BIOREGIONS & FUTURE STATE VISIONING

A Visually Integrative Approach to the Presentation of Information for Environmental Policy & Management

A thesis submitted in conclusion of the requirements for the degree of Doctor of Philosophy by

Jonathan Ball

BSc. (Hons) Ecology (University of York, 1987)
MSc. Forestry Business Management (University of Aberdeen, 1989)

The Robert Gordon University
Aberdeen
&
Macaulay Land Use Research Institute
CraigieBuckler
Aberdeen

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DECLARATION

The candidate has not, while registered for this PhD submission, been registered for another award of a university during this research programme.

None of the original material in this thesis has been used in any other submission for an academic award. Acknowledgements for assistance received are given under the heading of "Acknowledgements" and any other work has been acknowledged by its source and author.

The author of this thesis acquired and was responsible for any licence obligations of all 'telnet' and Unix graphical user interface emulation software used in this project for cross-platform computer work. All such software is declared to have been 'freeware'. All data provided by the Macaulay Land Use Research Institute (MLURI) remained stored on their main computers, none of it being downloaded to machines outside MLURI. No data provided by MLURI for the purposes of this project were used by any additional persons or for any purposes other than those expressly connected to the production of this thesis. At no time were any of the data used for commercial gain.

SUPERVISORS & FUNDING

Director of studies:	Professor Seaton Baxter, OBE FRICS DipPhil
Supervisors:	Dr D Miller, BSc PhD RICS Dr J Berry, BSc PhD
Collaborating establishment:	The Macaulay Land Use Research Institute Craigiebuckler Aberdeen UK
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ABSTRACT

This thesis explores the comparatively new philosophy of bioregionalism to see what it might have to offer the environmental management process. The foundations of bioregional philosophy stretch back into the early part of last century with roots in the thinking of the early 'anarchist geographers' such as Peter Kropotkin. Input also comes from contemporaneous regionalist planners such as Patrick Geddes and Lewis Mumford. However, it was not until the early 1970s that Alan van Newkirk coined the phrase 'Bioregion'. Since then there has been steady growth in bioregional literature that clearly aligns it to ecocentric philosophies that are embraced by social movements like "Deep Ecology". However, the most important part of bioregionalism is the bioregions construct. Whatever the philosophical inclinations of bioregionalist authors, the bioregion is presented as an identifiable entity, which is suited to be the basis for the formulation of strategy and planning and it is this that is of interest to this thesis.

The basis for the study is the hypothesis that the need for a holistic approach to environmental management and planning requires more than the incremental approaches currently used, if tragedies like Easter Island are not to be repeated on a larger scale. The idea of future state visioning is taken from industry and commerce and given an environmental perspective to provide the visionary dimension required by such a holistic process. However, a visionary process is best served by a visualization tool, particularly where non-expert, community participation is deemed essential. The process of mapping bioregions is just such a tool.

The proposal that bioregional mapping is suitable as a tool requires that bioregions, as a construct, are demonstrable entities, as claimed by the literature. Therefore, a mapping exercise that allowed the testing of this principle was undertaken for Scotland as the test area. A methodology was developed, using a Geographical Information System to assist in the mapping and analysis. Statistical analysis of the resultant theoretical bioregional model showed that the bioregions had good agreement with other methods of dividing Scotland into regions. They also showed better agreement with these other regionalisations than politically defined regions. The notion that watersheds can be substituted for bioregions was rejected. Therefore, it was shown that bioregions are demonstrable entities, albeit sensitive to scale. The bioregions produced from first principles were compared to an independent, qualitatively developed model. The results of this comparison reinforces a suggestion that a 'science of quantities' needs to be tempered by a 'science of qualities' when stakeholder participation and interpretation is important.

The dramatic story of the social and environmental collapse of Easter Island is a metaphor for the situation facing the Earth, as a whole on the one hand, and to introduce the arguments of sustainability and regionality on the other. Easter Island is isolated, with almost no external inputs, like the Earth, but on a different scale. However, it is also a part of the Earth. From many sources, there is agreement that the natural environment of the Earth is under threat, not just on the local scale but on a global scale as well.

Bioregions are proposed as a holistic way of mapping the environment to inform the future state visioning process, which is offered as a tool at the level of strategic management. Bioregional mapping and environmental future state visioning were proposed as vehicles for stakeholder participation and the recognition of cultural factors in environmental management and planning. Future work should include investigating future state visioning solutions to more localised and community focused environmental management problems.

Scotland, as the subject for analysis, provides a manageable compromise between the extreme isolation and singularity of Easter Island and the multiplicity of the regions of the world. Scotland is an area that has good data on its various forms of regionality, including cultural and biogeographic regions.

1 INTRODUCTION

"We feel our world in crisis. We walk around and sense an emptiness in our way of living and the course which we follow. Immediate, spontaneous experience tells us this: intuition. And not only intuition, but information, speaking of the dangers, comes to us daily in staggering quantities."

Rothenberg[1] (1989)

1.1 SETTING THE SCENE

The human relationship with the environment is of increasing concern as evidenced in part by the growing interest in human ecology. There is much discussion of impending ecological disaster for the Earth as a whole. These concerns were emphasised at the Earth Summit in Rio de Janeiro in 1992 (United Nations, 1993) from which the important package of resolutions, known collectively as Agenda 21, were drafted to try and address these problems. Since the industrial revolution, various activities are believed to have contributed to a gradual but accelerating decline in the global environment. For example, the Inter-government Panel on Climate Change (IPCC) is convinced that climatic change is taking place which will lead to less predictable weather systems, rising sea levels and rising temperatures (IPCC, 1995), and an inseparable part of local and global ecosystems is mankind and human activities. There is an example that, in microcosm, puts the paradigm of sustainable development in a global sense into some practical context. This example also serves as a way of introducing the themes of bioregions and future state visioning and demonstrates the importance of culture of the human response to the environment. Consider, then, the allegory of the environmental and social collapse of Easter Island.

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1 David Rothenberg was the translator of Arne Naess' book "Ecology, community and lifestyle". He wrote these words as part of his introduction to the book which he also edited.

1.2 THE ALLEGORY OF EASTER ISLAND

In their book "Earth Island Easter Island" Bahn and Flenley (1992) compare the situation of Easter Island with the predictions of the Club of Rome for the world as a whole. The Club of Rome was convened during the mid 1970s and was comprised of business analysts and computer specialists. The purpose of the group was to try to model the future of the Earth into the next century (Figure 1.1).

