THE USE OF NATURAL RESOURCES IN THE SCOTTISH HIGHLANDS, WITH PARTICULAR REFERENCE TO THE ISLAND OF MULL

by

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The highest function of ecology
is in the understanding of consequences

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DEDICATION

This thesis is dedicated to the people of Mull, who will make their own decisions and go their own way, no matter what an academic might tell them. My only regret is that I was not able to spend more time on the Island.

"....Now I watched, as the Earth turned fast, but still so that I could see the change and growth and dying away of patterns, how as the planets moved and meshed and altered and came closer to each other and went away again, exerting a pressure of forces on each other that bound them, on Earth the little crusts of matter that were men, that were humanity, changed and moved. Just as the waters, the oceans (a little film of water on the big globe's surface) moved and swung under the compulsion of the Sun and Moon, so did the life of Man, oscillating in its web of necessity, in its place in the life of the planets, a minute crust on the surface of a thickening and becoming visible of the Sun's breath that was called Earth. Humanity was a pulse in the life of the Sun, which lay burning there in a vast white explosion of varying kinds of light, or sound, which fluid lapped out into space holding all these crumbs and drops and little flames in a dance, and the force that held them there circling and whirling in their dance was the Sun, the energy of the Sun, and that was the controlling governor of them all, beside whose strength all the subsidiary laws and necessities were nothing..."

Briefing for a descent into Hell
Doris Lessing

CONTENTS

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Abstract

The thesis examines the use of natural resources in a case study area of the West Highlands, the Island of Mull. A review of history and description of present conditions leads on to an exploration of the island's future prospects and subsequently to a discussion of the island's problems in the more general context of remote Highland communities.

Mull has been the subject of extensive previous survey, a review of which forms a foundation to the main part of the work, the exploration of some possible future patterns of resource-use. Three specific scenarios of the period 1980-2030 AD allow assessments of carrying capacity for a human community. In each case, a maximum feasible solution is described for the supply of food and shelter, and to a lesser extent of energy and material goods (in other words, the support of an economy) within the constraints set by the scenario.

The first scenario explores a future in which Mull's present connections with the outside world are severed, enforcing self-sufficiency. In this case, the land and energy resources available on the island could support about 8000 people at a subsistence level. The second scenario envisages increasingly detailed resource planning at a national level. Mull's population is barely maintained, or declines to just below 2000, while raw material output, particularly of timber, and tourism potential is increased significantly. The third scenario anticipates a change of direction for remote communities, with a technologically sophisticated but self-reliant population. This community has considerable autonomy, and is able to provide food and energy for a population of about 10 000.

While these anticipations are exploratory and in no way predictive, they all envisage a large increase in output accompanied in two cases by increases in population, a contrast with the present situation of 2500 population, declining agriculture, constrained forestry and significant dependence on tourism. In the final chapters, the barriers to resource development are discussed and the concept of 'appropriateness', coupled to analysis of the functional roles of natural resources and technology, is put forward.

In the final analysis, there are clearly considerable current pressures in the direction explored in the second scenario. Whether this is desirable is questioned. It is recognised that attempts to direct development cannot succeed if they impose externally determined priorities and values, but may do so if they encourage and enhance community self-confidence.

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PART ONE DEFINITION

Chapter one - Introduction

Chapter two - Paradigms and methodology

CHAPTER ONE - INTRODUCTION

1.1 Aims and objectives

1.2.1 Origins

This dissertation evolved from the curiosity of an ecologist and natural scientist about the relationship of man with his environment. In some ways it is thus an essay in human ecology, in the sense used by Fraser Darling (1). This relationship between man and environment is an immensely diverse area, and involves the interests of many academic disciplines, including economics, sociology, psychology, ecology and other applied biological sciences, geography, history, philosophy and politics. It would be unwise, at least in the present day, to attempt to integrate this diversity of content and approach between the pages of a doctoral thesis. However, it is a basic premise of the project that the study of the interaction of humans with their environment, including other organisms and other men (2), will never make significant advances purely within the framework of academic disciplines. That is not to deny the utility of those disciplines, but rather to say that they provide necessary but not sufficient conditions for those advances (3).

This idea has been widely recognised in recent years, and the first tentative steps to synthesise disciplines have taken place. Most success has been achieved in the area of interdisciplinary studies, where an author limits his remit to two established disciplines, for example applied biological science and economics. Other attempts have been multidisciplinary, but the difficulties of adequately absorbing additional disciplines, and the interactions between them, increase geometrically. Richerson and McEvoy (4) sum up the consequences very neatly:-

> "...So the human ecologist is fated to be plagued always with a little worm of anxious doubt that his studies have not included all the important interactions that might have affected his research. He can never have observed and measured every conceivable variable, and a knowledgeable worker in one discipline, because of his greater competence on a narrower front, will often be able to object to his efforts, all the more so the broader and more integrative the ecologist tries to be...."

The appropriate response to this criticism is that while the specialised disciplines have indeed developed essential knowledge about unique aspects of human ecology, from this foundation and the study of real systems it is possible to learn about the integrated behaviour of complex and diverse human systems. This approach has been termed transdisciplinary (5). The approach is relatively new and so far lacks a definitive theoretical framework. The reasoning it therefore pursued and developed as part of Chapter two.

Thus far the subject area of the thesis has been identified. The purpose of this introductory chapter is to describe how this area has been focussed into operational objectives, and how the various parts of the thesis relate one to another.

1.1.2 Objectives

It is a second premise of the project that a transdisciplinary research project must find a focus, and that this may usually be achieved by being 'problem oriented'. That is not to say that one aims to solve problems, but rather that one aims to:-

> "....add to the understanding of the variables and the relationships bearing on the area, and hence learn how one may approach the problems and try to identify patterns or develop models which describe them." (6)

The Highland problem is one such problem area which is well-suited to this kind of approach. As a problem, its roots and characteristics in their totality are complex, and its resolution obscure. It has been characterised as a cultural problem, a social problem, a biological problem, a political problem and (most frequently) as an economic problem. An examination of the processes involved shows it to be none of these alone, but rather to contain elements of all of them. As a problem of peripheral areas, the problem set is recurrent across the world, while at the same time the particular historical processes in the Highlands of Scotland have produced particular local circumstances.

As a focus for a specific research project, 'the Highland problem' is itself too vague. The focus is sharpened in two ways:-

a) One of the most telling statistics characterising the Highland problem is the fact that while the land north and west of a line drawn through Glasgow, Dundee and Banff comprises one fifth of the land area of the UK, it contains a mere half a million people, less than 1% of the UK population and hence a comparable fraction of economic activity. Why should this be? What is preventing an increase in population and economic activity? Is the area producing as much as it could, or does its present condition represent a serious suboptimisation of natural resource-use? This last statement poses a specific question, and is the fundamental operational aim of the project. It also raises the question of 'carrying capacity' in the ecological sense of the maximum feasible level of sustained resource use by a species population. This question is placed in context with other strands of the study in Chapter two.

b) Research resources are limited, and information presents problems of availability, so a second means of sharpening focus is to concentrate on a smaller geographical area. This should be small enough to allow data collection to be feasible within the time limitations of the project, but large enough to include most of the elements of the larger problems which are the ultimate subject of study. The Island of Mull is such a case-study site. Extensive previous surveys provide a data base (an essential foundation for the study) unparalleled anywhere in the West Highlands. Being an island or, more accurately, a group of islands, it is geographically and culturally defined along coincident boundaries. This eases problems of system definition, a recurrent theme throughout the thesis.

The choice of Mull bears no particular significance beyond the convenience of data availability. The study lays no claim to providing a 'solution' to the island's problems, and certainly does not propose a prescriptive plan. Such practical objectives could only be achieved with the active involvement and assent of the community, a task completely outwith the scope of an academic research project.

The most important source of data was survey associated with the HIDB's 'Survey and Proposals for Development' (7), a study whose own justification and objectives are obscure. The Board, with a stated remit to:-

> "....assist the people of the Highlands and Islands to improve their economic and social conditions and .... (enable) them to play a more effective part in the economic amd social life of the nation..." (8)

and the categorical statement in their first report, that:-

> "....the Board will be judged by its ability to hold population in the true crofting areas...." (9),

is apparently in a central position to define operational objectives of development and hence criteria for aid to remote communities. However, the concluding remarks of a paper describing the Mull survey stated:-

> "....Discussion on the Mull study revealed how uncertain are the objectives of land use planning in such environments. The assumption (on which the study was apparently based), that population on the island should be stabilised was questioned; it was argued that better primary land management may well reduce, rather than increase, employment and thus encourage a decline in population. A further point was made for rather more effort to be put into maintaining a viable community on islands like Mull to save them from becoming 'just quaint survivals of folksy Celtic culture'" (10)(my emphasis)

This thesis looks at resource use with reference to such underlying assumptions; further stimulus is provided by Bryden and Houston:-

> "....The use of all productive resources.... could be improved in many sectors of the British economy. What is most necessary and most convincing is to show in some detail, and eventually demonstrate in practice, the kind of improvements that could follow from 'better' land use in the Highlands.... It is thus important that appropriate methods are used to identify the 'right' programmes and to choose the most effective means of implementing them." (11)

Thus the concept of appropriateness may be introduced. There are two distinct elements to the project. The first is the study of potential uses and modes of use of natural resources in a specific West Highland location. This part of the exercise is intellectually detached, to the extent that value judgements are avoided. The analysis is essentially exploratory rather than normative. Such work is sterile, however, unless one extends discussion to a second area, considering questions of purpose, objective function, welfare judgements or however the broad concept of appropriateness may be defined in a specific instance. In furtherance of these aims, two formal objectives are defined, corresponding to the two elements outlined above, in the form of questions:-

1. What is the potential of the Island of Mull for the support of a human community?
2. Given the current knowledge of the capabilities of the study area, what form of organisation and policy would enable the appropriate use of resources and technology there?

These two short questions obviously beg many others, but they sum up the substance of the problem this thesis seeks to investigate.

There are other contributory aims. The analysis of the economic situation of the UK presented briefly in section 2.1 and alluded to elsewhere in the thesis suggests a strong latent interest in the productive potential of the Highlands, and supports the belief that there will soon be a need to regenerate indigenous resource-use systems. This study contributes to this perceived need by (a) attempting to assess resource potential at a site, and (b) therefore developing the methodology and defining the information required to do this adequately elsewhere.

Coping with complexity itself presents a challenge, as multivariate interaction frequently produces unexpected results, termed 'counterintuitive' by Waddington (12). The study was carried out with these kinds of concepts very much in mind. Finally, the argument for transdisciplinary research outlined in section 2.1 is motivated by the belief that this study offers a small increment in the understanding of the problem characterised as the 'human problématique' (13).

1.2 Structure

The thesis may be considered to comprise four parts. The first sets the scene, defining terms of reference and structure. The second describes the system under study, the Island of Mull, and its present condition. The third section explores the future of the system under study. while the final section reviews the preceding exploratory discussions in the light of policy imperatives of the present. These parts fulfil quite distinct roles in the overall argument developed in the thesis. The following more detailed description of structure explains these roles.

1.2.1 Part one - Definition

This introductory part consists of Chapters one and two. Chapter one defines the broad subject area and objectives of the thesis, places it in its academic context, and describes the structure of the document. Chapter two examines some of the key issues, aiming to clarify their interrelationships. A discussion of the relationship between research aims and methods and the problems of decisionmaking in complex environments leads on to a discussion of the concept of carrying capacity, the use of 'appropriateness' and of models within the body of the thesis.

1.2.2 Part two - Description

The description of the study area occupies the next three chapters. This part of the thesis aims to give the newcomer an up-to-date picture of the history and present condition of Mull as a system supporting a human community. Chapter three considers the trends and limitations imposed by historical forces, significant constraints on its future development. Thus an examination of ecological, economic, social and political processes in the West Highlands forms an essential foundation to this descriptive phase.

Chapter four derives from the models described in Chapter two a list of the elements which together comprise the Mull system. The bulk of the chapter is taken up with a consideration of these in turn, thus providing a statement of the current status of the system. Chapter five looks at natural resources in more detail. The physical attributes of the island are summarised, assessments of land use capability discussed and the limits of current production examined.

1.2.3 Part three - exploration

The examination of policy options implied by the use of the word 'appropriateness' requires knowledge of history, present condition and future options. This part of the thesis examines three futures for Mull in detail. In Chapter six, a review of problems faced by the European macroeconomy leads on to three specific anticipations of the future on a fifty year time horizon. The consequences of the resulting socioeconomic environments for Mull are explored in more detail in subsequent chapters, in which, in the light of this discussion and the knowledge of history and present status, an assessment is made of the community the island would support. In Chapter seven, a major breakdown of the Western economy forces self-sufficiency on remote areas. In this context, the capability of the island's resources to provide food, shelter, energy and material goods (in other words, to sustain an economy) is considered. In Chapter eight, the current trends of centralisation of control are continued, aided by increasing sophistication of computer and communications technologies. The outcome of this future will tend to make the Mull economy even more open to the outside world. It seems likely that commercial forestry and up-market tourism will become predominant economic activities. The concept of carrying capacity becomes less relevant in this case, and the answer to the capability question is thus couched in different terms. Chapter nine describes, from Mull's point of view, a more interesting situation, because many economic activities will become internalised. The link between natural resources and economic activity will become closer, while the technological capability to provide solutions to specific problems will be essentially undamaged, unlike the first case. This scenario envisages a situation in which self-determination of community becomes an important principle.

1.2.4 Part four - synthesis

Thus far the thesis has concerned itself with the description and exploration of a study area and with its future prospects. This final part considers the Highland situation in terms of resource-use and technology, emphasising the importance of the interpretation of 'appropriateness'. Chapter ten compares and contrasts the three futures outlined in the preceding chapters and identifies the important features of the contemporary situation which may be influencing the direction of change. Chapter eleven examines the concept of appropriateness in more general terms, its application to resource-use and technology and the consequences for policy analysis and decisionmaking in relation to the West Highlands. Chapter twelve concludes the thesis with a review of the work contained within it, a brief discussion of the problems which it raises and an examination of the direction future work might take.

It is important to bear this framework in mind as the emphasis and focus changes from chapter to chapter. Only in the last three chapters do concepts of appropriateness receive detailed attention. The preceding analysis simply sets the scene for this final discussion.

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NOTES TO TEXT

1. F.Fraser Darling (1955) The West Highland Survey - an essay in human ecology.
2. The general definition of human ecology given by Richerson & McEvoy (1976) Human Ecology - an environmental approach
3. The relationship of the academic disciplines with ecological concepts is reviewed in detail by G.L.Young (1974) Human Ecology as an interdisciplinary concept Advances in Ecological Research 8 1-105. In conclusion, he remarks:- "....Human Ecology ....is a fragmented field, far from interdisciplinary, though many of its concepts are shared, ...most human ecologists are strongly discipline-oriented and....do not take advantage of the full range of ecological materials available in the literature....Even the implication that human ecology might with justification be confined within the boundaries of a single discipline is a fundamental error...." (pp 58-59)
4. Richerson & McEvoy (1976) op cit
5. "....The enquiry into human systems is transdisciplinary by necessity. Human systems encompass the whole hierarchy of natural systems - physical, biological, social and spiritual. Human systems management is not interdisciplinary or multidisciplinary, it does not attempt to unify scientific disciplines, but transcends them...." Zeleny and Pierre, simulation of self renewing systems in Jantsch and Waddington (1976) Evolution and Consciousness (Human systems in transition)
6. F.R.Bradbury (1977) taken from the text of a lecture delivered to the SRC/SSRC Joint Committee for interdisciplinary studies 4 November 1977
7. HIDB (1973) The Island of Mull - Survey and Proposals for Development HIDB Special Report No 10.
8. From the Highlands and Islands Development (Scotland) Act 1965 Section one.
9. From the first HIDB annual report (1967)
10. H.A.Maclean (1970) The Island of Mull: an experiment in landuse planning Recreation News Supplement 2 30-34

11. J.M.Bryden & G.Houston (1976) Agrarian Change in the Scottish Highlands pp137-138

12. C.H.Waddington (1977) Tools for Thought p 228.

13. The 'Human Problematique' is a term coined by the Club of Rome to describe the interactive nature of global problems - Meadows et al (1970) Limits to Growth pp 10-11. E.Jantsch (1975), in Technological Planning and Social Futures attributes the term to Hasan Ozbekhan in an unpublished manuscript.

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CHAPTER TWO - PARADIGMS AND METHODOLOGY

2.1 The execution and application of research

2.1.1 The Problematique

An important belief motivating this project is that man, as an evolving species on a finite planet, needs to spend much more time giving serious thought to the long term direction of his development. It is logical that continued growth in the consumption of materials and energy cannot be maintained within the bounds of Earth. The notion of a 'Spaceship Earth' has been widely used to emphasise the finite nature of our planet, and has been accentuated by the photographs brought back by astronauts of:-

> ".... a life-filled, green and blue Earth, wrapped in spiralling white cloud, slowly revolving in a black and inert void...."(1)

The concept is undoubtably ambiguous; does this imply permanent limits on human development, or can these apparent limits be surmounted? What form do such limits take? Are they physical, economic or political in nature? While accepting such problems, recognition of such a perspective opens a forum for the examination of the relationship between man and his environment which would not otherwise be valid.

Concern is fuelled by a second perception, that of continuing evolution of human societies and their associated economic growth. Sustained economic growth from the Second World War to the early 1970s in all parts of the developed world has now effectively ceased. It seems unlikely that such a continued increase in material output can be expected in the future. In addition, Third World countries are now entering the world economy with increasing effect. Much of the economic growth found in the world economy derives from these countries. In them, transnational corporations find attractive investment opportunities, there are natural resources, a large non-unionised labour force available at relatively low rates and a national political objective to try and close the gap with the First World.

The UK economy has suffered the consequences of this evolving situation. As a nation, growth had been initiated from easily-won indigenous natural resources, chiefly coal and iron ore, coupled with the technological advances which presaged the industrial revolution. From this foundation, Britain built up an empire which allowed her to maintain the initial impetus as indigenous resources were exhausted or became more difficult to work. The economy evolved into one which derived most of its net income from the value added by importing raw materials, processing them and exporting the resulting manufactures or semi-finished goods. This depended on: (a) the availability of cheap raw materials, and (b) the existence of markets for the sale of manufactured goods (for example, machine tools) which are not subject to extensive competition. In the economists' terms, Britain's comparitive advantage lay in the know-how and the physical infrastructure of an industrial economy in a largely preindustrial world. More recently, the UK has become more and more dependent on cheap sources of energy, sustaining a substitution of capital for labour which has become increasingly disciplined, militant and expensive. All these trends are now moving towards a nexus. Cheap oil or coal is a thing of the past. Raw material price trends of the future will be upwards. Other countries, especially those in the Third World, are increasingly reluctant to sell raw materials when they can undertake manufacturing on their own account; this same process also leads to increasing competition in world markets. Thus a country like Britain loses both the opportunity to buy in raw materials (except at a high price reflecting the alternatives open to the vendor) and the captive market in which to sell manufactured goods (except at prices competitive with other sources); the process of deriving a living from 'value-added' is thus squeezed from both ends.

Tinbergen (2) provides a detailed analysis of the distribution of wealth, both between and within countries. It is clear from this work and that of others that the only tolerable long-term objective in this area is for the gap between rich and poor nations to be narrowed. In view of the constraints outlined above, this will involve a virtual cessation of growth in the developed world, coupled with high growth in the Third World. Over the last decade, the dominant theory has held that only with the maintenance of high growth rates in the developed world will significant progress elsewhere be maintained. This notion has been termed the 'trickle-down' theory. The increasingly militant attitude of the 'Group of '77' developing countries at international meetings such as UNCSTD in Vienna in summer 1979 clearly demonstrates their deep distrust of such a concept. Therefore, such an unlikely future (ie. the cessation of growth in the developed countries) seems the only way to prevent a long-term polarisation of interests along the lines of the North-South dialogue between OECD and the Group of '77.

It envisages an eventual situation in which each nation depends in the first instance on those natural resources within its borders for the sustension of an economy. This concept of self-reliance (as opposed to self-sufficiency) is examined in greater depth in the course of the thesis.

An important feature of the problematique is its complexity. This is a peculiarly difficult concept to pin down in precise definition. Perhaps Waddington (4) caught its flavour in the aphorism:-

> ".... Two's company, three's a crowd and five or six is getting to be a shambles...."

The complexity of the modern world manifests itself in the quantity of information available and the rate of increase. The incremental adaptive response of the academic has been specialisation. As the following review describes, this has led to an increasing failure to cope with real world problems.

2.1.2 The methodology of the specialist

Perhaps the discipline which lays most claim to generality in analysis of human welfare is economics. It is therefore a suitable starting point for discussion as an example of methodological problems faced by others. The historical development of economics as a discipline and its evolution into the diversity of specialisms found today has been the subject of extensive analysis (5). As Fusfield (6) points out:-

> "....Economics as a theoretical and policy science is in disarray, with the post-Keynesian synthesis under strong attack for failing to explain or remedy the many economic ills of the 1970s...."

Indeed, current (1980) government policies are framed in terms which deny many of the concepts of Keynesian demand management without general agreement on an alternative strategy. Monetarist policies are dominant, but even these are not carried through with conviction.

Conventional wisdom in economics largely revolves around highly developed concepts of systems in or approaching equilibrium. The preceding section described the dynamic, evolving nature of the world system, from which it should be clear that the world system is not approaching equilibrium and appears unlikely to do so in the forseeable future. There is thus a gap between the realities of contemporary economies and those hypotheses which form a basis for their manipulation.

Fusfield identifies three aspects of this problem (7):-

i) Random events and uncertainty - The combination of subjective estimates of outcome probability and an irreversible, once and for all, decision could easily demolish the aggregate welfare-maximising tendencies of the theory. Where pure chance is involved, it was concluded that even a perfectly competitive system of self-adjusting markets may or may not be able to determine prices, quantities and other results.

ii) The feasibility of an optimal solution - "....In a complex and interrelated economy, any variation from the conditions assumed by the theory of perfectly competitive markets produces a less than optimal solution. There is no way to determine how far from the optimum the result will be (that is, a slight deviation from the assumptions could bring a large shift in the results). Furthermore, efforts to improve the results by changing other conditions will bring a different result, but we can't tell whether that will be just as far from the optimum as before, closer or further away...."

iii) Allocation decisions and complexity - Arrow (8) developed an 'impossibility theorem' which stated (in essence) that:-

"....if there are more than two fundamentally different ideological positions, none of which constitute a majority, and there are more than two policy options, it may not be possible to achieve a decision satisfactory to a majority...."

In a complex industrial society, multiple groups can develop in situations with intricate patterns of alternative choices; the traditional neoclassical conclusions about social choices in a democratic framework may not be possible in such a world.

Other writers have pointed out other features of the 'problematique' which influence this discrepancy between theory and practice.
For example, Henderson (9) points out the increasing transaction costs of complex situations; costs of isolating relevant information, social and environmental costs, side effects and other unexpected or unquantified costs of making a decision. The identification of these factors raises a central question of the criteria for assessing 'system success', and indeed the appropriate definition of the system itself. This in fact depends on the subjective and usually asystematic definition of system boundaries by the individual or group making that assessment. Such problems appear to have opened an abyss in which no solid foundation of 'facts' is available to the analyst. The initial response of the economist to such problems was to take a leaf out of the book of the physical scientist.

The success of the physical sciences has rested largely on a successful methodological approach to the testing of hypotheses. Theories of scientific method are now quite sophisticated, and inevitably other disciplines (ecology, economics, sociology, psychology) have tried to adopt the procedures in order to add legitimacy to their own theories. Macfadyen (10) considers the application of scientific method, defined by Popper and interpreted by Medawar, to ecological science:-

> "....Briefly, we select our field of practical investigation in order to test hypotheses. These hypotheses are determined by the general body of existing theory, and are arrived at by analogy or enlightened guesswork. The tests of observation should be the most critical one can devise in order to maximise the chance of negating the hypothesis. Whilst we cannot meaningfully establish the absolute 'truth' of a theory, (because induction cannot predict the rare but significant exception) we can at least test the logically necessary (deductive) consequences for our hypotheses and steadily improve their plausibility in doing so. Science advances by the imaginative production of new hypotheses about how nature works, and the critical testing of their consequences against testable observations...."

He goes on to include the contribution of Kuhn (11), who pointed out that the bulk of research was less concerned with the formation of new hypotheses or, in his modified and extended concept, paradigms, than with the defence of old ones. Macfadyen goes on to point out the problem of establishing causal relationships in a complex set of interactions, in this case an ecosystem, and concludes by pointing out the part to be played by modelling in the analysis of complex systems.

Such models may be defined as logical statements of the relationships of key variables and their interactions built in such a way as to aid understanding of the real world. A system may be defined at any level, and simply involves the delineation of an imaginary boundary around one particular group of variables. This view has many pitfalls, especially because it is hard to think about a system without using a model to do so. Thus it becomes near impossible to describe a system except in model form, so the system as perceived (at least on any one occasion) is synonymous with its model. The fact that systems can usually give rise to several models and can rarely, if ever, be expressed in only one is not self-evident from most definitions of a system (12). The system, being an abstract concept, is therfore, in practical terms, indescribable.

A second pitfall lies in the establishment of causal links in the building of models. The statement of interactions between variables in a model represents a hypothesis about the functional interactions in the real world. The extent to which a grossly simplified model of part of the real world reflects the actual interactions of the real world is extremely difficult to establish. Even if the model reacts in a similar way to observed changes in the system under study, it is difficult to establish the extent to which the causal pathways producing the particular effect in the model represent the actual web of causality in reality (13). Thus the established scientific method of testing by controlled experiment is not feasible, nor is it sensible to consider modelling as a substitute, for the reasons described above. This project was initiated in the belief that while these limitations appear overwhelming in the context of an overall approach, for real world problems they may be overcome in some measure. The appropriate conclusion is that 'facts' can only be useful in context, and that no universal body of theory will allow complete explanation of real world problems in the foreseeable future. This appreciation bringsone to the risks of the third pitfall of model building, arising from the first two.

One of the chief dangers lies in the relationship of mental models to physical ones. The mental models one chooses to describe the real world are an inextricable part of one's values, interests, hopes and fears. This still applies even when the mental model is translated into a computer program (14). All this is inevitable because of the gross simplicity of models in comparison with the real system. Models are not true or false; they have varying degrees of usefulness depending on the interaction between their level of complexity and their purpose. To suppose that a model represents a thoroughly objective and apolitical viewpoint is naive and highly misleading. A model formulated as a representation of reality inevitably contains implicit assumptions which condition its utility for policy purposes. It must be a primary aim of model validation to identify and comprehend these factors.

The study of complex systems, a relatively new discipline, has itself produced an impressive literature since von Bertalanffy published his 'General Systems Theory', still an important introduction to the subject. The discipline has now developed concepts (and hence a jargon) of its own, which are covered by Waddington (15) and placed in a wider context. Emery (16) develops the ideas of dynamic systems and thereby illustrates one of the recurrent methodological problems, described by Morris (17) in the following terms:-

> "....All these concepts are abstractions, which may or may not have an obvious counterpart in reality. Their use is an essential part of the modelling process mentioned earlier; their danger lies in two extremes, where the abstraction is taken too far, and the resulting abstract system contains no quantifiable elements, or where the conceptualisation stage is skimped in order to get to the interesting manipulation of a completely irrelevant mathematical model...."

A range of positions between these two poles can be identified in the various systems studies published in recent years, most tending to one or other extreme. The studies which have successfully trodden this tightrope are few. The significance of the division is made clear when the models are compared to the real world. At either extreme, the relationship with the real system is inconclusive and impossible to demonstrate or even attach reliability. As the systems approach has become a research tool of many other disciplines, the question of validation once again comes to the fore.

Thus the argument has come full circle. In dealing with real world systems, none of our 'rational' approaches to hypothesis testing, and hence to problem-solving, are capable of providing complete solutions. All that remains is the pragmatist's view that one must develop the minimum 'necessary and sufficient' level of understanding to solve the problem. This begs the question of criteria for judging success and appropriateness. The only possible basis is to place the problem explicitly in context of the overall system, which is dimly understood. Often the specialist will fail to do this. For example, a Dutch research team spent nearly ten years producing strains of barley high in lysine, an essential amino acid in animal feeds currently supplied as an expensive concentrate. The question posed is: to what extent did the (implicit) paradigms behind the research predetermine the range of possible solutions to the problem? In this case it was clear that the chief objective was to improve yields of feedstuffs and hence of animal protein, but includes the implicit assumptions that energy will remain relatively cheap (for cultivation and fertilisers) and that the continued operation of agriculture within an industrial milieu is inevitable. Alternative assumptions are thus automatically rejected; that fossil fuels are exhaustible, that an equally important role of agriculture (with productivity) is to sustain farmlands with ecologically wise methods, and that the single strategy of farm chemicals, mechanised cultivation and genetic engineering is open to question. In terms of the view of the future outlined earlier in this chapter, and in terms of the allocation of resources to alternative lines of research, this lack of conscious direction is clearly undesirable. Very few workers seem to be integrating results from different fields and approaching an economic and ecological alternative to conventional agriculture from a systems point of view (18). This is not to say that such problems are susceptible to unilateral solution, but rather to say that no progress will be made towards subjective goals of 'effective decisionmaking' without explicit discussion of such qualitative matters as 'direction' and 'progress'.

2.1.3 The transdisciplinary approach

The preceding argument identifies a need for a new approach to the application of knowledge to practical problems in human systems. Bradbury (19) defines the need in the following terms:-

> "....It is fatal....to attempt to force the problem onto its systematic academic base at the expense of distorting or ignoring important variables or aspects of it. The appropriate methods seem to be the case study one, which is largely descriptive, and then superimposed on this that very basic and early step in any scientific work which is classification...."

This project goes a little further. The case study and 'classification' (interpreted in this case as systematic description) form a basis for exploration of alternative futures for the study area. These three elements allow a discussion of direction, and hence of 'appropriateness', without appearing to impose one <u>weltanschauung</u>. The project draws on a wide range of disciplines in pursuance of its objectives. In no way could this be said to constitute a comprehensive (ie. all-encompassing) coverage of relevant concepts and items of information. The aim is to make use of necessary and sufficient information for the purpose. The project is the work of an ecologist with some knowledge of economics and systems analysis, the contributions from other social sciences being inevitably less comprehensive. However, the criticism of the political philosopher (20) that:-

"....the social and political thinking of the ecologists is marred by blindness and naïveté...."

is accepted, and it is hoped that such a charge can be avoided. The accusation derives from the reluctance of the orthodox scientist to take explicit account of the qualitative nature of human systems; hence the unidirectional approach to problems exemplified by the Dutch research team described above. The point has already been made that the thesis concentrates attention on real world problems, not with the objective of presenting a solution, but aiming to structure the problem in such a way that those more directly involved can gain a more comprehensive appreciation than would otherwise be the case. The project is therefore in some senses aimed at the decisionmaker, whose decisionmaking framework inevitably involves some conception of needs. This poses most serious problems for the public sector planner.

There is a curious circular argument underlying the rationale of planning, which goes approximately as follows:-

i) The planner is an expert, a technician employed to direct development through policy intervention, both fiscal and legislative;

ii) the planner should have as his prime objective the satisfaction of the desires of the public when planning development;

iii) but these desires are rarely concurrent with the resources available to fulfil them, nor is the average set of desires necessarily that most appropriate to development;

iv) therefore planners should evolve policy appropriate to the needs (as distinct from the desires) of the public, but who will define these needs and plan accordingly?

v) Therefore, the planner must, as an expert, define the needs of the public and plan accordingly.

Such a pragmatic definition sidesteps the issue of what a need is, and how needs can be defined. Just as the academic limits his concerns to the next obvious research target, unconsciously following an implicit strategy, so the decisionmaker at any level tends to make his decision not only in terms of relevant information he has to hand, but also within an implicit view of the world and its future. Keynes recognised this when he wrote:-

> "....Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist...." (21)

He should in fact have included most academic disciplines with economics; such people are using concepts about relationships in the world system which are all hypotheses essentially untestable by scientific means. The preceding argument should show that this is no reason to reject these concepts, or refuse to use them, because others then take their place, or the world must appear formless and unstructured. The most appropriate response is to accept their deficiencies and try to be aware that one uses such concepts and take explicit note when one does so.

Such an approach raises questions of value, of utility, of criteria for assessment which are brought together here under the umberella term of appropriateness. There are several interpretations which can be placed on the term, not necessarily incompatible, but each suitable for use in particular circumstances. Ackoff and Emery make use of the concept of a purposeful system (22) which is a suitable starting point for discussion. They looked at human behaviour as a system of purposeful or 'directed' events. The question of goals or objectives is a concern of economics and most branches of management and social sciences. Their concern was with an holistic view of human behaviour; and in pursuit of such a view they isolated two essential related concepts, structure and function. The classical groundwork of economic theory equates purpose with concepts of utility and profit maximisation. In a perfectly competitive market, the participant will maximise his utility in the light of his perfect information. Mathematical models developed in management science use profit maximisation as a proxy for utility maximisation as the objective function of an algorithm. However, organisation theory has recognised the idealised nature of such a model. Simon (23) introduced the concept of 'satisficing' as a substitute for optimising in the mathematical sense, which was developed by Cyert and March into a behavioural model recognising the realities of an environment of imperfect markets and inadequate information. Such a divergence simply points out that while mathematical models in management science may be capable of describing the effect of collective decisionmaking, they rarely explain the role of rationale and reasoning in such processes. This has been the field of the psychologist and the sociologist. Ackoff and Emery make clear the distinction between the goal-seeking systems of the economist or mathematician and their own concept of purposeful systems. The latter responds not in a mechanistic way to a predetermined program, but is capable of adaptive behaviour. The importance of this distinction is clear when the evolving nature of social systems is taken into account.

A few writers have made use of the ecological concept of niche in the context of human social and economic systems (24). If the hypothesis of system structure centres on an equilibrium, then adaptation of the individual or organisation to niche is encouraged, and specialisation to a well-defined role is apparently beneficial. If in fact the system is dynamic and evolving, niche characteristics will change and specialists will be eliminated. Generalists maintain adaptive capabilities; they are not usually well-adapted to a particular niche, but retain a considerable adaptive potential.

Thus the purposeful system involves a concept of 'fit' to perceived structure and function defined in terms of system dynamics. Ackoff and Emery see such systems as ideal-seeking in terms of a view of structure and function. In this project, it is recognised that understanding of structure and function in an evolving complex system can never be complete. Appropriateness therefore embraces both the idea of 'fit' and the idea of 'necessary and sufficient' explanation. A policy or objective is appropriate if the view of structure and function used in its determination is necessary and sufficient to produce a satisfactory response to it. The term is therefore adaptive. Under certain conditions, the profit maximisation model is a perfectly adequate policy. One can only say whether it is more or less appropriate than an alternative in the light of statements about the structure and function of the environment in which the policy was made.

Theoretically, therefore, there may be an absolute definition of appropriateness, but this would require perfect knowledge of system structure and function, and detailed knowledge of its future development. This is clearly impossible, so appropriateness remains as a comparative device.

In this project, appropriateness may be considered to take three interpretations corresponding to different parts of the work. The description of structure and function contained in the first few chapters is concluded in Chapter five with a discussion which essentially examines appropriateness in terms of contemporary aims and strategies. Part three sees appropriateness in terms of the maintenance of certain system functions in future circumstances which while feasible are very different from the present day. Both of these require some general models of system structure and function which are described in the remainder of this chapter. These two interpretations of appropriateness are not indicative, but descriptive. The third interpretation, limited to the last three chapters of the thesis, compares and contrasts the treatment of appropriateness in preceding sections and in conclusion examines the way that current aims and policies should be designed to cope with future uncertainty.

Earlier discussion in this section emphasised the importance of need as a determinant of policy. Ackoff and Emery discussed ideal-seeking systems in terms of ideals of plenty, truth, good and beauty. These are of limited value in the practical analysis of alternative futures, so a closely similar set of concepts framed explicitly in terms of need has been used (25). Maslow's hierarchy of needs forms the basis for separation of quantitative and qualitative analysis in Chapters seven, eight and nine.

The conclusion to Ackoff and Emery's work is an apposite concluding statement for this section:-

> "....Identification and analysis of ideal-seeking systems is in its infancy. The category is still generally unfamiliar. If we consider the twenty years it has taken to get from goal-seeking to purposive systems, we can hardly expect the next step to be much quicker. Understanding of this aspect of systems behaviour, however, seems to be essential if we are to solve the problems of adapting to the increasingly turbulent environments we are producing for ourselves...."

2.2 Models and methods

2.2.1 Principles

The discussion of appropriateness has emphasised the importance of explicit models of system structure and function. This model building must be viewed in the light of the previous discussion of such a process. In particular, the presence of dynamic and evolutionary elements means that no model is 'right' in absolute terms. The aim of this section is first to establish the principal features of a general model of human resource-use systems and then to develop that model in two ways, first as the basis for systematic description of current status, and second as the basis for strategic planning and purposeful manipulation.

It is relatively easy to build conceptual models of the world as a closed system (figure 2.1) because the only significant input and output is the energy derived from the sun, and the re-radiation of that energy in various forms. The generality of such a model is difficult to apply for practical purposes because of the range and diversity of conditions and processes across the globe. A focus on a smaller part of this macrosystem can alleviate to some extent the problems of data collection. But the microsystem is rarely properly considered as a closed system. Material flows, and flows of technical and financial capital, labour and waste products obscure the simplicity of the original concept.

Anthropological studies of remote societies, effectively cut off from the interdependent industrialised world system, have made wide use of these closed systems concepts to elucidate relationships between man and environment in this primitive context. Some of them have extended their interests to more complex societies, as have ecologists starting from the study of food webs and population dynamics in natural ecosystems. Most of these studies have revolved around the energetics of the system under observation:-

> ".... a human population, like all animal populations, has to expend energy in work in order to incorporate energy through consumption. In this respect, energetics would apply equally well to the study of man as to the study of other animals. In human energy relations, no individual is self-sufficient. Human existence is made possible by the work effort of individuals

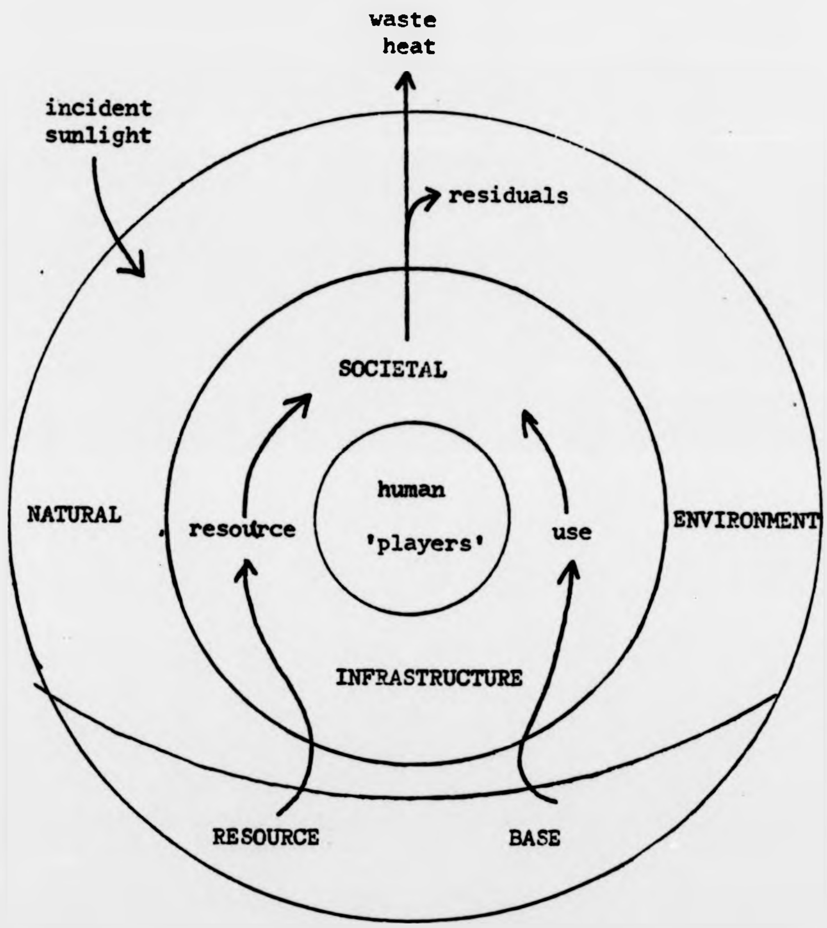

Figure 2.1 - Basic features of a human resource-use system

(and) social life is founded upon the principle of cooperative consumption of resources....The minimal self-sufficient unit includes at least a social group, such as a family or band, and at most includes economies involving hundreds of millions of people....The evolution of economic organisation has reached a point at which an individual's productive activity is usually the 'n'th removed from the ultimate source of the food he consumes...."

(26)

Thus the logical connection between economy and environment is established; the detail of that relationship is a relatively unexplored area. The two main concepts, of an economic system and of a physical environment or ecosystem are widely recognised. Less widely acknowledged is their interdependence. Another way of expressing the relationships in figure 2.1 is to consider a spectrum with the natural system (Nature) at one end and the socioeconomic system (Society) at the other (figure 2.2). This general concept is wideranging enough, but lacks specific applicability. A higher level of disaggregation of the various elements allows a design more appropriate to the description of systems dynamics in a Western economy (figure 2.3). By drawing a notional system boundary (dotted line), one can apply the model to any self-reliant economy, adding the dotted arrows to show transactions across the system boundary. At the regional economy level, these boundary transactions become a significant part of the total transactions of the system, and herein lies the problem. It is difficult to study whole planet systems because of their size, complexity and insufficient detail of information. At the same time, it is difficult to study a microcosm of that system because of its interaction with the larger entity of which it is a part. However, by focussing in from the large to the small scale, there is established a principle of system structure which integrates human societies with their natural environment, in the way described above in extracts from Lee (27).

In figure 2.3, the arrows indicate transfers of energy and materials. There are other transfers - of money, skills and technology - mainly in the left half of the diagram. As in figure 2.2, the structure is based on the poles 'Nature' and 'Society'. These lie across the system boundary and represent the two classes of influence of higher level systems. The area between the poles is divided up roughly between the features identified in figure 2.2, namely infrastructure, human

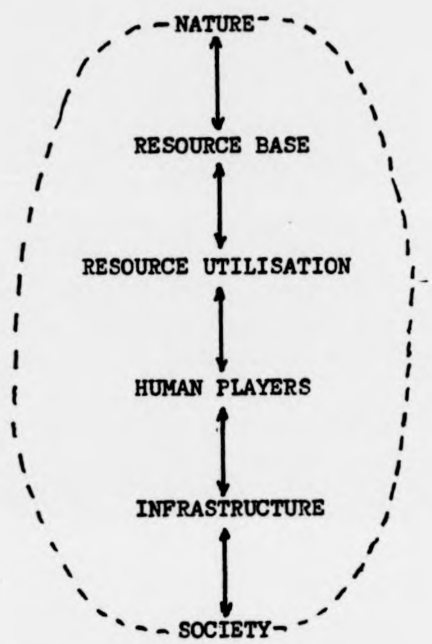

Figure 2.2 Spectrum of components of a human resource-use system

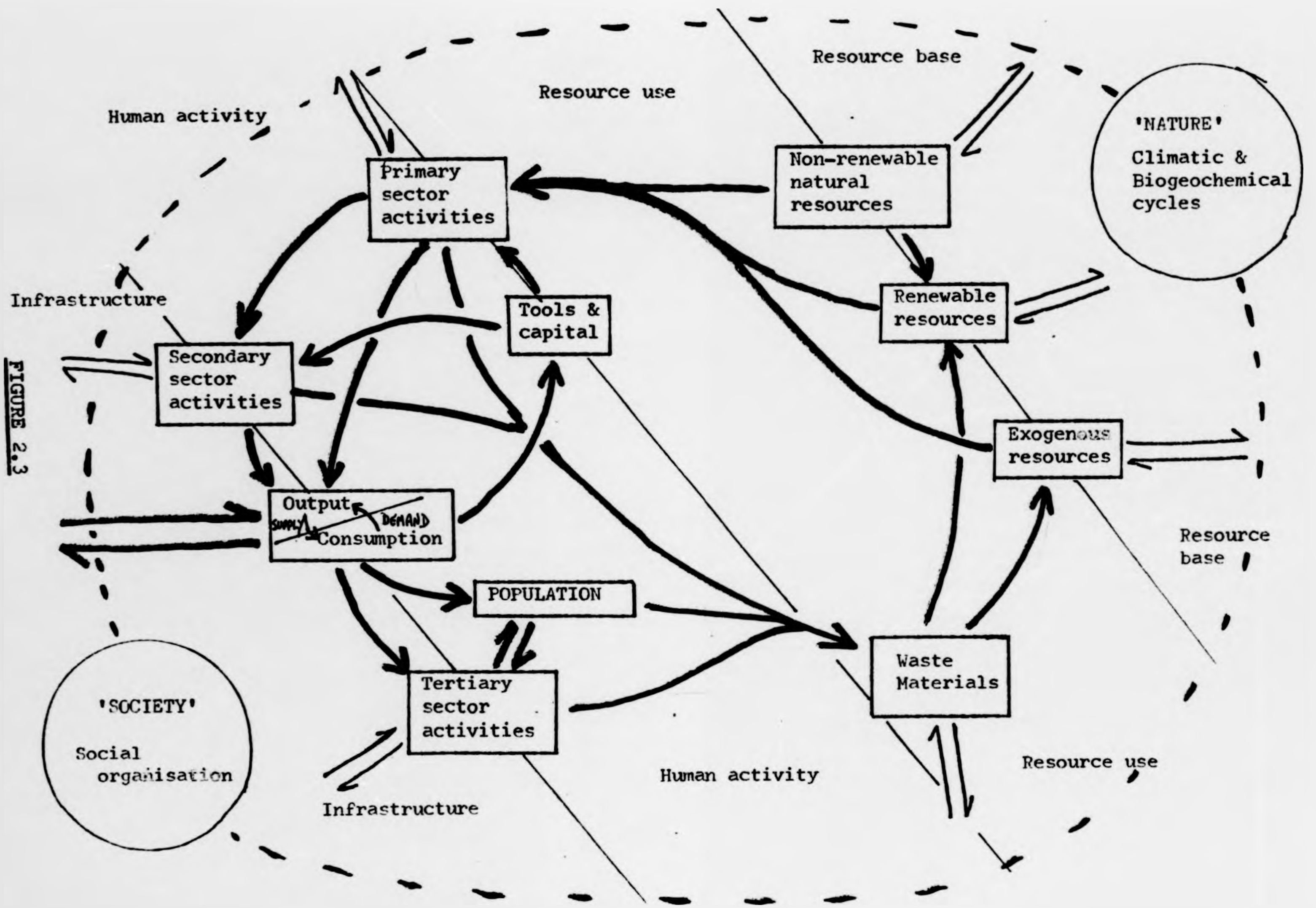
Resource base
Resource use
Human activity
'NATURE'
Climatic &
Biogeochemical
cycles
Non-renewable
natural
resources
Primary
sector
activities
Renewable
resources
Tools &
capital
Infrastructure
Secondary
sector
activities
Exogenous
resources
Output
SUPPLY
DEMAND
Consumption
Resource
base
POPULATION
Waste
Materials
Tertiary
sector
activities
'SOCIETY'
Social
organisation
Human activity
Resource use
Infrastructure

FIGURE 2.3

activity, resource use and resource base. The diagonal orientation is deliberate, avoiding any implicit concept of hierarchical separation. The divisions between the areas are arbitrary; the lines are better considered as intergrades rather than sharp divisions. The detailed structure within this framework contains ten 'black boxes' which represent the key physical entities and activities which together comprise the complete system. This general conceptual model may be applied to human resource-use systems at any level from global downwards. In analytical terms it is more useful at the smaller scale, establishing a hypothesis of structure and function for any human community living within a defined system boundary. The case study area of Mull is one such area.

2.2.2 Application to structure for status statements

This section describes the use of the general model as a tool to aid systematic description of the system under study. This is pursued in Chapter four, in which such a statement of system status is made. Making such a statement involves the disaggregation of the component features of each 'black box' in figure 2.3 to a level considered appropriate to the detail required. Taking each box in turn, these are the factors and important activities found therein:-

Exogenous resources - This part of the resource base includes inputs of water and sunlight from outside the system. In a specific site context such as Mull, an exogenously determined factor such as weather should be included.

Renewable resources - In the case of Mull, these are of prime importance. They include animal and plant life, both domestic and wild, and the soil, water and atmosphere in which they live, found within the geographical confines of the system. Such resources are able, by definition, to sustain a certain rate of depletion and therefore require a different quality of policy for exploitation than the following.

Non-renewable resources - Such resources are of great importance in contemporary industrialised human economies. They should be regarded as a capital stock, on which to draw for the future of the economy. Exploitation policy revolves around the difficult question of depletion rate. Such resources include mineral raw materials, metal ores, tars and oil products, fossil fuels (including peat) and stone for the construction of buildings and roads.

Waste materials - Both materials and energy may neither be created nor destroyed, although they may cross the system boundary or (exceptionally) be converted from one into the other. Thus a complete cycle of material and energy flows is required in the system. These materials include by-products, refuse, sewage and heat.

The primary sector - involves that part of human activity which undertakes the initial extraction and utilisation of natural resources, and includes agriculture, forestry, fishing, mining, quarrying and energy supply industries.

The secondary sector includes those human activities which produce physical artifacts and which depend on the output of primary industries for their raw material. They embrace manufacturing, processing and consruction.

Output and consumption - is the central concern of the economist; the output of economic activity for consumption, capital accumulation and export, and the nature of the trade balance across the system boundary.

Human population - is the population of economically active human beings and their dependents making use of the system defined by the boundary.

Tools and capital - Capital tends to be viewed as a homogeneous entity, but the same financial figure entered on two different balance sheets will represent two different combinations of physical assets; the common unit of measurement tends to obscure the difference. Thus the adequacy or otherwise of capital and equipment will depend on the way the owners fit the pieces together in operational combinations. This results in an overall complex of relationships which may be termed capital structure.

The tertiary sector - may be regarded in two parts, first the distributive and service sectors, second the administrative and government machine. The first includes shops and supply systems, transport services, telecommunications, visitor services, social and financial services, education and health. The second consists of national, regional and community government, the legal system and the church.

2.2.3 Application to function for system analysis

The second use of the general model is as a conceptual foundation for the analysis of system capability carried out for each of the three scenarios. Section 2.3 describes the origins and construction of the analytical model used and the concept of carrying capacity which lies behind it. Here the concern is with function and process - the activities which sustain the purposive system of human beings in Mull. Maslow's hierarchy of needs posits basic physiological requirements for food, drink and shelter as essential needs. These basic needs are common to animal populations, and are to a certain extent susceptible to quantification. The primary and secondary industries produce and process respectively the food and drink requirements of a population in a closed system. If the system is open, there may be a comparative advantage to the community in producing more or less of its own requirements of these particular products, depending on the communitie!s terms of trade. Mull at present produces an excess of certain types of foodstuffs in return for other needs. The self-reliant economies of scenarios A and C are able directly to apply the model described in 2.3.3 as a first approximation of system capability. In scenario B, the community is open and the terms of trade are such that food supply is imported.

Maslow's other levels of need - for safety and security, for belonging and affection, for esteem and ego and for self-actualisation - are the essential aspects of the qualitative nature of human systems. The function of the other parts of the general conceptual model described in figure 2.3 is to fulfill these needs and in so doing these sectors make demands on the resource-use system. Being less susceptible to quantification, these are discussed on a subjective basis for each scenario.

2.3 The concept of carrying capacity

2.3.1 A theoretical perspective

The first objective of the thesis, to determine the capability of the study area for the support of a community, involves the calculation of limits. The study of ecosystems has sometimes focussed on similar problems in the investigation of determinants of numbers of a species population.

For the limited case of a single species population in a closed ecosystem, there is experimental evidence (28) to support the proposition that colonisation of a new environment will proceed exponentially at first, but that later this rate of increase in population will be modified by resistance of limiting factors in the environment to an equilibrium population size. The limiting factors represent the effects of a finite resource base on an increasing population and, providing that the characteristics of this resource base remain unchanged, the population will be maintained indefinitely at the equilibrium number. This is the carrying capacity of the system for that species, and is expressed on a time/population size graph as the asymptote of a sigmoid curve defined by:-

$$N_t = \frac{K}{1 + e^{a-rt}}$$

where: N = number at time t   K = upper asymptote
r = intrinsic rate of increase   e = exponential
t = time
a = constant of integration defining position of curve relative to origin (29)

This accords with common sense, in that any species population within the conceptual boundary of an ecosystem and therefore restricted to a finite space, must logically be subject to a limit on its numbers. This limit will depend on the total resources available and the effectiveness of resource-use by that species. In other words, it has both quantitative and qualitative aspects.

While the evidence has indicated the presence of such a relationship in the simplest of systems, the evidence from multi-species systems is more ambivalent, and the complexity of real-world biological systems places them beyond the range of experimental analysis. Theory, however, has developed the application of the carrying capacity concept to such systems. In resource management, the concept of 'maximum sustainable yield', encountered in forestry, fisheries and range management, is based ultimately on the application of this theory to the manipulation of a biological system by man (30). It also recognises that the limits are not absolute; it may be possible to exceed them in the short term, but the sustainable yield is that which does not exceed the regenerative capacity of the exploited species. The concept of equilibrium is obviously crucial to this approach to resource management. Real systems are rarely, if ever, in equilibrium, species populations being continuously affected by fluctuations in critical resource parameters such as weather. It is thus incorrect to attach great importance to a particular value of K (above). The use of equilibrium as an abstract concept does, however, allow us to use carrying capacity as a foundation for deeper understanding of the relationships governing a real system. This may be pursued by examining the nature of the resource limits on a species population. In a real system, a species is likely to depend not only on independent variables such as weather, but also on other species which interact with the study species in the ecosystem. Thus the concept of niche is introduced, and with it the idea that each species has a 'place' in the structure and function of the system. Examination of these relationships is the main preoccupation of contemporary ecological research (31).

Human populations occupy a niche in almost every real ecosystem. Their role is often a dominant one, and in many well-documented cases the impact of their actions has caused large deviations from the pre-existing relatively stable system. From the evidence available, it appears that such instability is rare in those systems unaffected by modern man. Wilkinson (32) presents a series of case histories suggesting that primitive human groups regulated their activities in order to preserve the quality of their environment. More recent human communities do not display the same self-regulating capability:-

> "....Natural populations tend to establish themselves in an ecological equilibrium situation. Rather than over-exploit their resources, they build up a pattern and a rate of resource use which the environment can sustain indefinitely. Without this, the stable, well-balanced 'climax communities' of flora and fauna which ecologists describe could not exist.

The concept of an ecological equilibrium is meant to cover any combination of a method and a rate of resource use which the environment can sustain indefinitely. It may refer to a situation in which the population restricts its demand for resources to a level which the environment can supply naturally, or it may refer to a balance struck on the basis of particular cultural patterns of resource management by which the environment's production of particular resources is artificially increased. In this context, the 'carrying capacity' of an area of land is of course the largest population which can be maintained on it in ecological equilibrium, given the prevailing method of environmental resource exploitation. Ecological equilibrium situations are defined to be consistent with cultural stability from the point of view of subsistence and productive activities. If a society is in ecological equilibrium then it satisfies the ecological requirement for stability. It is not about to run short of the resources it depends upon...." (Wilkinson p.21)

Some of the more basic concepts of economics lie not far from these ideas of resource limits. The specification of land, labour and capital as factors of production is one of the older propositions of the discipline. This formulation is inadequate as a framework for economic processes in a physical environment, but can be extended to an alternative concept; resources may be considered in three classes:- (a) physical infrastructure, (b) energy and (c) skills (technology). The interaction of (a) and (b), manipulated by the application of (c) is held to be the basis of economic activity. Thus, remembering the theoretical basis of the general model in the previous section, there is the basis of a physical model of community needs (excluding, for the time being, qualitiative needs).

A community needs:
- food
- shelter
- energy
- material goods

A community has attribute and constraints in the form of:
- natural resources
- skills
- organisation
- financial capital
- physical capital (fixtures and machines)

A community uses its attributes and constraints to satisfy its needs.

In a closed system, this would be sufficient basis on which to collect information and, given a social and political context within which to define needs more precisely, calculate an estimate of carrying capacity. In the Western world at least, the system is far from closed at any level. Bishop et al (35) have pursued carrying capacity in a regional context, and put forward the following extended definition of the term:-

> "…. Carrying capacity is the level of human activity, including population dynamics and economic activity, which a region can sustain, taking account of the import and export of resources and waste residuals, at acceptable 'quality of life' levels in perpetuity…."

This definition takes account of more complex ideas:-

i) That 'capacity' includes both quantity (population dynamics) and quality (levels of need satisfaction inherent in 'quality of life')

ii) that 'capacity' is capable of extension to systems which are significantly open.

An awkward question arises from the phrase 'in perpetuity'. The significance of this concept in evolving systems is questionable. Since the future is unknown, in terms of the structural changes it will bring to a system, the course of technological change must also be unknown. However, there are certain elements of the present Mull system which are highly unlikely to be sustained, for example the present heavy dependence on imports of petroleum-based energy sources. This highlights a dilemma evident in the use of non-renewable resources; are they being used to 'improve' the economic system, or are they simply acting as a prop to existing 'flow' renewable resources? When deciding depletion rates, is it better to go for a high depletion rate in the hope of stimulating technical change, or to conserve this physical capital as long as possible in the hope that future technologies will make more effective use of them?

The rigorous use of the term 'in perpetuity' is thus, in the long term, open to question. Human economies are evolving dynamic systems which will develop in one out of a large number of possible directions. It is for this reason that three alternative anticipations are considered. There is, however, a need to give consideration to the problem of sustainability. The essential requirement for this project is that the system should be in good shape in the year 2030, ie. without serious human-induced constraints on the actions of future generations. Pitchford (33) uses these dynamics and the associated mathematics to conduct an investigation of optimum population. In an equilibrium model, this is a reasonable goal, but in an evolving system it is of limited use. Until much later in this thesis, the concept of carrying capacity is simply used as a device to allow the production of feasible solutions to allow examination of population limits in futures described by three radically different scenarios.

2.3.2 Previous use of carrying capacity in relation to human systems

There have been many crude attempts to define resource limits on a global and national basis involving the implicit or explicit use of carrying capacity as a central concept. Very few have attempted rigorous use of the concept in a detailed system analysis at a regional scale. Three such reports are of particular interest to this project.

a) The Pacific Northwest River Basins Commission study (1973)

This report (34) contains a regional exposition of the limits to growth concept, examines relationships between some macroeconomic variables and then proceeds to try and establish carrying capacity for the northwest states of the USA. The study is positive, in the sense that it advocates adoption of carrying capacity concepts as an integral part of regional planning, but:-

> ".... This study purports to present only the case for using carrying capacity concepts as one of the alternative methods for identifying long range regional goals. It speculates only briefly about the practical aspects of implementing the carrying capacity concept. It does not discuss in any detail the relative advantages and disadvantages of alternative methods for identifying long range goals...." (p.71)

The study does not make any explicit statement of the integrated nature of the human ecosystem, or express any coherent view of the future. It accepts existing organisational and economic relationships, even to the extent of assessing resource potentials of farmland in purely financial terms. It does, however, link Maslow's hierarchy of needs (25) to the concept of carrying capacity when studying human systems.

b) Bishop et al (1974)

This report (35) begins from a more fundamental base than the previous one, starting with ecological carrying capacity and working it up into a conceptual framework for human systems:-

"....In (a) closed system, carrying capacity may be viewed as the ability to produce desired outputs (goods and services) from a limited resource base, while at the same time maintaining desired quality levels in this resource base. There are four classes of interaction about which information is required to estimate carrying capacity:

1. Resource/production relationships
2. Resource/residuals relationships
3. Infrastructure/capability relationships (ie. infrastructure capability to handle flow and distribution of goods and services)
4. Production/societal relationships (ie. the capacity of both resources and production output to provide acceptable quality of life levels)...."

The main part of the report is a review of work in the field, illustrating the diversity of conceptual frameworks which have been employed, but making no concerted attempt to integrate the concepts into a coherent whole.

c) House and Williams (1976)

House and Williams (36) start from the conceptual framework outlined by Bishop and go on to build a mathematical simulation model of a national economy in its resource context. Their seventh chapter on model function demonstrates how ambitious this aim is, and how large the data base needed to fulfil it. Furthermore, the report illustrates the central problem of such large-scale simulations, the failure to model an evolving system. While variable relativities may change, the essential structure of the model remains the same. Thus the scope for analysing the need for changes in the structure of relationships between various components of the system is extremely limited. This problem may be illustrated by the MIT 'Limits to Growth' model (37) which made the assumption that structural changes were impossible, and therefore failed to model the system's adaptive capabilities. Collapse of a system with such a framework is inevitable. On the other hand, the UK Department of the Environment model SARUM'76 (38) made the opposite assumption; instead of assuming that relationships are fixed and that disaster is therefore inevitable, it assumes that feedback loops are such that most disasters are automatically averted. While such a view is probably more realistic, it lacks utility unless it is possible to analyse the content and hence the quantitative and qualitative consequences of such adjustments.

Returning to House and Williams' model, which is national rather than global, it fails to take any integrated account of the impact of external factors on what is undeniably an open system. For this reason, the relationship between the effort required to produce the model, and the practical uses to which it can be put, must weigh against the utility of the quantitative simulation approach.

2.3.3 The assessment of carrying capacity in Mull

The argument for the relevance of the carrying capacity concept to human populations has at least been exposed, if not proven. Further consideration has shown how difficult it is to apply in a particular situation. The concept that a human population depends on an endowment of natural resources and on its skill in manipulating those resources in order to satisfy needs isintuitive and quite easy to grasp. The application of the concept to a real world system which is complex, dynamic and open to other systems, therefore displaying interdependency, is quite another matter.

The solution to the carrying capacity problem lies in the application of the linear programming algorithm. The general problem can be expressed as:-

$$\text{Carrying capacity } (C^2) = \text{solution of } \left[\begin{array}{l} \text{maximise population} \\ \quad \text{subject to Individual needs} \\ \qquad\qquad\qquad \text{Technology} \\ \qquad\qquad\qquad \text{Natural resource endowment} \end{array} \right]$$

From a position of omniscience, and assuming linearity, it would be possible to optimise the solution, given disaggregation and definition of the constraints. However, in practice, omniscience eludes the investigator, some relationships are non-linear, some involve integer numbers, so that a more appropriate solution must be found.

Dearden (39) illustrates the need to examine systems in terms of limits and carrying capacity by using 'cup and ball' diagrams. In these, he is imagining the system as a cup containing a small ball which rolls around the interior in response to hand movements (human manipulation). The cup represents system constraints, while the movement of the ball represents system activity. If the movement of the ball is insufficiently controlled, it may leave the cup altogether; it will then have exceeded the constraints set by the cup and the system will have broken down. Such a concept also introduces the idea that control of the ball will become progressively more difficult as higher levels of activity cause it to approach the rim of the cup. Thus as carrying capacity of a resource-use system is approached, maintenance of progressively higher levels of output becomes more difficult, requiring more sophisticated understanding of system function.

The objectives of the thesis are to examine the possibilities for intensification and thus examination of carrying capacity is required. The three scenarios set future directions which are grossly different. These anticipations are not exclusive of other possibilities, but merely represent three broad directions which are of particular interest given the analysis in Chapter six. A way of reaching some conclusions about carrying capacity for each scenario is therefore required, regardless of the practical difficulties of doing so. The crude algorithm above may be adapted if one returns to Maslow's hierarchy of needs (25). The assessment of the general algorithm (above) depends on knowledge of:-

i) The quality of life which the situation is perceived to offer its inhabitants,

ii) the organisational structures which run that resource-use system,

iii) The physical supply capabilities of the resource-use system.

Maslow provides a convenient means of separating 'quality of life' in order to assess needs. The basic requirement of a feasible solution for a closed system are the satisfaction of physiological needs for food, drink and shelter. Thus the ultimate limit of the closed system is its ability to supply this. It is possible to devise a version of the algorithm for this purpose:-

Crude carrying capacity (C^3) = solution of [maximise population subject to: Dietary needs, Farming system, Land capability]

The constraints correspond respectively to needs, technology and natural resource endowment in the general algorithm.

Once again, given adequate information, an optimal solution is theoretically possible. However, information is inadequate, and hence the assumption has been made that for the two scenarios where this algorithm is used, a feasible solution is appropriate (in the sense discussed in 2.1.3) and sufficient to demonstrate the gross difference between the scenarios. The actual approach began by trying to solve the problem for a high population and working back to a feasible and acceptable solution.

While this provides a solution to the food supply problem, it only examines one aspect of need. The subsequent sections of Chapters seven, eight and nine,and the general assessment of Chapter ten, examine the other features of the system and attempt to come to a more realistic figure for carrying capacity, closer to C^2 than to C^3, termed Pragmatic Carrying Capacity (PCC).

Notes to text

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7. D.R.Fusfield (1977) op cit. pp 167-170
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13. For a detailed analysis, H.S.D.Cole (ed) (1973) Thinking about the Future considers these matters in the case of Forrester's and Meadow's global models, 'World 2' and 'World 3'.
14. Cole (1973) op cit. p 133
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18. The example was taken from media coverage of recent research findings; some of the alternatives are examined in R.Merrill (1976) Radical Agriculture.
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28. G.F.Gause (1934) The Struggle for Existence his work with paramecium is the classic study in the field.

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30. G.M.Van Dyne (ed) (1969) The Ecosystem concept in Natural Resources Management

31. The work of Andrewartha and Birch, Nicholson and Bailey, Lack, Wynne-Edwards and many others form the basic literature in the area. More recently, mathematical ecologists such as Holling, May and Jeffers have become increasingly involved.

32. R.G.Wilkinson (1973) op cit.

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PART TWO - DESCRIPTION

Chapter Three - The patterns of History

Chapter Four - The Mull System - present status

Chapter Five - An examination of natural resource use in Mull

CHAPTER THREE - THE PATTERNS OF HISTORY

3.1 - Introduction

It might be thought that the very large literature dealing with the history and development of the Scottish Highlands would render any such description an expendable luxury in this thesis. In fact, the very wide range of viewpoints expressed in this mass of published works makes a consideration of history a vital element in any appreciation of the West Highland situation. This chapter goes beyond a simple reiteration and summary of West Highland history to emphasise the crucial importance of historical processes, and to focus on those elements which are important determinants of the contemporary situation.

While the chapter focusses on Mull as an area in which such processes have taken place, the pattern of history is similar for most of the West Highlands, and broadly so for the land north and west of the Highland Boundary Fault. Events only figure in this summary of history where they acted as significant triggers or break-points for the various ecological, economic, social and cultural processes going on at the time. For a detailed account of events and individuals in Mull up to the present century, the reader is referred to Maclean (1), whose two volume work is probably the best extant account of the history of the study area. No definitive history of recent events has been written; Macnab (1) is the most adequate available source.

3.2 - Early History

3.2.1. Prehistory

The logical starting point for a summary of historical processes in the West Highlands is the end of the most recent glaciation, some 15 000 years before the present (BP). At that time, the area had acquired a landform close to that of the present, and was clothed in a largely treeless tundra. A further cold period began about 11 000 BP, which lasted for 1000 years. The present interglacial period can therefore be said to have begun some 10 000 years ago (2). Considerable research has been carried out into the ecological history of this period (3) through the examination of pollen preserved in peat deposits. There was a rapid amelioration of climate at this time, so the pioneer tundra was quickly succeeded by shrubs and birch scrub. Over the next 2000 -3000 years, forests of birch with pine and oak developed to cover most of Northern Scotland below 500m. Figure 3.1 (taken from Williams (3)) shows the distribution of the main types of this forest. The map shows that pine was rare in Mull, which had oak and birch associated with elm, ash, alder and hazel. This rich deciduous woodland would be replaced with birch/hazel scrub on exposed sites on the west coast, as altitudinal limits were approached and where soils were acid and poorly drained. The northern movement of oakwoods was halted about 5000 BP. Climate at this time was at an optimum; soon after, increasing occurrence of alder and sudden acceleration of bog formation indicates an increasing wetness of climate, a deterioration which slightly predates the first evidence of man's activities in these areas. From this time on, the condition of the ecosystem is increasingly influenced by man's actions, aided to a greater or lesser degree by natural processes, particularly climate. The map of forest types portrayed in figure 3.1 therefore represents an optimum climax vegetation which is prevented from re-establishment today by the combined influences of man and climate.

The first significant change which can be attributed to man's influence is the sudden reduction in elm which occurred about 3000 BC (5000 BP) (4). This coincides with the arrival of Neolithic man; the evidence suggests sporadic colonisation by Mesolithic groups long before this time, but they seem to have had little lasting effect on their environment in the West Highlands. These Mesolithic groups were hunter-gatherers, while Neolithic man practised primitive agriculture, necessitating local removal of the forest. It is thought that they had particular uses for elm, and therefore removed it selectively.

