (B)	ROSD (B)	RRBM (C)	RRBM (D)	RVBD (E)	RVBD (F)	WASPC	WAHMR
PISC		0	0	0	+	-	+	-	0	-	0	-	-	-	-	-	-	0	+	-
PSIA	0		0	0	+	-	+	-	0	-	0	-	-	0	-	-	-	0	+	-
PERA	0	0		0	0	-	0	-	-	-	-	-	-	0	-	0	-	0	+	0
PEIU	0	0	0		0	-	0	-	-	-	-	-	-	0	-	0	-	0	+	0
PDFA	+	+	0	0		-	+	-	0	-	0	-	-	0	-	-	-	0	+	0
FCPP	-	-	-	-	0		0	-	-	-	-	-	-	-	-	-	-	0	+	0
FFA	+	+	0	0	0	0		-	0	-	0	-	-	0	-	0	-	0	+	0
WCX	-	-	-	-	-	-	-		X	+	+	+	0	0	-	-	-	-	+	0
WCM	0	0	0	0	0	0	+	X		+	+	+	0	0	0	-	-	0	+	+
VCX	-	-	-	-	-	-	-	+	0		X	+	0	0	-	-	-	-	+	0
VCM	0	0	-	-	0	-	-	+	0	X		+	0	0	0	0	0	0	+	+
RWD (A)	-	-	-	-	-	-	-	+	+	+	0		-	-	-	-	-	-	0	0
RNAD (B)	-	-	-	-	0	-	-	+	+	+	0	0		0	-	-	-	-	0	0
ROSD (B)	-	0	0	0	+	-	0	0	+	+	0	0	0		-	-	-	-	0	0
RRBM (C)	-	-	-	0	-	0	+	-	+	-	0	-	-	0		-	0	0	0	0
RRBM (D)	-	-	0	0	-	0	0	-	-	-	-	-	-	-	-		0	0	0	0
RVBD (E)	-	-	0	0	0	0	0	0	0	0	0	-	-	-	-	0		0	0	0
RVBD (F)	-	0	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0		0	0
WASPC	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0		X
WAHMR	-	-	-	0	0	+	+	-	0	-	0	+	0	0	0	0	0	0	X	

Key: + Positive, 0 Indeterminate or negligible, - Negative, X Not assessed.

11.3 COMPLEMENTARITY, COMPATIBILITY AND COMPETITIVENESS OF RESOURCE USES

Those resource uses which have mutually positive effects on other resource uses on the same terrain can be discerned as complementary. Those which lack negative effects in either direction can be discerned as compatible. Those which have negative effects in at least one direction are competitive. From the summary of influences presented in Table 13, two main complementary or compatible groups can be readily discerned. One which is complementary is focussed on intensive or semi-intensive pastoralism with deer-farming and farm forestry. The other is of compatible uses centred on wilderness and natural area recreation, nature conservation and generally strict population control of wild animals. Where one use is practised then it is clear that uses of its complementary or compatible group are feasible. It is also clear that if resource uses of both these groups are to be assigned terrain in the Mavora then the two groups would have to be separated, for there exist several negative relationships between different members of the two groups.

It is also worth noting that some resource uses which received high weightings in the previous chapter (e.g. Group B recreation of open-space dependent kind) are compatible with many other uses. Group B open-space dependent recreation is compatible with all forms of pastoralism and forestry except the most intensive, with nature conservation generally and with other forms of recreation except Groups A and D and cottage building. Group C recreation in contrast is compatible with few other forms of resource use on the same terrain except moderate levels of nature conservation, lodge-building, and strict population control of wild animals. If Group C recreation activities are to be catered for in the Mavora they will have to be in a zone from which incompatible activities can be excluded.

11.4 ON-SITE AND OFF-SITE INFLUENCES AND RISKS

The consideration of use influences has been concentrated here on the effect of assigning a tract of land to one use on other uses of the same tract. Wildlife, water and human vision each travel across tract boundaries. The use of one terrain for intensive pastoralism or building developments could greatly affect the utility of another terrain within visual range for wilderness or natural area recreation or even for open-space dependent recreation. The conservation of visual landscape has been identified earlier as an important social need but such a consideration requires the appraisal of influences far beyond the site of actual use. Likewise the influence of intensive pastoralism or commercial forestry on downstream water regimes calls for off-site consideration. The influence of nutrient enrichment of catchment lands and of grazing animal behaviour on downstream water quality is also an important consideration. This is examined more thoroughly in Appendix 6. The tentative findings of this examination are used as a basis for the land use recommendations which follow, as are summary assessments of visual landscape influences and water regime influences.

An important element in multiple use management is consideration of risks of unwanted effects of one use on other uses. In such a category are the disturbance of livestock or their escape through opened gates, injury to recreationists from other recreationists or from disturbed animals, the spread of weeds and wild fire arising from accident. Such risks are real and need to be taken into account. It should be recalled, however, that such risks of lasting loss generally arise from the interaction of uses and not from one use alone.

A good example for analysis of risk of unwanted effects is fire in tussock grasslands. Fire is a familiar occurrence in tussock grasslands and it is widely argued that grazing reduces the risk of fire damage. This claim deserves closer analysis to illustrate the principles just expounded. Fire may cause serious damage to forests and shrublands and, in some harsh environments, it may cause long term damage to grasslands. In the short term it may adversely affect certain forms of wildlife in grasslands as well as reducing aesthetic quality. In the absence of grazing animals its effects on most grasslands in New Zealand last for a few years at most. In the presence of grazing animals damage can be longer term. Does grazing by animals reduce the risk of fire occurring or reduce its severity or increase its extinguishability? Clearly animal grazing has little effect on fire frequency itself, except in the case of improved grasslands. In semi-improved grasslands grazing management may reduce potential fuel loads and induce a fire-resistant sward between tussocks which may lower fire severity and increase the effectiveness of many fire-fighting techniques. In unimproved tussock grasslands it is very doubtful whether these effects are in any way significant, for animals may have little effect on standing fuel as their grazing is concentrated on the younger fresh tissues available. In effect then, the risk of <u>damage</u> from fire in unimproved tussock grasslands is generally heightened by the practice of grazing, at the same time as the risk of severe fire itself may be slightly reduced.

Fire plans therefore need to take account of the greater risk of severe fire occurring once land is destocked. On the other hand, management plans need to take account of greater risk of lasting damage to an unimproved tussock grassland, or indeed to the tussock element in a semi-improved grassland, that arise from allowing such grasslands to be grazed before the full vegetation physiognomy is restored after fire. These factors have different implications for different situations, especially for situations differentiated not just by ecological conditions but by management objectives. Examples of hypothetical situations will illustrate this point.

Suppose we have a grassland which is being used in accordance with planning objectives for semi-intensive pastoral farming and only in a secondary way for open-space recreation. If the maintenance of tussock physiognomy is an important desideratum in this pastoral use and if the manager does not have alternative grazing opportunity for the period needed for pasture rest after an accidental fire, then it will be very important to reduce the risk of fire occurring to very low levels. This might require the prohibition of all picnic and camp fires and even the temporary exclusion of potential agents of accidental fire such as recreationists. If resting and maintaining tussock physiognomy were not an important consideration or if the manager had alternative grazing opportunities in the event of fire, then the need to reduce the risk of fire occurring would not be as great.

Now suppose the same grassland were being used in accordance with planning objectives, principally for recreation, then the restoration of tussock physiognomy after fire would simply require the exclusion of grazing animals. Using the grassland regularly for pastoral purposes secondarily to its recreational use could aggravate the difficulty of finding alternative grazing in the event of fire.

These situations illustrate the importance and value of clarifying objectives of land use and of designing management plans or strategies that respect these objectives and any primacy or hierarchy within them.

The estimation of use impacts on other uses and on environmental conditions generally is a wider topic than the matter of use interaction and risk, illustrated here by consideration of the implications of accidental fire. In Chapter 6, when we considered definitions of suitability (pp.111-112), we introduced into a Land Systems context the criterion used by Brinkman and Smyth (1973) and Beek (1978) of avoiding unacceptable risks to land or water resources. By such a criterion we assessed some uses as unsuitable in some land systems. By the same criterion, we assessed several pastoral uses as <u>conditionally</u> suitable, pending the assessment of the risk of lake enrichment arising from pastoral use. As will be seen in Chapter 12 (p.170), we resolve this conditional suitability dilemma by assessing the water enrichment risks with the best information available to us (Appendix 6), and by redefining the appropriate land utilisation types as locality-specific (Appendix 7). We followed a similar but less formal approach in assessing the impact of different uses on visual quality of landscape and on bird or fish habitat. In these ways, the influence of particular uses on the environment and on other uses beyond the boundaries of the specific use locality has been taken into account.

In sections of 11.2 and 11.3 (pp.154-159) of this chapter, we have developed a formal procedure for checking the influence of each resource use on other uses of the same terrain. We have not, however, devised a <u>formal</u> procedure for assessing each such influence beyond the boundaries of the used terrain. We believe that such a procedure may be of value if it could be developed for application in a way that took account of the virtually universal characteristics of particular uses, e.g.,

motor-cycling always makes noise;
intensive pastoral farming virtually always enriches drainage waters;
picnicking always disturbs certain birds;
buildings always detract from the sense of wildness.

Although we recognize the value of such a methodology, especially for detailed land use planning in a multiple-use context, we have not seen the necessity for a formal methodology of this kind in the Mavora context.

CHAPTER TWELVE
Recommended Planning Programme

12.1 THE REGIONAL PLANNING CONTEXT

Important features of the administrative regional planning scene in this mountainous hinterland of Otago and Southland are:

(1) There are few resident settlers on the land.

(2) Commercial tourist interests tend to dominate the public images in neighbouring centres such as Queenstown and Te Anau.

(3) The Mavora-Greenstone represents a tension zone between the zones of influence of the greater Otago and Southland regions.

(4) Central government agencies for land and water management, Department of Lands and Survey, New Zealand Forest Service and Ministry of Works and Development, by virtue of the dominance of public lands of the Crown in the area, have the most powerful decision-framing roles.

It is open knowledge that these departmental roles have not always been in harmony. Indeed, it would seem from Molloy (1974) that agencies in or serviced by the Ministry of Works and Development, the National Roads Board and Town and Country Planning Division, have sometimes not been acting in concert in the wider issue of roading in this mountain terrain. Some exposition of the major issues involved should precede the enunciation of our recommendations.

12.1.1 The Roading Issue

The roading question is the pivotal issue in the Mavora. It is significant that it has been hitherto focussed on the margins of the Mavora rather than within it. Road development up to the Mavora Lakes in conjunction with farm development led to accelerated recreational use of the Mavora area itself. Roading development from the lower Mararoa into the Upper Oreti and through the Von valley to the east of the Thomson Mountains now links Mt Nicholas and Walter Peak stations to the Mossburn-Te Anau district. Road development from Queenstown northwards to Glenorchy and the Rees Valley was followed in May 1974 with the opening of the Dart River bridge linking Glenorchy with Kinloch on the north-west corner of Lake Wakatipu. Earlier, Lake County Council had included in its draft District Scheme a proposal to extend the road connection from Kinloch to Elfin Bay and the Greenstone Valley immediately to the north of the Upper Mararoa, with a view to linking with the Milford Sound-Te Anau highway. Following objections from the National Parks Authority, Fiordland and Mt Aspiring National Parks Boards, Federated Mountain Clubs and the Nature Conservation Council, the Town and Country Planning Appeal Board in September 1973 found that these roading objections were soundly based. The Board required that reference to the Greenstone be deleted from the Lake County scheme and that the county undertake a feasibility study of the alternative Kinloch-Elfin Bay-Centre Hill link to Te Anau. Wallace County Council has included proposals for consultations with the National Parks Authority and other affected parties and for route surveys to investigate alternative road links between Jacksons Bay, Te Anau and Queenstown. This it has proposed in keeping with its policy "to continue the investigation, development and upgrading of roads into areas of high tourist potential."

The case for maintaining the "Greenstone-Mavora region" as a natural area and open-space on-foot recreation zone has been cogently made by Molloy (1974), rebutting the earlier reported statement of the then Minister of Works (Mr Watt) that the Kinloch-Greenstone connection to the Te Anau-Milford highway was the "only logical outcome" of existing roading and bridging development. It is also clear from examination of the alternatives (Garratt and Dingwall, 1981) that a "water-level route" roading from Kinloch to Mt Nicholas and through the Von and Oreti valleys to the Mossburn-Te Anau district would serve existing pastoral and other interests as well as tourism. It is noteworthy that the western "lakes runs" which have been adversely affected by deteriorating steamer services over the years, would be brought much closer to a major port, freezing works, wool sale and farm supplies centre by a Kinloch-Elfin Bay-Mt Nicholas connection to Southland than has been their fortune since they were founded more than a hundred years ago.

Road development through the Mavora study area does not appear to be essential to any highly suitable land utilisation type considered in Chapter 6. Most other feasible land utilisation types would not become highly suitable if a road were built. Were a road to be developed right through the Mavora, the Upper Mararoa, the Pass Burn and down the lower Greenstone to Elfin Bay, then the Mavora and Upper Mararoa sections of the Thomson Land System and the Sugar Loaf Land System would remain conditionally highly suitable to Semi-Intensive Accessory Pastoral Enterprises (6.4.22) unless such land utilisation types were reformulated. If road making proceeded, the suitability of these land systems for open-space recreation activities would be reduced, their suitability for nature conservation would be adversely affected and the whole quality of recreational experience in the Mavora itself could be jeopardised as a consequence. There appears from our study to be no convincing evidence of need for such semi-intensive accessory pastoral development from the south in so far as conventional livestock are concerned. Any development of deer-farming within the Farm Settlement portion of the Mavora study area would almost certainly require some farm service road access from the existing road head at the lakes through the forested area to the east of North Mavora Lake and extending to a deer farm headquarters in the Campbell Land System. Whether or not this development is found to be warranted, there seems no justification for maintaining the vehicle track through the forest at the lake edge where it constitutes maximum loss of amenity. The possible future need for roading to serve accessory development for Elfin Bay station might be met by roading at the farm service level into the Sugar Loaf Land System from the existing Von valley road. Such a road would provide summer access only through the high but easy grade terrain of the glacially transgressed valley of the north branch of the Von. Such a road could terminate on the true left of the Upper Mararoa, serving the largest area of potentially developable pastoral land as well as a possible farm centre there. Such a road need impinge in no way on the Mararoa river flats or the proposed major walkway route through the valley.

The trenchant criticisms of roading developments into and through high mountain areas by the Nature Conservation Council (1976) by Molloy (1974, 1976), Mason (1974) and the Recreation and Tourism Working Group of the New Zealand Conference on Conservation of High Mountain Resources (Thomson, 1978), have been made as much in the interests of recreationists and tourists as they have been for the purpose of nature conservation. They have yet to be matched by positive planning commitments from local or regional planning agencies to roadless zones. Although some progress has been made towards the adoption of National Parks Authority policy on roading in parks by the National Roads Board, there is no general commitment at a national level to the concept of roadless zones. Without such commitments, we need only sustained resurgence of national economic vigour for Molloy's fear to be fulfilled: "It is easy to imagine the situation where no areas are left where the less active older person can go on foot."

It is also worth observing that such expensive roading of mountain terrain may easily be fostered by the competitive efforts of local bodies and small commercial centres to tap the mystique of unroaded wilderness, so that the trickle of resulting central subsidy and public commerce can be guided lawfully down local channels until eventually it grows into a flood of internal and external tourist dollars. The intervention of the Nature Conservation Council, National Parks bodies and the Federated Mountain Clubs has diverted the roading energies for the time being from the Greenstone. In its decisions of 1973, the Town and Country Planning Appeal Board has thereby reduced the risk that Te Anau would lose its dominance of access to Milford Sound. It has not clearly reduced the risk that the Upper Mararoa-Mavora might be roaded to make a Greenstone holiday. *That risk can be reduced to what would be acceptably low levels only by the positive designation of the Upper Mararoa-Mavora as a walkway to be left unroaded and by decision to commit road development to the Lake Wakatipu margin route from Kinloch to Mt Nicholas and through the Von valley. If these commitments are not made, then any other planning recommendations which may be made here might well be neglected or discarded in the event of a Mavora-Upper Mararoa road being planned or constructed in the future.*

12.1.2 The Agency Issue

Contesting of responsibilities for land management is not a new phenomenon in New Zealand, nor is it specific to the Mavora. The phenomenon is probably world-wide but it is possibly especially vigorous in New Zealand because of the history of the central government agencies, the weakness of local government, the great significance territorially of public land in New Zealand, and the special significance of the central government public service as a career opportunity in the national society. This phenomenon of inter-agency contest has profound psychological and sociological roots in any modern society, especially one in which there is active change in societal interests and aspirations or in which there is major adjustment to economic constraints. This kind of competitive situation is promoted when agency mandates deriving from different legislation are not clearly demarcated under clear constitutional arrangements. Inter-agency competition is itself exacerbated and becomes the more difficult for the participants to comprehend and live with when different agencies have different administrative structures and functions. Since all these contributing and aggravating factors have been present in New Zealand and have brought two major agencies cheek by jowl in the remote Mavora, it is not surprising that there has been contest and competition. It would be idle to pretend that such a situation has not existed or to suggest that it has been an aberration, arising from particular personalities. What is indeed remarkable and a tribute to the leadership of such agencies is the degree of cordiality and co-operation which has been fostered despite the factors working against them.