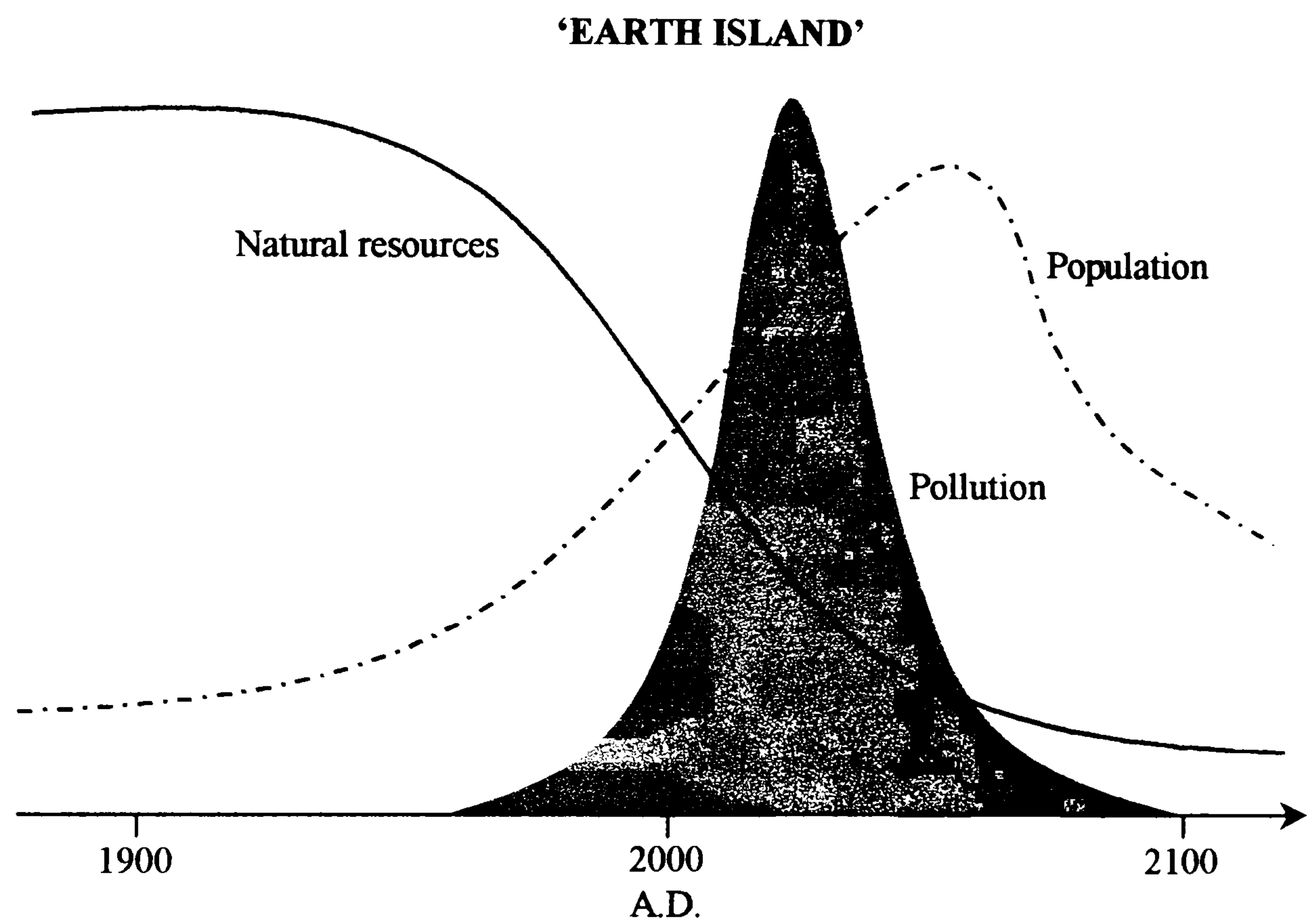

Figure 1.1: The Club of Rome's predictions of the Earth's future which predicts ecological and social collapse (reproduced from Bahn and Flenley, 1992).

A number of different scenarios were tested and all those which were based on trends of economic and population growth, which still continue, produced in the same result. Although the Club of Rome's findings (Meadows *et al.*, 1972) still remain controversial, with many experts refuting "The Limits to Growth", it would appear that we still remain on the course they predicted (Naess, 1989).

Easter Island is remote and difficult to reach, even by the standards of modern transportation. In the Pacific Ocean, it lies 2250 km from its nearest neighbour, which is Pitcairn Island. The nearest mainland, South America, is 3747 km to the Southwest. At the time of the Polynesian expansions it is unlikely that the settlers who found their way to Easter Island had had any outside contact for over a millennium before Europeans rediscovered it. Easter Island's remoteness and ecological and cultural isolation means that it is the closest model of a closed system, that includes human activity, where there is no prospect for mitigating any ill effects of that activity by any ecological or environmental buffering from the surrounding areas. Furthermore, the model also precludes the addition of resources, other than sunlight, from outside the system.

Various researchers have pieced the island's history together through archaeology, palaeobotany and pollen analysis. The results of this are shown in Figure 1.2.

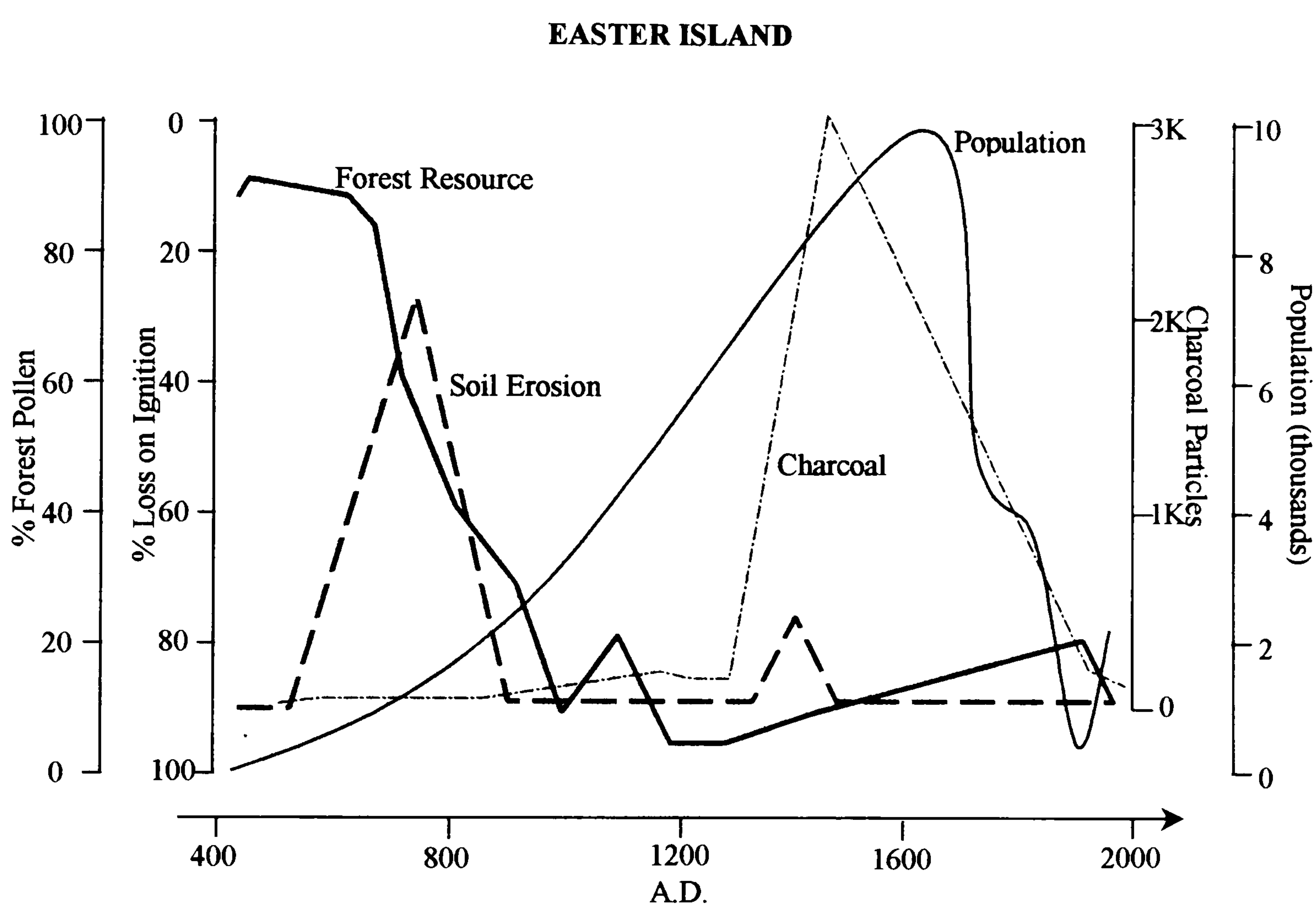

Figure 1.2: Easter Island's history seen through archaeology, palaeobotany and pollen analysis. Note the similarities with Figure 1.1 in decline of resources, sharp peak in pollution and the rapid population growth and subsequent crash (after Bahn and Flenley, 1992).

Bahn and Flenley (*op. cit.*) contend that, if the Club of Rome's findings have any veracity, they should be able to retrospectively 'predict' the deforestation and eventual population crash that occurred on Easter Island. Their contention is that Easter Island was an isolated, closed system from which, particularly following deforestation, the inhabitants had no means of escape. The planet Earth is effectively, likewise, a closed system from which we have no escape and so it is also an island.

Evidence from pollen analysis shows that Easter Island was heavily forested at the time of human discovery. It was the habit of the Polynesians, when colonising a new island, to bring with them certain food items in case the island was not able to support them. Traditionally this included plants such as bananas, chickens, pigs and the edible rat. It is clear that, if such items were brought to Easter Island only the bananas, chickens and rats survived. The native tree was very similar to the Chilean wine palm. A combination of felling the trees to assist in the manufacture and transportation of the incredible moai, or statues, and the consumption of seeds by the rats resulted in the crash of the tree population (Figure 1.2).

The incredible thing about the deforestation of Easter Island, as Bahn and Flenley (*op. cit.*) point out is that, the person who felled the last tree would clearly have known it was the last but felled it anyway. The felling of the last trees meant that there was no longer any possibility of building sea-going canoes. There would be no more fruit. There would be no possible continuance of the production of moai. Felling the last tree ensured that there would never be any chance of escaping from Easter Island despite the prospect of a dwindling food supply and certain disaster for future generations. In short, resources had been used at a rate beyond the region's carrying capacity.