Deforestation continued gradually over the following millenia and seems to have been accompanied by a deterioration in climate. The permanent removal of forest from the West Highlands therefore resulted from the complex interactions of man and climate, its irreversible nature being determined by the following hypothetical process of feedback (5). When the trees were felled, microclimate was altered with increasing exposure. A cooler and wetter macroclimate therefore increased leaching of the soil and depressed soil organism activity. This led to the formation of an acid mor humus, incomplete decomposition and peat formation. Leaching of soluble soil minerals also led to the formation of iron pan, and the quantity of water exceeded drainage capacities, both resulting in shallower rooting of

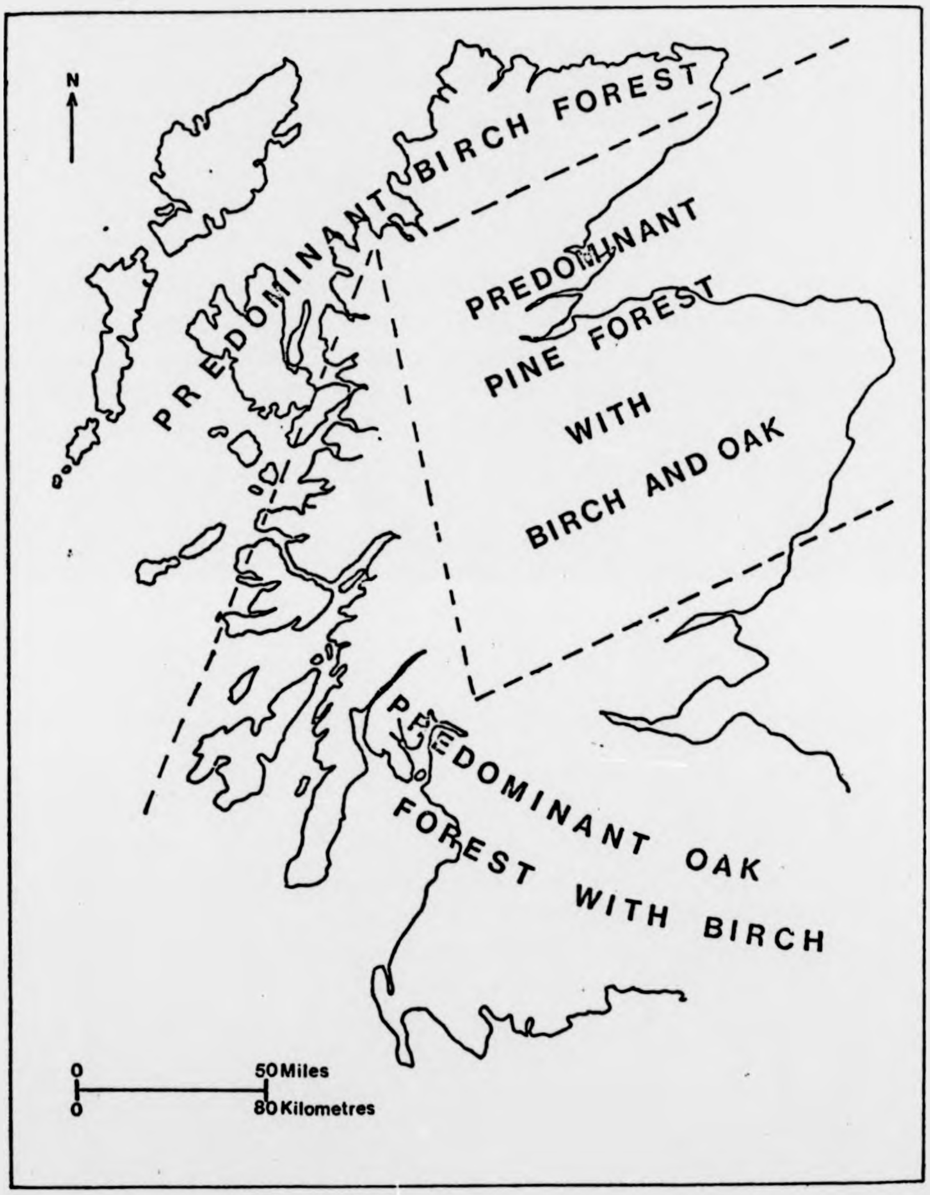


Figure 3.1 Map showing the distribution of the major forest types of Scotland

Figure 3.1 Map showing the distribution of the major forest types of Scotland

newly established trees which were therefore more susceptible to windthrow. Anderson (6) attaches much more weight to the natural effects of windthrow and direct impeding of drainage by fallen trees as primary factors in this process.

This took place over several thousand years, so even when the Romans explored the area in the early years AD, they described the country as 'heavily forest-clad'. The Neolithic peoples had by then been superseded by the 'Beaker people', the Bronze age and finally the Iron age in the last millenium BC. By that time, Celtic peoples had established themselves in the Highlands and Islands and the influence of their culture has been prominent ever since.

The Romans never really penetrated the Highlands except on expeditions. When they did enter the area, they found a pastoral people, subsisting on 'milk and meat, not bread'. Thus the traditions of pastoral agriculture were established from the earliest times. The Celts carried out some cultivation, for they introduced the plough, probably growing oats and bere (six-rowed barley).

The Romans left Scotland in the fifth century AD, leaving a country divided between the Scots, from Ireland, controlling the southwest; the Picts, of Celtic origin, in the north and northeast; Britons in the lowlands and Angles in the southeast and Northumbria. Mull lay on the boundary between two of these kingdoms, so when Columba came to establish a monastery on Iona in AD 563, he petitioned both the Pictish and Scottish kings for possession of the island.

3.2.2 The Norse Period (850 to 1250 AD)

The history of the West Highlands remains unchronicled for almost a thousand years, during which time the area was certainly populated. The evidence left to tell the story of these communities, their activities and the effects they had on the ecosystem is circumstantial. From about 750 AD, the Scandanavian influence spread down the West coast, first in the form of raids and plundering forays by the Norse and the Danes. Later, this was superseded by trading and settlement, with the result that the Norse influence is still detectable in the islands today, particularly in the form of placenames. In Mull, for example, names such as Mishnish, Mornish, Quinish, Aros, Ensay, Carsaig and Assapol are of entirely Norse origin. Others, such as Glen Forsa, Ardalanish and Erraid, are part Norse, part Gaelic.

From about 850 AD, the Norse ruled the Northern Isles, the Hebrides and certain coastal parts of the mainland, their influence extending as far south as the Isle of Man. This political influence lasted until the Thirteenth century, during which time the foundations were laid for the history of the following half-millennium. The way in which particular forms of social organisation and landuse evolved is largely unknown, but it was during this time that the clan system developed out of the family-tribal system which predated it. The predominant form of land-tenure, the run-rig joint-tenanted farm, also developed at this time. During this period, the community undoubtably made further depredations on the natural forests, cutting timber for firewood and construction and burning woods deliberately or accidently in the course of numerous raids and skirmishes.

The islands were ruled by the Norse and their lieutenants in an uneasy relationship with the Scottish Kings who controlled the mainland. In 1164, the isles rose under Somerled, Lord of the Isles, to challenge Malcolm IV of Scotland at Renfrew. They were beaten, and a century later another defeat at Largs led to the ceding of the Western Isles to Scotland in 1266.

3.3 - The Clan Period (1250 to 1750)

The change of sovereignty over the Hebrides only demonstrated the independence of the islands. The Lordship of the Isles was maintained and descendants of Somerled remained political and military leaders of some note. Two in particular, Donald and Gillean, are traditionally held to have lent their names to two clans, the MacDonalds and the Macleans, which became the dominant political forces in Mull. During most of this period, the Macleans were the dominant clan. It is during this time that the first extensive descriptions of the life of the community were written. This period also yields the first clear evidence of trade between the Highlands and the rest of Britain in the form of black cattle, driven south to markets in Glasgow, Falkirk and Crieff before fattening on lowland pastures. Landuse changed little over the years; by this time the amount of wooded land in Mull had apparently fallen to a low level, and landuse was predominantly pastoral, cattle outnumbering sheep, with cultivation for oats, bere and hay around the joint-tenanted farms. Each of these farms had inbye and outbye land, together with a share in common grazings. Transhumance was practised, thus exploiting upland grazing and avoiding the problem of keeping animals out of arable areas in an unenclosed landscape. The staples of the diet were oats, milk and dairy products with a little meat or fish. Exports of black cattle paid for imports of weapons and other necessary hardware. The social and political structures on which this system of landuse was based (see figure 3.2) gave great stability at a community level, but rather the reverse on a wider scale. Interminable feuding between the clans, particularly the Macleans and the MacDonalds, seems to have dominated the lives of the community in the 15th, 16th and 17th centuries, involving frequent cattle raids, burnings and other atrocities. In spite of this, the people appear to have been relatively healthy and active, although perhaps with a rather short life expectancy. Maclean (1) describes this period in great detail.

By the mid-Seventeenth century, constant feuding had greatly weakened both Macleans and MacDonalds, allowing the Argyll Campbells to occupy the power vacuum. Thus many of the clan lands changed hands, and in 1692 the estates of Maclean were forfeited to Argyle, chiefly as a result of Maclean's active support for the Royalist cause. From this time onwards, the influence of the outside world on Highland affairs has become more and more prominent, until now it is overwhelming. Correspondingly, the volume of information, opinion and analysis has increased so that while the remaining 200 years of history is susceptible to very detailed treatment, the following section concerning the assimilation of the West Highland population into the economic and political structures of Britain is of necessity a brief outline.

3.4 - The integration of the Highlands into Britain

The single event which signalled a significant acceleration of this process in the late Eighteenth century was undoubtably the collapse of the 1745/46 Jacobite Rebellion. That is not to say that what followed would not have happened but for Culloden, but rather that the event gave an added impetus to the process. Prattis (7) points out earlier events which were contributory - the Union of Crowns (1603) and the Union of Parliaments (1707) coupled with an increasing demand for beef. Thus began an erosion of the introverted social structures of the clans, by giving the chiefs a cash income and greatly increased

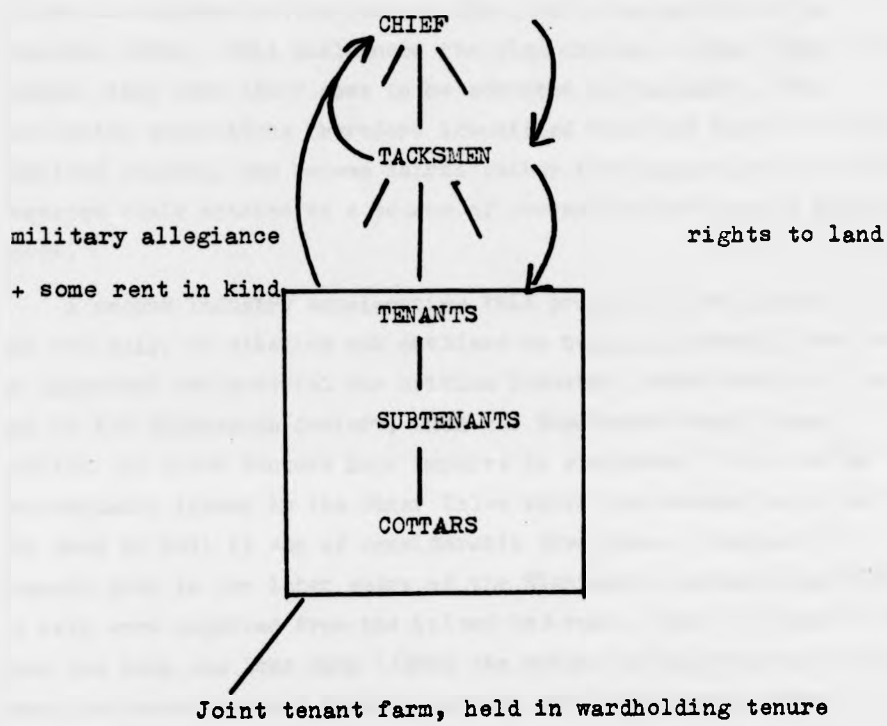


Fig 3.2 - Social structure of the clan

contact with the commercial and social life of Central Scotland and London. Land tenure in the clan period had been based largely on military allegience, little importance being attached to financial returns. The proscription of military activity, coupled with the increased demand for beef from the expanding industrial areas of the South and, in particular, from the British military, caused a gradual change in emphasis on the part of the chiefs from political to economic terms. This influenced the clan chiefs in other ways, for example they sent their sons to be educated in the south. The succeeding generations therefore identified less and less with their Highland origins, and became lairds rather than chiefs, in that they regarded their estates as a source of revenue rather than of military power.

A second industry accelerating this process in the coastal areas was the kelp, an alkaline ash obtained by burning seaweed. This was an important raw material for British industry, particularly at the end of the Eighteenth century, when the Napoleonic wars, import tariffs and other factors kept imports to a minimum. Kelp had an overwhelming impact in the Outer Isles where the seaweed was plentiful, but even in Mull it was of considerable importance. Maclean (1) reports that in the later years of the Eighteenth century, some 600 tons of kelp were exported from the island in a year. Gray (8) points out that the kelp was less than 1/20th the weight of the original weed. Thus the annual seaweed harvest in Mull must have reached some 12 000 tons.

The events which followed are well-documented and provide in their detail an account of the complexity of interactions between a community, its resource base and its markets. A series of papers by Gray (8)(9)(10)(11) describe the important features of the story.

Perhaps the first factor was the increasing dependence of the lairds on the limited range of products of their estates. The kelp industry was at first organised by tacksmen and individual entrepreneurs, but as prices rose the lairds established their rights to kelp up almost the whole of the West Coast. By the 1790s, monopolistic control had been established by compelling tacksmen to sell their tenant's kelp through the landlord. As time went on, the lairds penetrated further and further into the production process. This involved deliberate organisation of the workforce, involving modification of land tenure and farming systems.

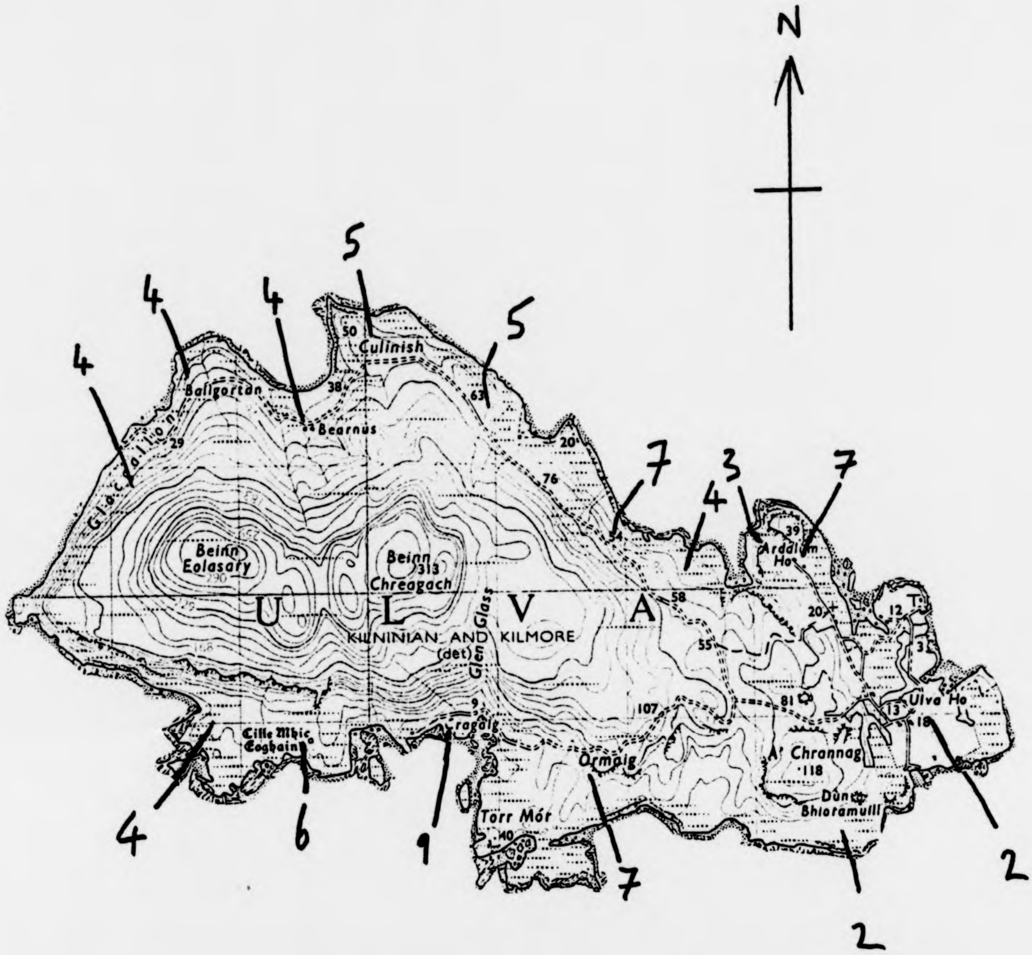
The educated lairds had returned to their estates with some knowledge of the farming systems of the lowlands, and therefore viewed the traditional run-rig system in a new light. The first moves to 'improve' Highland agriculture came in the 1770s, affecting inland glens more than the islands. Better land was placed into larger units, often let to incoming farmers and a capitalist farming system was set up to replace the subsistence-oriented joint-tenanted farms. The displaced families found work in the islands in the kelping, attempted to establish smallholdings on extremely poor ground or emigrated. This was happening on a small scale at first, but set the scene for more radical changes later on. Similar changes in land tenure also occurred in the islands, where lairds split up the joint tenant farms and reallocated families individually to smallholdings which were explicitly intended to be below adequate subsistence level, thus encouraging involvement in the kelp industry. Lairds discouraged emigration, encouraged immigration and further subdivided the land. These smallholdings were the first crofts. It is important to realise how recently these emerged; crofting is not really a traditional form of landuse (in the sense that its origins lie deep in the past), nor was it ever intended to provide an adequate living for a family.

This subdivision of land was made possible by the introduction and gradual acceptance of the potato in the Highlands (10)(12). The traditional agrarian system resisted this crop for many years following its first appearence as a decorative plant in laird's gardens, but the transformation of this system into bare subsistence units, with lairds recovering the larger part of the kelper's wage in rent, eventually led to almost complete dependence on the potato as a staple foodstuff.

Thus, in the early years of the Nineteenth century, the West Highland economic, political and resource-use systems had been transformed from the traditional systems operating only two generations earlier. In 1815, the Napoleonic wars came to an end, and with renewed imports of barilla, the kelp industry collapsed. Paradoxically, the collapse affected the kelpers only marginally, while the lairds were particularly hard-hit as they struggled to maintain the infrastructure in the hope of a recovery. Within a few years, most estates had run up substantial rent arrears, eventually leading to the sale of many of the remaining hereditary clan lands. This, coupled with the earlier forfeiture of estates following the '45, strengthened the trend towards culturally alien and absentee landlords. The lairds were faced with a problem; how to derive an income from an estate crowded with families scraping a subsistence from tiny plots of land and generating no cash surplus. An idea of the standard of living endured by these families may be gained from a contemporary description of their circumstances:-

> "....They delve their little farms with the spade and have no need of any considerable stock to begin life; all that is required is a cow, a small hut, a pot, fishing tackle and a rug or blanket...."

The changes wrought by the 'improvers' in the late Eighteenth century provided the stimulus for the next important change in the Highlands, the introduction of extensive sheep farming. This was the genesis of the Highland clearances. Whole communities were evicted by landlords whose authority over tenants was absolute. Gray (13) found evidence that sheep were introduced to Mull before 1810, but it was three decades later that this process began in earnest. Maclean (1) records the clearance of the Island of Ulva in 1841 of 73 families to make way for sheep (see figure 2.3). The full story of the clearances has been told elswhere (14,15), the gist of which is that the tenants of the estates had become regarded as a surplus population. This has been portrayed as a result of increasing numbers or of maldistribution of communities in relation to economic opportunity. Such a perspective ignores the importance of a third factor, the dependence of those communities on economic and political forces quite beyond their control. In fact, the situation resulted from a combination of all three factors; in the 1840s the system exceeded its constraints and simply broke down. By this time, the old economy had been thoroughly destroyed. It had depended on mutual interdependence between clan chief and clansmen/tenants, in which annual variation in the harvest was buffered by variation in the number of livestock carried, and if a succession of bad years reduced this readily liquidated capital to a very low level, the chief stepped in to finance purchases of grain, treated as a loan and paid off over a number of years. The decidedly one-sided nature of the laird/crofter relationship which replaced it undoubtably drained this buffering ability out of the system, so when the potato crop was destroyed by blight in 1846 and the years that followed, the system was weakened to the point of collapse and actual starvation was the result.



SCALE 1:50 000

Fig 3.3 - Map of Ulva showing extent of clearance of 1841.

- Total number of families evicted 73 - perhaps 500 people.

This tragic culmination of a century of uncontrolled change simply accelerated the process of eviction and consequent emigration. Mull had doubled its population between 1750 and 1850, partly through immigration, partly through natural increase, aided by kelping and the potato. The interior was largely cleared, however, and many families were left to scratch a living on clifftops and along the shore. When one considers that the latter date coincides with the height of Victorian expansion of the British Empire, the contrast between the lifestyles of urban dwellers, even the poor, and the destitute Highland crofter is placed in startling context. The matter eventually became a national issue, evidenced by the mass of written material preserved from the period.

The shape of the Highland society, economy and landuse for the Twentieth century was therefore taking shape. The land was largely deforested, and the inland glens were deserted. The remnants of the indigenous community scraped a living on the coasts, their numbers gradually being whittled away through a variety of processes. Their land parcels were clearly inadequate, and they attempted to acquire the extra income for a decent living in a number of ways. Fishing was advocated strongly by the lairds, but never really made any impact in Mull. Tobermory had been established by the British Fisheries Society in the late Eighteenth century, and although it was generally regarded as a success, that success was never built on fishing, but rather on merchanting and trade, aided by the excellent harbour and strategic position. A second way to supplement incomes in the rural community was seasonal migration as farm labour to the lowlands. This was a widespread practice from 1850 until the end of the century, when mechanisation, particularly of harvesting, eliminated the need for large numbers of short term casual workers. Emigration, to the cities of the south, to North America or to Australasia emerged as almost the only remaining option.

By this time, the condition of the Highlands had become a major national issue, along with factory conditions, child employment and other humanist causes of the late Victorian era. The Napier Commission was appointed to examine the condition of Highland crofters. This resulted in the Crofters Holdings Act of 1886, giving crofters a very high degree of security of tenure. That act, and others that followed, fossilised the system of land tenure in the West Highlands and have led to the flippant definition of a croft as:- '.. a small piece of land entirely surrounded by regulations..'. The introduction of this legislation marks a point at which the Highlands became truly integrated with the rest of Britain, and fully subject to external political control.

3.5 - The Twentieth Century

The census figures show a steady decline in the Highland population from 1841 to 1961, levelling out in 1971. Furthermore, the age structure of the population changed to give a preponderance of older people, particularly in rural areas. The result is often an exceptionally conservative community, conditioned by its history of disadvantage and the control exercised by older members to regard any change as detrimental in the long term. This is one of the contributory factors in the development of 'marginality', a process which, once begun, feeds on itself in a number of ways. The shortage of young, active and innovatory members in the community has been explained by Maclean (16) as follows:-

> "...The lack of any form of female employment means that the unmarried female sector of the population has to leave in search of work. This in turn causes emigration of the unmarried male population so that the community is deprived of its two most important sectors of population...."

Marginality has been examined in detail by Rawson (17), who identified another feedback loop; falling population leads to a fall in demand for services (schools, medical services, shops, garages etc.), which in turn leads to a decline in the provision of those services leading once again to decline in population. Even the recent cessation in decline in population of the Highlands masks a continuing concentration of population in urban centres. Prattis (7) has taken a slightly different view of marginality by looking at the processes of centralisation, and viewing the Highlands and Islands as one of a series of peripheral areas on the northwest margins of Europe.

The population of Mull declined from a peak of over 10 000 in 1840 to a low of barely 2000 in 1960. The intervening century was one of gradual decline. Clearances in the late Victorian period gave way to more or less 'voluntary' emigration in the early years of the present century. Various events accelerated the process. Profits from sheep farming declined towards the end of the Nineteenth century due to external changes in the market for mutton and wool, and perhaps due to declining production of over-grazed pasture. Many estates owned by wealthy absentee landlords were turned over to sport, particularly deer, a process which involved further evictions.

The First World War was almost the last occasion on which the military potential of the Highlands was mobilised. Prebble (15) describes the way that regiments were raised in the Nineteenth century, the lairds exercising their powers of eviction to ensure an adequate response from the community. Beside the road to Lochbuie, at Kinlochspelve, a war memorial testifies the numbers raised for the Great War in an area now almost entirely depopulated. Many of those named did not return.

After the Second war, a new feature emerged. In Mull, an influx of demobilised officers, almost all of southern origin, bought small and medium sized estates on the island. Their influence is clearly observable through the census figures for 1951, 1961 and 1971. While that influence is clearly discernable on the structure of the community, the influx of monied people does not seem to have altered the overall pattern of gradual decline. This was brought into focus by the 'West Highland Survey', published in 1955 (18). This was explicit in its assessment of Mull:-

> "....Mull, which holds some of the most fertile land in the Highlands and some equal to the best in the Kingdom, might well be looked upon as a countrside ruined by the sudden introduction of a foreign landuse in the colonial style, in this instance sheep farming in the extensive system....Mull and Ulva are cattle country equal to the best in the Highlands, and the extreme mildness of the climate, together with the natural grassiness, mean that the stock can be outwintered with very little imported fodder....The Highland paradox is apparent once again, in that here are green acres gone derelict while there is still congestion in the poverty-stricken Archean gneiss of Lewis...." (pp 47-49)

In 1960, M.A.M.Dickie, a former Chief Lands Officer for DAFS, was commissioned to report on the condition of the island (19). He too found dereliction and neglect, and passed on reports that estate owners were allowing land to go out of production, that houses on these estates were being allowed to go into disrepair and that any interference or attempts to encourage development of the community were being resisted or sabotaged.

Such surveys and reports all contributed to a political initiative in the early 1960s leading to the setting up of the Highlands and Islands Development Board (HIDB) in 1965. This government agency was viewed with some alarm by landowners, who anticipated a centralist state planning exercise which would implement a comprehensive development plan. In fact, it did nothing of the sort. Prattis (20) provides a lucid explanation of this failure in terms of the concepts of marginality described above, and the political framework within which the HIDB operates. Carter (21,22,23) acknowledges the importance of the condition and economic environment of the Highlands, but places much more emphasis on the faults in the economic analysis carried out by the Board as a basis for their policies. The HIDB were under pressure at an early stage to produce such a comprehensive development plan for Mull, and they eventually published their 'Survey and Proposals for Development' in 1973. As a survey, it gives an excellent picture of the condition of Mull as a land resource for a community in the latter half of the Twentieth century, and demonstrates some of the potential of the island for more intensive use of these resources. As a development plan, however, it has been a total failure. While some of the tentative proposals put forward in the plan have been put into effect, it is doubted that the presence of the Board influenced to course of events that would probably have occurred in any case.

There have been changes in landownership in the last half century which have resulted in large areas coming into state ownership. This is a trend which has been continuing. The Forestry Commission made their first purchase in the 1920s and are now the biggest single landowner on the island. Their plans do appear to be susceptible to influence by the HIDB.

Another phenomenon of recent years has been the proliferation of analyses of the 'Highland Problem'. These have in general followed fashions of thought in economics and sociology. They are reviewed by Carter (24), who uses the criticisms he makes as a means to provide evidence for his thesis of dependency. Such theories (of dependency or marginality) have largely replaced the previous orthodoxy of 'dualism', at least in academic circles. The latter contends that many of the characteristics of underdevelopment in the Highlands spring from the remaining influence of a preindustrial economy in the area. This could only be destroyed if the area were exposed to the rigour of market forces. The more recent analysis suggests that such exposure may simply reinforce underdevelopment. All such analyses have been shot through with ambivalence and ambiguity of definition, and few have questioned or even defined the objectives which would be regarded as representing a solution to the problem. One exception (25) presented a case for accelerating depopulation of rural areas which was couched in economic terms. This was never taken up or adequately answered.

The aim of this thesis is to review the future; for while this short history has set the scene to look at the effects of policy and the possibilities which are presented, the final outcome should be that past, present and future constitute a continuum which is susceptible to rational analysis.

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CHAPTER FOUR - THE MULL SYSTEM - PRESENT STATUS

4.1 Introduction

This chapter uses the conceptual framework established in Chapter two to describe the important features of the existing Mull system and the interrelations between the community and its economic and physical environment as it enters the last quarter of the Twentieth Century.

The system boundary encompasses the Island of Mull and its associated islands, principally Iona, Ulva and Gometra; this unit is hereafter referred to simply as Mull or the Island.

Mull is one of the larger Inner Hebrides, with a land area of 350 square miles (91000 ha.) rising to abour 3000' (1000m), bearing a resident population (mid-1970s) of about 2500, rising by as much as three times during the summer tourist season. Mull is part of the West Highlands, in a relatively southerly position, centred on 56° 30'N 6°W.

Mull is a sub-region in economic terms, and in reality rather far from the self-reliant economy depicted in the model. However, the assertion in Chapter two that even an open economy must depend in essence on the physical resources found within its geographical boundaries is maintained even at this small scale. The openness of the Mull economy is significant; exactly how much is not known. Most of the output of agriculture and forestry is exported, most requirements of the population are imported. McNicoll's input/output study of Shetland (1) showed that 78% of the investment capital spent in the area went to generate imports, and that two key industries, fish processing and textiles, exported 82% and 99% of their output respectively. Across the system, exports generated 56% of their value in imports (ie. they contributed £44 to the balance of trade for every £100 of exports). Mull can be expected to be at least as open, and probably more so. The systematic framework derives from the ten 'black boxes' described in the conceptual model in section 2.2. These have been disaggregated into about one hundred key factors listed below (Table 4.1). Disaggregation was taken to a level judged to represent an adequate level of detail. The list is by no means exhaustive, but the process of disaggregation has been systematic, if subjective; it includes all important elements of the system, at least insofar as this project is concerned. The parameters are of no ordinal significance, nor are they intended to be mutually exclusive.

The main purpose of the list is to establish a checklist from which the state of the Mull system can be assessed. Such a list can be, and in fact has been, updated over the course of the project; it provides a convenient method of doing so. The assessment of system condition is seen as an important foundation for the analysis of problems faced by it. This chapter establises such a framework for Mull.

Table 4.1 - List of important factors in the Mull system

Exogenous resources	01	Season	RESOURCE BASE
	02	Temperature	
	03	Precipitation and humidity	
	04	Wind	
	05	Light quality	
	06	Physiography and geology	
	07	Sea water	
Renewable resources	08	Lake water	
	09	Stream water	
	10	Soil water and drainage	
	11	Soil structures and types	
	12	Mineral nutrients	
	13	Fertilisers	
	14	Soil biota	
	15	Wild flora	
	16	Seaweed	
	17	Grazing range	
	18	Cultivated vegetation	
	19	Trees	
	20	Wild fauna	
	21	Deer	
	22	Sheep	
	23	Cattle	
	24	Other domestic stock	
Non-renewable resources	25	Stone for building	
	26	Stone for aggregate	
	27	Mineral ores	
	28	Fossil hydrocarbons - solid	
	29	Fossil hydrocarbons - liquid	
	30	Fossil hydrocarbons - gas	
Waste products	31	Machine byproducts	
	32	Refuse	
	33	Sewage	
	34	Heat	
Primary industry	35	Extraction industries	RESOURCE USE (part)
	36	Energy utilisation	
	37	Water utilisation	
	38	Fishing - Marine	
	39	Fishing - Freshwater	
	40	Fish Farming	
	41	Horticulture	
	42	Agriculture - Plants	
	43	Agriculture - Animals	
	44	Game management	
	45	Forestry	
Secondary industries	46	Food processing	
	47	Timber related industry	
	48	Other organic and chemical manufacturing	
	49	Inorganic processing and manufacture	
	50	Distilling	
	51	Knitting and weaving	
	52	Craft industry	
	53	Construction	

Table 4.1 (continued)

Output and consumption	54	Internal manufacture and use	RESOURCE USE (part)	
	55	Internal manufacture and export		
	56	External manufacture and import		
	57	Distribution of income		
Human population	58	Children (under 16)	HUMAN 'PLAYERS'	
	59	Male adult		
	60	Female adult		
	61	Retired people		
	62	Tourists		
	63	Visitors		
	64	Residents		
	65	Employment		
	66	Labour organisation		
	67	Domestic households		
Capital structure	68	Land tenure	SERVICES	INFRASTRUCTURE
	69	Location		
	70	Type and distribution of assets		
Tertiary sector	71	Financial and business services		
	72	Agricultural services		
	73	Shops and supply services		
	74	Posts and telecommunications		
	75	Garages and engineering services		
	76	Freight transport		
	77	Land passenger transport		
	78	Sea transport		
	79	Air transport		
	80	Leisure and recreation services		
	81	Public eating places		
	82	Hotels and Bed & Breakfast		
	83	Self catering accommodation		
	84	Housing		
	85	Social services		
	86	Health services		
	87	Ecosystem conservation		
	88	Primary education		
	89	Secondary education		
	90	Higher education		
	91	Religious attitudes and services	ADMINISTRATION	
	92	Public order and legal services		
	93	Community representation		
	94	Highlands and Islands Development Board		
	95	District council		
	96	Regional council		
	97	National government		
	98	Transnational government		

4.2 Systematic description of system status

01-05 Climate

As important factors influencing resource-use capability, the interaction of light quality, wind, precipitation and humidity, temperature and season are discussed in detail in Chapter five. Mull's climate presents problems not found in the more heavily populated parts of the UK, particularly those of high rainfall and moderate temperatures. The rainfall, at 1500mm to over 2000mm, causes drainage problems, particularly as a large proportion goes to very rapid runoff. This rapid runoff leads to equally rapid drought, a feature of the spring months when rainfall is usually low. The temperature regime is moderate, with mild winters and cool summers. Humidity tends to be high, and potential evapotranspiration relatively low. The northerly position gives long daylight hours in summer. Winds tend to be strong, imposing a severe constraint on biological activity in the exposed west and south-west of the island. The general picture is thus one of a moderate climate with two main detrimental features; high rainfall, and exposure. In situations where good drainage and shelter can be arranged, the land can be extremely fertile.

06 Physiography and geology

The island consists of three main land systems (2) reflecting different topography and geology:-

i) North Mull - Basalt rocks deriving from ancient lava flows form a characteristic stepped landscape and yield good soils in sheltered, well-drained locations.

ii) Central Mull - formed from the eroded caldera of a primeval volcano, is a mountainous and inhospitable area of granitic rocks and poor acid soils.

iii) The Ross of Mull (southwest) - is composed mainly of schists and granites giving generally poor soils, with occasional small pockets (up to 10 ha) of cultivable ground. Larger areas of cultivable ground are based on sandy links and present problems of moisture retention and nutrient status.

07 Sea water

The sea around Mull is a resource of considerable importance, for fisheries and potentially for energy production. Loch Cuan, at Dervaig, must have some potential for tidal power generation (considered in Chapter nine) while many sheltered waters form possible sites for fish farm cages. Tides are moderate, with a spring range of 4-5 m. Tidal currents are not problematic except off Duart Point, where turbulent waters are encountered when the tide is running.

08-09 Water

There are no large flowing water bodies in Mull. The largest catchments are estimated to generate mean flows of no more than 1 cumec (cubic metre per second). Flow rates are highly variable, as a high proportion of rainfall runs off the impervious geology. Any ground storage is found mainly in the peat bogs.

Two large lochs, Frisa and Ba, are to be found in Mull, along with a large number of smaller lochs and lochans. The only significant reservoir is the Mishnish Lochs, a series of small bodies of water united by the raising of the water level. Both large lochs owe their existence to glacial trenches, both are relatively deep (205 feet and 144 feet respectively) and are classic Highland oligotrophic water bodies. A survey at the turn of the century (3) placed them 29th and 51st largest water bodies in Scotland, although more recent reservoirs must now have changed the order.

Loch Frisa is $7\frac{1}{2}$ km long by a maximum $\frac{1}{2}$ km wide, and has a very small catchment, less than 4 times the area of the loch itself. At 75m above sea level, volume estimated at $102 \times 10^6 m^3$, it offers some generation potential.

Loch Ba is 5 km long by a maximum 1 km wide, and has a much larger catchment, fifteen times the area of the loch in one of the wettest parts of the island. However, it is only 12m above sea level, with a volume estimated at $45 \times 10^6 m^3$.

10-11 Soils

A detailed soils map is described in Appendix four. The pattern of soils depends primarily on geology and topography. Bibby describes the conclusion of considerable research (2) into these patterns, finding that the best soils are found on free-draining lower slopes. Bottom land in Mull tends to have impeded drainage, and peat formation is a common feature.

12 Mineral nutrients

Nutrients are a vital part of biological systems. The supply of these nutrients is critically tied to the complex chemistry of soil systems and environmental conditions. One mineral apparently in short supply on the basalt soils is Phosphorus, in fact because the element is locked into complexes in the soil chemistry. Forest operations use up to 350 kg/ha of imported rock phosphate to overcome this problem. The full list of important biochemical nutrient elements encludes Nitrogen, Phosphorus, Potassium, Sulphur, Carbon, Oxygen, Magnesium, Iron, Manganese, Boron, Molybdenum, Copper, Zinc, Chlorine, Cobalt and Aluminium.

13 Fertilisers

These are of two kinds, mineral and organic. Mineral fertilisers incorporate Nitrogen, Phosphate, Potash and Lime, which are exclusively imported. Organic fertilisers include manure, compost, seaweed and peat. These are internally produced, the extent of usage being unknown.

14 Soil biota

The activity of animal, plant and microorganism populations in the soil is recognised to be an important factor influencing production. For example, earthworms in neutral or base-rich soils aid the breakdown of organic matter which maintains fertility. In acidic soils, earthworms are absent or very much reduced in numbers, slowing down this process and thus reinforcing infertility. Soil is therefore much more than simply a chemical medium; it supports a complex of organisms. No specific information is available for Mull.

16-19 Vegetation

Mull is mainly clothed in heath and rough pasture, with Calluna and Molinia as dominant species. Bracken (Pteridium) is a major problem on the better soils, encouraged by overgrazing, inappropriate muirburn and a heavily weighted sheep/cattle ratio. Some steep slopes in all parts of the island carry scrub woodland of birch and hazel.

Seaweed is an important resource, particularly as a source of minerals. Some seaweed cutting is carried out, but the resource is undoubtably underused, and has some potential as a source of fertiliser.

Grazing range in Mull is largely of poor quality, while technically better land is infested with bracken. This is characteristic os the low stocking rates used and the extensive style of management. This in turn relates to the depressed state of hill farming. Cultivated vegetation covers less than 2% of the land area, with another 12% under plantation forestry. Even less is under arable, a mere 0.2% of the total.

Trees are an important landscape feature in the more sheltered parts of the island, particularly because over 80% of the land area is treeless. Conifers are found mainly in plantation, and hardwoods form some quite large areas of woodland, particularly at Gruline, Torloisk, around Tobermory and around Loch Spelve.

20-21. Wild fauna

There is a diverse range of wild animals and birds on the island. Deer are of considerable economic significance both from the point of view of stalking and of damage to forestry. A 1969 census by the Red Deer Commission estimated 3360, while more recent subjective estimates by those involved suggest as many as 4000. Feral goats are found on Laggan estate.

22 Sheep

The predominant breed is the inevitable Blackface and crosses thereof. Numbers have declined in recent years, so the Mull flock includes about 31000 breeding ewes, 7000 non-breeding ewes and 900 rams. Annual production of lambs can be as much as 24000. Management levels are generally low, lambing percentage at sale consequently lying between 45% and 70%, with a few units achieving 80% or 90%. Typical stocking rates are about a ewe to 1.2 ha, declining on poor ground to a ewe to 3 ha.

23 Cattle

The stock is overwhelmingly of beef breeds, in particular the hardy Luing and Highland. 5000 beasts on the island are predominantly held on a small number of larger units. These farms tend to be ones in which management standards are high and land use more intensive. A milk herd of Friesians is maintained at Calgary, supplying about half the summer milk supply for North Mull, while some small units keep one or two cows for milking.

24 Other stock

Poultry are widely kept, particularly on smaller units and crofts. Pigs are few and far between, less than half a dozen on the whole island. Goats are kept on a few smaller holdings, and there are a number of horses, particularly kept by enterprises offering pony trekking.

25-30 Non-renewable resources

Most construction nowadays uses concrete, bricks and other imported materials, but the local material is stone, of which there is no shortage. Quarry stone, demolition rubble and land improvement are all sources. Roofing slates of low quality were once produced from shale deposits, but most of those found in the island now have been imported. Roadstone, gravel and sand are in plentiful supply for local needs. A sand and gravel pit near Torosay and numerous roadstone quarries around the island form the existing workings.

Mineral ores are one particular class of resources whose perceived utility fluctuates tremendously with time. There is a wide range of minerals in Mull, but none are being worked at present. Iona marble and Ross granite have been worked in the past, mainly for building.

Fossil hydrocarbons are all imported apart from peat. Oil imports from the main supplier in 1977/78 amounted to 570,000 gallons. Total supplies probably amount to over 650,000 gallons. Oil products are also used in lubrication and incorporated in chemical imports, so total hydrocarbon usage for the Mull system is very difficult to determine especially when coal and gas is taken into account.

31-34 Waste products

Pollution is not a particular problem in Mull; certainly there are no significant sources of chemical emission. Domestic refuse presents several problems; the nature of transport links with the mainland make scrap dealing non-existent, so that such remote communities tend to become littered with abandoned vehicles and other durable items. In recent years, some attempt has been made to rectify this, with a central tip near Tobermory, and a refuse collection service now covering the whole island,(even Iona, making use of the new car ferry). Recently, Strathclyde region collected most of the scrap vehicles and dumped them in a disused quarry. Sewage treatment systems are non-existent, even in Tobermory, the most advanced installation in rural areas being a septic tank and soakaway. Waste heat is not a problem, except perhaps that produced by the distillery, which would be discharged into the sea.

35 Extraction industries

Quarrying has in the past had a place in the economy, with Ross granite and Iona marble used worldwide in public buildings. Over a century ago, attempts were made to open up and exploit the limited coal deposits in the Ross of Mull. These efforts failed because of the poor quality of the material and the inaccessibility of the deposits. At present, activity is limited to the extraction of aggregate and sand from morainic material near Torosay.

36 Energy utilisation

Mull presently imports almost all of its energy, in the form of electricity, coal, oil and gas. Peat cuttings and waste wood are sources of heat obtained on-island. Statistics of peat production are not easily obtained because of the non-commercial nature of the operation.

Electricity comes in a subsea cable from Kerrera to Grass Point, and a subsidiary feed comes between Lochaline and Fishnish. A small hydro installation at Tobermory generates a maximum 250kw. Typical system demand is for 2MW, 4MW peak, annual demand totalling 9.3GWh between 1500 consumers. Seasonal patterns of energy demand are diminished because tourism tends to bolster summer demand.

Fossil fuels come in by a variety of methods, and total inputs are consequently difficult to determine. Calor gas is supplied through Oban to a few stockists on the island. Oil products come to Craignure by coastal tanker, the Shell(UK) depot there handling 570,000 gallons per year. BP supply two filling stations by road tanker. Coal is brought in by road and sea.

Mull has a considerable potential for energy generation, and prospects for hydro-electricity, tidal, wave, solar and wind power are investigated in Chapter nine. Current energy demand adds up to an estimated 50GWh per year of primary fuel demand.

37 Water utilisation

Only the Tobermory area has a large mains water supply system; most areas of Mull have either individual or small local systems. The quality of supply is therefore variable, and only short periods of drought rapidly lead to problems, particularly on sites where impervious bedrock and rapid runoff result in minimal ground storage.

38-40 Fishing

Marine fishing, centred on boats at Tobermory and Bunessan, concentrates on Lobsters, shellfish and Salmon. Statistics are hard to decipher; official statistics are collected for Tobermory, Bunessan and Loch Buie, but when Oban is not far away, direct landings (especially of open sea fish, such as herring and whitefish) must often be made there. Furthermore, in the sense of legality, some parts of the industry habitually run a little close to the wind, so official figures may be less than accurate. The figures show landings to be highly variable from year to year, but the basic pattern seems to be for about £100,000 of lobsters and shellfish to dominate about £25,000 of other catches. The Mull Fisherman's Association represent the local interests of the industry.

On fresh water, inland lochs and rivers see little in the way of commercial activity, except insofar as the fishings can be let. The Mishnish Lochs have been stocked regularly for a number of years, and a recent enterprise has begun a similar operation on nearby Loch an Torr.

Any future expansion of fishfarming may be expected to find a number of favourable sites in and around Mull, with many sheltered waters suitable for sea cages. A small trout farm in Tobermory bay and a few shellfish rafts at Loch Buie and Bunessan are the sum total at the time of writing.

41 Horticulture

Mull seems, on the face of it, to be well suited to horticultural enterprises, with mild winters, long summer days and plenty of rain. However, few enterprises have been established, distance from markets and lateness of season being the chief constraints. Tomatoes and lettuces are grown in quantity in a market garden operation at Glengorm, and find a ready local market, despite premium prices.

Domestic gardens must produce a significant part of vegetable needs, but even so imports of fruit and vegetables weigh heavily on the balance of trade.

42 Agriculture - plants

Mull is grossly underutilised in terms of its capability for primary production. Arable land acreage has declined drastically in the last century, as has managed grassland. The acreage of rough grazing has correspondingly increased. Field crops are predominantly fodder crops, but, at 65ha in 1977, nothing like sufficient even for the cattle stock carried at present. 60ha of oats, largely in the Ross of Mull, and 15ha of maincrop potatoes grown in small areas all over the island, make up the bulk of the rest of the arable ground.

Grassland management is also on a small scale relative to the 91000ha of Mull, with about 700ha for hay and silage and about the same improved pasture. The HIDB report stated that 1850ha were capable of arable reclamation, and 3250ha suitable for managed grassland. There are only two combine harvesters in Mull, at Scallastle and Killiechronan, which gives another indication of the depressed condition of land cultivation. Most arable land is in small, topographically uneven areas, while modern high technology farming demands large areas of flat land to gain adequate returns to scale from large machinery.

43 Agriculture - animals

This is predominantly sheep and cattle. Sheep are kept in large numbers and in a variety of management regimes from excellent to atrocious. Poor returns in recent years have led to a steady decline, which a straight line regression suggests could lead to a collapse of the industry as early as 1990. Excellent markets in Autumn 1978 hinted at a reversal of the trend, but this was not sustained in 1979. Present production amounts to some 25000 beasts per year.

More cattle would be of great benefit to the grazings in Mull, but the price and availability of winter feed and the uncertainty of the market in recent years have inhibited any expansion.

Agriculture in Mull is therefore in an overall gradual decline, although the situation on any individual unit will not always reflect this. The symptoms of this decline are falling stock numbers, particularly of sheep, and decreasing areas under cultivation. However, there are units which demonstrate that, given the right conditions, good returns are possible. The basic problem is a lack of flexibility of the management systems dictated by present circumstances, so that success is critically dependent on a high standard of management.

44 Game management

There are thought to be 4000 Red deer in Mull, and a few Grouse and other game. The shootings are largely privately owned or let to private estates, but some of these are let out at prices of about £100 per stag. Poaching is considered locally to be a serious problem, poached animals being smuggled off the island for sale on the mainland. There is some Trout and Salmon fishing, but good rivers are few and far between. Angling interests centre on the Mishnish Lochs and nearby Loch an Torr. Coarse fishing is economically insignificant, but there is thought to be potential for a commercial eel fishery in Lochs Frisa and Ba.

45 Forestry

Forestry is the largest single production enterprise on the island, overwhelmingly a Forestry Commission operation, with a forest approaching 10,500ha. The only private plantations are at Gruline and Ardnacross. The potential for forestry up to one third of the total land area has been established (described in Chapter eight), but developing such a potential would seriously impede agricultural operations. Most of the Mull forest is young, thus production from existing plantations will not peak for many years. Between 1985 and the end of the century, the Mull forest will produce about 25,000 tons per annum, doubling and quadrupling in the first quarter of the 21st century. The projected increase over the next decade has led to speculation on the island that modification of handling facilities at Craignure (already operating near capacity) will include installation of a small chipping plant with consequent job prospects and the possibility of further downstream activities. The softwood timber produced on the island (the larger part of output) is best suited for industrial purposes - paper, chipboard etc. - rather than construction.

The Forestry Commission is rigidly administered with a well-defined hierarchy. Mull is part of a district based on Fort William, which itself is part of the North Conservancy based on Inverness. Five supervisory staff in Mull are in charge of a labour force of about 50. The forest is largely of Sitka Spruce, with Lodgepole pine on wetter sites and Larch on richer sites.

46-53 Secondary industry

The employment statistics show 13% in secondary industry, but these are mainly in construction. A small sawmill at Pennyghael uses 1500 tons of local timber, mainly for fencing materials.

The Ledaig distillery in Tobermory has a chequered history, and after five years in receivership shows little sign of reopening. Knitting and weaving are carried on as a craft industry along with silversmithing, art printing, woodturning, enamelling, leatherwork and pottery.

The construction industry is relatively large, but costs are high. It has been claimed that it is cheaper to import a prefabricated timber house from Norway and have that erected than to have one built using local materials and labour. Most materials must be imported - steel, tiles, cement, fittings and much of the timber. Mull softwood timber is not ideally suited for building or joinery due to its dimensional instability with changing humidity.

54 Internal manufacture and use

The products of certain primary industries find local markets, particularly vegetables (both commercially and domestically grown), milk (about half the supply for the north end of the island) and timber (for fencing materials and offcuts as a source of fuel). Peat is cut in many areas, particularly in the Ross. One small hydro electricity plant at Tobermory produces up to 250KW for the grid.

55 Internal manufacture and export

Most products of primary and secondary industry find a market off-island. Agriculture and forestry are the main sources with 20,000 lambs and cast ewes, 1500 calves and culled cows for beef and about

9000tons of timber every year, worth in all about £1 million at 1979 prices. The distillery, when in business, is the only significant manufacturing enterprise. Other exports include craft products and fish, mainly lobsters and shellfish.

56 External manufacture and import

Many requirements of the community are imported - consumer durables, processed foods, machinery, animal feeds, fertilisers, construction materials and, most important, energy in the form of electricity, oil, coal and gas.

57 Distribution of income

There is no direct Mull data for income distribution, but this will have an important impact on the consumption of goods and services in the future, due to the differing demand patterns of various income groups.

58-64 Population

Trying to determine an exact figure for the population of Mull would be pointless, because attempts to refine existing figures meet rapidly diminishing returns. The most recent 'accurate' figures available are in the 1971 census, which showed the population to be just above the 2000 mark. It is thought locally that there has been an increase in the past decade, and that resident population stands at about 2500. This is increased considerably during the summer, perhaps doubled, with further numbers of short-term tourists on a daily and weekly basis, together with seasonal workers and long term holidaymakers, bringing the summer peak to perhaps 7000.

Residents - At the 1971 census, over 85% of the population were Scottish-born; how many were Muileachs is not known. Less than 10% were of English or Welsh origin, with 5% from other more distant places. The age structures of the Mull population at the 1951, 1961, 1971 censuses shows an ageing population, with a considerable 'bulge' moving through and now approaching retirement, whose origins are known to have been an influx after World War II. If indeed the population is on the increase, that increase will have to be considerable if it is to overcome the losses to be expected by 1991. There is evidence to suppose this to be possible in the substantial increase in young people between 20 and 30 years old from 1961 to 1971, perhaps derived from the large population of children of an age to be offspring to the 'bulge' described above. This age group is traditionally susceptible to emigration, but this seems in the present decade to be being matched by a substantial influx of young people from the mainland. Interpretation of the 1971 census gives the following breakdown of population:-

Table 4.2 - <u>Approximate breakdown of population by social activity and age</u>

	age	number	%
Below school age	0-4	155	8
Primary	4-11	140	7
Secondary	11-18	155	8
Economically active male	18-60	575	28
" " female	18-60	525	26
Retired male	over 60	160	8
Retired female	over 60	315	15
Total		2025	100

Source: Small area statistics, 1971 Census

The relatively free access provided by the ferry services make it very difficult to derive reliable figures for Tourist numbers without detailed survey. The 1971 HIDB survey (published 1974) estimated 130,000, since which time further increases have been substantial. Unsubstantiated figures as high as 250,000 have been mentioned, which are not impossible when the peak season volume of traffic to Iona is considered. Many of these tourists are day visitors from Oban, shipped in busloads to Iona and back. It is estimated that over 10% stay on the island, many for a week or a fortnight.

A third category of population, distinct from the tourists, are the visitors, people who come to the island regularly, either for recreation or for business. These people have a considerable impact on the economy, by inflating demand on the housing market (for second homes) or by taking up seasonal employment particularly in the hotels. Their numbers are difficult to establish, but must be at least 1000, if one includes commercial travellers and local government officials.

65 Employment

The job situation in Mull is confused, because multi-occupation is common, most people having fingers in more than one pie. Estimates in 1969 for employment placed the total workforce at about 800, split between primary, secondary and service industries 34%, 13% and 53% respectively. Up to date estimates have been made in this project:-

Table 4.3 Division of labour estimated for 1978

PRIMARY	Forestry Agriculture Fishing Energy services	60 240 40 20	360	36%
SECONDARY	Manufacturing (mainly crafts) Construction	20 150	170	17%
TERTIARY	Education Transport Health Catering and hotels General services	30 40 20 180 200	470	47%
		1000	1000	100%

Estimated population breakdown for 1978:-

Children	450
Working	900
Seeking work	100
Housewives	450
Retired	600
Total	2500

66 Labour organisation

Although many of the jobs in Mull are run on conventional lines, there are distinctive features; multi-occupation, less significance attached to daily work routines and total lack of large-scale labour organisation. Unions are active mainly in transport and to a limited extent in agriculture. At the 1971 census, Mull had a lower than average proportion of the married female population in work, although this is something which may have changed significantly since then. Certainly, in the UK as a whole, large numbers of married women have gone out to work, causing a significant change in the pattern of labour organisation.

Domestic Households

The 1971 census enumerated 737 households.

Table 4.4 - Breakdown of household size at 1971 census

	%	
One person	24	177
Two person	34	251
Three	16	118
Four	11	81
Five	9	66
Six	3	22
Seven or more	3	22
	100	737

68 Land tenure

The general situation in Mull is still one of large private estates with farms let to tenants. The largest landowner is nevertheless undoubtably the State, the Forestry Commission holding large areas of unplanted land outside their 10,000ha forest, and DAFS owning some former private estates, in particular Calgary and Glen Forsa. The map described in Chapter five gives a more detailed account. Crofting is of significance in the Ross, although there are nominal crofts (small farms in fact) in other areas. The 1978 rating valuation identified 81 crofts, with a total rateable value of £6,438.

69 Location

The spatial arrangement of resources is an important factor influencing economic activity. The basic configuration of the island has been described in 06. The main communication pattern centres on Craignure at the eastern extremity, with main roads up the east coast to Tobermory and due west to Fionnphort.

70 Distribution and type of assets

For each existing activity there are requirements for fixed structures, capital equipment and working financial capital. The type location and ownership of these assets is a vital factor in determining investment decisions, and therefore development. However, establishing such a picture for a small community implies a level of interference in private affairs which this project has not attempted.

71 Financial and business services

There is now one permanent bank in Mull, a branch of Clydesdale in Tobermory. This branch also runs a mobile unit which tours the island on a regular weekly timetable. Insurance brokers and other agents all operate out of Oban. The HIDB trade directory for 1977 lists an estate agent, a chartered surveyor and a building surveyor/architect on the Island, but these people are only operating on an intermittent basis, their main activity being in a different direction.

72 Agriculture services

The government agency with responsibilities for Scottish agriculture is the Department of Agriculture and Fisheries for Scotland. Their annual budget of some £95 million (1979 estimates) includes over £60 million of state aid in the form of EEC price support, capital grants schemes and other forms of subsidy. Of particular importance in the West Highlands is the Hill livestock compensatory allowance, worth over £22 million per annum. Income from this source in Mull is estimated at some £150,000. DAFS administer the agricultural research institutes in Scotland, including HFRO and MISR, at a cost of £11 million. The three Scottish agricultural colleges receive about £10 million, about one third of which is used to run an advisory service. The West of Scotland Agricultural College have an advisor who covers Mull, together with Coll and Tiree, from an office in Oban. Aid is also channelled from DAFS through the Crofters Commission in Inverness. Finally, a veterinary surgeon serving the island is based at Fishnish.

73 Shops and supply systems

Most settlements on the island have only basic general store/post office facilities, plus tourist-oriented enterprises. Tobermory has a surprisingly wide range of shops for its size, including two small supermarkets, two butchers, a bank, launderette, painting and decorating, off licence/hardware, hairdresser and electricity board showroom, plus the usual post office, newsagents, gift shops and other tourist oriented ventures. Various mobile shops run on an intermittent basis. For specialist shops, Oban has most requirements or a means of getting them. Most people from South Mull, and many from the North, go to Oban for most of their needs. Mull is thus an extension of Oban's hinterland in this respect.

74 Posts and telecommunications

The GPO maintains 9 sub-postoffices in the area, and employ about 16 people for postal duties. The telephone system employs about 10. Radio and television reception is extremely variable. Tobermory and most of the East and Southeast coast get 3-channel colour reception from a mast at Craignure. A new mast at Glengorm, aimed primarily at Coll and Tiree, will extend this coverage to a limited extent. The Ross of Mull is particularly poor, and if 405 line black and white transmissions cease (as planned) many places will lose what reception they have. Scottish daily and early editions of some UK daily newspapers reach most parts of Mull by late morning. Sunday papers arrive on Monday. The only local paper is the Oban Times, published weekly on Thursdays. Mull is not considered large enough by the local authority to warrant library services.

75 Garages and engineering services

There are seven filling stations on the island, four of which also carry out repairs. At Bunessan, a light engineering and repair workshop carries on a variety of activities. Only four-star petrol and diesel are available as fuel for road vehicles; oil companies argue that the demand does not warrant the supply of the full range.

76-77 Transport by road

The strategic road pattern intended for Mull is for a 24'-carriageway derestricted route from Tobermory to Fionnphort via Craignure, the rest of the island being served by the existing single track roads with an 8 ton gross weight limit. This outline is largely achieved, with stretches from Tobermory to Salen and through Craignure to complete the main road, and some bridge renovation in other areas to bring them up to the 8 ton limit. Public Transport is limited to the main Tobermory-Fionnphort raod, other areas being served only by school buses. The number of coaches in season is large, and a local firm (Bowmans) uses seven or more buses between Craignure and Fionnphort (for Iona) on a two-hourly shuttle with the ferry in the summer season. The 1971 census noted 342 households with one car and 92 households with two or more cars (46% and 12% respectively).

Freight is transported by MacBraynes Haulage, who employ three drivers at Tobermory. Attempts to set up locally owned and run freight transport enterprises have met with limited success.

78 Transport by sea

There are two main piers at Tobermory, one at Bunessan and one at Craignure, the latter including a ramp for roll on/roll off car ferry operation. There are also slipways at Fishnish, Fionnphort, Iona, Ulva Ferry and Grass Point, plus other private small jetties at various locations.

Scheduled ferry services include roll on/roll off car ferries on routes from Oban to Craignure and Lochaline to Fishnish. Similar facilities are under construction for Fionnphort-Iona. Passenger/goods services include Oban and Coll/Tiree to Tobermory, Tobermory-Kilchoan (Ardnamurchan), Oban-Grass point, Fionnphort-Iona, Fionnphort-Staffa, Ulva Ferry-Ulva and Ulva Ferry-Staffa. There is also a summer hydrofoil service from Oban to Tobermory. Many of these are primarily summer services, but most run at least reduced services during the winter.

Fares, particularly for vehicles and goods, are well above road equivalent costs for the distances involved. Vehicles are charged by length, currently about £5 per metre on the main Oban-Craignure crossing. Caledonian MacBrayne employ four office staff and pier staff at Tobermory, four pier staff at Craignure and three fulltime boatmen on the Iona ferry. Other boat crews are not based in the island.

79 Transport by air

There is a grass airstrip at Glen Forsa, occasionally used by small airlines as a stop on a Western Isles scheduled service, by private light aircraft and by the occasional emergency flight. Military helicopters are available for medical emergencies and accidents.

80 Leisure and recreation services

This is a fluid area, with enterprises appearing and disappearing overnight. At present, facilities are offered for diving, sailing, shooting, pony trekking, golf, walking and sightseeing. A 1979 'Holiday Which?' report on Mull as a holiday area concluded that:- "...(Mull) has a gentler atmosphere.... more of a feeling of peace and being away from it all" (4)

81 Public eating places

A survey in 1978 showed there to be three restaurants in Tobermory, one each in Pennyghael, Fionnphort, Iona and Salen, together with a fish and chip shop and tearoom in Bunessan and tearooms attached to the abbey on Iona and to Torosay Castle.

82 Hotels and Bed and Breakfast accommodation

There are 15 hotels, 5 guest houses and perhaps 75 bed and breakfast establishments (1978), offering between 1000 and 1500 beds.

83 Self-catering accommodation

There are groups of chalets for let in Tobermory, Dervaig and Carsaig. Several planning applications for similar developments have so far been turned down. Several estates and other property owners let houses at high rents to visitors. All these facilities are fully booked in season, and it seems that the demand for this kind of accommodation is by no means satisfied. Any increase in tourist activity seems likely to increase demand for this kind of operation.

84 Housing

It is sometimes maintained that there is a shortage of housing on the island, a proposition which is difficult to determine either way. Certainly prices for owner-occupied houses are inflated because of the demand for second homes, and council housing is only being expanded in North Mull at present. There may well be a genuine physical shortage in the south, exacerbated by the lack of financial capital or security controlled by many families. Properties in several areas have been advertised for sale for several months, indicating a mis-match of demand and asking price. At the 1971 census, the breakdown of housing into ownership categories was as follows:-

Table 4.5 - House ownership (1971 census)

	%
Owner occupied	36
Council	21

(continued over)

	%
Private lease (unfurnished)	34
Private lease (furnished)	3
Non-permanent (caravans etc)	3
Other	3
	100

Since 1971, the council housing has increased at the expense of private unfurnished, a number of which have been sold off (therefore becoming owner-occupied) or let as holiday cottages as the part played in the rural economy by the large estates has declined. Another important feature of the housing situation in Mull is the high proportion of vacant property and absent households, a situation which is thought to have worsened in the seven years since the census. A total of 1058 dwellings included 107 empty and 214 absent households, probably mainly second homes and holiday cottages; the date of the census was April 25.

The breakdown of ownership in table 4.5 is based on the remaining 737 properties. In 1978, there were 211 council properties on the island, with a further 22 under construction at Salen and 40 planned for Tobermory. There are no current plans for further council housing in the Ross of Mull.

The overall effect of changes in the housing market in the 1970s has been to concentrate the resident population in existing settlements. The causes are:-

1. District council planning policy discouraging remote development, now passing out of fashion (1979).
2. Housing policy concentrating local authority developments in small areas on the grounds of unit cost of services.
3. Gradual selling-off or holiday letting of remote houses owned by large estates.

The perceived shortage of housing in Mull is due to imperfections in the market rather than a physical shortage of property.

85 <u>Other Social services</u>

Fire services - Tobermory has a fire engine manned by part time firemen.

Unemployment benefit and social security is administered from Oban and constitutes an important prop to some areas of the economy. The heterogeneous nature of employment on the Island makes this administration difficult, and this is undoubtably exploited by some sections of the population.

86 Health services

Medical services on the island are good, relative to the size of the community. There are three general practitioners, at Tobermory, Salen and Bunessan, with District Nurses at those three plus Craignure and Dervaig. One dentist based at Salen uses a mobile surgery, but apparently Oban gets much of the trade, particularly from South Mull. There is a small hospital and eventide home at Salen, with 10 beds, 4 of which are reserved for hospital cases. One ambulance is based nominally at Craignure. The main hospital for the area is in Oban most patients going across on the boat, although in emergency the airstrip at Glen Forsa or a military helicopter may be used.

87 Ecosystem conservation

The main government agencies are the Nature Conservancy Council (NCC), concerned with ecological problems, and the Countryside Commission for Scotland (CCS), concerned with landscape conservation. Neither maintains a staff on the island, but both have designated areas which they consider to be of importance. The 1977 Nature Conservation Review (5) contains reference to four sites considered to be of national or international importance - cliff habitats at Carsaig and Ardmeanach, upland at Ardmeanach and woodland at Loch Spelve. In addition, seventeen sites of special scientific interest (SSSIs) have been designated, mainly in woodland and coastal habitats, and including one major bog community, the Coladoir bog in Glen More. CCS have designated the area around Loch na Keal as a National Scenic Heritage Area.

88-90 Education

There are eight primary schools catering for about 150 children of relevant age, at Tobermory, Salen, Dervaig, Ulva Ferry, Lochdon, Pennyghael, Bunessan and Iona. They employ a total of 16 teachers, and 8 part time staff.

Tobermory High School is the only secondary school, catering for

11-16 year olds from the north end of the island. Children from South Mull go to Oban High School and board on a weekly basis. All children wishing to go beyond 'O'grades have to go to Oban. Bright pupils are sent to Oban at the earliest opportunity. The Tobermory school employs about 8 teachers.

For higher education, Mull is served by the national system of Universities and Colleges. Adult education is limited to the few evening classes held in Tobermory or to the Open University, but that only if reception of the programmes is adequate.

91 Religion

It seems a characteristic of Highland communities that a relatively high proportion of the population are regular churchgoers. The Church of Scotland minister, Mr Holroyd, estimates that of a resident population of about 2500, as many as 700 attend church on a regular basis. Tobermory alone has a regular congregation of 150, from a population of about 700. Other congregations include an Episcopalian church of about 40, and a Free Presbyterian church of similar size. Catholic Mass is celebrated in summer, mainly for the benefit of visitors. The abbey on Iona is the centre of a multidenominational religious organisation, the Iona Connumity, who conduct a programme of social service in Glasgow.

92 Police and legal services

There are at present four police officers stationed in Mull - a sergeant and constable at Tobermory, a constable at Salen and another at Bunessan. There are plans to place another at Craignure, but whether he will be in addition to the existing strength has yet to be resolved. The nearest courts and legal services are in Oban.

93 Community representation

Excepting the now defunct Tobermory Burgh Coundil, the longest established community body is the Mull & Iona Coundil for Social Service (SCSS) (6). The Council has apparently had some success in its appointed role as representing the interests of the community, including the building of the airstrip, the hospital and the creation of a tourist organisation. The Council is elected at its AGM, has an annual budget of some £2000 and patchy local organisation in various parts of the island, typically dependent on the presence of key individuals acting as a focus.

In 1974, the HIDB Mull report was followed up by the formation of the Mull Development Committee, initially for a three year period, extended by one year to May 1978. It comprised representatives of all organisations with a specific local interest in the Mull economy, and provided a limited local feedback to the Board in considering development proposals. This was chiefly hampered by considerations of confidentiality in discussing specific proporals; the committee was only given a broad outline of proposals by the HIDB, so there could be no detailed discussion of costs and benefits to the community of different strategies.

The most recent arrival has been the Community Council. In common with other parts of Scotland, the 1974 reorganisation of local government left little in the way of a forum for 'parish pump' politics. The first local proposals came in 1974, but it was April 1977 before the council held its first meeting. Elections were held on a postal ballot and attracted an 80% poll. There are ten members from various parts of the island, meeting on a monthly basis. They have no executive powers,and the council is run financially on a shoestring of £100 per year plus 1p per head of population. Even more recent has been the formation of a Community Council for the 120 inhabitants of Iona.

The area of local representation is thus confused. Eventually the Community Council will probably emerge as the chief voice of the community. A separate problem is whether Mull can be considered as one community. Geographically and socially, the island tends to divide into South Mull and North Mull, the former based on the crofting community of the Ross and Bunessan, the latter dominated by Tobermory.

94 The Highlands and Islands Development Board

The HIDB is a quango, neither a planning agency nor an executive body, whose remit has been described in 1.1.2 and whose historical roots and present problems were described in 3.5. Of their 1978 budget of £12.8 million, one quarter was used for grant aid, and an equal amount for loans for development. Over the period 1965 to 1978, some 30% of their assistance went to tourist-oriented developments.

The Board have devoted considerable time and effort to Mull, involving themselves in various different ways which have illustrated some of their more difficult problems. These began with their 'Survey and Proposals for Development' early in the decade, continued with the consultative Mull Development Committee from 1974 to 1978 and the appointment of an Area Development Officer from 1974 to 1977 (whose role was non-executive, acting primarily as an information and liaison officer between the Inverness headquarters and the local population). In 1977, the arrival of a new development officer coincided with an increase in the area covered to include Coll, Tiree, Colonsay, the Small Isles, Morvern and Ardnamurchan. He is, however, still based at Salen in Mull.

Up to June 1977, the Board had made grants of nearly £400,000 and loans of over £550,000 to a total of 125 applicants from Mull. There had been 162 applications in all, 37 being withdrawn or turned down.

95-96 Local Authorities

Mull comprises about 20% by population of the Lorn seat of Strathclyde region, and is in the northwest extremity of that large authority. The Councillor since May 1974 has been David Webster (Conservative) who was returned with a majority of 364. In May 1978 he was returned unopposed. Mull, with an electorate of 1800, forms ward 15 of Argyll and Bute district, whose headquarters are in Lochgilphead. From 1974 to 1979, Colonel Miller of Torosay estate represented the island and sat on the planning committee of the district council. On his retirement in 1979, John Wilson of Craignure, chairman of the Community Council, was elected.

The two levels of local government work closely together, the region covering strategic areas such as roads, transport, education, Police and Fire services and social work, while the district covers local matters - housing, local planning and building control, tourism and refuse collection. The rateable value of the Mull ward is £391,218 (April 1978) and for 1978/79 the region will levy 37p in the pound, the district 20p. Central government supported the region by 88p in the pound, the district by 19p, so the overall local authority yield (taking into account a 3p rebate to domestic ratepayers) derived from Mull is about 161p in the pound, about £630,000 per annum. The region employs about 25 people on the Island, the district about 21 (excluding education).

97 National Government

Mull forms a very small part (less than 5%) of the Westminster constituency of Argyll. This is a traditional Scottish Tory seat, held by Michael Noble until his retirement in 1974. In that year it was captured by the SNP and held for them by Ian McCormick until 1979, when a large swing turned his 4000 majority into a similar sized defeat. The present MP is John Mackay (Conservative).

Government agencies in Scotland are administered either directly from London, in the case of DHSS, Employment, Defence, Inland Revenue, Customs and Excise and some smaller bodies such as the Forestry Commission and the Nature Conservancy Council. The remainder are responsible to the Secretary of State for Scotland and include DAFS, SED, the Courts, Police, Prison, Fire services, Health boards, Scottish Economic Planning Department and SDD. Local authorities are administered through SDD. Mull as a community has no effective say in the running of this bureaucracy, while the administration is a quite considerable influence on activities on the island. The impact of this bureaucracy therefore parallels the climate as an exogenous influence on the Mull system.

98 The European Economic Community

This final factor is even more remote from the island. Elections in the summer of 1979 elected the first directly representative European Parliament. This, so far, has not established a significant level of control over the EEC bureaucracy in Brussels. The existence of the EEC has, however, had identifiable impact on Mull, with regional development fund grants for major road and ferry developments on the island channelled through Strathclyde Regional Council. The Common Agricultural Policy, administered through the DAFS, has likewise had a significant effect through grant aid and support pricing.

Thus the present state of the Mull system has been described. One area which has not been covered in detail by this description is the inventory of natural resources and the assessment of their present use and future potential. This subject is the focus of the next chapter.

Notes to text

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2. J.S.Bibby (1978) Geomorphology and Soils - Chapter five of The Island of Mull - A Survey of its Flora and Environment Edited by A.C.Jermy & J.A.Crabbe
3. J.Murray & L.Pullar (1910) Bathymetrical survey of Scottish Freshwater Lochs. Volume II - Challenger office, Edinburgh
4. Which? (1979) Holidays in the Scottish Islands - Holiday Which? Report, Feb.
5. D.A.Ratcliffe (ed)(1977) A Nature Conservation Review
6. I.Carter (1979) Community Development in Scotland - Paper to the British Association for the Advancement of Science Conference, Heriot Watt University, September 1979.

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Chapter five - AN EXAMINATION OF NATURAL RESOURCE USE IN MULL

5.1 Introduction

Earlier chapters establish a central concern with man/environment relationships, exemplified by the problems faced by rural communities. A key feature of this problem set is perceived to be underutilisation of natural resources. A case study area has been selected, and its history and current status described. The next stage in the analysis is to collect information on natural resource characteristics and the existing patterns of their management. The collection and analysis of this information is described in appendices three, four and five. This chapter summarises the information and analyses the production possibilities that are technically feasible in the present social and economic framework.