It seems essential for the good of the Mavora and for the people the Mavora might serve in whatever use or uses it is put to, that ways of living with and surmounting organizational contest must be found. It is beyond the scope of this study to prescribe ways to ensure such co-existence and co-operation, but it is worth noting that more than the two agencies need to be involved. In the assessment of social interest in uses of the Mavora, local and regional interest appear substantial in many of the more highly suitable uses for which there is inadequate alternative opportunity. How is a central government agency to deal with local and regional interests? It would perhaps be foolhardy for central government agencies to try to meet such local and regional aspirations without formal recognition of the elected or otherwise lawfully constituted local and regional representatives.

Both the major land administering agencies, through Parks and Reserves Boards, and Forest Park Advisory Committees, have established their own machinery for local consultation. A cynical view might see such merely as the reticulation of central government rather than its decentralisation. A more generous view would recognize the genuine opportunity here provided for local input and for local evaluation of departmental ideas. It is perhaps insufficient in many such situations to consult local or regional interests while retaining executive and fiscal power in the central agency. Planning responsibility is clearly lodged with district and regional bodies by present law. We recognize the practical difficulty of delegating responsibility to local people sparse on the ground in what is a tension zone between powerful interests in central government and at county level. Joint planning exercises involving both land administering agencies and district and regional planning bodies seem to be essential. The need to organize in this direction of local involvement and responsibility might well be perceived by the major central government agencies in the interests of their own mutual harmony. Opportunity seems to exist for such structural development under current statutes. The emergence of the Southland United Council has made such an opportunity proximate.

TABLE 14: SUMMARY OF SUITABLE USES AND RELATED FACTORS

Land Utilization Type	Suitable Land Systems (refer Table 11)		Summary of Social Interest (refer Table 12)	Alternative Opportunities (refer Ch.9)	Suggested Weighting (refer Ch.10)
Pastoral					
Semi-intensive accessory	Campbell Thomson Sugar Loaf	2.2 2.1 2.1	Medium	Low & ?	>1
Semi-intensive (deer)	Campbell Thomson Sugar Loaf	2.2 2.1 2.1	High	Medium	>1
Regular extensive accessory	Thomson Sugar Loaf	1.2 1.2	Medium	Medium	1
Farm Forestry Adjunct	Campbell Thomson Sugar Loaf	1.2 2.2 2.2	Medium	High	1
Nature Conservation					
Wildlife Maximum	Campbell Thomson Sugar Loaf Eldon	1.1 1.1 1.1 1.1	High	Low	>1
Wildlife Moderate	Above systems All other systems	1.1 1.2	High	Low	>1
Vegetation Maximum	Mararoa Livingstone West Burn Eldon	1.2 1.2 1.2 1.2	Low to Medium	Low	1
Vegetation Moderate	Mararoa Livingstone West Burn Eldon Campbell Thomson Sugar Loaf	2.1 2.1 2.1 1.1 1.2 1.2 1.2	Medium	Low	1

Land Utilization Type	Suitable Land Systems	Summary of Social Interest	Alternative Opportunities	Suggested Weighting
<u>Recreation</u>				
Group A Wilderness	West Burn 1.2 Mararoa 2.2 Livingstone 2.2 Eldon 2.2	Medium	Medium	1
Group B_1 Natural Area	Campbell 1.2 Thomson 1.2 Sugar Loaf 1.2 Others 1.1	High	Medium	>1
Group B_2 Open Space	Campbell 1.1 Thomson 1.1 Sugar Loaf 1.1 Others 1.2	High	Low	>>1
Group C Low Impact	Campbell 1.2 Thomson 2.2 Sugar Loaf 2.2 West Burn 2.2 Eldon 2.2	High	Low	>>1
Group D High Impact	Possible but discordant with whole	Medium	Medium	<1
Group E Cottages	Campbell 1.2	Medium	Low & High	<1
Group F Lodges	Campbell 1.2 Thomson 2.2	High	Medium	1
<u>Wild Animal Use</u>				
Strict Control	Sugar Loaf 1.2 Mararoa 1.2 Livingstone 1.2 West Burn 1.2 Eldon 1.2	High	Low	1
Recreational Hunting	Eldon 2.2	High	Low	>1

12.2 A DISTILLATION OF INTEGRATED PLANNING OBJECTIVES

In concordance with the spirit of the policy for high mountain resources as first enunciated and adopted at the 1977 Conference on the Conservation of High Mountain Resources (Anon, 1978) and further developed, formulated and approved by the New Zealand Government (New Zealand Government, 1979), we propose several planning objectives for the Mavora. These embody a set of suitable resource uses which are derived from the preceding evaluations of resources and use suitabilities as well as the social interest in such uses, alternative opportunities and the weightings suggested. The salient suitable uses and related factors are summarised in Table 14.

The uses which are here included are mostly those land utilization types which have emerged as conditionally or actually suited, either moderately or highly. Those which are only marginally suited are generally omitted. A draft set of planning objectives in keeping with the evaluations and assessments up to this stage have been put to central government and local agencies to gain and assess their reactions. It is now appropriate to fuse those elements of the several policies, goals and objectives outlined in Chapter 8, where they are compatible with one another and concordant with resource use capability and particular use suitability. Particular land utilization types, preferred on grounds of suitability for particular terrain, compatibility and lack of adverse influences on other uses, assessed social interest in or need for them, and deficiency of alternative opportunity, will be identified as recommended objectives for a joint planning process. They are reformulated as locality-specific uses for which suitability can now be recognized actually rather than conditionally. Unless otherwise described for this reason, the standards proposed are consistent with those described in Section 6.3 *et seq.* of Chapter 6. Details of the reformulated uses are presented in Appendix 7.

12.21 Goals for Joint Planning Activity (in order of priority for 1, 2, 3)

Proposed Joint Planning Goal 1: To achieve preservation of landscape condition and quality of the whole Mavora-Upper Mararoa area for the purposes of restoring vegetation, maintaining wildlife and fish habitat, promoting recreational use in suitable non-vehicular activities dependent on natural area and open space, especially the development of a section of N.Z. Walkway and accessory tramping routes.

Beech forest margins make for sheltered low–density campsites. While horse–riding is not frequent or a problem for other uses at present, increasing camping and walkway use would require special zones for horse–riding to be continued (22).

Proposed Joint Planning Goal 2: To develop and maintain an appropriate Recreation Facilities Area in the vicinity of the present road head at the Mavora Lakes.

Proposed Joint Planning Goal 3: To maintain and develop pastoral use on terrain suited to it and in zones where it does not militate against Goal 1 and Goal 2.

Proposed Joint Planning Goal 4: To secure harmonious integration of uses in the Mavora and adjacent districts consistent with district and regional planning policies of the region.

12.22 Planning Objectives for the Pursuit of Joint Planning Goals

Objective 1: Water Margin Protection: (a) Reserving of the Upper Mararoa waterway and flood plain by exclusion of all livestock by berm-fencing so as to minimise pastoral influence on the waterbodies and wetlands, for the maximum benefit in this sector of fishery and wildlife, consistent with Wildlife Conservation to Maximum (WCX).

(b) Reserving of the Mavora Lakes and shorelines and the connecting river and its shorelines, including exclusion of direct livestock influence and consistent with fish and wildlife management (Objective 6).

Objective 2: Walkway: Designating on the eastern shoreline of North Mavora Lake, on one or both margins of the Upper Mararoa flood plain, and on a path through the Pass Burn and the Greenstone Valley to Elfin Bay, a "Mavora Walkway", to be part of the New Zealand Walkway System, for Recreation: Open-Space-Dependent (ROSD) consistent with New Zealand Walkway standards, and establishing and managing thereon appropriate facilities.

Objective 3: Reservation and Restoration of Natural Vegetation and Landscape: In Eldon, West Burn, Livingstone and Mararoa Land Systems and the northern portion of the Thomson Land System, protecting all landscape whether native forests, shrublands, grasslands or other communities from all disturbing influences except what is locally incidental to Recreation: Natural-Area-Dependent (RNAD), consistent with Vegetation Conservation to Moderate Level (VCM) and, where warranted, by survey and investigation, consistent with Vegetation Conservation to Maximum (VCX).

Objective 4: Tracks and Routes: Identifying and recording suitable tramping routes and tracks, and if warranted, suitable horse-riding trails, in the northern and western land systems identified in Objective 3, including routes to the Upper Greenstone Valley, to the Eglinton Valley, and through the Upukeroa Valley to Te Anau, consistent with Recreation: Natural-Area-Dependent (RNAD).

Objective 5: Wild Animal Control: (a) Maintaining population control of wild animals consistent with the needs of Objective 3 in the Eldon, West Burn, Livingstone and Mararoa Land Systems and the northern portion of the Thomson Land System, as a buffer zone to Fiordland National Park, but integrating such control policy with the development of wild animal control in the Working Plans of Snowdon and Wakatipu State Forests.

(b) Maintaining population control of wild animals on the Sugar Loaf, Thomson and Campbell Land Systems consistent with the needs of adjacent farming uses, the maintenance and improvement of forest and other vegetation cover and condition, soil conservation and scenic values, but integrating such control policy with the development of wild animal control in the Working Plans of Snowdon, Von and Eyre State Forests. (Although this objective would at present accord with Wild Animals: Strict Population Control (WASPC), it may be evolved in practice more towards Wild Animals: Herd Management for Recreation (WAHMR), especially in an integrated programme. Recreational hunting is at present included in district forest working plans. Any wild animal control or management policy would necessarily have to take cognizance of deer-farming pursued under Objective 7.)

Objective 6: Fisheries and Wildlife Management: Preserve, develop and manage brown trout fishery of the Mavora-Mararoa system and the forest, wetland and open-country birdlife of the district, consistent with WCX standards for fisheries and wetlands and WCM standards for birdlife and native fauna generally. (Particular attention will be needed for control and exclusion of predators, especially dogs and cats, and for population management of potentially competitive adventive species, e.g. Canada goose. Closed game status for the whole area would otherwise continue as well as absolute protection of non-game birds.)

Objective 7: Promotion of Semi-Intensive Pastoral Farming: (a) Establishing a basis for negotiation with the runholder of Elfin Bay for (i) a reduction in the area of pastoral use to exclude the riparian portions of the Upper Mararoa Valley and the whole of the Mararoa Land System steeplands (see Figure 36); (ii) establishment and management of the proposed walkway and (iii) planning, technical and financial assistance with pastoral development to a semi-intensive level of suitable non-riparian terrain of the Sugar Loaf and Thomson Land Systems, as well as of other suitable terrain outside of the Upper Mararoa catchment; (iv) maintenance and enhancement of "open-space" standards for areas visible from the walkway in the planning and execution of the pastoral development; (v) possible development of alternative enterprises consistent with other named objectives and open-space standards.

(b) Establishing with the deer-farming industry and other interested parties a basis for developing a special purpose deer farm enclosed by fences on the suitable terrain of the Campbell Land System and the southern portion of the Thomson Land System, extending to the Elfin Bay run boundary from the beech forest east of North Mavora Lake, above the proposed walkway and fenced from it, and separated by the walkway from the lake and Upper Mararoa River. (New vehicular access would be required through the beech forest on land unit 3.2 to land unit 3.1 immediately to the north on Figure 35, distant from the lake and walkway. The present lake-margin vehicle track and stock mustering route would be closed to these uses.) This land use would correspond with a revised Land Utilization Type: Pastoral: Semi-intensive Deer-farming (PSIDF) and would include possible farm forestry but exclude regular sheep and cattle farming. In the event that a deer-farming use not prove to be needed, a more conventional PSIA: Pastoral: Semi-Intensive Accessory use could be designed in the same fenced area.

Objective 8: Development of Recreation Facilities Area: Cooperating in the planning, further development and management of a Recreation Facilities Area extending from the beech forest east of North Mavora Lake to the "old homestead" south of South Mavora Lake and including both east and west shores of lakes and river, providing for separate picnicking and camping facilities, non-power boating, group lodges (Recreation: Vacation Building Development RVBD: Group F) (if found to be warranted) and for other recreational activities consistent with the character of the area and compatible with one another of the set indicated in Recreation: Resource Based but Resource Modifying (Group C of RRBM). (Building development in this zone would be confined to Group F lodges etc. in designated areas and would not include any cottages, cribs (Group E) or any commercial facilities. Lodges would be subject in their design and management to the joint planning authority and would be required to be available for public use as well as for the group establishing them.)

Objective 9: Measures for Integration and Promotion of Uses and Safeguarding the Mavora: (a) Establish a structure and procedure for integrated effective consideration and implementation of this series of objectives. (At least three tenures are at present involved in the area, involving two departments of government and one private person. Other local and regional bodies and central government agencies have statutory responsibility of one kind or another. Others have actual or potential interests. Local citizens have particular interest. No formal structure yet exists for joint planning nor for joint implementation of plans. Some examples: (i) Structures which exist for preventing fires and for fighting them may not be sufficient; (ii) Inadequate structures and procedures exist for weed eradication or for controlling the invasion or increase of weeds, both terrestrial and aquatic; (iv) Little locally effective consideration is evident of alternative site planning for such recreational activities as trail-bike riding, jet boating, and four-wheel drive touring, activities which are not compatible with the character of the Mavora nor with the nature conservation, recreational and other uses proposed for it. Each of these functions is contributed to in some degree by different bodies. Consultation may occur, but no formal machinery exists for consultation or co-operation adequate for the Mavora as a whole among those concerned with it.)

(b) Establishing efficient arrangements with appropriate bodies with responsibility under Local Government Act, Town and Country Planning Act and other related Acts, to secure integration of "Mavora Planning" with District and Regional Planning, including regional roading planning.