To the inhabitants of Easter Island the moai were all-powerful gods who ensured the well being of the villagers who erected them. Each village vied with the others to produce ever bigger statues and ever more grandiose platforms for them to stand on. When starvation and social collapse over took the island it was these symbols of power that were the target of much of the violence which was previously unknown on Easter Island. Bahn and Flenley liken these moai to our modern day symbols of strength and power in the form of technology. They suggest that we should throw down our economic moai. This is the context of Deep Ecology.

This allegory clearly demonstrates the principle of the limits to growth. Continuous growth means, in reality, continuous acceleration. Indefinite acceleration is not possible in a finite world. The difference between the Easter Island situation and other regions of the world was that the islanders were not in a position to 'borrow' from other parts of the globe to artificially increase the carrying capacity of the island. It was imperative that the islanders lived within the limits of their region. Despite those limits being clear, they chose to ignore them and place their faith for the island's future fecundity in something of their own creation. This example not only re-enforces the findings of the Club of Rome but also provides a salutary lesson in the dangers of not 'living in place'.

1.3 RELATING THE EASTER ISLAND EXAMPLE TO PHILOSOPHICAL ISSUES

The example of Easter Island is a dramatic one, and its strength comes from the way it encapsulates nearly all of the philosophical issues that that are pertinent to the sustainability debate and environmental planning. These are summarised below:

1. **Finite resources** – Easter Island was a remote, inhabited island and there was no prospect for trade with other islands. The only 'outside' resources that could be obtained were fish and climatic resources such as sunlight and oxygen.
2. **(Un)sustainable development** – accelerated production of 'important', but unnecessary artefacts. One section of the population supported a large work force that was occupied in carving the moai. The moai were culturally important but their increasing size and number was unnecessary (like many artefacts of modern society).
3. **Environmental capital** – the island's resources were squandered, ultimately leaving an impoverished society. The environmental capital was mostly destroyed and there was no 're-investment' to maintain the capital. The Islanders also incurred the opportunity cost of the loss of 'environmental services' such as shelter from wind provided by trees.
4. **Social and inter-generational equity** – sections of society become disenfranchised, and the welfare of future generations was jeopardised with the destruction of the environmental capital. For a modern example see Haughton and Hunter (1996). As was discussed, this was not accidental and the perpetrators must have known that the short-termism of their actions would compromise the quality of life of future generations. Either this was not understood or the problem was seen as part of the future and therefore to be dealt with at some time removed from the present. The ethics of resource management were investigated by Haughton (1996). The concept of inter-species equity and the rights of nature have been widely debated and are well documented (e.g. Nash, 1989). If the notion of the rights of nature is accepted then the Easter Islanders clearly violated them.
5. **Quality of life, standard of living** – standard of living was measured by the size and number of moai, which was the Easter Islanders' closest equivalent to GNP. However, the more they pursued the creation of bigger and more moai, the more time and people had to be devoted to their production and the fewer the people available for primary production and the more the environment was degraded. This lead to a decline in the quality of life as food shortages, disease and violence increased. On this note it is instructive to look at the

case of Bhutan. In comparison to more developed nations, Bhutan is extremely poor, the average annual income being as little as $550 (de Jonge, 1999). However, in the late 1970s the King of Bhutan coined the phrase 'Gross National Happiness' as the measure by which Bhutan was to measured. It was a defiant gesture to signify that Bhutan would not "be bullied into measuring progress in purely material terms" (de Jonge, *op. cit.*). Quality of life and standard of living were explored by Thring (1970 and 1980) and Schumacher (1973) who both echoed the King of Bhutan's sentiments.

6. **Cultural Influences** - the influence of culture is interesting in the process. The cult of the moai can be considered to be to blame for the collapse of Easter Island. However there are two important points. The first is that it was when the pursuit of the manifestations of spirituality became an end in itself that excess became the norm. The second point is that the original cult of the moai had little to teach the people about care of their environment. The later spiritual tradition of the 'bird-man', which followed the collapse of society on Easter Island, was much more closely related to the environment and particularly fertility. There is not space here to discuss the ecotheology of Easter Island except to underline the fact that spirituality should not be underestimated as a powerful influence on the environment. As such, it adds additional weight to the importance of culture in environmental planning.
7. **Ecocentrism *vs.* Technocentrism** – technical advancements concentrated on producing moai and the development of sustainable agriculture was ignored. Ironically, the unbalanced technological advancements meant that other technical solutions were lost, in particular sea-going canoes, which meant the Easter Islanders' opportunities to supplement their food by fishing became limited.
8. **Knowledge by consensus** – a ruling elite dictated on all policy, including rights to certain food stuffs, in a top-down approach. In other words, there was no consensus and certainly no stakeholder input.

1.4 A HYPOTHETICAL 'MIND-EXPERIMENT'

Easter Island makes an interesting subject for a hypothetical mind-experiment. What if they had understood the principles of sustainable development? What if the Easter Islanders had taken a visionary approach to chart the future holistically? What if they had undertaken a mapping exercise, as a community project, to identify both the island's resources and areas of significance to the community, so as to manage their natural and cultural heritages effectively? It is the contention of this thesis that the story of Easter Island could have had a very different ending had the notions of bioregionalism and visioning been apparent at the time.

1.5 OVERVIEW OF THE ENVIRONMENTAL SITUATION OF 'EARTH ISLAND'

The story of Easter Island is indicative that social involvement in today's environmental management is now imperative. It is probable that there are no ecosystems left in the world today that are not affected in some way by human activities. These activities have progressed to such an extent that the in-built stabilising mechanisms of the planet's life-support services are themselves threatened (O'Riordan, 1994). The problems, so similar to Easter Island's, are summarised in the following quote:

> *"Underlying the Earth Summit agreements is the idea that humanity has reached a turning point. We can continue with present policies which are deepening economic divisions within and between countries - which increase poverty, hunger, sickness and illiteracy and cause the continuing deterioration of the ecosystem on which life on Earth depends."*
> *"Or we can change course. We can act to improve the living standards of those who are in need. We can better manage and protect the ecosystem and bring about a more prosperous future for us all."*
>
> from the introduction to Agenda 21, The United Nations (1993)

A question that needs to be addressed when considering ecosystem management or restoration is: 'What are we trying to manage, or to what are we trying to restore in the ecosystem?'. This question is especially poignant in the Scottish situation where human influence, often dictated by political and social change, has been the predominant force in shaping the nature of the ecosystems in the last couple of thousand years. Norway is often cited as an example of how things could be in Scotland, allowing for the differences. The two countries are similar in many respects. However, there is a higher population in Norway (as there was once in Scotland before the Highland Clearances). Norway also has a more integrated and mixed land use with a pattern of settlements in the valley (glen) floors, farming on the lower slopes and forestry on the upper slopes with a much higher tree cover than Scotland (FoE, 1996).

In ecology, the idea of "carrying capacity" is very important (for more information on the ecological definition of carrying capacity see Begon, *et al.*, 1986). This is the number of individuals and/or species that an area is able to support in a stable equilibrium (see glossary). There could be one or more limiting factors from the availability of food to a lack of suitable shelter. As humans are also dependant on the earth's resources, including space and materials with which to build, we are also bound by the limitations of a region's carrying capacity. The modern, industrialised world has found solutions that allow it to artificially increase the human carrying capacity of a region. It does so by the transportation of food and building materials from outside. Nonetheless, this is at the expense of resource depletion in other regions and pollution. Such movement of resources is only possible with transportation heavily subsidised by a fossil fuel economy that does not take environmental costs into account. Such a dislocation is not sustainable. Although a region can have its carrying capacity artificially raised it is still part of a larger system and, like a set of Russian Dolls, the hierarchy ends with the largest region, the planet to which, ultimately, all impacts are ultimately passed.

1.5.1 The Finite World of Resources

The world, viewed as a pool of resources, is finite (Baxter, 1996; see Figure 1.3a.). For life, people have a set minimum requirement for resources (Figure 1.3b.) as is demonstrated by Maslow's hierarchy of needs (see Gross, 1987). Mental well-being, which is often reflected in physical well-being, is achieved by satisfaction of spiritual needs (Figure 1.3b.).