Appendices three and four contain a description of physical environment attributes. Most of this information was gathered from existing sources rather than by field survey. First, the spatial patterns of these attributes are described, followed by discussion of the patterns to be observed through time. Such a physical infrastructure sets approximate limits to the options for resource use and hence economic activity. The main features of these attributes are considered in the first section of this chapter. Appendix five reviews methods developed for assessment of these limits and their application in Mull. Section 5.3 goes on from this discussion to describe current knowledge of landuse capability in Mull. The final section makes a first assessment of the technically feasible maximum output of the resource-use industries on the island.

5.2 Physical attributes - a summary

5.2.1 Spatial patterns

Appendix three describes the sources of information on spatial patterns of landform, climate, substrate and community infrastructure.

i) Landform - the incidence of high ground is often quoted as an important limitation on resource use in the Highlands. The range of altitude in Mull is 0 - 1000 m asl, but 78% of the island lies below 250m (800'), while 40% lies below 100m (300'). Incidence of high ground is therefore not of itself a direct limitation on resource use. Terrain, on the other hand, is difficult, restricting access for machinery to otherwise fertile areas.

The pattern of water flow is as one would expect for an island, with a large number of small catchments. Flow rates are highly variable, posing significant problems for the resource manager.

ii) Climate - Close examination of the available data shows how inadequate it is for any definitive assessment. The data which is available suggests that temperatures and frost occurences are comparable to or better than may be found in the rich farmlands of East Central Scotland. Exposure to prevailing southwesterly winds is certainly a problem for land managers, except in sheltered inland valleys and along the Sound of Mull. The available rainfall data, interpreted in independent analyses, is contradictory, reflecting the practical problems of interpretation. In particular, the automatic correlation of increasing rainfall with increasing altitude may be questioned. Water balance is certainly an important problem for the land manager, particularly foresters, as the prevailing wetness conceals a problem of seasonal shortage.

iii) Substrate - the basic geology of Mull has been described in Chapter four. The recurrent features are poorly formed soils and rock close to the surface. This derives first from the igneous nature of the rock, second from the effects of high rainfall and exposure and third from the vegetation history. The pattern of soil types is complex, extreme local variations deriving from microtopography. In general, the best soils are found on gently sloping low ground. Bottom land tends to suffer from impeded drainage, while exposure and poorer temperature regimes create skeletal soils on the tops.

iv) Community infrastructure - The pattern of settlement corresponds closely to the occurrence of better ground, while communications avoid areas of extreme topography wherever possible. A survey of the island in 1978 (see map in pocket) revealed over 4000 ha of land which has at some time been cultivated. 12 000ha of woodland and plantation, over 11 000ha of unenclosed pasture and 1500ha of deep peat leaves over 62 000 ha of rough grazing. Thus over 70% of the area is used on an extensive basis if at all. Most of this ground is inland and of higher altitude. Turning to land tenure, the boundaries of management units are relatively stable, but there have been changes in the nature of ownership, with the breakup of large estates and transfers to state and corporate owners. The available ownership boundaries date from the late 1960s and are now substantially out of date. However, the pattern of relatively large tracts of poor land is still predominant.

5.2.2 Temporal patterns

The seasonal patterns of light and temperature are described in Appendix four. While there is little evidence that the existing temperature regime is an important limiting factor on primary production, it may be commented that the equable West Highland climate is more vulnerable to longer term changes in temperature patterns. A two Celsius degree fall in mean annual temperatures would place the whole island on the extreme limits of marginal cultivation, at least so far as temperature is concerned.

Water balance is frequently portrayed as overwhelmingly wet. While rainfall is high and evapotranspiration low, the data available is insufficient to point up the fact of alternating oversupply and undersupply. There is a high probability of drought in spring and early summer, exacerbated by the low ground-storage ability of the rocks and soil.

Data on other cliamtic parameters is extremely sketchy. Exposure is a particular problem in the low-lying southwest parts of the island, and may well be the most important limiting factor for primary productivity.

5.3 <u>Landuse capability in Mull</u>

5.3.1 Landuse capability assessment

The previous discussion has reviewed the available information on Mull's physical characteristics, showing the generalised nature of the conclusions which may be drawn. Appendix five describes the strengths and weaknesses of methods of landuse capability assessement. Such surveys tend to accept the paucity of information and make subjective assessments. Thus, users of land use capability maps must be careful to use them in appropriate ways. This section considers the available information for Mull.

i) Capability for agriculture - The first published map was one prepared for the HIDB by MISR. It showed large areas of class 4 land (ie potentially cultivable), especially in the north of the island. This map is generally agreed to have been optimistic, and in later versions much of this ground has been placed in class five. The final published map places very few areas in class four, and may perhaps have moved to the other extreme. The division between the classes is as follows:-

	%	ha
Class 4 (potentially cultivable)	1.5	1 400
Class 5 (potentially pasture)	21.7	19 600
Class 6 (poor grazing)	71.5	64 600
Class 7 (of little use)	5.3	4 800
(open water)		(1 000)
	100.0	(91 400)

Table 5.1 Land classes and areas taken from 1979 MISR agricultural capability map.

Examination of the map shows that no land has been placed in classes 1-3. This is due to a blanket limitation imposed because 'no part of the island receives less than 1250mm of rain per annum'. The uncertainties associated with the rainfall map have been described in Appendix three.

Closer examination of the subclasses used by MISR reveals a class 5gs, containing a complex pattern of good soils, peat and rock. In principle, a substantial part of the 13 100ha in the subclass will be cultivable. This is in large part the land which in the HIDB report appears in class four. Many small areas within this are capable of growing crops. The limitation is not imposed directly by the land, but rather by the nature of existing agricultural machinery. It does, however, bring out the problem of mapping capability adequately in a complex terrain.

At first glance, the area of cultivable land in Mull would appear to be extremely low; this misapprehension is likely to be widespread when such a map is used by people with no personal knowledge of the island.

ii) Forestry - There have been no published maps of land capability for forestry in Mull. Existing plantations on the island cover 7 850ha, of which 7 500ha is Forestry Commission. Land acquired for planting suggests a forest area of 11 000ha by the mid 1980s.

The most authoritative previous estimate of potential forest land for Mull was made by a joint DAFS/FC survey of the island. This was carried out in 1967/68 and identified a grand total of some 28 000ha of plantable land. However, they felt that certain contemporary 'political and economic constraints', chiefly the strength of the agricultural and landowning lobbies, would reduce the practicable size of the forest to some 17 000ha.

A more recent map, produced by the site survey section of the Forestry Commission, was more candid about the prospects for forestry on the island. The map showed 80 400ha of plantable land (88% of the total area) divided into three classes as follows:-

	yield class	%	ha
1. High yield (for region)	12	11	10 100
2. Moderate yield	8	60	54 800
3. Low yield	6	17	15 500
		88	80 400

This very high assessment would lead the unwary to assume that Mull was highly suited to forestry. Indeed it is, but not to the extent implied by the total areas quoted here. The map fails to take into account the microtopography of peat bog and rock outcrop, and hence grossly overestimates the total area which will carry trees. The map is comparable in approach with the first MISR map for agriculture. No more detailed survey of plantability is available, so an assessment of forestry capability has been made from available sources. It is described in 8.2.1.

iii) Assessment of landuse potential in Mull. - The preceding review demonstrates the uncertainty associated with such assessment. For the purposes of the thesis, an assessment has been made using the best available information.* This incorporates a 1978 reconnaisance survey, using visual field assessment and air photo interpretation of previously cultivated land and areas presently and potentially cultivable. This survey was unable to take account of certain important constraints, chiefly the exact local nature of soil type and depth.

The 1977 agricultural returns show some 160ha under cultivation, less than 0.2% of the land area. This is generally thought to be well below the potential. The MISR land capability map (1979) shows some 1400ha (1.5%) of the island in class 4. The earlier MISR map published in the 1971 HIDB survey estimated 2000ha of potential arable. However, the 1978 survey contains some 4000ha in its top category. The criteria are rather wider, in that access by machinery and current condition were not accepted as constraints. The category simply included all land with some evidence of current or former cultivation.

The long term trends outlined in Chapter six seem likely to lead to a heavy pressure on cultivable land, but it must be borne in mind that this pressure will be constrained by the technological capability of the community. Much of the land mapped in the 1978 survey was previously cultivated using preindustrial techniques. These involved a degree of physical hardship unlikely to be acceptable in a technologically sophisticated and above-subsistence society, so an estimate of 3000ha of cultivable land is proposed as a first approximation. The main constraints experienced in selecting this land will be appropriate drainage and enclosure.

Managed grazing is the main use of ground in MISR class 5, and large areas are estiemted in all surveys. Managed grassland covers some 1600ha in the 1977 agricultural returns. The 1979 MISR map estimates some 13 000ha could be reclaimed to grassland 'with little risk of failure' under good management, but this includes some land currently under trees. The 1971 survey was more pessimistic, estimating 4000ha in this category. The 1978 survey, suitably interpreted, yields a figure of 8100ha (see table 5.2, below). The unreclaimed area of these classes will remain in rough grazing, the largest single land type in Mull, and much of this is very poor mountain ground. The 1979 MISR map estimates 65% of the total rough grazing area to be very poor. From the survey figures, this would leave 23 000ha of above-average rough grazing.

Interpretation of the 1974 MISR soils map in terms of the 1978 survey of cultivable land suggests a total of 1400ha covered by significant deposits of peat. Large areas of the island are troubled by local occurrences of peat, but in this case only large, deep deposits in areas of relatively low ground have been taken into account. The remaining land is under trees; 10 600ha of plantations and a further 1400ha of deciduous woodland and scrub. These figures are derived from existing areas and Forestry Commission plantable reserves to the mid-1980s. It is assumed at this stage that land presently under trees will remain so and that there will be no significant change in total afforested area. Closer examination of forestry potential is undertaken in Chapter eight.

Table 5.2 Summary of landuse potential

land type	%	ha
Crops and fallow	3.3	3 000
Grassland (a)	8.9	8 100
Forestry (b)	11.6	10 600
Other woodland	1.5	1 400
Peatlands	1.5	1 400
Rough grazing -fair	25.2	23 000
- poor	46.8	42 800
Inland water	1.1	1 000
Built-up	0.1	100
	100.0	91 400

(a) Area determined as follows:-

i) Upper boundaries determined largely by MISR class 5, lower boundaries by cultivable land category = 8724ha

ii) Add 1320ha left out of arable calculations (see appendix three) plus 2476ha, being the difference between actual cultivable areas identified on OS 1:10000 maps and the same areas delineated on the 1:100 000 map
Total 12520ha

iii) MISR state 65% of this to be usable, therefore final total area of managed grassland could be 8138ha

(b) The figure assumes no large scale transfers of land to forestry, and is therefore not an estimate of forestry potential. (see Chapter eight)

5.3.2 Existing land use

i. Agriculture - Farming in Mull is in a continuing gradual decline. Changes in markets and land tenure have failed to affect the steady fall in numbers of sheep and cattle. The agricultural statistics show a remarkably even decline in total sheep numbers from 77 500 in 1970 to 62 500 in 1978. Linear extrapolation of this trend would lead to a fall to zero by 2011, with a regression coefficient of 0.97. Cattle numbers have not changed in the same way; favourable markets in the early 1970s led to numbers increasing from 5100 in 1970 to 5800 in 1975. This was followed by a rapid fall to 4500 in 1978 after the market collapsed in 1975 and 1976. The central problem of farming in Mull is its dependence on these two products, opportunities for diversification in such a marginal area being very limited.

Concerted efforts by DAFS and the West of Scotland College of Agriculture have led to development of farms, particularly tenanted units, which officials claim will lead to improvement in the statistics in the next few years. However, if this were so, one might expect an improvement in the statistics for land use as more land is reseeded and winter keep conserved. In fact, areas of crops and grass have shown a relatively rapid decline since 1975, with cultivated land down from 180ha in 1975 to 156ha in 1978, and grassland from a peak of 3300ha in 1972 to 1400ha in 1978. Closer examination of cropped land shows that most of it is managed for fodder crops:-

	ha	estimated production (tons)
Roots	7	350
Green fodder crops	49	2500
Oats	75	225
Potatoes (for ware)	13	260
Miscellaneous & fallow	12	-
	156	

source: agricultural returns

The statistics for grassland reveal relatively small changes in grass for mowing, now at about 700ha. Assuming half of this goes to hay and half to silage, this represents about 1200 tons of hay and 5000 tons of silage. The total production of animal feed therefore supplies rather more than half of the feed requirements of the beef herd. Imports of hay and concentrates top up the supply, probably about 40% of the total. Most of the fluctuation in grassland comes from changes in the area of unmowed grass. A big increase in newly established grassland in 1972 was not maintained, implying that a movement towards reclamation was not sustained.

While the area of rough grazing has not changed significantly in the past decade, the statistics say nothing about qualitative changes because the category apparently includes all land not used for another purpose. In fact, much of the 72 000ha listed as rough grazing is not used for any purpose at all, being poor mountain land, bogs and land infested with bracken.

Employment in agriculture matches the slow decline revealed by the livestock statistics. Interpretation in Mull, where multi-occupation is common, is difficult, but the figures suggest that there are about 250 people working in farming, about half as employees, the rest working at their own hand.

ii. Forestry - The greatest single visible change in the Mull landscape in recent decades has been the large area of afforestation. This is overwhelmingly state forestry, less than 500ha being private production forest.

Table 5.3 Age structure of the Mull forest

planting period	ha
before 1920	34
1921 - 1930	148
1931 - 1940	414
1941 - 1950	147
1951 - 1960	1107
1961 - 1970	2502
1971 - 1980 (estimate)	5533
	9882

Adding the plantable reserves held by the Forestry Commission, this implies a total forest area of 10 500ha in the early 1980s. Until about 10 years ago, the FC was able to acquire very large tracts of land for planting. More recently, they have had to accept small parcels of land, often on low-lying and poorly drained land. This has led to a changing mix of species for planting, away from Sitka spruce towards Lodgepole pine, which is more tolerant of wet conditions. These two species are dominant at 54% and 34% respectively. Japanese larch is the third most numerous species at 6%. The changing nature of acquired land has also affected yield estimates. The earlier acquisitions contained a mixture of land classes, so the typical yield class for Sitka spruce is 12 (m^3/ha/annum). Lodgepole pine planted on poorer ground is only yield class 6, although the Forestry Commission apparently regard this as a pioneer species and expect better yields in subsequent rotations.

The Mull forest is characterised by a relatively large area of the plantations in check (ie. growing very slowly or not at all). This amounts to some 15% of the forest area. Most of it derives from the local condition known as basalt check, described in more detail elsewhere in the thesis.

The age structure of the forest explains the apparently low output - of about 10 000 tons per annum - which is coming from the earliest plantings of the 1920s coupled with thinnings from the much more extensive younger forest. The output is therefore predominantly of younger timber reflected in the nature of the main outlet, the pulp mill at Fort William.

The State forestry enterprise in Mull is organised on an industrial basis, and is administered largely from outwith the island. Five professional foresters head the operation on the island, with a labour force of about 55 manual and semi-skilled workers.

iii. Other resource-use industry - Game managment is limited to the letting of stalking for Red deer. About half the 4000 head of deer are found in the central area and the Laggan peninsula, and stalking rights are let in this area at about £100 per stag culled (1979 prices) on a number of estates. Poaching is a serious problem in many areas.

Fishing is an obvious resource industry, but one which the proximity of Oban renders relatively useless to Mull at present. A substantial shellfish industry produces winkles, scallops and lobsters for export, but fishery statistics are not a reliable guide to the size of this trade. The 150 tons per year quoted in the statistics is probably an underestimate of the yield from Mull waters.

The potential for mineral development is difficult to assess. Current activity is limited to sand and gravel extraction at Torosay. Mull has a large untapped potential for energy generation from hydro-electricity, wind, waves, tide and solar power. All such sources would be small scale. At present, a small (250 KW) hydro station at Tobermory is used intermittently as a supplement to the grid supply. Peats are dug in many parts of the island, but no statistics are available. The potential resource in known to be large.

5.4 A first glance to the future

5.4.1 Prospects up to 1990

i. Agriculture - There seems little reason to expect any significant changes in the present declining trends. An improvement in the lamb market in 1978 and 1979 seems unlikely to sustain a stabilisation or a reversal of the decline, when improving productivity in the Eastern Highlands and Southern Uplands is satisfying a static market. At present, farming in Mull is heavily dependent on support from public funds through national and European Community policies. The most likely change in this complex area is an increasing sophistication of intervention policies. This is likely to arise from the present demonstrable inadequacy of the Common Agricultural Policy as a tool for ensuring rational land use and agricultural production. Recent commentary suggests that this might take the form of increased regional aid, but unless markets are expanding this is unlikely to benefit hillfarming in Mull.

Another important factor will be the increasing price of energy and hence of transport. This will make imports of feedstuffs even more costly and exports of animals to distant markets even less profitable for the remote producer. There is therefore little chance of a marked increase in production and export of livestock. However, these same trends will make imports of other foodstuffs even more expensive, so there is a possibility that the island's only horticultural enterprise at Glengorm will be joined by others, that there will be a change of emphasis from beef to dairy cattle, and that the island might acquire its own slaughtering and processing facilities for certain products, such as wool, dairy, leather and meat. The success of such enterprises will depend on careful analysis of economic trends, especially of the economies offered by scale.

ii. Forestry - The relatively low area of wooded land in Britain is causing concern in the long term. Recent reports from the Forestry Commission and Centre for Agricultural Strategy propose aggressive programmes of afforestation. Government initiatives in the coming decade could easily be translated into increased acquisitions in Mull. The longer term consequences of such a direction are explored in Chapter eight.

Such an initiative would probably have little effect on patterns of land use in the next decade. A much more pressing problem is the mar marketing of current production. In recent years it has been relatively difficult to sell thinnings, and this problem will become critical if the pulp mill at Fort William closes, as was threatened in 1979. There is certainly a market for finished products such as paper and chipboard, but the Forestry Commission are extremely reluctant to start processing at their own hand. Private sector investors apparently see current economies of scale such that a projected enterprise could only be profitable when catering in size for a large percentage of the UK market. This would involve timber imports, and other countries are becoming more reluctant to export the raw material. There is therefore a danger that the UK will come to depend increasingly on imported finished goods, while standing timber in the Highlands is unable to find a market at a price making the forest enterprise viable. The resolution of this problem will be found in careful analysis of the full extent of the situation, taking into account supply of raw materials, demand for the product, the price of energy, economies of scale and changes in technology in the industry.

iii) Energy - The increasing price of energy in the next decade is likely to stimulate research into new sources and is likely to make them economically competitive. The prospects for energy generation in Mull are examined in detail in Chapter nine. It seems likely that pilot schemes in this area will be initiated in the 1980s.

5.4.2 Productivity from well-managed land

i. Agriculture - Sheep and cattle are kept in Mull under a range of management conditions. Their productivity depends to some extent on the inherent characteristics of the land on which they are run, but to a much greater extent on the level of management. In this section, the productivity of some better farms is examined, so that in the final section the potential increase in production for current products can be evaluated.

The first striking feature of agricultural management systems is the uneven distribution of cattle across the island. It seems that a beef enterprise is associated with a relatively large unit, usually employing labour over and above the farmer and his immediate family. Sheep only units tend to be run at a lower intensity, and are frequently part time enterprises. Thus it is fair to say that a substantial increase in output would involve qualitative changes in type of enterprise rather than simply qualitative changes in output. This is unlikely to happen, so the exercise is admittedly academic. It does, however, demonstrate that the island is physically capable of carrying a higher stock of animals and a higher productivity.

The average lambing percentage in Mull is about 70% at sale, about 20% of the lambs are retained as flock replacements and an equivalent number of ewes cast at about 60% of the price fetched by a lamb. Present stocking rates range from a ewe to 1.2ha to a ewe to 3ha. In more intensively managed units, a ewe to 0.75ha of good grazing seems to be a reasonable level.

More important in the management of a unit is the ratio between sheep and cattle. Across the island, the ratio of breeding cows to breeding ewes is one cow to every 24 breeding ewes. On units with a heavy accent on cattle, the ratio is about 1:6. This enables the use of cattle as a management tool as well as a product; the unselective grazing of cattle helps to maintain pasture and hill ground, where the nibbling sheep allow rank grasses and rushes to come through.

Cattle require large quantities of fodder to maintain them through the winter, and it is the willingness to provide this which distinguishes the mixed unit from the extensive sheep grazing enterprise. Many units simply do not have the cultivable land to provide such fodder, and the cost of imports is prohibitive. Other units, however, have more potentially cultivable land than they can use. In general, it is fair to assume that each cow requires 0.4ha (one acre) of cultivable land (for grain, roots, hay or silage) for its winter feed requirements. They will in addition need some imported concentrates which cannot be produced on the island in order to maintain a high level of production. The present level of production yields an average calving percentage of 85-90%. With first-class management this could be lifted to about 93%.

Sheep can also benefit from concentrates at certain times of the year, particularly at tupping and lambing. This practice is becoming more frequent in Mull, and there may well be an improvement in lambing percentage as a result.

ii. Forestry - Forest plantations in Mull do not display the same range of productivity attributable to management as agricultural units, chiefly because most plantations are managed by a single team, the Forestry Commission. The productivity of forest land in Mull is far more dependent on the inherent quality of land foresters are able to acquire for planting. In recent years they have not been able to acquire the better land, because this has been retained for agriculture. This situation will continue until the conditions for acquisition change. The typical yield class for the Mull forest at present is 9. If the present planting situation continues, it could decline to 7 or 8. The better land presently classed as improvable grazing and better rough grazing could attain a yield class of 12 or more under Sitka spruce, and the area within this capability amounts to twice the existing forest area. It could not pass into forestry without either a dramatic decline in agricultural output or a marked intensification of management on the best ground (a possibility examined in Chapter eight).

5.4.3 Production potential

This section estimates the maximum sustained output from the existing agricultural and forestry systems based on the productivity described in the previous section and the land potential listed in table 5.2.

i. Agriculture - The amount of fair grazing and pasture listed in table 5.2 totals some 31 000 ha. At one ewe to 0.75 ha, this amounts to some 40 000 breeding ewes. Lambing at 90% would therefore yield 36 000 lambs, allowing 28 800 to be marketed along with 7200 cast ewes. This would bring in (at 1978 prices) some £730 000. compared with an estimated £470 000 at present.

Cattle at one cow to 6 ewes would number 6700. The 3000ha of potentially cultivable land would be able to handle most of the fodder requirements for such a herd. Calving at 93% would yield 6200 calves, of which 4800 might be brought to market, the remainder being herd replacements or lost through mortality. 1100 culled cows would also contribute to total revenue as follows (1978 prices):-

4800 calves	@ £120	576 000
1100 cows	@ £200	220 000
Gross revenue		796 000

This figure may be contrasted with an estimate of current revenue of £205 000.

The preceding calculations are regarded as an absolute maximum technically possible production given aggregate statistics about land capability and management systems. They take no account of the realities of unit size or of the available markets.

ii. Forestry - The actual production forecasts for the Mull forest are examined in detail in Chapter eight. At an average yield class of $9m^3$/ha/annum, the existing 10 000 ha forest could be expected to reach a sustained yield of 90 000 tons per annum, worth about £1.2 million at present prices. This compares with present revenues of some £130 000. The comparison is, of course, completely unfair, because the existing revenue is actually a product of the age structure of the forest.

iii. In conclusion - The calculations thus show a technically possible increase in the productivity of land in Mull of about 100% in real terms. This completely academic calculation raises two questions; first, what are the barriers preventing achievement of this production?; second, is the product mix used in these calculations necessarily the most appropriate? The remainder of the thesis, rather than attempt to refine these approximate calculations, explores the problems which these two questions have brought to light.

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PART THREE - EXPLORATION

CHAPTER SIX - SCENARIO GENERATION - CONSTRUCTING EXPLORATORY VIEWS OF THE FUTURE

6.1 Introduction

Thus far, the examination of the Mull community as a system has concentrated largely on internal factors, and on the past and present. An assessment of carrying capacity inevitably involves a view of the future, and the influence of external environment which will shape that future. This chapter examines the external environment of the Mull system and takes a broad view of its future. From this broad view, three distinct anticipations (1) are generated, forming the political and technological context for the next section of the thesis. They represent three possible scenarios of society's response at a regional and national level to the future as considered earlier in the chapter. A view of the future is an issue which receives scant explicit attention in most development studies, and yet development is entirely concerned with the future. Views of the future which are declared are frequently presented as straightforward extrapolations of past and present trends. Almost any trend extrapolated far enough will become nonsensical. The crucial question for such an approach is to ask how far the trend may usefully be extended, and what direction it will take thereafter.

Trend extrapolation as a method of forecasting is justified on two grounds; first, that it is the best available, on the grounds that any 'hard' data is better than none at all, and second that prediction of the future is logically impossible and hence current trends are the only possible basis for expectations (2). There is an element of validity in this position. It <u>is</u> logically impossible to <u>predict</u> the future, and it must be emphasised that the present exercise is not an attempt at prophecy. As Calder (3) pointed out:-

> "....forecasting is inevitably an art rather than a science, even though computers and other fancy techniques are being applied to it; these may give spurious authority to what are essentially hunches...."

It is believed that while there are strong historical forces underlying the changes in the human system, that these are not immutable and that there are alternative directions open to society:-

> "....In any given age, people are to some extent prisoners of their own fate. Individuals will find it impossible by themselves to change whole societies or overthrow political regimes; but equally they are not utterly impotent, condemned to stand as spectators on some moving staircase of history ...." (Hall,4.)

Thus it is particularly important that research into resource development should take account of the future, for one is evaluating the feasible alternatives open to whole communities of people. The focus of this project is the Island of Mull. World events certainly influence Mull, through prices and policies, and therefore the future course of world events will affect the island and the options open to the people living there. The general outturn of these events at a national and international level is an exogenous influence on the Mull system. Our interest in these external events is concentrated on the response of the Mull system to its environment. The framework for the chapter is thus in three parts; first, a general 'broad - brush' review of key issues identifies those factors which it is thought will be of particular importance in the next half-century; second, the discussion and identification of possible responses to this environment of problems; third, a description of the general nature of the three alternative futures explored for the community in Mull.

6.2 The key issues

The world system has seen some remarkable changes in its physical statistics since the last world war, but the processes and relationships involved have been relatively stable. Extrapolation of many current trends to the end of the century gives rise to an impossible combination of circumstances, due to the exponential nature of many of these trends. Examples include population, energy consumption, resource extraction, distribution of skills within the labour force (leading to the majority being accountants/engineers/doctors by the turn of the century). In some cases these trends are accelerated exponentials (5). Some writers (eg Toffler) anticipate the continuation of these trends, others call for their curtailment. The former seems a recipe for chaos, the second for stagnation. Between these extremes, it seems certain that a restructuring of processes and relationships of the existing world system will occur. The 'problem landscape' of the next half-century may be split into five regions:-

1. Resources and energy
2. Internationalism
3. Coping with complexity and change
4. Information access
5. Conflict and political process

6.2.1 Resources and energy

The systems concepts described in Chapter four demonstrated the crucial position of the resource base in the problematique. Society continues to fail to make allocation decisions which are logical in terms of system function, while our consumption and subsequent disposal of the ultimately finite stock has been increasing. Consumption has been increasing rapidly in the Western world in the Sixties and early Seventies. Taking the USA as an example, protein consumption rose at between 1% and 3% per capita per year, mineral requirements at between 2% and 6% per capita per year and total energy consumption at about 3.5% per capita per year.(6). The problems arising from such increases in resource use will be the root of many of the crises afflicting the world of the future. The 1973 and 1979 oil crises were perhaps the first widely recognised symptoms of this more general problem.

The resource situation is complicated because resources are not distributed evenly around the globe, nor is the political allegience and influence of different political power blocs. International diplomacy has taken on an unexpectedly more important role as the resource rich nations and commodity organisations have begun to realise their strategic position. The Third World is rapidly becoming a significant power bloc in its own right, although at present speaking with many tongues. Tables 6.1 and 6.2 demonstrate the dependence of Britain on imports of raw materials and food in return for exchange generated by value added to manufactured goods. At present, Britain is fortunate in having the resource of North Sea Oil, without which the situation would be very much more difficult. Department of Energy figures (7) suggest that such a contribution is unlikely to be significant much beyond 2000AD.

Energy is a central concern in this area. In the Western world, the price of energy has been falling in relation to other costs of production for fifty years (8), thus encouraging mechanisation and the substitution of capital for labour. Certain of our energy resources, particularly oil, occupy crucial positions in the existing patterns of activity in society. Establishing hard data about the reserves available is academic; the amounts available depend more on price, demand, technology and entrepreneurial organisation. However, it seems certain that the real cost of extraction will increase, causing considerable changes in the patterns of energy use over the next half-century. The debate encompassing this issue is already (1979) well under way; energy strategy is an important

TABLE 6.1 Trade balance of the UK (1976)

(all figures in £ millions)

item	imports (cif)	exports (fob)	balance
Food, beverages, tobacco	4983.3	1692.5	-3290.8
Basic materials	3247.7	735.0	-2512.7
Fuels	5668.7	1264.7	-4404.0
Semi-manufactured goods	7997.4	8851.3	+853.9
Finished goods	9225.5	12765.0	+3539.5
Other	425.4	853.9	+428.5
Totals (rounded)	31584	26162	-5422

Summary (corrected for trade costs)

Imports (fob)	29013
Exports (fob)	26162
Visible balance	-3589
(Invisible trade)	+2452
Current balance	-1137

SOURCE: Annual Abstract of Statistics 1979, Central Statistical Office HMSO

TABLE 6.2 Import dependence of the UK on some industrial raw materials

material	imports as % of consumption
Aluminium	100
Chromium	100
Copper	71
Iron	80
Lead	27
Manganese	100
Molybdenum	100
Nickel	100
Phosphates	100
Tin	93
Titanium	100
Tungsten	100
Zinc	96

SOURCE: Institute of Geological Sciences (1976) UK Mineral Statistics 1976 HMSO component of the three anticipations below. The resource base rationale for this project has been described in Chapter two, and the three anticipations reflect contrasting approaches to this problem. The 'limits to growth' approach has been shown to be simplistic (9); a UN study of the year 2000, headed by Wassily Leontief, concluded that:-

> "....The principal limits to growth in the world economy are political, social and institutional in character, rather than physical...."

Even so, it is the attitudes and approach to the resource base and its development employed in these processes which will be a major factor in the course of future events.

6.2.2 Internationalism

One of the most significant developments of the last half-century has been the appearance of a variety of multi- and trans-national organisations. The League of Nations and its successor, the UN, are the most obvious governmental manifestation, while the commercial examples include transnational corporations with interests, investments and profit centres in all parts of the world coordinated and controlled to a greater or lesser degree from a central headquarters. These organisations depend on three features of the world system:-

i) the speed of contemporary communications
ii) the universal similarity of economic organisations
iii) the complexity of modern economic and commercial affairs, which allow transnationals wider freedom of action in increasingly regulated national economies by exploiting the inability of any one government to control all the features of its environment.

Governmental transnational organisations (UN, EEC, OPEC, OAU, OECD etc.) have to some extent attempted to develop a wider based coordination. Such attempts seem to come under great pressure in times of recession when a nation's short term interests may best be served by unilateral action.

There is also evidence to suggest that dissident political organisations both peaceful and militant have developed international connections on the grounds that if the political systems to which they are opposed are international in nature, opposition must also coordinate on an international basis.

All this is well established in the late 1970s, but until thirty years ago it hardly existed. It seems unlikely to decline in the future, and hence the global dimension must be seen as a permanent parameter of the human problematique. These international organisations will have crucial impact in the Third World, particularly as this is the area in which significant economic growth will be found in the next half century. A brief glance at the contemporary world situation (1979) indicates that considerable changes may be expected across the world within the time horizon of this study. Africa is at present adjusting to the demise of colonialism, and may be expected to be politically and economically unstable for perhaps two decades. Both Latin America and South East Asia have been through this process and (particularly the former) may look forward to considerable growth and development by the turn of the century. Japan and Australasia share many of the problems of the industrialised world, particularly in heavy dependence on energy and raw material imports; their future depends very much on the approach taken by China in this period. China has emerged from a period of intense internal reorganisation, and may perhaps continue to be introspective as industrialisation proceeds. However, there seems to be a strong possibility that their attitude will be much more outgoing, and that a mutually beneficial special relationship with Japan may emerge (10).

The predominant feature of the world scene as far as the Western World is concerned will be the diminishing role of the big powers, particularly America and Russia, in world affairs. The balance between the two should prevent domination by one or both unless the African and Middle Eastern situations are badly mishandled. Whatever the outcome, the role of supranational organisations will be crucial, and they offer more prospect of stability than there has ever been in this arena.

6.2.3 Coping with complexity and change

The problems posed by complexity are not currently identified with any specific discipline; there are elements of the theme to be found in most social and applied sciences, in economics, sociology and operational research. The growing interdependence of the world system has led to many serious problems as decisionmakers at all levels try to solve the problems arising in a complex dynamic system in an incremental fashion. Attempts have been made to conceptualise the systems dynamics involved (11). Emery lists four factors which have contributed to the emergence of what he calls 'turbulent environments'.

a) Growth such that organisations are so large as to induce autochthonous processes in their environment.

b) Deepening interdependence of economic and other factors of society - thus the study of the various parts does not give an adequate representation of the working of the whole.

c) Increasing reliance on sophisticated science and technology, understood only by a few, for example in monitoring and control systems in the economy or in maintenance of high technology.

d) Increasing speed of communication thus radically reducing the response time of the system.

to which one could add a fifth, the exponential increase in available information (see 6.2.4 below).

Coping with this situation poses serious problems for both individuals and institutions. Society as a whole does not understand when to intervene, for what precise ends and in what ways. Institutions generally defend means rather than ends, indeed ends become increasingly difficult to identify. The traditional position of any ruling power group, in that it will attempt to maintain political stability and prevent too violent a perturbation of the existing socioeconomic order, becomes inadequate to cope with the adaptive problems it encounters. This failure manifests itself as a failure of economic rationality, for example where scarce non-renewable resources are used to produce throw-away items. It parallels the resource problem as the second driving force behind the economic dilemma, the failure to create a human urban infrastructure, to devise an adequate system of education and the failure to foresee critical side-effects, exemplified by Thalidomide. In general, there is a failure to appreciate the longer-term consequences of decisions.

This failure of institutions is matched by, and interacts with, the failure of individuals to cope with the environment that society presents. The consequences are manifold, subtle and at present sub-critical. The main class of response may be termed 'alienation' - the failure of a person to develop a sense of place, of belonging and responsibility toward his surroundings. The struggle to cope results in a variety of stress symptoms; high suicide rates, death from stress-related diseases, neuroses, withdrawal and detachment. Roszak (12) analyses this situation and argues that the spiritual and moral foundations of society are being submerged, that the individual needs an understanding of certain abstract concepts (such as good, conscience, humanity, self-discipline) in order to make sense of his surroundings. Given the complexity of social and economic organisation and the lack of any evident ethical or social principles, individuals feel they lack any meaningful relationship to the wider society or any particular part of it. They are divorced from other people and objects to such a degree that they feel incapable of free action, or they behave self-destructively.

Another disturbing aspect of the complex interactive nature of our society is the 'tragedy of the commons' examined in detail by Garret Hardin (1972):-

> "....Each man is locked into a system that compels him to increase his ... (use of common goods - water, air, space) ... without limit, in a world that is limited. Ruin is the destination to which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all...." (13)

The extension of this problem to all individual allocation decisions - to consume material resources, have children, holiday in remote areas - emphasises the inability of the individual to take an adequate perspective on the totality of the system of which he is a part. Hardin's conclusion is that survival of the species depends on the emergence of an elitist managerial minority armed with powers to regulate human behaviour in the collective interest. The implications of this are profound, not only for the Western World, but also for the totalitarian states, where the inability of the managerial elite to acquire such powers has been clearly demonstrated; for example, the failure of the USSR to motivate its citizens to fulfil successive five year plans, or of the Shah to maintain political stability in Iran.

For the manager, the decisionmaker, the problem has the makings of a paradox, as examined in Chapter two. The more knowledge and understanding the expert accumulates, the less likely are his recommendations to accord with the desires of those affected by them and (in the absence of total coercion) the less likely they are to submit to his plans and proposals. The future here seems to lie in two distinct directions;

either to the development of psycho-social methods of surveillance and control, increasing the ability of the technocratic elite to cope, or to the deliberate concentration of effort on increasing individual self-awareness and hence collective decision-taking and regional self-reliance.

6.2.4 Access to information

The store of knowledge accumulated by man is truly immense, and is expected to double inside a decade (14). One of the consequences of exponential growth trends is that well over half the scientists who have ever existed are at work today. This is also true of engineers, architects, doctors and most other professional groups. The prime concern of the decisionmaker at any level is to maximise the relevant information on which to base his decisions. This is hindered in two ways, first by the uncoordinated flood of literature from relevant and related areas, and second by the obstacles to identification and isolation of the relevant items.

On the first count, the volume of information being generated in any particular filed of interest is remarkable. The first two journals devoted wholly to science were started in 1665. Since 1760, the number of new journals established has doubled every fifteen years, so that the total now stands at over 100,000 (15). This increase has been matched by comparable expansion in other areas of the media. The individual response to this has tended to be specialisation, narrowing the range of enquiry and attempting to comprehend a relatively minute area of the overall macrosystem. But we have implied (6.2.3, above) that an overview of the system is essential for fully 'rational' (ie. total system-oriented) decisionmaking to be achieved. This brings one to the second feature of the problem, the obstacles to effective use of the available information. These obstacles are of three types; political, social and technological.

i. Political - One of the most fundamental bases of political power is the control of information. International diplomacy thrives on it, and even down to the most petty level, political interactions revolve around access to crucial items of information. There is no coordination of information control at any high system level; the only controls tend to be negative and counterproductive, for example the all-embracing section two of the Official Secrets Act in the UK. This political aspect of information access is deeply rooted and unlikely to change radically as a result of any deliberate policy.

ii. Social - Some of the most profound changes in society arise from changes in the pattern and extent of information access, for example in the rising power of trade union movements in the West, and increasing sophistication of negotiation at many levels. Education is crucial to the process of sophistication. The existing system of education tends to train an elite minority in the art of effective use of information, both through the necessary mental training (for example in scientific method) and through introduction to the administrative and technical machinery of information retrieval. The majority are at present excluded from this process, although still subjected to the uncoordinated barrage of information through the various media; and yet an important factor governing alienation is the inability of ordinary people to see the salient factors on which decisions are taken.

iii. Technological - It is in this area that profound changes may be expected in the next half-century. Advances in computers, microelectronics and communications technology will form the basis of a radical change of approach to decisionmaking whose direction is still far from clear. The potential of the technology makes it possible to direct efforts both to the (small-scale) local use, enabling democratisation of decisionmaking processes, and to (large-scale) improvement of surveillance and control systems.

6.2.5 Conflict and political process

Conflict between individuals and groups of individuals is a universal fact of life, and one which receives little constructive attention in most problem-oriented studies. Conflict may occur at many levels of organisation, and at a range of intensities from verbal argument to all-out war. Conflict is usually ultimately a consequence of problems of distribution - of resources, wealth, environment, costs and benefits between groups and areas. For these purposes, the problem is split into two facets, physical conflict and intellectual conflict.

i. Physical conflict - This is an area in which radical changes have taken place in the last half-century, although some of these changes have only recently been widely acknowledged. The most radical change has been the decline of conventional warfare. The increasing sophistication of guerrilla warfare techniques makes it difficult to mount large conventional campaigns, and impossible to achieve total victory over hostile territory without annihilating the existing communities. The development of nuclear weaponry has so far made the greatest military powers a great deal less trigger-happy, because it effectively places the politicians and tacticians in the front line. Conflict between groups may be geographical, one region against another, or ideological, politically based intra-regional conflict. For the future, areas of increasing concern will be the proliferation of nuclear weapons to smaller, less stable states and even dissident groups, and the sophistication of guerrilla warfare in its many forms - in the technology employed by the urban guerrilla and the international terrorist, for example. The grenade and the rifle are becoming outdated and increasingly ineffective. A new generation will emerge with more sophisticated techniques, matching more sophisticated countermeasures by the dominant power-wielding groups.

ii. Intellectual conflict - The basis for intellectual conflict, which can lead to physical engagements, is conceptually a difficult area, infringing on philosophy, religion, politics and metaphysics, and touching on most disciplines of academic concern. The forum of this conflict is the political process, the social mechanism for resolution of conflict without bloodshed. Its foundations have received close attention since primitive times, yet its nature is not clearly understood. In inter-war America, there was a movement maintaining that all conflict arose from linguistic misunderstandings, and that a sufficiently precise system of language would bring world peace. However, the problem seems in reality rather more complicated. For the future, the main challenge to the political process will come from its ability to maintain 'system stability' sufficient to avoid violent perturbations leading to bloodshed, by keeping conflict within this arena. Figure 6.3 is a pictorial representation of this situation. The direction of change is set by historical factors and contemporary pressures, so the room for manouevre is limited. A veer to the right of the diagram will lead to the discontinuity and consequent disruption. A veer to the left will avoid this consequence. The political process must identify those factors which influence direction and act accordingly.

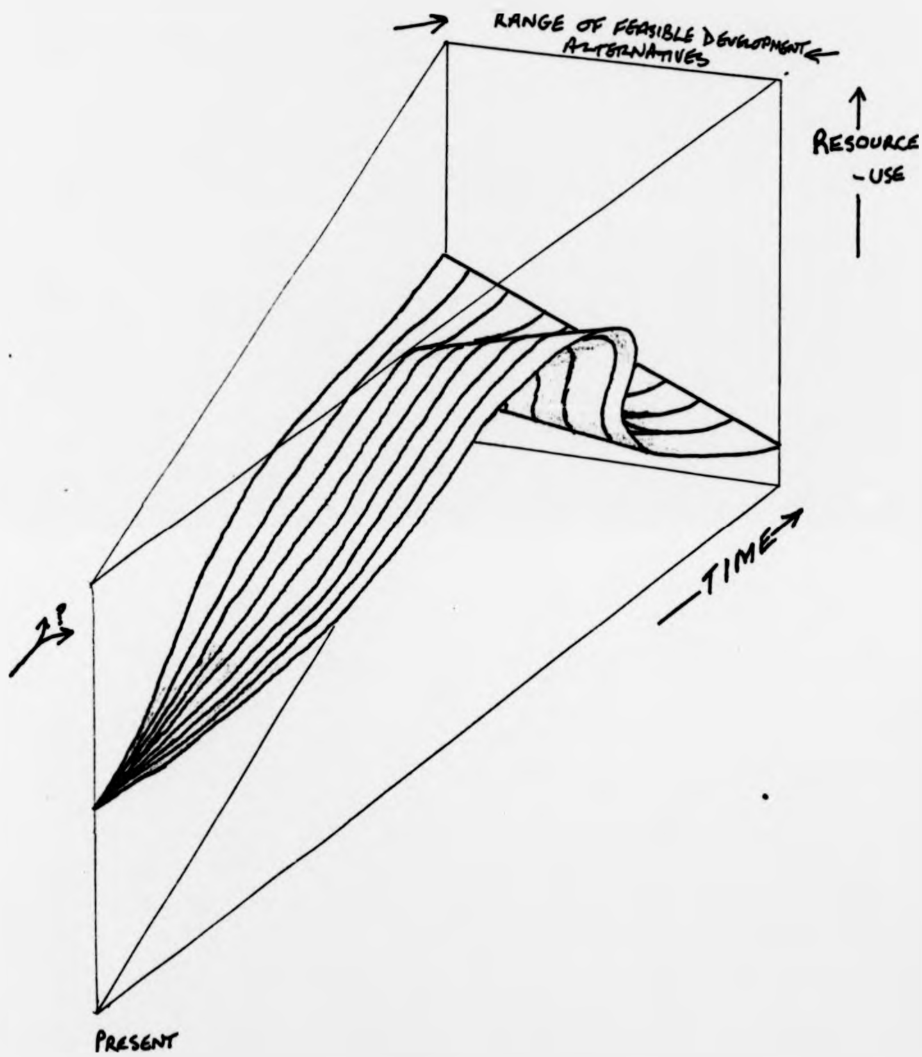

FIGURE 6.3 A concept of political process (described in 6.2.5)

6.3 Possible responses

There are a multitude of possibilities open for the future - and the combinations of those possibilities are infinitely numerous. Here we are interested in possible futures for Britain, particularly the Scottish Highlands and especially the 346 square miles and 2500 people of Mull. The diversity of response world-wide will inevitably be immense, so while the general direction of a global response is of interest, it is only relevant insofar as it affects the focus of the study. Criteria on which to compare responses are difficult to establish, and at this stage it is not useful to try and produce quantitative comparisons.

The criteria on which methods of social and economic organisation are judged remain completely subjective. Concepts such as quality of life or standard of living are a synthesis of more subtle concepts which changes from decade to decade and from generation to generation. Western society is in process of emerging from a period in which possession of material goods has been the main criterion of success. This position is evolving in several ways; the marginal benefit of additional goods declines, Hirsch's 'positional goods' cannot match rising expectations and there is a hint of a reaction against the blind acquisition of possessions for their own sake. Naturally, there is a wide diversity of individual opinions on the important criteria for 'quality of life'. Any assessment of the future shape of society based on such concepts must therefore take this dynamic factor into account. A scenario of 2030AD based entirely on 1979 opinions is unlikely to make much sense.

Figure 6.4 (overleaf) shows the approximate direction of the anticipated responses against the criterion of 'quality of life' - totally subjective, and subject to changing terms of reference over time. This is represented by the changing colour of the background from blue to yellow. It is felt that current trends favour a move away from a concept of quality of life largely dependent on the possession of a certain mix of material goods, towards a more sophisticated conception based perhaps on psychological theories such as Maslow's hierarchy of needs (16). The diagram is deliberately painted freehand to emphasise the qualitative nature of the statement, and the gradual broadening and fading toward the background reflects the increasing uncertainty encountered as we look further into the future. The basic

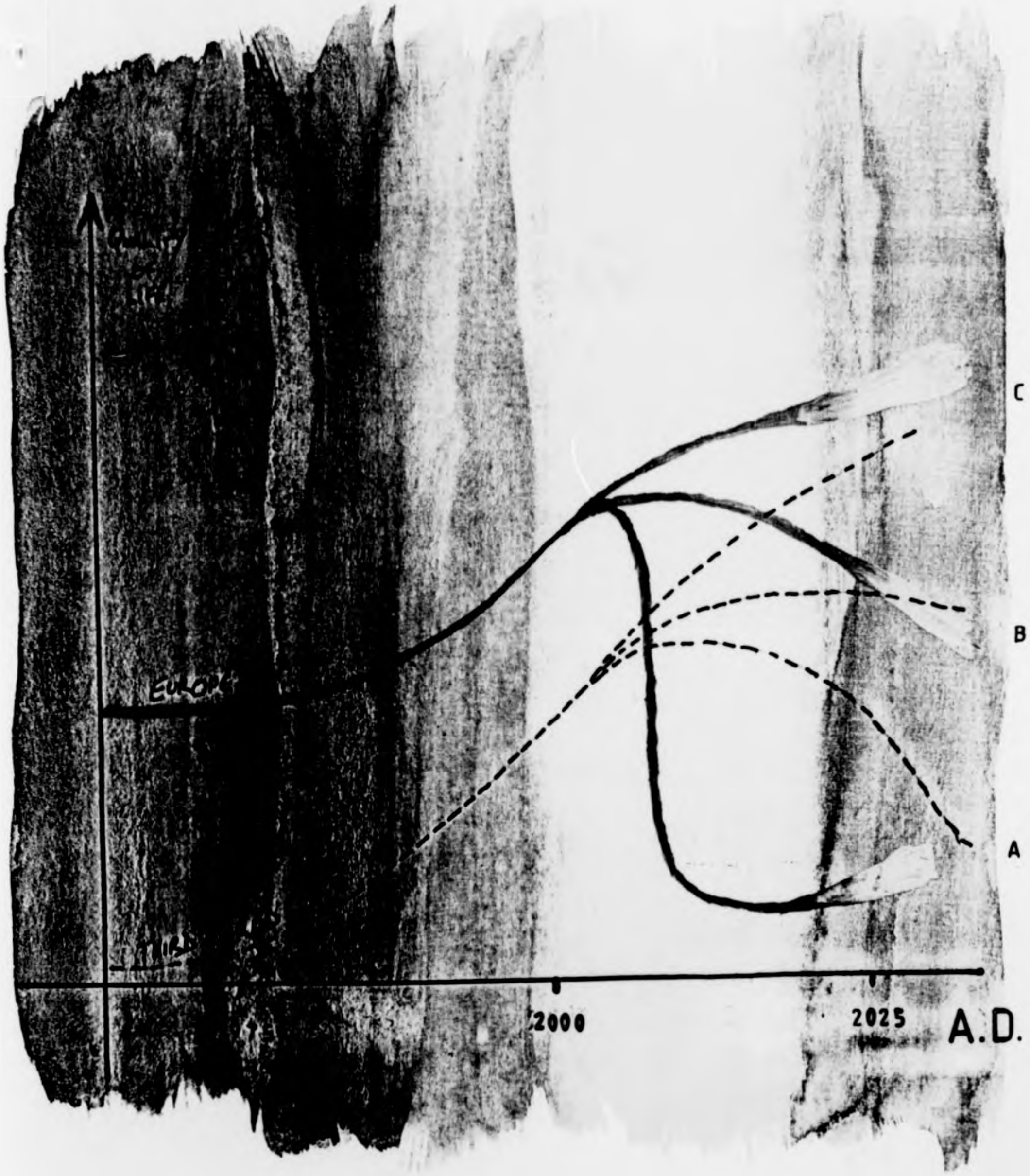

Figure 6.4 <u>Broad scenarios of change</u>
(see text p. 115)

features are a significant turning point and period of change about the turn of the century, as the complex of problems described above comes to a head. Three alternative responses to this crisis or series of crises generate alternative anticipations A, B and C. It should be emphasised that these anticipations are intended to be general in their application; if Mull were to find itself either in A or B or C, the rest of Scotland and probably Western Europe will be considered to follow a similar path modified by the particular circumstances of the locality.

In the first anticipation, the problem solving mechanisms of society fail to cope and hence interdependency of the world system breaks down. This is the general drift of the 'doomsday' scenario popularly outlined by several writers (17). While perhaps less likely than either of the other anticipations, it is of great academic interest because it explores the consequences of the Mull community being thrown back entirely on its own resources. Thus it is termed 'enforced autarky' or the Crusoe scenario.

In Anticipation B, the problems are dealt with in a mechanistic manner - reduction to clearly defined 'black and white' sub-problems susceptible to technological solution. This is the 'technical fix' scenario described by Chapman, among others (18). In its more extreme form, the classic visions in Orwell's '1984' or Huxley's 'Brave New World', of an all-enveloping corporate state, controlled and run by a technocratic elite, is a logical outcome of this direction. Developments in information technology make this direction one of the more likely trends, at least for the Western World. It is possible that development in such a direction would generate its own contradictions, resulting in a sudden shift to one of the other anticipations.

In Anticipation C, appreciation of the nature of the problematique leads to a radical restructuring of society over several decades, along the lines advocated by many authors (19). This approach is radical be because it grapples with the problem in new ways and develops novel apparatus for their resolution. It is not a regressive movement, turning its back on 'progress', but instead deliberately transforms the concept of progress itself, making use of technology as a tool to assist problem-solving. The literature in this area seems to be characterised by a 'utopian', normative approach. The exploration of such a future in this study is certainly optimistic, but is also realistic about the problems likely to be encountered.

One point that has been made in connection with these anticipations is that they all represent 'extreme' positions, with little connection with 'reality'. To such a criticism there are several answers:-

i) Taken to their logical conclusions, the paths indicated certainly represent radically different societies to those existing today. However, straightforward extrapolation of current trends produces a situation impossible to envisage. All three anticipations are possible, if not probable.

ii) The earlier discussion in this chapter emphasised the dynamic nature of the existing world system. The one thing one can be quite sure about is that the world of 2000 or 2025 AD will be substantially different from today. Therefore any fifty year projection will tend to appear extreme.

iii) The purpose of these anticipations is exploratory - they represent a closer examination of some contrasts in contemporary society. It is felt that they represent true alternatives to the extent that they are mutually exclusive, with limited amounts of grey in between. The most 'surprise-free' is B, in that many of the strong historical forces would appear to be pushing us in that general direction.

iv) The use of such anticipations is, of course, a device to enable further discussion of the <u>present</u> direction of communities like Mull. Previous chapters examined the past and present condition of the community; this section explores the far future before the final chapters return to an examination of the prospects for the immediate future.

6.4 <u>Three anticipations for Mull</u>

6.4.1 Anticipation A - Enforced autarky

'Doomsday' scenarios usually derive from the inability of the political process to cope with the complexity and interdependence of the world system. There are many internally consistent scenarios leading to collapse; this one draws heavily on Rattray Taylor and Toffler (20). It is gradual in its development until the final disintegration of interdependency. It matches Society's present tendency to approach decisionmaking in an incremental fashion, which continues until the adaptive capability of the economy is exhausted.

The international trading system, on which the European economy depends, is itself dependent on the international money markets for its continued operation. This financial system possesses a complexity well beyond the ability of any single organisation to control. Perturbations in the stability of this system may have profound effects on national economies closely connected with it. The UK economy is one such, with substantial international dealings in Streling.

As the Third World develops, the UK's competitive position is eroded. Manufacturing industry is less profitable and therefore less able to invest in technological change. In a dynamic economic system, any activity must adapt or decline as circumstances change. Strategic industries are propped up by the state, and multinationals find the investment opportunities elsewhere more attractive. Thus the tax base is eroded, and at the same time more demands are made upon it. The increasing rates of tax make further inroads into the diminished profitability of the remaining viable industries and the cycle of decline continues.

This decline puts some pressure in the state services and living standards generally. The influence of unions and other pressure groups makes the maintenance of living standards at 1980 levels a top priority. A government is elected in 1984 and 1989 which promises to use North Sea oil revenues for this purpose, a substantial part of the pre-existing national debt having been paid off by this time.

In the early 1990, the decline of North Sea oil revenues gradually precipitates a crisis. World energy prices have risen steeply as the few remaining producers attempt to conserve supplies. The nuclear power programme is a failure, due to the vast capital requirements of the programme, a shortage of technical skills, and many severe malfunctions caused by technical failures and human error. This is exacerbated by continued harrassment by middle-class environmental pressure groups. The combination of resource shortages and the (by this time chaotic) financial system leads to international political and eventually military conflict over resource supplies. Fortunately, the strategic arms limitation agreements of the early 1980s and technical advance in the detection and neutralisation of missiles make thermonuclear weapons largely ineffective. However, local conflicts in many parts of the world involving relatively crude fission devices destroys most of the urban economic infrastructure. The surviving communities are thrown back on their own resources, and their ability to barter with close neighbours.

In Mull, this cataclysmic outturn of world events manifests itself in two ways. First, the energy crisis leads to reduced supplies and a rapidly increasing real cost of transport. For a time, this is subsidised by national government as part of their living standards programme, but when the crisis deepens this is withdrawn. The population is given the choice of a move to urban centres, or continued residence without state support. The majority take the latter course, and elect two executive councils, for north and south of the island. The final breakdown of the urban industrial areas cuts off any remaining input from outside, but the councils have arranged conservation and storage of certain vital products - steel, lubricating oils etc, which will give the community a chance of adapting to new circumstances. The whole accent of island life is on internal affairs. There is a considerable movement back to the land, a return to old manual methods of cultivation, and general enforced self-sufficiency in all economic activities. The people turn to religion and a social order with parallels to the clan system, except that the top position is occupied by the executive councils. Education is reduced to basics, because the hands are needed on the land, and the skills of the preexisting system are not considered relevant to the current objective, which is simply survival.

As the years pass, refugees from elswhere who moved in and occupied surplus land are gradually assimilated into the community, after first being viewed with considerable suspicion. Some limited trade links are established with the mainland, based on barter and carriage by pedlars. Health care is basic, particularly since medical supplies are no longer available. The birthrate rises, as does the infant mortality rate. Population may be expected to rise until such time as the social structure adapts to establish new moral restrictions on childbearing. Community discipline is self-administered and presided over by the councils. Punishments are summary, including the death penalty by hanging for the most serious offences.

Energy sources are a major limiting factor. Peat and timber are important sources of heat. A rigid social hierarchy would allow an attempt at reforestation, especially now that many of the sheep and cattle grazings are little used. There is considerable attention to building in remote areas to facilitate land utilisation. Rattray Taylor offers the following comment on the 'doomsday' scenario:-

"....Society will break up into small groups and culture will be preserved in secular 'monasteries'. Recovery will be slow, but eventually a new renaissance will dawn, a new (and perhaps wiser) tradition will be established...." (17)(21)

6.4.2 Anticipation B - A Centralisation scenario

The world faces the same set of problems, but the continued development of computer systems and mathematical models enables predictive computer models to be used with confidence in decisionmaking in the late 1980s. The nuclear power programme is highly successful, and the development of controlled fusion systems late in the century solves the energy crisis, at least for the present. The bureaucratic machinery of the State therefore takes more and more decisionmaking upon itself, and operates according to a national plan which closely monitors and tunes the economic system. The problems of social cohesion outlined in previous sections result in increasing crime and acts of violence as individuals and groups try to gain personal advantage from the all-embracing machinery of the State. The response is essentially technological, the development of more and more effective countermeasures; in time, everybody carries identity cards, suspect individuals are subjected to continual surveillance, methods of interrogation and other aspects of psychological control become ever more effective. The result is a society in which the passive majority are controlled by a sophisticated technocratic elite. This pattern of development is generally matched on a world basis, and although there are local perturbations, the ensuing conflicts are limited by agreement. Trading agreements ensure a division of natural resources, because the computer models have demonstrated that to have a region of the world significantly depressed is a potential source of instability.

Strategic policy for the West Highlands is based on a detailed review of national natural resources carried out in the 1980s. Land use policy becomes much more closely integrated into the statutory planning process with the integration of relevant agencies into a Ministry of Land Use during the decade. This ministry took as its starting point three reviews of UK timber supplies (22) which drew attention to the heavy dependence (more than 90%) on imported timber and to the supply difficulties expected from the turn of the century. Additional stimulus came from the first complete systematic surveys of land use capability in the early 1980s, and from the development of computer-processed satellite imagery as an aid to resource management. The important aspect of this development was, however, the strategic argument for forestry. Supplying nations are increasingly reluctant to release raw timber, preferring the export of timber products with their higher value. This is seen to have grave implications for employment and activity in the wood processing industries of the UK. It might be argued that the large rises in market prices for raw timber relative to other commodities would lead to a switch to alternative materials, particularly plastics; it must be remembered that crude oil supplies are expected to become difficult about the same time, and that there has even been discussion of the potential of timber wastes as petrochemical feedstock.

Thus there are strong arguments in favour of a policy of aggressive afforestation. The most obvious areas for the application of such a policy are the uplands, and thus a review of these areas was initiated. The review found that the main use of the uplands was for pastoral livestock production, that the meat produced found an unstable market which was unlikely to expand significantly and that technical changes in the industry would lead to the concentration of activity on the better areas and the integration of beef production with lowland dairy enterprises. This left the hill farmers of the West Highlands, heavily subsidised by the government and facing continuing increases in costs with little prospect of an improvement in the market, with an extremely poor outlook in the long term. Closer study of the problems of hill farming in the West Highlands revealed the generally low intensity of resource use in the area, the impracticality of any significant increase in intensity and the other contributory factors such as the retention of large areas of land primarily for sport and the problems of making effective use of the large areas of common grazings.

Probably the most important problem of agriculture in management terms is one of the least understood, being the influence of climate in marginal areas as outlined in Appendix four. It seems certain that climatically marginal areas involve a much higher level of risk in an annually cropped agricultural system. This is recognised and defrayed by government subsidy and guaranteed prices, and particularly by the import of hay and other feedstuffs whose production on the island, while technically feasible, involves relatively high risks of harvest failure and consequent disastrous results. Forestry is much less vulnerable to these annual fluctuations in climate. Beyond the establishment phase, production depends on mean temperatures over a number of years, and temperature patterns in a particular year are less important. Trees also offer some advantages in maintenance and enhancement of soil fertility, being more deeply rooted and therefore able to draw nutrients from lower reaches of the soil.

Trees are not without their problems. Basalt check has already been mentioned, apparently being caused by a phosphate deficiency affecting young trees in the establishment phase. Exposure is a major problem in coastal areas, both physical exposure and exposure to salt spray. Finally, impeded drainage, particularly on peaty bottom lands, leads to shallow rooting and consequent susceptibility to windthrow. Suitable drainage schemes can provide some solution to this problem. Basalt check is prevented by spreading rock phosphate and the exposure problem may be ameliorated by careful plantation design and species selection.

Thus a nationally determined resource use strategy is developed which sees the West Highlands as an area for large scale afforestation. State aid to agriculture (from national and EEC funds) is concentrated on improving farms in the East Highlands and the Southern Uplands, while aid to the West Coast is gradually phased out. Thus distinctive regional differences in approach are developed.

The Mull community are given little opportunity to influence the course of these events. Policy is determined entirely in the national interest in the belief that in the long term this focus will maximise the benefit to the community as a whole. The agricultural sector therefore continues to decline as government support is gradually withdrawn. Land thus passes out of agriculture into forestry, tending to pass into State ownership in the process. Forestry becomes the key employer. Large estates are broken up, and crofting declines as an economic activity, especially since a series of Crofting Acts in the 1970s and 1980s leads to many crofters becoming owner occupiers. The crofts themselves change hands on the open market at high prices, many as holiday homes for executives from the central belt of Scotland, England and the Continent.

After the turn of the century, the indigenous population is confined to Tobermory, Salen, Craignure and Bunessan. By this time, the big estates have all either broken up or been turned over to the State. Over 90% of the land area is now under State control. The only secondary industries are a wood chipper at Craignure, which eases handling problems for timber exports, and a small sawmill producing fencing materials. In winter, the population is low, but in summer a considerable influx of seasonal workers service the tourist industry. A sense of community is almost absent. All Mull children are taught in Oban from the age of ten upwards. The education system is geared to selecting the bureaucratic elite, and has a rigid examination structure which is viewed in official circles as an efficient filtering system. One reflection of the success of psychosocial control is the apparent contentment of the population at large with the system, as it is seen to 'put you in your proper place' in social terms. Religion is insignificant; religious services are still involved in major events, marriage, death and public occasions, but a regular congregation is a thing of the past. Health care is heavily centralised, skills being concentrated on technologically intensive repair techniques. Emergency helicopter strips in the four settlements transport the sick to Glasgow. Oban possesses only basic facilities, able to cope with minor ailments, convalescence and maternity. The level of technological sophistication is high in all areas. Forestry, for example, uses much heavy machinery, and labour productivity is high, but the skills available on island are limited to routine maintenance and minor repairs. Transport is an important element in the economic setup, based largely on hydrogen and methane burning internal combustion engines. The hydrogen is generated by electrolysis of water, the methane from fermentation of animal wastes on large factory farms in the central belt of Scotland, from which most indigenous food production is derived.

The consequences of this mode of activity on the Mull economy are effectively to integrate it with the larger West Highland economy, which is itself closely integrated into the Scottish industrial economy. In economic terms, the Mull system is probably more than 95% open to the outside world. The basic pattern is one of raw material extraction, mainly timber, imports including virtually all the communities's requirements. Food products are extensively industrially processed and packaged, agricultural operations on the island being limited to sparetime 'hobby' activities. Energy is exclusively imported - there are no Mull sources, except for a limited amount of peat cut, dried and sold on a luxury 'novelty' market in Edinburgh and Glasgow. Building and construction is all prefabricated off-island, and residential development is limited by statute to the four settlements.

The key to this scenario is the sophistication of technology, particularly in the fields of microelectronics and telecommunications. This allows better control of the complex systems of society, but at the same time leads to a more authoritarian state-controlled form of government which allows the individual very little freedom of action.

6.4.3 Anticipation C - A Reorientation scenario

The basis of this anticipation is a gradual but radical change of social orientation arising from the recognition of several fundamental problems of contemprary society. First, the concept of limits to economic growth, not necessarily entirely of a physical nature, has been described and analysed in detail by Hirsch (23). This analysis is paralleled by Hall (24), who questions the validity of so-called 'economic rationality' and goes on to describe an alternative to the 'technopolis' which he terms 'humanopolis'. This vision of the future involves considerable decentralisation of power and dispersion of populations:-

> "....Such a settlement form would give interesting possibilities for using natural systems (earth, wind, sun and vegetation), would reduce heating and cooling loads, and would tend to develop self-contained utility systems...." (Hall,p 113)

Emery (25) arrives in a similar area from discussion of structure and process in complex social systems, postulating ideals of 'nurturance, homonomy, humanity and beauty'. The basis of, and the necessity for, such utopian ideals is examined in detail by Roszak (26), while Schumacher (27), in another exposition of 'appropriate' philosophical concepts concludes:-

> "....There is no economic problem and, in a sense, there never has been. But there is a moral problem. and moral problems are not convergent (capable of being solved for all time, so that future generations can live without effort); no, they are divergent problems, which have to be understood and transcended by each generation in turn...." (Schumacher p 160)

The emerging society holds central the belief that 'Man is nature rendered self-conscious' - not a particularly new idea - and therefore bearing a considerable responsibility for long-term stewardship of the environment. Thus two approaches to development are dominant; first, the need for caution in order to maintain diversity and alternatives, second the need for coordination of knowledge so that the consequences of particular decisions can be elucidated.

Thus, intense public debate in the 1980s and 1990s stems from the recognition:-

i) that most of our highly centralised and excessively complex institutions lack flexibility, and have an inherent tendency to confuse ends and means (28);

ii) that there is a vital distinction between exchange-value and use-value in the economy. The industrial economy of the late 1970s recognises only exchange-value; the post-industrial society will have to recognise use-value if it is to survive (29);

iii) that the purpose of an education system is to help the individual to coordinate his awareness and understanding of the world about him, and help him to cope with his environment and the challenges it offers (30);

iv) that the concept of science and technology as an apolitical force is a fallacy, and that, in particular, decisions about development and application of technology are an inherent part of the political process.

The mechanism by which these four concepts are absorbed into society is most significantly one of decentralisation. This follows from increasing awareness of self, leading to an increasing demand for self-determination; such a desire can only be fulfilled for the majority within fairly small units. The historical precedent for this desire is there, witnessed by the increasing importance of trades unions in the affairs of the economy. There are dangers associated with decentralisation, particularly when this threatens the finely balanced interdependencies upon which the world system depends. In the final analysis:-

> "....Decentralisation. which has come to mean a world without organised interconnection, must become omni-centralisation, a world in which modern means of communication allow every neighbourhood to be simultaneously the centre of the world. The goal is not merely self-management, but global self-management; not merely participatory democracy, but participation on a world scale...." (31)

Such an approach involves the idea that community is the basic social unit, and denies the primacy of hierarchies. Argument that hierarchies are inevitable is rejected, to be replaced with a hypothesis that hierarchy is one element of social organisation with distinct limits to its effectiveness. The use of the hierarchy does require active or passive assent and cooperation of those individuals at the lower levels of the societal pyramid. The difficulty of maintaining that assent in contemporary society is illustrated by the dilemma of the planner outlined in Chapter two. The way out of this particular impasse pursued in this scenario involves the devolution of decisionmaking and control to a community level. The hierarchy is not abandoned, but operates on the principle that direction and policy should be maintained at the lowest possible level, rather than the opposite case found in today's hierarchies. The only large-scale model of such organisation is the Chinese system of production brigades and communes. The historical development of such a system from the cultural history of Imperial China, with a largely illiterate peasant population at its base, is not matched anywhere in the West. A different model, and a different approach based on Western culture, will have to be developed. At a national level, changes in the administrative structures and policies for industry following 'soft energy paths' (32) are key developments. The increasing power of the Third World countries, and development of their own industries and transnational corporations, forces a policy of self-reliance (as distinct from self-sufficiency) on the Western World. The EEC becomes an important economic entity in this respect.

In Hull, the formation of two community councils in the mid 1980s, followed by local government reforms in the 1990s, gives the residents a greater level of self-determination than at any time in the past 300 years. The government-backed resettlement programme of the 1990s leads to an increasing population, but more significant is the input of financial and technical capital associated with this programme. The community councils adopt the role of cooperatives, with the ultimate aim of setting up and internally run and controlled microeconomy. At first, this activity is confined to service industries, but gradually comes to include more aspects of the economy.

Advances in audio-visual communications have caused radical changes in education and commerce by the turn of the century, travelling to work or to school being much less common. Trade is centred on the concept of self-reliance (33), surpluses of a range of products derived mainly from timber and stock being exported. Energy is generated from an integrated all-island scheme producing electricity and bottled gas from tidal, wind, solar and hydro sources, loads being matched with the help of pumped storage schemes. Peat and surplus timber are used as supplementary heat sources. The construction and operation of this system illustrates the high level of technical competence in the community. Such skills are respected without paying undue attention to academic qualifications; the important requirement is considered to be the development of a set of skills appropriate to one's own circumstances. Land management is equally sophisticated, deriving from the development of the concept of 'ecodevelopment' (34) into practical systems of management. The food requirements of the population are derived from dietary requirements and the techniques available for home production. In health, the accent is on preventative medicine, appropriate lifestyle and diet playing an important part.

The scenario is not without its problems. Internal political struggles, usually beginning from a clash of personalities, result in frequent meetings at all levels. The development of a community consciousness has this tendency, because nobody wants to take action before all the possible consequences have been thought through. The physical limitations of the land are another constraint, and representations at a higher level, both by the community councils and by the Highland area as a whole result in redistribution within the national economy to aid reclamation schemes and to fund research and development work.

The basis of this anticipation is thus one of internal reorganisation with outside help, resulting in a self-reliant community fully integrated into the UK economy with its communications links, but not so dependent for trade as at present.

Notes to text

1. An anticipation is defined by Jantsch (1967) as a 'logically constructed model of a possible future on a confidence level as yet undefined' in Technological Forecasting in Perspective OECD Paris.

2. "....While aware of the great uncertainties that surround the future, the group consider it realistic to assume that no major changes will occur in either a continuing aim of people for an improved material life or the capability of the world's economic systems to supply it. Thus on the demand side, it is not considered that significant changes in taste will occur. Although prices of commodities capable of replacing, or being replaced by, wood products may display different trends from the past, there is no basis for forecasting such change...."
Forestry Commission (1977) Wood Production Outlook for Great Britain

3. N.Calder (1969) Technopolis
4. P.Hall (1977) Europe 2000 p. 33
5. J.McHale (1972) World Facts and Trends
   D.L.Meadows et al (1974) Dynamics of Growth in a Finite World
   C.H.Waddington (1978) The Man-Made Future
   R.Ackoff (1978) The Art of Problem-solving
6. T.O'Riordan (1976) Environmentalism p. ii
7. Department of Energy (1978) Development of the Oil and Gas Resources of the United Kingdom (The Brown Book).
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9. J.Maddox (1972) The Doomsday Syndrome
10. V.Smil (1976) China's Future - a Delphi Forecast Futures 9 (6) 474-489
11. E.Jantsch & C.H.Waddington (1976) Evolution and Consciousness
    F.Emery (1975) Futures We're In
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    R.May (1971) Stability and Complexity in Model Ecosystems
12. T.Roszak (1972) Where the Wasteland Ends
13. G.Hardin (1972) Exploring New Ethics for Survival
14. B.P.Menon (1977) Global Dialogue - the New International Order
15. C.H.Waddington (1977) Tools for Thought p.32
16. A.H.Maslow (1943) A Theory of Human Motivation Psychology Review 50 370-396

17. For example:-

    G.Rattray Taylor (1975) How to Avoid the Future

    A.Toffler (1975) The Ecospasm Report

18. P.Chapman (1975) Fuels Paradise - Energy Options for Britain

19. P.Hall (1977) op cit

    F.Emery (1975) op cit

    I.Illich (1973) Tools for Conviviality

    T.Roszak (1972) op cit

    E.F.Schumacher (1973) Small is Beautiful

or in the fiction area:-

    E.Callenbach (1975) Ecotopia

    A.Huxley (1962) Island

    B.F.Skinner (1948) Walden Two

20. see (17).