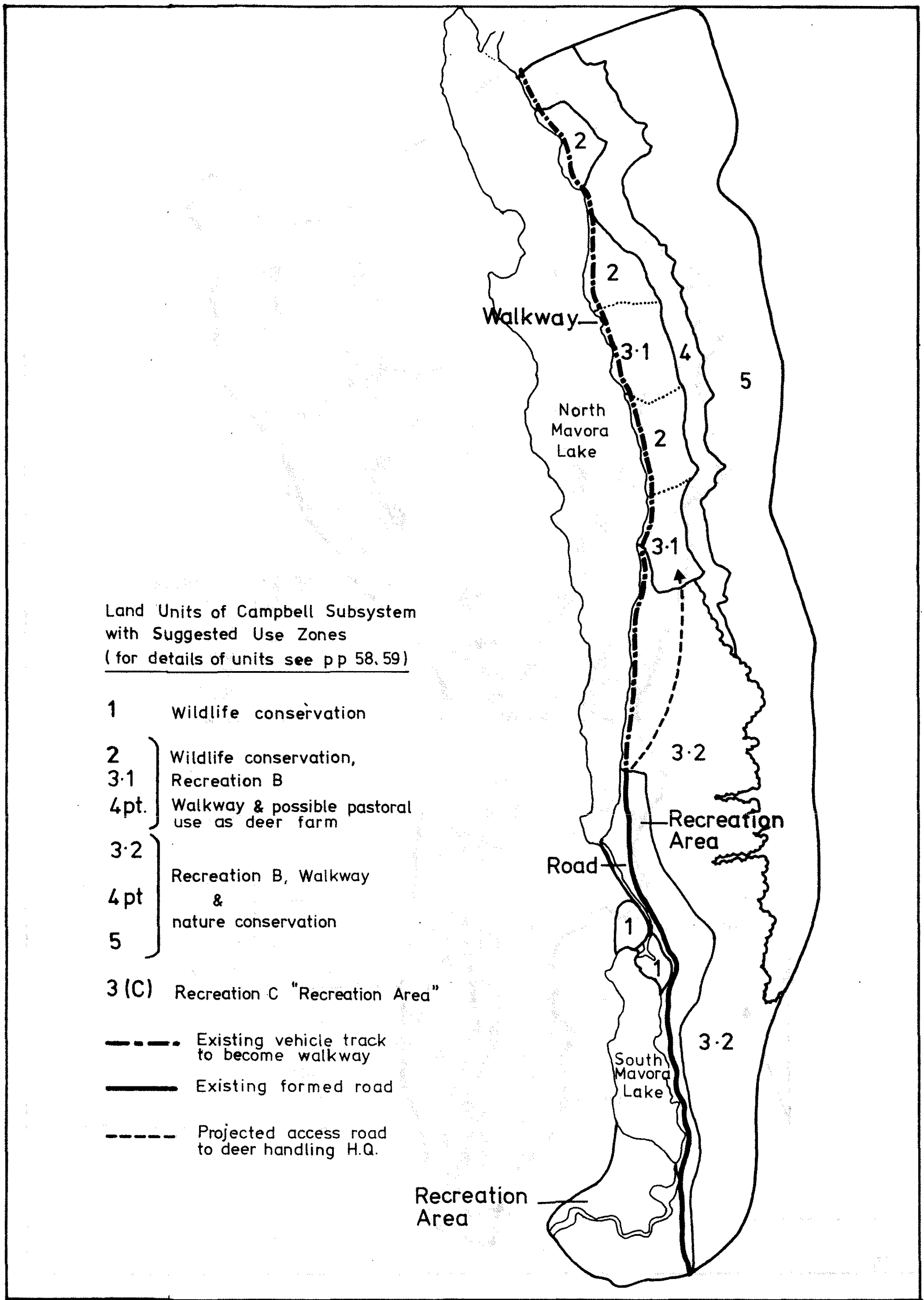


FIGURE 35: SUGGESTED USE ZONES FOR CAMPBELL SUB-SYSTEM

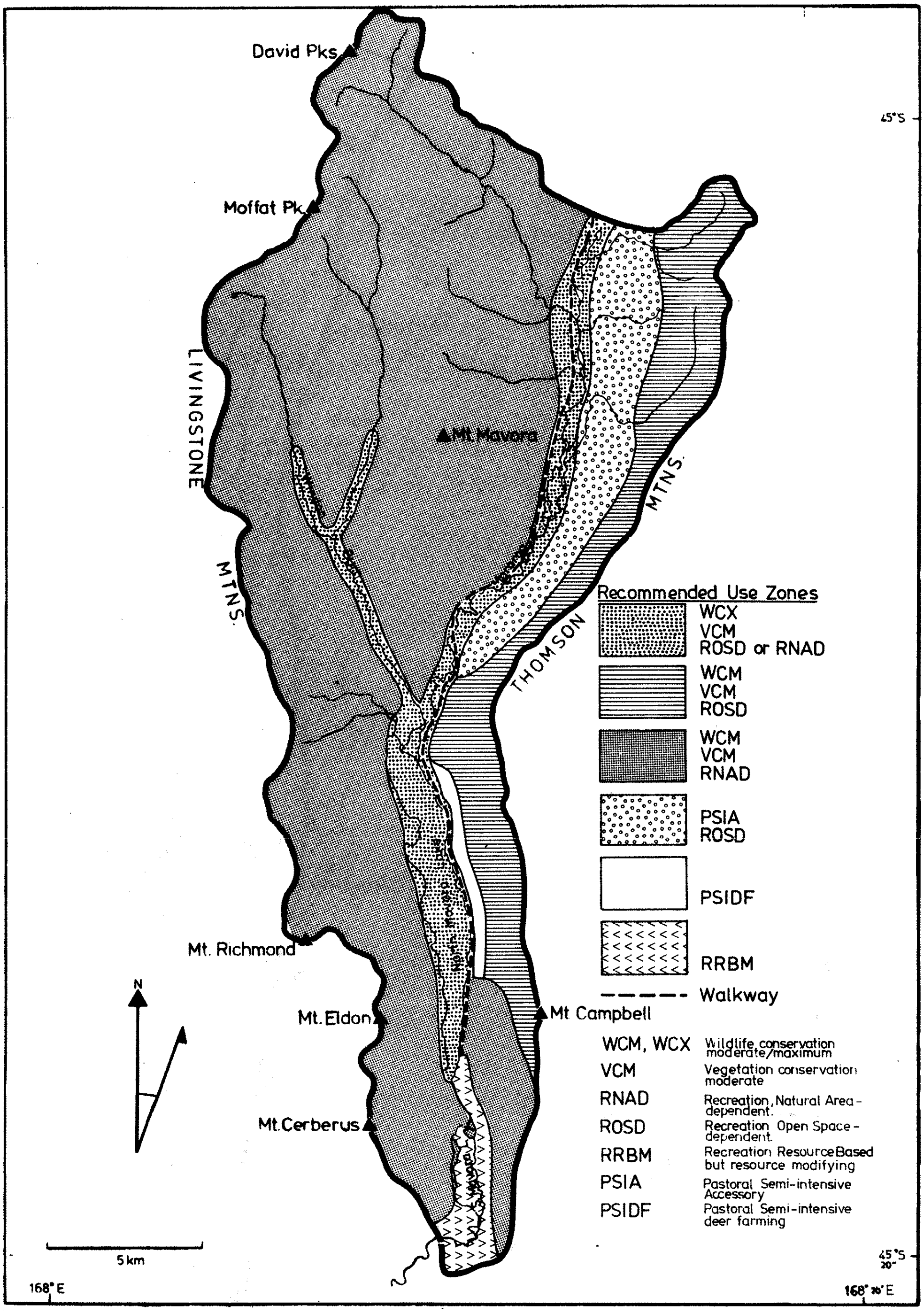


FIGURE 36: RECOMMENDED USE ZONES FOR MAVORA STUDY AREA

12.3 RECOMMENDATION FOR IMPLEMENTATION

There are many tasks which are implicit in the objectives formulated above. It is not unusual for senior administrators to call for enumeration and budgetting of such tasks before they consent to the goals and objectives for the pursuit of which the tasks will be required. Our recommendation takes a different course. We recommend that the interested parties be convened to consider jointly this report and the goals and objectives which have been distilled from the study to consider the evaluations and assessments that have been made, and to discern for themselves why alternative resource uses have not been proposed and why those which have been proposed are made in the way they are. We believe that if the interested parties follow this recommendation they will arrive at that kind of collective motivation which will ensure a fruitful outcome to this study. Such a fruitful outcome may well include modification or amendment of the proposed objectives. Almost certainly no fruitful outcome for any objective will ensue if the essence of Objective 9 is not agreed to.

Our recommendation is:

> *That the land-administering departments, New Zealand Forest Service and the Department of Lands and Survey, agree to inviting the Southland United Council to convene and host on their and its own behalf representatives of the parties named to a Mavora Planning Workshop to examine and agree to act on recommendations on the matters of the proposed goals and objectives of this report.*

12.31 Suggested Programme for Action

Interested parties could include the following:

Local Parties:

- Mr R.J. Metherell, runholder, Elfin Bay
- Federated Farmers branch (Mossburn)
- Rural women (e.g. W.D.F.F. or C.W.I. branch)
- Te Anau, Manapouri and Mossburn residents (or Community Council)
- Wallace County Council
- Lake County Council
- Travel and tourist interests
- Young Farmers' Club

Regional Parties:

Federated Farmers Southland Provincial District
Southland Acclimatization Society
Otago/Southland National Parks & Reserves Board
Southland Youth Adventure Trust
Southland Education Board
Southland Catchment & Regional Water Board
Southland United Council
Royal Forest and Bird Society (Southland)
Otago University

New Zealand Parties:

New Zealand Council for Recreation and Sport
Wildlife Service of Department of Internal Affairs
New Zealand Deer Farmers' Association
Federated Farmers of New Zealand
Young Farmers' Clubs (New Zealand)
New Zealand Deer Stalkers' Association
Federated Mountain Clubs of New Zealand
Tourist and Publicity Department
Travel Agents' Association of New Zealand
New Zealand Travel and Holiday Association
National Roads Board
Water and Soil Conservation Authority
Ministry of Works and Development
Ministry of Agriculture and Fisheries
Ministry of Transport
Commission for the Environment
New Zealand Walkway Commission
National Parks and Reserves Authority
Nature Conservation Council
Land Settlement Board
Department of Scientific and Industrial Research
Ministry of Energy (Electricity Division)
Department of Lands and Survey
New Zealand Forest Service
Lincoln College

This meeting of parties, after due notice and preparation, could devote one whole day, preferably at Te Anau, to examination of the general character of the proposed goals and objectives, concentrating on expounding views endorsing or criticizing proposed goals and objectives and correcting any omissions or errors of fact or interpretation. If the meeting arrived at a consensus on the second day, that the proposed planning objectives represented a worthy starting point, it might agree to a planning group consisting of the following:

Local representatives:

Federated Farmers, Mossburn
Te Anau-Manapouri residents
Local rural women
Wallace County Council

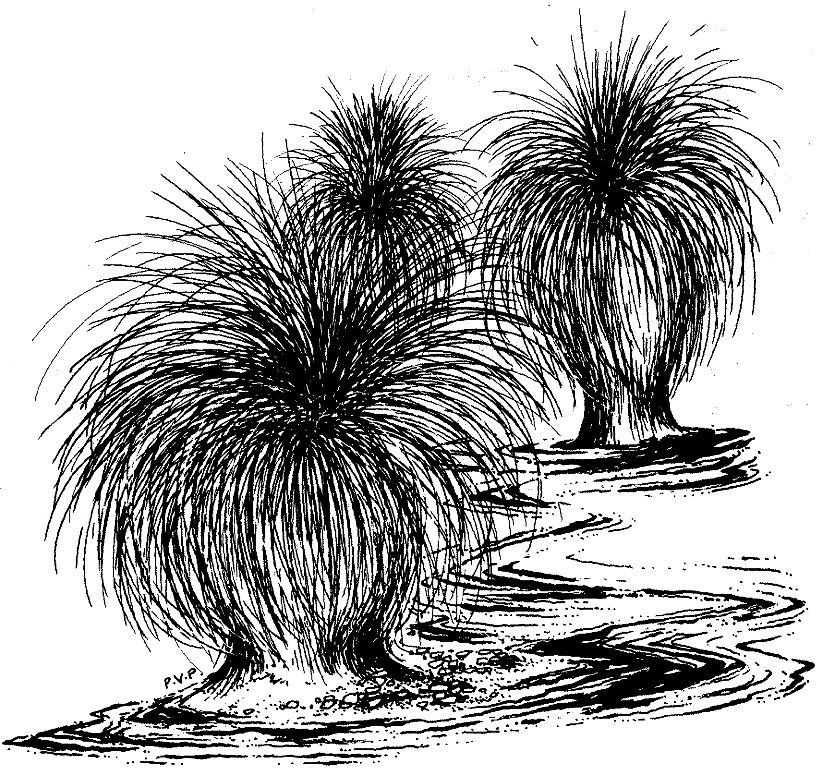
Regional representatives:

Southland United Council
Southland Catchment Board
Southland Acclimatization Society

New Zealand representatives:

Department of Lands and Survey (2)
New Zealand Forest Service (2)
One other to be chosen

This group of 12 could be expected to meet immediately and to meet again within a month (with a field inspection of the Mavora area) to formulate any revisions to the proposed goals and objectives and to recommend this formulation to the constituent original parties for endorsement. They would then meet again to draft a proposed structure and programme for implementation, in accordance with Objective 9 above.


P.V.P.

CHAPTER THIRTEEN
Summary Outcomes of the Study

13.1 GENERAL LESSONS IN LAND EVALUATION

From assembled knowledge of land and water in terms of inherent characteristics, and from analysis of use experience there and elsewhere with similar resources, it has been possible to arrive at an assessment of use suitability for each considered use, not simply of the appropriate land units, water margins or water areas, but of the land systems themselves. For grazing, for wildlife conservation and management, for landscape appreciation involved in so many recreational activities, for the maintenance of water quality free from damaging influences, little significance could be attached to use of the land unit in isolation from the land system in which it occurred. The land system did not have to be evaluated as a whole for each of these uses but the extent of suitable land units had to be taken into account. Likewise the presence within the land system of land units with low capability or high risk for a particular use affected the suitability of the land system or of portion of it for that particular use. This caused us to redefine the use as specific to the suitable areas. The lesson we have learned is that land systems retain the essence of practical unity which is otherwise lost if each unit of land is mapped and evaluated in its own right. We have been reinforced in this assessment by checking our suitability assessments against the limitations indicated by previous capability classifications.

We found ourselves discovering some "common sense" lessons as we worked our way through the use suitability assessments. One lesson was that to be realistic we had to assess the suitability of resources at a dimension appropriate to the use considered. Secondly, each use warranted its own assessment of the suitability of resources for it. Some terrain, for example, was highly suited both to bird life conservation and to extensive pastoralism. Other terrain was poorly suited to the one and well suited to the other. This principle of separately assessing land suitability for each use to be considered had been recognised by the U.S. National Resources Planning Board 40 years ago, but has not been widely applied in this country. The suitability of particular resources for a particular use was recognized to depend on the level of culture or management applied to these resources for that use. To take this into account and to assess the implications of one use of a resource to other uses, we had to consider several scenarios involving different assumptions of management. These were described as land utilization types. Such an approach proved workable. We did not attempt to develop an exhaustive check procedure to take account of all uses at all levels of culture.

Could we have simplified the land evaluation procedure by introducing even more of the intuitive element? Clearly the answer to this question in the Mavora is affirmative. If we had considered fewer use options we would have had occasion to discard fewer, but we would not have revealed any reasons for discarding them.

In the past we have not had well-developed procedures for translating capability information to recommendations of use. The first Land Use Capability Bulletin published in full for the Soil Conservation and Rivers Control Council was the report of a survey of the Mararoa River Catchment carried out in 1959 (Dunbar *et al*, 1966). As stated in that report (p. 47) "the land use capability classification attempts to show the maximum possible safe use for the land". On the same theme it further stated "the recommended land use plan is based on the land use capability plan but may differ in some respects according to the various social and economic influences of the time". Not surprisingly, for there was then no examination of such social and economic influences, substantial tracts of Capability Class IV and VI land on the east of Mavora Lakes and in the Windon and Upper Mararoa valleys were recommended for productive forestry with moderate limitations <u>or</u> for non-arable sheep and cattle farming with moderate limitations, according to present forested or unforested condition. The whole of the valley floor of the Upper Mararoa and Windon Burn was recommended for pastoral use with moderate or severe limitations. Indeed, the extensive flats and terraces at the head of North Mavora Lake were illustrated as potentially arable, but it was stated that "it would be unwise to cultivate them at present. The improvement of areas already developed in the lower catchment would bring greater returns." No land in the valley floor of the Upper Mararoa or Windon was recommended for any use other than pastoral and no mention was made of special protection of such riparian land.

An example of the deficiencies in translation from use capability to recommended use is seen in the Whitestone Valley. Riparian land of the Whitestone Valley further west had been recommended for arable or pastoral use, generally with slight limitations in accordance with Capability Class II or V. Later, Howard (1973) pointed to neglect of river management in pastoral development in that area. In truth, the problem arose from technical deficiencies in translating from land capability to recommended land use to take hydrologic effects into account. No planning system can have perfect foresight. The important fact which Dunbar and Hughes (1974) later recognized was that "problems which arose during development were able to be solved comparatively rapidly by modern scientific knowledge and investigation." Although the hydrologic problems have generally been solved we have also paid a perhaps unnecessary price in loss of wetland habitat and loss of naturalness. We may also have excessively drained some terrain with consequent aggravation of summer drought.

How have we approached the translation problem nearly twenty years later? What principles of land and water resource management did we invoke? What planning process did we develop? First, drainage performance in quantity and quality of water is the product of a hydrologically-integrated system. We accepted that as a principle. In this kind of system the riparian zone is the most sensitive and susceptible to influence. Whole catchment planning may be often redundant and is always difficult to quantify. Riparian zone planning is seldom unnecessary, especially in flood plains, and its significance can at least be estimated. We therefore allowed the significance of water quality and of the riparian zone as a habitat for wildlife to affect our final evaluation of land for other uses. We take account of such off-site influences in other areas where they appear significant.

Second, the range of uses that must be kept in mind in resource use planning has increased rapidly in recent years, especially because of the back-country boom in recreation (Mason, 1974) and the less resounding interest in biological conservation (O'Connor and Molloy, 1979). Such uses cannot be readily prescribed from a single land use capability classification system. We have demonstrated the value of specific use suitability assessments, as well as the significance of whole landscape appraisals for some uses. Our specific use suitability assessments have taken the form of an economist's benefit/cost ratio as now endorsed by FAO authorities (Brinkman and Smyth, 1973). Our estimations of these ratios are unashamedly subjective and qualitative. In those uses amenable to quantification of costs and benefits, we are confident of the correct order of our estimations.

Third, the social considerations that must be taken into account <u>before</u> making resource use recommendations must be assessed in as fair and balanced a fashion as are the considerations of resource capability or suitability. The range of factors we have included in this Mavora study has encompassed the following:

(a) The social needs for uses and for products of uses, e.g. timber, beef, wool, water, electricity, fishing, tranquility.