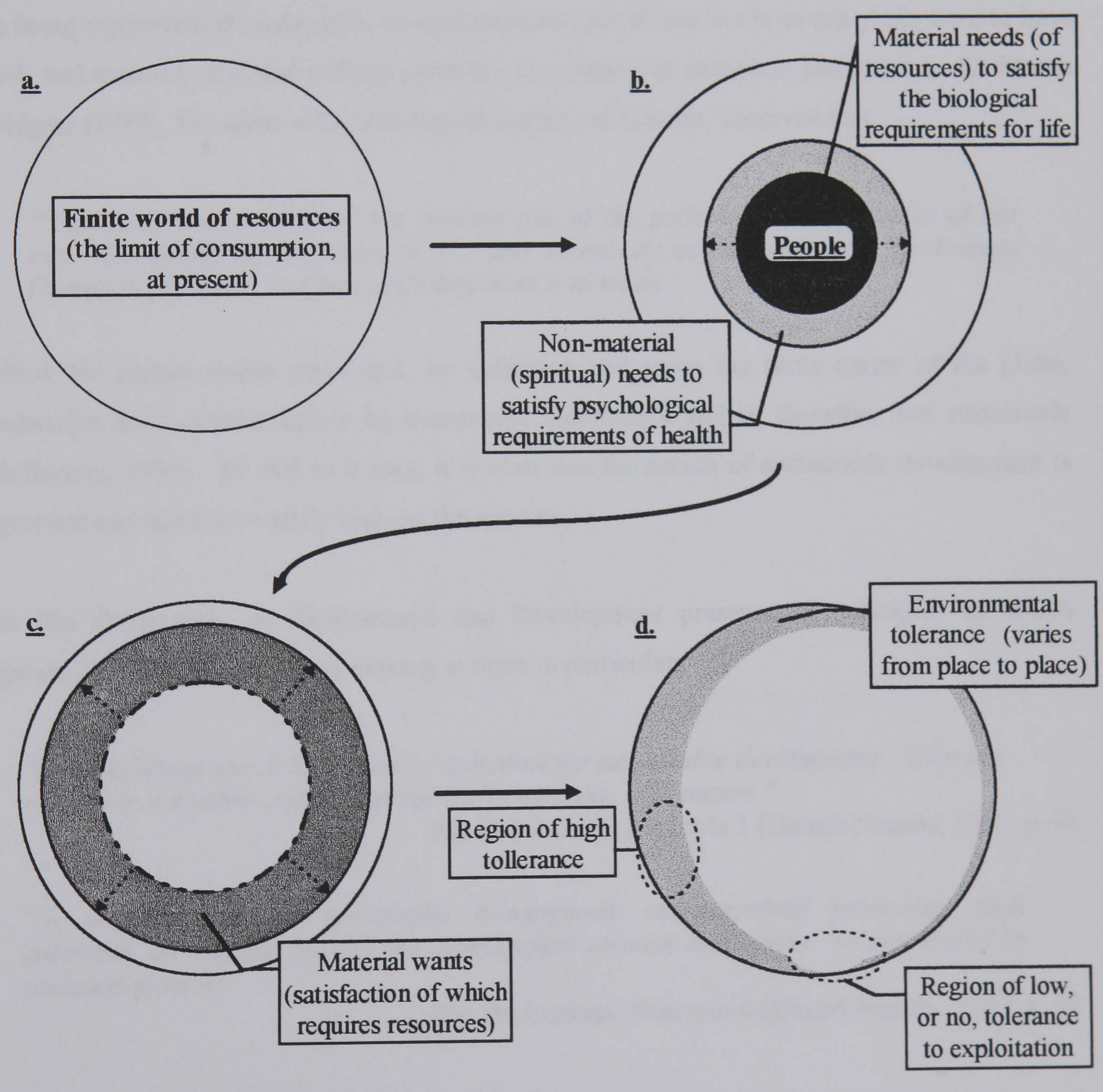

Figure 1.3: Resources, wants and needs, a dynamic representation of people's interaction with their environment (after Baxter, 1996). Arrows represent a variable horizon within the pool of resources.

Humans also have complex wants, such as a bigger house or a car, which are not necessary for life at the basic biological level but which also require the use of resources (Figure 1.3c.). There is a certain amount of robustness in the environment (Figure 1.3d.), which is capable of absorbing the exploitation of extra resources to satisfy the wants, but this tolerance is locally variable (*e.g.* compare the soils of Africa to the soils of Kent and the styles of agriculture they can support). Environmental tolerance interplays with sustainability and biodiversity. It is the final source of last resources and ecosystem services.

1.5.2 The Sustainable Development Challenge

The main debate on how to reconcile the needs of economic growth with ecological maintenance has centred on the popular concept of "Sustainable Development". A question mark hangs above the over-used phrase 'sustainable development'. Few people would admit to not being supporters of sustainable development but the phrase has been too glibly used to have much real meaning anymore without carefully considering its definition and context. Sir Martin Holdgate (1997), President of the Zoological Society of London, observed that:

> *"'Sustainable development' has become one of the politically-correct theses of our era. Everybody is in favour of it – and everybody defines the term, on Humpty Dumpty's principle, to mean what they want it to mean."*

Indeed, the pedant might argue that, by definition and given the finite nature of the globe, sustainable development cannot be maintained indefinitely and is, therefore, not sustainable (McBurney, 1990). Be that as it may, it is clear that the notion of sustainable development is important and therefore rightly high on the agenda.

The Rio Declaration on Environment and Development presents 27 principles on which Agenda 21 is based. It is worth looking at three in particular:

> *"Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature."*
>
> Rio Declaration, Principle 1 (United Nations, 1993, p. 9)

> *"In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it."*
>
> Rio Declaration, Principle 4 (United Nations, 1993, p. 9)

> *"To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies."*
>
> Rio Declaration, Principle 8 (United Nations, 1993, p. 10)

The concept of sustainability in its modern guise was first developed in response to impacts on the natural environment where the loss of a certain species or even life as a whole became a threat. One of the most quoted definitions of sustainability comes from the report of the United Nations World Commission on Environment and Development (WCED) usually referred to as the Brundtland Report (1987). In this report, "Our Common Future", sustainable development is defined as

"development which meets the needs of the present without compromising the ability of future generations to meet their own needs."

Whatever the definition, sustainability is a prerequisite for continued existence of all living things. Sustainable development is a broader concept than sustainability and includes issues on the quality of life (English Heritage, 1995) and the integration of social, economic and environmental spheres of activity (Figure 1.4).