21. W.Miller (1970) A Canticle for Leibowitz

22. Forestry Commission (1977) op cit

    R.Fairgrieve (1979) A Policy for Forestry

    Centre for Agricultural Strategy (1980) A Forest Strategy for the UK

23. F.Hirsch (1977) Social Limits to Growth

24. P.Hall (1977) op cit

25. F.Emery (1975) op cit

26. T.Roszak (1972) op cit

27. E.F.Schumacher (1977) A Guide for the Perplexed

28. J.Davis (1977) paper to conference on Appropriate Technology and Institutional Change, 5-7 September, Newcastle University

29. T.Athanasiou (1977) Compost and Communism Undercurrents 24 31-34

30. I.Illich (1971) Deschooling Society p 78

31. T.Atanasiou (1977) Compost and Communism part II Undercurrents 25 19-20

32. National Centre for Alternative Technology (1977) An Alternative Energy Strategy for the UK

    G.Leach et al (1979) A Low Energy Strategy for the UK

33. J.Galtung et al (1979) Self Reliance

34. As defined in Ambio (1979) 2/3 p113

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CHAPTER SEVEN - ANTICIPATION A - ENFORCED AUTARKY. A CRUSOE SCENARIO

7.1 - Introduction

This chapter examines the response of the Mull system in terms of resource use to the first anticipation outlined in the previous chapter. The object is to describe the characteristics and support capabilities of the economy under these conditions. This is achieved by calculating the maximum population which can be fed on the island given constraints of land, technology and circumstance. The initial calculation of 'crude carrying capacity' as defined in Chapter two is viewed and adjusted in the light of these constraints and the pressure on resources arising from other levels of need.

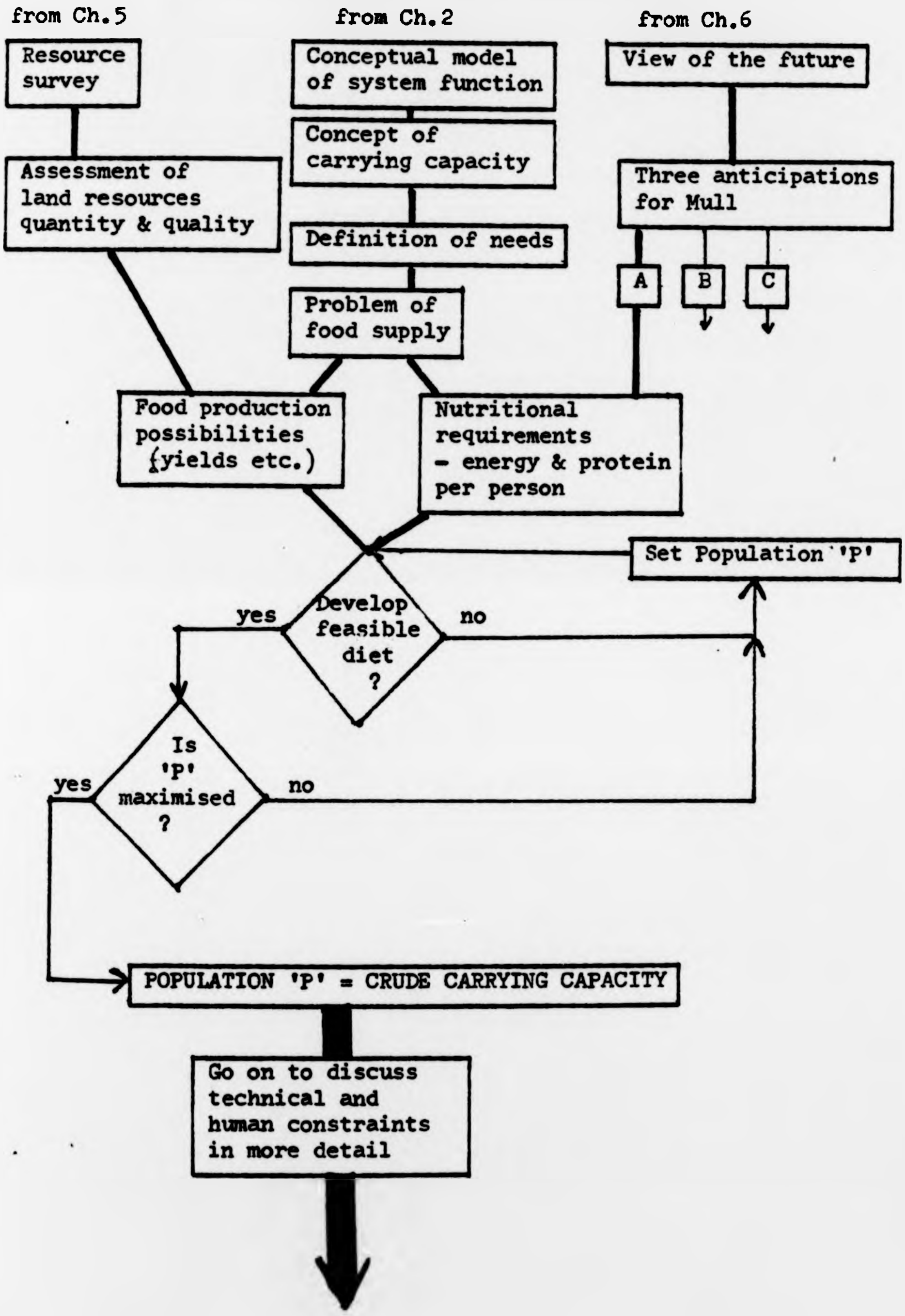
Figure 7.1 shows the relationship of the various elements of the calculation. It can be seen that there are several unknowns in the equation which are resolved by successive approximation on the basis of assumptions about crop production possibilities and dietary needs. It is important to recognise that this scenario is an attempt to assess system status toward the end of the time horizon of the anticipation. It is not intended to describe an immediate response to a sudden crisis, but rather the endpoint of a period of relatively rapid change in the island's environment.

7.2 - An estimate of crude carrying capacity

This first anticipation is the closest of the three to the closed system of the concepts described in Chapter two. It is therefore the easiest to apply carrying capacity concepts to in a meaningful way. In fact, the situation would parallel that found two or more centuries ago, with the vital difference that the community has experienced (and will remember) its intervening history. One might therefore expect an integrated response to the problems arising from the loss of contact with the outside world. As a start, an estimate is made of the ability of the island to support the community with a technological input comparable to that found 200 years ago at the end of the Eighteenth century. In this section concern centres on the satisfaction of the lowest level of need defined by Maslow, basic physiological requirements for food shelter.

Figure 7.1 describes the important features and sources of the calculation. This section describes the shape of a feasible solution

Figure 7.1 - System diagram for the derivation of Crude Carrying Capacity - Objective to maximise population on a feasible and adequate food supply



to the problem. It was achieved by a process of successive approximation as follows; only the final iteration is described in detail in order to avoid repetition. The main decisions and conclusions reached along the way were:-

1. Set population at arbitrary high figure of 25,000
2. Define dietary requirements as described in 7.2.1
3. Is it possible to feed this population given the inputs shown in the diagram?
4. The answer is no. While energy needs can be met from a diet consisting largely of potatoes, protein is inadequate because insufficient land is left to support livestock. The island could only support such a population on an inadequate diet.
5. Second iteration. Set population at 15,000
6. Is there a feasible solution?
7. The balance of diet is improved, but there is still heavy dependence on the potato, while protein is still inadequate.
8. Third iteration. Set population at 12,000
9. Diet still judged inadequate
10. Set population at 10,000
11. Feasible solution developed as below.

7.2.1. Nutrition

The diet of the Eighteenth century Highlanders was monotonous and poor. The staples were oats, potatoes, milk, meat and fish supplemented with a little wheat (usually imported) and vegetables (if seed were available). By early in the next century the Mull connumity could well be reduced to the same state, lacking petroleum for machinery, fertilisers for crops and grass and markets for livestock. Yields of arable crops will be the main casualties in such a situation. Livestock will be less seriously affected, although winter feed for cattle will be more difficult.

While there is considerable disagreement among nutritionists about appropriate criteria for an adequate diet, official conventional wisdom at present (1) seems to favour energy and protein as basic measures, with recommendations for the average individual of 2200 kcals and at least 63g of protein per day. An essential reference in the application of these standards to actual diets is McCance and Widdowson's

'The Composition of Foods' (2). It is recognised that such a crude interpretation of contemporary food science cannot do the discipline justice, but the standards are held to be sufficient for the purpose in view of the other uncertainties involved. The potato occupies a crucial role in the diet that emerges in 7.2.4, and a question about that role is discussed at that point.

Other nutrients and vitamins are given recommended intake levels in the official guidelines, but while these were checked in the research for this section, the exact contribution of important sources such as certain vegetables is unknown. The assumption has therefore been made that these minor factors do not affect the situation sufficiently strongly to make a significant difference to the outcome.

7.2.2. Land available for cultivation

The final section of Chapter five reviews the potential of the land for productive purposes in the 1970s. In this anticipation, it is expected that there will be a major disruption of existing agricultural systems resulting in a heavy pressure on arable land. The tendency will be for the maximum possible area of arable to be used, although the productivity achieved per unit area will be relatively low. The plots will be small, dictated by the topography and the method of cultivation, probably using animals. The area of such land in Mull is open to debate. Land in fact comes in a wide variety of shapes and forms; the threshold between cultivable and non-cultivable, beyond which the marginal effort required would not be justified by the returns, is practically impossible to determine in any absolute sense. The approach here is pragmatic, and relates land availability to its likely use, beginning with the framework of 'capability' outlined in Chapter four.

Wheat is the most exacting of the field crops in the diet. Good arable land is in extremely short supply in Mull. The Macaulay map identifies less than 1.5% of the land area in the top category (ca. 1300ha) and climatic and topographical limits place even tighter restrictions on land for wheat. A detailed examination of the 1978 survey suggests a maximum 100ha suitable for this crop under the conditions of this scenario.

The second most exacting crop is the potato. It is easy to see why this crop made such a difference to the food supply when it was introduced to the Highlands in about 1750 (3). Its importance in the food supply is demonstrated in table 7.4, where it makes significant contributions to most components of the balanced diet. The area which could be devoted to the potato is probably very large - perhaps as much as 5000ha. Such a large area would result in a dangerous dependence on crop success which, as history has shown, cannot be relied upon. In this iteration, the aim is to use less than 500ha for this crop, given the production limits described below. In the diet developed here, the high value of potatoes as a staple vegetable has been recognised, and an upper limit of 1kg/person/day imposed. The actual amount incorporated into the diet is therefore fixed, so that production is determined by the size of the population.

Similar considerations apply to the oat, the traditional staple cereal of the Highlands. However, it is one of the hardiest of cereals, and hence a more generous limit of 1000ha will be imposed for the time being.

It is expected that intensive domestic vegetable production in gardens will occur so long as suitable seed is available. The material contribution of these to the diet is small (see 9.2), except in terms of vitamin supply. The main justification is the maintenance of diet diversity.

Animal productivity is a complex subject, and its impact on land requirements is subtle. However, the types of land required fall into four distinct categories:-

i) arable
ii) grass for cutting
iii) grass for grazing
iv) rough grazing

Cattle require elements from the first three, sheep from the last two. Poultry may be expected to occupy mostly shared space in farmyards, but will also require some arable production in the form of grain. The areas available may be obtained by subtraction from figures summarised in Chapter five.

Arable - Of 3000ha available, up to 1600ha are required for cultivation, therefore at least 1400 are available for fodder production.

Grassland - The whole of an estimated 8100ha are available

Rough grazing - The whole of an estimated 23,000ha of fair quality land are available.

This ignores the very large area of poor or useless rough grazings. The scenario assumes no encroachment on forest land, at least within the time horizon of 50 years, and that use of poor mountain land will be minimal.

7.2.3. Production potential

It is one of the central constraints of this scenario that access to external non-renewable energy resources is effectively eliminated. The present dependence of farming systems in general on such sources makes it very difficult to estimate the yields to be expected under any other system. The only evidence available for the relevant areas comes from the historical record. It would, however, be wrong to use yields from the past as a formula for the future. Standards of management and understanding of biogeochemical systems have been transformed, and much of this will remain, at least for the life of the scenario. Hence yield estimates are pitched between the disastrously low yields of the Seventeenth century and those of the energy intensive systems of today.

Food production systems are not just a matter of yields. The route from the field to the kitchen involves many quite substantial losses on the way. For plant material, these are primarily:-

i) The need to separate and store seed, in a low intensity system about one third of the crop, and

ii) losses in processing (eg milling) and storage, which in temperate climates might be expected to average 20% of the net output.

For animals, any specially produced feedstuffs will be subject to similar losses, plus those incurred in butchering. An animal system is also complicated by the fact that its harvest is effectively a regulated cull on a maintained population, be it eggs, milk or carcases.

From the preceding discussion, it should be obvious that some products are limiting factors, while the rest are widely variable, depending on the desired composition of the diet and the level of cultivation achieved. Wheat production will be lower than present day levels of consumption would require, while high-yielding potatoes are subject to an upper limit on their contribution.

The yields from wild animal populations are calculated from known present day levels of production, and their contribution to individual diet determined by the magnitude of the human population.

The following summaries describe the production characteristics of each crop and its contribution to the diet.

a) Wheat

Present day yields range from 3 to 5 tons of grain per hectare. This involves a seed input of 0.2 tons per hectare (4). A primitive system would yield three times the seed input; a number of yields quoted from the late medieval period (5) were grouped around 1.3 tons per hectare with a seed input of 0.3 tons per hectare. These figures are for other parts of Scotland, so an estimated yield for the poorer ground of Mull is 1.3 tons per hectare with a 30% seed input. The 100ha would therefore yield 130 tons, of which 91 tons would be available for consumption. After processing, the remaining 73 tons would feed 10000 people at 20g/head/day.

b) Potatoes

Present day yields for maincrop potatoes vary from 20 to 40 tons/ha (4). Seed input is about 5 tons/ha. Using similar criteria to those in (a), a yield of 15 tons/ha might be expected from the same seed input. This would produce 6000t from 400ha, of which at the most 4000t might be available for consumption. This would feed about 10000 people at 1012g/head/day.

c) Oats

In the land strategy outlined in the previous section, priority is given to other cereals (wheat, and barley frown for stockfeed) and potatoes. Hence, low yields are to be expected. Current yields are from 3 to 5 tons to the hectare, from a seed input of up to 0.25t/ha. A pessimistic estimate will therefore yield 0.8t/ha and hence total production of some 800 tons per year. This leaves available production of some 450 tons, which will supply 10000 people at 123g/head/day.

The next stage considers an animal products strategy which would result in an acceptable mix of livestock (no over-dependence on one source) and make maximum use of wild animal populations. Table 7.2 considers these foodstuffs for a 10,000 population, and reflects a balance derived from previous iterations of the problem. Key assumptions include a desire to minimise the sheep/cattle ratio, and to keep within the limits of fodder production. Variety of diet is also an important consideration. Having set these production targets, the following analysis examines the problems which would be encountered in fulfilment.

Table 7.2 - Animal Products Strategy - output required for 10,000 population

Item	Dietary requirement (g/head/day)	Annual requirement (Kg/head/year)	Total annual requirement (tons/year)
Mutton	41	15	150
Beef	26	9.5	95
Venison (a)	5	1.9	19
Shellfish (a)	8	3.0	30
Lobster and crab (a)	5	1.9	19
Cheese	50	18.3	183
Milk	500	183 (litres)	1.83 (10^6 litres)
Eggs (b)	0.5 (b)	183 (b)	1.83 x 10^6 (b)

a) treated as limiting in original iterations

b) these figures are numbers rather than weight per unit time

d) Sheep

The yield of edible material from a sheep is affected by a number of factors including:-

(i) the breed and nutritional status of the animal,

(ii) the pressure on protein resources, influencing the amount of the animal utilised,

(iii) the skill of the butcher.

Table 7.3 - Carcase composition, percentage of liveweight (a)

Item	Beef	Mutton	Venison
Meat	40	28	48
Edible offals	8	10	2
Blood	5	9	8
Bones	8	6	8
Fats	10	10	2
Gut	10	12	10
Hide	19	25	22
	100	100	100

(a) it is assumed that differences in body composition between animals of different weights are negligable

sources (6)

It is thought that since slaughtering will be local and there will generally be some pressure on food resources, utilisation will tend to a maximum. It is estimated that a fat sheep comprises 28% meat by weight, with a further 10% of edible offals. (Table 7.3, note (6)) The weight calculated in table 7.2 will therefore require 11,300 animals of mean liveweight 35Kg. The number of animals in the complete system depends on the range of animals utilised. If it is assumed that cast ewes will be slaughtered and eaten, as seems likely, then this output will be achieved with a smaller flock. The flock will be self-maintained, so some of the ewe lambs will be retained, together with a smaller number of ram lambs as replacement tups.

Producing 11,300 beasts for slaughter will require the maintenance of a flock of 16200 breeding ewes, if the production characteristics are assumed to be:- (7)

> 80% lambing rate at birth, producing 13,000 lambs, of which there is 13% mortality in the first six weeks of life, leaving 11,300 lambs.
> Flock replacement (rams and ewes) of 25% for age and mortality needs 4100 lambs, leaving a total of 7200 for slaughter, plus about 4000 cast ewes, heavier on average than a lamb.
> Rams required to be maintained at 2.5% of breeding ewes = 400.

Thus 11,200 animals are available for slaughter, equivalent in meat terms to 11,300 lambs, from a flock which reaches peak summer numbers of about 32,000. The adjustment to this level of output will require a slight improvement in the general standards of management. It is hoped that this could be achieved first by the reduction in the size of the flock in Mull, from some 62,000 to 32,000 beasts, thus allowing concentration on better grazings; second by the use of supplementary feeds at critical times of the year; third, the improvement of lowland grazings offers an opportunity of better winter grazing and hence higher ewe productivity. Contemporary lamb output in Mull is about 6[illegible] per hundred ewes per year, as opposed to 70 assumed in the calculations above.

e) Cattle

A beef animal yields 40% by liveweight, plus another 8% of edible offals. The size of the breeds used will determine the size of the herd. It is anticipated that a general purpose animal, producing dairy and beef products and sufficiently hardy to spend 6 months of the year on the hill, will be popular. Such animals tend to be smaller than the more specialised breeds, and produce less meat and milk. Once again, a mix of old and young animals is to be expected; assuming a relatively low mean liveweight of 300Kg, the demand for beef calculated above would be satisfied by an output of 660 two-year-old animals, some of which will be substituted by older animals as herd replacements. Assuming :- (i) 90% calving (ii) 20% herd replacement each year (iii) one bull to every 40 cows (iv) 5% calf mortality (v) heifers drop their first calves at 3 years and (vi) young animals slaughtered at two years (8), the total herd will be

Breeding cows	772	
Calf output	695 less 5%	660
1 year heifers	155	
Store animals	505	
Bulls	35	

Thus a herd of some 2200 animals, based on about 780 breeding cows, could produce 505 young animals and 155 older beasts each year, sufficient to supply the meat requirements calculated earlier.

Milk requirements are rather more difficult to calculate since the industry is at present largely separate from the beef production systems, and there is only one herd in Mull, sited in one of the more favoured areas. Furthermore, the traditional method of milk production was for each house to have one or two cows. Such a system makes sense when transport is severely restricted, as would be the case in this scenario. Thus the milk production system may be expected to comprise two different approaches; the use of surplus milk from the herd and a substantial number of individually-managed animals.

Milk can be used in a number of food processing activities. The diet outlined in figure 7.2 includes milk and cheese (9). Thus the total milk requirement in the quoted diet for 10000 population requires an annual output of some 3.6 million litres. If 30% is supplied from the herds, and 70% from the croft cows, this implies an annual contribution of 1600 litres from each herd cow, not impossible for a dual purpose breed. If the croft cows can give 3000 litres per year (as a result of careful management), the supply could be met by about 840 cows.

Feed requirements for the total number of cattle (3000+) are substantial. In addition to the four land resources listed above, there are by-products of arable production which have some relevance, if only as bedding. The production figures outlined above suggest that about 2500 tons of oat straw will be available as roughage. It will certainly be worthwhile growing barley and a root crop, while sutably managed areas of grassland will yield silage. The traditional feed is hay, but the high autumn rainfall and uncertainty of the weather makes this a high risk product in most parts of the island. It will be a worthwhile crop in the Ross and some parts of the North end of the island. Exactly how much feed could be produced in this way is difficult to say, but local opinion (10) suggests that stock capacity for cattle is determined by the availability of arable land for these purposes. In Mull, it is considered that one acre of arable per animal provides a rough guide. This yields a total arable requirement of 1200ha for the total herd of 3000 animals. This figure and that calculated for food requirements comes to a total of 2800ha, a figure comparable to the estimate of 3000ha made in section 7.2.2.

f) Venison

The wild Red deer herd in Mull currently numbers some 4000 beasts (11), which might be expected to maintain itself, if not increase, in the circumstances outlined in this scenario. Research on Red deer populations suggests that an annual cull of up to 20% may be sustained (12), yielding some 800 carcases. This would be a maximum yield; as we are assuming some pressure on resources, the actual yield seems likely to approach this figure. A yield of 750 carcases has therefore been assumed, at an average liveweight of 50Kg. Venison is remarkable in having extremely low levels of fat, particularly in wild animals, and thus a relatively high yield of protein in the flesh (13). About 50% of the liveweight is usable meat, yielding 19 tons of meat, sufficient to feed a population of 10000 at an average 5g per day.

g) Shellfish

Current production of winkles alone out of Mull amounts to over 30 tons each year (average over the past decade)(14). The annual variation from this mean is large, mainly due to the casual nature of the industry. It is assumed that production of winkles and other shellfish could at least be maintained at current levels. There is extensive evidence of the use of shellfish resources in the past, particularly in times of famine.

h) Crabs and Lobsters

Other crustaceans currently collected around the shores of Mull include Lobsters and Scallops. Crabs do not figure prominently in a commercial fishery, but are certainly caught in lobster pots. Scallops live in deeper water, requiring diving gear or a motorised vessel with a trawl for their collection. Hence it is considered that crabs and lobsters will continue to be caught by small boats using pots.

Present production of shellfish other than winkles amounts to some 50 tons per year, largely composed of lobsters and scallops (the ratio is not known). Taking into account the additional problem of making effective use of a boat, a yield of 18 tons per year of crabs and lobsters seems quite attainable.

i) Eggs

The diet outlined above includes an egg per person every other day. This implies a level of production of some 5000 eggs per day. [illegible] eggs per [illegible]. Poultry in intensive high output units can lay up to 270 eggs per year. If free-range hens in Mull can produce (on average) an egg every other day (ie 183 per year) then the number of hens required will approximate the number of people at 10,000.

7.2.4. Synthesis

The diet outlined in table 7.4, yielding 2200kcal per head per day, and 84g of protein, forms the basis of an acceptable food strategy, using the natural resources of Mull and capable of feeding 10,000 people. Wheat and oats are limiting. Any attempt to increase meat production will increase protein production or lead to energy deficiency. The amount of potatoes has been adjusted to what is thought to be an absolute maximum at 1kg per head per day. This is a very large quantity of potatoes, but it depends on the adequacy of the information of the nutritional content of foods, and the nutritional requirements of the individual. A recent paper by Tudge (15) casts doubts on the adequacy of this information in relation to metabolism

Table 7.4 - <u>Main components and the composition of diet, anticipation A</u>

Item	limits(i)	quantity(ii) g/person/ day	Kcal(ii)	g protein(ii)
Wheat	73t	20	64	2.6
Oats	450t	123	493	15.2
Potatoes	3694t	1012	860	21.3
Milk		500	325	16.5
Cheese		50	200	13.0
Egg		25	35	3.0
Mutton		41	136	6.0
Beef		26	73	4.1
Venison	19t	5	10	1.7
Shellfish	30t	8	1	0.2
Lobster	18t	5	2	0.4
			2200	84.0

(i) See text

(ii) all figures are averages per person per day derived from total annual supply. No account is taken of variation between individuals and between days (eg seasonal changes).

of 'dietary fibre', chiefly cellulose and hemicellulose. It is suggested that there was evidence that such materials are not metabolically inert in humans, but are converted into volatile fatty acids and absorbed. Many subsistence economies have diets high in fibre, and the old Highland diet based on oats and potatoes must have been similar. On the basis of the nutritional value attributed to these foods in the standard works used today, an adequate diet would have involved eating vast quantities. Taking assumptions from Tudge, metabolism of fibre could reduce the potato requirement to 865g without affecting the overall energy balance.

The solution presented in table 7.4 is not unique. Some adjustments would be feasible, but any increase in population could only be fed by increasing the proportion of potatoes, while lower populations would have a wider range of options, discussed in the final section of this chapter. To conclude this section, it may be said that a population of 10,000 could be fed in Mull, involving the production of:-

73 tons of wheat
3700 tons of potatoes
450 tons of oats
11300 sheep for slaughter from a flock of 30000 (peak numbers)
660 cattle for slaughter from a herd of over 3000, also producing
1.87 million litres of milk and
183 tons of cheese
750 Red deer carcases
30 tons of shellfish
18 tons of crabs and lobsters.

This would involve the use of:-

3000ha of arable land,
ca. 8000 ha of improved pasture
ca. 20000 ha of rough grazing.

The remainder to the chapter examines the constraints on this strategy in more detail, and places it in context with other levels of need.

7.3 - Technical Constraints

The following sections make a somewhat artificial distinction between the 'technical' and 'human' constraints on the food strategy outlined above. Inevitably the two elements are interactive; however, the distinction aids systematic analysis of impact. The systematic approach is aided by reference to the concepts described in 2.2. The technical constraints tend to occupy the right hand side of figure 2.3, while the human constraints come from the left. Technical constraints may be grouped into six areas:-

7.3.1. Natural environment

a) Climate

The analysis of climate in Appendix four argues that the West Highland climate, characterised by high rainfall and exposure to strong winds, is inimical to annual crops, even though the average parameters of climate are not particularly unfavourable. This variability of climate is one reason for the present low level of arable cultivation on the island. It makes no sense to the individual farmer to take the risks involved in growing his own animal feed (particularly hay) when there is a guaranteed supply at more-or-less controlled price available from the arable farms of Central Scotland. In this scenario, this option is closed, and the resulting heavy pressure for arable reclamation exposes the population to increasing risk (and hence diminishing returns) as more land is brought under the plough.

b) Soils

The diminishing returns to increased arable cultivation are also a function of soil type, itself heavily influenced by the long-term climate. The 1978 survey identified about 4000 ha of land which appeared to be technically capable of cultivation. In this scenario, given the limited technical capability of the community, it is thought unlikely that attempts to cultivate more than about 3000 ha will be worth the risk involved. Considerable attention will have to be given to the improvement and maintenance of the fertility of these cultivated soils, and to a lesser extent the care of some 8000 ha of managed grazings and grassland.

c) Wild fauna and flora

It must always be remembered that any system of land use is modifying an existing natural or semi-natural ecosystem with its own production processes and its own sets of relationships. It is inevitable that there will be direct interactions between the wild species and the managed systems. The main fauna of importance in this context are the Red deer, hares and rabbits. The deer have been written into the food strategy as a supply of protein, and will require virtually no management apart from the cull. However, they require low ground in winter, and will tend to maraud arable land, particularly in the area with a relatively low proportion of potential arable land.

Rabbits are an unknown quantity. Certainly they were a major nuisance before the advent of myxomatosis, so their importance depends on the response of the population to changes in land use. It seems certain that control will be necessary, yielding a further supply of protein. Hares are predominantly found on the hill, only coming to low ground in hard weather. While unlikely to cause a serious problem, they will provide another protein source provided that some form of capture is practicable.

The direct influence of wild flora is more limited; perhaps the most important is the control of bracken, particularly on the basalt soils of North Mull. In the past, bracken was limited to a few gullies and other isolated areas, and conserved as a bedding for cattle. It seems likely that this could be the case again, if the kind of labour-intensive agricultural system envisaged came into operation.

d) Season

The most important exogenous variable acting on the biological system is undoubtably the cycle of seasonal change. The impact of this cycle on the food strategy will depend on the degree of integration and internal organisation of the island community. It is feasible to arrange production and storage to minimise winter shortage at a community level (discussed below). The opportunity to do this is successively reduced at the family or individual levels.

7.3.2. Other contributions to the food strategy

It has already been pointed out that while the diet described is more than adequate, it does not attempt to include every variety of food eaten by the population. It aims to describe the basic strategy for staple foods so that calculations of the productive potential of the land resources may be carried out. It is expected that there will be a strong desire on the part of the community to add variety to their diet, and that this could be achieved in some of the following ways.

a) Vegetables and fruit

Certain limited areas of the island are well-suited to horticultural operations. In this scenario, it is envisaged that garden cultivation of vegetables will be widespread, depending on the availability of three things; suitable seed, manure and labour. One of the more important consequences of the enforced isolation of the island will be the end of imports of selected and highly developed seed from specialist producers on the mainland. Once again, the nature of the response will depend on the level of organisation of the island community. If the individual gardeners have to conserve their own seed, it is expected that the contribution to food supplies from this source will be low.

b) Fish

A traditional part of the islander's diet, this has been left out of the main calculation because the likely yield from this source is uncertain. Present landings of fish on Mull recorded in official statistics come from relatively large motorised vessels, and bear no relation either to the size of the potential catch from Mull waters (most of which is presently landed in Oban) or of the demand for fish when other sources of supply are cut off. On the other hand, a relatively undisturbed inshore fishery exploited on a spare time basis by small boats with relatively simple gear would be likely to yield a substantial benefit at favourable times of the year.

c) Rabbits and other game

The possible contribution from game is discussed above, and depends on the size of the respective wild populations, and the availability of suitable methods of capture. While guns are certain to be carefully preserved, ammunition will be in very short supply, so the favoured method of capture is likely to be some form of trapping, or the use of ferrets and dogs.

d) Other domestic stock

The food strategy does not take into account pigs, goats and the full range of poultry. Small numbers will probably be kept by individuals, but there is no tradition of pig husbandry on the island, while the others are unlikely to provide a major additional contribution to the diet.

e) Miscellaneous foodstuffs

There are many foodstuffs which tend to be taken for granted, whose production in such a seige economy would be difficult. Sugar is one such; our present supplies come partly from Caribbean sugar cane, and partly from English and European sugar beet. The raw material is extensively processed in large scale industrial plant, a process not easily reduced to a 'cottage industry' scale, even if the raw material were available. The answer to this problem is honey. Visualising the parameters of an appropriate bee-keeping system for this scenario is difficult. Contemporary bee-keepers take most, if not all, of the honey in the autumn and keep the swarm alive with industrial sugar. In times gone by, the swarm was poisoned before any attempt was made to remove the honey, thus leaving the next year's supply to the chance acquisition of a wild swarm. A sustainable system would be to leave the bees enough honey to survive the winter, remembering that their numbers are much reduced over that period. Yields of up to 25kg of comb honey per hive under this system have been claimed (16). The summer food supply for bees is plentiful, particularly when the heather is in bloom, thus as a source of sugar, beekeeping would be very attractive. A group of products which suffered from supply problems in the distant past was seasonings. Salt can be produced by evaporation of seawater in salt pans, a process which is bound to be carried out in the Ross of Mull, where sunshine hours are long, or by boiling seawater in a pot. Herbs will be grown in gardens, and it is even possible that spices might be grown in any remaining glasshouses.

7.3.3. Additional output from the food strategy

A considerable number of non-food items will be produced as by-products of the food strategy, as well as output from otherwise unproductive land.

a) Wool

Goodwin (17) mentions a figure of 2.6 kg of wool yield from a shorn ewe. This implies a supply to Mull of some 40 tons per year, or some 4 kg per person per year.

b) Hides

A new secondary industry to the island will be tanning, for the output of animal skins will be very large; 660 cattle, 11300 sheep and 800 deer, quite apart from any rabbits, hares and other less numerous animals.

c) Fertilisers

The domestic animal population will be an important source of fertiliser from two sources. First, the blood, bones and offal produced in butchering may be used to produce bonemeal, a valuable lime-rich fertiliser and feedstuff for poultry. This may be expected to yield a maximum of about 60 tons of bonemeal per year, if the total blood, bones and offal in each carcase were used, and produced dry bonemeal some 40% of the weight of the raw material.

The second source of fertiliser is the manure from intensively managed animals, the output of which will depend on the number of animals, the length of time they are kept and the method of management. Store cattle yarded on bracken bedding will yield ten tons of manure each year, so winter feeding will yield 5 tons per beast. For 500 store cattle, the yield will therefore be 2500 tons. Any animal folded on low ground or pasture over the winter will contribute droppings and urine.

d) Other animal byproducts

The chief of these will be fats, some of which will be edible while others may find applications in lubrication, waterproofing and lighting. There are opportunities for small technological improvements in processing over the course of the scenario, for example in preventing rancidity and developing better burning oils. The maximum yields from animal sources will be some 54 tons of beef and mutton fat. Other byproducts include , horn and gut.

e) Timber

An important land use which has so far received no mention, the timber supply will be a critical factor in the success or otherwise of the community. The main uses will be construction and as a source of high grade heat. The level and continuity of output will depend on the level of organisation of the community, but over-exploitation will be discouraged by the lack of high-technology felling aids beyond the hand axe. Potential output is already largely determined by existing plantations. Production figures over the life of the scenario have been calculated using the model described in more detail in Chapter eight.

Table 7.5 Timber output to 2030

year	annual output (tonnes)
1980-85	13 800
1986-90	22 500
1991-95	18 900
1996-2000	17 200
2001-05	21 800
2006-10	31 200
2011-15	50 300
2016-20	43 600
2021-25	85 600
2026-30	89 800

This assumes a sixty year rotation, with no substantial plantings from 1980 onwards. The outcome is thus already determined for much of the scenario. The extreme front-loading of forest investment is illustrated by these figures. Even if the forests are almost untouched, quantities of timber will be available long into the future. However, soon after the time horizon of the scenario, output quickly falls away to low levels. An alternative prospect is for planting programmes to be continued at a maintenance level, about 200ha each year under this regime. This would have little impact on output until the next century, when first and second thinnings from the more recent plantings boost production. In the period 2026 to 2030, production would be increased by 17 000 tons each year to 106 000 tons per annum. More importantly, supply is assured at around 80 000 tons per annum for the future. This latter strategy will emerge only in a well-organised society, able to support those engaged in forestry. The individual's time will be constrained by a shortage of energy; an activity such as forestry establishment is in effect a 'sink' of effort with no identifiable return for that individual. The timber which eventually results is. however, an importantsource of energy and materials.

7.3.4. Other material inputs to the food strategy

A detailed exposition of the equipment and inputs to the food strategy in this scenario would serve no useful purpose. This section serves only to illustrate the range of such items and to discuss those which seem likely to pose the major problems.

a) Horses

The loss of fuel for internal combustion engines is probably the most serious single blow the island suffers as a result of isolation. Some form of motive power for transport and making use of cultivation machinery is necessary. Ponies have been used in the past for the transport function, but are not powerful enough to haul a plough. Thus larger plough-horses will be requires if the total area of 3000 ha is to be cultivated. In the past, much of the cultivation was done by hand, using the cas-chrom. It does not seem feasible to expect 3000ha to be maintained in this way by a population of 10 000, although undoubtably some land will be cultivated in this way. The use of horses is therefore to be expected, in spite of the feed costs incurred. Historical records suggest that a pair of horses can be expected to plough an acre a day, and this is backed up by more recent writings (18). If ploughing takes place chiefly in the autumn and spring, with a little in summer (ploughing fallow land), and there are thirty ploughing days in each period, the arable area of 3000 ha could be covered by 200 horses. At other times, the animals could be involved in lighter cultivation tasks (harrowing etc.) or in transport. The feed these animals consume will be mostly grazing, although a supplement of grain will be required when they are working hard (up to 10kg of grain a day when ploughing).

b) Machinery

Agricultural machinery is generally well-built and long-lasting, so adaptation of the existing stock of implements might be expected to supply a large part of the need. Adaptation, improvement and even the fabrication of new tools, both for farming and other activities, will require a revival of smithing. Stocks of various metals can be expected to last a considerable time with the amount of useless machinery resulting from the loss of fuel supply. Another land activity is a possible consequence of this - the maintenance of coppice scrub woodland for the production of charcoal for melting down iron and steel. This could be carried out on steep slopes at low altitudes, many such areas already being suitably wooded.

c) Fertilisers

Keeping land in good heart by the application of fertilisers will be another major constraint on production. Fertiliser comes from many sources other than the mineral sources predominant today. Seaweed will probably be the most important single source. In the days of the kelp industry, Mull produced about 600 tons of kelp ash annually (19), which implied collection of about 12 000 tons of tangle. This was acheived by a population of about 10 000, but they devoted a large part of their time to its collection.

Sources of calcium are particularly important for the acid soils found in many parts of the island, and sources include bone meal (about 60 tons per year) and shell sand. Winning the sand is relatively easy, but removal of large quantities will cause substantial ecological damage to the machair vegetation, which forms good grazing. There are occasional deposits of limestone and calcareous sandstone (20) which might also be used for this purpose.

Animals will also yield manure in considerable quantities if kept in yards or stalls. Perhaps 3000 tons could be derived from this source. Composting of wastes could be another source, perhaps primarily for vegetable gardens. Bracken is high in nutrients, particularly potash, and when used for stock will yield a rich manure. Peat is a source of humus and nutrients, and may find horticultural applications.

The one nutrient likely to cause the biggest problem is nitrogen, as few of the fertilisers listed are rich in this mineral. Thus particular attention will have to be paid to the cultivation of legumes and consequent development of high nitrogen activity in the soil.

d) Genetic resources

Seed has already been identified as a significant problem, whose magnitude depends on the specific crop concerned, and more generally on the level at which seed conservation is practised. Animal breeding is less of a problem; there is a long tradition of stock breeding on the island, and this may be expected to continue.

e) Other hardware

Fencing will increasingly become a major problem as wire supplies dry up. There are three alternatives to a fence, all considerably more labour intensive; a wall, which is permanent but involves a considerable investment of labour in its construction; a hedge, which requires considerable maintenance; and constant herding of animals, which is extremely labour intensive. It is though that some combination of these three will maintain order in the system of cultivation, but that this represents another major disincentive to further expansion of cultivation.

Guns have already been mentioned. Ammunition, particularly for rifles. will be difficult to obtain, although this is the sort of low bulk/ high value item we might expect to be imported by pedlars. The use of guns will therefore tend to be restricted to essential uses - culling deer, perhaps shooting cattle and defensive purposes.

7.3.5 Energy requirements and sources

The agricultural system itself is essentially powered by the sun and both human and animal muscle power in this scenario. However, the infrastructure supporting that system, and the processing industries and domestic system making use of its products will function much more effectively with a contribution from other energy sources. In this scenario these other sources will be limited by plant availability; the 250KW hydro station at Tobermory could well survive the time horizon of the scenario, supplying a small amount of power at a local level. The only other sources are heat sources, from wood and peat. The level of use of these resources depends on the degree of organisation of the community. Both supply and demand are difficult to estimate without much more detailed examination if uses. However, energy in the domestic situation will involve low-grade heat for space heating and high grade heat for cooking. It has been estimated that a household using wood for cooking will use 1.5 to 2 tons per year (21), which for 2000 households might involve 4000 tons per year. This is well within the capability of the Mull forest on the output figures listed above. Furthermore, a traditional source of fuel for these purposes is peat, and it is to be expected that utilisation of peat deposits will be greatly increased. The problem will come when food processing and other secondary industries demand large amounts of high grade heat in order to achieve their output. This is likely to be another important constraint on the level of population in this scenario.

7.3.6 Other material requirements

a)Housing

The supply of housing is an important factor in the consideration of satisfaction attempted in the final stages of this chapter. The current housing stock is of about 1000 dwellings, most of which can be expected to be maintained over the life of the scenario. The settlement survey carried out in 1978 showed a further 1000 ruins or sites of previous houses. It is obvious that any reconstruction or new building will have to be built to lower standards than those already in use once the imports of materials such as bricks, plaster, tiles, piping and other fittings has been prevented. A second factor is the size of households, which are expected to increase once the level of health care declines. Furthermore, housing will need to be situated close to the areas of cultivation, which is not necessarily the case at present. As much as 60% of the existing housing stock is situated outside built up areas. Any new housing will inevitably tend to be built in more remote locations, thus adding to the problems of adequate servicing.

b) Communications

An invaluable asset of the island is its system of metalled roads, which transform the transport situation from that of 200 years ago. Even with a minimum of maintenance they will remain passable for years. Vehicles will obviously require adaptation, but the materials available should allow fabrication of carts and other wheeled vehicles. Personal transport will be severely limited, its form being more dependent on social structure than anything else. It may well be possible to keep the telephone system working using power from the Tobermory hydro plant.

c) Other materials

The full list of items which will no longer be freely available is almost endless. It is not useful to try and compile this list, but sufficient to say that it is assumed that problems caused by their absence either have already been touched upon, or will not have any significant additional impact.

7.4 Human constraints

The importance of the level of organisation of the community has been mentioned at a number of points in the previous section. Evidence supporting this assertion is difficult to establish, coming mainly from the historical record and therefore lying open to reinterpretation. The influence of humans on their environment has two elements, quantity and quality. The first affects mainly the scale of the resource utilisation system and the impact of settlement structures relative to the natural system on which they are imposed. The second is the most important single element in the whole scenario. The outcome of future events is critically dependent on the sorts of people involved (ie their beliefs, morals and outlook) and on the way they organise themselves. This ection looks at four such determinants of the impact of the community on its environment.

7.4.1 Input to the food strategy

a) Numbers

The estimated population of 10 000 used as the basis for food supply calculations does not represent 10 000 man-years of work. An examination of the existing age structure (Chapter four) and projection on various sets of assumptions indicates that there is little possibility of a fourfold increase in population by 2030 occuring simply through increase in the net birth rate. Consequently, the anticipation includes the expectation of a large scale influx of people by the turn of the century. This could hardly be less than about 3000, in which case the population at mid-scenario would be 6000 or more, half 'local' and half incomers. If this population reached 10 000 by 2030, it would imply a substantial number of young mouths to feed, and/or a maintenance of present life expectancy standards. The population, due to its age structure, would also have a considerable momentum for further increase, and would consequently run into serious trouble by exceeding resource limits not far beyond the time horizon.

Thus the eventual size of the population is determined by the rate of immigration in the first half of the scenario, and then by the relationship between birth and death rates thereafter. A midpoint (pre-collapse) population of over 6000 would be quite acceptable, and gradual increases might be expected thereafter. This expectation would have an active full-time workforce of 4000 supporting a population of 8000 by the year 2030. These issues are discussed in more depth in Chapter ten.

b) Skills

Manual skills and conceptual knowledge (of biological systems and engineering) will obviously be of the utmost importance. Adaptability will be the most important factor. Even in a highly organised community with a well-developed division of labour, each individual will need a wide variety of talents in order to make the largest possible contribution.

7.4.2 Community structure

The first characteristic that will emerge, even before the end of the century, will be the resolution of Mull into two distinct districts, one north of a line from Ardmeanach to Fishnish, the other south and west. While at present people identify with Mull as an entity, the political and social divisions within the island today show signs of this internal distinction, which is heightened by geographical fact.

In order to make the food strategy work, it is necessary to assume that each of these communities has considerable internal coherence. A high degree of organisation allows a high degree of division of labour and thereby more effective use of resources, in the same way that the division of labour among the cells of a fish differ from those of a sponge. For suitable models of organisation, the most obvious place to look is into the past. It seems clear that the feudal community structures of the Sixteenth and Seventeenth centuries will not be tolerated by an educated population, at least half incomers to the area and with a historical memory of the freedoms of the Twentieth century. It seems very likely that power will centre on the two executive councils elected before the turn of the century, and that these will be dominated by the remnants of the upper-middle-class landowning families of the present day. There is a distinct danger that this domination might lead to the development of an authoritarian regime with a marked distinction between 'us' and 'them'. This could lead to rebellion and collapse, or a reinstatement of the parafeudal system which held sway until relatively recent times in the West Highlands. Such a system of organisation would inevitably lead to inequality of distribution and consequent sub-optimisation of resource use (because the people doing the work are not those reaping the benefits, hence there is little incentive to effective management). The structure which might be expected to lead to most effective resource use bears some parallels with the Chinese production brigade system. The land is in community ownership, and work done cooperatively, with work credits for each individual's contribution corresponding to a relatively centralised distribution of output. Whether such an equitable system could evolve depends essentially on the trends in private ownership between now and the end of the century. If the amount of individually owned and occupied land declines further, the chances of a proto-communist system emerging are strong. If at that time, however, a large part of the land (particularly arable) is still in the hands of a few individuals, they are unlikely to relinquish that land without a struggle.

7.4.3 Services

The most important consequence of a high degree of social organisation is the resultant high level of support offered by the service infrastructure. In systems terms, the closer to the productive potential of the land that the community is working, the higher the quality of control required to maintain the integrity of the system. These control problems are exacerbated in this case by the relative shortages of materials and energy.

Education is obviously an important component of the infrastructure. Maintaining the school system will be an important factor determining the longevity and sustainability of the society. However, the content of the curriculum and the length of time spent in the school system will be greatly modified. The impact will be less obvious in the primary schools, where emphasis will be laid on reading, writing and arithmetic. The secondary schools will be much modified, with a curriculum much more related to the final use the pupil will have for what he has learnt. It seems unlikely that full-time education will go beyond the age of 15-17.

The system of health care is unlikely to survive in such a coherent form. The extensive training facilities enjoyed by doctors and nurses today will not be available from the turn of the century, and may be expected to be much curtailed well before that. A doctor recently installed in practice at the turn of the century might well still be in reins by the time horizon of the scenario, barring accident and disease. These men will be key members of the community, and essentially irreplaceable unless a system of apprenticeship is adopted. Their effectiveness will be greatly curtailed by the cessation of medical supplies, so increases in both the death rate and the birth rate are to be expected. In particular, the infant mortality rate will increase as the scenario evolves.

A danger of the resulting changes in population dynamics is that the birth rate will outstrip the death rate in an uncontrolled fashion. It has already been pointed out that a population which expanded towards 10 000 by the year 2030 would find itself in serious trouble soon thereafter. There is evidence from the less-developed world that an adequate nutrition, coupled with inadequate health care (due to undersupply of drugs and equipment) may have precisely this effect. In the circumstances, the most feasible solution is for the appearence in the society of moral strictures on uncontrolled procreation, and hence on sexual activity.

A system of exchange will be another requirement of the organised society. It seems unlikely that paper money will continue to be accepted. Coinage may well survive, but opportunities for maintaining the supply are unlikely. Therefore a more or less sophisticated method of barter may be expected. If the community retains a high level of organisation, it seems possible that some centralised system might register credit in an abstract way, and thus regulate and expedite exchange between individuals.

How such a system might evolve depends on developments in exchange systems between now and the end of the century. If physical money declines, to be replaced by credit ratings, the latter outcome seems quite possible. Progressive collapse of the financial system over a number of years, with its accompanying loss of confidence, might lead towards barter.

Security, both internal and external, will be an important consideration in a dispersed society. The extreme condition would be a reversion to the lawlessness of the Thirteenth and Fourteenth centuries. However, certain elements of weaponry seem likely to survive which were not available in those times, particularly the use of gunpowder. It is impossible to say how this aspect might evolve, except to say that military operations, both offensive and defensive, are likely to place a constraint on the time spent on resource management activities. Internal security depends entirely on the shape of the society which emerges. The more organised the community, the more likely they are to maintain a formal system of law and order.

There are a variety of other services whose presence or absence will make a difference to the effectiveness of resource utilisation. Veterinary and agricultural advice will aid achievement of production potential. The range and variety of personal services will depend on the level of organisation.

7.4.4 Administration

It should be quite plain by this stage that the effectiveness of the resource use system is critically dependent on the level of internal organisation the community acquires, and also that the preceding analysis of carrying capacity is constructed under an assumption that such organisation exists. There seems little reason to suppose that if the island community is capable of organisation at this level, that coordination at a higher level is completely out of the question. The main problem will be one of energy and material needs for transport; thus although the import and export of goods will be difficult, it does not follow that the people themselves are equally isolated. Indeed, it seems unrealistic to suppose so. The main drift of the anticipation is that the urban industrial infrastructure is thoroughly destroyed, but even a large scale loss of life resulting from such an event could not prevent re-emergence of wider organisation by the end of the scenario. Such a re-establishment of political ties is bound to be turbulent, thus it is in the Island's interest to be well-placed in this respect. The councils are the obvious vehicles, but whether they rule by consent or coercion is impossible to predict, and even after the event such a verdict would depend on the observer's viewpoint. Certainly, even the most liberal and democratic council would need to maintain a public order system and the ability to deal out punishment to offenders. It seems very likely that traditional close links between the administration and the church will form the basis of such control. One way to make people respond to one's wishes is to convince them that by doing so they are doing the 'right' thing, obeying some natural or supernatural law. The moral code and preaching of the Christian church is just such a doctrine, and need not necessarily be identified with either an authoritarian or a liberal regime. Its teachings are equally capable of development in either direction.

It is therefore maintained that a vital prerequisite of the organisation of the community is a large scale readoption of religious belief, thus providing a common moral framework upon which administrative organisation can be constructed. As the most convenient available doctrine, Protestant Christianity is seen as the most likely candidate.

7.5 The likely outcome

7.5.1 Changes over the life of the scenario

While the picture painted in this chapter is of an island community radically different from that of today, it does not follow that its development would necessarily involve radical, discontinuous change. It is in fact anticipated that the scenario could take place simply by continuous adaptation to changing circumstances over the course of years. The main anticipated areas of change are as follows:-

a) Diet - The replacement of a food system based mainly on external sources with one depending on the island's internal supply capability is one of the most obvious changes, particularly in terms of its impact on landuse. A summary of the changes in the typical diet is presented in table 7.6. There are some quite substantial changes apparent from this table, notably the fall in protein and energy derived directly from meat, and the increase from vegetable sources. This is perhaps surprising in an agricultural system which is almost exclusively based on livestock at present. It derives from the difficulty of providing sufficient

Table 7.6 Aggregate changes in diet (% composition)

source	energy (Kcal)		protein (g)	
	UK average 1976	Basic Mull diet 2030	UK average 1976	Basic Mull diet 2030
Meat	17	9	34	14
Dairy	32	23	29	35
Vegetables	7	46	9	31
Cereals	30	22	26	20
Fruit	4	-	2	-
Sugar	10	-	-	-
	100	100	100	100

supplementary feed for livestock other than sheep, and the use of limited arable land for the production of plant material for direct consumption. In ecological terms, it makes sense to take food from a lower level in the food chain, thus avoiding the energy losses from a change of trophic level, provided that nutritional requirements are met. More detailed examination of the pattern of consumption is meaningless unless the effects of substitution of the various marginal products listed above are taken into account.

b) Population - The previous section outlined the likely changes in population during the scenario. The main characteristics are a steady rise of total population and a small but steady stream of immigration up to the end of the century. A surge of immigration (over a decade) increases the population from about 3000 to about 6000. From then on, the dynamics of population will change, so that by 2030 there will be a higher proportion of young people, life expectancies will shorten and infant mortality rates and birth rates will both be well up. Whether the population will stabilise without substantially exceeding 10 000 depends on the success of the community in adapting to its changed circumstances. The final expectation of this chapter is for a final population of 8000, whose resource requirements are described in 7.5.2.

c) Community - The present-day relationships within the community are certain to undergo changes in the future. Exactly how this might happen is difficult to foresee; in essence, the island will become more inward looking, will focus itself on two centres, Tobermory and Bunessan, and will absorb a large number of culturally alien people. At the same time, the development of power centres on the island will add to a marked increase in political turbulence, the outcome of which will depend partly on the circumstances, and partly on the personality relationships of the individuals involved. The outcome of this struggle will determine the effectiveness of the resource-use system.

d) Land use - The present pattern of agriculture will become increasingly unattractive as ties with outside markets disintegrate. Thus there will be a gradual shift to the kind of pattern outlined earlier, the most notable feature being the reclamation of cultivable land, which will be 'worked up' over the course of years. Certainly it would be impossible to implement such changes successfully over a period of less than a decade. The division of land between forestry and agriculture will be essentially unchanged, while use of poorer hill grazings will decline. Agriculture will concentrate on the better land. Settlement will tend to disperse, and will correlate in density with available good land.

7.5.2 Production outcome at 50 years - population 8000

a) Diet - Table 7.7 presents a final approximation of the diet and total annual food requirements for a population of 8000. In this case, approximations of the contributions from the more important marginal items are included. It should be noted that limiting items and livestock have been maintained, and thus contribute more to the diet at the expense of the potato. Heavy dependence on this one crop is thus reduced.

Table 7.7 Diet composition and food production for 8000 population

Item	g/head/day	Kcal/head/day	g.protein/ head/day	Total annual consumption (tons)
Wheat	25	79	3.3	73
Oats	154	617	19.1	450
Potatoes	757	643	15.9	2250
Milk	500	325	16.5	1.46×10^6 (a)
Cheese	50	200	13.0	146
Eggs	25	35	3.0	1.46×10^6 (b)
Mutton	51	170	7.4	150
Beef	34	96	5.5	99
Venison	6.5	13	2.3	19
Shellfish	10	1	0.3	30
Other Crustacea	6	2	0.5	18
Fish	10	8	2.0	30
Honey	4	11	tr	12
(game)				
(vegetables)				
Totals		2200	88.8	

(a) units = litres/year

(b) units = no. of eggs

b) Land use and stock - The diet outlined in table 7.7, feeding a population of 8000, would require the following areas of land and numbers of livestock:-

Wheat	100 ha	
Oats	1000 ha	
Potatoes	225 ha	
Milk	2920t milk	33% from beef herd @ 1400 l/annum/beast
Cheese		67% from 650 croft cows @ 3000 l/annum/beast
Eggs	8000 hens producing 183 eggs/hen/year	
Mutton	11300 animals from a herd of 30 000	
Beef	ca 700 animals from a herd of 2500	
Venison	ca 750 animals from a wild population of 4000	
Honey	from about 500 hives	

The conclusion is made that this is a reasonable output from 3000ha of cultivable land, 8000 ha of improved grazings and 20 000 ha of rough grazing. This leaves over 12 000 ha to woodland, 2000 ha of peatlands, and consequently some 46 000 ha of mountain land supporting the Red deer population in summer, and perhaps occasional summer grazing of stock. The arable land is found in three main areas; 1200ha in the Ross, 1400 ha in North Mull and 400 ha around Loch Don.

c) Status of the system in 2030 - With the circumstances outlined above and an accompanying stable political situation, the resource utilisation pattern should be sustainable for many years. Chief dangers will be uncontrolled increase in population and unwitting dependence on nonrenewable or easily depleted resources. It seems very likely that a wider political and economic system will return and that the community of Mull will eventually find themselves once again involved in a macroeconomy of which they are an insignificant part.

7.5.3 The satisfaction of needs

The approach to carrying capacity outlined in Chapter two emphasised the importance of quality of life to human individuals. The concept of hierarchy of needs was introduced at that point. It is quite clear that while the circumstances outlined in this chapter would provide sustenance and shelter for a population up to four times the size of the present one, the quality of life of such a community would in several ways be lower than that obtained in the present day. On the other hand, there might be compensations. Unfortunately, no means of trading off these gains and losses can be devised.

a) Basic physiological needs (hunger, thirst, oxygen, sleep) - The prime objective of the calculations in this chapter are to satisfy these needs, and so it would be tautological to discuss the success of their achievement.

b) Security needs (freedom from pain, protection of (a)) - In general, standards of security will fall. The community will be much more vulnerable to crop failure, disease and external interference of a malicious nature. The size of this fall will be related to the extent to which political structures are in control of the system.

c) Belonging needs (friendship and affection) - These needs operate on at least two levels, the community and the family. The community will be much more close-knit so that an individual happy with his social situation may feel more satisfied than he would do at present. However, an individual who was unhappy with his place in the social structure would find his relationships very difficult to alter. The family seems likely to become extended (in terms of the number of generations to be found in one household) which again will have an ambivalent effect on the aggregate level of satisfaction.

d) Esteem needs (prestige and status) - The opportunities for satisfaction of status needs by acquisition of material goods will be extremely limited. It is held that the strength of desires to make such acquisitions will be an important factor determining the way the community organises itself, as outlined in 7.4.2.

e) Self-actualisation needs (expression of capacities and talents) - It would appear that there is nothing inherent in the scenario to change the aggregate level of satisfaction of these needs from the present day. Certainly the opportunities will be very different, but whether this constitutes improvement or decline is beyond the scope of this study.

7.5.4 Conclusions

In the enforced isolation of anticipation 'A', pushing the land resources of Mull to the limit would provide for the basic needs of a population of 10 000. However, this would represent a high-risk situation, with the community vulnerable to over-population and crop failure. The final outcome has therefore been designed around a population of 8000, based on an assumed net immmigration of 3000 by the end of the present century, with mainly natural increase thereafter. Comparative discussion of the three scenarios is the subject of Chapter Ten.

Notes to text

1. Dietary requirements are taken from the DHSS publication (1970) Recommended intakes of nutrients for the UK Chairman Dr R Passmore
2. Food value for different food products is derived from A.A.Paul and D.A.T.Southgate (1977) McCance and Widdowsons' The Composition of Foods
3. L.M.Livingstone (1974) Sheiling transhumance and changes in land use in the Scottish Highlands Unpublished M.Phil Edinburgh University
4. J.Nix (1977) Farm Management Pocketbook
5. T.B.Franklin (1952) A History of Scottish Farming
6. Figures interpreted from J.K.Jacques (1978) Energetics of some meat processing industries TERU Discussion Paper no 2 and from Rowett Research Institute (1974) Farming the Red Deer.
7. Derived from ,D.Houston (1977) The effect of Hooded Crows on Hill sheep farming in Argyll J.Appl.Ecol. 14(1), and from Nix (1977) op cit
8. D.H.Goodwin (1977) Beef management and production
9. MAFF (1977) Output and Utilisation of Farm Produce
10. West of Scotland Agricultural College Area Advisor(1978) pers. comm.
11. HIDB (1973) Survey and Proposals for Development and from residents
12. The appropriate cull rate for wild deer populations is the subject of intense debate; the main problem is the identification of the total population from which the cull is to be taken, as deer do not obey estate boudaries. A recent report demonstrated the range of opinion on the subject. B.Mitchell et al (1977) Ecology of Red deer: A research review relevant to their management in Scotland
13. Rowett (1974) op cit
14. DAFS statistics
15. C.Tudge (1979) The ins and outs of roughage New Scientist 21/6/79
16. J.Seymour (1973) Self-sufficiency
17. D.H.Goodwin (1971) The Production and Management of Sheep
18. T.B.Franklin (1952) op cit , J.Seymour (1973) op cit
19. P.A.Macnab (1970) The Island of Mull
20. A.C.Jermy and J.A.Crabbe (1978) The Island of Mull: A Survey of its Flora and Environment
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CHAPTER EIGHT - ANTICIPATION B - MULL ON THE PERIPHERY - A CENTRALISATION SCENARIO

8.1 Introduction

The final sections of Chapter six set the scene for this scenario with an anticipation of increasingly centralised decisionmaking coupled with intensification of resource use. The expectation under these conditions is for forestry to become the primary landuse, with agriculture in a minor secondary role. This chapter examines the characteristics of such a pattern of resource use, and assesses the size and nature of the community which might emerge towards the end of the scenario. This chapter is therefore different in nature in that carrying capacity as a purely biological characteristic of a human community in a closed system is not a central subject of analysis. However, the logic of national planning policy in this case dictates that the community is on the island as a tool of resource use. Without net benefit to the economy in terms of raw material output, the community would not endure. Thus the outcome is still dependent on the ability of the island to produce raw materials and the size of the community is determined by a range of factors including the size of this contribution to the national economy.

8.2 Natural resource use strategy

This strategy focusses on forestry as the primary land use. Joint activities are agriculture, in a radically different form from the present, and tourism of an equally different nature.

8.2.1. The potential for forestry in Mull

i) Land resources

The discussion of land capability in Chapter five described previous attempts to define capability for forestry, and suggested that the available figures were either very rough estimates or not entirely free of modification for non-technical reasons. For this reason, a separate desk study using available information was carried out to establish a figure for the purposes of this scenario.

The study was based on the 1974 MISR soils map, interpreted with the help of Bibby's contribution to the British Museum Flora of Mull (1), Toleman's observations about forestry potential in Argyll (2), the brief soils memoir in a recent MISR report(3) and some personal observations

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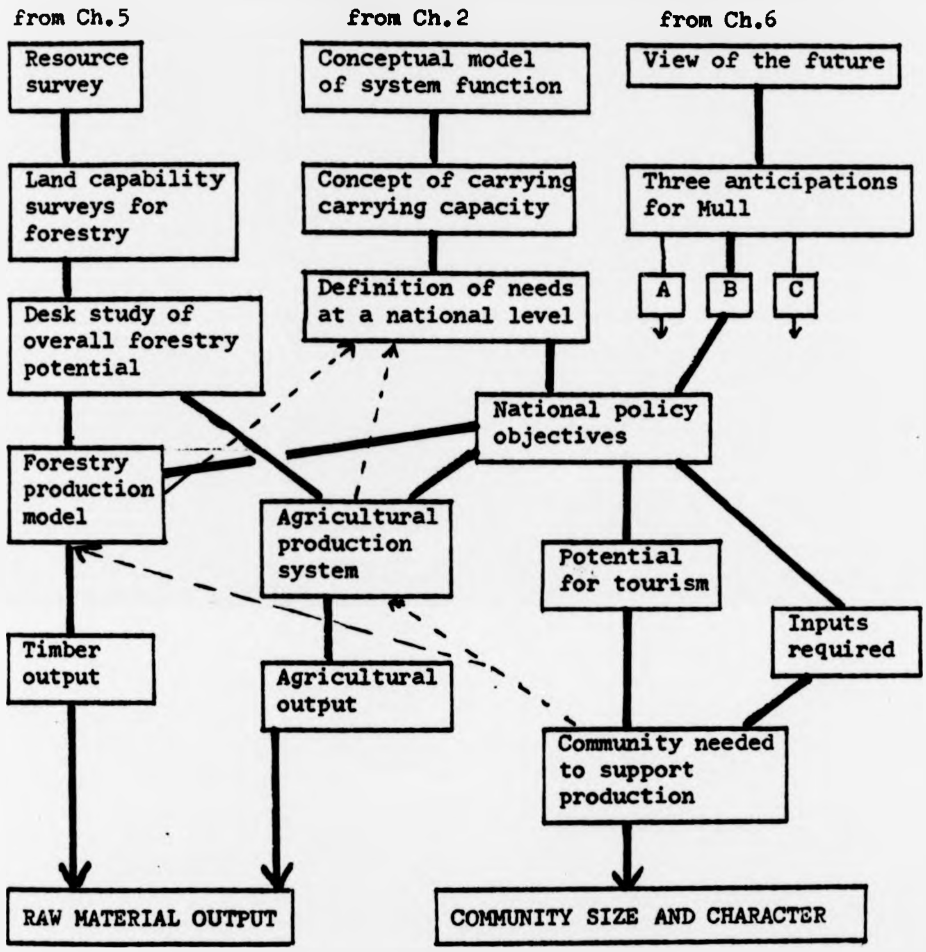
Figure 8.1 - Diagram illustrating the development of the resource use strategy - Objective to maximise useful raw material output in accordance with national priorities



of plantations of the island.

The first limitiation was to eliminate all ground over 250m, and poor low lying ground assigned to capability class seven on the more recent MISR capability map (mainly comprising cliffs and ground exposed to the southwest). For each complex on the soils map, information on the percentage of the area covered by the various components of that complex was assessed and estimates of the suitability of the main soil types for forestry were made. Thus the Knockan complex comprises 15% lithosols (4) and hence a maximum of 85% of the area covered by that complex is suitable for forestry. Some of these complexes are inherently unsuitable for forestry, and are listed as such by Bibby (5). From this a gross total of land capable of growing trees was derived. 2000 ha of the best lowground was retained for agriculture. The remaining land totalled 36,000 ha, made up of 7,600 ha of hill peats, 11,000 ha of peaty gleys, 4200 ha of poorly drained soils with induration, 2700 ha of podzolic soils and 10,500 ha of brown earths on basalt. This desk study was thus carried out purely on the basis of physical limitations, first climatological and topographical, second pedological. Soils constraints derive mainly from rooting depth (affected by drainage, rock and induration) and fertility. The figure of 36,000 ha has been taken as the maximum technically feasible area of plantation forest on the island.

ii) Production systems

In view of the uncertainty involved in forecasting management techniques and technology over fifty years, a relatively simple forest production system has been assumed. It proposes a sixty year rotation of conifers, with thinnings at 25 years and 40 years, removing 20% of the standing volume on each occasion. Final clear felling takes place at 55 years, and the ground is rested for five years before replanting takes place. From this a simple production model has been employed to predict output from the existing plantings (see table 8.2) using areas, yield class and planting date figures supplied by the Forestry Commission. The existing Mull forest is being planted at a rate rather more slowly than necessary to reach the maximum forest size of 36,000 ha, which would require annual plantings of 600 ha, as opposed to recent figures of 350 ha. Thus the maximum development of forests envisaged in this scenario will involve a substantial increase in planting rates. These matters are considered in more detail in the next two sections.

The Forestry Commission's own production models include a 15% correction for bare ground within the forest blocks (6), but in view of the different method of land assessment described in the previous section, which attempted to exclude such areas of thin soils, rock outcrops etc., it is felt that the incorporation of such a blanket requirement would simply compound the estimate. Thus the model may slightly overestimate production from present plantings.

iii) Existing plantations and output

Forestry Commission figures detail each block of trees in the Mull forest by species, yield class and age (divided into five year age classes). Thus the uniform application of the model (somewhat crude because actual outcome will be influenced by actual plantation performance and available markets) yields average annual output of first thinnings,

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TABLE 8.2 - Forestry Production Model

1. Plant in year 0
2. Ignore increment in establishment phase, to year 5
3. First thinning harvests 20% of volume increment at year 25

$$\text{Total volume at first thinning, } V_1 = \frac{\text{Area(ha) x Yield class x 20}}{5}$$

$$\text{volume thinned} = V_1 \times 0.2$$

where area = area planted in five year period
yield class = increment m^3/ha/year

4. Second thinning harvests 20% of standing volume at year 40

$$\text{Total volume at second thinning, } V_2 = 0.8V_1 + \frac{\text{Area x yield class x 15}}{5}$$

$$\text{volume thinned} = 0.2V_2$$

5. Final felling at 55 years clears all standing volume from ground

$$\text{Final volume } V_3 = \frac{\text{Area x Yield class x 15}}{5} + 0.8V_2$$

6. Land fallow to year 60 and then replanted.

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second thinnings and final felling for each five year period to 2030. These are presented in table 8.3.

Thus forestry output from the Mull forest may be expected to increase by a factor of ten over the life of the scenario on current plantations alone. It is apparent that in later years this is dependent on large areas planted in the 1960s and 1970s reaching felling age, and that without further plantings the operation will decline thereafter.

TABLE 8.3 - Expected output from the Mull Forest 1980-2030

Time period	figures in m^3/year			
	1st Thinning	2nd Thinning	Final felling	Total
1981-85	4200	400	11700	16200
1986-90	3900	1900	20800	26500
1991-95	10200	3200	8800	22200
1996-00	11100	6500	2600	20200
2001-05	(1) 7500	6000	12000	25500
2006-10	(2)	15800	21000	36700
2011-15		17200	41500	58700
2016-20		13000 (1)	38800	51800
2021-25		(2)	101000	101000
2026-30			105700	105700

All figures rounded to nearest $100m^3$

(1) - estimate to total 1976-80 plantings

(2) - output from here on dependent on plantings after 1980

iv) Activity levels up to 2030 and final output

The output calculated in table 8.3 is growing on 6000 ha of ground. With land resources of 36000 ha it would seem at first sight that substantial increases in output are possible. In fact, the age structure of the plantations has produced the result, and designing the management regime so that it constitutes a sustained yield system by the end of the scenario does not result in significant changes in output until the end of the scenario and beyond. Thus in terms of the perceived shortfall of global timber supplies by 2020, little can be done at this stage. One way in which this problem could be alleviated would be to pay urgent attention to the problem of check. At present, 1200 ha of recent plantations are in check. This is largely due to the condition known as 'basalt check', thought to be a deficiency of available phosphate deriving from an effect of soil chemistry where phosphates (actually present in quantity in the soil) become locked into complex ions based on aluminium.

A rapid solution to the problem could make a significant contribution to output in the critical period. This is illustrated in table 7.4. It is assumed that 33% of the area in check is reclaimed in 1981-85, 33% in 1986-90 and the remaining 33% is never reclaimed, at least in this rotation. If reclaimed plantations are assumed to begin at year five, in the rotation at their time of reclamation the output will be as shown in table 8.4. It may be noted that even with prompt action in this area, the output derived from final felling is beyond the time horizon of the scenario. This effect of rotation length is even more marked with plantings undertaken from 1980 onwards.

Land acquisition is a time consuming process, and existing reserves will not allow an immediate planting rate compatible with the aim of maximising forestry output, which would be 600 ha per year (36,000 ha on a 60 year rotation). Reserves of plantable land at 1980 are expected to be about 1750 ha. If this is regarded as a five year reserve, it is well below the 3000 ha required. Thus an important task from 1980 onwards will be the acquisition of 3000 ha of plantable land every five years. This will eventually be matched by areas coming out of first rotation, so that by the end of the scenario most of the 36,000 ha will be under trees. Such an intensive programme of reforestation would result in an output pattern similar to that detailed in table 7.5. This assumes that each five year period sees equal plantings of Lodgepole pine and Sitka spruce at their modal yield classes.

Such a system would stabilise in the middle of the next century with an annual output of about 285,000 m^3 of timber every year. It would involve planting 600 ha, thinning 1200 ha and felling 600 ha each year, together with other care and maintenance activities.