(b) The alternative means of supplying each particular social need in the region, after the manner of Gibbons and associates in Victoria as developed in the Little Desert case.

(c) The weightings attached by society or its rulers, either explicitly or implicitly, to each possible benefit accruing to different members of society, after the manner of Whitby and associates (1974) in England.

(d) The positive and negative interactions of different proposed uses in specific sectors of the study area to determine the degrees of complementarity/compatibility/competitiveness of such uses.

Finally, to provide a coherent perspective against which we could view our approximation of social aspirations, we found it necessary to identify for each governmental agency or public organisation interviewed, the policy, goals and objectives that each held. Until we converted the statements of intentions or aspirations of different bodies to a common framework, we found it impossible to recognize clearly the convergences or divergences of different ambitions. Our experience has indicated that when a common structure is used of policy, goals and objectives, there is increased perception of what is in common among such aspirations and much better understanding of the residual differences.

The final stage of our planning process has been to distil goals and objectives to be recommended for adoption or endorsement by various decision-makers. At the present time there is no body in New Zealand quite like the Land Conservation Council of Victoria, which is empowered by statute to make such decisions about the use of all public lands. For non-forest lands, the Land Settlement Board has some such functions. We do not believe that there should be such a body to make decisions about use of all public lands until it is clearly recognised how it should act. For this reason we believe it is important to study procedures such as we have evolved for framing the decisions. It should be noted in this respect that our colleagues in Victoria were already confident of their planning procedure before they had enacted their enabling legislation.

Some of our findings in favour of particular uses for particular terrains were easily made because of congruence of social interest and land suitability. For these it was easy to frame a planning objective. For other findings it was not so easy and we had to spend time in consultation to clarify societal goals and confront them with the facts of the Mavora. A hierarchy of goals arose from these consultations and from our own consideration of assessed social interests and alternate means of their satisfaction. Looming large in our minds was respect for the integrity of the Mavora country itself, the order in variety which is the essence of natural beauty. In essence we found that we arrived by a painstaking analytic and synthetic process at a solution which is almost McHarg-like in its simplicity. If we have succeeded in designing with nature it is more by analysis and confrontation of fact and value than it is by intuition or, still less, by mysticism. There is a place for each approach.

Some of our proposed resource use objectives, therefore, arise not just from the suitability of particular areas for particular uses, but more especially because of such factors as expected interactions between a use in one area and other highly valued uses in other areas. For assessing some of these interactions we have used intelligent guesswork. Where matters are of some moment and can be clarified by specific research or investigation, we have indicated what needs to be investigated. Where there is inadequate confidence for decisions to be made in favour of particular resource developments without detriment to the environment, we recommend that decisions be made that keep options open. For example, if research shows that pastoral use of river flats does not adversely affect aesthetic quality, water quality, fisheries, wildlife habitat and land and channel stability, then pastoral use can be resumed. Our inclination is to a set of planning objectives which does most to keep options for the future open. That set of planning objectives does not include maintenance of the *status quo*. We believe that an ever-changing regional community, involved through its representatives in the decision-making on the Mavora, will have regard for its grandchildren and favour such an inclination to future choice. In showing that inclination we follow the guidelines for high mountains provided by Government (New Zealand Government, 1979) and those recommended by the best of international authorities (Dasmann and Poore, 1979) for high mountain terrain. We also apply the understanding of our scientists (Molloy *et al*, 1980) and the principles of our resource managers concerned with the integration of conservation and development (Nature Conservation Council, 1981).

13.2 FUTURE PROSPECTS FOR THE MAVORA COUNTRY

While we recognized the wider regional dimensions of planning (cf. Section 12.1 of Chapter 12), we confined our study to a single upper catchment. We found that it was possible to propose as appropriate a set of use objectives which could be integrated in this one upper catchment. The range of these suited uses was almost as great as the range of possible uses examined but, of course, not all considered were preferred. Recreation, especially on foot, and nature conservation, especially of wildlife, have emerged in apparent dominance as the preferred uses for which there is great need and for which the Mavora is in general extraordinarily well suited.

Extensive pastoral use which the Mavora country has enjoyed or endured for a century or more is proposed to be phased out in favour of development to semi-intensive pastoral farming on the one hand and nature conservation and restoration on the other. It is proposed that, in general, this Mavora section of the New Zealand Walkway will be aligned close to the waterbodies and form a buffer between them and the zones of pastoral use and development. One commentator has remarked with relish on the prospect of having "one relatively accessible valley free from the smell of sheep and the sight of dead cows"! Pastoral development in the middle distance, carried out to a semi-intensive level, even involving some well-designed farm forestry and fencing as well as pasture improvement by oversowing and topdressing, need not diminish the sense of tussocky open space to be experienced on the walkway through the Upper Mararoa and along the foot of the Thomson Mountains. On these less humid but infertile slopes, fans and moraines there is little prospect of rapid healing of damaged grasslands without topdressing and oversowing. Such land can still be maintained as an improved tussocky pasture. The wetter remainder has the prospect of reverting to nature.

It is likely that huts for trampers and walkers will be needed near the present site of the Musterers' Hut overlooking the junction of the Upper Mararoa and the Windon and the upper reaches of North Mavora Lake. The sharp crags of Mt Mavora itself, Moffat and David Peaks and the gaunt ridges of the Livingstone Mountains sweeping down against the western sky to Mt Richmond and Mt Eldon above Snowdon Forest, each and all beckon to the hardy and strong to tramp it out to the Greenstone and Lake McKellar, to the Eglinton or down through the Upukeroa to Te Anau. The waters of the lake and river will themselves lure the fly fisherman. The wetlands, untramped by cattle, will give bird watchers delight. For any who thinks on it, here will be one lake-head valley still in tussock, neither swathed in pastures nor drowned for hydro-electricity. The history of glacier ice and of landslides and fan building make the valley itself a place of interest, distracting the walker's attention from the rugged peaks to the north. It is a place for discovery, for wonder, for re-creation.

At one end of the Walkway, Elfin Bay, is a homestead long isolated across the water of Wakatipu. At the other is the picnic delight of northwestern Southland, South Mavora Lake. The prospect that the two will remain connected through the Mararoa only by a footpath makes the future improvement of Von Valley access to the markets of Southland important for western Wakatipu runholders. The development of a difficult route through the Greenstone would have brought Kinloch and Glenorchy closer in travelling time to Milford with its facilities already overtaxed (Garratt and Dingwall, 1981). It is the Walkway significance of the Greenstone added to the problem of physical capacity of Milford that weighs heavily in favour of Greenstone preservation from roading. Development of a water-level route on the west side of Lake Wakatipu would make an alternative Queenstown to Te Anau route of about the same length as the present route through Mossburn. Use of it by vacationers would probably increase recreational pressure on the Recreation Facilities Area developed at South Mavora and the southern end of North Mavora. Lake Wakatipu ferry services can be expected to be stimulated by the designation of Walkways in the Greenstone and the Mavora. The recreation, tourism and transport interests of Wallace and Lake Counties must consider a whole network of interacting forces and responses, involving agriculture and forestry as well, and affecting both people and environment in the whole of northwestern Southland and Otago. The days of development by poking roads through passes and up narrow storm-filled valleys because there is no road yet there are surely ended.

It was in pastoralism that the Mavora began in European times and it is a clear prospect that newer forms of pastoral farming can continue there with even greater benefit to the individual farmer and the community than before. By restricting farming use to levels and areas where it will not adversely affect nature conservation and recreational objectives, the fillip for development is provided that can bring such farming to a sustainable condition that it has never enjoyed in a hundred years. For the runholder at present occupying most of the Upper Mararoa Valley, there is an inevitable prospect of a change in way of life.

While technological innovations make a change to sustainability possible for him, we cannot escape the implication that he would merit generous consideration from the Land Settlement Board by his co-operating in the public interest, in line with our proposed objectives. It is clear to us that the public interest is best served by the prospectus that we here submit and we recognize that the Land Settlement Board has both the responsibility and power to serve such public interest in such Pastoral Land, whether it be leased or not. Nevertheless we are confident that both Government and people would recognize the debt they should owe the runholder for his full participation in this multiple-objective venture.

We are conscious too, that the prospectus we have proposed for the remainder of the Mavora Farm Settlement is not as most of the Department of Lands and Survey staff concerned have visualized it. We see no future prospect of continued extensive cattle grazing in the Mavora and we see only limited opportunity for semi-intensive sheep or cattle farming. We believe the social values of nature conservation and recreation on an extensive scale in the tussock grasslands of northwestern Southland greatly outweigh the modest benefits that might be expected by extending pastoral development in the last remaining fastnesses of the Mavora or the Upukeroa. We believe, however, that the prospect we offer of a possible special purpose deer or wapiti enterprise may allow the Department to continue its work of service to farming in a new and valuable way.

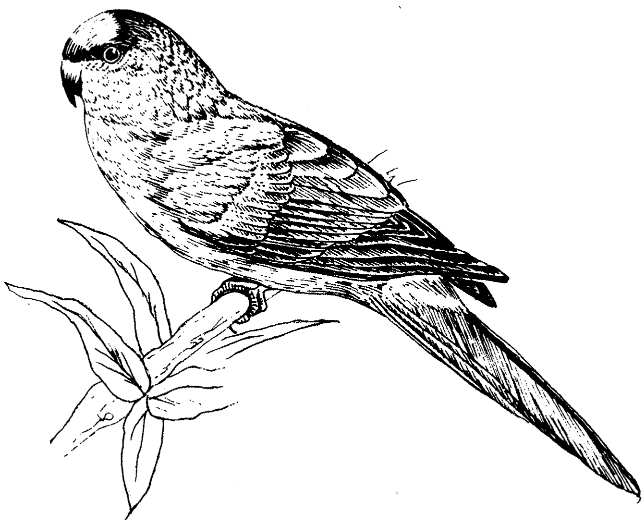
We are of the view that the grasslands of the Thomson and Campbell Systems on the Thomson Mountains need repair and we would like that repair to be paid for without it being a total drain on the public purse. We are not confident that the repair can take place effectively without topdressing and oversowing. We see the best prospects of such costs being met in a deer-farming enterprise but, as we have indicated, we see the alternative prospect of securing rehabilitation in a semi-intensive pastoral enterprise of a more conventional type.

We are conscious too, that we have rigorously excluded such recreational uses as trail-bikes and four-wheel drive vehicles as well as the conventional driving for pleasure from our prospectus for recreation in the Mavora proper. We identify such activities, as well as power-boating (except, perhaps, for access only), as incompatible with recreational satisfaction in the Mavora to be derived from the activities for which it is so well suited. Even more strongly do we claim that such powered activities are incompatible with the natural character of the Mavora itself. We do not rule out the possibility of facilitating such activities elsewhere, in the more southern sectors of the Farm Settlement or in other unalienated public lands in the district. Indeed, we would strongly recommend that such activities be guided and promoted on terrain suited to them, even to the extent of designing Motocross courses. Unless such opportunities are taken we shall continue to hear reports of unauthorised entry and of abiding damage being done to bogs and other natural enclaves.

We are conscious of how little is formally known of nature in the Mavora. We believe that it will amply repay biological conservation and sustained investigation, not least for the opportunities to examine plant and animal adaptations to the sharp climate and soil gradients which are found there, especially in the Livingstone Mountains but probably elsewhere as well. For science as well as for recreation we foresee that footslogging may well come again into its own in Mavora. We foresee, in the preservation of Mavora, great value for the scientific understanding of the natural processes which underly our use of soils and vegetation and of the cultural processes which interact with them. We consider that on grounds of climatic relevance as well as on grounds of National Park purpose, it would be preferable to establish and sustain such research in Mavora rather than in Fiordland National Park. We consider that reservation of large areas of tussock grassland in the Mavora and allowing them to revert to a natural condition will contribute significantly to an appropriate southern component of such grassland and forest research for the future.

We see no likely prospect that watershed management in the Mavora will contribute materially to any improvement of water discharge regimes in the Lower Mararoa River. We believe that future research being developed elsewhere may clarify such a prospect. If a clearer prospect emerges that watershed management may affect Mararoa discharge, then local research could lead to its application where relevant. Meanwhile, none of the planning objectives which we have proposed is likely to do anything but improve the prospects of hydrologic regulation.

We see no reason <u>in the Mavora</u> why the prospective diversion of part of Lower Mararoa flow to the Oreti or its possible abstraction for supplementary irrigation in the district should not be assessed, each in its own right and in relation to present uses for angling and power generation. We believe, however, that virtually all parties with whom we have discussed the issue would reject as abhorrent, artificial engineering controls which would alter the natural dimensions and character of the Mavora country, its river and lakes and its water margins. We see no reason why the whole Mavora Lakes-Upper Mararoa water system should not enjoy the fullest protection of law and of the minds and wills of present and future New Zealanders.



REFERENCES

ANON, 1978: Proceedings of the Conference on the Conservation of High Mountain Resources, November, 1977. Wellington, Department of Lands and Survey. 346pp.

AUKERMAN, R.; DAVISON, J., 1980: The Mountain Land Recreationist in New Zealand. Lincoln Papers in Resource Management 6: Lincoln College, Tussock Grasslands and Mountain Lands Institute. 243pp.

BAUMGART, I.L., 1976: Land use and the needs of society. In Dale W.R. (Editor) Land Use Policies. Studies in Public Aministration 21: 118-135. Wellington, New Zealand Institute of Public Administration.

BEEK, K.J., 1978: Land Evaluation for Agricultural Development. Wageningen, International Institute for Land Reclamation and Improvement Publication No.23: 333pp.

BENNEMA, J., 1975: General introduction to land evaluation. Proceedings of the International Seminar Land Evaluation in Arid and Semi-Arid Zones of Latin America. February 1974. Rome, IILA.

BRINKMAN, R.; SMYTH, A.J. (Eds.), 1973: Land evaluation for rural purposes. Summary of an Expert Consultation, Wageningen, The Netherlands, October 1972. Wageningen. International Institute for Land Reclamation and Improvement Publication No.17: 116p.

BURNET, A.M.R.; WALLACE, D.A., 1973: The relation between primary productivity, nutrients and the trout environment in some New Zealand lakes. Fisheries Research Bulletin 10.

BURNET, A.M.R.; WALLACE, D.A., 1975: Entrophication and the trout environment In Jolly, V.H.; Brown, J.M.A. (Editors) New Zealand Lakes. pp 158-162. Auckland, Auckland University Press.

CHAVASSE, G., (No Date): Unpublished mimeo. Farm trees for Southland. New Zealand Forest Service.

CHRISTIAN, C.S., 1958: The concepts of land units and land systems. Proceedings of the 9th Pacific Science Congress 20: 74-81.

CHRISTIAN, C.S.; STEWART, G.A., 1968: Methodology of integrated surveys In Aerial Surveys and Integrated Studies. Proceedings of Toulouse Conference 1964. Unesco Natural Resources Series 6: 233-280.

CLAWSON, M.; KNETSCH, J.L., 1966: Economics of Outdoor Recreation. Baltimore, The John Hopkins Press for Resources for the Future, Inc. 328 pp.

COULTER, J.D., 1973: Ecological aspects of the climate. New Zealand Meteorological Service Miscellaneous Publication 409F.

CRAW, D., 1974: Geology of the West Burn. Unpublished Bachelor of Science (Hons.) thesis, University of Otago.

CUTLER, E.J.B., 1977: Soil resource surveys, interpretations and applications. Lincoln College, Lincoln College Press. 272pp.

DASMANN, R.F., 1972: Environmental Conservation. (3rd ed.) New York, Wiley & Sons. 473p.

DASMANN, R.F., 1973: Classification and Use of Protected Natural and Cultural Areas. I.U.C.N. Occasional Paper No.4: 25pp. Morges, International Union for the Conservation of Nature and Natural Resources.

DASMANN, R.F.; POORE, D., 1979: Ecological guidelines for balanced land use, conservation and development in high mountains. Gland, Switzerland, International Union for Conservation of Nature and Natural Resources. 40p.

DAVIDOFF, P.; REINER, T.A., 1961: A choice theory of planning. Journal American Institute of Planners 28: 103-115.

DEPARTMENT OF LANDS AND SURVEY, MANAGEMENT PLAN TEAM, 1975: Mavora Lakes recreational area; draft management plan. (typescript) 24p.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, SOIL BUREAU, 1954: General Survey of the Soils of North Island, New Zealand. N.Z. Soil Bureau Bulletin 5: 286pp.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, SOIL BUREAU, 1968: General Survey of Soils of South Island, New Zealand. N.Z. Soil Bureau Bulletin 27: 404pp.

DUNBAR, G.A.; HUGHES, J.G., 1974: The effect of land development on the environment. New Zealand Agricultural Science 8(3): 110-119.