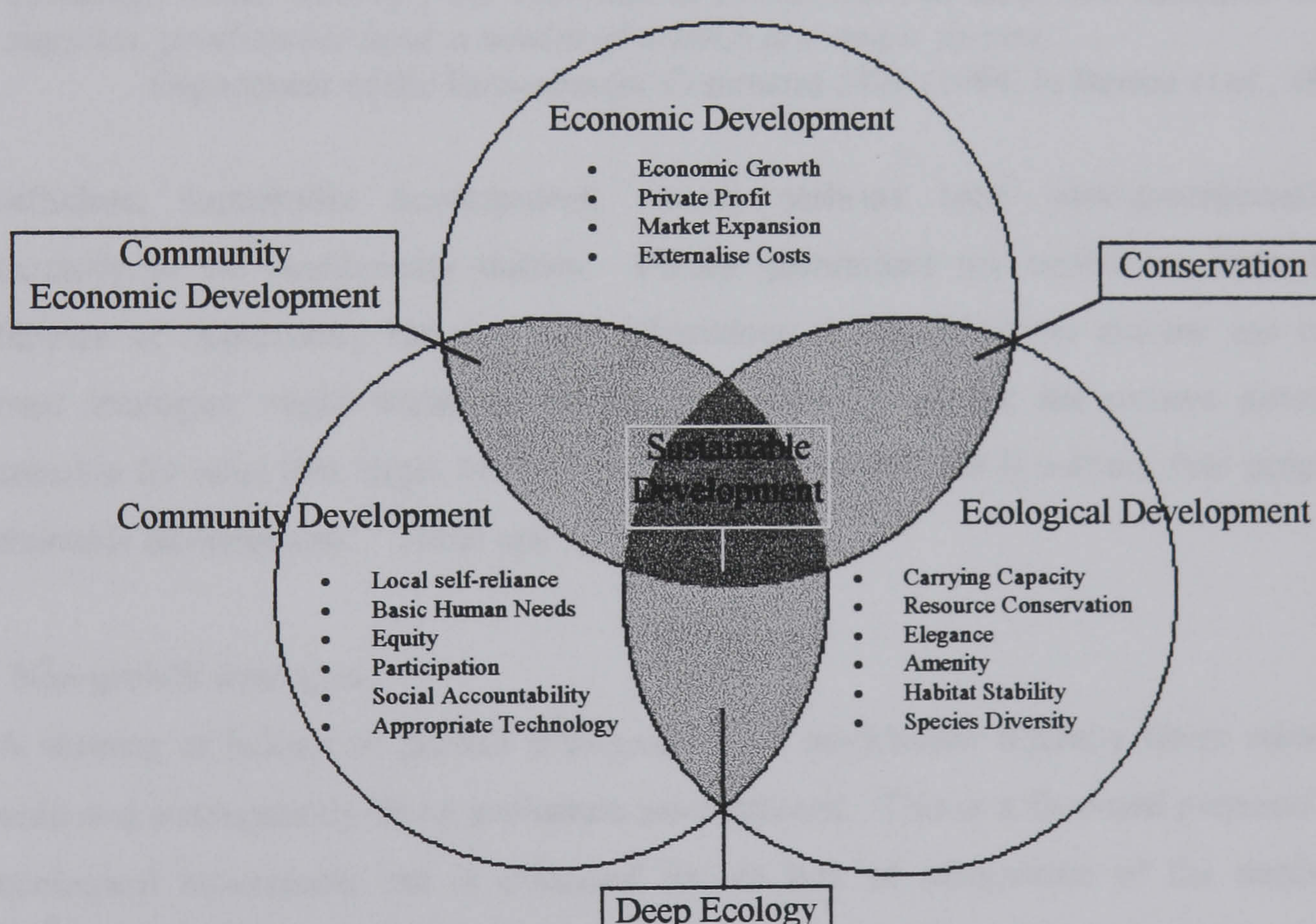

Figure 1.4: The sustainable development challenge. Source: International Council for Local Environmental Initiatives (1996, with minor adaptation).

Sustainable development includes concepts such as the sense and meaning of place, community identity and aesthetics. Sustainable development must also be considered at the level of multiple time frames (Jacobs and Mulvihill, 1995) to allow for the different periodicities of integrated natural and social systems. Despite the recognition of the different habitats and environments required by a myriad of other species, real recognition of the significance of the human environment did not arrive, politically, until the Rio package (United Nations, 1993).

> *Sustainability is about the maintenance of the health of the biosphere and the husbanding of key resources of air, water, land and minerals.*
>
> Barton *et al.* (1995)

The most prevalent notion of development currently restricts itself primarily to economic growth. Some might argue that the words 'sustainable', in the environmentalist sense, and 'development', in the business sense, cannot be meaningfully juxtaposed. Be that as it may, sustainable development, as defined by the government means:

> *".... living on the earth's income rather than eroding its capital. It means keeping the consumption of renewable natural resources within the limits of their replenishment. It means handing down to successive generations not only man-made wealth (such as buildings, roads, railways) but also natural wealth, such as clean and adequate water supplies, good arable land, a wealth of wildlife and ample forests."*
>
> Department of the Environment Command 2426 (1994, in Barton *et al.*, 1995)

Nonetheless, sustainable development, cannot enshrine total inter-generational equity particularly in the biodiversity debate. Future generations are unable to determine their preference of opportunity sets, as their inheritance is dependent on current use of assets. Current strategies might widen or narrow the inherited set but the present generation is responsible for what that might be (Perrings, 1993). Martell (1994) outlines four proposals for 'sustainable development'. These are:

1. Non-growth strategies

   A slowing or halting of growth is proposed as a mechanism whereby fewer resources are used and consequently fewer pollutants are produced. This is a favoured proposal of many ecological movements but is criticised for its lack of recognition of the needs of less developed countries (LDCs). Indeed, social equity would seem to require the burden of responsibility to be shouldered by more developed countries (MDCs), which leads to the second proposal.

2. De-development

   This proposal is centred on the belief that the environmental problems of LDCs are largely due to the over development of MDCs. MDCs would be required to de-develop in compensation for the development of LDCs. Apart from being a strategy that could be expected to be very unpopular in MDCs, this strategy does not break the cycle of dependency. Many ecocentric groups question whether LDCs should be even trying to attain the level of growth achieved by MDCs, given the known environmental damage which such levels of growth have caused.

3. Self-reliance

   Self-reliance is needed to break the cycle of dependency of LDCs on foreign investment. Self-reliance is enshrined in the Brundtland definition of sustainable development. This is implicit in bioregionalism.

4. Appropriate technology

   Appropriate technology is sensitive to both the local environment and to the ability of the indigenous people to maintain the technology without outside help. Appropriate technology applies to MDCs as well as to LDCs. Many environmentalists would argue that the modern agribusiness of MDCs, with its reliance on artificial fertilisers and intensive management methods and their combined detrimental environmental impacts (pollution of water sources, loss of topsoil, damage to bird and other insectivore communities *etc.*), is not appropriate.

Bioregionalism suggests itself as a goal that would incorporate all four of these proposals, in varying degrees, depending on the resources and environmental robustness of a locality.

1.5.3 Environmental Space

A study by Friends of the Earth (Friends of the Earth, 1996) identifies environmental space as a possible indicative tool for delimiting use and disposal of resources within a region. Environmental space is the area that each individual within a given country is allowed to occupy in relation to consumption of resources as calculated equitably on a global level. Environmental space is comparative at the global level and is defined by three criteria; *viz.* the absorption capacity of the environment for the water stream, the lifetime of reserves and the carrying capacity of the environment. The balance and interplay of these criteria determine the environmental space of an individual resource.

This seems a reasonable basis for comparative assessment and certainly seems equitable in its attempt to re-distribute resources evenly. The original assessments used in determining E-Space were admirable in clarifying physical resource consumption but they did not allow for the fact that resources have different cultural values in different regions and that this affects people's understanding of the need to conserve resources (Kativik Environmental Quality Commission *et al.*, 1992). These local cultural values are closely linked to the type and amount of resource available in the locality where these values arise (Steward, 1955). Instead, E-space was reified as a parameter for all cultures in all locations.

The Friends of the Earth (FoE) study (*op. cit.*) identifies three categories of resource groupings. These are global, continental and regional resources. Water has been identified as the primary regional resource indicator in the FoE report. However, a problem with environmental space as a universal principle can be seen by looking at the variation in the regional availability of water and the local values placed upon it. Water, in environmental space terms, should be equally precious in Scotland as it is in arid zones such as the Sub-Sahara. However, because of the specific local meanings of water in terms of its relative abundance, the Scots see abundant water consumption and disposal as a given right whereas natives of the Sub-Sahara place immense value on small quantities of water and for them the concept of waste water is anathema. As can be seen, the cultural significance of the resource is influenced by the practicalities of its availability. People in Scotland have developed their own cultural response to water abundance and, likewise, the Africans concerned have developed cultural responses to water scarcity and the practicalities that imposes on them (Stevenson and Ball, 1996).

In each case the response is human adaptation to a regional variation. The original concept of environmental space undermines this proper diversity of cultural response to resource variation by demanding that all cultures (and therefore regions) have the same access to resources. Taken to its logical conclusion, this scenario of equitable universalisation suggests that water should be redistributed, regardless of the environmental cost, throughout the world to even out availability. Few would propose such a strategy but, although now much tempered by MacLaren *et al.* (1997), the original description of E-space illustrates the trap into which many "equity" evaluations fall when regional variations and cultural adaptation are ignored.

Regionalism must play its part in the determination of environmental space. Environmental space should be no more fixed and immutable (regardless of potential international agreements) than the relative materials standards that currently exist around the world. It might be more productive if an algorithm that would account for the availability of resources could determine environmental space. Like a balloon, environmental space would expand in more sparsely resourced surroundings and contract in more densely resourced places. This flexibility, or 'headroom' (see MacLaren *et al., op cit.*), begins to accommodate pluralistic multicultural adaptations in relation to resource conservation (Stevenson and Ball, *op. cit.*).

The example of water, above, in no way denies the right of indigenous communities to adequate physical resources for survival. Neither does it excuse the consumption of resources at someone else's expense that obviously needs to be tackled in more developed countries. It does question the sometimes excessively prescriptive attitude that exists amongst proponents of equitable sustainability. It asks that we consider the relative way in which people consume resources and be careful about how we define the words like "adequate" in relation to different places. This is the notion of 'equality of opportunity rather than equality of outcome' of McLaren *et al.* (1997). We should not impose definitions on other cultures but rather listen to their understanding of resources in the first instance. This highlights the importance of stakeholder participation that will be built upon later in the discussion on future state visioning. In its favour, environmental space emphasis the importance of primary consumption rather than end use of a resource or the setting of targets for the emission of, say, carbon dioxide that encourages the use of resources up to the limits set by end use regulation.

The need for a regionalistic approach and recognition of local distinction has become part of political thinking as evidenced by United Nations Agenda 21 in 1992[2] (United Nations, 1993). The most significant key issues include the protection of the physical and ecological environment, promoting local economic stability and enhancement of community involvement and inclusiveness. The sustainable development debate turns on the main dialectics of technocentrism distinguished from ecocentrism and of efficiency versus equity (O'Riordan, 1995).