8.2.2. Agriculture

Without doubt the agricultural lobby is at present the strongest influence on land allocation on the island. Early forestry acquisitions involved taking over whole estates as they came on the market, no matter how much land was 'plantable'. More recent negotiations have centred on acquisition of land 'suitable for forestry'. Unfortunately, some

TABLE 8.4 - Effects on output of reclaiming plantations in check

Time period	total from table 8.3	output from reclaimed plant^n^s	total output
1981-85	16200		16200
1986-90	26500		26500
1991-95	22200		22200
1996-00	20200		20200
2001-2005	25500	2600	28100
2006-10	36700	2600	39300
2011-15	58700		58700
2016-20	51800	4000	55800
2021-25	101000	4000	105000
2026-30	105700		105700

TABLE 8.5 - Output pattern with aggressive reforestation policy

Time period	total from table 8.4	output from new plantings	final total output
1981-85	16200		16200
1986-90	26500		26500
1991-95	22200		22200
1996-00	20200		20200
2001-05	28100		28100
2006-10	39300	15900	55200
2011-15	58700	22800	81500
2016-20	55800	22800	78500
2021-25	105000	43400	148400
2026-30	105700	58100	163900

ALL FIGURES IN CUBIC METRES OF TIMBER ROUNDED TO THE NEAREST 100 m^3

of the best land for forestry is also better agricultural land, either as pasture or good rough grazing. The strength of the agricultural lobby has ensured that such land has, for the time being, stayed in hill farming. The Forestry Commission's recent acquisitions have tended to be of bottom land (eg Glen Forsa) with problems of drainage and therefore of rooting depth and windthrow. This scenario supposes a change in this balance towards the foresters, probably as a result of more explicit national government policy on landuse, as outlined in Chapter six. The consequences of such a change will not be immediately apparent on the island. On these projections, by the turn of the century some 6000 ha will have passed into forestry. It is expected that the strength of the agricultural lobby will ensure that much of this land will be of poorer quality in the earlier years, but radical changes in sheep management systems will remove this constraint from the 1990s. It has already been assumed that 2000 ha of the best land will be retained for agriculture. It is possible that this land will be used to sustain a significant intensification of sheep production. Intensive sheep systems are already under investigation (7) involving yard feeding or even stall feeding in winter, with rough grazings only used in the summer months. The forestry strategy only uses about 50% of the ground below 250m in Mull, and thus there will be numerous open areas within the forest boundary dictated by soil conditions. These will sustain summer grazings as proposed by Adams (8). The production characteristics of such a system might be as follows:- (9)

Stocking at 12 ewes per forage hectare & 150% lambing rate at birth allows 24,000 ewes to be maintained on 2000 ha. 36,000 lambs are born, of which 32,000 survive to maturity. 25% of these are required for flock replacement, leaving a surplus of 24,000 lambs for market. This is almost identical to existing output from extensive systems. Thus the agricultural output from Mull will only change to the extent that cattle management is abandoned, while changes in land use would be dramatic.

8.2.3. Tourism

Tourism will form an important element of the Mull economy under this scenario. It will offer little in the way of permanent, year round employment, but will indirectly aid the service industries (shops, trades and public services) and support a few hotels and guest houses. It is anticipated that activity will be concentrated on the West coast of the island, and particularly in the Ross of Mull and Iona. Predicting the size of this activity is extremely difficult because the demand for tourism and related services is completely dependent on surplus disposable personal income in the national economy and abroad, and is therefore also dependent on the condition of those macroeconomies. It is anticipated that the structure of the tourist industry will change during this scenario, with a continued increase in the demand for second homes. Iona will continue to be a major attraction for visitors to the West Highlands. It is possible that cheap travel and higher incomes will lead to a move away from the week or fortnight holidays in Mull which are currently the elements of tourism which make most contribution to the economy. The hire of accommodation - hotels, guest houses, chalets and cottages and the use of secondary services such as shops and leisure activities are the important parts of this contribution. A new feature in this area will be the involvement of national and European companies interested in developing the leisure potential of the island for the medium-stay visitor.

In contrast, day visitors to Iona only affect transport services from Oban to Iona via Craignure and Fionnphort, and secondary services on Iona. The importance of their contribution is derived from sheer weight of numbers. Finally, the second homes field contributes to rates, and to secondary services when the houses are in use; a possible third contribution is the provision of a caretaking service for these houses, which might provide full-time employment for a few people in places where second homes are concentrated.

The most significant feature of tourism is its seasonality. For this reason it is thought unlikely that any significant permanent employment will be generated from this source. Certainly the labour market will be buoyant in summer, and the families whose chief source of income lies elsewhere (for example in forestry) will make use of the opportunities offered. Immigrant labour will also be important, so that the distinction between consumers (owners of second homes etc) and providers of services (incomers spending up to six months of the year on the island every year while involved in a leisure-related enterprise) will become blurred. Thus regarding the tourist sector as an activity of the 'Mull system' and as an element of 'carrying capacity' is conceptually inappropriate.

8.3 Internal relationships of the resource use system

8.3.1. Other contemporary landuses

The impact of the landuse strategy on agriculture has already been described. Game management as a significant landuse on Mull is chiefly confined to Red deer, and concentrated on the central massif and the Laggan peninsula. Concern has been expressed about the effects of browsing animals on maturing plantations (particularly of Sitka spruce, the most successful species from the point of view of production) in Highland Scotland. It is anticipated that a large expansion of forestry in sensitive areas will lead to a heightening of conflict between these interests, particularly when plantations restrict deer access to low ground grazings and shelter, or when deer cause appreciable damage to maturing trees.

The absence of roe deer from Mull is of considerable benefit to the forester, as this species lives in woodland and is responsible for much of the damage to plantations elsewhere in Scotland. There could conceivably be demands to introduce Roe deer for sporting purposes, but it is expected that such demands would be resisted.

8.3.2. Material inputs to forestry

There are four main classes of input to forestry in the shape of seeds, fertiliser, machinery and energy. It is one basic assumption of this scenario that suitable energy to power machinery is available, and that appropriate seeds or seedlings will be available, either imported or grown in a nursery on the island.

Fertiliser inputs are hard to define, especially for a long term projection such as this. Bishop (10) quotes 'standard' FC inputs of Phosphorus, Potassium and Nitrogen in the form of rock phosphate, muriate of potash and prilled urea reapectively. He implies that one application per rotation of Potassium and Nitrogen is sufficient, with two of phosphate in certain areas. The Mull forest is certain to be one such area. This implies inputs as follows:-

Rock Phosphate	450 tons/year
Muriate of Potash	120 tons/year
Prilled urea	225 tons/year

Both fertilisers and machinery inputs may be expected to change in both quantity and quality as techniques of management improve. There are two ways in which the technology may be expected to evolve:-

i) development and refinement of existing techniques, and
ii) breakthrough of new processes and approaches.

The first is defined by the rate and direction of continuing change. The latter is the wild card, and may lead to profound changes in the existing mode of activity. The effect of railways on canals, or the effect of jet air transport on transatlantic passenger steamers are obvious examples.

In the case of forestry, the most obvious change of type (ii) to be expected will be in response to changes in energy sources. In this anticipation it is assumed that some form of internal combustion engine will continue to be the most effective power source for mobile machinery. Static machinery will probably make more use of electricity due to the premium price attached to liquid fuels.

The developments of existing technology will be in terms of improved machinery for ploughing, harvesting and other management operations. Advances in hydraulics for harvesting and timber handling, and in design of rough terrain vehicles are seen as the main specific improvements. The second area of development is expected to be predominant, being improvements in plant breeding and more sophisticated management regimes using better knowledge of the relationships involved in tree cultivation. This will include a move towards improved monitoring and site management to exploit that knowledge.

8.3.3. Labour inputs to forestry

Bishop (10) quotes some general figures for labour requirements by forest operation. The utility of these figures for the Mull forest depends on:

i) the management regime in use,
ii) the existence of special conditions or constraints in Mull,
iii) the changes in management technique occurring over the life of the scenario.

Uncertainty is therefore high. However, using the management regime and programme outlined in this chapter, labour requirements would develop along the lines suggested in table 8.6.

These labour requirements are currently defined in terms of active cultivation operations. Labour productivity in these operations has been increasing in recent years (11) and has doubled in the 15 years from 1950-1975 (in terms of employment per hectare). These trends could easily wipe out any increase resulting from increasing the forest area, particularly as high levels of employment are not envisaged until towards the end of the scenario.

TABLE 8.6 - Labour requirements for Mull forest 1980-2025

Time period	81/85	91/95	01/05	11/15	21/25
Establishment (0.072 man-year/ha)	(350)(b) 25	(600) 43	(600) 43	(600) 43	(600) 43
Maintenance (0.0021 man/ha) (a)	(9200)(c) 19	(14800) 31	(20700) 43	(25700) 54	(30100) 63
Logging (.00175 man-year/m^3)	(16200)(d) 28	(22200) 39	(28100) 49	(81500) 143	(148400) 260
Transport and milling (.0025 man-year/m^3)	40	55	70	204	371
TOTAL	112	168	205	444	737

(a) assuming this is a figure for the whole forest
(b) annual plantings in period (ha)
(c) total planted area at end of period (ha)
(d) output, taken from table 8.5

It seems unlikely that simple trend extrapolation will suffice, because i) limiting factors, particularly substitution of capital and energy for labour, will be encountered.

ii) there will be qualitative changes in job definition.

The latter possibility has already been touched upon in the previous section. The 'cup and ball' concept of system control, mentioned in Chapter two, introduced the idea that running a complex system up towards its limits involves the acquisition and use of progressively more detailed information on system status. Thus a marked increase in monitoring of environmental conditions and plant performance will be required. This in turn will require a number of technicians to maintain the instruments and the flow of information, which will allow the adoption of more sophisticated management techniques requiring this data. The research upon which such techniques might be based is already under way in many parts of the country.

A second qualitative change in the labour requirement will be the replacemant and increased 'productivity' of administrative staff due to the introduction of progressively more sophisticated automatic computer-based administrative systems. This is important because it will allow the field staff more time to improve their control of the biological production system for which they are responsible.

8.3.4. Community structure

In the open system envisaged in this scenario, the identification of a well-defined 'community' is much less useful than in the two alternative cases. Certainly, it seems highly unlikely that there will be any substantial increase in the resident population, indeed it may well decline. The extent of such a decline will be determined by:-

i) the establishment of any secondary industries, and
ii) the size and nature of the service industry supported by the tourist sector.

These are discussed in more detail in 8.4.2. and 8.2.3. respectively. It does seem likely that increasing labour productivity in forestry and the sorts of structural changes in the service sector outlined above will lead to a significant decline in resident population.

The likely location of such a community in four settlements (Tobermory, Salen, Craignure and Bunessan) has already been suggested. The urban orientation of the community and the tendency to concentration found in the 1970s (aided by public housing policy) make this development highly probable, and likely to be effectively complete by early in the next century. Administration of the community will be carried out by local authorities and government outside the island, very much as today. The Community Council will add a local voice to questions of local relevance, but will have no significant statutory powers.

8.4 External relationships of the resource use system

8.4.1. Exchange

In such an open system, the question of exchange value is crucial to the continued function of the island economy. This exchange may be considered in three senses, financial, energy and barter.

i) Financial

The corporate state envisaged in this scenario will be in essence a centrally planned economy. Thus the concept of price, and the idea of an absolute value at a point in time measured by a monetary sum will have much less relevance. In a centrally planned economy, price is recognised to be a manipulated variable and hence not given the elevated status it sometimes acquired in the free market economy. However, the relationship of prices of inputs to the value of output will have to yield positive returns as long as money remains the medium of exchange. It must be remembered that forestry will not be the only positive revenue raising activity on the island. The tourist trade will provide some limited benefits, but the kind of activity envisaged will only extend to marginal activities - provision of services and leisure facilities in season, and perhaps a caretaking function out of season.

Having made these caveats, it is possible to discuss prices in a general sense. At 1978 prices, the FC were getting £13.15 per m^3 at the forest gate. The 30,000 m^3 and the 150,000 m^3 at 2010 and 2030 would be worth £400,000 and £2,000,000 respectively. The latter is well in excess of the combined output of forestry and agriculture at present. The anticipated sustained yield of a 36,000 ha forest of 285,000 m^3 would be worth £3.75 millions each year. Furthermore, the relative price of timber is expected to increase markedly by the end of the scenario. A fourfold increase (such as that of oil after the OPEC cartel in 1973/74) would imply a forestry revenue of £8 millions rising to £15 millions by the middle of the next century.

ii) Energy

Energy inputs and outputs provide a framework for analysing 'energy profitability' in crude terms. Does the energy value of the timber produced (derived mainly from sunlight conversion in photosynthesis) exceed external energy inputs from machinery, fertilisers etc?

Once again, uncertainty surrounds the likely size of the inputs as the scenario proceeds. Bishop's coverage of this area (10) shows how difficult it is to obtain reliable data. Using the FC aggregate figure quoted by Bishop, the 36,000 ha forest would require an annual input of 54,000 GJ for silvicultural machinery. The energy yield of the timber would be 14.7 GJ per m^3 (12) or a total of 2.2 million GJ/year by the end of the scenario and 4.2 million GJ/year later in the century, a considerable net 'revenue' of energy. However, this too is no absolute value. The ultimate determinant of utility is not an exchange-value, but a use-value.

iii) Balance of trade

The final measure of benefit is to look at the utility (in physical, rather than economic, terms) of the x tons of timber produced in return for the required inputs. The argument outlined in Chapter six seems to eliminate any alternatives for Mull, while at the same time establishing a need for timber as the raw material for a wide range of wood-based manufactures, and possibly as a petrochemical feedstock. In return, Mull can expect a range of products and services from the wider system

i) inputs to continue forest operations; seed, fertiliser, machinery, energy.
ii) food
iii) consumer durables and services
iv) technical services for machinery and management systems

8.4.2. Opportunities for secondary industries

Timber is a versatile material with a wide variety of applications. West Highland softwoods are not particularly suitable for structural timbers, and thus most of the options open involve some level of processing. The possibility of installing a chipping plant before the end of the century has been mentioned earlier. Economies of scale in such plants make units of 30,000 m^3 per year or more economically feasible at present - such a plant could be accommodated from 1985 onwards, thus easing log handling problems at Craignure. The opportunities for further processing on the island depends on the relative importance of factors influencing location. The one favouring Mull is the presence of a raw material. Others include any other raw material inputs, energy and markets for the product. Contemporary products based primarily on wood include particle board and paper, while an example of a product involving joint inputs would be the polymer Cellulose acetate, made from wood pulp and Acetic acid. Further possibilities are dependent on the direction of technological change. For example, increasing constraints on petroleum hydrocarbons are already providing a stimulus for research into substitutes, and a source of organic chemicals such as timber may well prove attractive in certain circumstances. Such developments would involve the hydrolysis or pyrolysis of wood to gain liquid and gaseous hydrocarbons as a feedstock for the chemical industry. The extent to which such developments might happen in Mull will depend on the structure and centralised nature of industry. In this scenario it is thought unlikely that such developments could be expected on the island.

8.4.3. Administration of Mull

The administrative structures directly affecting the island, local government and government agencies, are likely to remain very much as at present. The main changes will come with increasingly sophisticated central government control over policy at a progressively more detailed level. The impact of this control on the balance between forestry and agriculture has been described in an earlier section. Such a government would not tolerate individuals or organisations who deviated from their alloted task. The system therefore would be autocratic, with information and control systems held at the highest level, and in control of a 'technocratic elite'. It is fruitless at this point to speculate how such a future might come into being and how it might look. It does, however, represent the outcome of a number of significant contemporary trends, as discussed in Chapter six.

8.5 An assessment of carrying capacity

8.5.1. Numbers

Present employment in forestry in Mull is between 50 and 60. Such employment amounts to less than 10% of a total force dominated by the service sector (up to 60% of employment). While employment in forestry will have reached 200 by the turn of the century, employment in agriculture will have declined from the present level. Thus in that period population is expected to remain stable, with a transfer of labour from agriculture to forestry. It is unlikely that such a transfer would involve simple changes of jobs by individuals. Owner-occupier farmers in particular are not a group likely to do this. The evolution of this transfer is thus likely to involve considerable migration, and consequently (because of availability of housing and the desires expressed by the incomers) population will tend to be concentrated in the four centres. Thus far, total population may be expected to stabilise or decline slightly. Other factors could have considerable impact on this pattern, for example the introduction of a shorter working week, the staggering of hours and wider employment of women. The conventional picture of a male breadwinner working a 40 hour, five day week with occasional overtime, supporting a housewife and children, is likely to be replaced by a much more open structure in which attention is focussed on the individual rather than the family as a basic unit. This contrasts with the tight local hierarchy of allegiance foreseen in Chapter seven.

The second half of the scenario presents much more uncertainty. The increase in output from forestry seems unlikely to involve an increase in the labour force as large as that calculated in 8.3.3. The possibility of structural changes in the tourist industry as outlined in 8.2.2. would tend to lead to a contraction of the service industry on the island, so a fall in population might be expected, to between 1500 and 2000, perhaps 700 in Tobermory, 300 in Salen, 300 in Craignure and 400 in Bunessan.

8.5.2. Need satisfaction

It is assumed that adequate income for the resident population will enable the community to satisfy needs at Maslow's first two levels.

At the third level, a sense of local community is absent, with a highly mobile population moving from job to job in and out of Mull quite frequently. Loyalty is felt first to the individual's interests and then at a national rather than a local level.

At the fourth level, ego and esteem needs are still manifested largely in material terms - more material possessions equals more satisfaction - but probably tempered by an awareness of a tradeoff between time spent earning and leisure time spent consuming income.

At the fifth level, those well up in the management hierarchy are given ample opportunity to test their capacities and achieve at an intellectual level. Further down, these needs tend to be more difficult to satisfy in an occupational context, such that people find outlets in a variety of leisure based activities.

8.5.3. Conclusion

The analysis presented in this chapter amply demonstrates the difficulty of applying carrying capacity to a significantly open system. As most real world systems are in this form, it perhaps hints that carrying capacity is not a useful concept for analysis of human resource-use systems (or economies). This limit is pursued and discussed in the final chapter of the thesis.

The final word should perhaps be reserved for a discussion of numbers. At the end of the scenario, a Mull turned over to intensive forestry, agriculture and tourism will support a permanent population of barely 2000. Is this the carrying capacity of the island? It could be argued that the primary raw material output from the island (timber) is supporting a large number of people in other communities who are engaged in process industries. This suggestion is thought to have some validity, but it is also recognised as fact that no analytical techniques are currently available which would be capable of demonstrating and quantifying such a belief. These issues are the centre of attention in Chapter ten.

Notes to text

1. J.S.Bibby (1978) Geomorphology and soils - Chapter five of A.C.Jermy & J.A.Crabbe The Island of Mull: a Survey of its Flora and Environment

2. R.Toleman (1974) Land classification in the Forestry Commission - paper in MAFF Technical Bulletin No 16

3. MISR (1973) Soils on the Island of Mull - in Annual Report 1972/73

4. MISR (1973) op cit

5. J.S.Bibby (1978) op cit

6. R.Steele and J.Balfour (1979) Nature Conservation in Upland Forestry - Objectives and Strategy

7. HFRO (1979) Science and Hill Farming - HFRO 1954-1979

8. S.N.Adams (1975) Sheep and cattle grazing in forests - a review J.Appl.Ecol. 12 143 - 152

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11. D.Turnock et al (1977) The Lochaber Area - a case study of changing rural land use in the West Highlands of Scotland

12. D.A.Tillman (1978) Wood as an energy resource

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CHAPTER NINE - ANTICIPATION C - SELF-DETERMINATION FOR MULL - A REORIENTATION SCENARIO

9.1 Introduction

This chapter examines the impact of anticipation 'C' on the Mull community. It begins with an examination of the limits of resource use under these circumstances. The first stage objective is similar to that in Chapter seven - the maximisation of population on an adequate food supply - but the criterion of adequacy is different, and the terms of technology considerably more optimistic. This calculation of crude carrying capacity follows the pattern set in Chapter seven (see figure 9.1), but the economy which emerges is unlikely to be closed; later sections therefore consider the terms of trade patterns along with the technical and human constraints on the system.

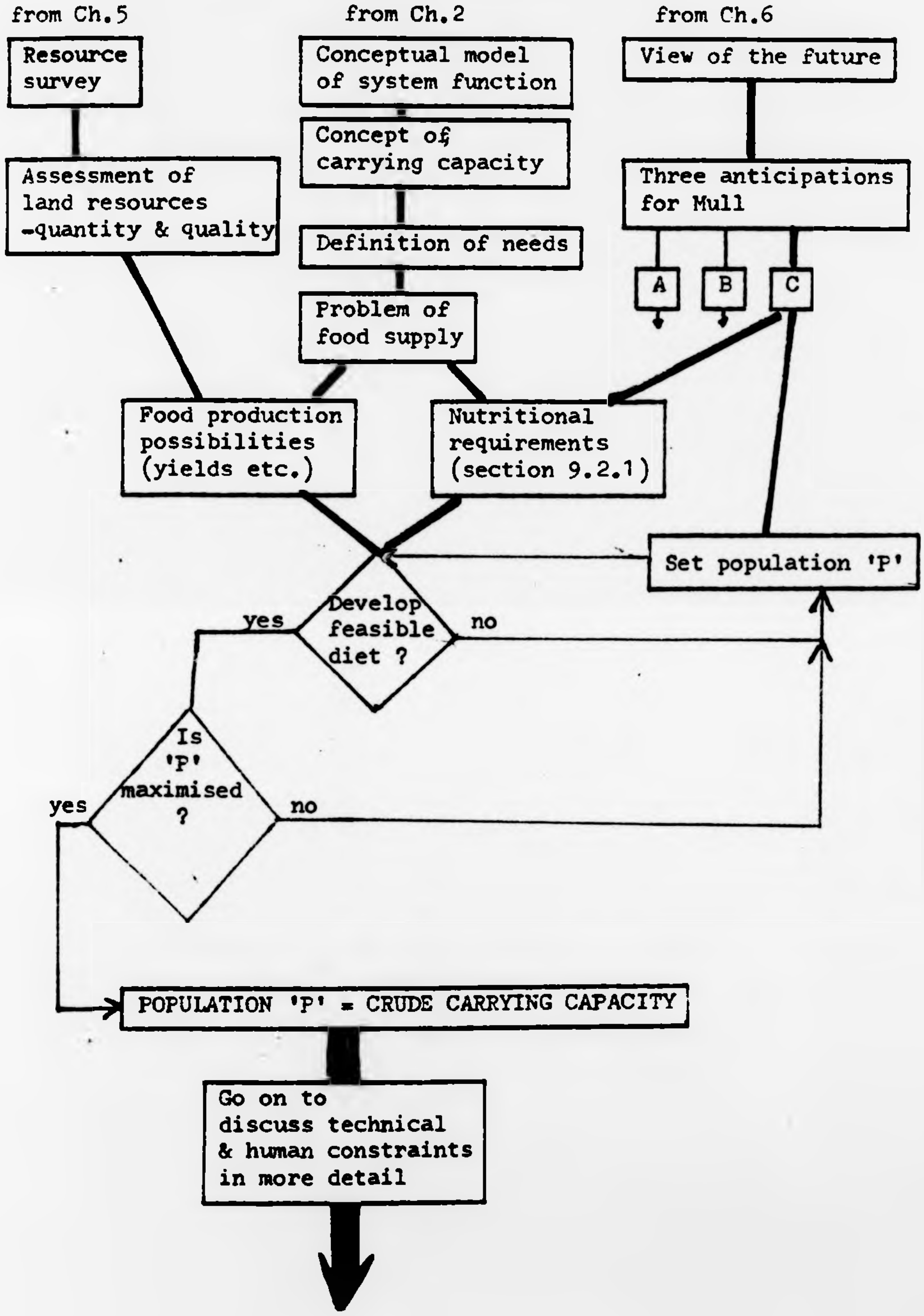
9.2 An estimate of crude carrying capacity

Once again, considerable uncertainty forces adoption of a 'successive approximation' approach to provide an eventual preferred feasible solution to the C^3 problem. In particular, estimation of yields and the statistics of the associated farming system is much more difficult, because nowhere is such a system in operation, nor is there appropriate historical data to consult. Therefore, an important simplifying assumption has been made, that existing yields of most field and horticultural crops will be maintained in spite of radical changes in the system of husbandry.

The path followed to the preferred feasible solution was very similar to that in Chapter seven, starting with a high population and finding that protein requirements could not be met without unacceptable assumptions on diet composition or land capability. The first and second iterations for 25 000 and 15 000 populations thus led to the final solution described here for a population of 12 000.

This section begins by describing the origins of the diet and the nutritional standards set. It then states the land available and specifies a plant production strategy and an animal production strategy which will produce sufficient to satisfy these dietary requirements for a population of 12 000. Discussion of cultivation techniques and energy requirements is left until later in the chapter.

Figure 9.1 - System diagram for the derivation of Crude Carrying Capacity - Objective to maximise population on a feasible and adequate food supply



9.2.1 Nutritional standards

A community approach to decisionmaking in Mull will necessitate planning of resource use for the community (rather than allowing each activity to go on in apparent isolation, except where direct conflict arises over competition for land or other resources). A second feature will be the rejection of many of the values of an urban society, including the desire for highly processed convenience foods. A recent study of diet in the UK (1) examined the composition of food intake and concluded that intake of animal fats and sugar was too high, while the intake of dietary fibre was too low. The high sugar/low fibre mix was considered to be associated with highly processed foods, which are also energy intensive, involving numerous process stages, centralised production facilities and large distribution networks.

A study of land resources in Glen Lyon and Strath Tay centred on Aberfeldy (2) considered the consequences of adopting a 'wholefood' diet brought to the group's attention by the local GP, allied with a policy of self-sufficiency. The diet corrected most of the imbalances mentioned in the CAS report (1), but failed to adapt the diet to local land capabilities. This scenario takes the Aberfeldy study diet as a starting point and modifies it in the light of the CAS report and the range of crops which it might be feasible to grow in Mull. Thus the constraints imposed on the diet were:-

i) Optimum energy provision should be 2200 kcals/head/day (3) according to food values provided by Paul and Southgate (4).
ii) The minimum protein requirement is 63g/head/day (3).
iii) The intake of fats, particularly animal fats, should be reduced from present day levels (1).
iv) Cholesterol intake should be reduced from present day levels of 500 - 600 mg/head/day to 300 mg/head/day (1).
v) Dietary fibre intake should be at least 36g/day, of which at least 22g should be derived from cereals (1).
vi) Sugar intake should be less than 50g/head/day (1).

The question concerning the metabolic role of dietary fibre, considered in Chapter seven, is neglected in this case. It is possible that fibre could contribute more to the diet than Paul and Southgate (4) would suggest, perhaps as much as 200kcals (5), but the evidence is not considered sufficiently reliable for this to be taken into account here.

9.2.2 Land available

The quantity of different classes of land available on the island, primarily a technical characteristic, is the same in essence as in the other scenarios. The starting point for all three is the examination of land capability in 5.3. The difference lies in the varying ability of the community to modify those characteristics for useful purposes. In this case, a minimum area of cultivable land is 3000ha, as in Chapter seven. However, ability to modify that land and deliberately improve its productive potential is much higher. This land is the key to the island's agricultural potential. It is required for gardens, glasshouses, field vegetables, cereals and the production of animal feed. A novel use proposed in this scenario is the possibility of cultivating plants for vegetable oils with an eye to margarine production. The plant production strategy described below requires 1000ha of this land. The subsequent analysis of animal products examines the ability of the remaining land to support adequate animal populations; the land available amounts to 2000ha of cultivable land, 8000ha of improvable grassland and 23 000ha of fair rough grazing. It emerges that the preferred mix of animal products (defined by the constraints on diet) underuses the poorer ground, and that a large proportion of the cultivable ground is required for cereal production. These issues are discussed at a later stage.

9.2.3 Production potential

Section 9.2.1 described the nutritional parameters on which the food model rests. This section describes the development of the model to provide a feasible solution for a population set at 12 000. Plant products were examined first, then the feasibility of an animal products strategy. These two stages were juggled within the constraints of the diet until the feasible solution emerged. The starting point was the Aberfeldy diet listed in appendix 9A.

i) Plant production strategy.

First, cereal production was set at a level sufficient to supply 22g of fibre/head/day. Assuming yields of wheat and oats of 4 t/ha, this implies production from 300 ha, and makes contributions to other elements of the diet. The consumption pattern for vegetables and fruit in the Aberfeldy study was adopted with minor modifications, including the elimination of sweetcorn and the addition of mushrooms, and the estimation of feasible local yields. Those items requiring glasshouse conditions were identified and have been listed separately. Most of these vegetables and fruit are intended to be grown in a market garden situation, while potatoes, turnips, swedes and cereals are grown on a field scale. From the detailed analysis listed in appendix 9B, the plant production strategy for a population of 12 000 would require the following land uses:-

under glass	14.9 ha
gardens and allotments	111.0 ha
field vegetables	23.7 ha
field cereals	300.0 ha
orchards and fruit	271.2 ha
total	720.8 ha
<u>plus</u> an allowance for land in fallow, under rotation	(280)
Total	1000 ha

This strategy would produce the materials and contribution to diet listed in table 9.2.

The contribution from these sources being calculated, the balance was made up from the animal products strategy described below. Once again, the balancing of protein and energy requirements leads to the use of the potato as a 'filler' once the limits on animal production have been reached. These limits include full use of the available arable land for feedstuffs, maximum acceptable levels of cholesterol in the diet and adequate protein input. Increasing the animal products component of the diet beyond the strategy outlined here would require either the assumption that more land can be brought under cultivation or that total population is set at a lower level. The simplest way of balancing the diet is by increasing the contribution from the vegetable component, bringing the potato to 225g/head/day from the original Aberfeldy figure of 153g/head/day.

Table 9.2 Plant production strategy - summary

Site	items	g/head/day	kcal/head/day	g.protein/head/day
Under glass	Aubergines Celery Cucumber Peppers Lettuce Courgettes	175	21	1.3
Garden scale	Asparagus Broad beans Runner beans Beetroot Broccoli Brussels sprouts Cabbage Carrots Cauliflower Kale Leeks Marrow Mushrooms Onions Parsnips Peas Spinach	360	83	7.2
Field scale	Potatoes Turnips & swedes	235	193	4.8
Cereals	Oats Wheat	274	985	35.0
Fruit	Apples Pears Raspberries Blackberries Loganberries Strawberries Gooseberries Currants Cherries Plums Rhubarb	360	109	2.1
Total all plant products		1404	1391	50.4

ii) Animal products strategy

Cattle produce joint outputs of meat and dairy products, thus a decision to produce certain quantities of one implies the production of the other. The diet developed here includes a large contribution from dairy products, primarily because of their value as an energy source and of lesser components of the diet such as vitamins and trace elements. Feeding a population of 12 000 on the diet outlined in the appendix would require the following output of dairy products:-

Milk	1.8 million litres	(1.8 m litres milk equivalent)
Cheese	180 tons	(1.9 m litres milk equivalent)
Butter	110 tons (may be substituted by margarine)	(2.6 m litres milk equivalent)
total		6.3 million litres milk

This would require some 2500 milking cows if each cow were to give 2500 litres of milk each year. The maintenance on the island of such a herd would involve a herd composition (on the same assumptions as those made in Chapter seven) deriving from 2500 breeding cows producing 2200 calves per year, of which 2100 survive to maturity. Of these, 500 are required for herd replacement. There will be 500 more heifers from the previous year's calving, and 65 bulls to service the herd. Thus 1600 calves are available for meat production, implying another 1600 stores if they are grown to 18 months. Herd composition will therefore be:-

Breeding cows	2500	
Heifers and calves for herd replacement	1000	(two year classes)
Bulls	65	
Surplus calf output	1650	
Store cattle	1600	
Total	ca.7000	

Thus a herd large enough to supply milk requirements will also be capable of supplying over 1600 store cattle each year for beef. This implies meat production of 360 tons if the animals are slaughtered at 450kg. A population of 12 000 on the diet described would require 289 tons of beef, so there is a surplus from this source. There are two ways this could be managed internally, either slaughtering animals at a lower average weight (and therefore younger) or reducing butter consumption and substituting a margarine derived from other sources.

The former could involve slaughter at about 350kg, while the latter would save arable land assigned to cattle feedstuffs, substituting with a crop such as oilseed rape. Substituting 50% of butter consumption with margarine would require 72 ha of such crops, and would reduce the herd from 7000 to 5500 and output of store cattle to 1300, sufficient to supply beef needs at the higher liveweight. This alternative herd would comprise:-

Breeding cows	2000
Heifers and calves for herd replacement	800
Bulls	50
Surplus calf output	1300
Stores	1300
Total	ca.5500

This second strategy is the preferred solution because consumption of margarine will reduce the level of polyunsaturated fats in the diet and because the food value is derived from a smaller area of land, so overall there is a net saving in the demand for cultivable land.

The cattle herd is the main user of fodder. While grazing of improved pastures and the hill will provide most of their food in the summer months, supplementary feedstuffs are required in quantity in winter. There are considerable benefits in terms of manure production and lower mortality in stall-feeding or yarding systems over the winter. Calculating rations for such an operation is a complex business, and calculations presented here are by no means definitive. The ration taken as a starting point was recommended by Fraser Darling (6) for the West Highland situation, and has been modified by the substitution of silage for some of the hay, potatoes for some of the swedes and crushed barley for some of the crushed oats. The criteria for the diet in terms of dry matter content (DM), starch equivalent (SE) and digestible crude protein (DCP) were taken from the Scottish Agricultural College advisory leaflets (7).

Stock feed strategy - first approximation

	daily weight fed (kg)	DM (kg)	SE (%)	DCP (%)
TARGET		9	6.7	0.85
Hay	4	2.55	1.40	0.18
Silage	10	2.00	1.20	0.24
Potatoes	4	0.95	0.75	0.03
Swedes	10	1.15	0.73	0.11
Oats (crushed)	2	1.72	1.19	0.16
Barley (crushed)	2	1.72	1.43	0.14
TOTAL		10	6.70	0.86

From the above table, the land requirements for one beast for one day will be:-

	yield t/ha	kg/m^2	m^2/ration-day
Hay	5	0.5	8.0
Silage	19	1.9	5.3
Potatoes	30	3.0	1.3
Swedes	50	5.0	2.0
Oats	4	0.4	5.0
Barley	4	0.4	5.0
Total			26.6

- Therefore, the ration for one animal for one day requires 26.6m^2.
- For 5500 animals the required area would be 14.6 ha.
- Thus the available 2000 ha of such land could provide fodder for the herd for a 137 day winter, for example from October 30th to March 17th.

Further examination of these figures and the calculations used to arrive at a solution reveal that a feasible solution within the strict confines of the calculation would be to feed only silage and potatoes, and this would allow a longer period of feeding as follows:-

Stock feed strategy - second alternative

	Daily weight fed (kg)	DM (kg)	SE (%)	DCP (%)
TARGET		9	6.7	0.85
Silage	30	6	3.6	0.72
Potatoes	17	4	3.1	0.13
Total		10	6.7	0.85

Land requirements:-

	yield t/ha	yield kg/m²	m²/ration-day
Silage	19	1.9	15.8
Potatoes	30	3.0	5.7
Total			21.5

- Therefore 5500 animals will use the products of 11.8 ha each day
- Thus the available 2000 ha could provide fodder for the herd for a 169 day winter, for example from October 21st to March 31st.

While this alternative strategy allows supplementary feeding over a longer period, it does place heavy dependence on two crops, one of which has historically been subject to complete crop failure. In addition, the calculation is critically dependent on the adequacy of the college leaflet's statements on nutritional requirements. It is very likely that a more detailed specification would reveal additional, less important, requirements that this diet could not meet. The first alternative is therefore the preferred solution and would involve the following areas under the various crops:-

Hay	600 ha
Silage	400 ha
Potatoes	100 ha
Swedes	150 ha
Oats	375 ha
Barley	375 ha
Total	2000 ha

A further question concerns the choice of breed. At present, established herds show a bilateral distinction between high-yielding but non-hardy dairy animals and (generally) hardy beef breeds which are poor producers of milk. However, present trends in the industry suggest a reduction, or perhaps the elimination of this distinction. An appropriate response of the existing hill cattle industry would be to develop a dual purpose hardy breed in the next decade. If they did not, the longer-term prospects in such a situation would be bleak. It is anticipated that such a breed would not be a large-volume producer such as the Friesian or the Holstein, capable of yielding over 5000 litres of milk per year with appropriate levels of supplementary feeding, but would perform consistently at lower levels of nutrition, and while suckling a calf.

The second important element in the animal products strategy is the sheep. Sheep are an attractive prospect for meat production because they can survive largely on the open hillside, with small supplementary feed inputs and with some low ground shelter and winter grazing. However, the problems associated with setting up an ecologically sound grazing system involving sheep suggest that the community would do well not to become over-dependent on them. The dietary contribution suggested in the appendix 9B would involve an annual production of about 4000 lambs for market, implying (for a management system with similar characteristics to that outlined in Chapter seven) a total herd of some 7500 ewes producing about 6000 lambs per year:-

Breeding ewes	7500
Lambs born	(6000)
Lambs surviving	(5400)
Lambs to market	4000
Lambs to flock replacement	1400
Rams	200
Wethers	1400
Peak flock numbers	14500

Such a flock, reaching peak summer numbers of over 14 000, represents a considerable reduction in the existing flock and therefore of grazing usage. Local estimates that 1.3 ha of rough grazing are required per breeding ewe would imply that 10 000 ha of the 23 000 ha of available land would be needed for this flock. Thus all of the grazings for similar flock management would allow an output of over 5000 lambs which would be surplus to the food requirements of the community. This would imply a flock of some 17 000 ewes, which would also produce about 45 tons of wool.

The animal products strategy includes contributions from three other species of domestic animals; pigs, poultry and bees. Others (such as goats) might be expected to be used, but no specific calculations have been made concerning their status.

Pigs are almost unknown in Mull at present, and hence there is no tradition of management. Two features of the existing pig industry in the UK are expected to change in the course of the scenario. First, the increasing price of energy will force abandonment of the existing industrialised, energy intensive modes of production; second, the increasing ecological consciousness of the agricultural sector will lead to a trend away from specialisation to high quality managment of mixed units. Pigs occupy an important niche in any such system with their ability to utilise many waste products and turn them into edible material. The appropriate production figures are not easily available, current statistics reflecting predominantly the existing intensive methods of production. The contribution to the animal products strategy with a 12 000 population would require an annual contribution of some 110 tons of pigmeat. About 60% of the body liveweight can be recovered as meat, so this implies a total annual liveweight production of 183 tons. A good fat pig weighs about 80kg (8,9) implying output of about 2300 animals every year. Sows are prolific, producing about 20 young per year under extensive systems of management (10). Thus there would only be a need for about 150 sows, and a total herd of about 2500. Foods will be waste products such as skimmed milk, kitchen swill and stock feed potatoes, while the animals will also serve a valuable role in land improvement and management, folded pigs being used for bracken control and surface clearance prior to reseeding (11).

Poultry are also a marginal product increasing the overall useful output of the agricultural system. There are plenty of hens on the island today, mainly free-range, and it is this form of management which is anticipated for the future. The eggs and meat contributed to the diet suggest a flock averaging between 15 000 and 20 000 birds, supplying 24 000 birds for the table and 2.2 million eggs (ca. 180 per laying bird) each year. Once again, they are expected to fit in with the rest of the farming structure without making large demands on it. Perhaps the feed requirements of these two classes of livestock will require the growing of barley or oats. The barley would have alternative uses in brewing and distilling.

One component of the contemporary diet which would be difficult to supply from the island is sugar. It is thought that any community would want to maintain some level of sugar in the diet, even though it is not strictly necessary. One solution would be production of surplus to trade for imports of sugar. Another would simply involve learning to keep bees. A hive may be expected to produce 25 kg of honey in the comb every year. Care will be needed to prevent excessive inroads into the bees' winter food supplies. The 9.1 kg/person/year suggested in table 9.3 would imply about 4500 hives, not an excessive number when the large area of heather moorland offering a food supply for the bees is considered.

iii) Exploitation of wild animal populations

This source of supply was considered in detail in Chapter seven. There are three classes of such food sources; land animals & birds, freshwater fish and marine animals (fish, crustaceans and molluscs). The yields of deer, crustaceans and other shellfish are assumed to be the same as those outlined in Chapter seven. In addition, sea fishing is expected to yield at least 50 tons of fish each year, and quite probably much more. Such catches will tend to be seasonal, and thus there is some strength in an argument to use such sudden and relatively unpredictable surpluses in a small processing plant for fertlisers, animal feeds and oils. Inland fisheries, for trout and salmon, will yield small amounts, and a novel prospect is the exploitation of eel populations, thought to be significant in Lochs Frisa and Ba.

9.2.4 Synthesis

Figure 9.3 summarises the main features of the food strategy, which yields adequate energy and protein, and fulfils the constraints set in 9.2.1, for a population of 12 000. It involves the production of a wide range of foodstuffs and relatively high inputs of skill and energy. In terms of the conceptual model of economy described earlier in the thesis, it thus uses available skills to intensify the use of natural resources in Mull. The scenario implies a considerable area of land under intensive cultivation. It is probable that such an area could not be brought into cultivation in the quantity suggested without very considerable coordination of effort on the part of the island's community.

The areas under glass represent a considerable investment in structures and are envisaged as community-owned enterprises centred on settlements in favoured locations. Garden vegetables will be derived partly from gardens and allotments and partly from market-garden scale operations. Horticulture will therefore be an important skill in the community. Field crops will require careful selection of suitable land and high standards of husbandry, particularly for cereals. It is anticipated that orchards and fruit growing will be concentrated on suitable sites with associated shelterbelts and appropriate topography.

The calculation of 12 000 crude carrying capacity in no way suggests that this is is an optimum population. Community planners might substitute production for export against production for internal use. This,however, depends on other factors, particularly energy production.

The food strategy may be summarised as follows:-
3000 ha of cultivable land are used, 8000 ha of improved grazings and 10 000 ha of rough grazings. This produces 3500 tons of vegetables, 1600 tons of fruit, 1200 tons of cereals, 5million litres of milk, 1350 cattle, 4000 sheep, 2300 pigs, 24 000 chickens and 2.2 million eggs every year, as well as exploiting a wide variety of wild animal

populations. Such a scenario represents a considerable increase in the level of resource use in Mull.

Table 9.3 Summary of diet composition (as detailed in appendix 9B)

Item	g/person/day	kcal/head/day	g. protein/ head/day	land/head (m^2)
Vegetables				
- under glass	175	21	1.3	12.4
- garden	360	83	7.2	92.5
- field	235	193	4.8	19.7
Cereals	274	985	35.0	250.0
Fruit	360	109	2.1	226.0
Dairy	146	358	13.0	see text
Meat	139	381	22.2	see text
Honey	25	70	trace	see text
Total		2200	85.6	

9.3 Technical constraints

9.3.1 Natural environment

The inimical nature of climate and soils raises the question whether the yields specified in the food strategy for fruit, vegetables and cereals could be achieved. They certainly could be in extremely limited areas of the island, but the areas listed above would require an extensive programme of recultivation and reclamation, coupled with the planting of shelterbelts to reduce the local effects of exposure. Most of the techniques of reclamation are already in existence, but nowhere in the West Highlands has the potential of these techniques for land reclamation been thoroughly tested.

The previous section considered only agricultural potential, while the outcome makes it clear that other uses, particularly forestry, will have an important place in the overall economy. The analysis of forest potential, detailed in Chapter eight, shows how the pattern and scale of output of forest products is already set for the first half of the scenario. Opportunities exist for small increases in output above this projection by the first decade of the next century. In view of the prospects for land use outlined above, in particular the under-use of rough grazing, it seems very likely that forests will be maintained and felled areas replanted, and that there will be some afforestation of open ground. This implies about 500ha of thinning, 250ha of clear felling and a further 250ha of replanting each year, a system which would stabilise by the mid-21st century to an annual production level of some 80 000 m^3 per year. This involves a forest area of some 15 000 ha (slightly more than at present). The more significant development from the point of view of input will be the establishment of trees and other woody plants for shelter and amenity. This will in the long term yield a more diverse range of timbers for general use, and will improve yields from other biological production systems by improving microclimate. Total timber production in the system might therefore be expected to be maintained at about 100 000 m^3 per year by the end of the scenario.

9.3.2 Energy resources

A potential use of the island's resources which is at present grossly underused is the generation of energy. The development at this stage of a picture of Mull as an economy rather than simply as a food producing system requires that some assessment be made of the necessary inputs. Energy is obviously important, with imports to Mull estimated at some 50 GWh per year. At present, this goes almost entirely on transport and domestic uses. The detailed analysis of energy will not be pursued here; this subsection simply looks at estimates of primary energy supply potential and the range of end-uses, and assesses the capability of supply to meet demand. In this way energy imports can be minimised, thus improving the balance of payments. Indigenous sources of energy available in Mull are mainly renewable in nature. The chief common characteristic of such sources (hydro, wind, tidal, wave, solar) is their naturally variable nature which never automatically matches the demand pattern. A storage element is therefore required; it is envisaged that this could take two forms, pumped storage of water for electricity gneration, and electrolysis of water to make bottled hydrogen. The first of these is a well-proven technology, and in this scenario it is expected that the first scheme in Mull will be in operation by the end of the present century. These storage elements will be supplied through the grid by a variety of renewable energy sources.

Hydro-electricity generation is on first sight very attractive, since Mull has very high rainfall and a mountainous terrain. However, the radial nature of runoff from an island means that most catchments are small, while the impermeable geology allows little in-catchment storage of water and hence flow patterns that tend to high flow rates during and immediately after rain, falling rapidly to very low rates in dry periods. Utilising such runoff from a small catchment necessitates trading off efficiency of utilisation of runoff (the proportion of runoff passing through the turbine) with the capital cost of dams and other engineering works capable of improving the pattern of water supply to the turbine. A preliminary survey using 1:50,000 maps and simple technical data (12) revealed 19 sites with a potential yield of at least 0.2 GWh per year (Table 9.4 and map 9.1). These estimates were calculated using the following simple model:-

$$\text{Annual energy output (GWh per year)} = (R - P_e) \times r \times A \times H \times 0.6$$

where:- R = annual precipitation (m/year)

P_e = potential evapotranspiration (m/year)

r = capture factor, assumed to be 0.4 (ie. 40% of runoff passing through turbine)

A = area of catchment above capture point (m^2)

H = head of water from capture point to turbine (m)

0.6 = mechanical system efficiency (penstock, turbine & generator)

The model is most applicable to relatively high head systems using a Pelton wheel driving an alternator. The traditional water wheel is a high torque, low rpm machine more suitable for low head sites with a relatively high flow of water. Thes sites have not been taken into account, and so there are other sites where smaller hydro-electricity installations or water wheels (for direct mechanical applications such a milling) could be used.

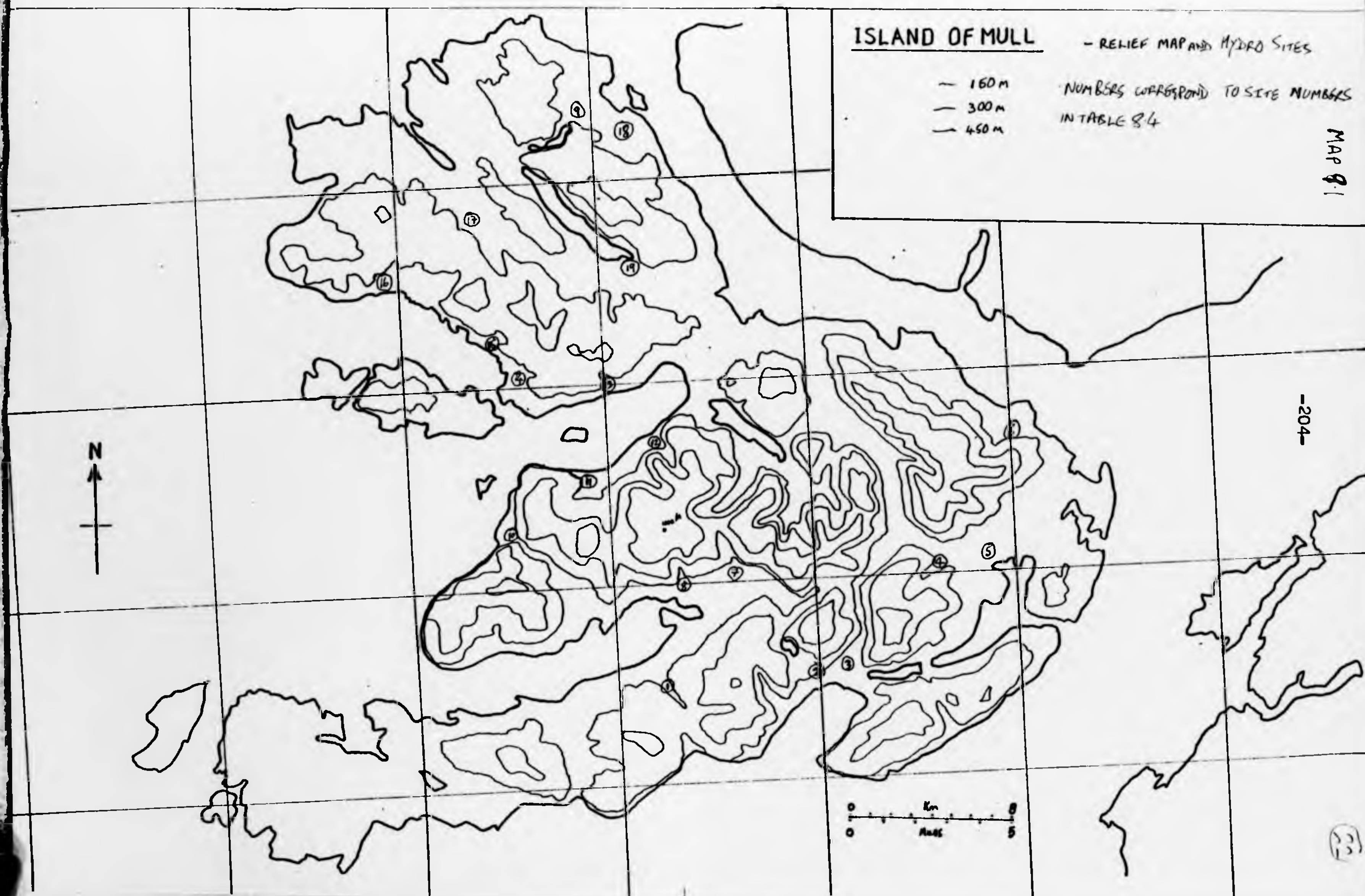

ISLAND OF MULL
- RELIEF MAP AND HYDRO SITES
— 160 m
— 300 m
— 450 m
NUMBERS CORRESPOND TO SITE NUMBERS IN TABLE 8.4
MAP 8.1
N
Km
Miles

Table 9.4 - Major sites with hydro-electricity generation potential

Site	Catchment area (ha)	Head (m)	Annual output (GWh)	Mean power (KW)
1. Glen Leidle	975	75	0.86	98
2. Loch Fuaron	288	200	0.78	90
3. Airdeghlas	856	45	0.53	60
4. Gleinn Sleibte-coire	408	120	0.67	76
5. Loch Bearnan	456	60	0.38	42
6. Scallastle	308	105	0.44	50
7. Teanga Brideig	392	105	0.56	64
8. Glean Dubh	376	75	0.38	44
9. Mishnish	592	135	0.66	76
10. Balmeanach	264	90	0.25	28
11. Derryguaig	1060	60	0.66	75
12. Scarisdale	468	60	0.29	33
13. Kellan Mill	480	120	0.59	68
14. Lagganulva	316	90	0.30	34
15. Kilbrennan	360	90	0.34	38
16. Kilninian	248	135	0.26	30
17. Kengharair	184	105	0.20	22
18. Druimfin	1200	60	0.74	85
19. Loch Frisa	3425	30	1.04	120
Totals			9.9	1133

The use of wind to generate electricity is a less well-tried technology, but preliminary examination suggests it might be an attractive option for the West Highlands in the future. At a purely theoretical level, the power flux behind the average windspeed across the island, on a front (say) 40km long by 50m high, is expressed by:-

Maximum useful power (watts) = $0.65\ AV^3C_p$

where A = cross-sectional area (m^2)
V = average windspeed (m/second)
C_p = power coefficient = 0.59
(13)

For a mean windspeed of 6 m/second, this represents a power flux of some 163MW. This would amount to an annual energy supply of over 1000GWh. Thus even 5% of this figure would more than cope with the existing primary energy demand on the island. Twenty windmills with a maximum useful output of 1 MW, capable of delivering this for 25% of the time and 50% for another 50% of the time could supply 80 GWh (14). Favourable sites for mills are abundant in Mull, the main problem (apart from technical feasibility) being the physical dangers associated with these machines. Access to their immediate vicinity must be restricted, so remote sites are preferable; there are also possible amenity objections and technical problems of matching the power generated to an electricity grid.

Tidal power is a renewable energy resource which has seen little application, but large amounts have been spent on research and development. The only full-scale unit in operation in Europe, at La Rance in France, illustrates the design concept on which development studies are focussed. This involves a large funnel-shaped estuary with a large mean tidal range (at least 5 m.). Such sites are rare in the Scottish Highlands, but a different opportunity is presented. There are a number of large sealochs with relatively narrow entrances and consequently a substantial tidestream. There is one such site in Mull, Loch a' Chumhainn, rear Dervaig, which has an area approaching 1 km^2, an entrance about 100 m across and a mean tidal range of 2.6 m. A consultant giving evidence on the feasibility of the proposed Severn barrage (15) suggested that potential energy (measured in GWh per year) would be:-

$$P = 1.2\ AR^2$$

where:- A = area impounded (km)
R = mean tidal range (m)

Thus for this site, P = 8.1 GWh per year, of which perhaps 25% would be usable, ie 2.0 GWh, or a mean output of 230KW. Whether the relationship holds for the radically different circumstances of the Mull site is unknown.

Solar power, in an area of persistent cloud cover, would not appear at first as an attractive option. However, the Island of Tiree, ten miles to the west, has the meteorological station recording the highest long-term mean annual sunshine hours in the UK. Low-lying western areas -Iona, The Ross of Mull and Mornish - may well have quite a significant potential. Solar powered systems producing hot water are already installed in Iona. Proved solar technology at present is mainly concerned with space heating and the production of hot water, both end-uses which have a poor seasonal match of demand with this source of supply. However, future development of photovoltaic cells may well allow a contribution to electricity supply from this source. Potential output is difficult to quantify at this stage.

Wave power could conceivably make a contribution to an integrated system such as the one envisaged here. Power fluxes of 70 KW/metre of wavefront are quoted (16). 1 Km of barrage, able to extract 30% of this power for 30% of the time, would generate over 50GWh each year (14).

Two other energy sources are already used on the island, in the shape of waste timber and peat. 5000 tons per year of timber would represent 20 GWh of heat (17). Their main application would seem to be as a source of space heating, hot water, cooking and other direct heat sources. Conservation will be an important aid to efficient energy use, particularly in the domestic situation; up to 30% of domestic energy uses could be saved in this way (18).

Two hydroelectric pumped storage schemes would be a vital component of an integrated supply system for the island. One prime site on the south coast would use Loch Fuaron as an upper reservoir and Loch Buie as the larger lower reservoir. The height difference is over 200 m, and a supply capable of delivering power without input for seven days would yield about 10 MW mean supply (88 GWh per year), plenty of power provided the means were available to fill it. A second scheme in the north could have two stages, the three reservoirs being Loch Frisa, the Mishnish Lochs and Loch an Airde Bheinn. This scheme would be slightly smaller, but offers the opportunity of making use of catchment water over a wide area by pumping surplus water from Loch Frisa up to Mishnish and letting it out through Tobermory. This could probably generate 55GWh per year on similar assumptions.

Distribution and supply networks for such an ambitious scheme certainly present problems, but they are not thought to be insuperable. Careful monitoring and skilled control would be required to keep the system functioning efficiently. A considerable bonus would be the integration of hydrogen production into this pattern, thus producing a fuel suitable for transport and mobile machinery as well as electricity.

In conclusion, it can be said that Mull holds out a range of attractive possibilities for power generation. The crude calculations described here may be brought together to provide a first approximation energy strategy.

Primary supply to electricity (and possibly to hydrogen):-

Hydro	10 GWh/year
Tidal	2 GWh/year
Wind	80 GWh/year
Wave	50 GWh/year
Total	142 GWh/year

Hydroelectric pumped storage:-

Loch Fuaron	88 GWh/year
Mishnish Lochs	55 GWh/year
Total	143 GWh/year

Matching such potential supplies to appropriate end uses is not practicable without considerable further research into the technical characteristics of the technologies involved and more detailed environmental data to calculate potential output. Present energy use of 50 GWh/year for a population of 2500 probably does not not necessarily imply a need for 240 GWh/year for 12 000, because the existing demand consists mainly of transport and domestic uses. With changes in the economy leading to less energy use for passenger transport and better domestic energy use, the 140GWh/year plus timber, peat and solar sources which this review has identified would be quite sufficient to enable the community to become self-reliant in energy.

9.3.3 The shape of the economy

Thus far, the specification of the scenario has leant heavily on self-sufficiency. The concept of self-reliance goes further, however, and involves the evaluation of a rather more open system. Such an economy would for political and social reasons have a far higher preference for internal transactions than at present. Elimination of external trade would lead to serious sub-optimisation of resource use, a situation corresponding to that in Chapter seven. It is anticipated that the community will need to import hardware, particularly machinery and some materials, and would thus need to export commodities whose value on external markets would be of similar magnitude to the imports. The necessity for such a balance of trade is unavoidable - the main questions surround its size and composition, particularly in relation to the internal economy of the island. While it is not envisaged that the present overwhelming volume of external trade should be eliminated overnight, it is held that an important criterion of the necessity for imports will be whether the island is capable of producing an adequate substitute.

Exports, on the other hand, will be based on industries processing natural resources derived from the island. This will include a range of timber products and perhaps surplus agricultural output. The vague nature of such a statement simply emphasises the importance of external circumstances in determining the shape of the island's economic activity.

Certain novel processes seem likely to be developed; the use of timber, peat and other organic materials as a chemical feedstock for an organic chemical industry has been proposed in the 1970s. The main apparent barrier to such developments in the present day is the importance of economies of scale. The cost savings of large volume processing plant outweigh the extra cost of assembling raw materials at a single site and distributing the products. The transport element in this procedure is energy intensive, therefore a society with higher relative costs of energy will have less incentive to use larger plant. The development of local processing plant producing chemicals and plastics therefore seems probable rather than simply possible in this situation. This raises another interesting series of questions, concerning downstream processes manufacturing finished goods. Will such processes necessarily be carried out close to the point of origin of the raw material? What if one product requires materials from different areas? In such cases the question of locational advantage arises. From such a standpoint, Mull would appear to be well-placed. Its natural resources are not immense, but energy (otherwise expensive) is available. A coastal position encourages transport by sea (relatively cheap). With increasing recognition of the importance of social factors, Mull is quite clearly an attractive place provided certain facilities (communications and a community large enough to provide peer groups of a variety of ages and inclinations) are available.

In the final analysis, the shape of the economy will merely be influenced by these technical factors. The forces which shape its character will arise from the efforts and motivation of the population, whose actions are the subject of discussion in the next section.

9.4 Human constraints

9.4.1 Inputs

An examination of the history of change in the West Highlands suggests that the community in Mull are extremely unlikely to embrace this scenario and commence a vigourous campaign to turn it into reality. The Highlander has long been noted for his caution when faced with new ideas, and his reluctance to relinquish long-established social and economic relationships. It has been suggested (19) that this is:-

> "....an adaptive response made by populations as a protection or hedge against the disadvantages that accrue to them as a consequence of the way they are integrated with the economic system of a wider society...."

in other words, that conservatism (in the widest sense) has been a sensible response in the context of a community in decline. However, this scenario will only take root in a different context, one that (as argued in Chapter six) is already beginning to take shape. In Mull, the decline in population which has lasted over 200 years shows every sign of stopping, and even perhaps being reversed. Secondly, the last vestiges of hereditary landlordism are likely to have gone by the end of the century. Herein perhaps lies the most controversial aspect of the scenario. It is held that the development of resource-use outlined above will only take place if those resources, most particularly land, are in common ownership and under direct control of the community. This goes against a thousand years' tradition of ownership rights; but the necessary motivation required of individuals to make this pattern of resource-use work could never be achieved unless each individual has an equitable stake in the outcome. The present generation of landowners are, by and large, individuals of the highest integrity; but a system which gives even a chance of one person making off with a killing (in other words taking financial capital out of the system), the motivation for others to ensure its success cannot be generated. As one landowner pointed out to the author:- "..If the government squeezes too hard (with tax), I will not be the loser. I can always sell up and go abroad. The losers will be the people who work for me." He undoubtably told the truth. The failure of the political system at large to grasp this particular nettle will lead most probably towards a form of anticipation B, in which land is largely under the external control of the state and possibly business institutions (insurance trusts, pension funds, investment enterprises). Whatever the mix, the likelihood of Mull residents being able to reap the benefits of their actions would be low, and thus so would motivation. The alternative of a continuation and a revival of hereditary landlordism seems remote, unless anticipation A comes to fruition well before the end of the century.

The precondition of community ownership and control being satisfied, the range of skills that the population will need to develop is impressive. Of primary importance will be horticulture, agriculture and energy generation technologies. The number of people engaged in these areas will depend on:-

i) the amount of appropriate energy available to support the agricultural system,

ii) the development of appropriate techniques of cultivation and animal husbandry (an important first move in this direction would be to set up a small community-backed research unit to look into this question),

iii) the relationship of occupation to lifestyle, and the extent to which any one individual may be involved in a particular job.

iv) The first three will all affect the ability of the system to engage in manufacturing and trade, and the level of servicing required to maintain the economy.

The specification of skills and manpower requirements is thus dependent on the organisation and structure of the community.

9.4.2 Community structure and administration

i) Administration

In this section, the expected social structures reflect in large measure the more desirable aspects of the structures described in the parallel section of Chapter seven. The main difference is that the development of such structures is conscious and deliberate. As Robertson asserts:-

> "....My guess is that the new name of the game will be the development of shared consciousness; and that religion, politics and economics will come together again in this single vision of the meaning of life...." (20)

At this stage, the picture of Mull drawn in the final pages of Chapter six may be regarded as the appropriate model for an institutional framework for the resource-use strategy developed earlier. Geographically, there is some sense in the development of two interdependent communities operating as multi-function cooperatives. The following aspects of this framework are of particular importance.

ii) Systems of exchange

The majority of transactions between individuals are expected to take place within the system boundary. Most external transactions will be made by the cooperative as an entity. Thus internal exchange methods need not necessarily be identical to those used at a higher level. Perhaps the most appropriate method at this local level would be for each individual to have a credit account with the cooperative, to which he can contribute through work done within the community, rates for different tasks being mutually agreed, and which he may use for trading transactions with others. The most important problem this approach would face would be maintaining the balance between the freedom of the individual to allocate 'his' resources as he sees fit and the control of the cooperative as an entity over aggregate resource allocation in the system. It is envisaged that the relatively small size of the unit will make this easier to resolve than would be the case in a larger system.

Another element of the exchange problem is touched upon in Chapter seven. It is envisaged that, certainly in the initial stages, an appropriate level of investment of skills and materials would necessitate some redistribution of those two resources on a national basis. In view of the expectation of considerable increases in population, this could well be tied in with a national programme of resettlement and reconstruction of disadvantaged areas like the West Highlands.

iii) Education and health

The structure of these essential services under community control would surely be radically different from the present. Education would be more integrated with, and thus its programmes more closely related to, the processes and activities generated within the system. Health would be an important issue, with explicit knowledge of human physiology and psyche leading to discussion and subsequent adoption of appropriate diets and lifestyles. It is with this in mind that the diet described above was devised. The accent would therefore be on preventative medicine so that the role of the specialist medic would centre on coping with accidents and the (reduced) level of disease and ill-health that remained. The extent to which 'appropriate' lifestyles can be specified is very limited. They would evolve from the particular circumstances and processes in the evolving future.

9.4.3 The satisfaction of needs

This is a suitable point to return to the underlying criteria of success in determining carrying capacity - the satisfaction of need. The detailed specification of potential for satisfying physiological needs, and the necessary structures to support that system, seem to point to a tradeoff between a high population at basic levels of need satisfaction, or a rather lower population, pressing less on the absolute capability of their natural resource base, enjoying higher stability and satisfaction of needs at a higher level. There is therefore some doubt whetherthe projected population figure of 12 000 should actually be regarded as a target. Specification of such a balance would be difficult, including as it does both quantitative factors such as food, housing and material inputs, and such inherently qualitative factors as sense of community, ego and self-esteem and self-actualisation. The final section of this chapter speculates on the development of this scenario from the present to a likely outcome by the year 2030.

9.5 A likely outcome for anticipation C

The main part of this chapter has been concerned with limits encountered at an advanced stage of the scenario. This section describes the changes to be expected over the life of the scenario; this is not intended as a prediction, but rather to put the disparity between the present and the anticipated future into context.

9.5.1 Food.

An important development in this area is the deliberate pursuit of a more healthy diet, some features of which have been described above. At the same time, the desire for self-reliance leads to the specification of a diet derived from local food resources. It is expected that the former will precede the latter, the move away from highly processed products enabling wider use of indigenous products. It is expected that the dietary changes will come before the turn of the century, but that continued development of the diet and reclamation of arable land will restrain the full development of the food strategy until the second decade of the new century.

Another important aspect of the food strategy relates to demography. The calculations in section 9.2 assumed a population of 12 000, a remarkable increase from the present 2500. Mention has been made of the likelihood of a resettlement programme, and it is expected that this will bring in an extra 5000 people by the first decade of the next century, with perhaps a slower rate of immigration thereafter as resource-use systems are regenerated. Such a limit would reduce the likelihood of the Muileachs being swamped by an alien (predominantly urban-derived) culture. Natural increase is expected to be moderate or negligable throughout the scenario, with high standards of health care and lifestyle aiding effective family planning. Thus population figures are estimated as:-

Year	population
1980	2500
1990	3000
2000	5500
2010	8000
2020	9000
2030	10000

Thus, at the midpoint (2005 AD), population will be 6500, rising to 10 000 by the end of the time horizon. This pattern of demography suggests a pattern of landuse changing as follows:-

	1980	2005 (b)	2030
Arable (ha)	150	1500	3000
Pasture (ha)	2000	4400	8000
Rough grazing (ha)	78000 (a)	25000+	10000+
Forestry (ha)	10000	12000	15000

(a) a residual - not necessarily in use

(b) assuming similar dietary pattern and production systems as 2030

Such a significant reclamation of land involves a considerable increase in knowledge of techniques and the production systems involved. The only way in which this is likely to be achieved is if pilot work were put in hand to establish appropriate methods for reclamation in Mull. This might be done by setting up a small, externally-funded research and development unit, with the express intention of developing, demonstrating and disseminating new ideas with the active involvement of the community. Such a strategy lies behind the statement by Bryden and Houston (1977), quoted in Chapter one.

Another important element of food production will be the vexed question of land ownership. The making over of state land in the 1990s will be a considerable boost to the idea of a cooperative, but at that point it must be expected that a substantial amount of land will still be in private hands. Legislation resulting in compulsory purchase will become more and more likely unless certain concessions are made by the landowning fraternity by this time. This might mean making over land to a trust for the use of the community cooperative, provided thereby that any future financial advantage accrued to the community rather than to the individual, and that safeguards should be built in to minimise the opportunities for either party to renege on the deal. Otherwise, compulsory purchase will result in land passing into state hands, the taxing of capital gains making large inroads into any advantage landowners gain by liquidating their assets.

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9.5.2 Energy

The hydro-electric element of the energy potential outlined above is capable of construction and implementation in the near future, beginning perhaps with the northern pumped storage scheme. This would in the first instance use off-peak electricity from the central boards. Moves towards generating electricity internally should be being made by the 1990s, and most of the small hydro schemes listed could be operating by the end of the century. Solar heating may also be expected in some parts of the island from now onwards. A rather more difficult problem involves fuel for machinery and transport. The development of suitable hydrogen generation systems (large research programmes are currently under way in the USA, West Germany and Japan, but not in the UK) may be expected to provide a viable alternative to petroleum by the end of the century. In Mull, this will provide a stimulus for utilisation of additional sources of primary power, first wind and then waves, in order to use hydrogen technology rather than import the fuel. Tidal power is seen more as a one-off scheme. An interesting possibility is that the site may be picked up for use as a testing ground to find how power might be derived from Connel (Loch Etive) and Ballachulish (Loch Leven), to name but two similar sites in the region. The rough estimates in the section on energy showed how such a scheme could make a significant contribution to supply.

Alongside this development of indigenous energy sources will be a radical change in attitudes to energy use. Development of methods of conservation will be implemented and the analysis of energy flows alongside financial flows will become prominent in decisionmaking systems. Both these developments are in hand today, and may be expected to take effect before the end of the century. They may be expected to stimulate efforts to find out more about the basic systems relationships and thus increase sophistication of understanding and control of resource use systems. The effectiveness with which such a system may be used is in direct proportion to the understanding of the way it works. Thus to 'work up' an ecosystem like Mull closer to its limits must involve a concomitant increase in understanding unless its stability is to be threatened.

End uses are difficult to predict. Electricity and hydrogen are generated from compatible sources of primary power, and it is envisaged that these two supply modes will cope with most demands. Domestic and 'industrial' uses will increase at the expense of transport. Passenger transport in particular is expected to decline with changing fashions in Tourism. All these factors derive from the shape of the economy as a whole, to which attention is now teurned.

9.5.3 Economy

Mull's economy depends at present on the export of sheep, cattle, timber and shellfish, coupled with a net income from tourism. There are, however, important 'invisible' earnings. For example, there are a relatively high proportion of residents receiving pensions - a net input of finance from government and pension funds. There are also early-retired and relatively wealthy individuals whose level of economic activity is partially or wholly composed of income from external investments. The balance of trade is thus much more than simply the difference between material imports and material exports. This should be borne in mind as the development of the economy outlined here is described.

The formation of the cooperatives will result in an important new element in the economy. For the first time, an organisation will be taking decisions of direct economic significance with the well-being of the community of Mull as its primary objective. At first, its activities will be limited to the service industries, then perhaps to some experimental involvement in the secondary sector - perhaps into downstream manufacturing from timber resources. A big hurdle on this route will be the handing over of the primary industries to this community-based organisation. At first, this will be primarily forestry, plus those estates and farms in public ownership. The present hierarchical structure of the Forestry Commission will be dismantled, leaving individual forests under local control, with a smaller control body acting in an advisory role on management and cultivation techniques. Forest products will be processed or semi-processed. It seems very likely that a small chipping plant will be installed at Craignure before 1990, to ease handling problems associated with roundwood. The possibilities for manufacture will depend on availability of energy, expertise and the identification of markets.