DUNBAR, G.A.; PRICKETT, R.C.; HOWARD, G., 1966: Land Use Capability of the Mararoa River Catchment, Southland, New Zealand. Land Use Capability Survey 1: Wellington, New Zealand Soil Conservation and Rivers Control Council.

FISH, G.R., 1970: A limnological study of four lakes near Rotorua. New Zealand Journal of Marine and Freshwater Research 4: 165-194

GARRATT, K.J.; DINGWALL, P.R., 1981: Environmental assessment of road routes between Queenstown and Milford Sound. Environmental Series No.4: 79pp. Wellington, Department of Lands and Survey.

GIBBONS, F.R.; and DOWNES, R.G., 1964: A study of the land in South Western Victoria. Melbourne, Soil Conservation Authority of Victoria.

GIBBS, H.S., 1968: Soil classification for land use pp 124-130. In New Zealand Soil Bureau. Soils of New Zealand Part I. Soil Bureau Bulletin 26(1): Wellington, Department of Scientific and Industrial Research.

GIVEN, D.R., 1976: A register of rare and endangered indigenuous plants in New Zealand. New Zealand Journal of Botany 14: 135-149.

GREENE, E.S., 1973: Spatial distribution of Bosmina meridionalis (Cladocera) in two Fiordland lakes. B.Sc. (Hons.) thesis, University of Canterbury (unpublished).

GRIFFITH, E., 1975: Classification of land for irrigation in New Zealand. New Zealand Soil Bureau Scientific Report 22. 66pp.

HAYWARD, J.A., 1977: The hydrology of a mountain catchment and its implications for management. Proceedings of soil and plant, water symposium, Palmerston North, 1976. N.Z. Department of Scientific and Industrial Research Information Series 126.

HAYWARD, J.A.; BOFFA, F.D., 1972: Recreation in the Waimakariri Basin. Lincoln Papers in Resource Management No.3: 140pp. Lincoln College, Tussock Grasslands and Mountain Lands Institute.

HAYWARD, J.A.; O'CONNOR, K.F., 1981: Our changing 'natural' landscapes In New Zealand, Where are you? Proceedings of the New Zealand Institute of Landscape Architects' 1981 Conference, Wellington: 33-41.

HENDEE, J.C.; STANKEY, G.H.; LUCAS, R.C., 1978: Wilderness management. (Washington, D.C.) Forest Service, U.S. Department of Agriculture, 381pp. Miscellaneous Publication no.136S.

HOWARD, G., 1973: The relationship of land use capability assessment to land use planning in the Mararoa River catchment, Southland, New Zealand, pp 11-17. In Seminar on Land Use Planning, Wellington, Ministry of Works for National Water and Soil Conservation Organisation.

HOWARD, G., 1976: Land resource survey for New Zealand. New Zealand Agricultural Science 10(1): 23-28.

HUNTER, G.G., 1977: New Zealand land resource inventory worksheet, Eglinton (S.131). Wellington, Water and Soil Division, Ministry of Works and Development.

HUNTER, G.G., 1978: New Zealand land resource inventory worksheet, Mavora (S.141). Wellington, Water and Soil Division, Ministry of Works and Development.

IRWIN, J., 1975: Checklist of New Zealand Lakes. New Zealand Oceanographic Institute Memoir 74: 161pp.

JACKSON, D.S., 1973: Soil factors that should influence allocations of land for forestry and agriculture. New Zealand Journal of Forestry 18: 55-62.

JOLLY, V.H., 1968: The comparative limnology of some New Zealand lakes. Part I: Physical and chemical. New Zealand Journal of Marine and Freshwater Research 2: 214-259.

JOLLY, V.H.; BROWN, J.M.A. (Editors) 1975: New Zealand Lakes. Auckland, Auckland University Press. 388pp.

JOLLY, V.H.; IRWIN, J., 1975: Thermal conditions In Jolly, V.H. and Brown, J.M.A. (Editors) New Zealand Lakes. Auckland. Auckland University Press/Oxford University Press: pp 90-105.

KAPLAN, A., 1958: On the strategy of social planning. A report submitted to the Social Planning Group of the Planning Board of Puerto Rico, September 10, 1958. Mimeographed (cited in Davidoff & Reiner op.cit.).

LEAMY, M.L., 1963: The correlation of soil classification and soil capability of the Upper Clutha Valley, Otago, New Zealand. Transactions of Joint Meeting of Commissions IV and V of International Society of Soil Science (1962): 749-754.

LEAMY, M.L., 1975: Competition for productive land in New Zealand. New Zealand Agricultural Science 9(3): 91-97.

LEE, W.G.; MEURK, C., 1975: Personal communications from W.G. Lee and C. Meurk at Botany Department, University of Otago.

LISTER, R.G., 1976: Overview and summary In Dale W.R. (Editor): Land Use Policies. Studies in Public Administration 21: 181-185. Wellington, New Zealand Institute of Public Administration.

MATHIESON, R., 1976: Guidelines and Criteria for rural land use. Land Use Research Report No.1, Wellington, Department of Lands and Survey.

McCOLL, R.H.S., 1972: Chemistry and trophic status of seven New Zealand lakes. New Zealand Journal of Marine and Freshwater Research 6: 399-447.

McCOLL, R.H.S., 1978: Chemical runoff from pasture: the influence of fertiliser and riparian zones. New Zealand Journal of Marine and Freshwater Research 12: 371-380.

McCOLL, R.H.S., 1979: Factors affecting downslope movements of nutrients in hill pasture. Progress in Water Technology 11: 271-285.

McCOLL, R.H.S.; HUGHES, H.R., 1981: The effects of land use on water quality - a review. Water and Soil Miscellaneous Publication No.23: 59pp. Wellington, Water and Soil Division, Ministry of Works and Development.

MASON, B.J., 1974: Back country boom. National Parks Series 1975, 2: Wellington. Department of Lands and Survey for the National Parks Authority.

MINISTRY OF WORKS, WATER AND SOIL DIVISION 1971: Land use capability survey handbook. A New Zealand handbook for the classification of land. Wellington, Government Printer. 139pp.

MINISTRY OF WORKS AND DEVELOPMENT, WATER AND SOIL DIVISION 1975: TIDEDA Output for Mararoa River Flow at Mt York (unpublished).

MOLLOY, L.F., 1974: Public use and enjoyment of indigenous State Forests. Address to Forestry Development Conference November 1974. Wellington, New Zealand Forest Service.

MOLLOY, L.F., 1976: An outline of the assessment of the recreational value of the New Zealand outdoors. Revised edition. Wellington, Federated Mountain Clubs of New Zealand.

MOLLOY, L.F., (Compiler) 1980: Land Alone Endures: Land Use and the Role of Research. New Zealand Department of Scientific and Industrial Research Discussion Paper No.3. 286pp.

NATURE CONSERVATION COUNCIL 1976: Roading. Nature Conservation Council Information Leaflet 15: 6pp.

NATURE CONSERVATION COUNCIL 1981: Integrating Conservation and Development. A proposal for a New Zealand Conservation Strategy. Wellington, Nature Conservation Council. 64pp.

NEW ZEALAND FOREST SERVICE 1975: Unpublished draft working plan for Snowdon State Forest. New Zealand Forest Service, Invercargill.

NEW ZEALAND GOVERNMENT 1979: Deciding the Use of High Mountain Resources. Government Policy Statement, November 1979, 8pp.

NILSSON, R., 1975: Personal communication from R. Nilsson, Fauna Conservation Officer, Department of Internal Affairs.

O'CONNOR, K.F., 1962: Success and failure in the culture of mountain soils. Proceedings of the New Zealand Society of Soil Science 5: 31-38.

O'CONNOR, K.F., 1972: Planning for recreation among other uses of mountain land and water resources. Review Tussock Grasslands and Mountain Lands Institute 24: 26-41.

O'CONNOR, K.F., 1972a: The agricultural contribution to pollution. Proceedings of Fertilizer Seminar 1972. Napier, East Coast Farmers' Fertilizer Company: 35-46.

O'CONNOR, K.F., 1978: Planning for the integration of uses in the New Zealand high mountains. In Proceedings of the Conference on High Mountain Resources (November 1977). Wellington, Department of Lands and Survey. 103-115.

O'CONNOR, K.F.; MOLLOY, B.P.J., 1979: Biosphere Reserves for New Zealand: a prefatory essay. pp 3-7 In Robertson, B.T., O'Connor, K.F., Molloy, B.P.J. (Editors). Prospects for New Zealand Biosphere Reserves. 78pp. New Zealand Man and the Biosphere Report No.2. Lincoln College, Tussock Grasslands and Mountain Lands Institute for National Commission for UNESCO and Department of Lands and Survey.

PUREY-CUST, J.R., 1975: Personal communication from J.R. Purey-Cust, Principal Forester, New Zealand Forest Service Invercargill.

REDFIELD, A.C., 1958: The biological control of chemical factors in the environment. American Scientist 46: 205-221.

ROBERTSON, W.A. 1972: A guide to a planning process for National Parks. Wellington, National Parks Authority of New Zealand. 32pp.

ROCKELL, J.D. 1976: Land Use I - Forestry. In Dale, W.R. (Editor): Land Use Policies Studies in Public Administration 21: 136-143. Wellington. Institute of Public Administration.

SIMMONS, D.G.; DEVLIN, P.J., 1981: The recreational hunter. Lincoln College Department of Horticulture, Landscape and Parks Bulletin No.33. 155pp.

SMITH, J.; DAVISON, J.; GEDEN, B., 1980: The public mountain land resource for recreation in New Zealand. Lincoln Papers in Resource Management 7: Lincoln College, Tussock Grasslands and Mountain Lands Institute 310pp.

SOUTHLAND CATCHMENT BOARD, 1969: Unpublished report. A land use capability study of the Mavora region.

SOUTHLAND CATCHMENT BOARD, 1975: Personal communication from Engineering Staff, Southland Catchment Board concerning streamflows.

STOUT, V.M., 1976: Personal communication from V.M. Stout, Department of Zoology, University of Canterbury.

SUTTON, R.R., 1975: Personal communication from R.R. Sutton, Senior Ranger, Southland Acclimatisation Society, Invercargill.

SYERS, J.K., 1974: Effect of phosphate fertilisers on agriculture and the environment. New Zealand Agricultural Science 8. 155-164.

SYERS, J.K.; HARRIS, R.F.; ARMSTRONG, D.E., 1973: Phosphate chemistry of lake sediments. Journal of Environmental Quality 2: 1-14.

TAYLOR, N.H.; POHLEN, I.J., 1962: Soil survey method. New Zealand Soil Bureau Bulletin 25: 242pp.

THOMSON, A.P., 1978: Report of Recreation and Tourism Working Group. pp 143-152. Proceedings of the Conference on Conservation of High Mountain Resources. November 1977. Wellington, Department of Lands and Survey.

TURNBULL, I.M., 1974: Geology of the Thomson Mountains, northern Southland, New Zealand. Unpublished Ph.D. thesis, University of Otago.

UNITED STATES DEPARTMENT OF AGRICULTURE, 1961: Soil survey trout creek watershed, Colorado. Forest Service and Soil Conservation Service Series 1958, No.5.

UNITED STATES NATIONAL RESOURCES PLANNING BOARD, 1941: Land classification in the United States, U.S. Government Printing Office.

WALLACE COUNTY COUNCIL, 1975: Wallace County Council district scheme, scheme statement and code of ordinances.

WENDELKEN, W.J.; HANNAN, R.F., 1974: Land - the prime resource. Unpublished Paper for 1974 Forestry Development Conference. Mimeographed. 54pp.

WHITBY, M.C. *et. al*., 1974: *Rural Resource Development* (1st edition). London, Methuen. 244pp.

WHITBY, M.C.; WILLIS, K.G., 1978: *Rural Resource Development: An Economic Approach* (2nd Edition). London, Methuen & Co. 303pp.

WILLIAMS, P.A.; GRIGG, J.L.; MUGAMBI, S., and O'CONNOR, K.F., 1978: Soil chemical properties beneath tall tussocks (*Chionochloa*) in South Island, New Zealand. *New Zealand Journal of Science 21*: 149-56.

WOOD, B.L., 1962: *Geological Map of New Zealand 1: 250,000 (1st ed.) Sheet 22, Wakatipu.* Wellington, Department of Scientific and Industrial Research.

Appendices
(pages XXVii to XXXViii)

APPENDIX 1(a) MONTHLY RAINFALL NORMALS FOR SURROUNDINGS OF MAVORA

	Lat S.	Long	Ht M.	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mountain Country to North																	
Glenorchy	44 51	168 23E	311	3	110	100	110	100	110	100	90	90	110	110	110	90	1230
Knobs Flat	44 58	168 02E	360	3	180	160	190	220	200	170	160	170	210	230	210	200	2300
Te Anau Basin to West																	
Te Anau 21 miles	45 11	167 53E	229	2	109	94	99	112	104	91	112	99	99	114	137	114	1284
Te Anau Downs	45 11	167 50E	229	2	109	86	122	127	102	109	89	119	152	140	127	112	1394
Te Anau	45 25	167 43E	213	2	94	86	102	97	102	99	86	84	99	102	99	86	1136
Te Anau	45 25	167 44E	215	2	89	84	99	99	99	109	89	86	94	102	97	89	1136
Te Anau Kakapo Rd	45 24	167 53E	305	2	86	81	97	97	97	107	86	84	91	99	94	86	1105
Te Anau Kakapo Rd	45 25	167 48E	274	2	78	61	99	94	64	100	73	83	100	94	92	85	1023
Lowland to South																	
The Key (Whitestone)	45 32	167 50E	290	2	78	62	92	92	66	73	76	73	90	91	85	77	955
Centre Hill Mossburn	45 35	169 08E		2	150	122	140	117	114	104	71	66	76	109	135	137	1341
West Dome	45 38	168 14E	274	2	89	81	97	91	97	94	81	79	94	97	94	81	1075
Wakatipu - Mid Dome Lowland to East																	
Queenstown Aero	45 1	168 44E	349	2	68	57	69	59	61	52	50	45	57	54	54	55	681
Queenstown	45 02	168 40E	329	1	74	66	76	71	79	66	64	61	76	76	76	64	849
Frankton	45 01	168 43E	338	2	69	58	69	61	69	58	56	53	66	66	69	56	750
Kawarau Gates	45 02	168 44E	320	2	64	56	66	58	66	56	53	51	64	64	66	53	717
Cecil Peak	45 06	168 36E	351	2	81	69	81	74	81	69	66	64	79	79	81	66	890
Wye Creek	45 08	168 46E	335	2	64	53	64	56	64	53	51	48	61	61	64	53	692
Kingston	45 20	168 43E	313	2	84	74	86	79	86	74	71	69	84	84	86	71	948
Garston	45 28	168 41E	308	2	86	69	81	66	66	58	41	38	43	64	76	79	767
Eyre Creek	45 31	168 29E	244	2	79	69	81	74	84	71	66	66	81	81	81	66	899
Glenfalloch Stn	45 33	168 40E		2	94	76	86	71	69	64	43	41	48	66	84	84	826
Athol	45 31	168 35E	290	2	91	74	86	71	69	64	43	41	46	66	81	81	813
Mid Dome	45 34	168 30E	386	2	107	86	102	86	84	76	51	48	56	79	97	99	971

Index to types:
1 A station with a complete good quality record from 1941-1970.
2 A station with incomplete record but high confidence in the estimated values given.
3 A station with incomplete record and medium confidence in the estimated values given to the nearest 10mm.

Source: Compiled from N.Z. Met. S. Misc. Pub. 145 (1973).