1.6 INTRODUCING BIOREGIONALISM

A comparatively new movement is emerging with the promise of developing a meaningful mechanism for yoking economic and ecological demands together. Moreover, this movement does not aim simply to preserve the remaining natural or semi-natural environment. It recognises the importance of restoration. This movement is "Bioregionalism". The term "Bioregionalism" was first coined by Alan van Newkirk, a biogeographer, in the 1970s (Alexander and Talbot, 1996). A Bioregion is a place defined by its life forms not by legislature. Further extension of the idea soon included local human societies so that local people might be empowered to promote restorative, healthy change in their surroundings.

Easter Island is small enough to be considered as a single bioregion and its isolation makes it a metaphor for the Earth as a whole, or single, system. However, the surface of the Earth can be

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2 Although, the exploitation of environmental and ecological thinking for political motives has the danger of being nihilistic rather than a guiding hand allowing a more harmonised human presence in the natural world (Lovelock, 1979) there scope for optimism (O'Riordan, 1994).

sub-divided into many sub-systems, whether they are bioregions, biogeographic zones, or some sort of political regionalisation. For the sake of a meaningful investigation of bioregions it was decided that Scotland offered a good example. Being part of an island, the scope for direct interaction with neighbouring regions is reduced. Furthermore, it is large enough to be likely to contain a number of regions of its own. Therefore, Scotland provides a compromise between the singularity of Easter Island whilst allowing the study of a more manageable number of regions than the Earth as a whole.

The concept of sustainability can only have real meaning if it addresses the fundamental issue of carrying capacity. Human societies cannot consume more resources than nature produces and they cannot produce more waste than nature can absorb in the long run. Carrying capacity varies from place to place and there is no one allowable level of consumption of resources '*per capita* per unit area'. There must be a regional basis for sustainable consumption, which is why Local Agenda 21 is important, through its acknowledgement of regionality.

A proposal for the bioregions of Scotland has been produced by Douglas Aberley, a bioregional activist and community and regional planner, who teaches bioregional planning at the University of British Columbia. Aberley also studied at the University of Edinburgh for a number of years where he developed a great understanding of Scotland and its people. This combination of knowledge, interest and application make Aberley a useful source of an intuitive bioregional definition of Scotland. He has produced such a definition (Aberley, 1995) and it includes not only approximate bioregional boundaries but also subdivision that he calls 'community regions'. Although many organisations such as Scottish Natural Heritage (SNH) and Historic Scotland (HS) have conducted work on regionalism, none have gone as far as Aberley's full picture of bioregionalism for Scotland.

1.7 SCOTLAND: A BRIEF OVERVIEW OF PERTINENT ISSUES

In this thesis, Scotland will be used as a 'test bed' for the identification of bioregions. It is therefore appropriate to put some of the issues above into the Scottish context. Following devolution, at the time of writing, the new Scottish Parliament had been open for only a couple of months. It remains to be seen how the environmental policy of the new Scottish Assembly will develop. The political context of this thesis is important but must be largely based on policy from the former Scottish Office as there has been insufficient time for the new parliament to formulate much policy of its own.

1.7.1 Sustainability Studies for Scotland

There have been a number of sustainability studies in Scotland. These studies emphasise that there is an immediate need to address the paucity of the quality and quantity of information at all levels (FoE, 1996). These studies also make the common statement that there is a difficulty in obtaining up-to-date information at the regional, not to mention the national level. The Borders Enterprise joined forces with the Rural Forum, Scottish Natural Heritage and Scottish Enterprise to set up the Borders Forum for Sustainable Development following a study in Ettrick and Lauderdale districts. The former Fife and Strathclyde Regional Councils also commissioned studies of sustainability indicators within the UK Local Agenda 21 pilot project.

By the mid 1990's sustainability was firmly on the political agenda. The Scottish Office (1995) highlighted a need to identify regions within Scotland, what each could offer and how this could be exploited in new ways commercially (Scottish Office, 1995). The British Government endorsed the need for research into the integration of social and environmental issues:

> *"A more holistic approach is called for, involving a comprehensive procedure to identify total environmental and social costs and alternative solutions to construction problems."*
>
> OST (1995a)

A holistic approach to the environment includes both the natural and the built environments. Sustainable development of the construction industry and associated businesses would be enhanced by the development of a new vernacular architecture (Scottish Office, 1995) based on a regionally appropriate approach to environmentally benign building materials (Stevenson and Ball, 1998). This is in opposition to the widely held ethos of globalization and unification of standards and materials (or harmonisation as the process is often euphemistically called).

Scottish Natural Heritage, with the Scottish Office, conducted a trilogy of studies for Scotland into land use in the uplands, lowlands and use of freshwater (summarised in Friends of the Earth, 1996). The conclusion from these studies was that Scotland was not developing sustainably socially or economically. In 1998 the Scottish Office Report "Towards A Development Strategy for Rural Scotland" was published. There were four stated overall policy aims, that rural development strategy must:

1. not set rural Scotland apart;
2. reflect the diversity of rural Scotland;
3. work through an integrated approach;
4. facilitate community involvement.

It is notable that a holistic approach and community involvement are high on the agenda but the mechanism for the integration of both the communities and holism is less clear. However, as Holdgate (1997) points out, there is a big difference between an issue being on the agenda and a mechanism for that issue to be addressed.

1.7.2 Regionalism in Scotland

Scottish Natural Heritage in conjunction with the Macualay Land Use Research Institute (MLURI) produced a biogeographical zonation of Scotland. As discussed earlier, bioregional definitions have often been arrived at by "guesswork" based on a feeling of what is "right" by a cursory glance at the local water catchments. The work by SNH and MLURI is the first in Scotland to use patterns of both flora and fauna to produce a biogeographical classification (Usher and Balharry, 1996). This study contributed an important layer to the bioregional classification.

The Scottish environment has certain distinctions which, in themselves, suggest that a regionalist approach to protection and sustainable development is necessary. For example, geomorpholgical features such as the Highland Boundary Fault create significant divisions between different parts of the country. The regionality of Scotland is encapsulated by Usher and Balharry (1996):

> *"The environment of Scotland is extremely variable. Scotland is located on the intersection of two global-scale boundaries: it is on the oceanic/continental margin, and it straddles the forest zones of the temperate (nemoral) deciduous woodlands and the boreal coniferous woodlands."*

1.7.3 Historic Cultural Regionalism

For bioregionalism to work there needs to be a local cultural identity to bind the people together and enable them to identify with their surroundings. Scotland has very strong cultural traditions and its heritage is identifiable, as a whole, as being distinct from the rest of Britain. A snapshot of the development of Scotland would show a cultural synergy of ancient Picts, Norse and Irish invaders. However, there are distinctions within Scotland itself. In very broad terms these can be divided into six general areas of the mainland. These are:

1. the agricultural area of the Borders;
2. the Western lowlands of Dumfries and Galloway;
3. the 'anglicised' area around Edinburgh, once part of the old Kingdom of Northumbria;
4. the more industrial and heavily Irish-influenced Glasgow region;

5. Doric Aberdeenshire;
6. the Highlands.

The Islands provide another division both culturally, through the greater Nordic influence (particularly the Northern Islands) and physically through their separation from the mainland.

1.8 RATIONALE FROM WHICH THE THESIS' AIMS WERE DEVELOPED

The rationale for the research in this thesis is set out in the following ten points, which include the hypotheses which are to be investigated in the course of this thesis (numbers 5 to 8):

1. the environment is suffering from unsustainable practices and resource exploitation and these unsustainable practices affect not only the natural environment but communities and their culture as well;
2. a greater appreciation of regional resources, environmental and social carrying capacities and the interaction of environmental and social systems is necessary for planning holistic environmental strategy;
3. community involvement, which is place-specific by definition, in environmental management is desirable and necessary and, furthermore, it is a stated aim of present Government policy;
4. development of environmental policy needs a new strategy if it is to integrate community involvement with the many different environmental issues and, at the same time, overcome the limitations of incremental planning;
5. environmental management needs a process similar to the successful community and industrial visionary processes, that have allowed progress in due directions with input and a sense of ownership by stakeholder groups;
6. a successful visionary technique needs a tool for visualisation to allow the vision to be mapped on to real physical and cultural landscapes, and patterns of land use;
7. the intersection of vernacular culture, place-based behaviour and community with the natural environment must be taken account of for the formulation of successful and relevant environmental strategy and, therefore, requires a more holistic construct than other constructs currently used in environmental planning such as watershed management or ecosystem approaches;
8. such a tool and visionary process must enable communities to integrate their place-based knowledge with more generic scientific knowledge to create a synergy of information on which a visionary plan can be based;

1.9 THE AIMS OF THIS THESIS

It is against the backdrop of the issues raised in this chapter and how they might be addressed, that this thesis has been structured. It will take a critical look at bioregionalism, investigate how the ideas of future state visioning might be moulded to help the environmental management process and what the concept of bioregions might have to offer. Building on the rationale in the previous section, this thesis is based on five premises:

1. The depth of the ecological and environmental problems that currently face the globe are not insurmountable but are unlikely to be overcome by incremental planning which, by definition, lags behind the problem. Effective responses require a visionary approach.