A large group of peripheral industries seems likely to grow up around the food production system, processing non-food byproducts such as leather, horn, oils and fats, bonemeal etc. This will depend on the island developing its own slaughtering facilities. Such a facility may be one way of bringing the farming fraternity into the cooperative system, because increasing problems of marketing will force individuals into a workable cooperative scheme. At present, marketing cooperatives can never succeed as commercial enterprises while individuals retain the right to drop out temporarily to make a quick buck on a good deal. In the end, by the first decade of the 21st century, the cooperative will have developed into a locally-controlled microeconomy, still dependent on the outside world, but now generating and reinvesting capital (in terms of skills, finance and fixtures) internally. Agriculture by this time will have changed its nature, swinging away from livestock to horticulture, fruit and field crops, and diversifying its livestock interests. These tendencies and trends will be encouraged by the increasing cost of transport, which will disadvantage remote sites of production and encourage decentralisation of economic activity by creating an environment in which peripheral economies (such as Mull) may regenerate.

9.5.4 Carrying capacity

The analysis contained in this chapter highlights the qualitative aspects of carrying capacity. A capability to provide an appropriate diet for 12 000 people is not an absolute limit; more could be accomodated if the diet were to be modified, or if the production relationships were radically altered. The dynamics of such relationships are considered in Chapter ten. The figure of 12 000 therefore corresponds with the cultural and political framework within which the scenario is constructed. One factor remains ill-defined, the question of **standard** of living. It is inevitable that a considerable part of economic activity in Mull will be oriented towards the establishment of a favourable balance of trade. As land resources are the main raw materials, it does not make much sense to maximise food production at the expense of other elements in the hierarchy of needs. The extent of this tradeoff in the future is difficult to establish from the present. What is certain is that explicit recognition and use of such a concept will aid the effectiveness of the resource-use strategy.

In conclusion, therefore, Mull is expected to be supporting a population of 10 000 by the year 2030, four times the existing population and slightly more than anticipated in Chapter seven. There is a considerable difference between these scenarios, for the population in this case have more opportunity to satisfy needs at all levels, a more stable population (without the threat of population size exceeding resource capability) and hence a more sustainable system of resource-use. The final question concerns their future prospects. These are very good, whether they decide to try and maintain stability and equilibrium, or whether they find another developmental objective. The latter is historically more likely, and the future adaptive potential presented by the outcome of this scenario can only aid them on that path.

* * * * * * * * * * * * *

Notes to text

1. C.J.Robbins (ed) (1978) Food, Health and Farming
   Centre for Agricultural Strategy paper no 7.
2. H.Liddell (ed) (1979) The Aberfeldy Project - A Study in Self-Sufficiency
3. R.Passmore (1970) Recommended intakes of nutrients for the UK
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Appendix 9A - Detailed components of the Aberfeldy diet (2)

	item	kg/person/year
Vegetables -	Asparagus	2.0
	Aubergine	7.5
	Broad beans	2.0
	French/Runner beans	6.1
	Beetroot	7.3
	Broccoli	1.4
	Brussels sprouts	8.2
	Cabbage	10.4
	Carrots	25.0
	Cauliflower	9.5
	Celery	9.1
	Courgettes	6.1
	Cucumber	3.2
	Kale	2.5
	Leek	7.9
	Lettuce	6.8
	Marrow	3.4
	Onion	17.7
	Parsnip	2.0
	Peas	5.4
	Peppers	3.2
	Potato	55.8
	Spinach	15.7
	Swede	1.4
	Sweetcorn	5.0
	Tomato	27.9
	Turnip	2.3
Fruit -	Apple	49.0
	Pear	8.9
	Raspberry	8.4
	Blackberry	6.4
	Loganberry	8.2
	Strawberry	10.2
	Gooseberry	2.0
	Currant	12.0
	Cherry	11.1
	Plum	11.1
	Rhubarb	4.1
Dairy Produce-	Butter	18.2
	Cream	10.5
	Milk	16.6
	Yoghurt	26.7
	Cheese	15.0
	Eggs	264 eggs
Meat		10.9
Grain (various)		69.5
Nuts		9.5

Other contributions from fish, poultry, herbs and honey not quantified.

Appendix 9B - Detailed composition of diet used to calculate food production strategy

A summary table is presented in table 9.3

Vegetables

Under glass	kg/head/ year	yield t/ha.	area m^2/head	g/head/ day	kcal/head /day	g.protein /head/day
Celery	9.1	36.7	2.48	24.9	1.2	0.1
Cucumber	3.2	219.3	0.15	8.8	0.9	tr
Peppers	3.2	35.0	0.91	8.8	1.2	0.1
Tomatoes	27.9	113.1	2.47	76.4	10.7	0.7
Lettuce	6.8	23.0	2.96	18.6	2.2	0.2
Courgettes	6.1	150.0	0.41	16.7	1.7	0.1
Aubergines	7.5	25.0	3.00	20.5	2.9	0.1
Sub-total			12.38	175.0	20.8	1.3
Garden scale						
Asparagus	2.0	1.5	13.30	5.5	1.0	0.2
Broad beans	2.0	10.3	1.94	5.5	2.6	0.2
Runner beans	6.1	10.0	6.10	16.7	3.2	0.3
Beetroot	7.3	30.7	2.38	20.0	8.8	0.4
Broccoli	1.4	15.0	0.93	3.8	0.7	0.1
Brussels sprouts	8.2	12.5	6.56	22.5	4.1	0.6
Cabbage	10.4	25.0	40.20	28.5	4.3	0.5
Carrots	25.0	38.1	6.56	68.5	13.0	0.4
Cauliflower	9.5	19.6	4.85	26.0	2.3	0.4
Kale	2.5	15.0	1.67	6.8	0.6	0.1
Leeks	7.9	22.8	3.46	21.6	5.2	0.4
Marrow	3.4	12.0	2.83	9.3	0.7	tr
Mushrooms	5.0	127.9	0.39	13.7	1.8	0.2
Onions	17.7	33.9	5.22	48.5	11.2	0.4
Parsnips	2.0	22.0	0.91	5.5	3.1	0.1
Peas	5.4	3.1	17.42	14.8	7.7	0.7
Spinach	15.7	12.0	13.08	43.0	12.9	2.2
Sub-total			92.52	360	83.2	7.2

(continued over)

Appendix 9B (continued)

Field vegetables	kg/head/ year	yield t/ha.	area m^2/head	g/head/ day	kcal/head /day	g.protein /head/day
Potatoes	82.1	30.5	27.40	225.0	191.3	4.7
Turnips	3.7	32.5	1.14	10.1	1.6	0.1
Sub-total			28.54	235.1	192.9	4.8
TOTAL VEGETABLES			135	770	297	13.3
Cereals						
Oats	50	4.0	125	137	549.4	17
Wheat	50	4.0	125	137	435.7	18
TOTAL CEREALS			250	274	985	35
Fruit						
Apple	49	11.0	45	134.2	47.0	0.3
Pear	8.9	5.0	18	24.4	7.1	0.1
Raspberry	8.4	4.5	19	23.0	5.7	0.2
Blackberry	6.4	5.5	16	17.5	5.1	0.2
Loganberry	8.2	5.5	15	22.5	3.8	0.2
Strawberry	10.2	6.5	16	27.9	7.3	0.2
Gooseberry	2.0	6.0	4	5.5	0.9	0.1
Currant	12.0	5.5	22	32.9	9.2	0.3
Cherry	11.1	3.0	37	30.4	14.3	0.2
Plum	11.1	3.5	32	30.4	7.9	0.2
Rhubarb	4.1	35.0	2	11.2	0.7	0.1
TOTAL FRUIT			226	360	109	2.1

Appendix 9B (continued)

Dairy	g/head/day	kcal/head/day	g.protein/head/day
Margarine/butter	25.0	182.5	tr
Milk	54.8	36.0	1.80
Cheese - Cheddar	20.5	83.0	5.33
- Cottage	20.5	20.0	2.80
Egg	25.0	37.0	3.10
Sub-total	145.8	358.5	13.03
Meat			
Beef	66.0	185.0	10.40
Mutton	12.0	40.0	1.70
Pork/Bacon	25.0	85.0	3.40
Poultry	11.0	8.0	1.40
Venison, Game & Marine	25.0	63.0	5.25
Sub-total	139.0	381.0	22.15
Honey	25.0	70.0	tr
TOTAL ANIMAL PRODUCTS	309.8	809.5	35.18
GRAND TOTAL		2200	85.6

PART FOUR - SYNTHESIS

Chapter ten - Discussion and comparison of the scenarios

Chapter eleven - The appropriatenees of resouree use and technology

Chapter twelve - In conclusion

CHAPTER TEN - DISCUSSION AND COMPARISON OF THE SCENARIOS

10.1 Introduction

This chapter examines the analysis of the 'potential of the Island of Mull for the support of a human community' carried out in the preceding three chapters. It examines the adequacy of the methodology and compares and contrasts the results, concluding with an assessment of the important common features identified. A particular interest is the relationship between the present-day situation and these long-range futures. The point was made earlier that the scenarios are exploratory, examining the future from the perspective of the present in order to see where some perceived present-day trends might be leading the community of the study area. This chapter examines the notion of appropriateness as defined by the need to maintain system function in the three scenarios, and opens the discussion of the more normative definitions of appropriateness considered in the final chapters.

The chapter begins with an examination of the carrying capacity concept and its use in the three scenarios. This is followed with a comparison of the treatment given to various aspects of resource use and technology in the scenarios. Finally, conclusions about the outcomes of the scenarios for Mull provide a lead-in to a more general discussion of appropriateness in Chapter eleven.

10.2 Carrying capacity

The theoretical background and rationale for using carrying capacity was described in Chapter two. This left several problems unresolved, which receive attention here.

10.2.1 The feasibility and adequacy of the solution

Maslow's hierarchy of needs specifies five levels of concern for individual needs. The C^3 calculation in the second sections of Chapters seven and nine produces a feasible solution in terms of basic physiological needs for food and water. However, the solution's feasibility is only assured for these basic needs. The satisfaction of higher level needs for security, belonging, esteem and self-actualisation will have some effect on the demand for physical output and the characteristics of skills and organisation within the community, affecting all physical output. In addition, the causal relationships of the food strategy itself are incompletely specified, and hence the solution to the C^3 algorithm is feasible only if the assumptions of production characteristics hold. In particular, analysis of labour and energy requirements is rudimentary in both cases.

Constraints may be considered to take three forms:-

I) Absolute system constraints - these are not susceptible to manipulation by human agency, and include climate parameters, total land area and technical relationships governed by the laws of physics. They are in fact relatively few.

II) Techno-economic constraints - these depend on the skill and resources of the community and the perceptions of costs and benefits held by the population. For example, the area of cultivable land depends as much on the perceptions of what is worth reclaiming as much as on the techniques of doing so. Such constraints are specified in these scenarios on the basis of available circumstantial evidence.

III) Arbitrary constraints - these are imposed by the author in an attempt to cut down the level of complexity and produce a manageable calculation. A prime example of this is the specification of the plant products strategy in Chapter nine, where the actual constraints imposed by the dietary requirements would allow many different combinations of (say) quantities and types of vegetables. This is reduced to one combination by imposing an essentially arbitrary mix of vegetables.

The imposition of type III constraints is acceptable as long as the assumption (that doing so does not seriously influence the outcome for the total C^3 algorithm) holds. If a small change in one such constraint could make very large changes in the overall outcome, then the proposition that a feasible rather than an optimal solution is sufficient (because the important coefficients change more between scenarios than within them) cannot be sustained. This is undoubtably a serious shortcoming of the approach. However, attempts to improve the situation return immediately to the relationship of the model (however incompletely specified) with the real system. This may be illustrated by the development of a fodder strategy in Chapter nine. If the dietary requirements of cattle are completely met by the specified constraints on dry matter, starch equivalent and digestible crude protein, it is possible to specify a simpler diet allowing production of more ration-days on the same land area. Such a course of action affects two constraints. It is known that the specification of diet is incomplete. The animal's nutrition also involves fibre, vitamins and trace elements which should theoretically be specified. Knowledge of animal nutrition is sufficient to do this for cattle, and composition of fodder could be the subject of a series of assumptions based on the available evidence. However, such analysis would be far more detailed than other associated areas, and important factors such as the seasonal variation in nutritional needs of the animal, or energy and labour requirements for fodder production are ignored. Secondly, the dependence on two crops increases specialisation and reduces adaptive capabilities in the event of crop failure, disease or other such unexpected changes in system status.

Similar considerations apply to human nutrition. The constraints specified similarly fail to take into account vitamins, trace elements and other minor needs, and undue adherence to the stated dynamics results in a situation which stretches dependence on particularly nutritious or productive crops. In Chapter nine, some of these problems are tackled with type III constraints as outlined above, but the community in Chapter seven is open to these risks. Coping with these problems blurs the distinction between the C^2 and C^3 algorithms, and the final sections of Chapters seven and nine reassess the solution in terms of some C^2 constraints. It should be clear that C^2 constraints are even less well-specified than the C^3, and also that the C^3 stage was necessary to reach any feasible solution at all. In these sections, the C^3 solution is treated as a partial solution and changes resulting from the application of C^2 constraints are briefly considered. Space and information are such that a more detailed assessment of C^2 cannot be sustained in this project. The outcome is therefore termed 'Pragmatic Carrying Capacity' (PCC).

Chapter eight is developed in a different way, and thus is less directly comparable to the other two. The difference derives from the specification of a much larger system boundary within which Mull is a small component. The centralised planning anticipated in the scenario assigns Mull a specialised role within a larger strategy which might overall take a similar form to the holistic approach of Chapters seven and nine. In Chapter eight, Mull is assessed on its ability to fulfil an assigned role. The assessment may be stated on the form of another LP algorithm:-

Size of Community (C^1) = solution of [size of community needed to supply labour requirements for <u>maximum raw material output</u>
given: Nature of output
Technology
Resource endowment]

The resulting C^1 cannot be regarded as a carrying capacity, because massive transfers of raw materials across the system boundary are enabling the support of communities outside the study area. There are similarities, however, and it is on these that this chapter concentrates in order to point out the significance of these three long-range scenarios for the present situation in Mull. The major similarity is that an important principle in the approach to strategic planning outlined in the development of the scenarios in Chapter six is that a component area like Mull should be in broad balance in terms of inputs and outputs. Unless one returns to explicitly economic models, the only way this balance can be evaluated is in terms of the satisfaction of individual needs both within the study area and at some abstract higher level. This is because of the heterogeneous nature of the tradeoffs, with physical outputs of timber, lambs and wool being evaluated along with unquantified benefits such as ability to satisfy the needs of tourists.

10.2.2 A comparison of outcomes in terms of need satisfaction

i) Basic physiological needs

Food is the most important of these, and it is around the expected food strategy that much of the discussion in the scenarios has revolved. Chapter eight differs in that food supply is assumed, and is largely imported. Table 10.1 shows a comparison of diet composition between the scenarios if one assumes that the essential characteristics of a diet for Chapter eight would resemble the present day pattern, with most food imported to the island and most of that in a highly processed form. The differences stem from type III constraints on diet (particularly the high cereal content in Chapter nine and the high vegetable content in Chapter seven), and a series of type II constraints, most important of which is illustrated by the low contribution from meat in Chapter seven. The pressure on land resources in this chapter, coupled with low yields, produces a situation in which the size of the population

Table 10.1 - Comparison of diet composition

Item	Energy (kcal/day) as %			Protein (g/day) as %		
	Chapter seven	Chapter eight (1)	Chapter nine	Chapter seven	Chapter eight	Chapter nine
Meat	9	17	17	14	34	26
Dairy	23	32	16	35	29	15
Vegetables	46	7	14	31	9	16
Cereal	22	30	45	20	26	14
Fruit	-	4	5	-	-	-
Sugar	-	10	3	-	-	-
Totals	100	100	100	100	100	100

(1) Present day diet taken from HMSO figures, thus assuming that Chapter eight diet is the same.

can be increased by reducing the contribution from animal sources to the minimum level compatible with meeting protein requirements. The reason for this is obvious; animals require fodder, and the overall efficiency in terms of energy and protein production of such a system is less than an alternative in which land growing fodder is used for a crop for direct human consumption. Animals are worth having for two reasons, first because they produce a high-protein food from a low protein, bulky fodder and second because they are able to use ground which is not suitable for cultivation, particularly hill ground. Sheep are able to use such ground almost exclusively, but overdependence on sheep meat was countered by type III constraints on variety of diet, and by doubts about the wisdom of heavy use of hill ground exclusively by sheep.

The shape of Chapter nine diet was much more clearly laid out in the specification deriving from evidence of the impact of diet on the health of the population. In addition, higher crop yields were assumed (a type II constraint). Thus the total amount of protein is similar to the present day figure, but a larger proportion of that will come from vegetable sources, and the contribution from dairy products is reduced. This maintains cholesterol and fat intake within the constraints. It should be clear that if the crop production capability of Chapter nine were applied to the dietary standards of Chapter seven, the maximum possible population could increase substantially. This increase would be damped by the need to take a disproportionate extra area of agricultural land for fodder production.

Other components of basic needs are water and shelter. Given the prevailing climate of Mull and the landform, water is unlikely to be a problem even for much larger populations than those envisaged here, and the issue has therefore been assumed as a non-problem, except to mention the circumstances under which drought can occur. Housing and clothing are the physical needs to satisfy shelter. Plentiful wool and leather, and a substantial and underused existing housing stock assure first approximation satisfaction of these needs in Chapters seven and nine. In Chapter eight, supply of such items is once again assumed to be imported.

ii) Security needs

These take two forms. The first is 'security of supply' of the basic needs outlined above. The importance of the assessment of risk in terms of crop failure, disease and other expected changes in system status has already been discussed. Returning to Dearden's cup and ball concept (from Chapter two), if the ball is given to sudden and unpredictable jerks and changes of direction as it moves round the cup, it will be necessary to maintain the ball at a lower level on the sides of the cup in order to prevent it leaving the cup completely. Thus in the Mull scenarios, the system must be run at less than the highest intensity if the system is closed. One way of doing this in the food strategy is to retain a wide range of products in spite of differences of performance against criteria such as yield and energy and protein output. In Chapter eight, the problem may be assumed away by stating that Mull is 'insured' against such risks because it is a component of a much larger and diverse system. This is one of the main benefits of the interdependent nature of the existing Mull system.

The second aspect of security is that of protection from the depredations of other individuals and communities. In Chapters seven and nine, manpower and materials must be diverted to this purpose. Without considerably more detailed knowledge of system function, it is not possible to assess the impact this might have.

iii) Belonging needs, esteem needs and self-actualisation needs

The higher level needs become progressively more difficult to assess from the point of view of their quantitative significance. These three levels are all thought to be important determinants of individual performance and motivation, and hence up to a point act in a positive fashion on the system (ie. the desire for higher esteem should improve individual motivation, performance and thus improve overall system performance). Such qualitative considerations are the underlying reasons for the importance of modes of organisation, discussed at length in the later parts of each chapter. In the absence of any framework for the objective evaluation of the role of such needs, discussion now turns to the overall use of resources and technology in the three scenarios.

10.3 Resource use and technology

Previous discussion has considered the Mull system as a device for satisfying the needs of a human population. This section turns to the comparison of the different modes of use of resources and technology in each scenario with the present day situation. This discussion is carried out under five headings:- land, energy, machinery, skills and organisation.

10.3.1 Land

All three scenarios considered land as a common resource at the level of the whole system. At present, it is academic to do so; land is the property of individuals who hold rights over it, and there is no means whereby the use of that land can be planned in terms of system function. Land use is subject to the pressures of 'the market', distorted by a range of factors including location, availability of information about its dynamics and status, and government intervention in the shape of laws, taxes, grants and subsidies. Thus at present it is possible to see estates with large areas of cultivable ground unused because the prevailing economic circumstances as perceived by the owner do not justify the use of such areas. All the scenarios examine future situations in which land use is intensified; the argument supporting this expectation has been expressed earlier in the thesis. In Chapter seven, isolation and the pressures of an increasing population force reclamation of land for cultivation. The farming system is low input/low output, with limited abilities to provide fertiliser input, cultivate the ground except by labour intensive methods and control pest outbreaks.

In Chapter eight, production priorities imposed from above lead to a considerable intensification of livestock production on a smaller area, the balance going to forestry. In Chapter nine, increasing self-reliance of the community leads to increasing intensity of land use in the sense of reclamation and improved yields.

Forestry is maintained in Chapter seven, maximised in Chapter eight and slightly increased in Chapter nine. Forest management implies a long term view of priorities which may not be maintained in Chapter seven.

10.3.2 Energy

At present, energy is exclusively imported. The three scenarios show large differences in the nature of their energy supplies. In Chapter seven, energy is a considerable constraint on resource-use. Agriculture is largely dependent on animal and human muscle power. Wood and peat are the main heat sources. In Chapter nine, technical skills allow the exploitation of renewable energy resources. The analysis suggests that such sources are plentiful. In the absence of adequate data on the end uses required, it was not possible to specify the desired contribution from each source. Chapter eight assumes the import of energy supplies. This will not be largely petrochemicals as at present, but will be in the form of electricity and a substitute transport fuel. It is conceivable that a Chapter eight-type scenario could make use of some renewable technologies - wave and wind power are examples. If this happened, however, design and installation would be inspired and executed from outwith the island.

Another difference between the scenarios is the difference to which energy use is analysed and planned. At present, such activities are unknown at the local level, and rudimentary at the national level. In the first scenario, this approach is maintained, energy supplies being ad hoc and limited in flexibility. In Chapter eight, the general level of organisation and planning at a national level suggests some kind of management of supply mix, but the detail of such management is not considered at a local level; energy supply to the community is 'given'. Only in Chapter nine might one expect some local analysis of primary sources and end uses, and some matching attempted.

10.3.3 Machinery

Machinery is imported to the island at present, and local maintenance is rudimentary, being chiefly limited to parts substitution. In Chapter seven, these imports are cut off, and a scavenging technology is envisaged which makes use of the stock of machinery on the island (most of which will be useless in its original form because of the lack of energy resources) to produce devices of use in the changed circumstances of the scenario. In Chapter eight, the existing situation is continued and developed with more sophisticated and highly engineered machines which are even less suitable for local maintenance. Chapter nine represents a radically different situation, with devices suited to local conditions designed and built on the island, although materials and some standard components may be imported. The development of such a future would be critically dependent on the immigration of people with suitable skills (discussed in the next Chapter) and a suitable perception of economic costs and benefits of self-reliance. Such an approach to machinery use implies that value is attached to adaptive capabilities as well as to specialisation. This is pursued in depth below.

10.3.4 Skills

A technology may be defined in terms of machinery and skills. These skills may take the form of ability to design, build and use the machines, or the ability to manage a purposeful system and achieve a desired output or objectives. Skills can therefore be practical or abstract. The present-day community in Mull may be thought of as having a range of skills sufficient to maintain its existing function, but insufficient to allow developments of the kind envisaged in the scenarios without substantial modifications. The community at present lacks the range of skills required by a self-sufficient or self-reliant community, and lacks the depth of knowledge within the existing skill range to permit the intensification envisaged in Chapter eight. Thus the scenarios may be characterised by the skills required for their fulfilment.

In Chapter seven, many old rural skills for cultivation, using animals, preparing and storing food without modern aids and adaptive skills for coping with isolation will be required. In Chapter eight, the skills to use sophisticated machinery and to control an intensive resource use system will have to be improved, but the range of skills will still be limited, and hence dependency on external support maintained or increased. Chapter nine envisages immigration of people with new skills, particularly engineering, and improvement in depth of existing skills. The three alternatives may be characterised in terms of ecological niche with relation to equilibrium and evolving systems as described in 2.1. Breadth of skills is equivalent to adaptive potential, while depth of skills parallels specialisation. Chapter seven requires an adaptive community, generalists but not particularly well-adapted to the niche. Chapter eight requires a high level of specialisation and hence heavy reliance on the maintenance of stability of system status, for example in markets and prices for timber, imposed from outside. Chapter nine represents a situation where both adaptation and specialisation are important. This can only occur if the system is highly organised, such that the self-reliant economy can sustain a considerable internal division of labour.

10.3.5 Organisation

As the least easily quantified characteristic of the community, organisational structures and processes are the least susceptible to useful speculation. The cup and ball concept suggests that intensification of resource-use requires 'improvement' of organisational structures in the sense that manipulation of the resource-use system will have to be more directed and sophisticated if output is to increase and be maintained. Organisation is thus identified as a crucial factor in all three scenarios and for very similar reasons. To some extent the importance attached to organisation stems simply from the acceptance of the principle as outlined above. What evidence is there that the principle has any significance in the real system? Such evidence is circumstantial. Given the situation in Chapter seven, it should be clear that no individual can absorb and practice all the skills required to run the resource-use system. Division of labour, and some level of specialisation, is required to run the resource-use system. Division of labour, and some level of specialisation, is required, which implies social organisation and the ability to allocate resources and rewards. It is argued from this that higher levels of specialisation within the community require higher levels of supportive organisation. Chapter eight envisages specialisation of community within a wider economy, while Chapter nine introduces qualitative concepts of flexibility, purpose, awareness and motivation of individuals and communities to develop a model of organisation which gives communities self-reliance while maintaining a considerable division of labour within them.

10.4 Conclusion

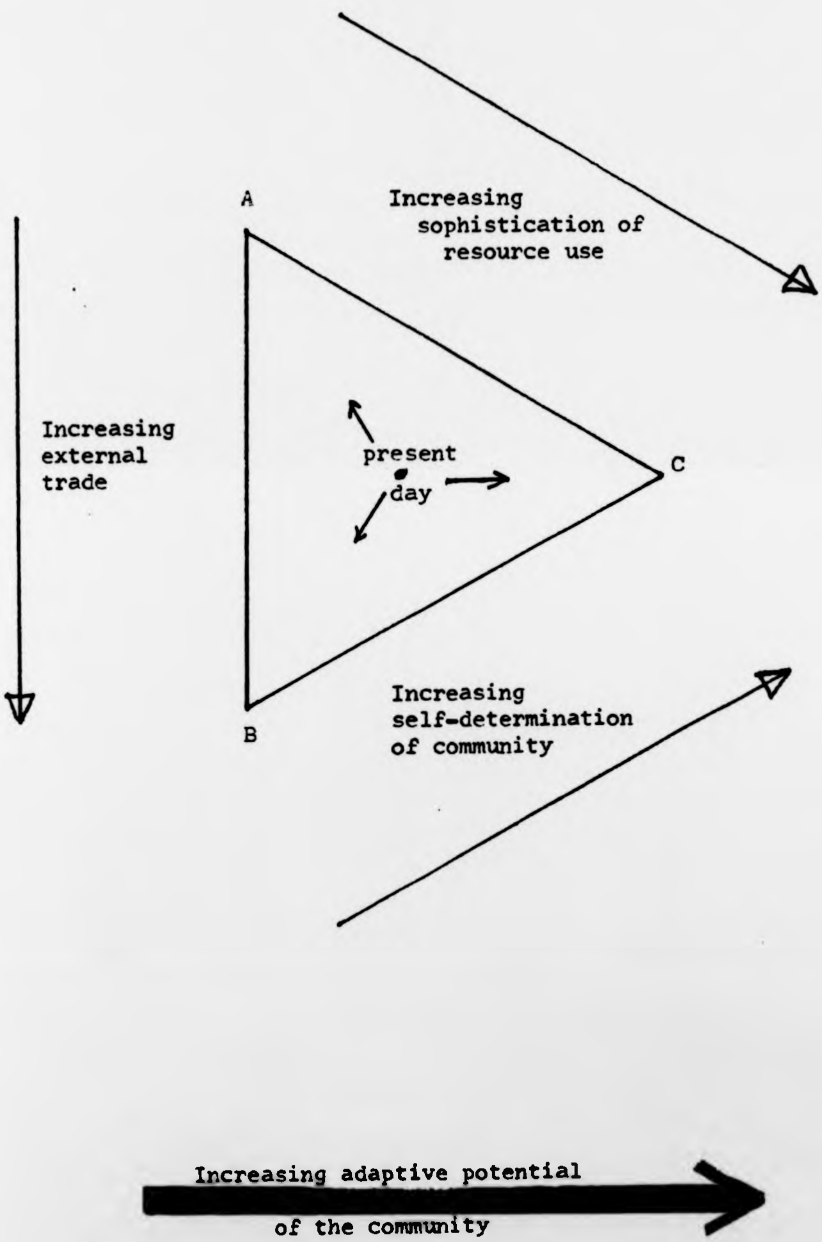
10.4.1 Numbers and appropriateness

The exploration of alternative futures for Mull has left unanswered any questions of the 'right' strategy or the 'right' size of community for the island. Chapter seven calculates a feasible solution to the situation of isolation which will provide the food requirements for 10 000 people. A strategy taking such a figure as a target is regarded as risky because the pressure on resources probably outstrips the technical ability of the community to cope with an uncontrolled disturbance such as a crop failure. A brief glance at demography shows that a population growing towards such a target would be very likely to overshoot the limits. The final section of that chapter therefore defines a PCC of 8000. This figure assumes an approximately linear relationship between population size and resource-use capability. Evidence for such a relationship is rudimentary; it is possible that a larger community will allow greater division of labour and hence more effective resource-use. Without further information on labour inputs to various activities it is impossible to assess this possibility. Therefore, given the current knowledge of the dynamics of such a system, an assessment of carrying capacity under anticipation A suggests that Mull could support 8000, representing the midpoint of a range estimated at 6400 to 9600.

Chapter eight maximises resource-use rather than population. The community is industrialised, concentrated and maintained at its 1970 level of about 2000, representing the mid-point of a range estimated at 1600 to 2400.

Chapter nine considers a situation in which the organisation and management of Mull as a system is radically reappraised. The food strategy will feed a population of 12 000, but similar doubts about the adequacy of the assessment when other elements of standard of living are taken into account leads to the conclusion that a population of 10 000, representing the mid point of a range from 8000 to 12 000, would be a reasonable assessment of PCC on the basis of current information.

Figure 10.2 - Relationships of some unquantifiable aspects of community character in the scenarios



In this case, immigration is the predominant means by which the increase in population occurs, with natural increase taking a secondary role.

There are other distinguishing features of the scenarios apart from numbers. Figure 10.2 illustrates the more important ones. There is no inherent preference for one scenario against another. 'Appropriateness' of a scenario depends on the criteria defined for evaluation of the term. If the present is taken as a point at the centre of the triangle, and the passage of time forces movement away from that point, it can also be seen that the three scenarios are not entirely mutually exclusive. It would be possible for early direction towards (for example) B to be suddenly redirected towards A. A first indication of a possible criterion for appropriateness, adaptive potential, is shown at the base of the diagram. This gives a lead-in to the discussion of the next two chapters.

10.4.2 The value of the scenarios

As has been emphasised elsewhere, the scenarios are simply a device to allow exploration of long-range futures for the Mull community. Their utility lies in relation to other areas of knowledge - of history and present status in particular - covered elsewhere. The appropriate courses of action for present-day decisionmakers which might lead to appropriate use of resources and technology in the longer term future explored in these scenarios is the subject of discussion in Chapter twelve.

The scenarios have illustrated the complexity of system dynamics in the West Highlands, and the paucity of information about those dynamics. They do not as a result offer definitive answers to the rhetorical questions posed by the attempt to determine 'carrying capacity', but they have allowed alternative futures to be set up for comparison with the expectations of present strategies. They are not exclusive of other anticipations, but in the absence of statements about such alternatives they may be regarded as first approximation statements of such expectations.

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CHAPTER ELEVEN - THE APPROPRIATENESS OF RESOURCE USE AND TECHNOLOGY

11.1 Introduction

This chapter re-examines some of the issues described and speculated upon in previous chapters in a wider context. The interactions between technology and resource-use do not constitute a widely-recognised field of study. Research in the area has focussed on the processes involved in technological change and technology transfer without, in most cases, explicit examination of the context within which these processes take place (1). This chapter examines the planning and management of resource use and technology in the Scottish Highlands, and thus provides further background to the discussion of 'appropriateness' in its normative sense. The chapter begins with an examination of perceptions of planning and management. This is followed by an assessment of the present levels of planning and management in the West Highlands, using the Mull community as an example. Then an examination of the importance of technological change, and of the need to direct such qualitative changes in the system's environment lead to the final section which summarises the existing situation. Thus, by the end of the chapter, the Mull system described, assessed and explored in previous chapters is placed in context of its present-day environment. The final chapter draws conclusions from this evaluation.

It is perhaps worth defining three terms used repeatedly in this chapter. A planner is taken to be an agent of government primarily concerned at present with resource allocation in the public sector. A manager is usually in charge of an economic enterprise - a farm, a forest or a business. Both planners and managers may be described as decisionmakers, to the extent that decisions thus made affect the activity of real-world systems.

11.2 Perceptions

11.2.1 Ideology and resource management

Perhaps one of the most difficult aspects of summarising the characteristics of a complex 'mess' of problems, such as that described in this thesis, is to establish an adequate conceptual base for discussion. There is no doubt that different individuals involved in resource management in the Highland area hold radically different views of the way the world works. This diversity of weltanschauung makes the generation of any generally acceptable conclusion about the 'appropriateness' of resource management very difficult. A detailed examination of these views is unlikely to shed much light, being more likely to unearth more and more obscure philosophical conundrums. On the other hand, failure to recognise these views will tend to produce conclusions acceptable only to those with similar views. In order to strike a balance, this section attempts a brief overview and definition of the range of opinion about planning and resource management.

There are two opposing views of the dynamics of an economy which may be presented as opposite extremes. On the one hand, the economy is seen as a homeostatic system of relationships tending towards equilibrium, while on the other it is seen as a set of relationships with little inherent stability and certainly no automatic mechanism for 'appropriate' allocation of effort. These two extreme positions lead respectively to the conclusions that no planning is necessary and may even be undesirable (disturbing a 'natural balance'), or that each decision must be made in the context of an all-embracing plan or blueprint designed to meet every eventuality. A proponent of the former would fail to accept the significance of 'appropriateness', because his concept of economy is self-adjusting. The latter view accepts the idea of appropriateness wholeheartedly, but then goes on to plan comprehensively on the basis of one particular dominant view of what is appropriate.

In reality, few people hold these extreme views. Most people accept that some measure of intervention to manipulate the economy is necessary, and also the need for flexibility to allow individuals some measure of choice and make adaptation to changing circumstances possible.

Planners are usually planning urban land use and are concerned with allocation of resources. The problems they encounter in attempting to do this have already been described in section 2.1.3. In the rural sphere, the planner is in a much weaker situation, one in which the balance is set much more towards the first extreme outlined above. There is no public sector planning of rural land use, and only vestigial planning laws controlling agriculture, forestry and sport. The planner has much more control over the design and development of the physical infrastructure of the economy - roads, services, community developments etc.

The typical decisionmaker in the field of rural land use is the individual resource manager; farmer, forester, laird or crofter. He makes his decisions on the basis of his knowledge of the resource he controls and the environment in which he operates. The general information and perceptions available to such individuals are therefore the chief determinants of the pattern of resource use.

11.2.2 Information

Chapter five reviews the readily available information about Mull as a physical environment. The point is made that Mull has been extensively studied from this viewpoint. In spite of this effort, the conclusion is reached that much of the information lacks the reliability or, in particular, the level of detail to be of much use is assessing the ability of that environment to support a human community. From an intellectual viewpoint, the problem lacks an essential property for its solution. Isolating relevant data is a vital step in the classic approach to problem-solving which involves establishing relationships and using appropriate data to calculate answers. Ideally, one would like to know the productive capabilities of Mull in far more detail, the inputs required to achieve particular outputs, the order of preferences of the community for a range of goods and some further idea of the quantitative ability of such goods to satisfy needs. Armed with this information, it would be possible to calculate, with a known degree of precision, the capability of Mull for the support of a community. This information is similar to that required by the manager to make economically 'rational' decisions, or the planner to produce 'rational' plans.

While such data is lacking in Mull, the situation is worse over the larger part of the Highlands and Islands. A closer look at the uses to which such factual information is put reveals two quite distinct processes. First, research tries to establish relationships and hence elucidate process in particular parts of a system; second, information is used informally and formally to monitor the state of a system and hence to manage it. The economist will immediately point out that such monitoring will incur a cost which must be set against any additional revenue resulting from more intensive management. It is safe to say that no study has ever been attempted of these relationships in the Highlands and Islands, and that the quantity of rigourously collected monitoring data for resource management is very low indeed.

Some of the preceding discussion might suggest that landusers in the West Highlands are managing resources with inadequate understanding of their functional characteristics. This is not the problem; most managers have intimate local knowledge and experience which enables them to maintain successful enterprises and make 'sensible' decisions (in the sense that solutions to specific problems are found). Such decisionmaking is not made on the basis of explicit analyses of relevant information. In form it is often almost intuitive, not even involving conscious analysis of the situation. This wealth of experience is a vital resource in the production process, but is not readily accessible to the new manager. This is particularly obvious in the relatively low intensity hill farming and crofting in Mull. The main drawback of such a method of assessment is the impossibility of any adequate assessment of management success.

While one element of experience is obviously a history of trial and error, such an approach to resource use must, by its very nature, tend to produce cautious, conservative managers and be more suited to medium and low intensity management systems. As intensity increases, the manager requires more precise information about the condition of his system and more explicit understanding of its function. In order to achieve this, the 'lessons' of experience must be subject to more rigourous analysis and individual decisions taken with a heightened awareness of context.

The parallel between this situation and that which developed historically in industry derives from this increase in intensity. More sophisticated technology requires more sophisticated control techniques for its successful operation (for example, higher quality steel requires more precise knowledge and control of its constituent impurities - carbon, manganese, cobalt, chromium etc.). This involves more precise organisation, which in turn requires more detailed analysis of situations. This requires explicit discussion and analysis of 'experience'. The resource manager producing a desired output from a biological system must follow a similar process. Therefore, while existing organisation and management of biological systems has historically been adequate, an increase in intensity in future will require a more sophisticated approach to decisionmaking.

11.3 The present structure of decisionmaking

11.3.1 Planning agencies

The development of the role of local planning authorities is the most immediate physical symptom of the increasing intervention of government in the functioning of the economy. Inevitably, this development has been almost entirely in an urban context. Regulations on building design were the first manifestation of this involvement and have developed into extensive controls on location, incentives to develop less-favoured areas, and almost complete control over the development of infrastructure.

More recently, attention has turned to rural areas, primarily as a result of the wide impact of the urban society on its environment. The Regional and District authorities have found themselves more and more involved as arbiters of developments in rural areas (gas and oil pipelines, industrial developments, recreational developments and so on) and 'rural planning' has come to mean the control of urban impact on the countryside. This is a long way from comprehensive planning of activity in the rural sphere, but the trend continues in such a direction. The Scottish Development Department (SDD) has acted in a coordinating and advisory role, and has issued a series of 'planning guidelines'. Some of these are concerned with obvious matters; several concern themselves with the problems of controlling mining for aggregates, petrochemical developments and water supply, but there are also guidelines on recreation and landscape conservation, agriculture, forestry and nature conservation. The Countryside (Scotland) Act 1967 established the Countryside Commission for Scotland (CCS), which acts in an advisory role to local authorities on recreation and landscape conservation, and provides grant aid for country parks and countryside nanger services. Such developments have led to the designation of large areas of countryside for various purposes, for example, National Park Direction Areas, Areas of Great Landscape Value, Green Belts, Scenic Heritage Areas and Sites of Special Scientific Interest, for reasons which have little to do with the primary purposes of resource industries such as agriculture and forestry. These industries, however, find themselves increasingly constrained by the activities of planners, even though statutory control of landuse is extremely limited.

In 1972, the Select Committee on Scottish Affairs at Westminster published the report on 'Land Resource Use in Scotland' (2), which examined land as a resource, and therefore as a subject for planning control. The report, and in particular the four volumes of evidence submitted to the committee, reveals the plethora of agencies with a greater or lesser interest in land use, and also reveals the lack of effective coordination between them. In its recommendations, the committee recognised that any effective reorganisation of the existing 'ad-hoc' structure would involve considerable upheaval and dislocation of the government machine. Instead, they made a number of proposals including the setting up of a 'Land Use Council' as an independently constituted forum for discussion of rural affairs. The implication was for increasing intervention in natural resource management and a rationalisation of function of the many agencies involved. In addition, they recommended the establishment of a Land Use Unit, which would provide an overview of the Scottish situation for the advice of local authorities and central government. In its reply (3), the Conservative government of the day rejected the proposals on the grounds that the establishment of a new independent body would first diminish the 'democratic' control of the Secretary of State and of local councils over planning, and second create more bureaucracy. Instead, it established the Standing Committee on Rural Land Use (SCRLU), on which the main statutory agencies (DAFS, SDD, SEPD, CCS, NCC & FC) are represented. There are no independent members, each individual therefore representing the interests of his agency. The committee has the power to set up working parties on particular matters. There has been a working party on land classification in lowground areas which has completed its work, and two others are examining land classification in hill areas and rural land use information systems. RLUIS, in particular, is interesting because it is examining the feasibility of setting up a comprehensive data bank bringing together the information held by a very wide variety of agencies. This development gives one considerable reason to doubt that the outcome has had the effects (of preserving democracy and reducing bureaucracy) intended.

It would appear that SCRLU and its servicing (carried out by DAFS and SDD) must absorb as much manpower as the Select Committee's proposals for a Land Use Council and a Land Use Unit. In addition, the Standing Committee has maintained a very low profile to the public, and in no way can it be said to constitute an independent voice. Instead, it is firmly in the control of the executive. Whether or not this constitutes greater democratic control than a quango such as the proposed Council is open to debate, and forms part of a wider problem of accountability of the Scottish Office bureaucracy to the Scottish people.

For the future, it seems unlikely that SCRLU will make a greater impact. It also seems unlikely that a Conservative government committed to trimming the public sector will advance the Committee large sums of money to set up an RLUIS, as the logical next step from the existing pilot project. The framework remains, however, as one important stimulus which could lead in the direction illustrated in the second scenario.

11.3.2 Other government agencies

The activities of three government-funded bodies have particular importance for land users in the Scottish Highlands and Islands.

i) The Department of Agriculture and Fisheries for Scotland, the public agency with responsibility for administering Government policy to agriculture, was described briefly in Chapter four (item 72). Agriculture is seen nationally as a vital strategic industry, and the market for agricultural products is subject to very extensive intervention. The policies determining the support strategy adopted by DAFS are agreed at a European level as part of the Common Agricultural Policy (CAP). Indirect intervention in the market through support pricing and a capital grants system is not matched by any sanctionary controls on land resource allocation, apart from the requirement for FC to seek DAFS clearance for planting proposals, which amounts to a DAFS veto on conversion of land to forestry. The nominally independent Agricultural Advisory Services have been heavily involved in local efforts to link expertise and capital in farm modernisation, but the further link of individual farm management objectives to national or EC policy goals has proved difficult, at least partly because the policymaking centre is remote from and unresponsive to the problems of the local farming community. This problem is not unique to the Highlands, and may be one cause of the apparently intractable EC budget problem, with a CAP consuming a larger and larger proportion of the total budget.

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ii) The Forestry Commission is the government agency for forestry, which combines two distinct roles in a single organisation. As Forestry Authority, it administers a range of controls and grant aid incentives which assist the private sector and also acts as a source of technical advice. The scale of intervention is rather less than in agriculture, and the agency has a correspondingly smaller budget; however, as a Forestry Enterprise, the FC is the largest landowner in Scotland, with assets valued at about £550 million (1979) in a State forestry operation which equals the total private sector in size. Policy for forestry is not coordinated at the EC level, attempts to establish a European policy having fallen victim to involved political wrangling over agriculture.

There has been a UK forestry policy since the formation of the FC in 1919. At first, this was based on a perceived need for a strategic timber reserve in times of war. A review of forestry policy at the end of the Second World War confirmed this objective, but the Zuckerman report of 1957 questioned its relevance in a nuclear age. In 1971/72, the most recent major review of forest policy concluded that the justification for forestry on purely economic grounds was questionable, but emphasised the social value of State forestry in remote areas.

The private sector was depressed until the late 1940s, but total activity is now of the same order as the FC. Intervention in the private sector includes a blanket control on felling through a licence system and a grant aid system known as the Basis III Dedication scheme, in which a landowner or occupier undertakes to keep an area of land under trees and managed in line with an agreed Plan of Operations, in return for a lump sum planting grant and subsequent maintenance payments. The main incentive to the private forestry sector, however, derives from special tax allowances, which include income tax relief on forest investments and partial exemption from Capital Transfer Tax on forest assets. These are administered by the Treasury, not the FC, and are therefore a rather indirect tool of forest policy (4).

In 1980, forest policy is once again under review. The new resource-based version of the old strategic argument was rehearsed in Chapter six (p121-122) and this concern about timber has led to the publication of a number of reports, in particular the FC's own 'Wood Production Outlook for Britain' and the more recent Centre for Agricultural Strategy report on forestry (5). At the same time, competition for forest land has increased as supply has become restricted, forcing the price up and reducing the scale of planting.

The barriers to increased afforestation are partly artificial, deriving from the DAFS veto and the political pressures exerted by amenity pressure groups. Solutions put forward have ranged from compulsory purchase powers for the FC (with all the connotations of 'land nationalisation') on the one hand, to lifting the restrictions imposed by other land uses, thus reducing the bureaucratic constraints on the operation of the market on the other (neglecting, in turn, the importance of fiscal policies as an artificial incentive to forestry).

iii) The Highlands and Islands Development Board is a regional development agency, generally regarded as an important influence because of its central concern for the health of the Highland economy (se 1.1.2, 3.5 and 4(94)). However, with an annual budget for grants and loans of some £6 million per year (1978/79), it controls only a small part of the total Government aid which flows into the area from many other agencies. It is not therefore a planning agency or an executive body with any coercive control over Highland communities. The HIDB approach to its task has been the subject of extensive criticism, by local people and academics alike. This criticism focusses on three particular factors:-

a) the political structure within which the Board operates,
b) the almost total lack of influence of Highland people over its activities,
c) the link between it policies and spending priorities and the objectives it was set up to pursue.

The first of these is a continuing and crucial constraint. Location in Inverness has produced a body which itself suffers from the remoteness from political power centres which it was set up to combat. The second point has received some recognition from the Board in recent years, with the setting up of local offices in several parts of the Highlands. Whether this will ease the problem (that the HIDB, itself remote from Edinburgh and London, is also remote from the communities it was set up to serve) remains to be seen. Local influence on its decisions is limited to the handful of notable Highlanders on the Board itself and the 42-man Consultative Council.

The third point perhaps illustrates the others. The HIDB put forward a land use policy in 1977 which proposed that it should be given limited powers of sanction over landowners guilty of 'bad' land use. The were unable to secure such powers from the Government, and indeed the proposals were not treated with much enthusiasm in the Highlands. The HIDB has always been a body of specialists and experts, and consequently has a slightly paternalistic approach to its work. The early years illustrated this with the Mull survey; more recently, there has been evidence of a more responsive approach with the cautious support for multi-function cooperatives in the islands, but the link between the Board's policies, its spending patterns and its achievement of its aims has never been subject to public analysis and debate.

11.3.3 Individuals

Studies of economic and social development in remote areas tend to overplay the role of agencies, forgetting that (with the exception of the Forestry Commission) these are at best only enabling organisations, and therefore cannot initiate action on the ground. This can usually only be done by individual owners in the present political climate. Theoretically, of course, there is no reason why an agency should not initiate its own enterprises; this is frequently advocated by such studies. A very brief review of the political realities reveals that this is extremely unlikely at a time when there is a reaction against interference by the State in other walks of life. The actual use of resources on the ground is therefore in the hands of thousands of individual managers - owners, tenants, crofters, farmers and foresters. These are the people toward whom grants, subsidy, loans regulations and market controls are directed.

In the Highlands, the estate owner or laird is a crucially important figure. On some estates, the owner works the land at his own hand, but a more typical situation is the estate divided into tenanted farms. The laird is really the only medium through which both active farming and forestry is carried out on the same tract of land. In Mull, owner-occupiers also seem to be more likely to combine hill cattle with sheep, whereas most tenants have only sheep. Virtually no estates are put down entirely to trees, unless by management agreement with one of the commercial forestry organisations. Foresters, therefore, are rarely their own master, and in most parts of the Highlands forestry is heavily influenced by the activities and mode of operation of the Forestry Commission. Finally, a unique feature of Highland resource use is the crofter, usually involved in multi-occupation and therefore extremely difficult for the academic intruder to analyse. Some 'crofters' have relatively large areas of land, and are therefore more accurately regarded as small tenant farmers. The typical pattern for the West Highlands, however, is the small croft (less than 10 ha) and the crofter with several other strings to his bow, such as fishing, service industries or tourism.

The Highland laird still retains remarkable freedom of action over the use of his land. If he has the financial resources, he can literally do anything he likes with it. The only absolute controls over his activity are planning controls on building, and even these only apply to residential construction, such as housing and tourist chalets. In recent years, however, such individuals have come under increasing external pressures. The business world has moved away from the concept of the individual entrepreneur to the corporate transnational organisation, and the evolution of the tax system during this century has aided a redistribution of wealth. In the early years of the century, 1% of the population owned 60% of the wealth. This figure has now declined to around 30%, although this is still apparently high by European standards (6). This change of environment brings protest from the lairds that their estate is capable of producing a range of products equalled by no other existing mode of land use. This claim is not without foundation, but under the present system there is no guarantee that this will happen, and indeed lairds exercise their freedom to hold large areas of ground exclusively for sport, or to buy and sell property for speculative purposes, with little regard for the management of the land within it, or for the community dependent upon it.

The farmer, whether owner or tenant, is usually dependent on his land holding for his livelihood. The most significant pressures come from the market - the price of his inputs and the problems associated with marketing. Appropriate resource use and planning are not matters which exercise his mind in the face of these daily pressures. The problems of hill farming in Mull have been described briefly in Chapter four. These problems are faced by farmers in all parts of the Highlands. The necessity to sell stock by auction in distant markets poses the most serious problems. Once a farmer has gone to the expense of transporting his stock to market, he literally cannot afford to bring them back if the price is not right. Furthermore, his stock will lose condition in transit, and thus he tends to get a lower price than the farmer close at hand. Buyers in such auctions are less numerous than sellers, so if a few key dealers go elsewhere on the day, prices will tend to be low. The main feature of the market is thus uncertainty. Cattle, for example, sold at autumn sales, pass through several sets of hands in the course of the winter as store cattle. The fattened beasts are eventually sold for slaughter, butchering, processing and finally the product is retailed. The hill farmer therefore provides a part of the raw material for a much larger processing industry which experiences ups and downs generated within a much wider environment. It is partly in recognition of this marginal situation that subsidy support is provided to hill farmers. This is not preventing a continuing decline in the industry in the West Highlands.

Another problem faced by the hill farmer is the limited range of activities which are viable on his land. He therefore has little opportunity to diversify into other areas such as cropping or horticulture. While lowground farmers can diversify when markets are depressed, as beef markets were in 1974 and 1975, the hill man has a choice of sheep or cattle or some combination of the two. His opportunities for activity in completely different areas are limited by the institutional framework within which he operates. Forestry, while technically a viable landuse, is of no economic value when starting from scratch. Grants and loans for forestry are not designed with the farmer in mind. The NFUS have proposed (7) 'advances on income' to farmers to encourage planting. This would undoubtably suit their membership, but the suggestion (like so many others) is based as much on self-interest as on any wide-ranging examination of resource-use.

Foresters are almost all employees. The Forestry Commission is the largest employer, and the organisation is run on professional and pseudo-industrial lines. This derives partly from FC's roots in colonial administration, the military style in which it was organised in the early years, and the sheer scale of operations in some areas. Management is insulated to some extent from the pressures of taxes and markets, because trees are of marketable age over a longer period. There have been periodic problems with the marketing of smaller timber from thinnings at present, apparently because the processing industries are slow in adapting to supply opportunities as the Highland forest develops. Foresters in the private sector are very much subject to tax pressures, as this is the basis on which private planting has been encouraged. The private sector is largely dependent on the exploitation of the investment characteristics of a production forest in the light of current fiscal regimes. Funds are derived both from wealthy individuals and organisations looking for particular kinds of investment. Forestry is also, therefore, a marginal subsector of a financial system which on the whole is not concerned with the way in which natural resources are used. Even the Forestry Commission is not immune to this pressure because it must justify its use of public funds to an agnostic Treasury, expressed in terms of an expected rate of return.

11.3.4 Communities

The preceding discussion has centred on the two primary landuses in Mull. This does not reflect the full range of resource use in the Highlands, nor the opportunities for economic activity open to the communities in such areas. The discussion has borne in mind the concept of economy discussed in Chapter three, but Mull is by no means solely dependent on its land resources for the sustension of its economy. Tourism feeds on the quality of its landscape, but income derives from the expenditure of the tourist himself rather than the direct productivity of the resource. Fishing utilises marine resources and provides a valuable supplement to income. Its contribution to the economy is not easy to determine, particularly as many individuals are working on a part-time basis and do not welcome close examination of their rewards. Finally, Mull has an above-average number of retired or wealthy people living at least in part on pensions and external investments. This must provide a substantial supplementary income to the island which may be classed alongside government regional aid and social security payments as an extra income in the island's hypothetical balance sheet. Mineral resources have received little attention here, although in some parts of the Highlands they have considerable local importance.

This set of resource industries supports a service sector partly directly financed from within, partly from outwith local areas. Into the first category come shops, tradesmen, small local firms of builders and agricultural contractors. In the second category, local authority services play a vital role in the life of the community. The maintenance of services in the face of declining population poses a major problem for remote areas, especially as reduction in services such as schools, public transport and shops can be a reinforcing factor in such a decline. On the other hand, in absolute terms there can be no justification for the support of such services unless there is an economic base providing a financial foundation for the community. The extreme vision is of a community of unemployed or heavily subsidised people using a service .. industry which only survives because of aid and subsidy in transport services, price support etc. Such a community lacks a logic for its existence.

Tourism is a particularly interesting case, in that it dominates that life of many rural communities and yet any assessment of costs and benefits is extremely difficult. Considerable research on the impact of tourism reveals that only a small part of the total expenditure of a tourist in pursuit of his holiday is made into remote communities, and of that small part a high proportion flows straight out again relative to other industries. Furthermore, tourism in Scotland is highly seasonal and depends essentially on surplus disposable income held by people living and working in other parts of the national and international economy. Tourism is thus extremely vulnerable to changes in the health of national economies. The dependence of Highland tourism on the private car therefore makes it vulnerable to increases in the price of petrol. In spite of these factors, the HIDB has put £21 million into tourism between 1965 and 1978, the largest single category of financial assisstance and about 30% of the total for that period. Land development received only 8.7% in the same period, although this apparent imbalance does not take into account parallel support provided by DAFS.

While this thesis has viewed a community as an economic system, this is a concept which is not widely used. The earlier discussion of the agriculture and forestry sectors has emphasised the marginal nature of local activity in both sectors, and the distant and centralised location of policymaking bodies. Communities have virtually no voice in these areas. Recent developments in the Western Isles suggest that this can change, following first the formation of Comhairle nan Eilean as a unitary local authority and second the formation of several community cooperatives. The wayin which these multi-function cooperatives will integrate community economies remains to be seen, but success in this area would be a strong stimulus encouraging the direction described in the third scenario.

11.4 Technology and change

11.4.1 Defining technology

'Technology' is a word often grossly misused and often a substitute for careful thought. The variety of definitions found in the Concise Oxford Dictionary offer little assistance:-

a) the science of practical or industrial arts,

b) the ethnological study of the development of such arts, or

c) the application of science.

For a detailed discussion of the definition of technology, the reader is referred to Cross et al or to Boyle et al (8). For the purposes of this study it is sufficient to consider technology as the mix of skills, machinery, managerial talents and information used by the community. Technology is thus seen as one of a number of influences (including the natural environment, philosophical and religious beliefs and political power relationships) which together determine the shape and form of the community. In many ways it is analogous to the part played by 'skills' in the socioeconomic models presented in Chapter two.

The 'appropriateness' of technology is an extension of concern with the direction of technological change. Technology is not an exogenous parameter in the sense intended by the term 'technological determinism'. The proposition that technology determines the pattern of our lives has a considerable history, and at first glance appears to hold many attractions. For the economist, for example, technology is a 'given' factor, not interactive with other elements of the economy. The consequence of acceptance of such a proposition can only be passive acquiesance to technological change. This section sets out to demonstrate that technological change is an integral part of the economy and is susceptible to purposeful manipulation in pursuit of developmental objectives.

11.4.2 The importance of technological change

The final sections of Chapter three outlined in the briefest form the processes of change in the West Highlands from the early Eighteenth century to the present. The absorption of a subsistence society into the developing industrial complex of Great Britain produced great changes, the consequences of which have been described elsewhere. It is interesting to go over some of this ground to illustrate the part played by technological change, and try and draw out some concepts which will be of use in analysing the present situation.

The self-reliant Highland economy of the early Eighteenth century supplied southern markets with cattle, a trade that increased with the Napoleonic wars at the end of the century. In addition, demand for potash in industrial plant in the Lowlands and in England created the kelp boom around the turn of the century. The end of the Napoleonic wars virtually ended the trade in these primary products. The West Highland community therefore faced a problem. While they could survive through subsistence farming, increasing contact with the south had created aspirations which could only be met through cash income over and above subsistence. One solution was seasonal labour to Lowland farms. Highlanders and Irish came to such farms in large numbers at harvest time, armed with sickles and rakes, and thus a solution was found for almost two generations (9). Labour intensive hand harvesting is a technique suited to almost any size and shape of field, and for that reason is still to be found in the remoter corners of the Highlands. Arable land in remote areas tends to be in small patches and until this time the best arable land in Central Scotland had been found on sloping ground facilitating free drainage, and also tended to be in small plots. Improvements in agricultural techniques, especially of drainage, in the Eighteenth and Nineteenth centuries allowed the use of level low ground. The consequent closer control of water levels, coupled with improved cultivation techniques, led to better yields. Such farms soon became predominant in growing cereals. Fenton (9) describes the organisation and execution of harvest on such farms, with the work team or 'bandwin' consisting of women using sickles and men gathering, tying and making stooks. Threshing was mechanised from a very early date, and cultivation was in the main done with horses, so the harvest was the only remaining entirely manual operation, apart from sowing which used relatively little labour. Attempts to replace the sickle with the larger scythe seem to have met with limited success, mainly because the scythe was seen as a man's tool, while the sickle was used by women. The necessary reorganisation of the bandwin was resisted and hence the scythe, in spite of superior technical characteristics, had still not entirely replaced the sickle when modernisation occurred. David's analysis (9) of the mechanisation of harvesting brings out another important feature of technological change, which he terms 'technical interrelatedness'. In the case of cereal harvesting, other innovations were needed before mechanical harvesting with primitive reapers became sufficiently attractive to replace the migrant labour force. Drainage, especially effective subsurface drainage, has already been mentioned. Another, perhaps more important, factor was the pattern of ploughing. The old ridge and furrow ploughing pattern, still visible in ground which has been permanent pasture since that time, was not well-suited to the harvesting mechanism of the reaper. It is therefore interesting to see that the Lothians was one area which adopted mechanical reaping at an early stage, and was also a pioneer in mechanising ploughing, with the use of stationary steam engines. This destroyed the ridge and furrow pattern in the large, level lowground fields, at the same time making the terrain more suitable for reaping machines. Thus a range of technical changes led in time to the redundancy of the migrant Highlanders.

Causality in such a process is difficult to establish, partly because of the integrated nature of the various technical changes and partly because of the complexity of other non-technical influences, including pattern and type of land tenure, markets for products and factor prices of inputs such as labour and fertiliser. Wilkinson (10) clearly considers such changes to be direct responses to ecological imperatives; in other words, that environmental factors such as population pressure expressed as demand for food and materials were the driving force for technological change. The alternative view, that technical improvements allowed a higher standard of living which in turn led to increasing population, is diametrically opposite in its assessment of causality. David's analysis stresses the importance of economic analysis, but also brings in reliability and acceptability as qualitative factors. From his analysis it is quite clear that any assessment of such factors was not carried out at a community level, but rather by individual entrepreneur farmers and landowners, with the majority of the community as passive recipients.

The example of harvest mechanisation therefore demonstrates how a community may be profoundly affected by technological change entirely outwith their control. The Highlanders found their subsistence capability seriously reduced by potato blight, which compounded their problems. Thus the population of Mull fell by 50% between the 1820s (at 10 500) and the 1870s (at 5000). This decline continued until the 1971 census. The part played by technological change in this decline is obscure, but it is quite certain that some influence stemmed from the increasing concentration of innovation and economic activity in lowland agricultural and urban areas. Technological change in remote rural areas was frequently coupled with social and economic changes generated outside the community, who frequently felt that such changes were outside their control and often not in their own best interests. Such processes led to the reputation of these communities for conservatism and resistance to change. Higgins (11) describes two contemporary cases, the first of which failed to take these factors into account, the second of which appears to have succeeded precisely because it came to the community in an appropriate way.

The first case involves a 'resource survey' in the West of Ireland, an area with close similarities of history with the West Highlands. The survey studied soils, climate, geology, crop production, horticulture, grassland, forestry, animal feeding, animal health, fisheries, economics, marketing, tourism and transport. The survey therefore corresponds closely to the HIDB report on Mull both in approach and date, and was, if anything, even more comprehensive. The survey concluded that a major reorganisation of the agricultural system was needed, involving reclamation schemes and relocation of displaced agriculturalists. While the report was generally welcomed, Higgins describes the outcome, cautiously, as follows:-

> "....One thing is clear. The specific recommendations made by the survey team have not been implemented. Not even one of the proposed 650 farm units has been established....Commercially, the impact on the economy of West Donegal was, and still is, nil. While we cannot emphatically declare it a failure in an absolute sense, for the purposes of this study it is reasonable and certainly more accurate to regard it as an attempt to stimulate innovation which is, as yet, unsuccessful...." (Higgins, pp 173-174)

Higgins' study clearly showed a difference in the perception of the local community and the survey team of the survey's impact. The former blamed the lack of an explicit implementation strategy, while the latter thought that if the survey's recommendations had not been implemented, there must be something wrong with the conclusions which had been drawn or with the recommendations themselves. A third group, local agricultural advisors, felt that little could be done because of unreceptive attitudes in the area. Higgins, in a detailed statistical examination of his data, concludes that this third factor was not of primary importance. Instead, he concludes that while a wide range of factors were cited as reasons for failure, the failure to produce an explicit implementation strategy (which would itself have explained how the many practical problems might have been circumvented) was the most important:-

> "....(This study) suggests that there is a need for better dialogue and involvement of all key action groups, particularly the recipients, at both the planning and implementation stages of such programmes. Clearly the promulgation of research findings of itself will not be adequate to stimulate innovation in a programme of this kind. More attention must be given, in conjunction with local change agents, to the development of effective innovation strategies, which are acceptable to the recipients...." (Higgins, pp 204-205)

Higgins' second example is the successful adoption of new land drainage technology in County Kerry. Once again, a survey of agricultural potential was the starting point. This survey was apparently a much simpler affair than in the previous example; it found large areas of poor ground with iron pan and induration causing poor drainage and peat formation. Experimental work was showing that deep ploughing (to a depth of 30 inches) was mixing mineral and organic horizons and improving drainage. Earlier attempts at reclamation had involved rotovation, reseeding, liming and manuring. This only provided temporary relief, because rotovation did not go deep enough to break up the iron pan. While experiments with bulldozers had taken place in various parts of Ireland, drainage grants were only available for conventional pipe drains, which had proved ineffective on these soils. In 1966, a small area of Kerry around Annascaul was designated as a pilot area and given its own agricultural advisor. Experiments with winch ploughs and bulldozers initiated by two local farmers, with the advisor's help, led to a change in the grant system to include such techniques. However, considerable local scepticism, coupled with the lack of a really suitable plough for cost-effective operation were important barriers to wider adoption. In 1969, the Ballyferriter Cooperative examined the Annascaul experiments, invested £55 000 in imported bulldozers, ploughs and other reclamation equipment, and had soon reclaimed over 1000 ha.

> "....Effectively, the Coop sold the idea to the farmers.... It organised an extensive dissemination campaign of meetings, lectures and talks with local farmers. It was able to generate a demand for work at a level which was eventually critical in convincing Land Project officials to recommend grant payments on the purchase of imported equipment for deep ploughing. Under different circumstances, the advent of heavy machinery of this kind in the Ballyferriter area would certainly have been regarded with scepticism, possibly even with ridicule...." (Higgins p 137)

Higgins studied the post hoc perceptions of the individuals involved in this case. He found three basic elements which seem to have favoured adoption of the innovation:-

a) a pre-existing perception that increased intensity of resource use on the individual farm was desirable,
b) confidence, both in the reliability of the innovation (shown by the Annascaul experiments and the experience of early adopters) and in the markets for increased output, and
c) the availability of venture capital in the form of grants minimising financial risk.

In addition, Higgins noted a large number of secondary innovations apparently triggered by deep ploughing (12). The wide range of these innovations provides further examples of David's concept of technical interrelatedness and the idea of compounding factors in technological change hinted at in the discussion of harvest mechanisation.

In conclusion, Higgins comments:-

"....These results show that innovations can be found, and innovations promoted at a relatively rapid rate, even in these disadvantaged areas, given certain essential conditions. Far from writing off the possibilities of achieving any kind of technological breakthrough as some writers have done, greater effort is required to promote innovations in these areas. This will pay off when appropriately planned, preferably through local change agents and ideally involving local development organisations...." (Higgins p 161)

It should be quite clear that this detailed account of Higgin's work may be justified by its direct relevance to the West Highland situation. The conclusion to be drawn is that technological change is an essential factor to be taken into account in any attempt to direct economic development.

11.4.3 Managing technological change

If there are a range of alternative technical solutions to particular problems, there must be factors external to the technical characteristics which influence the selection of one of the alternatives. Perhaps an important factor is chance, but any suggestion that random selection is an important mechanism is rejected; instead, it is suggested that most influences derive from tangible and identifiable sources. Such sources may be external to the community under study. Such influences have been discussed in Chapter six as factors influencing the choice of scenario. Consideration of these influences alone allows only passive examination of appropriateness, in the sense that the study describes only how the process works without any attempt to improve that process for positive benefit. This final extension of the concept poses the question:- 'Benefit to whom?'. The explicit discussion of costs and benefits of technological change is a comparitively recent phenomenon, and has uncovered some difficult questions:-

- In a society priding itself on decisions taken ostensibly on the basis of factual evidence, how can suitable 'facts' be established concerning the appropriateness of a technology?
- Even assuming this to be possible, how can such knowledge lead to the effective manipulation of technological change to positive ends?

Several writers have commented on the ideological changes which have led to the notion that a technology may be controlled (13). In the past, any technical innovation which found a market and widespread application was by definition a crucial aspect of 'progress', Only since the economy has been seen to be a mechanism which need not adjust automatically to provide the best of all possible worlds, and since the range of potential technical options has become so wide that perfectly viable options have to be abandoned, has the notion of choice, and with it the possibility of directing technological change, begun to surface. The discussion of such control is inevitably deeply bound up with political ideologies, so that separation of ideology from analysis is an impossible task. Instead, an attempt should be made to recognise the part played by political bias in such works. Some ideologies, leaning heavily on the extreme laissez-faire concepts described in 11.2, refuse to recognise the problem. If, however, the logic so far is accepted, the crucial issues may be listed as:-

i) Who should do the controlling?

ii) Towards what ends should control be directed ?

iii) How can such ends be achieved?

Thus, one returns to the questions of planning, of management and of decisionmaking. The ends towards which technologies should be directed have been listed by Davies et al (14) as reliability, economy and acceptability. The assessment of such factors is only possible within a framework of agreement on function and role. It will be noted that economy is listed as one of three factors. It is not possible to make an adequate assessment purely on the basis of economy, for reliability involves both quantitative (eg cost of breakdown) and qualitiative (eg consequences of breakdown) factors, and acceptability is an almost entirely qualitative assessment of role and consequence. Thus technology may be described as a factor susceptible to positive management. Planning, in the widest sense, of a system involves the allocation of resources and the direction and assessment of technology.

11.5 An overview

11.5.1 The status of different interest groups

It is towards the future, in particular the immediate future, that this final section turns. Elsewhere in the thesis, the past, the present and the far future have been assessed. The most difficult area is in the near future, and this section examines the position of key interest groups in relation to it.

i) The Agriculturalist

It should be clear from earlier chapters that recent research in agriculture, particularly hill sheep farming, holds out considerable possibilities to improve productivity per unit of land. The basic strategy involves closer control of the grazing system resulting in fuller utilisation of pasture and careful monitoring of nutritional condition, including the administration of supplementary feed. While these improvements are obtainable in the West Highlands, there seems little doubt that better results can be obtained in the Eastern Highlands and Southern Uplands. Markets for livestock are unstable and seem unlikely to expand significantly in the face of a stable population. In addition, the hill farming community is under increasing pressure to justify the relatively high level of government support it is given (over £20 million per annum). The prospect of pressure to improve productivity therefore implies either oversupply or the transfer of land into other uses.

Interest groups within the farming community include NFUS, representing both owner-occupiers and tenants, the WSAC advisory service who have the skills to put such technical improvements into practice, and landowners, whose concern is with a balance of interests including farming at the estate level. Such interest groups operate primarily at a local level and have certainly influenced the improvement of farms and the pattern of afforestation in recent years. At a national level, farmers depend on NFUS, sympathetic MPs (mainly Conservative) and the actions of DAFS as the relevant government agency. It is fair to say that the farming community is stronger and certainly more coherent at a local level.

Such a view of the immediate future takes little account of external factors affecting the local scene. One of the most obvious of these is the price of energy, particularly of fuel oils. The impact of continued increases in the running costs of most farm machinery is difficult to assess, but it certainly makes intensification less attractive. New management systems involving increased use of machinery and fertiliser for pasture improvement (coupled with changes in the timetable of management) thus seem a less likely scenario for the West Coast.

ii) The Forester

Technical improvements in forestry have already resulted in changes in labour productivity. This change is almost wholly derived from increased use of machinery, in particular the use of larger and more powerful machines. Mechanisation has also led to the increasing intensity of land use within the forest, with large ploughs and drainage machinery enabling a higher proportion of the ground within the forest to be planted and more uniform yields to be obtained from that ground. It is difficult to see what major changes the immediate future might bring. While heavily dependent on machinery, forestry is not, over the whole rotation, a particularly energy intensive industry. Further improvements are likely to result from modification of systems of management, for example the identification of areas subject to windthrow hazard, allowing either wider spacing of planting or later application of thinning. The present heavy dependence on Sitka spruce planted in large stands in the West Highlands is viewed with concern by some foresters, and has led to suggestions that stand size in the second rotation should be smaller, with species mixtures allowing the use of a wider range of less hardy species such as Douglas fir, Western hemlock and Noble fir.

The larger part of plantation forestry in the West Highlands is FC owned and run, and subject to central State funding. Decisionmaking is devolved only to a regional level, and local communities have little say in the planning and management of plantations. In the near future, pressure for increased afforestation will lead to changes in this form of organisation. Encouragement of the private sector seems likely to be an important tool in any national government aid to forestry. In the past, such encouragement has been aimed almost entirely at large landowners with surplus capital. A real impact could be made in the West Highlands if farmers and crofters, controlling relatively small areas of ground and with meagre capital resources, were enabled to engage in forestry. Such a scheme would look at the possibilities of establishing small woods on farms and common grazings, with consequent impacts on forms of management. Foresters argue that such plantings entail high establishment costs (for fencing) and result in lower yields due to edge effects. On the other hand, new fence lines are of great benefit in improvement of the hill farm, and the trees offer shelter to stock. No systematic studies of such joint benefits have been made.

iii) The Community

While agriculture and forestry are important components of the ecology of West Highland communities, this importance is by no means overwhelming. Tourism and service industries are equally important, producing a diversity of interests influencing community opinion. One thing these interests all have in common, however, is the overwhelming importance of external affairs, affecting markets, the demand for exports and the prices of imports. In fact, the community in Mull have little effective control over their affairs. This dominance of external interests extends to natural resources, in that outsiders are free to purchase land and manage it without reference to local community interests. Carter (15) describes the problems faced by the Mull and Iona Council for Social Service in their attempts to influence land use in Mull.