APPENDIX 1(b) CLIMATOLOGIC SUMMARIES FROM MID-DOME AND QUEENSTOWN

158552 Mid-Dome Lat. 45 34S Long. 168 30E Ht. 386 M.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (millimetres)														
Highest monthly/annual total	1949-1970	156	147	168	324	227	260	152	85	109	161	178	203	1222
Normal	1941-1970	107	86	102	86	84	76	51	48	56	79	97	99	971
Lowest monthly/annual total	1949-1970	49	22	56	31	33	40	18	4	11	23	39	10	808
Average number of days with rain 1.0 millimetres or more	1949-1970	10	8	10	10	10	13	10	9	8	10	12	9	121
Maximum 1-day rainfall (mm)	1949-1970	44	59	46	84	53	80	53	33	30	54	57	86	84
Estimated water balance														
Average runoff (mm)	1950-1971	13	8	15	43	51	89	69	36	23	25	20	15	407
Average deficit (mm)	1950-1971	8	5	3	.	.	.	.	.	.	.	.	3	19
Temperature (degrees Celsius)														
Highest maximum	1949-1970	34.1	32.2	32.1	26.1	21.0	18.9	17.3	19.1	21.2	24.2	28.9	28.6	34.1
Mean monthly/annual maximum	1949-1970	29.1	27.8	26.6	21.9	19.0	15.1	14.8	16.2	19.0	22.2	24.1	26.4	30.1
Mean daily maximum	1949-1970	21.0	20.9	18.5	15.1	12.1	8.5	8.0	10.5	13.3	15.8	17.2	19.2	15.0
Normal	1931-1960	14.3	14.2	12.4	9.9	6.7	3.8	3.2	5.1	7.8	9.8	11.7	13.3	9.4
Mean daily minimum	1949-1970	8.6	8.3	7.1	4.7	2.0	-0.4	-1.2	0.2	2.1	4.5	6.0	7.3	4.1
Mean monthly/annual minimum	1949-1970	2.0	1.7	0.3	-1.3	-4.1	-6.1	-7.5	-5.8	-3.6	-2.4	-0.7	0.7	-8.2
Lowest minimum	1949-1970	-0.7	-1.5	-1.9	-2.9	-7.1	-7.8	-12.5	-11.1	-11.6	-6.1	-3.3	-2.8	-12.5
Mean daily range	1949-1970	12.4	12.6	11.4	10.4	10.1	8.9	9.2	10.3	11.2	11.3	11.2	11.9	10.9
Mean daily grass minimum	1949-1970	5.5	5.6	4.4	1.9	-0.7	-3.1	-3.9	-2.6	-0.8	1.4	2.7	4.3	1.2
Days with frost														
Ground frost Average	1949-1970	4.[illegible]	4.9	4.4	7.5	14.4	18.4	22.4	19.1	13.8	9.8	5.5	3.4	147.9
Frost in screen Average	1949-1970	0.2	0.1	0.4	2.4	8.3	16.2	19.8	14.2	8.0	3.5	1.3	0.4	74.8
Earth temperatures (degrees C)														
Average at 0.10 metres	1949-1970	15.1	14.7	12.6	9.1	5.9	2.9	1.9	3.3	5.8	10.3	11.4	13.9	8.9
Average at 0.30 metres	1949-1970	16.3	16.2	14.3	11.0	7.8	4.6	3.4	4.6	7.1	9.9	12.6	14.9	10.2
Relative humidity (%)														
Average at 9 a.m.	1949-1970	70	75	78	80	82	81	82	78	72	66	67	69	75
Vapour pressure (MBS)														
Average at 9 a.m.	1949-1970	11.2	11.4	10.4	9.0	7.5	6.0	5.7	6.2	7.0	8.4	9.0	10.4	8.5
Special phenomena														
Average no. of days with snow	1949-1970	.	.	0.1	0.5	0.7	2.9	3.2	2.0	1.4	1.2	0.4	0.3	12.7
Average no. of days with hail	1949-1970	0.2	0.2	0.1	.	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.2	1.6
Average no. of days with thunder	1949-1970	0.4	0.1	0.2	0.1	.	0.1	0.1	0.1	.	0.3	0.3	0.4	2.1

158061 Queenstown Lat. 45 2S Long. 168 40E Ht. 329 M.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (millimetres)														
Highest monthly/annual total	1890-1970	202	183	276	176	264	149	182	187	221	231	197	151	1126
Normal	1941-1970	74	66	76	71	79	66	64	61	76	76	76	64	849
Lowest monthly/annual total	1890-1970	6	3	7	3	11	8	2	1	8	2	8	11	530
Average number of days with rain 1.0 millimetres or more	1890-1970	9	7	7	8	8	7	7	7	8	9	8	8	93
Maximum 1-day rainfall (mm)	1890-1970	63	53	122	54	50	65	76	57	62	73	74	62	122
Estimated water balance														
Average runoff (mm)	1890-1970	3	3	8	13	25	36	36	30	30	28	10	5	227
Average deficit (mm)	1890-1970	23	25	20	5	.	.	.	.	.	.	3	13	89
Temperature (degrees Celsius)														
Highest maximum	1930-1970	34.1	32.3	29.3	27.3	20.8	19.8	16.4	18.6	21.0	25.6	28.8	31.7	34.1
Mean monthly/annual maximum	1930-1970	28.9	27.7	25.7	21.2	17.4	13.9	13.1	15.3	18.1	21.7	23.9	27.0	29.6
Mean daily maximum	1929-1970	21.5	21.4	19.2	15.3	11.2	8.2	7.7	10.0	13.0	15.8	17.7	20.4	15.1
Normal	1931-1960	15.6	15.6	13.7	10.6	6.8	4.3	3.5	5.4	8.1	10.4	12.4	14.6	10.1
Mean daily minimum	1929-1970	9.7	9.8	8.3	5.7	2.6	0.3	-0.6	0.8	2.9	5.0	6.7	8.8	5.0
Mean monthly/annual minimum	1930-1970	4.6	4.2	2.6	1.1	-1.7	-3.7	-4.4	-3.2	-1.4	0.2	1.5	3.8	-4.9
Lowest minimum	1930-1970	0.7	1.2	0.0	-1.7	-6.7	-6.1	-7.8	-5.9	-4.1	-2.5	-1.6	0.8	-7.8
Mean daily range	1929-1970	11.8	11.6	10.9	9.6	8.6	7.9	8.3	9.2	10.1	10.8	11.0	11.6	10.1
Mean daily grass minimum	1930-1970	5.3	5.3	3.7	1.2	-1.6	-3.7	-4.6	-3.5	-1.7	0.4	2.1	4.4	0.6
Days with frost														
Ground frost Average	1929-1970	1.6	1.5	4.2	9.7	18.5	23.7	26.5	23.9	18.3	12.3	5.8	2.6	148.6
Frost in screen Average	1929-1970	.	.	.	0.1	5.2	14.2	18.5	11.4	2.6	0.6	0.1	.	52.7
Relative humidity (%)														
Average at 9 a.m.	1929-1970	66	70	73	77	81	81	82	78	71	68	66	66	73
Vapour pressure (MBS)														
Average at 9 a.m.	1929-1970	11.1	11.5	10.4	8.8	7.0	5.9	5.5	6.0	7.1	8.4	9.3	10.6	8.5
Sunshine (hours)														
Highest	1935-1970	300	261	218	170	136	102	122	155	208	258	307	307	2136
Average	1935-1970	245	199	180	130	92	73	86	121	160	194	214	239	1933
% of possible	1935-1970	53	51	47	41	32	28	31	39	46	48	49	50	45
Lowest	1935-1970	161	141	131	92	58	52	57	84	112	136	156	158	1670
Special phenomena														
Average no. of days with snow	1929-1970	0.1	0.1	0.1	0.3	1.0	2.0	2.3	1.8	1.5	0.9	0.6	0.3	11.0
Average no. of days with hail	1929-1970	.	0.1	0.2	0.1	0.2	0.1	0.2	0.2	0.3	0.5	0.4	0.2	2.5
Average no. of days with thunder	1929-1970	0.4	0.5	0.3	0.3	0.2	0.2	0.1	0.3	0.3	0.4	0.7	0.5	4.2

APPENDIX 1(c) WATER BALANCE DATA FOR NEIGHBOURING AREAS

xx

Key: Rainfall monthly normals (RR), potential evapotranspiration (PE), calculated runoff (RO), number of days runoff (NR), water deficiency (DE) and number of days of dryness (ND) at various rainfall stations. Soil moisture storage capacity is assumed as 75 millimeters. Data are set out in matrix form:

RR (mm)	PE (mm)
RO (mm)	NR days
DE (mm)	ND days

units: mm/month, days/month.

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Year	
Mountain Country to North																										
Knobs Flat[1]	116	118	95	92	221	67	206	39	213	18	128	11	153	12	206	26	359	50	260	81	203	101	187	119	2347	734
Lat 44 58S Long 168 02E	24	3	13	2	123	7	167	11	192	11	115	9	141	9	181	11	315	16	177	10	111	7	70	4	1629	100
Ht 1180 ft Period 7 yrs	8	3	8	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	6
Te Anau Basin to West																										
Te Anau Downs[2]	75	118	67	92	155	67	127	39	97	18	86	11	103	12	116	26	171	50	162	81	106	101	107	119	1372	734
Lat 45 11S Long 167 50E	0	0	0	0	54	3	83	6	76	8	67	7	91	9	93	9	127	9	83	7	34	3	16	1	724	62
Ht 750 ft Period 9 yrs	24	7	32	10	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	3	17	15	85	27
Te Anau[1]	88	118	70	92	125	67	111	39	80	18	90	11	83	12	88	26	109	50	108	81	95	101	98	119	1145	734
Lat 45 25S Long 167 44E	0	0	0	0	25	2	64	6	57	8	74	9	70	9	66	8	66	6	36	3	18	3	9	0	485	54
Ht 705 ft Period 10 yrs	24	7	25	9	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	4	14	4	74	25
Lowland to South																										
Plains Station[1]	85	118	68	92	135	67	85	39	82	18	66	11	78	12	62	26	138	50	109	81	73	101	107	119	1088	734
Lat 45 34S Long 167 52E	5	0	0	0	39	2	35	5	59	9	50	7	66	9	38	7	95	9	34	5	11	2	12	1	444	56
Ht 1000ft Period 9 yrs	34	10	30	10	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	5	18	5	99	32
Wakatipu - Mid Dome Lowland to East																										
Queenstown[2]	75	150	63	115	75	85	74	45	75	20	63	05	60	10	58	25	71	55	76	95	69	120	61	145	820	870
Lat 45 02S Long 168 40E	0	0	2	0	7	0	13	1	35	5	49	7	50	7	38	5	29	3	13	1	4	0	0	0	240	29
Ht 1030 ft Period 56 yrs	75	18	59	16	27	11	5	4	1	1	0	0	0	0	0	0	0	0	7	3	34	10	79	20	287	83
Queenstown Aero[2]	42	158	27	121	88	88	65	48	58	21	55	7	48	10	32	27	82	57	63	96	34	126	52	157	646	916
Lat 45 61S Long 168 44E	0	0	0	0	6	1	11	1	23	5	41	7	34	7	12	3	45	4	1	0	0	0	0	0	173	28
Ht 1145 ft Period 7 yrs	115	25	93	23	33	14	9	6	1	2	0	0	0	0	0	0	0	0	10	4	73	20	106	23	440	117
Cecil Peak[2]	55	150	37	115	88	85	64	45	45	20	53	5	60	10	56	25	106	55	92	95	64	120	78	145	798	870
Lat 45 06S Long 168 36E	0	0	0	0	3	0	12	2	15	1	31	5	43	6	34	5	71	6	11	2	12	2	5	1	237	30
Ht 1150 ft Period 7 yrs	89	21	77	20	17	8	2	6	3	4	0	0	0	0	0	0	0	0	4	4	44	13	71	18	307	94
Wye Creek[2]	53	150	39	115	90	85	80	45	58	20	52	5	47	10	43	25	72	55	75	95	45	120	59	145	713	870
Lat 45 08S Long 168 46E	0	0	0	0	3	0	15	2	30	6	41	5	31	7	23	4	36	2	4	1	2	0	0	0	185	27
Ht 1100 ft Period 9 yrs	92	21	76	20	19	8	6	4	1	2	0	0	0	0	0	0	0	0	5	2	55	15	85	26	339	92
Mid Dome[1]	89	118	70	92	103	67	92	39	87	18	99	11	77	12	62	26	64	50	77	81	82	101	75	119	977	734
Lat 45 34S Long 168 30E	3	0	2	0	14	2	35	3	55	8	86	12	65	10	39	7	25	4	13	2	5	1	5	0	347	49
Ht 1268 ft Period 22 yrs	35	11	23	8	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	4	37	11	111	37

1 PE is Penman copy of Gore

2 PE is Penman copy of Queenstown

SOURCE: Compiled from calculations by N.Z. Meteorological Service, courtesy J.D. Coulter.

APPENDIX 2: SUMMARY SOIL DESCRIPTIONS IN THE MAVORA REGION

Typical profiles are described for soils of proposed new associations in the Mavora region on silicious material. Summary notes are given of textural variants to supplement the information in text pages 34-47. Profiles for soils of other sets represented in Table 1 on page 34 are described in Soil Bureau Bulletin No. 27, General Survey of the Soils of South Island New Zealand (1968).

1. ON FANS - ELDON ASSOCIATION

Parent material:	Mainly indurated sub-schist gravels and stones.
Land form:	Intermediate fan with stony surface, slope 4°, aspect west.
Rainfall:	About 1500mm annually.
Altitude:	660 m.
Vegetation:	Stunted matagouri, sweet vernal, browntop and flatweeds.
Drainage:	Well drained.
Erosion:	Slight to moderate frost heave and wind erosion.

Profile:

0-12 cm A	Dark yellowish brown (10YR 3.5/4) silt loam; very friable (fluffy), weakly developed crumbs, some small rocks and stones; many roots; distinct boundary.
12-24 cm B_1	Brown - dark yellowish brown (7.5YR - 10YR 4/4) stony silt loam; very friable - loose; weakly developed fine crumbs and single grain; distinct boundary.
24-45 cm B_2	Yellow brown (10YR 5/6) stony very gritty silt; partially compact; prominent thick red/yellow (5YR 6/8) cutans on stones; indistinct boundary.
45-65 cm B_3	Brown yellow (10YR 6/6) stony silt loam; very friable; very weak crumb and incohesive grains; cutans far less prominent on relatively unweathered rock fragments.
65 + cm C	Light brown/grey (2.5Y 6/2) gravels and guts.
Variants	Silt loams on toes of fan with shallow and stony loams higher on fan.

2. ON MORAINE - MAVORA ASSOCIATION

Parent material:	Angular till (erratics) from indurated sub-schist mainly with some basic volcanics and ultra-basics.
Landform:	Rocky surfaced, rolling and moderately steep moraine with remnant kame terraces; slope 8^{o}, aspect east.
Rainfall:	About 1700 mm annually.
Altitude:	690 m.
Vegetation:	Narrow leaved snow-tussock, fescue tussock, some moss and sweet vernal.
Drainage:	Well drained.
Erosion:	Severe frost heave and wind erosion where exposed.

Profile:

0-18 cm A	Dark brown (7.5YR 3/2) stony silt loam; very friable (fluffy); weakly developed fine crumb; many roots; distinct boundary.
18-31 cm B_{21}	Yellowish red to strong brown (7.5YR-10YR 5/8), very stony silt loam; friable; very weak fine crumbs and single grain; cutans and clay accumulation on stones; some roots; distinct boundary.
31-43 cm B_{22}	Yellow brown (10YR 5/8) stony heavier silt loam; friable, weak fine crumbs, few roots.
43 + cm	On morainic material.
Variants	Shallower on hummocks and deeper in hollows.

3. ON OUTWASH TERRACE - WINDON ASSOCIATION

Parent material:	Terrace of post glacial outwash predominantly indurated sub-schist.
Landform:	Undulating intermediate to high terrace, with boulders on surface, subrounded; slope 2^o; aspect south.
Rainfall:	About 1600 mm.
Altitude:	670 m.
Vegetation:	Stunted matagouri and briar, fescue tussock, sweet vernal, browntop and some white clover.
Drainage:	Well drained.
Erosion:	Subject to wind erosion if disturbed.

Profile:

0-11 cm A_1	Dark yellow brown (10YR 3/4) silt loam, friable to very friable; moderately developed fine crumbs; tight fine root system; indistinct boundary.
11-24 cm A_3	Brown to dark yellowish brown (7.5YR-10YR 4/4) stony silt loam; very friable; weak fine crumb structure; some roots; indistinct boundary.
24-36 cm B_2	Strong brown (7.5YR 5/6) stony silt loam; very friable; very weak fine crumb; few roots.
36 + cm	On boulders and gravels.
Variants	Silt loam to stony shallow silt loams; some profiles closer to AC horizons with colour B_2 in gravels partly cemented.

4. ON COLLUVIAL LOWER SLOPES - SHIRKERS ASSOCIATION

Parent material:	Colluvium from Caples group.
Landform:	Moderately steep, concave colluvial slope; slope 14^{o}; aspect south.
Rainfall:	1900 mm.
Altitude:	750 m.
Vegetation:	Narrow leaved snow tussock, red tussock, moss, flatweeds, sweet vernal.
Drainage:	Poorly drained.
Erosion:	Slight scree accumulation from slope above.
Profile:	
0-15 cm A	Brown to dark brown (10YR 4/3) heavy silt loam; weakly to moderately developed fine nuts and crumbs; friable; many roots; distinct boundary.
15-31 cm B_{21}	Pale yellow (2.5Y 7/4) stony silt loam; very friable; weakly to moderately developed fine nuts and crumbs; some distinct thin cutans on stones and peds; indistinct boundary.
31-42 cm B_{22}	Light grey (2.5Y 7/4) stony silt loam; very friable; very weak fine nuts and crumbs; some faint cutans on peds; few roots.
42 cm C	Light grey - grey(5Y 6/1) silts with little clay, grits and gravels.
Variants	Some better drained stony silt loams.