2. An effective visionary approach can only be taken if a holistic method of mapping a region and its cultural, natural and physical environments is found. Such a mapping method should account for differences between a scientific view of the region and the qualitative perspective of the region's stakeholders.

3. Humans are an inextricable part of, and influence on, the environment and local cultural distinctions are partly determined by the local environment. This is a theory supported by Geddes (Robson, 1981), Reclus (Dunbar, 1981) and Royce (Entrikin, 1981). However, this thesis does not support the theory of environmental determinism as championed by Ellen Churchill Semple in 1911 (Frenkel, 1994). Therefore, a sense of place is important in the sociological and psychological senses of the word. Furthermore, there is an ethical dimension to environmental management.

4. To enable the practical application of environmental and ecological design principles, there needs to be an acceptance of consensual science with greater détente between natural and social scientists and empirical or cultural wisdom. This is best achieved through greater stakeholder participation in planning and management of the environment.

5. The local ecology and geomorphology determine local natural resources. Local ecology is influenced by local mineral resources, climate and soils (Sale, 1985). Therefore, regionality is important because of local variation of natural resources and their sensitivity to impacts. The regional approach to specifying all materials (where possible) helps to reducing embodied energy, encouraging regional appropriateness, and maintaining local cultural traditions and local economies.

1.10 THESIS LAYOUT AND 'MIND MAP'

Bioregionalism is a multi-disciplinary field of study. The breadth of the subject material and unresolved debates, which are still current in many areas, make it difficult to formulate a definitive and final bioregional definition for Scotland. Further, the unresolved nature of the bioregional debate means that there is not always a clear rule base from which to work. Therefore, there will be three threads to this thesis:

1. The first thread will explore bioregionalism as a philosophy (Chapter 2), akin to Deep Ecology, and determine whether it has anything to offer that might set it apart from Deep Ecology or other branches of environmentalism.

2. If bioregions are to be more than just an interesting study, there needs to be a purpose to them. This is the theme of the second thread. Future state visioning is a tool whose worth is beginning to be understood in business planning (Stewart, 1993). It is proposed in this thesis, that future state visioning provides a planning tool for environmental management to overcome the short comings of incremental planning, enable a holistic approach and encourage stakeholder participation in both the planning process and the implementation of the plan (Chapter 3). It will be proposed that bioregionalism, through its place-centred, community centric approach to environmentalism provides, through the construct of bioregions, the focus for environmental future state visioning within the meaning of the term sustainable development as used in Agenda 21. Therefore, the process of how bioregions might be mapped will be introduced in the context of visioning.

3. The third thread will investigate bioregions. Bioregions are claimed by bioregionalist to be demonstrable entities. An attempt will be made, through the process of mapping bioregions for Scotland (Chapters 4), to test this assumption (Chapter 5 and 6), which does not appear to have been tested before. This final thread is the least philosophical but the most critical. If bioregions cannot be demonstrated to be statistically, significantly, distinct from each other then the previous two threads remain as philosophical discussion. If bioregions can be shown to be demonstrable entities, then the second thread of this thesis becomes actionable.

A 'mind map' (Figure 1.5) is provided to help navigation through the three threads and graphically demonstrate how they connect to each other. The three threads grow out of the background philosophy, which was be raised by the allegory of Easter Island.

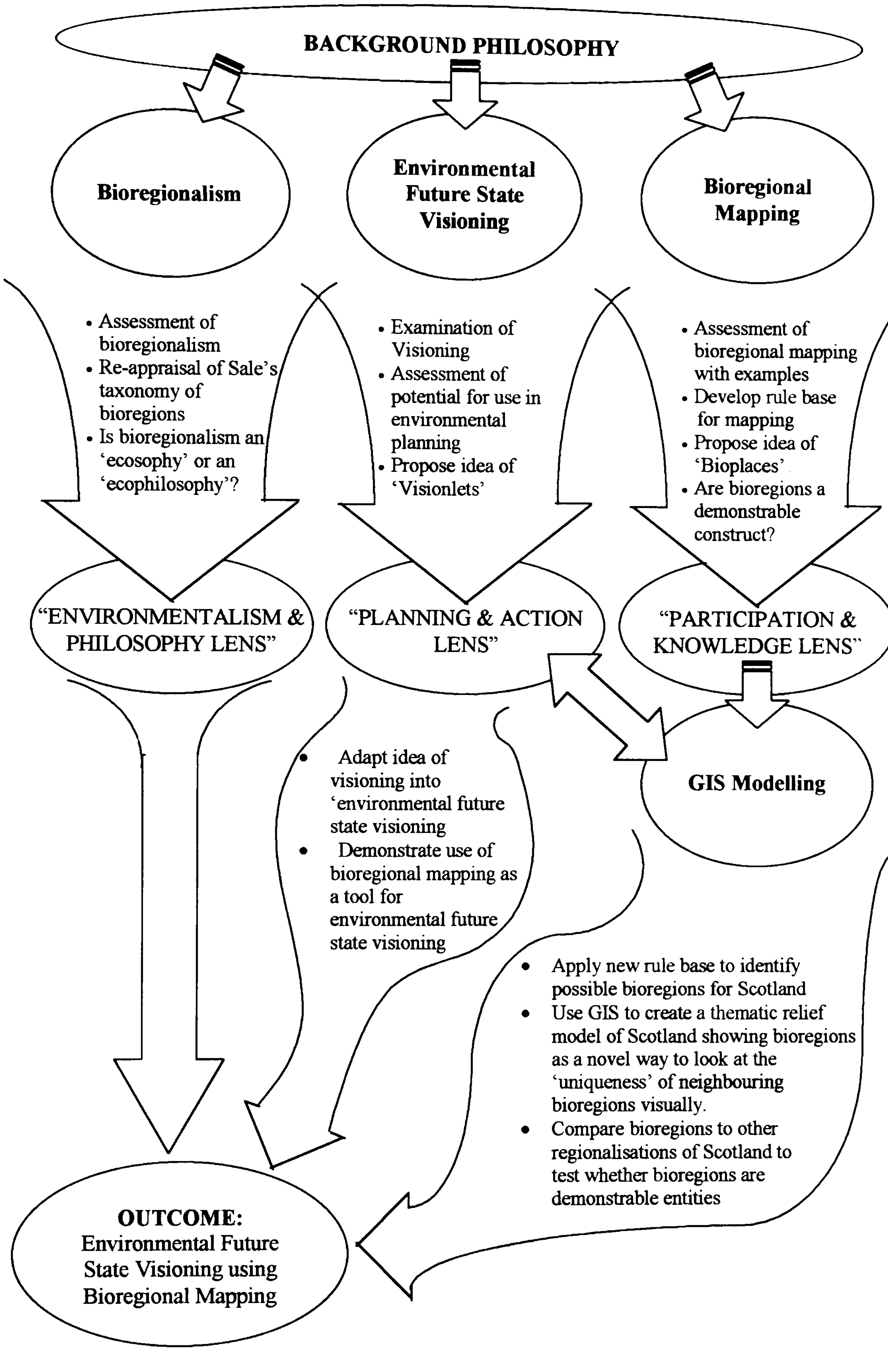

Figure 1.5: 'Mind map' of the flow of ideas through the three main threads within the thesis.

2 BIOREGIONALISM

"The key to understanding bioregional restoration lies in the recovery and reconstitution of the human community. What is community? How is community created? What might the act of ecological restoration have to contribute to building and sustaining community?"

McGinnis, House and Jordan; 1999

2.1 INTRODUCTION

In this chapter, the influences, foundations and development of bioregional thought will be charted. The commentary on the literature will be built up during this chapter and Chapter 3 to enable conclusions to be drawn about the nature of bioregionalism and to inform the methodology that will be used in the critically investigative sections of this thesis.