In these circumstances, any suggestion that 'appropriateness' of technology should be a concern of the CSS or of the more recently formed Community Council appears ridiculous. Even if they were to consider such arcane matters, past experience shows that it would be of little consequence. But perhaps this is where an explicit view of the future would force a different conclusion. The landowners of military extraction who together created the 'officer's mess' syndrome in Mull are becoming fewer, and do not seem to be being replaced. There seems to be a reaction against central State control of land through FC and DAFS. There are fewer people with the necessary capital to buy up and control large areas of land. In this developing situation there is surely scope for a well-informed Community Council to demand consultation at the least in any attempts at rural resource planning, and perhaps in the long run for the development of a community cooperative to actually manage such resources. Such moves would thus be a small step in the direction described in the third scenario.

What issues would form part of a community concern with 'appropriateness'? The cost of energy has already been identified as a subject of increasing concern for the future. Energy in Mull is almost exclusively imported. The 'appropriateness' of such arrangements is limited to current cost-effectiveness. The questions of reliability and acceptability receive no explicit consideration. Perhaps an initiative to produce more energy from internal source might not be strictly cost-effective, but yields benefits in increased security of supply. The existing mix of energy use is largely unknown, and without such local information appropriateness cannot be evaluated. In fact, the 'cost-effectiveness' of the existing mix of energy-use is framed in terms of appropriateness to the supplier. NOSHEB prefer to import most of their electricity from centralised generation facilities. Shell(UK) prefer to import four star petrol only because of the costs of distribution facilities for additional grades.

From such examples it can be seen that 'appropriateness' involves the consideration of the interaction of purely technical factors with the range of social and economic factors which make up the community's interest.

> "....It is in the area of human belief systems (or social thought) and organisation, not in the area of technological discovery, that the key to the problem of restoring the environmental balance with minimum loss of life and suffering is to be found...."
> (16)

The focus therefore returns to the main common ground between Chapters eight and nine , the question of organisation. As Morrison points out: "....It is clear that we could increase significantly the degree to which we exercise conscious control over our socio-economic development..." The technical competence and awareness of the community will be an import important factor in any such development.

iv) The Outside World

As externally powered influences exert such an important pressure on a remote community such as Mull, their own interpretations of appropriateness are obviously relevant. The relationship between Mull and the rest of the world is theoretically symbiotic. Mull supplies resources and facilities in return for goods and services. The suggestion is sometimes made that the relationship is one-sided, either in that the outside world extracts more than 'its due' or that Mull is somehow parasitic, operating at a net loss in terms of social costs and benefits. No adequate study of such a difficult question has ever been attempted. The relationship is rarely subject to public debate, and hence no widespread understanding of its nature exists. There is little doubt that many of Mull's problems stem from it, for example the vagaries of livestock markets, the current difficulties with the sale of first thinnings from forestry or the imbalances created by a demand for peak season recreational facilities and accomodation. Similar considerations are of relevance to the problems Mull poses for the outside world. Services such as public transport, road maintenance, posts and electricity supplies are clearly relatively more expensive and difficult for dispersed communities. In most cases it is not considered cost effective to develop technical solutions specific to such communities. On the other hand, without these services the net benefit of meat and fish, timber and recreational space, would not be available. The problem is really the tremendous size discrepancy between the 2500 people of Mull and the 5 million in Scotland or the 55 million in the UK (one of 2000 or 22 000 such groups respectively). Mull, and any other such community, has no effective voice beyond its single District councillor. It is therefore very difficult for effective communication to take place between the community and those deciding, for example, the revision of prices structures in the CAP or the shape of future afforestation grants. These external decisionmakers, moreover, do not operate in a vacuum, and are subject to pressures of their own environment. Decisions taken by them tend to be designed to deal with issues at the broadest possible level, and hence centralised decisionmaking with little reference to local circumstances is self-reinforcing.

Thus the opposing pressure of a centralist rationale leading in the direction of Chapter eight may be characterised. The outcome of the conflict of interests determining the criteria for appropriateness will be the crucial factor shaping the future of the West Highlands.

11.5.2 Appropriateness and planning

Returning to the aims of the thesis laid out in Chapter one, a crucial question is: 'Is the area producing as much as it could, or does its present condition represent a serious suboptimisation of natural resource use?'

Having examined a case study area within the Highlands, discussion of such a question may be attempted. History has shown that without intervention the existing economy of Highland communities can be subject to serious misallocation of resources and organisation, while an idealised planning system based on comprehensive information about function and process fails to model the inadequate information available in the real world. Mutch (17) describes such a concept of planning before going on to describe its inadequacies. The outline is similar to that used in Chapter five, the ecologist setting up technically feasible alternatives to be ranked by the economist and selected by the politician and administrator. The main objection to this concept is that:-

> "....Virtually any crop production is technically possible, even in the most inhospitable of environments, provided that sufficient capital and labour can be supplied to the system ...." (Mutch p 261)

The range of feasible alternatives thus derives far more from context - the characteristics of the environment within which the system under study operates. At present, Mull is closely integrated with the UK economy because that economy is capable of supplying the material component of 'standard of living' more cheaply and with more reliability than the island could itself. In return, the relatively tiny community of Mull can only offer marginal products to larger scale activities off the island. In Chapter seven, the probable response of the island community to isolation is examined. While such a future would not be able to offer the same level of material consumption, it would apparently support a higher population on the island's resources. The same is true of the future described in Chapter nine, in which there are more opportunities for more intensive resource use. Such opportunities would allow a more favourable balance to be struck between per capita material consumption and total population. All three futures represent a more intensive use of resources. What basis is there to say that any of these alternatives constitute 'best use', or are more appropriate? This can only be judged on the basis of the objectives of a purposeful system. This implies a system of planning and organisation which must design and invent active adaptation and control of a system in its environment, as opposed to one which attempts to predict and prepare for a system outside its control. Such an approach represents a radical departure from that adopted by the institutions and organisations described here. The resource manager has no choice but to react to the constraints of his environment, but if he accepts the possibility that he is able to influence the shape of his environment by the decisions he makes, then resource managers collectively are in a position to make better use of their resources by technical criteria, because the instititutional constraints may be changed. The planning agencies, on the other hand, must move away from the concept of the prescriptive plan, and in Ackoff's phrase (18) should become facilitators of the planning of others for themselves. This does not mean setting up vaguely justified schemes of fiscal and financial incentives. It requires active investigation of institutional barriers facing hill farmers, foresters and others, and exploration of ways of demolishing such barriers.

Such a purposeful community could only develop on the basis of a defined objective to provide an acceptable standard of living for each member of the community, from an economy based on the natural resources found within the geographical boundaries of such a community. Refining such a broad aim into operational objectives returns the argument full circle to the problems of complexity described as a prelude to the development of scenarios in Chapter six. A review of the broad outline of this argument is to be found in Chapter twelve.

Notes to text

1. E.M.Rogers and F.F.Shoemaker (1971) Communication of Innovations note that of 1500 publications on innovation they considered, only 38 concerned themselves with 'consequences' (in the sense of external effects and influences on the innovating organisation)
2. Select Committee on Scottish Affairs (1972) Land Resource Use in Scotland HC 511 (71/72) Volumes I to V
3. Scottish Development Department (1973) Land Resource Use in Scotland Cmnd 5428
4. W.E.S.Mutch (1975) Taxation and sustension of forestry in Britain Scot. For. 29 307-320 - is a useful summary of the use of fiscal incentives in forestry. Mutch also proposes a system of taxation which would operate at a much more refined level to produce the kind of forestry that is required.
5. Forestry Commission (1977) The Wood Production Outlook for Britain
   Centre for Agricultural Strategy (1980) A Forest Strategy for the UK
6. Figures from the report of the Royal Commission on Distribution of Wealth, 1979.
7. National Farmers Union of Scotland (1978) Agriculture and Forestry - A Policy Statement
8. N.Cross et al (1974) Man Made Futures
   G.Boyle et al (1977) The Politics of Technology
9. A.Fenton (1976) Scottish Country Life provides some of the background, &
   P.A.David (1975) The landscape and the machine: technical interrelatedness, land tenure and mechanisation of the corn harvest in Victorian Britain - Chapter five of Technical Choice, Innovation and Economic Growth - provides most of the technical detail.
10. R.G.Wilkinson (1973) Poverty and Progress - an ecological model of economic development
11. T.Higgins (1977) Research Planning & Innovation Chapters 10 & 11
12. T.Higgins (1977) op cit Appendix A5
13. For example:-
   D.Davies et al (1976) The Complete Technologist Chapter two
   R.Du Boff (1974) Economic ideology and the environment in H.G.T.Van Raay & A.E.Lugo (eds) Man and Environment Ltd
   D.&R.Elliot (1977) in Boyle et al op cit
14. D.Davies et al (1976) op cit pp 24-25
15. I.Carter (1979) Community development in Scotland; Promises & Problems - paper to BAAS Conference, Heriot-Watt University, September

16. J.F.Morrison (1976) Man, organisation and the environment
in van Raay & de Lugo (eds) op cit

17. W.E.S.Mutch (1974) Land Management - an ecological view
J.Env.Management 2 259-267

18 R.L.Ackoff (1979) Resurrecting the future of Operational Research
J.Opl. Res. Soc. 30 (3) 189-199

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CHAPTER TWELVE - IN CONCLUSION

This final chapter draws together the various strands of the thesis and reaches a final conclusion. The thesis has examined a real resource-use system, the community of Mull, and explored possible futures for it. In the concluding chapters, Chapter ten compared and contrasted the outcomes of the scenarios, and attempted to identify links and common features. Chapter eleven reviewed the general problem of defining 'appropriateness' in relation to resource use and technology. It concluded that a definition of appropriateness cannot be produced independent of context, and that patterns of resource-use can only be judged in terms of a purposeful community (one having explicit aims and objectives) able to establish its own criteria for appropriateness. Chapter twelve examines these conclusions in terms of the present-day Mull system explored earlier in the thesis. A review of the earlier chapters helps to place the Mull system in its historical context and is a reminder of its dynamic and evolving nature. The next section reviews the aims and objectives laid out in Chapter one and assesses the extent to which they have been met. A final discussion reviews the conclusions, constituting as they do the endpoint of a transdisciplinary project. The relationship of this endpoint to those reached by other approaches is compared, and an assessment of future directions is made.

12.1 Review

12.1.1 The Mull system

The Island of Mull is an example of the community, economy and natural resource base typical of the West Coast of the Scottish Highlands. Chapter three briefly described the known history of the island and its neighbourhood. This history serves as a reminder of the continuing changes which have enveloped the Mull system in the past, and which will continue in future.

Mull was at one time heavily wooded at low altitudes, with a limited range of tree species in the most exposed sites. Early human communities accelerated, but were not the only cause of, the decline of these woods. They were replaced with a predominantly pastoral farming system which has prevailed in one form or another until the present.

From the Eighth Century until the Eighteenth Century, the social system sustained a relatively stable system of resource-use . The locally self-sufficient communities were not able to sustain a higher level of organisation, and hence armed conflict, raids and feuds were frequent. The political instability of the area, coupled with the increasing ability of central government to exercise effective political control over peripheral areas and changing perceptions of economic needs and capabilities, led to the integration of such areas into the Scottish and UK political and economic system. This change in the external environment of Mull disrupted the stability of the system, and the consequent adjustments led to famine, mass emigration and economic disadvantage. The population of Mull declined by a factor of five between 1820 and 1950, but the standard of living of the remaining community attained and broadly kept pace with the rest of the UK as an industrialised Western European nation.

The present status of the 91 400 ha of the study area is thus of a marginal rural community of about 2500 resident population, based on extensive livestock raising, forestry and tourism. The island produces about 25 000 lambs and cast ewes for sale each year, together with 1500 calves and culled cows from its agricultural operation. The numbers of sheep are falling steadily, while problems of cost and markets in beef production seem unlikely to change markedly. Forestry is a relatively new industry, with a 10 000 ha forest largely planted since the Second World War. Present production of some 10 000 tons per year is expected to increase to 20 000 tons or more in the 1980s. Most of the forest is owned and managed by the State orestry Commission; without their Government-backed longer view of investment, it is unlikely that a forest of this size would have been established. Tourism has been a buoyant industry in recent years. Its largest problem has been seasonality; for the ten week peak summer season, demand, for accomodation in particular, outstrips supply. For six months over the winter, demand is negligible. Tourism accentuates Mull's marginality, because as an industry it satisfies non-basic needs for people resident outside the area. It is therefore vulnerable to changes in tastes and external circumstances. The openness of the island economy is accentuated by its adoption as a retirement home or a retreat by people whose primary source of income lies outside the island. Thus pensions and external investments are a significant revenue supporting the island's population.

The Mull community therefore exhibits a considerable dependence on the outside world. Energy, consumer goods and many foodstuffs are imported; whether the balance of imports and exports is positive or negative is unknown, especially since the invisible balance of financial transactions appears to be significant. The community has no control over this balance, lacking effective internal organisations and planning; different industries and activities are managed in isolation. The Community Council has only a marginal advisory role to the District Council based in Lochgilphead on the Mainland.

The review of Mull's natural resources in Chapter five concluded that resource constraints are not, in themselves, limiting factors on total output. Climate parameters are not particularly inimical to plant and animal growth. The main features are the large areas of poor quality and high ground, and the dispersed and uneven nature of the relatively small area of cultivable ground, coupled with a climate of high rainfall and exposure with unexceptional summer temperatures. Winters, however, are mild and snow is almost unknown on low ground. Survey and review of existing information leads to the conclusion that, from a purely biotechnical point of view, there are 3000 ha of cultivable ground and about 8000 ha of land capable of reclamation to permanent pasture, without infringing on the existing area of forest. An estimate of the production potential of the existing activities on the island suggests that a 60% increase in sheep production and a 280% increase in cattle output could technically be sustained using existing technology. Forestry could sustain as much as a nine-fold increase with full use of the existing area, but this would take time to achieve.

12.1.2 Futures for Mull

A detailed exploration of three anticipations for Mull's long-term future forms the bulk of Part three. These three futures are derived from the discussion in Chapter six, which asserts that the shape and form of the Mull community is largely determined by external forces. An examination of current trends and problems in this external environment leads to the specification of three alternative possible futures. The problems are grouped into five classes, which are the supply of natural resources and energy, the interdependence of the world economy, the social and political problems caused by complexity and change, access to and effective use of information and finally mechanisms for the resolution of conflict. The three scenarios based on these futures in Chapters seven, eight and nine attempt to produce a figure for carrying capacity based on the algorithm described in Chapter two. The results may be summarised as follows:-

In the first scenario, failure of the world system to cope with its problems leads to a breakdown of interdependence and enforced self-sufficiency for Mull. Intensive use of land resources with limited technology governed mainly by availability of energy allows support of about 8000 people at a subsistence level comparable in quality to the early Eighteenth Century. The community would face a considerable threat of over-population, but this apart, the expectations beyond the fifty-year horizon of the scenario would be good.

In the second case, the present dependence of the Mull community on decisions taken in remote power centres is sustained and enhanced by development of computer-based decisionmaking systems centralising political control of the economy. International circumstances force intensification of resource use in what are currently under-used marginal areas. Mull is identified as capable of sustaining a considerable increase in afforestation to a total area of about 36 000 ha. Agriculture concentrates on intensive sheep rearing and produces present-day levels of output on 2000 ha of cultivable land. This, plus tourism, supports a population of about 2000, and greatly increased exports of raw materials. The outcome is a community even more dependent on the outside world; the concept of carrying capacity and community, dependent on definition of a viable system boundary, are largely unusable in this case.

The third scenario envisages a change of direction from the single-minded pursuit of economic growth and material goods. The question of values, and the search for higher levels of satisfaction in Maslow's hierarchy, such as esteem and self-actualisation, become prominent. In pursuit of these goals, the community becomes technologically sophisticated and self-reliant. Basic needs are satisfied within the island, without the predominance of imports of food, durables and energy seen today. Production of raw materials and energy from sustainable sources allows a self-contained microeconomy to develop. Application of the carrying capacity algorithm suggests a population of about 10 000 people with some indications that standard of living would remain high. The prospects for continued development beyond the scenario horizon in harmony with the constraints of the system are very good.

12.1.3 Resource use and technology

The size of the population calculated in the three scenarios should be treated with caution. They relate only to the ability of the system to supply food needs, on the assumption that the criteria of need and the production functions of the system are adequately specified. However, these are relatively minor problems in relation to the higher level needs of the human community. Criteria for assessment of these are less easy to specify, and their effect on the ability to satisfy physiological needs is unknown. It is not clear, for example, whether pursuit of a higher needs such as belonging or esteem will depress or ehhance the ability of the community to satisfy its more basic needs. There is evidence to suggest that a highly organised community, commanding an appropriate range and depth of skills, will be able to fulfil its needs more efficiently (in the sense of securing a larger output of need-satisfying products from its relatively fixed resource base) than a community which lacks such integration. As Chapter five suggested that Mull's natural resources are technically capable of higher output, does this mean that the level of integration is low and that resources could be more intensively used to meet needs in some more appropriate way? Such a question cannot be answered without reference to some set of criteria, some measure of appropriateness. In economic terms, the costs of inputs and the price obtained for outputs, measured by the profitability of the enterprise, gives some measure of current performance. Comparison of this with expected returns from other enterprises or investments gives some idea of the value of intensification (higher output from the same resource base) through the concept of opportunity cost. However, these comparisons only hold for a particular set of relativities in the price structure. The value of a possible change which would restructure these relativities can only be assessed if most of the interrelationships between the various commodities can be specified.

Moreover, even this ambitious exercise could only yield indirect evidence of the community's performance as a system for satisfying needs insofar as those needs may be measured in cash terms.

Chapter ten explored some of the less easily quantified qualities of the Mull community. In figure 10.2, the three scenarios were characterised in terms of three factors. The first is a situation in which external trade decreases and sophistication of resource-use declines. Thus the community's interaction with the outside world is reduced along with its ability to manipulate its resources and environment in pursuit of need satisfaction. The second scenario involves a greatly increased interdependence with the outside world; however, the community loses more of its limited powers of self-determination to the extent of losing most of its identity. In the third scenario, a self-reliant community interacts strongly with the outside to exchange skills, but not so much for its material requirements. The community has much more self-determination than the present-day, coupled with increased understanding and managerial skill in its use of natural resources. This scenario has an additional quality of considerable importance in assessing long-range goals - it has greater adaptive potential, which is to say that it will be better able to cope with a changing external environment. In all three cases, the scenarios are both quantitatively and qualitatively different from the present day.

Chapter eleven provides evidence that present day policy objectives in resource use from government and resource manager alike, are not well designed from the point of view of assessing 'appropriateness' in an era of changing relationships of resources, users and values. This assessment must carry with it a definition of context, which can only be provided by a purposeful (goal-seeking) system. The chapter concludes that such a purposeful system could develop in Mull in pursuit of the objective to provide an acceptable standard of living for each member of the community from an economy based on the sustainable use of the natural resources found within the geographical confines of that community. To refine such a broad aim into operational policies for Mull goes beyond the scope of this thesis, but the point may be made that the definition may be applied at various hierarchical levels in the human community, from the global level to the individual enterprise.

12.2 Reviewing the questions posed

The significance of the conclusions may be explored by returning to the questions posed in Chapter one. The thesis examined the Island of Mull as a case study of the problem set known as the Highland Problem. The primary question was to establish the nature of the limitations on the system's activity. The question posed on page 5 was:- 'What is the potential of the Island of Mull for the support of a community?'.

It was recognised at the outset that the answer depends on the definition accorded to the words in the question, in particular 'potential' and 'support'. The framework of Maslow's hierarchy of needs was used and it was discovered that numerical answers were only achieveable for the limited sense of 'support' in terms of food supply. The self-reliant community of the third scenario had the potential to support a community of 10 000 in these terms. However, the three scenarios together with the present day situation show how dependent 'potential' is on external circumstances. Maximising raw material output to meet national UK definitions of need could lead to the 'support' of a population of less than 2000. Choosing between these contrasting futures requires value judgements about the relationship between individual community and nation, and some preferences for the alternative ways in which the outside world might exert its influence. The first scenario, exploring a future in which Mull is isolated, showed the island capable of supplying subsistence needs to a population of 8000, but a standard of living which would be regarded as undesirable by present day standards. The conclusion drawn is that the limits on the Mull system activity are not physical in the sense that larger inputs (of skills, materials, labour) could bring larger returns. Present day values dictate that these returns would not justify that input, or perhaps present day policies are not couched in terms which adequately value this tradeoff.

The second question on page five extends the examination of potential into the question of value judgements. The first question explored the possibilities for increased size and activity of the island's community. This question explores the means and justification for such an increase:-

> 'Given the current knowledge of the capabilities of the study area, what form of organisation and policy would enable the appropriate use of resources and technology there?'

Current knowledge is considerable but incomplete (Chapters 4 & 5). Organisation and policy thus needs to be oriented towards the ability to cope with inadequate information. This involves value judgements on requirements for extra information, which can only be achieved within the context of an overall objective against which values may be measured (in terms of their contribution to that objective). In other words, an adequate answer to this question requires the specification of normative criteria for appropriateness. If the term is established from the point of view of the community, the examination of alternative futures suggests that the establishment of a local, democratically controlled decisionmaking centre, in the shape of a community council with executive powers, or of a community cooperative, might allow the development of a larger and more self-reliant community. Against this are the current political conventions of landownership and management, the small size of the community in terms of numbers and the widespread belief that such a course of action would be 'uneconomic'. Viewed in this light, the latter statement appears simply as an assertion couched in terms of different criteria for appropriateness. A crucial question which remains unanswered is the relationship of size to viability. Could a community as small as Mull guarantee its people an adequate standard of living in the scenario outlined above? The argument against such a development suggests that it could not, while the present system, by implication, can. But the present Mull system is dependent on three particular externally determined supports. First, the Hill Livestock Compensatory Allowances, second the continued investment in afforestation by the Treasury through the FC with expectations of relatively low returns and the private sector with expectations of tax relief for off-island assets, and finally the current taste for island holidays and retirements and the cash to spend in pursuit of such ends by a large number of people from quite different economic circumstances. The withdrawal or collapse of any one of these would prejudice the whole future of the community.

This gives a clue to the shape of appropriate policies. Mull as an island at present has no policies, or the organisational structures to produce them. The agencies whose policies influence the course of events in Mull are tailoring their responses to remote external pressures of national and European politics. At the local level, these policies are not integrated and may conflict (or more often be ill-designed for) local needs. However, they command resources on a scale which enables them to dictate the environment of resource-use in Mull, and individual resource managers, commanding relatively small resources also have to respond to the dictates of this environment.

Discussion therefore moves on to a third issue, the roots of the 'Highland Problem', characterised on page three as a relatively low level of population, economic activity and natural resource use. This is not simply a function of poor resource quality. A historical analysis (p 11/12) suggests that more important was the past perception of more rewarding opportunities elsewhere, a perspective which carries a considerable momentum in the policymaking structure of national and international organisations. However, the conclusion of the argument on page 12 is that the resource quality of the Highlands will soon be receiving more attention. How should this be translated into policies which make best use of the opportunities?

A feature of natural resource planning is the large number of agencies involved and their tendency to take up a competitive stance one to another (p243-247). The HIDB has the clearest statement of overall objectives as a regional development agency. This is to obtain better primary land management and to maintain or increase job opportunities and incomes. It also advocates a coordinated approach to problems of rural resource management. The HIDB, however, commands relatively small financial resources. The Highland Regional Council has complained that, as an elected body, it controls only a small fraction of the public money spent in its area through the various central government agencies. The DAFS is compromised by its concern with agriculture outwith the Highlands and by the overall influence of broad EEC policies. The Forestry Commission is nominally a commercial enterprise and can make only limited concessions to social objectives. It seems clear that increasing pressure to intensify resource management would lead to increasing conflict between these and other agencies.

The second scenario illustrates the kind of future which might emerge as a result of resolving such conflicts with few accompanying changes. Total resource outputs would be larger, but at the cost of greatly increased inputs of energy, materials and capital, coupled with significant organisational support costs of bureaucracy and servicing. This might not be the most 'appropriate' solution to a need for more intensive resource use. For example, such a scenario would not create the organisational structures necessary to exploit the considerable potential of energy resources in Mull (section 9.3.2) which might make a large difference to the 'return' on investment of resources and skills in pursuit of an overall aim of increased output. There is little doubt that the third scenario, with a local scale of policy analysis, integrated across the range of economic activity by a community power focus, would exploit such opportunities, given the means to deploy some of the resources presently commanded by remotely managed large organisations.

The question posed on page 3:- 'Is the (West Highlands) producing as much as it could, or does its present condition represent a serious sub-optimisation of natural resource use?' may be answered quite simply. The area could produce more in absolute terms, but its present condition only represents a serious suboptimisation when valued in terms of a need for increased resource use. Its present condition is, by definition, 'appropriate' within the limitations of policies pursued by today's organisations and managers. Policy and its execution is therefore the key to change in the West Highlands.

The final aim mentioned on page 5 concerns elucidation of complexity and the nature of the human 'problematique'. The relationship between data, models and values has been explored in the case study of Mull. This has shown that deficiencies of understanding exist at many levels, making holistic understanding difficult. This is a considerable barrier to integrated (or transdisciplinary) analysis: however, the problems posed by the need for government agencies and individual managers to design appropriate policies serve to underline the necessity to pursue such holistic ideals.
This thesis has not, perhaps, advanced the understanding of these complex issues very far, but it has confirmed the need to study them and emphasised the importance of context in this regard.

12.3 Appropriateness in the Scottish Highlands

This final section makes some concluding observations arising out of the conclusions drawn above. It tries to step back from the immediate discussion of the thesis itself to take a short look at the work in a wider context.

The rationale for a transdisciplinary approach was rehearsed at length in Chapter two, so perhaps the final conclusion (above) that a holistic view is valuable is tautological. However, this is in the nature of such work. Research rarely, if ever, takes a problem from first principles and after analysis provides a definitive and unqualified answer. Normally, research starts with the results of others' work and takes up the problems they raise. Its own conclusions form the basis for new equations, new problems, which in turn may be taken up by others in an open-ended process. Explicit discussion of direction in such an environment is important, because research resources are limited and ought to be directed to maximum benefit. Research resources in this case were limited (about three man-years of effort) and this reality determined the depth of analysis at many points. Retrospective comparison with other approaches to the same problem must take this into account, and only attempt to compare like with like. A research team with multidisciplinary skills and a large budget could undoubtably have gone much further, but this misses the point. Most alternative approaches involve a less ambitious range of interests, examination of a smaller part of the problem (an example would be an exploration of the barriers to the improvement of hill land) and would necessarily have involved abandonment of the transdisciplinary aims adopted at the start.

In systems terms, a leading alternative would have been the construction and validation of a more explicit quantitative model. Incomplete modelling concepts were used in the course of the work, a particular example being the similarity between the carrying capacity calculations and a linear programming algorithm (section 2.3). The incomplete specification of the quantitative relationships in the carrying capacity calculations was an important reason for the tentative nature of the conclusions about carrying capacity in each scenario. The use of a more explicit model would have reduced this source of uncertainty; however, such an approach has two particular drawbacks. The first, entirely practical, is that the specification of a suitable model and its constituent relationships would require research resources beyond the scope of this project. The second is that, by definition, a quantitative model can only account for quantitative relationships, and must ignore or only indirectly account for qualitative factors such as skills, values, needs and organisational effectiveness. To ignore or assume insignificance in these factors would be to abandon the aim of transdisciplinarity, of using readily available analytical tools and information to explore a real system. However, a body desiring more specific information on the productive capabilities of Mull's natural resources would be well advised to explore quantitative modelling. This thesis has argued that such an exercise would only be worthwhile within an explicit context. If such a rationale has been specified, then a suitable quantitative model would yield interesting insights into aspects of the Mull system which were explored only superficially in this thesis.

Adoption of a transdisciplinary approach has allowed exploration of the qualitative aspects of the Mull system, assisted by a limited exploration of its quantitative features. The ideal of a holistic appreciation lies behind this approach, but there is no sense in which this thesis has been comprehensive. A holistic analysis would have to be comprehensive but, however desirable, is unrealistic in practice; the requirements for transdisciplinarity are of 'necessary and sufficient' (or appropriate) depth of analysis (p 19).

The focus of the project was the 'Highland Problem', exemplified by the Island of Mull. This was characterised in terms of population, resource use and economic activity.relative to the rest of the UK. This in itself is not holistic - the problem has cultural and political aspects which were not explored in depth. While concentration on resource use did allow exploration of the functional relationship between community and its resource base, there are undoubtably some aspects of history and present-day Mull which remained obscure - for example, how important is the apparent inability of the community to retain and plough back generated capital in prolonging its dependence on policy decisions in remote agencies? Such speculation is perhaps the next phase, one of the questions raised by the work, which has shown that the 'Highland Problem', in Mull at least, does not stem from absolute constraints on natural resources; different policy priorities and community powers would permit more intensive use of those resources, and perhaps support of a larger population. The location of powers of policymaking and execution within the community would permit both of these, but the thesis has not said how a desirable structure might be achieved.

The first objective of planning for the community must be survival, and the second to maintain and enhance standards of living. These imply a concern not only with day to day existence, but also a longer term concern with the functional characteristics of the economic, technical and resource based pressures on the system. An appropriate policy is one which contributes to these objectives.

The present-day agencies are not 'appropriate' in this sense. Policies are set with a minimum of integration and a minimum of adaptation to local circumstances. While this is acceptable for an extensively managed resource base, increasing intensity will sharpen conflicts between policies in the absence of deliberate coordination. Increasing intensity of land use therefore requires increasing integration of land use policies so as to make best use of capabilities and resources at a local level. To produce a plan which does not take account of these pressures is to produce an inappropriate design, with little chance of successful implementation because of the failure to account for the pressures imposed by the physical and political environment.

Successful policies, plans and managers need information, and this is deficient in both quantity and quality. Characterisations of the resource base and its production functions are inadequate to model likely responses to changing inputs; furthermore, the benefits and costs of different organisational and managerial models are inadequately understood. This wide range of possibilities lacks a scale of priorities based on an explicit rationale or statement of purpose. An important basis for such a rationale is the specification of community needs; historically, change has been an exogenous variable for Highland communities. While the outside world will always be an important influence, the present extent of dependence for policies, decisions and capital is seen as undesirable. Many of the information needs, particularly for organisational and managerial purposes, could be satisfied by way of practical demonstration of alternatives at the community scale.

The last word, therefore, lies with the community. The community scale of analysis would seem to be a neglected area for the academic. Nevertheless, communities are important and in many ways form an appropriate basis for resource management. Policies should be based on their needs and expectations, and in the longer term should aim to encourage a community's self-confidence and integrity.

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APPENDICES

APPENDICES

Appendix one - Abbreviations used in the text

Appendix two - Bibliography

Appendix three - Technical notes on natural resources - spatial patterns

Appendix four - Technical notes on natural resources - temporal patterns

Appendix five - Technical notes on natural resources - land use capability assessment

APPENDIX ONE - Abbreviations used in the text

AGM - Annual General Meeting
BP - Before the Present (years)
C^1 - Size of Community
C^2 - Carrying Capacity
C^3 - Crude Carrying Capacity
CAS - Centre for Agricultural Strategy (Reading University)
CCS - Countryside Commission for Scotland
CSS - Concil for Social Service
DAFS - Department of Agriculture and Fisheries for Scotland
DCP - Digestible Crude Protein
DHSS - Department of Health and Social Security
DM - Dry Matter
EEC - European Economic Community
FC - Forestry Commission
GP - General Practitioner
GPO - General Post Office
HFRO - Hill Farming Research Organisation
HIDB - Highlands and Islands Development Board
IIED - International Institute for Environment and Development
ITE - Institute for Terrestrial Ecology
LUC - Land Use Capability
MAFF - Ministry for Agriculture, Fisheries and Food
MICSS - Mull & Iona Council for Social Service
MISR - Macaulay Institute for Soil Research
MO - Meteorological Office
MP - Member of Parliament
NCC - Nature Conservancy Council
NFUS - National Farmers Union for Scotland
NOSHEB - North Of Scotland Hydro Electricity Board
OAU - Organisation for African Unity
OECD - Organisation for Economic Cooperation and Development
OPEC - Organisation of Petroleum Exporting Countries
RSGS - Royal Scottish Geographical Society
RLUIS - Rural Land Use Information System
SARUM - Systems Analysis Research Unit Model

SCRLU - Standing Committee for Rural Land Use
SCSS - Scottish Council for Social Service
SDD - Scottish Development Department
SE - Starch Equivalent
SED - Scottish Education Department
SEPD - Scottish Economic Planning Department
SNP - Scottish National Party
SRC - Science Research Council
SSRC - Social Science Research Council
SSSI - Site of Special Scientific Interest
UK - United Kingdom
UN - United Nations
UNCSTD - United Nations Conference on Science & Technology for Development
USA - United States of America
USDA - United States Department of Agriculture
USSR - Union of Soviet Socialist Republics
WSAC - West of Scotland College of Agriculture

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APPENDIX TWO - Bibliography

The following bibliography does not purport to be comprehensive. It is, however, a list of works consulted in the course of this research. Acts of Parliament and annual reports of government agencies have been left out, together with minor leaflets and newspaper articles which have influenced the course of the work.

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APPENDIX THREE - TECHNICAL NOTES ON NATURAL RESOURCES - SPATIAL PATTERNS

A3.1 Integrating the data

An important activity in the early stages of the project identified the various relevant sources of information and brought them together at a comparable scale. The mapping scale chosen was 1:100 000 (1cm:1km), which accords with the 'reconnaisance' level of survey according to Whyte (1) and falls between the extensive and intensive levels defined by the Land Resources Division of the UK Overseas Development Ministry (2). In the ODM classification, the extensive survey aims to make a detailed inventory and a broad assessment of agricultural potential at a regional level. Intensive survey aims to locate and define specific developments. The aim here is intermediate; both to make a broad assessment of land characteristics and to identify areas deserving closer scrutiny.

The various sources of information are diverse, and none are at 1:100 000. Information was transferred freehand onto 1:100 000 working maps, using the National Grid as a reference framework. The maps therefore had limitations deriving from the scale and the production process. The most important source of error derives from the method of transferring information. It is not thought that this is a serious source of error, but could well become so if the maps were to be used for anything more detailed than the rather general use made of them here. The diazo production process for the base maps introduced a minor source of error ($\pm$ 1%) as a result of paper stretching in copying. A third limitation is the size of the minimum mappable unit (the minimum mappable area, as opposed to a point, the boundaries of which may be delineated with confidence on the map), which in this case is about 0.25cm^2 (5mm x 5mm). With especial care, areas of 0.1cm^2 (ca. 3mm x 3mm), may be identified, but the larger limit is considered to be a more appropriate standard. At this scale, the minimum mappable unit represents 25 ha on the ground, a substantial area when it is remembered that active arable land in Mull occupies only 160 ha (1977 agricultural census), less than ten times the minimum mappable unit in total.

The areas of ground in the various categories were measured using a simple dot grid. The transparent overlay used for this purpose was 10 x 10 cm and contained four evenly spaced dots per square centimetre. Each 10 x 10 km square on the map was thus measured, the subtotals crosschecked and aggregated. The final totals were rounded to the nearest 100 ha. These figures are the main output of the map work, and only one of these maps (that resulting from the 1978 land survey) has been reproduced and appended to the thesis. For the others, the source of the original map has been quoted in each case.

The information collected in this way has been categorised into four classes:-

- Landform - particularly altitude and hydrological features
- Climate - temperature, exposure, rainfall and water balance
- Substrate - geology and soils
- Community infrastructure - land use, land ownership, communications and settlement patterns.

A3.2 Landform

The source of landform information was the 1:10 000 series of Ordnance Survey maps produced from surveys in 1974. Two maps were produced from this data, one showing the general form of topography in the form of altitude contours, the second showing significant water courses and bodies of open water.

i) Altitude

The incidence of high ground is often cited as an important constraint on economic development in Northwest Britain. Analysis of the map shows that this may be a misapprehension:-

Altitude class (m)	%	area (ha)
0-50	22.2	20 300
50-100	16.5	15 100
100-150	15.0	13 700
150-200	12.5	11 400
200-250	11.5	10 500
250-500	18.8	17 200
500-1000	3.5	3 200
Total	100.0	91 400

Almost 40% of the land lies below 100m (325 feet) and almost 78% lies below 250m (800 feet). Thus less than a quarter of the island's land surface can accurately be described as 'high ground'. It is true that this derives from the typical landform of an island, falling away on all sides to the sea, but it would suggest that high ground may not of itself be a critical limitation in the evaluation of Highland resources. The presence of high ground, however, is associated with other features affecting adjacent lower ground, notably climate and geomorphology. These are discussed in detail below.

The actual range of altitude in Mull is 0-1000 metres above sea level. Land above 250m is of very limited use for grazing and occasional marginal forestry in sheltered, south-facing sites. Below 250m, the land manager's interest intensifies as the range of viable management options increases.

A secondary feature of altitude is topography and terrain. This places restrictions on the use of machinery for access and cultivation. It is difficult to map at 1:100 000 because many of the critical features are small in relation to their importance. Another approach to such problems may be found in Bibby's use of land systems and land facets (3). These describe the typical topographic types found in Mull.

ii) Hydrological features

This map was also derived from Ordnance Survey material, describing the significant water courses and lochs, and the boundaries of the major catchments. While the island is typical in that it contains a large number of small catchments, the complexity imposed by topography eliminates any obvious pattern. The map was used together with rainfall and altitude maps to identify and evaluate sites for the calculation of hydro-electric potential in Chapter nine.

A3.3 Climate

The climate component of physical environment is usually considered at three levels. First is macroclimate, the regional characteristics of climate and weather systems, in this case for the whole of Mull. Most of the readily available information is at this level. The second level is mesoclimate, the field level, where macroclimate is modified by local topographic and vegetational features (for example, south-facing sheltered slopes may be expected to produce a more equable environment than one would expect from the overall macroclimate). The third level is microclimate, the immediate environment of the individual organism. Macroclimate is therefore essentially independent of management decisions, whereas mesoclimate and particularly microclimate are subject to modification by human intervention. The climate features described on maps are thus only part of the influence of climate on resource-use systems.

i) Accumulated temperature over 5.6°C

This map was drawn from the MISR map of Scotland at 1:625 000 scale (Birse et al, 1970). It is therefore a very approximate guide to temperature regimes, interpolated from relatively few point data. The breakdown of areas below is probably a fair assessment of temperature classes, but the use of the map to assign a particular point on the ground to a particular class is less easy to justify.

Temperature class (day-degrees C/year)	%	area (ha)
more than 1375	36.5	33 400
1100-1375	37.5	34 300
825-1100	20.0	18 300
550-825	5.5	5 000
less than 550	0.5	400
Totals	100.0	91 400

Thus three-quarters of the island enjoys a temperature regime comparable with that found in the rich arable farmland of the Lothians or Fife. It would therefore appear that temperature is not a critical constraint on biological production in Mull, although a final conclusion would require far more detailed analysis. The question is pursued in Appendix four, in a review of the importance of temporal patterns of temperature. For example, Francis (4) suggests that accumulated temperature may be particularly significant for particular periods of the year, and suggests that this might be during spring and early summer, when leaf formation takes place.

ii) Accumulated frost

This map was also derived from the MISR bioclimatic maps. Once again, as the influence of altitude on frost is built in to the MISR approach to map production, the pattern of the map is largely determined by the landform:-

Accumulated frost (day-degrees C/year)	%	area (ha)
less than 20	35.1	32 100
20-50	42.9	39 200
50-110	17.9	16 400
110-230	4.1	3 700
Totals	100.0	91 400

Comparison with the MISR national map shows most of Mull to be better placed for frost than almost anywhere at the same latitude in East Scotland. However, care is required in interpretation of this parameter. The map is based on interpretation of the standard deviation of monthly mean temperatures, and not on any observation of frost occurrence. Since the monthly mean temperatures in Mull rarely, if ever, fall below 0°C, the map is therefore very largely dependent on the reliability of the analysis of variation. The occurrence of frosts is in any case more closely related to the pattern of daily minimum temperatures than to monthly means. The Aros meteorological station data shows an air frost occurring on about 50 days in the typical year, and a ground level minimum of 0°C or lower on about 140 days. The station is sited in the second class (20-50 day-degrees per year) on the map.

As with the previous parameter, the map takes no account of seasonal patterns of frost occurrence. The economic significance of frosts depends on the occurrence of early and late frosts. The generally more equable climate of the West Highlands may make such frosts more frequent, thus cancelling out any benefit implied by the aggregate statistic.

iii) Exposure

Drawn once again from the MISR bioclimatic maps at 1:625 000, this assessment of exposure can only be regarded as a first approximation. It is, however, the best available systematic survey for this parameter.

Average windspeed class (ms^{-1})	%	area (ha)
2.6 - 4.4	12.0	11 000
4.4 - 6.2	61.8	56 500
6.2 - 8.0	23.1	21 100
more than 8.0	3.1	2 800
Totals	100.0	91 400

Low ground in Mull therefore tends to be considerably more exposed than comparable ground in East Central Scotland. Only in sheltered valleys and along the east coast away from prevailing westerly winds is a similar level of exposure to be found. This amounts to 12% of the land area. Once again, however, the two 'better' classes cover 75% of the island. The pattern of 25% of the island being extremely inhospitable is thus strengthened.

iv) Rainfall

The available information on distribution of rainfall provides an interesting object lesson in map interpretation. Two maps are available, from the Ministry of Housing and Local Government and from the Meteorological Office. Dated 1967 and 1977 respectively, they use largely the same data, showing a similar but significantly different pattern of rainfall, reflected in the analysis of areas:-

Rainfall class (mm)	1967 map %	area(ha)	1977 map %	area (ha)
less than 1250	3.7	3 400	4.4	4 000
1250-1500	10.5	9 600	7.2	6 600
1500-2000	32.5	29 700	47.4	43 300
2000-2500	33.2	30 300	27.6	25 200
more than 2500	20.1	18 400	13.4	12 300
Totals	100.0	91 400	100.0	91 400

The more recent map therefore suggests that rather less rain in total falls on Mull in the course of a year, and the areas of the higher classes is correspondingly reduced. However, there must be particular doubts about the construction of the original published maps from relatively few point data across Scotland. In particular, the use of altitude as a determining factor, used in both maps, appears to be based on one pair of readings between Fort William and the summit of Ben Nevis. While there is undoubtably a connection between altitude and rainfall in the West Highlands, it seems extremely unlikely that it will take the form of a simple direct relationship along the same lines as temperature or pressure lapse rates. It is considered that the more recent map is more reliable, but that neither does justice to local and sub-regional circumstances in Mull because of their original scale of 1:625 000 and coverage of the whole of Scotland.

iv) Potential water deficit

The map was the fourth taken from the MISR maps. It therefore displays the same faults of broad grain at the 1:100 000 scale. Furthermore, it is derived from the interpretation of two primary sources, the 1967 rainfall map and the calculation of potential evapotranspiration for a number of stations. The map gives an impression of overwhelming wetness for the West Highlands, derived from the high rainfall figures and the low potential evapotranspiration resulting from cool summer temperatures.

Wetness class (mm PWD)	%	area (ha)
deficit 50-25	1.9	1 700
deficit 25-0	6.6	6 000
excess 0-500	59.1	54 100
excess more than 500	32.4	29 600
Totals	100.0	91 400

Potential water deficit appears of limited use in an annual context. The seasonal variations of this parameter, based on locally derived data, is of more direct use, and this is pursued in Appendix four

A3.4 Substrate - geology & soils

Maps of the structure of the island are available in several forms. Geological maps, both solid and drift editions, are available for most of the island at 1:63360. These are extremely detailed; a more general map at 1:250 000 shows the close correspondence between geological structures and Bibby's land systems.

MISR have surveyed the island and have published a soils map (1974) which recognises 16 soil series and 23 soil complexes, divided on the basis of parent materials into 12 associations. The map, at a scale of 1:63 360, is therefore extremely complex, displaying 44 different soil types, reflecting the complexity of soil structures typical of the West Highlands. The diverse topography, with its influence on drainage and mesoclimate, produces an intricate pattern of soils, predominantly poor by national standards. The isolated pockets of better soils are thus of crucial importance, and mapping at a relatively small scale presents problems. The better soils tend to be found on sloping ground; where drainage is impeded, peat formation becomes a predominant feature. At higher elevations on moderate slopes, podzolisation and iron pan occurs due to leaching by the high rainfall coupled with low ambient temperatures. The basicity of the parent material (basalt) makes this feature much less predominant in North Mull. The soils are generally characterised by shallowness, poor quality and complex patterns with frequent rock outcrops. Cultivation technology in contemporary agriculture is not adaptive to these conditions, but it does not follow that such areas are not amenable to cultivation.

The classes distinguished on this soils map are of little direct use to the resource manager. Considerable research has been carried out by MISR as the basis for a soil survey memoir to accompany the map, but this has yet to be published (5). This map forms the basis of the various MISR landuse capability assessments, described in detail in 5.3.1.

A3.5 Community infrastructure

The existing patterns of landuse, ownership and communications are an important constraint on future opportunities. Four working maps were drawn up from this part of the survey.

i) Existing land use

This map was drawn from field survey and interpretation of other maps. As it carries otherwise unpublished information, a copy is included in the endpaper of the thesis. It distinguishes six classes of land:-

Land class	%	area (ha)
1. Cultivated land and previously cultivated areas	4.6	4 200
2. Good grazing and other unenclosed pasture	12.4	11 300
3. Woodland (largely unproductive)	1.5	1 400
4. Production forest (private and state-owned)	11.6	10 600
5. Major deep peat deposits	1.5	1 400
6. Rough Grazing	67.2	61 400
7. Built-up	0.1	100
8. Open water	1.1	1 000
Totals	100.0	91 400

The classes are held to represent significant landuse classes on the island. The first, derived from rapid field survey in 1978, is found in small areas in many parts of the island. The broad outline of these areas has been delineated on the maps, and the actual areas of class one noted for each site from measurements of 1:10 000 Ordnance Survey maps. The balance between this total and the one obtained by measuring class one areas on the 1:100 000 map has been assigned to class two.

ii) Land ownership

The land ownership boundaries were taken from the 1:63 360 maps prepared by Millman (1969) and lodged in West Register House in Edinburgh. It is important to recognise that these are not, in most cases, the boundaries of management units, and that there have been significant changes in the ownership pattern in the ten years since they were drawn up, particularly through changes in the Forestry Commission's holdings. Millman did divide the larger estates up into separate marches, reflecting an historical pattern of individual farm or grazing units.

iii) Communications and settlement patterns

This information was taken from the 1:50 000 and 1:10 000 Ordnance Survey maps, and was carried on two working maps, one displaying current and abandoned settlements, the other displaying road and sea communications. Several points of interest emerged.

a) Common sense suggests that historically, settlements will have been founded in the more favoured locations, reflecting favourable combinations of the physical attributes described above. If this is not the case, other historical factors will have had a part, particularly local politics.

b) The existing infrastructure of settlements is an important physical determinant of future developments.

c) Current local authority planning policy has effectively prohibited new residential developments in isolated areas. Recent changes in outlook may lead to a change in this situation in future.

d) Weight restrictions on roads in remote areas can seriously restrict prospects for enterprise development, unless suitable water-based facilities are available.

e) Distance from a road or track can preclude agricultural or forest development, or greatly increase the cost of such a development.

Notes to text

1. R.O.Whyte (1977) Land and Land Appraisal (after USDA)
2. Baulkwill (1972) quoted in Whyte (1977) op cit
3. J.S.Bibby (1978) Geomorphology & soils - Chapter five of The Island of Mull - A survey of its flora and environment
   Edited by A.C.Jermy and J.A. Crabbe
4. P.E.Francis (in press) Some climatic factors in land assessment in Land Assessment in Scotland RSGS symposium 25/5/79
5. J.S.Bibby (1979) Pers. Comm. - even this work, however, does not attempt to relate soil conditions to yields of agricultural crops.

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APPENDIX FOUR - Technical notes on natural resources - Temporal Patterns

One feature of ecological systems which is frequently ignored is their dynamic nature. Physical characteristics are always changing and evolving. Many such characteristics display patterns and cycles of change on a time basis. Chief among these is the seasonal cycle of climate, especially temperature, rainfall and windspeed. This section therefore establishes the range and nature of climatic patterns in Mull.

A4.1 Radiation inputs

The regularity of these patterns originates in the seasonal changes in intensity of the Sun's rays as received at ground level. Table A4.1 shows the seasonal change in daylength, and in incidence of direct solar radiation. Table A4.2 shows the solar radiation associated with these patterns, and consequently provides a measure of the solar energy input to the island. The neatness of the curves in Figure A4.1 (taken from Table A4.2) is an indication of the generalised nature of these figures. Variation adds a complex pattern derived from:-

a) the daily cycle of light and dark,
b) the seasonal cycle of daylength,
c) the occurrence of weather systems bringing essentially random fluctuations of cloud cover, wind etc.,
d) year to year fluctuations in climatic means, and
e) orientation and position of a specific site, and the amount of skylight available.

No direct information on these effects is available for Mull. However, the most pertinent consequence of changes in the energy balance are the changes in temperature which result. These are considered in more detail in the following section.

A4.2 Temperature

Summarising temperature fluctuations is made difficult by the continuous nature of temperature as a phenomenon. The variation of temperature derives from radiation balance; data is only available for one site in Mull, in the form of 24-hour means of maximum and minimum temperature for each month. From this, the 24-hour mean temperature for each month may be calculated. This figure takes

TABLE A4.1 - HOURS OF DAYLIGHT AND SUNSHINE FOR 56° North

Month	Hours bright Sunlight (a)	Hours Overcast (b)	Total Daylength (sunrise to set) (c)
January	1.2	5.9	7.1
February	2.2	6.4	8.6
March	3.2	7.4	10.6
April	5.0	8.1	13.0
May	6.0	9.3	15.3
June	6.0	11.1	17.1
July	5.0	12.5	17.5
August	4.5	11.6	16.1
September	3.5	10.4	13.9
October	2.2	9.4	11.6
November	1.5	7.8	9.3
December	1.0	6.5	7.5

Sources (a) Met Office Climatological Memo 74
Average daily duration bright sunshine
1941 - 1970
(b) = (c) - (a)
(c) Whitakers Almanack 1977

(all times in metric hours.)

TABLE A4.2 - SOLAR RADIATION INPUT

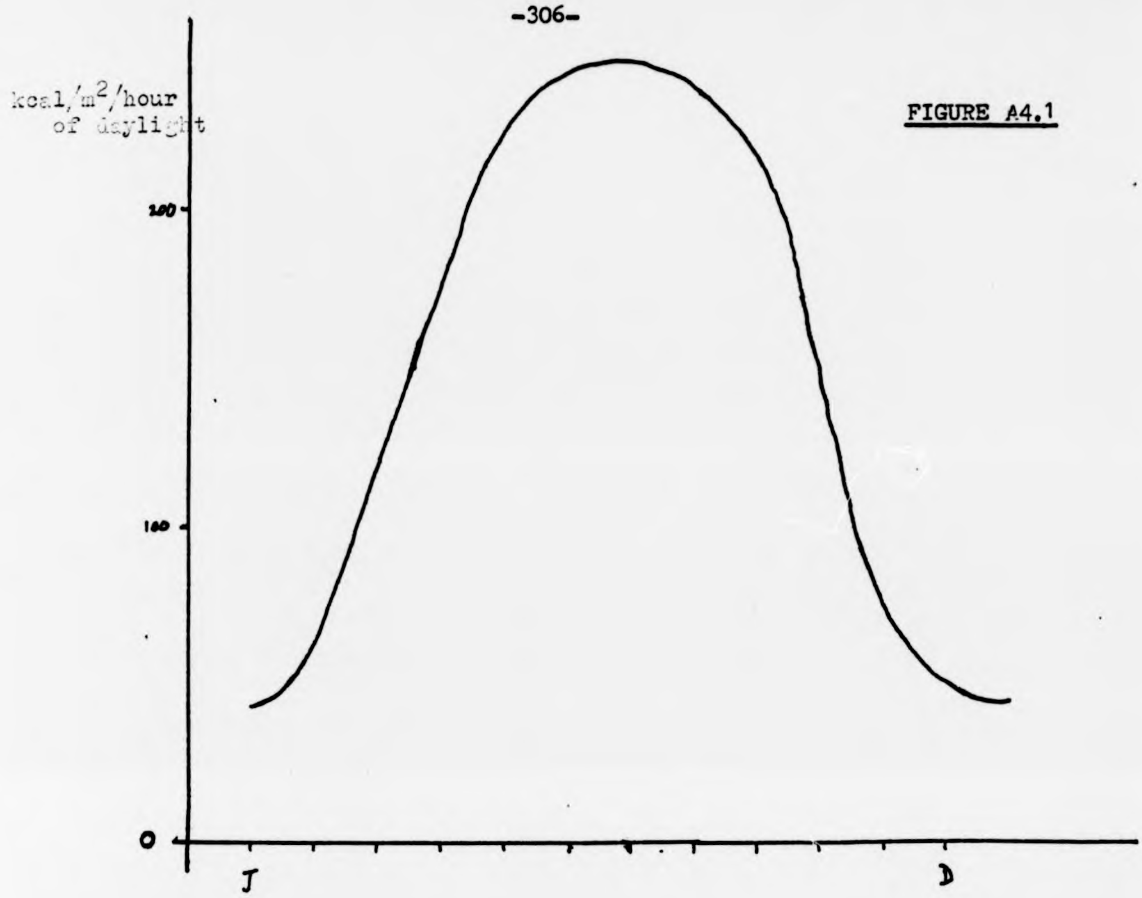
Month	outside atmosphere Kcal/m²/day (a)	at ground level kcal/m²/day (b)	at ground level Kcal/m²/hour of daylight. (c)
January	1075	312	44
February	1911	559	65
March	3345	1290	121
April	5973	2300	176
May	8123	3526	231
June	9317	4171	244
July	9556	4257	243
August	8362	3827	238
September	6450	2924	210
October	4300	1677	144
November	2389	731	79
December	1433	430	57
Annual mean	5186	2167	154

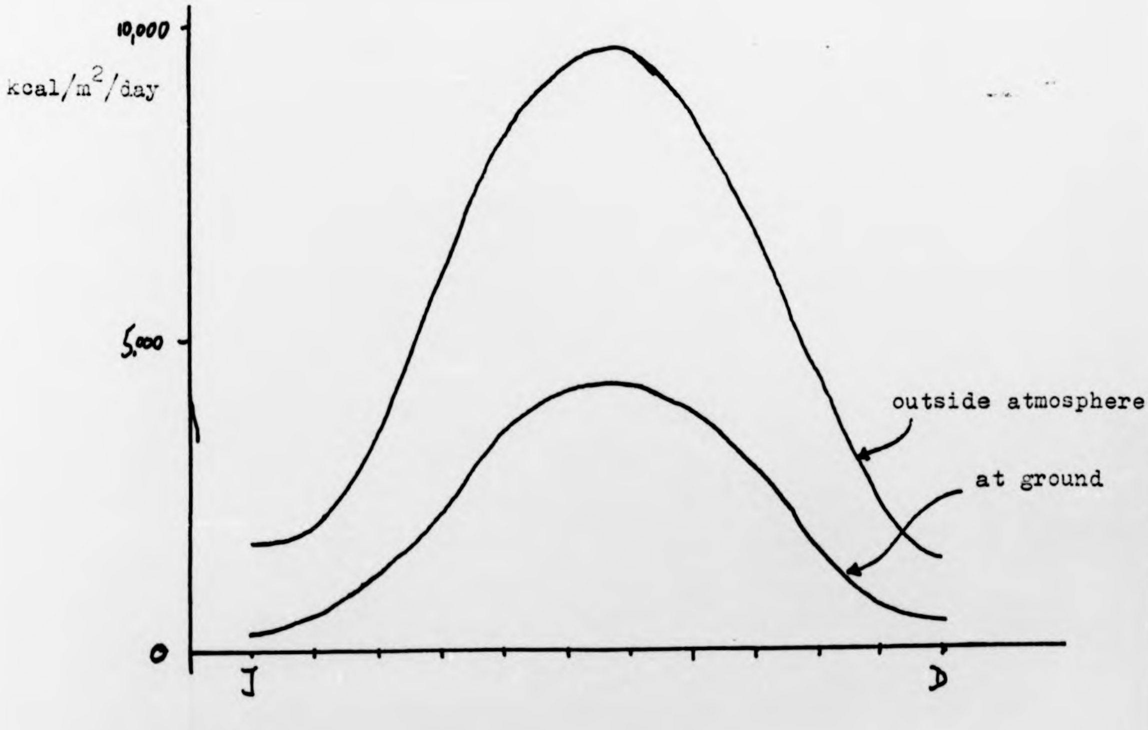
Source; (a) I. Campbell (1977) Energy and the atmosphere Wiley, London - figures for 56°N.

(b) Met. Office - derived from global radiation figures for Dunstaffnage, by Oban, for years 1975 & 1976.

(c) = (b) divided by daylength figures from above.

FIGURE A4.1


kcal/m2/hour of daylight
200
100
0
J
D


10,000
kcal/m2/day
5,000
outside atmosphere
at ground
0
J
D

no account of the fluctuation of temperature in the course of a day, being simply the median points between the recorded maximum and minimum screen temperatures each day of the month expressed as a mean.

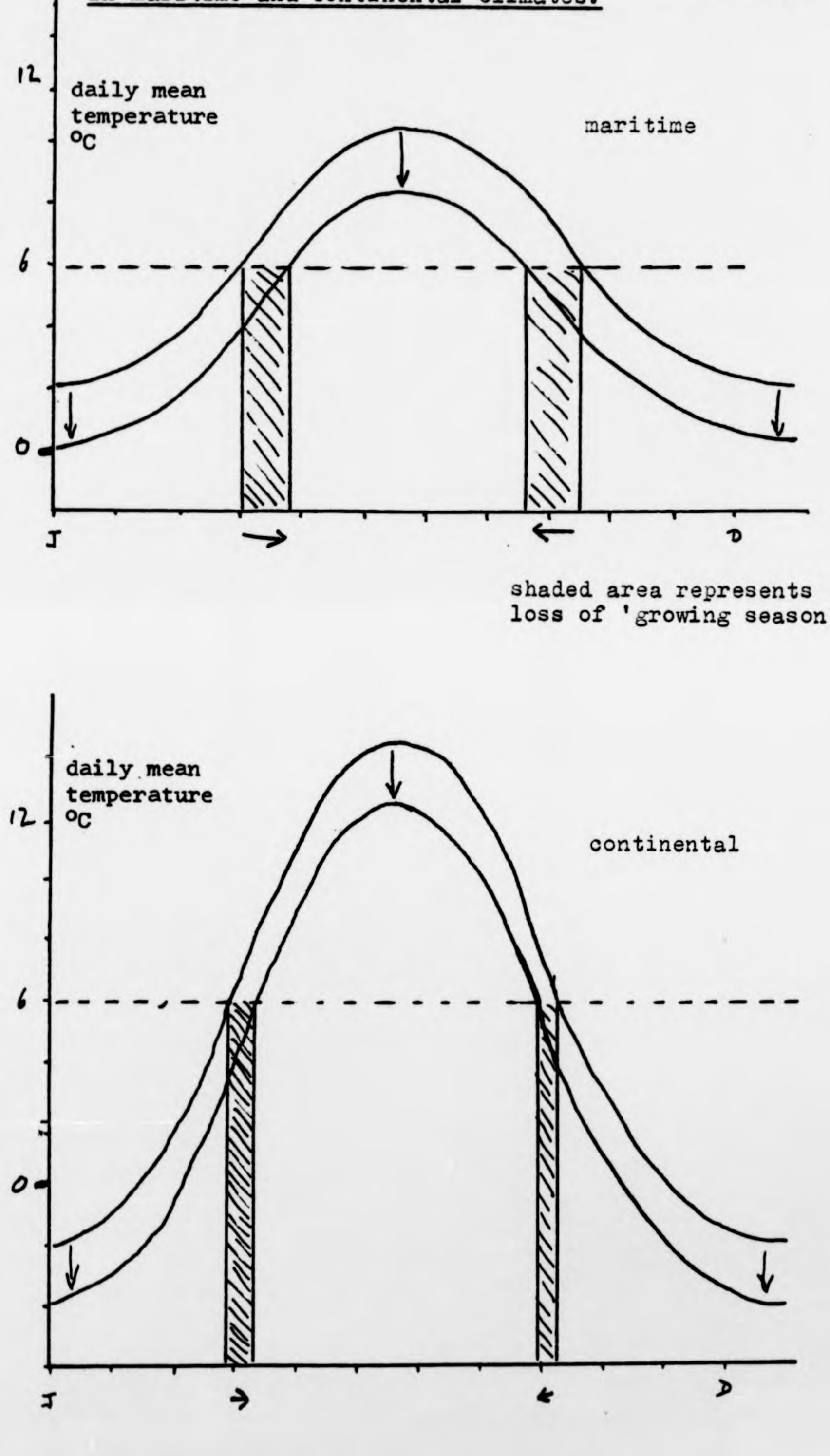
Mull is typical of the West Highlands of Scotland, indeed characteristic of the northwest margins of the continent of Europe, in the climatic importance of oceanic influences. The buffering effect of large water bodies on macroclimate is remarkable. This is the main reason for the differences between east and west coasts of the UK, the west being characterised by milder winters and cooler summers, together with higher humidity and precipitation. Mull's climate is therefore prone to high rainfall, but relatively less liable to extremes of temperature on a seasonal basis. While providing a more equable climate for animal life, it presents relatively large risks for plant production, particularly cropping of annual plants, when longer term (annual or decadal) changes are taken into account. This arises because it has been shown that the rate of plant growth is related, given adequate water and nutrients, to temperature above a certain base temperature at which growth commences. Thus, an equable climate is proportionally more vulnerable to variation than an extreme climate, chiefly through the effect on the length of the growing season. This is illustrated in Figure A4.2. Information on such long-term fluctuations in temperature is limited even on a national basis, and there is some disagreement over its relevance (1).

i) Long term changes in temperature

For Mull, there is no information on long-term temperature regimes. The one station giving regular reports to the Meteorological Office is the Forestry Commission at Aros, only operational since November 1966. Various other stations on the island have submitted records from time to time. A comparison of the Aros monthly means for the decade 1968-77 with the MO figures (2) based on the period 1931-1960 shows the more recent figures to correspond closely with the earlier, while lying slightly below them. Evidence for upwards or downwards shifts in the entire temperature pattern is not available; Manley's analysis (3) of decadal running averages from 1659-1973 in central England shows a slight drop in mean temperatures

FIGURE A4.2

- Illustration of effects of 2° fall in mean temperature in maritime and continental climates.



between the two periods. It is interesting to see from this work that the last two decades were one of the longest periods of consistently high mean temperatures for several centuries.

ii) Short term changes in temperature

The longer term trends are superimposed on year-to-year fluctuations in temperature which are of critical importance to an agricultural economy. Parry (4) has examined the relationship between this variability, altitude and the frequency of harvest failure in the upland situation. He shows that as accumulated temperature in a particular year is an important factor in determining harvest yields, and that while there is an approximate linear relationship between ambient temperature and altitude, the relationship between accumulated temperature and harvest is quaşi-exponential. Applying his analysis to the Aros figures shows that the present climate at that site is well-suited to the growing of oats, at least as far as temperature regimes are concerned (Figure A4.3). The analysis makes the following assumptions:-

a) If accumulated temperature over 4.4°C in a particular year fails to exceed 970 day-degrees, there will be a crop failure of oats.
b) The median of the highest and the lowest daily temperatures is the daily mean temperature, and the average of these daily mean temperatures for each month is the monthly mean temperature. The monthly mean temperature is the basis for calculating accumulated temperatures.
c) The variation of these temperatures from year to year is the source of variation in the harvest of oats.
d) The variation from year to year of monthly mean temperatures is random, and normally distributed.

Applying the Aros data for 1968-77 to Parry's analysis, it is possible to get some idea how cropping might be affected by plantings at different altitudes and by changes in the longer term mean temperatures.

Increasing altitude affects crops to an extent dependent on the lapse rate used in the model. The use of Parry's figure of one Celsius degree per 143 metres (0.7°C per 100m), causes the 50metre intervals to appear as shown on Figure A4.3. While Birse and Dry (5) use the widely accepted lapse rate of 0.6° per 100 metres for the UK, there is evidence (6) to suggest that a higher lapse rate is appropriate for West coast maritime uplands. Parry places 'marginal land' in the harvest failure

FIGURE A4.3

- Relationship of frequency of harvest failure with increasing altitude, after Parry, based on Aros data.

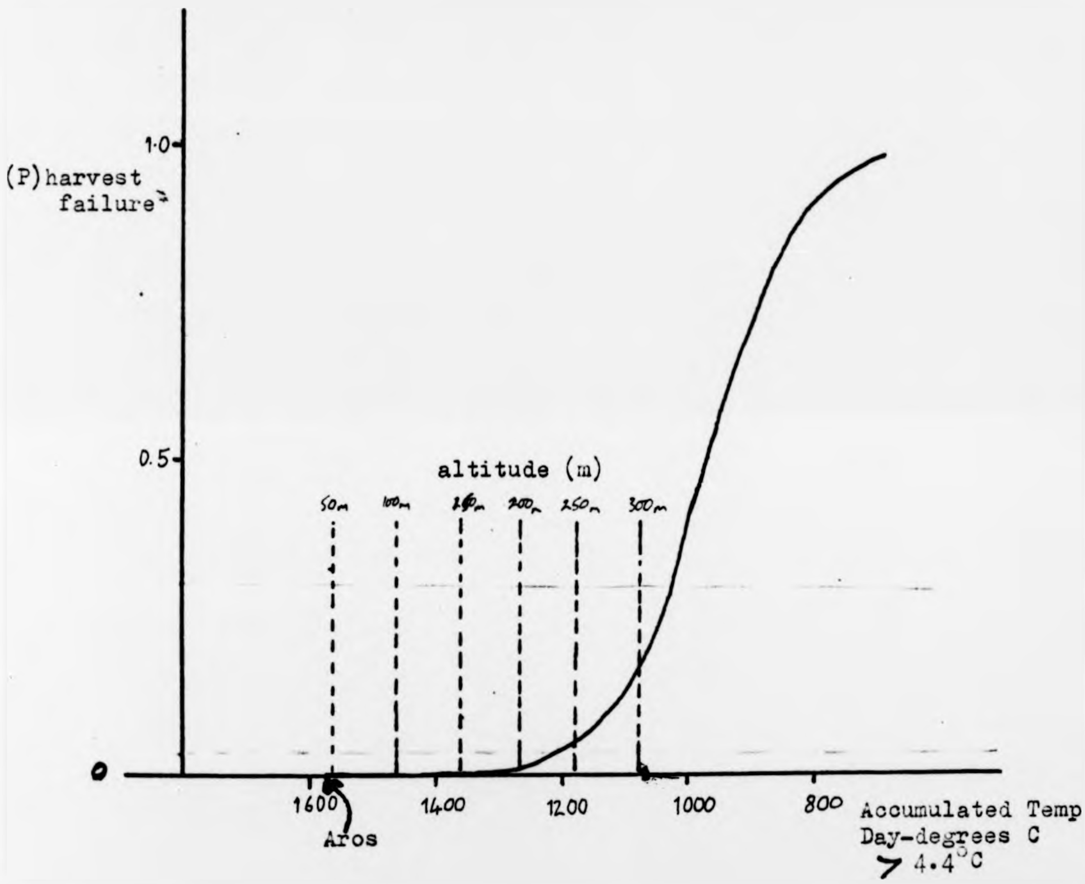
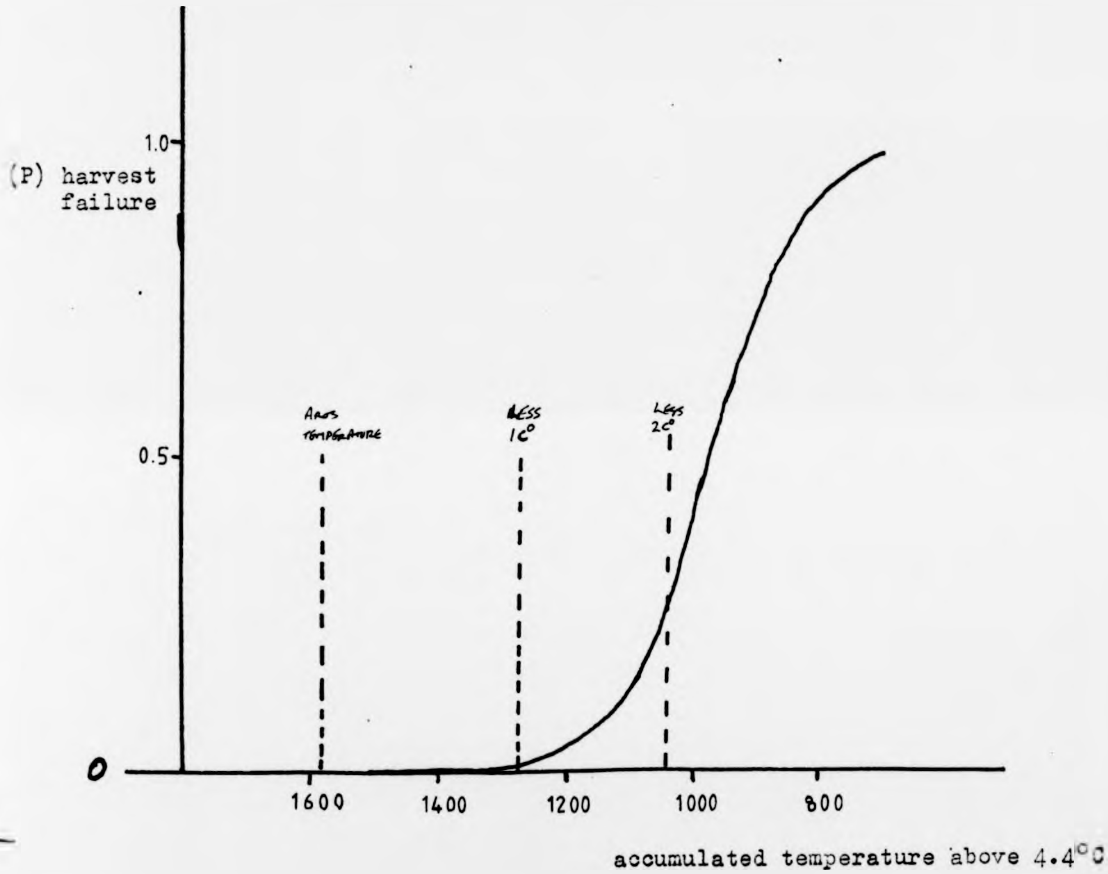


FIGURE A4.4

- Consequences on accumulated temperature of changes in decadal mean temperature - Aros, Mull.



probability range 0.03 to 0.3, which places the altitudinal limits for oats at between 230m and 330m ASL. This would seem to be rather high for Mull, but precipitation, exposure and geology are also important; for example, oats will not grow in soils with a pH of less than 4.3.