5. ON STEEP LOWER HILL SLOPES

Parent material:	Mainly subschist of Caples group.
Landform:	Steep to very steep mountain slope on shady side; slope 23°; aspect south.
Rainfall	About 1800 mm.
Altitude:	900 m.
Vegetation:	Narrow-leaved snow tussock, dracophyllum, hebe and some subalpine species.
Drainage:	Well drained.
Erosion:	Occasional small slip or scree.
Profile:	
0-10 cm A	Brown (10YR 5/3) silt loam; very friable; weak fine crumbs; many roots; distinct boundary.
10-27 cm B_1	Brownish yellow to yellowish brown (10YR 5.5/6) stony heavy silt loam; compact but very friable on disturbance; very weak crumbs; indistinct boundary.
27-53 cm B_2	Brownish yellow to olive yellow (1Y 6/6) gritty stony, heavy silt loam; friable; weak fine blocky structure, some fine faint mottles; indistinct boundary.
53 + cm C	On light olive grey (5YR 6/2) gritty silt.
Variants	Silt loams, stony silt loams, stony shallow silt loams (severe erosion phases and scree on sunny slopes).

APPENDIX 3: ESTIMATION OF LAKE VOLUMES

Volumes of the two Mavora lakes were estimated in the following manner:

1. Maximum dimensions and surface area were found from published sources to be as follows:

	North	South	
Length (km)	11.4	2.8	
Width (km)	1.7	0.8	
Depth (m)	100	45	(Stout 1976)
Area (km^2)	10.83	1.23	

2. Within the limitation of maximum recorded depth of each lake and with some knowledge of the influences of geomorphic processes in these glacial lakes on bathymetry, contours at approximately 30 metre intervals were extrapolated from the surrounding land contours shown on N.Z.M.S. 1, S.131, S.141 to produce the accompanying bathymetric sketch map (p.xxvi).

3. At 1 km intervals from north to south of each lake, profiles were drawn to scale from the contours, as illustrated by the accompanying map.

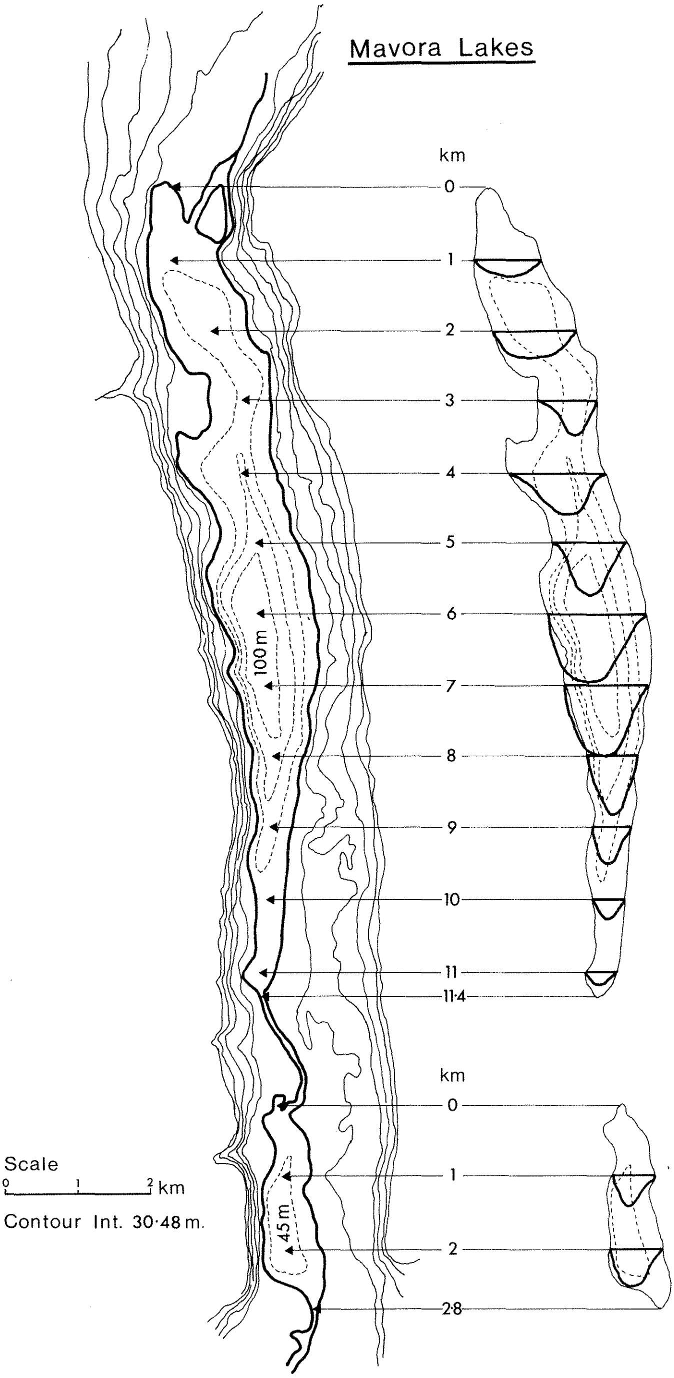
4. Profile areas were measured using a planimeter, giving areas in $m^{-2} \times 10^4$, estimated to an accuracy of between 10 and 20 percent, as indicated below.

5. For each segment of the lake, between profiles A_1 and A_2 etc., volume or capacity was calculated by the formula

$$V = \left(\frac{A_1 + A_2}{2}\right) \ell \; 1000$$

where V is volume in litres,
A_1, A_2 are areas of successive profiles, in square metres
ℓ is length or distance between profiles, in metres.

6. The volume of each lake was then calculated by summing the successive segment volumes as indicated on p.xxviii.


Mavora Lakes
km
0
1
2
3
4
5
6
7
8
9
10
11
11·4
100 m
km
0
1
2
2·8
45 m
Scale
0 1 2 km
Contour Int. 30·48 m.

Calculations:

	Profile No.	Area $m^{-2} \times 10^4$	Volume $\ell \times 10^{10}$
North Lake	0	0	
			0.921
	1	1.842	
			2.565
	2	3.289	
			2.828
	3	2.368	
			3.223
	4	4.079	
			4.079
	5	4.079	
			6.250
	6	8.421	
			8.092
	7	7.763	
			5.658
	8	3.553	
			2.960
	9	2.368	
			1.315
	10	0.263	
			0.395
	11	0.526	
			0.105
	11.4	0	
		Total Volume	$38.328 \times 10^{10} \ell$
South Lake	0	0	
			0.658
	1	1.316	
			2.171
	2	3.026	
			1.210
	2.8	0	
		Total Volume	$4.039 \times 10^{10} \ell$

APPENDIX 4: CHECKLIST OF BIRDS IN THE MAVORA (after Sutton, 1975).

1. <u>Water Birds</u>

Grey Duck - *Anas superciliosa* - Resident and breeding - common.

Mallard Duck - *Anas platyrhynchos* - Resident and probably breeding. Common introduced species.

Black Swan - *Cygnus atratus* - Resident and breeding - in small numbers. A few pairs breeding annually.

Canada Goose - *Branta canadensis* - A few birds usually present.

Paradise Duck - *Tadorna variegata* - Resident and breeding - abundant. Lakes important as moulting area.

New Zealand Shoveler - *Anas rhynchotis* - Present in small numbers.

New Zealand Scaup - *Aythya novaeseelandiae* - Resident and breeding - abundant.

Marsh Crake - *Porzana pusilla* - Resident and breeding - small numbers in swampy vegetation.

Kingfisher - *Halcyon sancta* - Present in small numbers - no recorded breeding, but possible.

*Black Shag - *Phalacrocorax carbo* - Resident and breeding in two small colonies.

Little Shag - *P. melanoleucos brevirostris* - Resident and probably breeding.

Crested Grebe - *Podiceps australis* - Occasional visitor.

*Black-backed Gull - *Larus dominicanus* - Resident in small numbers.

Black-billed Gull - *Larus bulleri* - Resident in moderate numbers.

Black-fronted Tern - *Chlidonias hybrida* - Resident in small numbers.

White-faced Heron - *Ardea novaehollandiae* - A few birds present - possibly breeding.

2. <u>Wading Birds</u>

S.I. Pied Oystercatcher - *Haematopus finschi* - Semi-migratory - present August - March - breeding.

Banded Dotterel - *Charadrius bicinctus* - As for S.I. Oystercatcher.

Pied Stilt - *Himantopus himantopus* - Resident and breeding - a few pairs.

Spur-winged Plover - *Lobibyx novaehollandiae* - Resident and breeding. Moderate numbers - increasing.

3. <u>Native Bush Birds</u>

Grey Warbler - *Gerygone igata* - Resident and breeding - abundant.

Rifleman - *Acanthisitta chloris chloris* - Resident and breeding - abundant.

Brown Creeper - *Finschia novaeseelandiae* - Resident and breeding - moderate numbers.

Silver-eye - *Zosterops lateralis* - Resident and breeding - small numbers.
S.I. Pied Fantail - *Rhipidura fuliginosa fuliginosa* - Resident and breeding.
S.I. Robin - *Petroica australis australis* - Resident and breeding - very numerous. Notable feature of avifauna.
Bellbird - *Anthornis melanura* - Resident and breeding - abundant.
Tomtit - *Petroica macrocephala macrocephala* - Resident and breeding - abundant.
Yellowhead - *Mohoua ochrocephala* - Resident and probably breeding - present in small numbers.
Yellow-crowned Parakeet - *Cyanoramphus auriceps* - Resident and breeding.
Red-crowned Parakeet - *C. novaezelandiae novaezelandiae* - Resident and breeding. Both species of parakeet very numerous - the best place in Southland to see these two species.
Morepork - *Ninox novaeseelandiae* - Resident and probably breeding - few.
Kaka - *Nestor meridionalis* - Recorded regularly - breeding status not known.
Long-tailed Cuckoo - *Eudynamis taitensis* - Summer migrant from Pacific Islands - October-March - common.
Shining Cuckoo - *Chalcites ludidus* - Status as for Long-tailed Cuckoo.

4. Open Country Species

Kea - *Nestor notabilis* - Occasionally recorded.
Harrier Hawk - *Circus approximans* - Resident and breeding - common.
New Zealand Falcon - *Falco novaeseelandiae* - Resident - now scarce.
New Zealand Pipit - *Anthus novaeseelandiae* - Resident and breeding - abundant.
Chukar - *Alectoris chukar* - Introduced - sparse numbers on steep tussock slopes - probably breeding.

5. Common Introduced Birds

*Blackbird - *Turdus merula* - Resident and breeding - abundant.
*Song Thrush - *Turdus philomelos* - Resident and breeding - moderate numbers.
*Starling - *Sturnus vulgaris* - Resident and breeding - common.
*Skylark - *Alauda arvensis* - Resident and breeding - abundant.
*Chaffinch - *Fringilla coelebs* - Resident and breeding - very abundant.
*Redpoll - *Acanthis flammea* - Resident and breeding - very abundant.
*Greenfinch - *Carduelis carduelis* - Resident and probably breeding.
*Yellowhammer - *Emberiza citrinella* - Resident and breeding - small numbers.
*Hedge Sparrow - *Prunella modularis* - Resident and breeding - small numbers.

*Species not protected.

APPENDIX 5: LIST OF TREES SUITABLE FOR THE MAVORA

Trees suited to the Mavora might be found among the more hardy of those recommended for the inland zone in "Shelter trees for Southland", notes prepared from G. Chavasse (NZFS).

Soil and exposure in the inland zone can be rather critical and species for any individual planting must be selected with care.

(a) High Shelter:

Radiata pine is recommended only for fast short-term shelter except for favoured sites. Probably the best high shelter is *Populus nigra* var. *italica* where there is ground water, but *Pseudotsuga taxifolia*, *Pinus ponderosa* and *Pinus nigra* all do well. *Eucalyptus gunnii* is suitable on deeper soils and several other species listed below appear to be suitable.

Cedrus atlantica
Cedrus deodara
Nothofagus solandri var. *cliffortioides*
Pinus silvestris
Sequoia gigantea

(b) Low Shelter:

The number of low shelter species which have had adequate trial is limited. The following can be recommended:

Crataegus monogyna
Cupressus arizonica
Cupressus torulosa
Ilex aquifolium

(c) Shade and Ornamental Trees:

The following can be recommended. It is probable that trials will reveal quite a wide variety of suitable species for more sheltered conditions.

Acer pseudoplatanus
Aesculus hippocastanum
Betula alba
Fagus silvatica
Juglans regia
Larix decidua
Nothofagus fusca
Populus nigra

Quercus robur
Salix babylonica
Sophora microphylla
Sorbus aucuparia
Tilia vulgaris

SPECIES FOR TRIAL

A large number of trees and shrubs deserve further consideration. The list below suggests those which are worthy of trial.

Abies pinsapo
Abies concolor
Abies nordmanniana
Acer saccharum
Alnus glutinosa
Carpinus betulus
Castanea sativa
Cedrus libani
Cupressocyparis leylandii
Cupressus goveniana
Cupressus sempervirens var. *stricta*
Eleagnus angustifolia
Eucalyptus coecifera
Eucalyptus linearis
Eucalyptus urnigera
Fraxinus excelsior
Fraxinus pennsylvanica var. *lanceolata*
Juniperus communis
Juniperus virginiana
Picea smithiana
Pinus banksiana
Pinus coulteri
Pinus jeffreyi
Pinus mugho
Pinus pinea
Pinus wallichiana
Populus alba var. *pyramidalis*
Populus nigra var. *sempervirens*
Prunus lusitanica
Quercus palustris
Sorbus aria
Ulmus pumila

APPENDIX 6: ESTIMATION OF WATER ENRICHMENT RISK FROM PASTORAL USE AND DEVELOPMENT

The Role of Nutrient Enrichment in Eutrophication

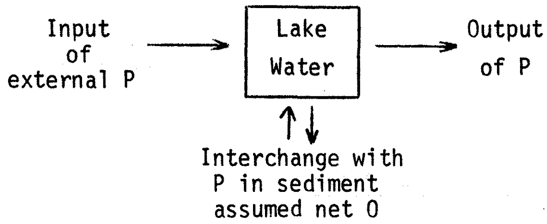
There is documented evidence in New Zealand that by-products from agricultural use of a catchment may supply the limiting nutrients for biological production in lakes, leading to eutrophication and reduced dissolved oxygen concentrations in summer (McColl, 1972). It may be speculated that a trout fishery could benefit from an increased feed supply resulting from higher plant productivity. Burnet and Wallace (1975) have cited an American conclusion: "Although the fertilisation of lakes has increased their productive capacity, its practical success in terms of net fish yield to anglers is doubtful." In New Zealand there is increasing weight of evidence (Fish 1970, Burnet and Wallace 1975) that would suggest that oligotrophic lakes are a more suitable environment for trout, that highly eutrophic lakes are not a suitable environment, and that low oxygen levels in summer are marginally affecting trout fisheries in such lakes as Rotorua (N.I.). The role of topdressed pastures in enriching water is examined by McColl (1978,1979). The pollution by products of agricultural use of a catchment has been reviewed by O'Connor (1972) and more recently by McColl and Hughes (1981). Processes of transfer to water range from soil loss, containing both organic and inorganic phosphorus and nitrogen, soil leachates, containing especially soluble nitrate in drainage waters, to direct additions to water bodies of animal wastes or of fertilizer from careless application practice, especially from the air. Regardless of the process by which pollution occurs, the principal enriching agents are nitrogen and phosphorus. Either phosphorus or nitrogen is likely to be the limiting nutrient for biological production in lakes. Although there are some situations in which nitrogen may be limiting, there is always a possibility of such deficiency being soon corrected by di-nitrogen fixation by such organisms as blue-green algae, so long as phosphorus supply is not limiting their growth. Redfield (1958) has demonstrated from both marine and freshwater studies of productivity the controlling role of phosphorus from the geochemical substrate. Syers (1974) and Syers, Harris and Armstrong (1973) point to the twofold importance of phosphorus in controlling eutrophication. Not only is phosphorus often the limiting nutrient in lake surface water but measures to retard eutrophication through nutrient control are more likely to succeed with phosphorus than with other nutrients.

These authors point to the complexity of influences on dissolved inorganic phosphorus in lakewater, which is the available form of phosphorus for aquatic growth. Not only may external phosphorus enter the system from inflowing waters or other processes mentioned, but there may be interchange of phosphorus among sediment and water compartments through both chemical and biochemical reactions. Sediment phosphorus may be released to overlying water through suspension of particulate forms or transport of dissolved forms through turbulent mixing and diffusion. De-oxygenation of lake bottom waters associated with advanced eutrophication enhances release of sediment inorganic phosphorus. Once eutrophication occurs, it therefore tends to be perpetuated by providing a lake sediment source for the otherwise limiting nutrient, dissolved inorganic phosphorus. Reduction of external inputs after eutrophication has occurred, therefore, requires a long time before the problem is abated.