Table A4.3 <u>Relationship of altitude, accumulated temperature and probability of harvest failure for oats</u>

Altitude (m)	Day-degrees	standard deviation	probability (harvest failure)	expected frequency (1 year in..)
50	1550	128	very low	very low
100	1460	128	0.00007	15 000
150	1360	128	0.0043	230
200	1270	128	0.0096	104
250	1180	128	0.05	20
300	1090	128	0.167	6

Changes in mean temperature are shown in Figure A4.4, which illustrates the effect of a fall in mean temperatures of one or two degrees Celsius. This would have a dramatic effect on climatic limits. A one degree fall would bring marginal land down to 80m - 180m ASL, while a two degree fall places the whole island in the extremes of marginal cultivation. Such a fall in a fifty-year period is not entirely without precedent; Manley (3) shows a change of annual mean temperature from 8°C to 10°C between 1700 and 1740.

In agricultural terms, particularly in a subsistence economy, one bad harvest is not in itself a critical occurrence. Two or more consecutive bad harvests often are, and can do long-term damage to the structure of the economy. Parry examines the probability of two consecutive harvests in his Normally distributed model, but at the same time points to the evidence for clustering of good and bad years. Thus the probabilities are higher than would be expected if the assumption of a randomised Normal distribution held. The evidence for such clustering in Mull, is inconclusive since detailed data is only available for one station for a ten year period. However, in that decade, the two coldest years were 1972 and 1973, and two of the three warmest years were 1975 and 1976.

It may be concluded that, on the basis of accumulated mean temperatures, low-lying parts of Mull are comparable to many apparently more fertile areas in East Central Scotland; Jermy and Crabbe (10) consider it "....virtually the northernmost area of this regime of warmth, which may account for the southern and mediterranean element in the flora that is absent, for instance, from Skye and Rhum...." (Jermy & Crabbe, p 6.8). On the other hand, it seems that an alternative conclusion is that the temperature regime in Mull is not the main limiting factor on primary production. Other climatic parameters certainly are, and one of these is the complex of interactions involved in moisture balance.

A4.3 Moisture balance

The climate of the West Highlands is invariably described as moist, and this is borne out by the relationship of mean precipitation and potential evapotranspiration displayed in Figure A4.5. Nowhere, in the average year, is there a deficit of moisture, and in winter, excess moisture is abundant. However, precipitation is immensely variable from year to year, and holds only the most basic of seasonal patterns (Figure A4.6) in that there is a general tendency for higher winter rainfall. This matches observations from other areas (7) and stems from the fact that rainfall in Northern Britain arises from the frontal systems continually sweeping in from the Atlantic, coupled with orographic effects of high ground.

In Figure A4.5, the monthly precipitation figures one standard deviation below the mean are also displayed. These show that in late spring and early summer there is a significant chance of a potential water deficit. Each month is independent, so the chances of the pattern shown actually occurring are remote. In view of this, the expected frequency of occurrence of a potential water deficit is calculated on a month by month basis for the relevant period:-

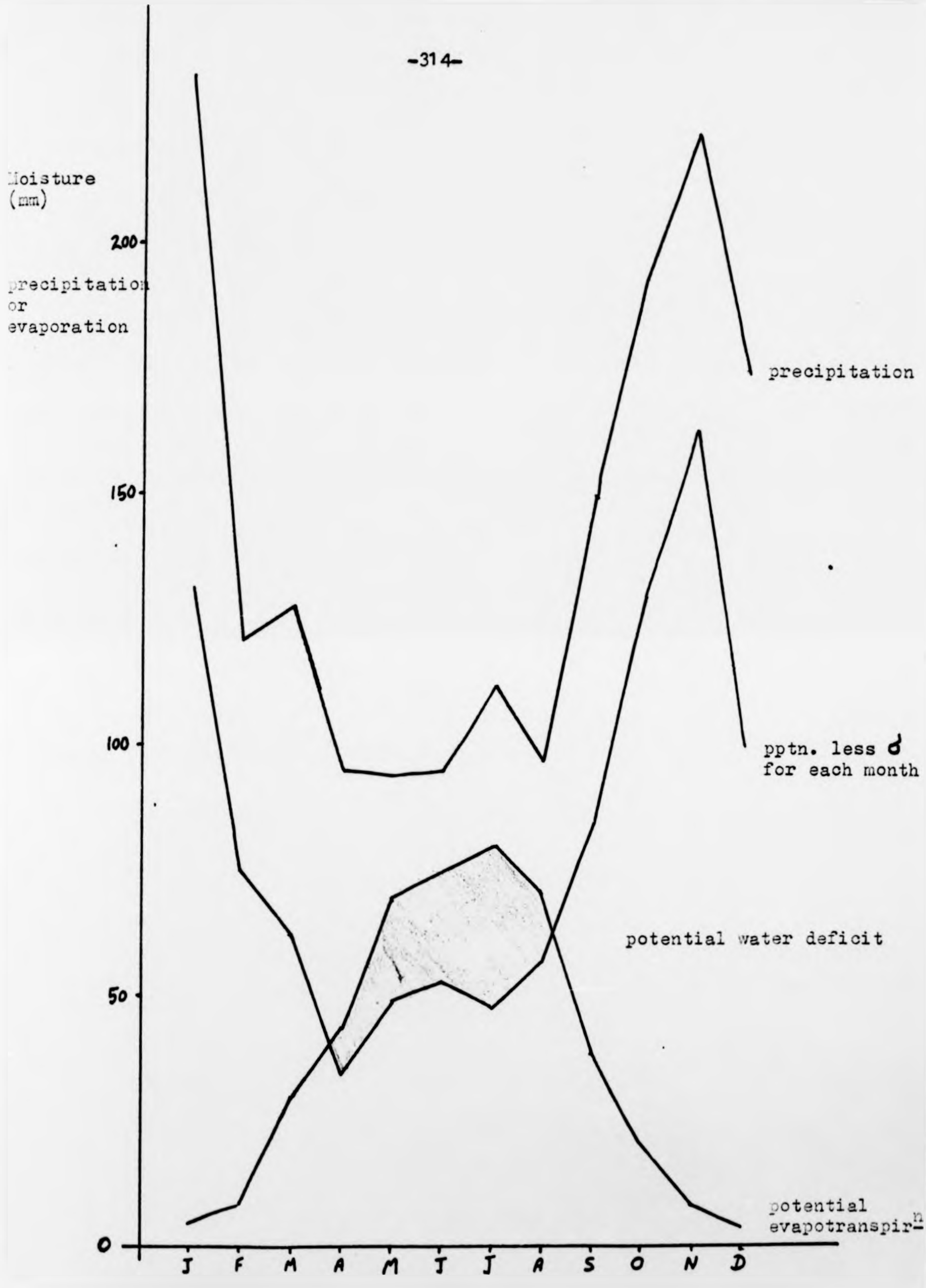


FIGURE A4.5

- The relationship of precipitation and potential evapotranspiration , Aros, Mull 1968-77

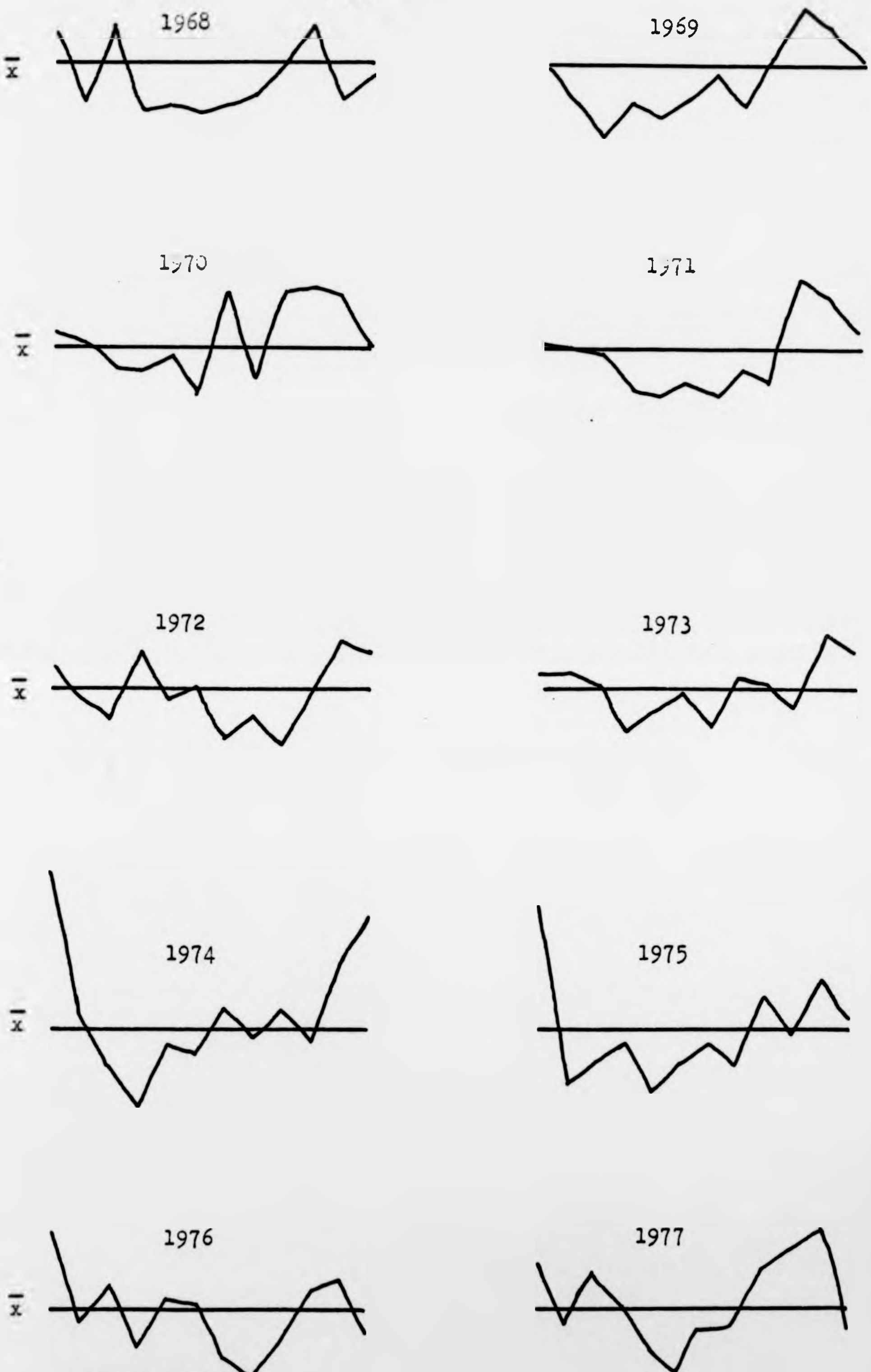


Figure A4.6

\- Annual patterns of rainfall, Aros, Mull 1968-77

(all diagrams to scale, $\bar{x}$ = 143 mm = mean monthly pptn.)

Table A4.4 Expected frequency of potential water deficit in spring and summer

Month	(P) Precipitation pot. evap.	Expected frequency (1 year in..)
April	0.202	5
May	0.297	3 or 4
June	0.316	3 or 4
July	0.310	3 or 4
August	0.250	4

Thus there is a high probability that this condition will occur in at least one of these months in any year. Over the period 1968 to 1977, a water deficit occurred in more than one of these months in five of the ten years. Water deficits in themselves are not necessarily significant; in most lowland sites they are an annual occurrence. However, they may be of more significance in Mull for pedological and geological reasons. The rocks of the island are largely impermeable to water, runoff is rapid and soils are thin, tending to be either free-draining or peaty. Thus a period of low rainfall very quickly causes drought conditions sufficient to affect plant growth. This circumstance particularly affects young plantations of trees, which rapidly use up the immediately available water and are unable to draw on any deeper reserves of ground water.

Generalised figures for atmospheric humidity are available from MO reports (8) and are displayed in Figure A4.7. They reflect the generally high humidity and moist nature of the climate. Information on the patterns of variation in relative humidity is not available. Vapour pressure, a key determinant of potential evapotranspiration and the basis for relative humidity calculations, varies seasonally as displayed in Figure A4.8. Snow cover is minimal except on high ground, and persistence of snow cover is almost unknown. There are no long-term records for Mull, but figures from nearby sites (9) (Rhum, Tiree and Islay) show occurrence at sea level to be between 1 and 12 days per year. The Aros figures show an average 9 days per year when snow was observed lying at 0900 hours, and 19 days on which snow or sleet was observed to fall each year between 1968 and 1976. Manley (14) suggests a linear relationship of 14 days extra snow cover for each 100m increase in altitude.

Figure A4.7

- Distribution of different levels of atmospheric Relative humidity

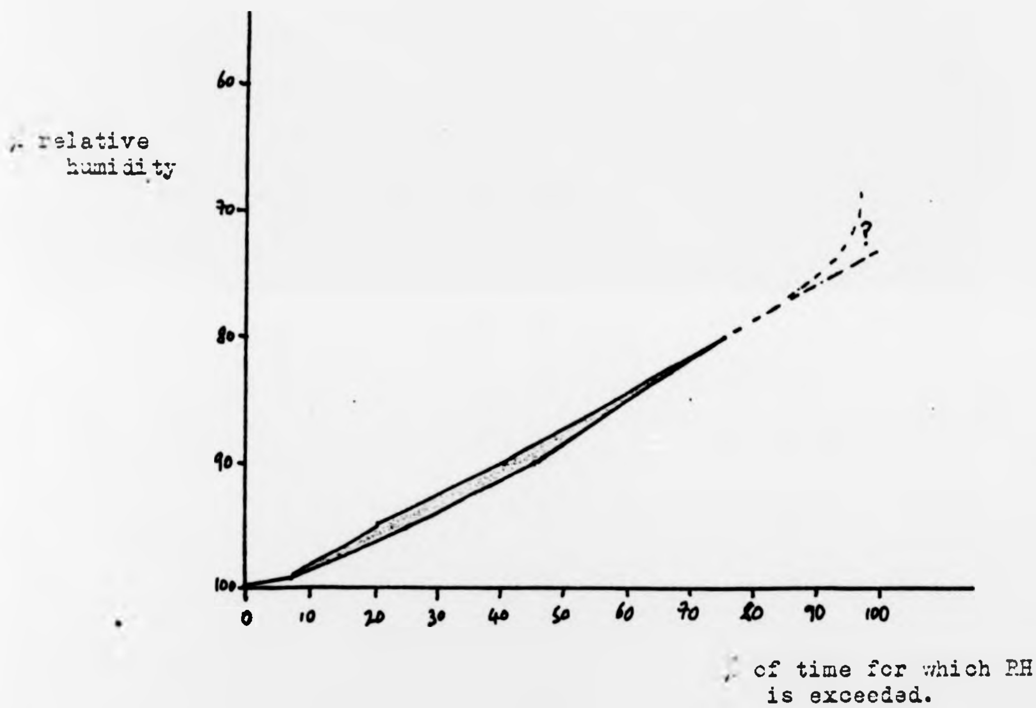
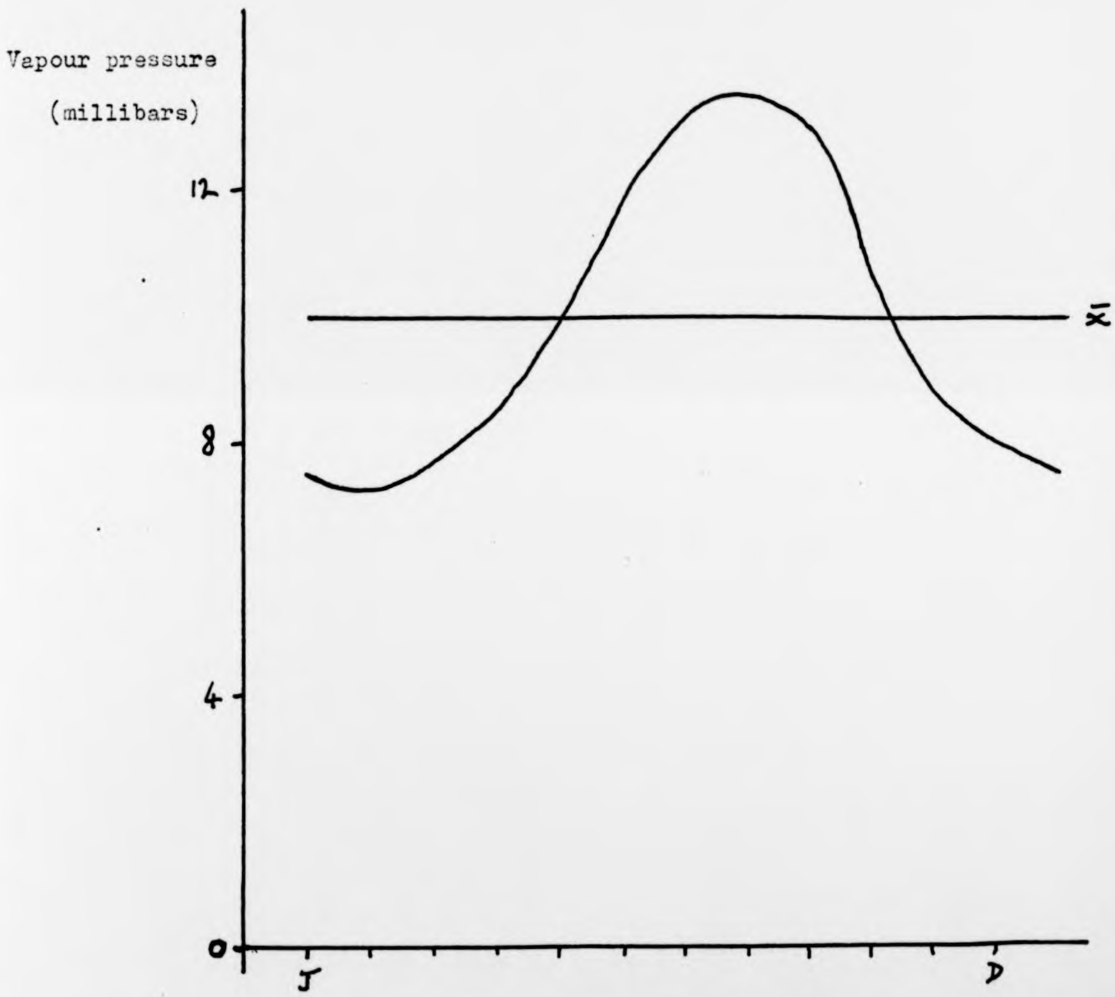


Figure A4.8

- Seasonal changes of vapour pressure



A4.4 Wind

Exposure to wind is the main limiting factor on biological production over large areas of Mull. Its effects derive from three sources:

i) Salt spray carried by winds blowing off the sea can scorch plant growth and affect soil chemistry on low ground exposed to the southwest. Spray seems to have less effect when the ground rises steeply from the sea, presumably because it is not carried up more than a few metres (10).

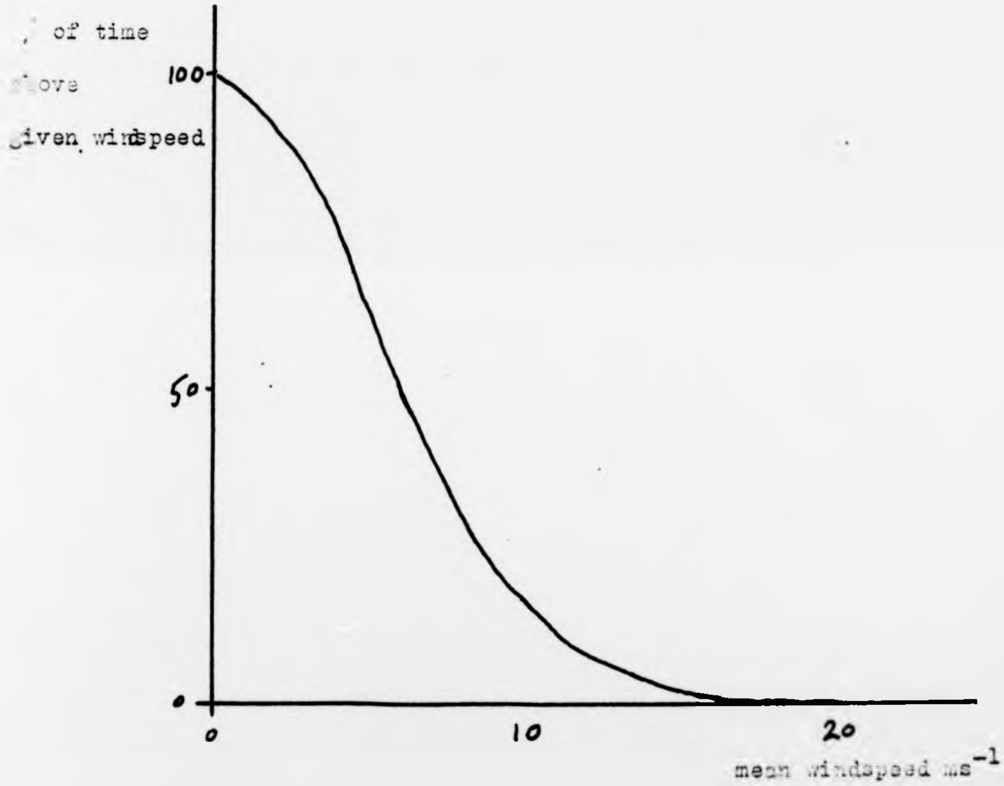
ii) The physical effects of high windspeeds affect most crops to a greater or lesser degree. Trees on poorly drained soils are susceptible to windthrow, and cereal crops are particularly vulnerable in late summer and autumn. Parry (11) suggests that an average windspeed of 4.4 ms^{-1} is generally coincident with the cultivation limit for oats, one of the hardier of cereals. The Macaulay map of exposure places the larger part of Mull outside this limit.

iii) Wind affects various other parameters, thus influencing the overall pattern of climate. Chief among these are surface temperatures, particularly of homiotherms and other warm bodies, which tend to be decreased by increasing windspeeds (the effect depending on the energy balance between the surface and the air represented by the temperature gradient between them) and evapotranspiration, which depends in a similar fashion on the relationship between humidity at the leaf surface and the ambient air humidity. Both these effects derive from changes in boundary layer conditions resulting from increased windspeed.

Useful data on windspeed is possibly more difficult to obtain than any other parameter. Temperature and rainfall are measured at all meteorological stations, while wind data is collected at very few. The nearest such station to Mull is Tiree. A MO interpretation of the available data (12) yields a distribution of windspeeds for Mull (Figure A4.9) but it must be remembered that biological production is governed by environmental conditions at a particular site. Data for the mesoclimate and microclimate levels is not available.

Figure A4.9

- Distribution of windspeed with time



A4.5 Hydrology

Direct data for stream flows in Mull is not available. The only evidence is provided by precipitation data. A rough calculation from this data yields a total precipitation over the island of 1.8 billion tons per year. This is equivalent to a river flow averaging 58 cubic metres per second, about the size of the Forth at Stirling (13), were it all to flow from one catchment. In fact, being an island, Mull has a large number of catchments, and the flows from any one may be expected to be very much smaller. Furthermore, the yield above excludes the influence of evaporation, which will depress this total yield to some extent. Variations in stream flow are considerable. The impermeable nature of the geology and the small, steep catchments produce a situationin which most of the runoff occurs in relatively brief periods of high flow. The only significant storage sites are the peat bogs and the various inland water bodies.

An examination of the Aros figures for 1966-77 shows that the maximum rainfall for any 24-hour period in each month averaged 25mm, suggesting that over 20% of the total rainfall will occur on less than 5% of the days in the year. More precise data for distribution of precipitation is not available.

Notes to text

1. M.L.Parry (1978) Climatic change, agriculture and settlement Ch 1
2. Meteorological Office (1970) Climatological memorandum no 43
3. G.Manley (1974) Central England temperatures: monthly means 1659-1973. Q. J. Roy. Met. Soc. 100 389-405
4. M.L.Parry (1976) The significance of the variability of summer warmth in Upland Britain Weather 31 (7) 212-217
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6. S.J.Harrison (1974) Problems in management and evaluation of the climatic resources of upland Britain, pp51-58 in J.A.Taylor (ed) Climatic Resources and Economic Activity
7. K.Smith (1972) Water in Britain
8. MO (1975) Maps of mean vapour pressure and frequencies of high relative humidity over the British Isles. Clim. Mem. no 75
9. MO (1971) Clim. Mem. 70
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11. M.L.Parry (1973) Secular climatic change and marginal agriculture Trans. Inst. Brit. Geogr. 64
12. P.G.F.Caton (1976) Maps of hourly mean windspeed over the UK Met Office Clim. Mem. no 79
13. Water Data Unit (1968) Surface Water Yearbook 1964-65
14. G.Manley (1952) Climate and the British Scene

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APPENDIX FIVE - Technical notes on natural resources - Land use capability assessment

A5.1 The concept of land use capability

The idea of producing maps showing the 'best use' of land has an undeniable appeal. However, this potential for economic activity is not an independently quantifiable entity. The concept of 'fitness' of a site has physical, biological, economic and cultural facets. Capability is therefore a complex concept influenced by topography, soils, climate, fauna and flora, the quality of contemporary management, the history of management, the existing physical and social infrastructure for economic activity and finally on the condition of the wider economic system in which a particular activity is carried out. In other words, capability derives from the interactions described in the conceptual model in Chapter two.

The concept of landuse capability can therefore be used at a variety of levels, from the purely physical assessment of land characteristics to the integrated synthesis of information leading to prescriptive land use planning. This diversity of possible roles leads to confusion about the function of land use capability assessment. In practice, land use capability tends to be end-use oriented. There are systems of landuse capability assessment for agriculture, forestry, recreation and nature conservation. There is no established methodology for choosing between these landuses. Before considering these formal systems, a closer examination of the underlying concepts and information needs of landuse capability classifications will be made.

The preceding discussion may have given the impression that assessments may be built up from a physical base, each level including more qualitative judgements about the capability of the land to fulfil a particular role. Such a system would be based on purely physical data - topography, soils and climate - superimposed on which would be an expression of technical characteristics for the particular land use. A choice between land uses would therefore have to be developed at a third level. Such a simple linear approach would be quite adequate in a system near equilibrium, but ignores the dynamics and evolution of the real system. For example, a physical characteristic such as wetness is influenced to a marked extent by the history of management, of drains and of other improvements. For the future, a crucial question is the assessment of possible improvements and of the amelioration of limitations. This is first a technical problem, then an economic one.

Land use capability assessment is often presented as such a three-stage process; first physical, then technical and finally economic assessment. While this presents a suitable model for a first approximation, it should not be regarded as providing a definitive assessment. The surveyor is faced with a real, evolving system with a history. His simplest startingpoint is to examine the physical characteristics, but he should recognise that they cannot be regarded as independent variables.

The physical assessment of land is relatively well-understood, although there is still disagreement as to what constitutes a basic survey. Physiography, soils and potential primary productivity are all put forward as an appropriate focus for 'objective' base surveys.

i) <u>Physiography</u> has four basic qualities:-

- geographical position	- longitude & latitude
- slope	- angle and form
- roughness	- obstacles to movement
- flood & erosion hazard	

In practice, objective assessment of such qualities is difficult (1) and uniformity of classes across the UK (or even further afield) impossible to achieve. A development of the approach accepts these constraints and identifies land systems (2). Bibby describes such land systems in Mull, but there is no published map based on his work.

ii) <u>Soils</u> have four basic qualities:-

- physical factors	- texture, structure, depth, drainage available water capacity, stones...
- chemical factors	- nutrient deficiencies, organic matter, nutrient toxicities...
- biological factors	- susceptibility to pests, diseases, weed infestations
- distribution patterns	- uniformity or variability

As the direct medium for plant growth, soils are an obvious focus for the capability assessor. However, examination of the list of qualities reveals that very few may be regarded as independent factors. Most are influenced by other factors, physical or technical, and soils may thus be regarded both as a product and a determinant of landuse. The

MISR have published a soils map for Mull, described in more detail in Appendix three.

iii) Primary productivity - has only recently emerged as a possible focus for base surveys. Such an approach would try and establish the inherent ability of the land to produce plant material. Whether such a theoretical ability, representing a susnthesis of the effects of physiography, climate, and soils on plant growth, can be separated from human-induced modifications of the system remains to be seen.

iv) Climate is generally recognised to be a crucial factor determining land use, and to a great extent to be an independent variable. As a focus for basic survey, it is necessary but insufficient for the purpose. Climate has three basic qualities:-

- solar radiation - temperature, duration, variation, frost hazard etc.
- rainfall - quantity, intensity, humidity...
- exposure - wind

These have been examined in detail in earlier sections.

A careful synthesis of these factors will give an adequate approximation of the physical characteristics of the land which will form a basis for the second level of survey, examining the technical characteristics of the land in terms of the limitations encountered and the managers' ability to modify them. While this physical basis will be 'objective' to the extent that it depends on quantified assessment of various physical properties, it is important to distinguish such objectivity from any idea that the assessment represents a statement of immutable, unchangeable characteristics. They are capable of modification in a number of important ways.

The second level of capability assessment is therefore an attempt to establish the technically feasible level of productivity under management. It is comparable to the basic concept of economy described in Chapter two, where materials and energy (the physical characteristics) have been examined, which in a natural ecosystem are capable of independent function. An examination of the relevant skills (technology) allows identification of the possibilities for modification of this natural system to produce useful output. This stage is normally carried out in the context of a particular land use, but there are certain general principles used in all cases. At this level, capability assessment is an attempt to evaluate land productivity, whether for a physical output (in agriculture or forestry) or the achievement of other objectives (recreation etc.).

Land productivity = f. (set of physical characteristics). as modified by management skills

Output may be derived from the resource on a scale and quality related to the skill and understanding involved in management. The skill lies in identifying the important limitations, while understanding enables the amelioration of that limitation. The extent of our ability to apply management skills in this way is itself limited by knowledge, in the form of concepts and data. The concepts (of understanding) emerge from research and development in the relevant field. The data results from survey work. Complete evaluation of a site would require a very large data set, which is rarely, if ever, available. Considerable resources devoted to survey may not be cost effective in terms of increased productivity. Thus the third level of land use capability assessment concentrates on economic and cultural imperatives. While it cannot be carried out until at least some work has been carried out on the other two levels, it cannot be regarded as an independent exercise. In particular, the assessment should ideally take into account the effectiveness of the survey itself.

A5.2 Formal systems of LUC assessment

The more recent LUC assessments usually have a well-defined theoretical base but, as the earlier discussion has suggested, usually lack a sufficiently comprehensive data base to translate theory into practice. Mull is unique in the West Highlands in having a published LUC map for agriculture (3). There have also been exploratory surveys for forestry. These have been discussed in detail in Chapter five. Such surveys are typical in that they assess land capability for only one kind of land use. The main formal systems for each type are now examined.

i) Agriculture

Studies of capability for agriculture began in the 1940s with an almost entirely subjective division of land into seven classes to produce maps used internally by DAFS. Later modification reduced this to four classes (A,B,C&D) on smaller scale maps for new regional authorities in the 1970s. In England and Wales, MAFF produced a five-class system surveyed in a similar subjective way (4). The focus of these surveys was on arable farmland, and thus their utility in the West Highlands is very low. Nearly all Mull would be in class 5 under the MAFF system. Neither system is sufficiently fine-grained to assess the value of the semi-natural grazed plant communities which form the larger part of the land of Mull. The extent to which the surveys assess 'capability' as opposed to current use is difficult to establish. The divisions are based primarily on physical criteria, with a technical element "....assuming a moderate level of management....". It was stated explicitly in the MAFF study that factors such as farm structure, adequacy of fixed equipment and location should not be allowed to influence the primary grading of land based on physical limitations.

The monograph by Bibby & Mackney (5), published in 1969, described a system based on more detailed survey, and deriving mainly from soils maps as base information. The Bibby/Mackney system shared a number of common roots with the MAFF system in the extensive American research and survey of the USDA and the Canada Land Inventory. The system recognises seven classes, only four of which refer to arable land. It is thus comparable in broad terms with the MAFF system, but allows more detailed survey of upland areas. Mull was the first Highland area to which this system was applied, as part of the HIDB survey in 1969-1971. It was discovered that the limitations of soils survey (described above) made application of a system based on soil survey very difficult. Substantial research since then has resolved many of the problems, and a map for Mull was published in 1979. The system is described in detail in the monograph, but two features should be mentioned here. The system actually portrays the degree of flexibility for agricultural operations. Increasing limitations reduce flexibility, and hence the ability of management systems to switch to alternative strategies as costs and prices change. For example, sheep are a feasible use of class one, while barley is not a feasible use of class five. The system also defines capability in terms of the technology available under current levels of good management. Technical breakthroughs in (for example) drainage or cultivation could render the maps inaccurate.

The most recent development is that MISR have been contracted by the Scottish Office to produce a rapid reconnaisance survey at 1:250 000 (seven maps for Scotland) by 1981 using this system, modified to accept a base survey combining soils and physiography, as outlined above.

ii) Forestry

Pioneering work in the field of assessment for forestry once again comes from the Canada Land Inventory, which used a seven-class system based on expected production levels of timber. This was, however, a survey of extensive virgin forests, with plenty of scope for controls and detailed research in a relatively undisturbed environment. In Scotland, the main concern is with afforestation and the yields which might be expected from land which is currently under a different land use. Objective assessment is almost impossible, because trees have radical effects on the physical characteristics of the land, the dynamics of which are still poorly understood. The concept of intrinsic capability of a particular parcel of land is thus far less useful.

The Forestry Commission do not have a formal system of land use capability assessment. A broad reconnaisance survey of Scotland has been carried out to gain some idea of the area of plantable land available. This 1:625 000 map is based on a subjective assessment of conditions for growth, and assumed that most low ground would remain in agriculture. In contrast, individual site acquisitions are surveyed at a scale of 1:10 000 for soils, topography and other factors, from which the boundaries of plantable land are delineated.

The Forestry Commission make a clear distinction between these two levels of survey, and admit the shortcomings of the former. However, the latter does not show intrinsic capability, beacuse it is based on the definition of land 'able to grow an economic crop of timber' and is subjectively assessed on that basis. Recent research within FC has brought in the concept of a 'land system' to this area (7), which is thus proving to be (within limits) a unifying concept in the area. Once again, this has been a response to the problems encountered in the Scottish uplands, where the rugged microrelief has prevented the successful use of the established approach based on soil types. Such an approach is of interest to the resource manager, because he can associate particular management regimes with particular landform units; they will have a characteristic yield distribution, drainage pattern, fertiliser requirements, susceptibility to windthrow and requirements for extraction machinery. At a regional level therefore, staff can associtate particular landforms with particular yield classes and species suitability. However, Toleman (7) concludes his review:-

> "....A more sophisticated system to replace this must await basic research work and results on site limitations and requirements for individual species...."

iii) Recreation

While there have been attempts to devise comprehensive systems of capability assessment for recreation, the most successful have concentrated on detailed local survey. The parallel with agriculture may be drawn that in both cases the aim is to maximise user-satisfaction (8). The difference is that the output from agriculture or forestry is essentially quantifiable, whereas the output from recreation is not. Indeed, while there is a basis for defining those physical criteria determining user-satisfaction in theoretical terms, there is no evidence to suggest that users analyse a site in those terms. Thus an element of randomness is introduced which is very difficult to isolate.

Assessments of landscape have run into particular problems of this type. The Countryside Commission for Scotland (CCS) investigated sophisticated methodology founded on the land system concept (9), only to adopt an explicitly subjective approach to the selection of its Scenic Heritage Areas (10) and seems to be working towards legislation for notification of these areas in place of the current National Park Direction Areas.

iv) Nature conservation

Land assessment for nature conservation is a relatively recent development, central to which is NCC's Nature Conservation Review (11). This is of interest because it attempts to systematise assessment of a particularly complex set of interests. Nature conservation is concerned with protection of the diversity of wild plants and animals and the integrity of their habitat from man's influence, manifesting itself in two ways. First is the modification of management techniques to achieve conservation objectives while minimising impact on other management objectives, second the identification of key sites where natural or semi-natural habitat may be preserved. The Nature Conservation Review establishes key criteria of extent, diversity, naturalness, rarity and fragility, which are applied to specific sites in pursuit of this latter aim.

A5.3 Use of LUC by managers and agencies

A frequently neglected aspect of capability assessment is the explicit consideration of the use to which the assessment will be put. This is part of the wider issue of appropriateness which has been covered in Chapter eleven. At this point it might be useful to consider who actually uses LUC surveys. Apart from academics, there are two groups who might be considered to be candidates, resource managers (farmers & foresters) and planning agencies (local authorities, HIDB, SDD etc.). Formal systems of LUC assessment are usually aimed at the latter, and it is usually these agencies who pay for the survey. Such surveys are usually at a reconnaisance level of detail (1:100 000 or more) and their use is therefore limited to the provision of background information for considerations of strategic planning at a regional or national level. They are therfore used to evaluate the potential uses of broad classes of land, and are of little use for the assessment of a particular site. Resource managers are more interested in detailed local survey, but only forest managers make systematic use of them. This is probably because forestry (particularly State forestry) is much more of an industrial activity, with a higher turnover of managers on a particular site. Effective management therefore depends on efficient transfer of local knowledge to incoming managers. In contrast , farming still depends largely on individuals with detailed local knowledge and experience. If, as anticipated, land use continues to intensify, particularly in the upland areas, effective management of any activity will involve increasing collection and use of site data (cf. the cup and ball concept introduced in Chapter two). At an agency level, the same tendency will lead towards increasing intervention and prescription of management options. It should be clear from the preceding discussion that existing systems of capability assessment are not able to fulfil such a role. In particular, they do not portray the ability of land to respond to radical changes in the approach to management. This crucial point is not often recognised by remote administrators.

* * * * * * * * * * * * *

<u>Notes to text</u>

1. A.A.Rowan (1977) <u>Terrain Classification</u> FC Forest Record 114
2. C.J.Lawrence et al (1977) The use of API for land evaluation in the Western Highlands of Scotland <u>Catena</u> <u>4</u> 341-357
3. MISR (1979) Land Use Capability for Agriculture - map of the Island of Mull at 1:63 360. Soil Survey of Scotland
4. MAFF (1966) <u>Agricultural Land Classification</u>
5. J.S.Bibby & D.Mackney (1969) <u>Land Use Capability Classification</u>
6. M.J.Locke (in press) Land assessment for forestry <u>in</u> <u>Land Assessment in Scotland</u> proceedings of RSGS symposium.
7. R.Toleman (1974) Land capability classification in the Forestry Commission in MAFF, <u>Land Capability Classification</u>
8. J.Tivy & M.Johnstone (in press) Assessment of the physical capability of land for recreation ,in <u>Land Assessment in Scotland</u>
9. Land Use Consultants (1971) <u>A Planning Classification of Scottish Landscape Resources</u>
10. CCS (1977) <u>Scenic Heritage Areas</u>
11. D.A.Ratcliffe (1977) <u>A Nature Conservation Review</u>

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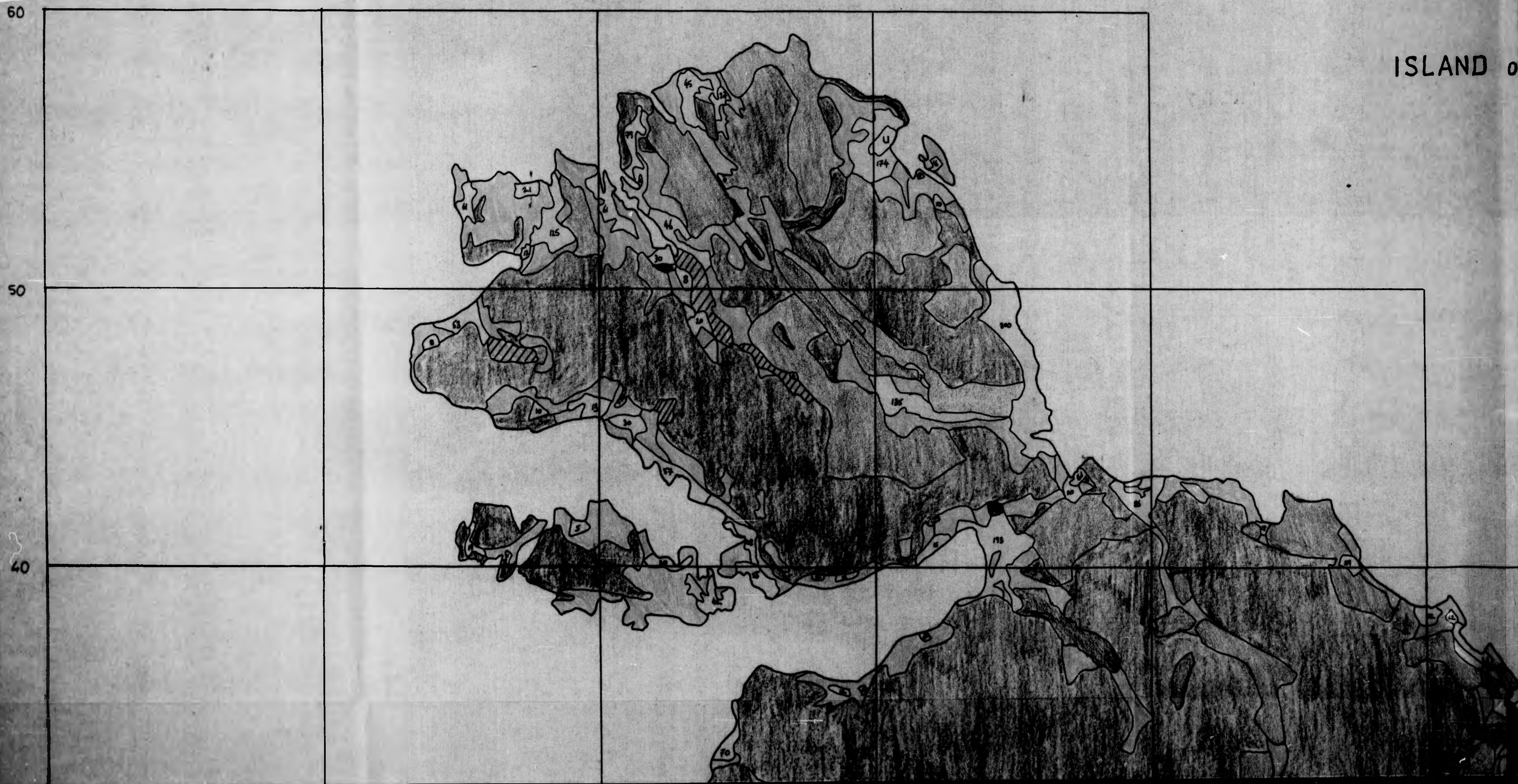
A1



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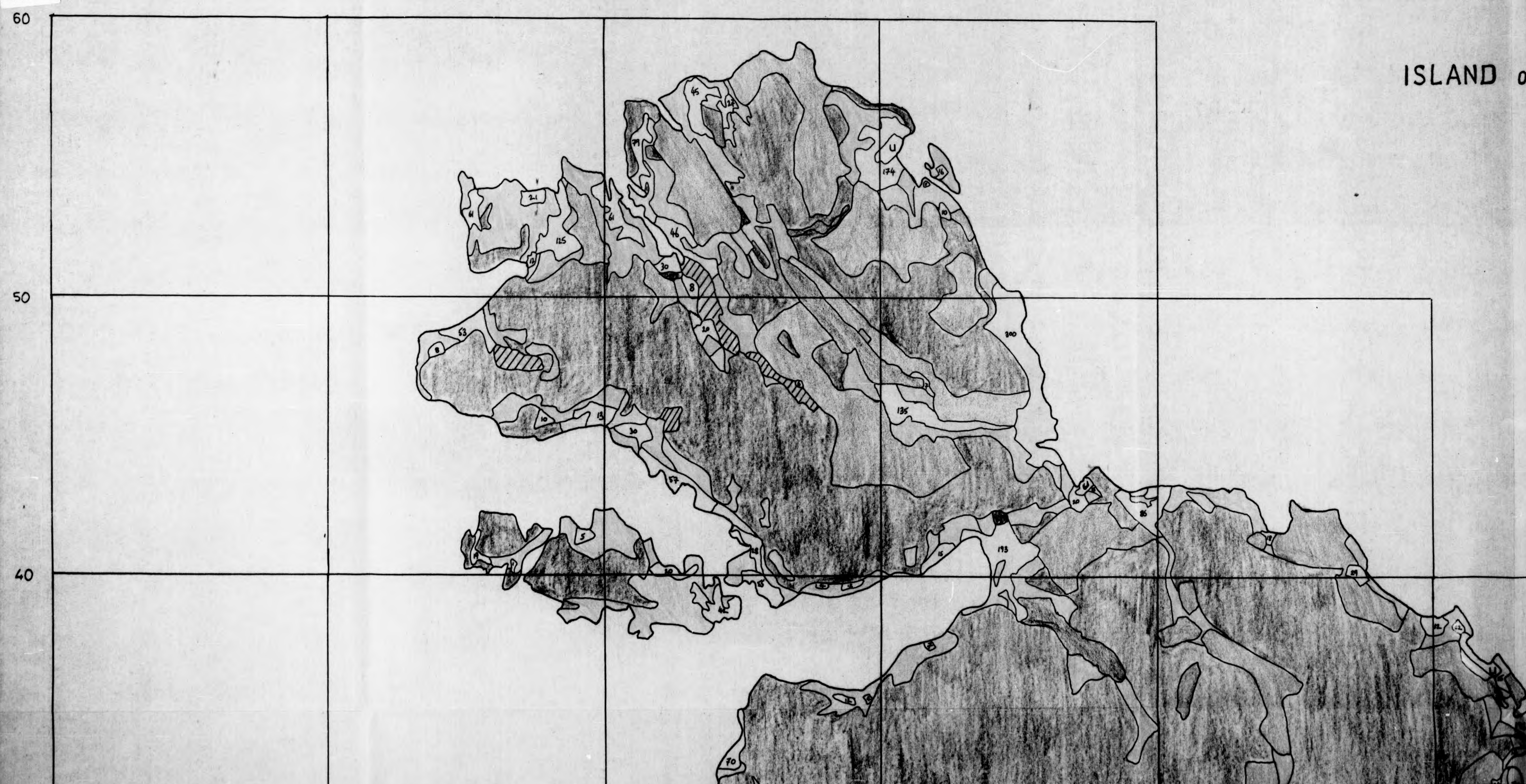

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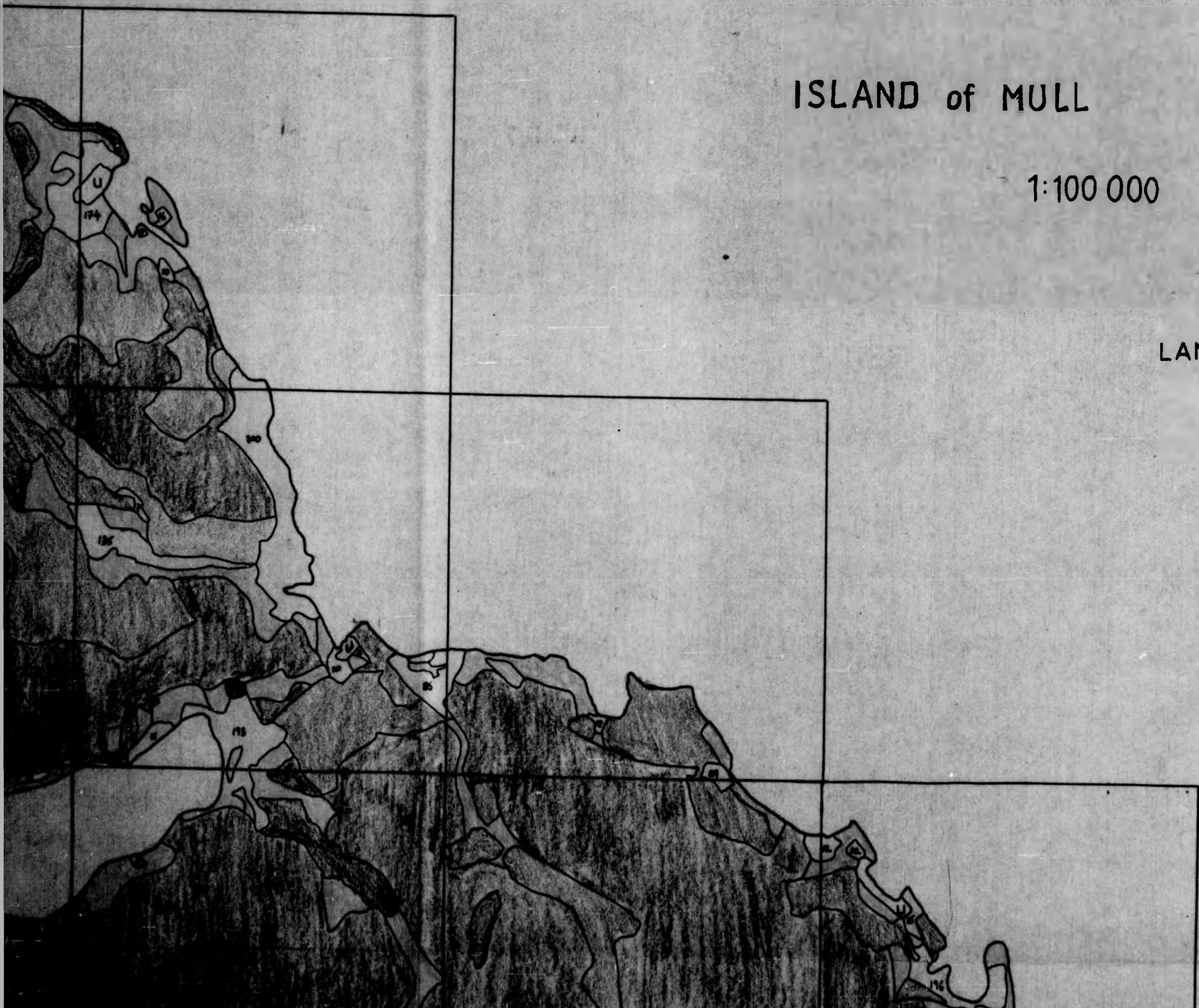


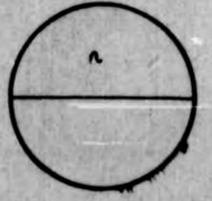
ISLAND of MULL

1:100 000

LAND - USE

Sources:

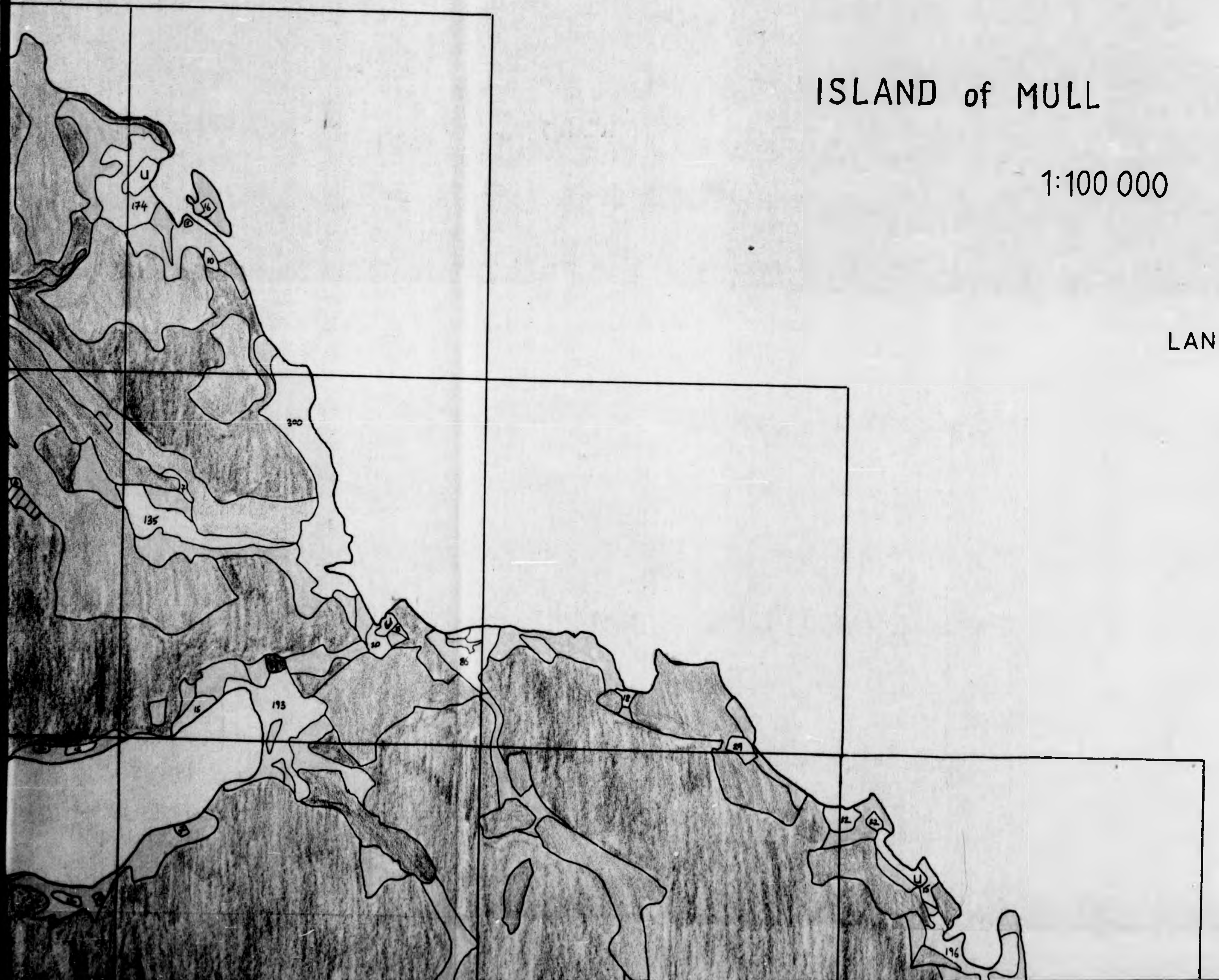
- Field Survey, Spring 1978
- Ordnance Survey 1:50,000 Maps + 1:10,000 maps
- MISR Land-Use Capability Map



Cultivated land and previously cultivated areas (n = actual area in ha. of Class One within bounded area – see appendix 3.5)

Good grazing and other improvable

A2



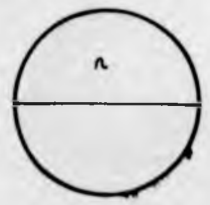
ISLAND of MULL

1:100 000

LAND - USE

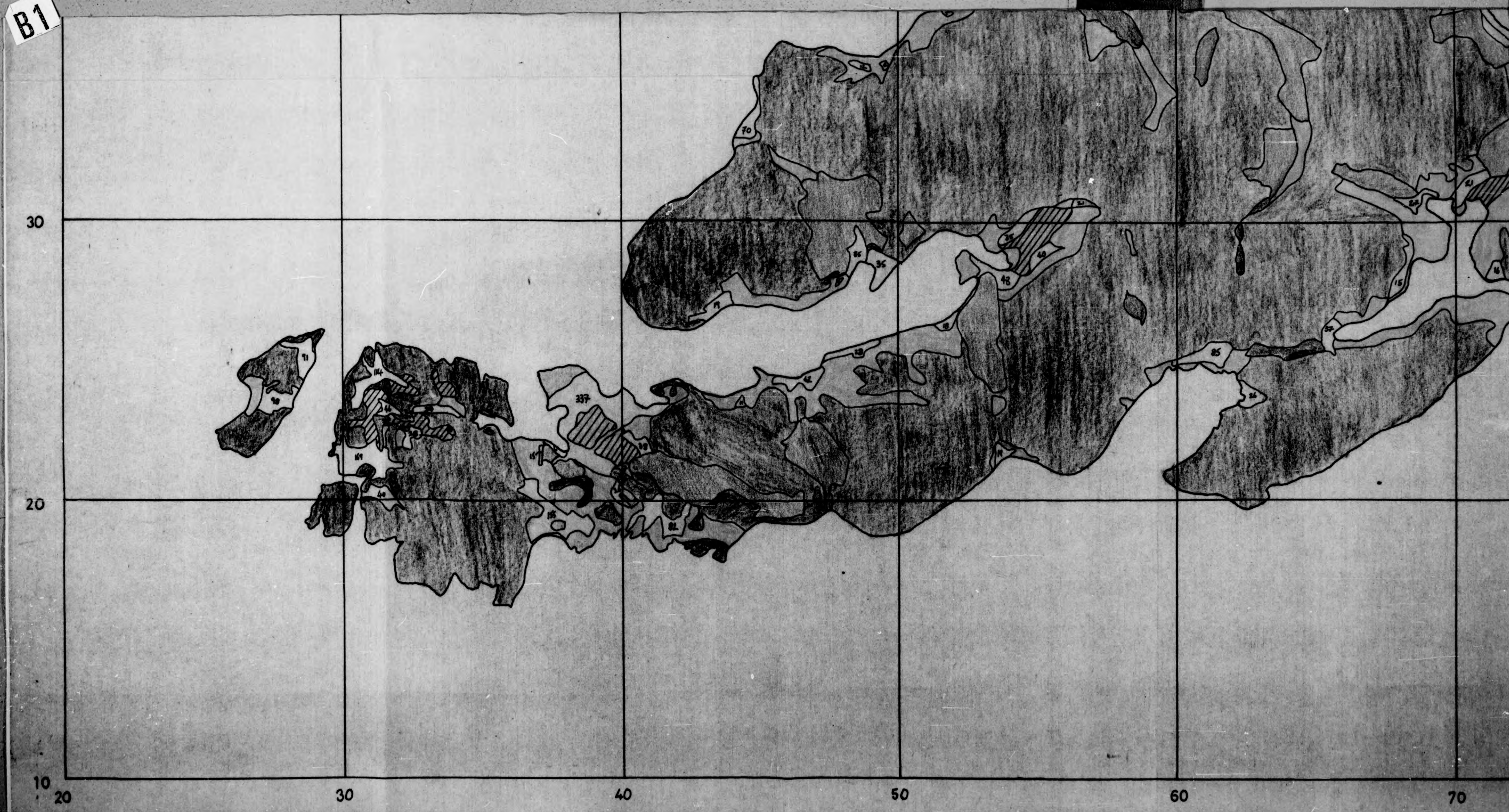
Sources:

- Field Survey, Spring 1978
- Ordnance Survey 1:50,000 Maps + 1:10,000 maps
- MISR Land-Use Capability Map



Cultivated land and previously cultivated areas
(n = actual area in ha. of Class One within bounded area - see appendix 35)

Good grazing and other improvable
pasture


B1
30
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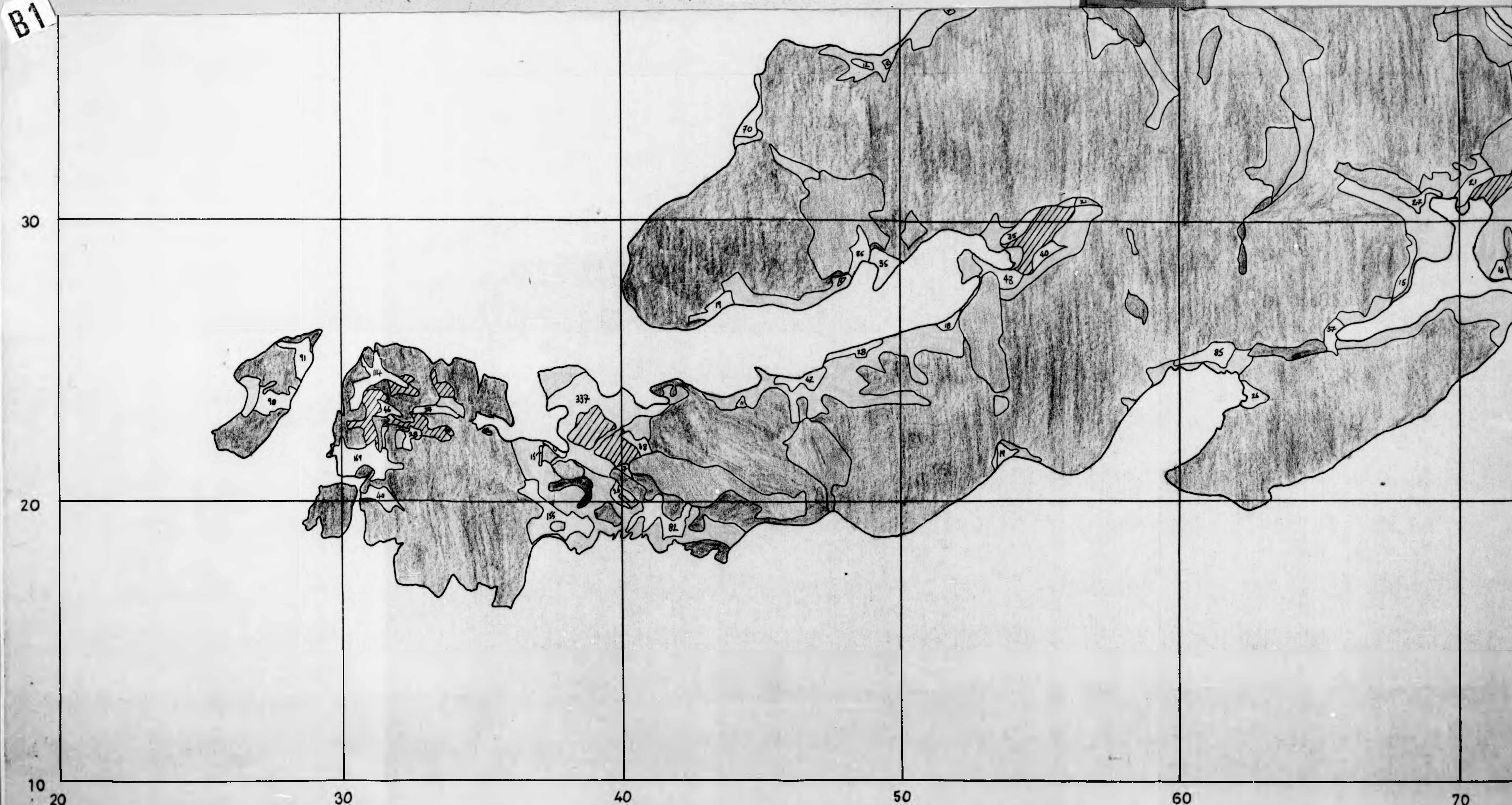
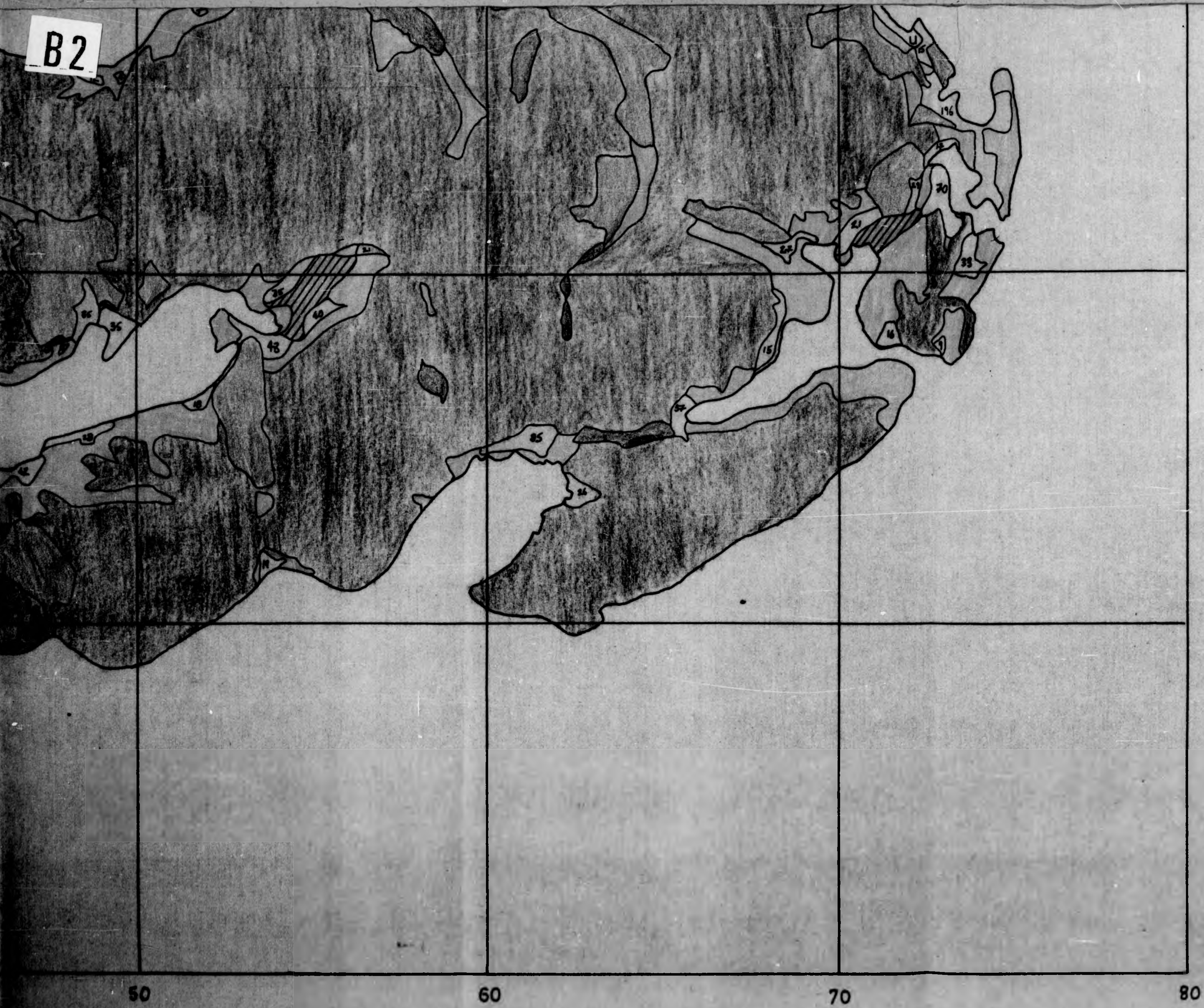
60
70

B1





(n = actual area in ha. of Class One within bounded area – see appendix 3.5)

Good grazing and other improvable pasture
(hatched areas = Major deep peat deposits)

Woodland
(largely unproductive)

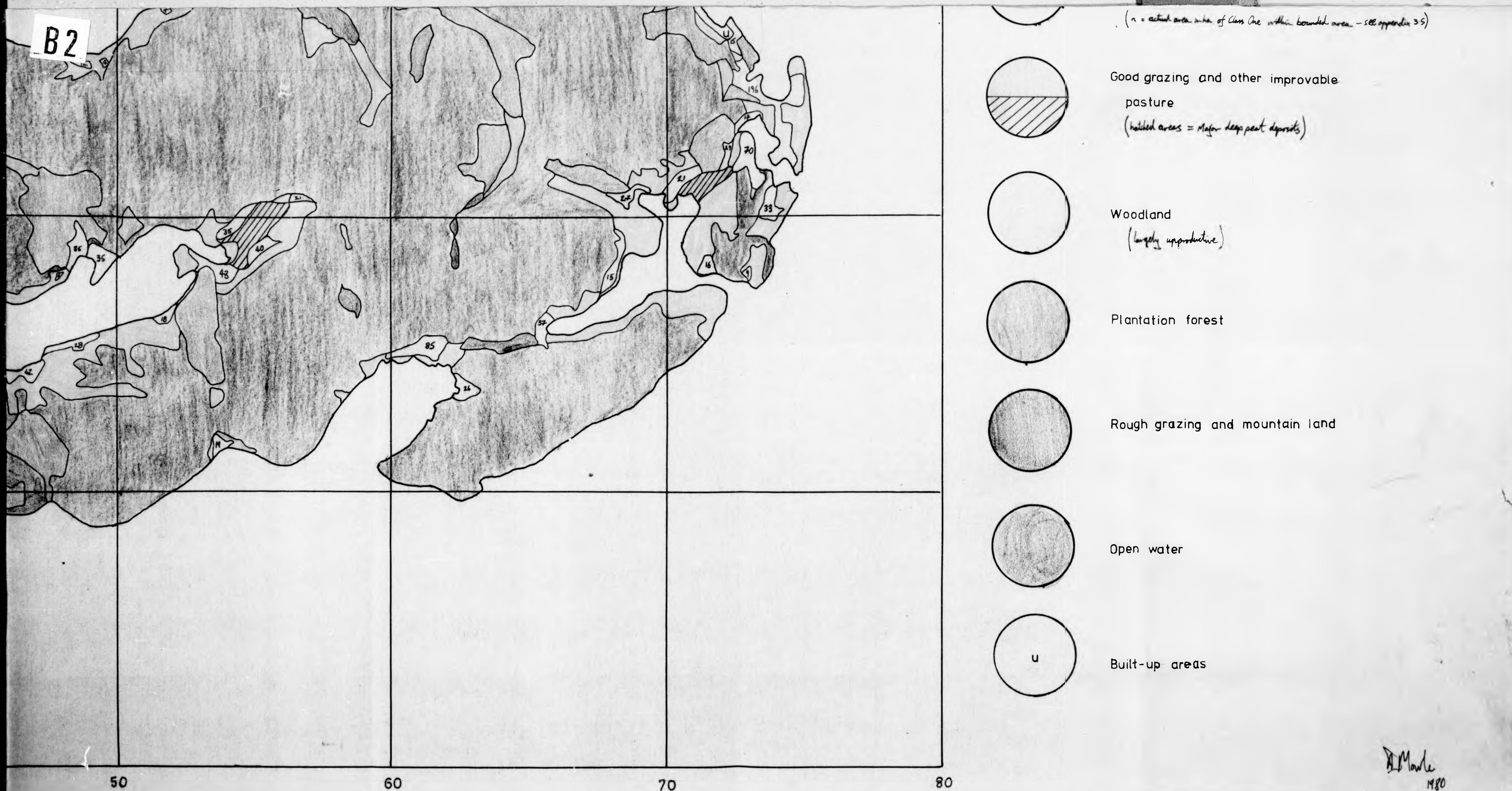
Plantation forest

Rough grazing and mountain land

Open water

u Built-up areas

D Marle
1980


B2
(n = actual area in ha of Class One within bounded area – see appendix 3.5)
Good grazing and other improvable pasture
(hatched areas = Major deep peat deposits)
Woodland
(largely unproductive)
Plantation forest
Rough grazing and mountain land
Open water
u
Built-up areas
50
60
70
80
D. Mawle
1980

III

8925'82

END