The essence of eutrophication control is therefore prevention by limiting injurious levels of external phosphorus inflow.

A Simple Model of Lake Enrichment

Our approach to estimation of the risk of injurious levels of inflow has been to develop a coarse but simple model. It is assumed from the analyses and experiments of Burnet and Wallace (1973, 1975) that inorganic phosphorus concentrations in excess of 0.01 ppm represent a danger level for New Zealand lakes. It is also assumed that gains in phosphorus to the lake water would come principally by agricultural influxes into the lake. The lakes and supplying streams lie in a basin predominantly of low P solubility sediments. If a flush of new sediment enters the lake, it is assumed that it has the same low P solubility and inferred that the concentration of P in the lake water will not change materially. If new sediment derived from superphosphate or dung-enriched wash entered, then P concentration within the lake would rise, proportional to the new solubility. Losses from the system are assumed to be almost entirely through the outflow from the lakes, and gains in nutrients are assumed to be through surface and subsurface inflows at constant rate, then we can have the following model:



which can be mathematically expressed as follows:

$$\frac{dy}{dt} = A-BY$$

where Y = P in lake in kg
t = time in years
A = constant input rate of P in kg/year
B = fraction of Y lost in outflow per year

This expression of rate of change in concentration of phosphorus in lake per year can be integrated as:

$$Y = \frac{A}{B} + (Y_0 - \frac{A}{B})e^{-Bt}$$

where Y_0 is nutrient in lake at zero time.

For North Mavora Lake (see Appendix 3):

$$B = \frac{\text{outflow from lake in litres per year}}{\text{volume of lake in litres}}$$

$$= 1.07 \text{ which can be taken as } 1.$$

Now if Y_0 is taken as 0

Then $Y = A(1-e^{-t})$,

that is, the maximum concentration will be achieved at the concentration of inflowing water, reaching 63% in one year, 86% in two years, 95% in 3 years and more than 99% in 5 years.

For South Mavora Lake, where outflow per year is ten times volume, the rate at which lake concentration will reach the concentration of inflow is 63% in 5 weeks, 86% in 10 weeks, 95% in 15 weeks and more than 99% in 6 months.

From these calculations, it can be recognized that combined inflows must be kept at a level safely below 0.01 mg P/litre.

Application of Model

The level which we suggest as safe would be half that level, i.e. 0.005 mg P/litre. As the river flow is some 4.1×10^{11} litres per year, then we would suggest an upper safe limit of some 2000 kg P/year in the inflow.

This annual level is represented by 20 tonnes of superphosphate OR the dung of 500 to 1000 cattle, dependent on their level of P intake.

Let us assume that losses of superphosphate to drainage waters are 0.5 per cent per year of what is applied. Then the safe upper limit would be reached with the annual application of 4,000 tonnes of fertilizer alone. If losses from fertilizer were as high as five per cent, which would not be unexpected in the event of topdressing the whole of the valley of the Upper Mararoa, then the safe upper limit would be reached with 400 tonnes of fertilizer, almost certainly insufficient even to maintain the fertility of the 3,000 hectares proposed for topdressing as Class VI land by Federated Farmers (Chapter 8, p. 135). Even at losses of 0.5 per cent, applied maintenance topdressing on 3,000 hectares at 250 kg superphosphate per ha would represent losses to the waterway of 375 kg P/year.

These above calculations of possible losses from fertilizer are calculated as though there were no likely losses from animal dung. If we assume that without berm fencing some 20 per cent of dung is deposited in waterways or floodways so that it is transported in inflows to the lake, then the upper limit for cattle dictated by our safe inflow level of 2000 kg P/year would be 2,500 to 5,000 on an annual basis, provided no fertilizer use or loss occurred.

If we assumed maintenance topdressing on 3,000 hectares and an unavoidable loss of 375 kg P/year therefrom, then the safe cattle numbers on such well-fed pastures without berm fencing could be calculated at a maximum of about 2000 on an annual basis. As this level of stocking on 3,000 hectares would almost certainly be uneconomic on oversown and topdressed pastures, we are forced to the conclusion that topdressing and oversowing would require berm fencing as an essential accompaniment, if economic development that was ecologically defensible were to be achieved. This conclusion is reinforced by the consideration that a 20 per cent loss of dung phosphorus represents a loss from the pasture system of some 16 tonnes of superphosphate from 2,000 cattle on an annual basis and some 24 tonnes if the topdressed area of 3,000 hectares were stocked at an economic level.

None of the above calculations makes allowance for the net inflow of phosphorus that may occur from erosion of relatively fertile alluvial lands as a consequence of berm grazing by livestock. Numerous examples of this kind of effect are to be observed at the present time in the north-western Southland district.

Conclusions

Our conclusions, therefore, are as follows:

1. Current grazing levels are probably within the tolerance levels of the lake systems but may be approaching them through acceleration of riparian erosion, quite apart from other factors causing local damage to the fishery in the headwaters.

2. In the absence of topdressing and oversowing, the major step to reduce the danger of lake eutrophication would be berm fencing or reduction of cattle numbers or both.

3. In the presence of topdressing and oversowing of suitable terrain in the Upper Mararoa and above the lake, berm fencing would be essential to prevent lake quality deterioration.

4. In the event of topdressing and oversowing, every effort would have to be made to avert and prevent direct losses of fertilizer or fertilized soil to the water bodies contributing to the lake. For this reason as well as the above, such development work should be excluded from the floodplain and the vicinity of the water bodies.

5. These conclusions which have been made to avert lake eutrophication are also cogent for protection of wildlife and fishery in the tributary waters. For these objectives other considerations may also apply.

APPENDIX 7: SPECIFICATIONS OF RECOMMENDED USES

In following Beek's (1978) approach to the assessment of land suitability (or "the fitness of a given tract of land for a defined use") we have identified in Chapter 6 a number of relevant use possibilities called "land utilization types". These have been considered as development alternatives in the primary evaluation we carried out at a land system level. These land utilization types were outlined in descriptive terms so that the reader could readily visualize what was being considered as alternative uses. To allow them to be more carefully assessed and to define the recommended uses of our proposed joint planning goals (Chapter 12), it is necessary to specify the "key attributes" of the recommended land utilization types. Key attributes are the most fundamental characteristics which define the land utilization types. In Beek's (1978) approach these key attributes are identified as *produce, labour, capital, management, technology,* and *scale of operations.* Beek proposed the preparation of a structured checklist of major and minor determinants of land utilization as an intermediate step in the determination of key attributes. We have not considered this intermediate step as a formal necessity in the case of Mavora. It has been easier to define our land utilization types, principally because of the specific locational aspects of several of the recommended uses and because of their character as necessarily government agency operations. Reference to Beek (1978) will reveal that governmental and locational determinants are included with the other key attribute categories in the structured list of determinants.

The land utilization types identified in proposed joint planning objectives are enumerated below with their key attributes as well as locational and governmental features. They are grouped under four headings: NATURE CONSERVATION, RECREATION, WILD ANIMAL CONTROL and FARMING.

NATURE CONSERVATION

WCX: Wildlife Conservation to Maximum

Produce: Maximum sustainable populations of trout for angling and of native birds for recreational enjoyment and for the preservation of biota in a natural habitat.

Labour: Governmental and Acclimatization Society manpower for protection, improvement and maintenance of habitat and strict control of predators, including man.

Capital: Share in public capital for exclusive use of animal influence as integral part of habitat protection, improvement and maintenance.

Management: Planning, census, periodic patrolling, monitoring and control of populations, control of predators.

Technology: Normally serviced by boat or on foot, but with occasional aircraft if needed.

Location and Scale of Operations: Whole of riparian lands, wetlands and water bodies of the Windon and Upper Mararoa valleys, as indicated in Map of Figure 36.

WCM: Wildlife Conservation to Moderate Level

Produce: Healthy and sustainable populations of lake fish for angling and of native birds and other animals of forest, lake margin and open-country, consistent with closed game status and absolute protection of non-game birds.

Labour: As for WCX.

Capital: Nil.

Management: Periodic census, periodic patrolling and monitoring, control of predators and possibly of competitive adventive species.

Technology: As for WCX.

Location and Scale of Operations: Whole of Mavora area with special emphasis on Eldon, Westburn, Thomson, Livingston and Mararoa Land Systems and unit 1 of Campbell Land System (see Fig. 35).

VCX: Vegetation Conservation to Maximum

Produce: Preserved populations of native plants in natural habitat and conditions for scientific, educational and related purposes.

Labour: Government agency personnel.

Capital: Fencing and other protective investments if warranted.

Management: Nature Reserve status of designated areas if warranted by survey with consequential management plan.

Technology: Servicing on foot but with helicopter assistance if warranted.

Location and Scale of Operations: At areas to be designated as possible outcome of surveys; otherwise not-operative.

VCM: Vegetation Conservation to Moderate Level

Produce: Restored and maintained vegetation in natural or similar condition for maintenance of landscape quality, recreational enjoyment and maintenance of habitat.

Labour: Government agency personnel.

Capital: Nil

Management: Exclusion of disturbance by domestic and wild animals (exotic), control of fire, reseeding of depleted areas with initial topdressing as required.

Technology: Servicing on foot within area with essential supplementary use of aircraft.

Location and Scale of Operations: Eldon, Westburn, Livingston, Mararoa Land Systems, Windon sector of Thomson Land System and upper slopes of Campbell, Thomson and Sugar Loaf Land Systems.

RECREATION

RNAD: Recreation: Natural Area Dependent (Group B1)

Produce: Opportunity for recreational activities such as back-pack camping etc., including route-marking, emergency shelter and possibly some track-making and possibly bridge building.

Labour: Government agency personnel.

Capital: Provision for safety features, especially for emergency use.

Management: Provision for foot access recreation as characterised in Section 6.3.52 (p.108) but regulating use, especially in seasonal volume, possible provision of horse-riding access in limited zone.

Technology: Servicing and patrolling on foot within area with supplementary use of aircraft if essential.

Location and Scale of Operations: Eldon, West Burn, Livingstone Land Systems and Windon Valley sector of Thomson and Mararoa Land Systems. If horse riding access is to be provided it would be confined to defined zone of these western land systems.

ROSD: Recreation: Open Space Dependent (Group B2)

Produce: Opportunity for on-foot recreational activities including back-pack camping and walking (including family parties), fishing, study of natural history, enjoyment of open-space scenery.

Labour: Government agency personnel with cooperation from local farmer.

Capital: Substantial requirement for provision of Walkway facilities (including huts and bridges) and securing of exclusion of other influences such as domestic animals and vehicles.

Management: Survey and design to New Zealand Walkway standards, including, in this instance, exclusion of horse traffic and pastoral animal impact from most sectors of Walkway. Maintenance of open-space character of landscape vistas in both Upper Mararoa and in Thomson Land System alongside lake. Regulation of volume and character of Walkway usage and fishing.

Technology: Servicing and patrolling on foot within area with supplementary use of aircraft and boat if necessary, especially for building supplies.

Location and Scale of Operations: Campbell Sub-System (Fig. 35) and Thomson and Sugar Loaf Land Systems (Fig. 36).

RRBM: Recreation: Resource-Based but Resource-Modifying (Group C - Low Impact)

Produce: Provision of opportunities and facilities for vehicle-accessed recreation such as camping, picnicking, fishing, non-power boating.

Labour: Government agency personnel.

Capital: Additional capital for facilities may be shown from detailed planning of area, as designated in Figure 35 and Objective 8 (p.173).

Management: Detailed Management Plan required for facilities area to be designated. This would include provision for continuing management and servicing.

Technology: Vehicle-serviced, with moderate to high level of recreational and scenic reserve facilities provided, e.g., sanitation, picnic, fireplaces, partly serviced camping area, water safety, off-road parking.

Location and Scale of Operations: As designated in Figure 35 and including area to west of South Mavora Lake and Mararoa River and extending to "Old Homestead area" to the south.

RVBD: Recreation: Vacation Building Development (Group F - Lodges)

Produce: Provision of opportunity for co-operating non-commercial groups to build recreational lodges for group accommodation and possibly to share building facilities, e.g., cookhouse, showers, as partial service to motor campers.

Labour: Government agency personnel for site planning and supervision of standards only.

Capital: Nil requirement for provision of opportunity only. (Capital requirements of lodge building are responsibility of co-operating group.)

Management: Detailed Management Plan required for facilities area to be designated would include site planning for this opportunity. Building specifications and nature of site agreement would be subject of negotiation with co-operating body.

Technology: Vehicle-serviced, high facilities area standard but appropriate to location.

Location and Scale of Operations: To be negotiated within Management Plan for Facilities Area in general vicinity of South Mavora Lake.

WILD ANIMAL CONTROL

WAC: Wild Animal Control (Respecified)

Produce: Attainment and maintenance of population control of wild animals consistent with the needs of restoration and maintenance of natural vegetation and landscape to west and north of Mavora Lakes, and consistent with needs of adjacent farming uses and of maintenance and improvement of forest and other vegetation cover and condition and of soil conservation and scenic values on land to east and north east of Mavora Lakes.

Labour: NZ Forest Service personnel or as arranged by NZFS.

Capital: Possible hut facilities for purpose.

Management: In accordance with Working Plans for Wakatipu, Snowdon, Von and Eyre State Forests and in keeping with wild animal control policy for Fiordland National Park.

Technology: As appropriate to above forest working plans.

Location and Scale of Operations: As specified under "Produce" and in Objective 5 (p.172).

FARMING

PSIA: Pastoral: Semi-Intensive Accessory

Produce: Pasture-fed livestock, meat and wool, in conjunction with seasonal and complementary use of related land beyond the study area.

Labour: Lessee-occupier with hired labour.

Capital: Substantial development capital required for which Rural Bank and related programmes would be appropriate.

Management: Substantial pastoral development, especially involving over-sowing, topdressing and fencing, including berm fencing in the Upper Mararoa lower slope and subdivision fencing on the terraces, downlands and lower hills of the Thomson and Sugar Loaf Land Systems, initiated as a pastoral development programme for the Elfin Bay run as a whole. Pasture improvement, fencing, buildings and any afforestation or shelter-planting would be undertaken to a Run Management Plan to be negotiated, to serve and maintain both pastoral use and landscape quality as indicated in Objective 7(a) (p.172-173).

Technology: Aerial operations for pastoral improvement. If vehicle access is desirable for the run development programme, the feasibility should be examined of a road from the Sugar Loaf Land System on the true left of the Upper Mararoa through the high saddle to the North Von and thence to the Von Valley road (see p.165). Alternatively, farm access road might be evaluated from the Elfin Bay homestead through the Pass Burn into the Upper Mararoa. This would require evaluation with detailed Walkway assessment.

Location and Scale of Operations: As indicated in Figure 36, this land use would be excluded (i) from all of the Mararoa Land System to the north west of the Upper Mararoa River, (ii) from all of upper hillslopes of the Thomson and Sugar Loaf Land Systems and (iii) from all of the river flats of the Thomson and Sugar Loaf Land Systems. These upper steeplands and river flats to be excluded from pastoral use are identified as land units in the descriptions of the Sugar Loaf and Thomson Land Systems (pp.60-63). (It may also be noted (pp.70-71) that the Mararoa Land System is confined almost entirely to steeplands and that the major valley lands at their foot are represented as part of the neighbouring Thomson and Sugar Loaf Land Systems.) It is not expected that this land use would extend beyond the south western boundary of Elfin Bay, unless the deer farming use proposed for the Thomson and Campbell subsystems is, for some reason, not proceeded with.

PSIDF: Pastoral: Semi Intensive Deer Farming

Produce: Breeding stock of selected red-deer as well as deer products.

Labour: Lands and Survey Field Operation and Farm staff but may involve co-operation from Deer Farmers' Association.

Capital: Substantial requirement for complete boundary fencing adequate to prevent deer escape and (if hygiene of herd is significant) to prevent ingress of wild deer, at least into certain areas.

Management: Pasture improvement by oversowing and topdressing of fans, moraines and lower hillslopes of Thomson Mountains. Forest planting in selected protected areas to give shelter. Rearing of breeding stock of selected Red deer, Wapiti or hybrids. Separation of area from Walkway zone close to lake margin.

Technology: Limited four-wheel drive vehicle use within the deer farm terrain. Intensive contemporary deer farming technology including provision of winter feeding, subdivision fencing for controlled mating.

Location and Scale of Operations: On designated land units of Campbell Sub-system as illustrated in Figure 35. New vehicle access to be provided through forested land unit.