2.1.1 The Spectrum of Environmentalism

To understand the philosophical genre of bioregionalism it is necessary to locate it in the spectrum of environmentalism. To do this, the question of where the various environmental philosophies stand in relation to ecocentrism and technocentrism needs to be answered. Obviously not all philosophies that purport to be environmentally based are necessarily ecocentric. Figure 2.1 is reproduced from O'Riordan (1981) because it clearly shows the major philosophical divisions in the field of environmentalism. The discussion of bioregionalism that follows will show that it is aligned to the left side of Figure 2.1.

Environmentalism

Ecocentrism — *Technocentrism*

Ecocentrism

Deep ecologists

1) Intrinsic importance of nature for the humanity of man

2) Ecological (and other natural) laws dictate human morality

3) Biorights - the rights of endangered species or unique landscapes to remain unmolested

Self-reliance Soft technologists

1) Emphasis on smallness of scale and hence community identity in settlement, work and leisure

2) Integration of concepts of work and leisure through a process of personal and communal improvement

3) Importance of participation in community affairs, and of guarantees of the rights of minority interests. Participation seen as a continuing education and political function

(Deep ecologists and Self-reliance Soft technologists)

4) Lack of faith in modern large-scale technology and its associated demands on elitist expertise, central state authority and inherent anti-democratic institutions

5) Implication that materialism for its own sake is wrong and that economic growth can be geared to providing for the basic needs for those below subsistence levels

Technocentrism

Environmental managers

1) Belief that economic growth and resource exploitation can continue assuming:
a) suitable economic adjustments to taxes, fees etc.
b) improvements in the legal rights to a minimum level of environmental quality
c) compensation arrangements satisfactory to those who experience adverse environmental and/or social effects

2) Acceptance of new project appraisal techniques and decision review arrangements to allow for wider discussion or genuine search for consensus among representative groups of interested parties

Cornucopians

1) Belief that man can always find a way out of any difficulties whether political, scientific or technological

2) Acceptance that pro-growth goals define the rationality of project appraisal and policy formulation

3) Optimism about the ability of man to improve the lot of the world's people

4) Faith that scientific and technological expertise provides the basic foundations for advice on matters pertaining to economic growth, public health and safety

5) Suspicion of attempts to widen basis for participation and lengthy discussion in project appraisal and policy review

6) Belief that all impediments can be overcome given a will, ingenuity and sufficient resources arising out of growth

Figure 2.1: Representation of where the major divisions of environmentalism lie on the ecocentrism - technocentrism continuum (O'Riordan, 1981)

2.1.2 'Ecophilosopy' or 'Ecosophy'?

Arne Naess (1989) distinguishes between 'ecophilosophies' and 'ecosophies' (Table 2.1). Naess asserts that the word 'philosophy' can have two meanings. The first meaning is that of a field of study and the second meaning applies to one's own personal value system and gestalt.

Table 2.1: The distinction between 'ecophilosophy' and an 'ecosophy'. Reproduced including the original emphasis from Naess (1989, pp. 37)

	All-inclusive	**Concentrating on relations with nature**
Field of study	philosophy	*ecophilosophy*
Position, point of view	a philosophy	an *ecosophy*

The word 'ecology' derives from the Greek *oikos,* meaning 'house' or 'household', and *logos,* meaning 'knowledge' or 'reason'. *Oikos* is taken in the wider sense of the word to mean, more specifically, the environment. In this strict etymology of the word 'ecology' it is a field of study and not a philosophy. It is remarkable how often this elementary mistake is made which can lead to considerable confusion. 'Ecosophy' is derived from *oikos* and *sophia*, meaning wisdom as in 'philosophy'. As such, an ecosophy can be expected to have a 'softer' edge to understanding through a greater intimacy with the subject in hand but still respecting the scientific norms of impartiality. In Figure 2.1, the four headings of 'Deep ecologists', 'Soft technologists', 'Environmental managers' and 'Cornucopians' are each representative of an ecosophy.

2.2 WHAT IS BIOREGIONALISM?

2.2.1 A Brief History of Bioregionalism

The terms "Bioregionalism" and "Bioregion" are neologisms around twenty years old. Bioregional traditions date the emergence of bioregionalism to the early 1970's. Aberley (1995) lays much emphasis on the synergeous interaction between the cultural activist and founder of the Planet Drum Foundation[1] Peter Berg, ecologist Raymond Dasmann and the Pulitzer Prize

1 The Planet Drum Foundation was set up in 1973 to promote bioregionalism and bioregional study worldwide (Aberley, 1999). Based in North America, the Foundation produces its own literature, notably the biannual journal *Raise The Stakes* and a series of nine "Bundles" of poems, polemics, posters and essays on bioregionalism.

winning poet Gary Snyder. However, the coining of the term "Bioregion" is usually ascribed to the biogeographer, Alan van Newkirk (Parsons, 1985 and Aberley, 1999), although he is purported to have contributed little to bioregionalism since 1975. However, van Newkirk was more interested in the construct of the bioregion rather than the ecosophy that has subsequently emerged out of it. The development of bioregionalism was originally based on a populist grass-roots interest in a holistic process of social change for environmental protection.

The word 'bioregion' is roughly translated into the expression 'life-place' in the Planet Drum Foundation's promotional flyer. The word can be regarded as a concatenation of "life", from the Greek root "*bios*" and region or "territory". The name stems from van Newkirk's reasoning that nature was organised into communities along lines of ecological association, which were dependent on common environmental characteristics. Peter Berg (1977) links, in the word 'bioregion', the sense of a geographical terrain and the sense of a "terrain of consciousness".

Bioregionalism, as an ecosophy, includes much philosophical thought that is not directly related to the identification of bioregions. As such, much of the philosophy of bioregionalism is open to debate without effecting the validity of the bioregional construct of identifiable entities. In some parts of the world, notably North America, bioregionalism can be seen as a contemporary social movement (Flores, 1999). As such, again, the distinction between bioregions and bioregionalism needs to be drawn in much the same way as a distinction should be made between ecology and the social and political ecology movement.

The philosophical basis of bioregional thought can be dated from before the beginning of this century with notable contributors such as Lewis Mumford and Patrick Geddes (Aberley, 1995). Indeed, some advocates of bioregionalism claim that the ideas can be traced to more primal origins and to the aboriginal cultures of indigenous groups before technocentrism and the arbitrariness of political boundaries divorced people from the landscape (McGinnis, 1999a). Although, whether such peoples were bioregionally inclined by default in that their existence was necessarily biocentric because the technologies simply did not exist for a technocentric regime of life remains another question. Furthermore, not all pre-industrial societies are good examples of biocentrism as the example of Easter Island demonstrated. In any event, it was not until the mid 1980's that Kirkpatrick Sale contributed to the growing need for a more rigorous intellectual and academic study of bioregionalism. A trawl of the Bioregional Internet sites and newsgroups shows some concern at the intellectualisation of bioregionalism.

2.2.2 The Focus of Bioregionalism

The goal of Bioregionalism is the development of a territory to its fullest potential to enhance human quality and standard of human life without detriment to the natural environment while promoting the continued coexistence of humans and other species (Sale, 1985). More than this, bioregionalism is promoted as a restorative philosophy (Aberley 1999) to enhance the natural environment and allow it to flourish as it did before the pressures of human exploitation became too great. In a way it can be viewed as a partnership between *Homo sapiens* and the surrounding environment to their mutual benefit. To attain this goal, bioregionalism challenges the globalisation of culture and economy that exports wealth to distant banks and corporate offices. It is through globalisation that extremely large cities such as London Paris and New York can maintain themselves through an ecological footprint that stretches far beyond any reasonable notion of region. The environmental wealth of other nations is borrowed to support such cities.

Bioregionalism envisions what could be done in any region if all its funds, facilities, stocks and talents were used to their fullest, limited only by the carrying capacity of the land, ecological and moral constraints, which can be considerable. Bioregionalism stresses the need to open up to the communitarian values of co-operation, participation and reciprocity. These are the processes most central to the bioregional idea (Sale, 1984). Bioregionalism purports to provide an alternative to globalization through local autonomy, sustainability and improved quality of life.

McGinnis (1999b) refers to the "boundariness" of the world's ecosystems and the lives of their inhabitants and it is his contention that biotic communities, including humans are more concious of and responsive to natural boundaries than artificially imposed ones. The connotations of the word "boundary" conjure up images of crisp divisions between areas but it is better to think in terms of indeterminate boundaries (Burroughs, 1996) such as transition zones. These transition zones are the natural indefinites of the environment. The transitions from pasture to river, grassland to forest or even land to sea are areas that are more or less indefinable. The focus of bioregionalism tries to look across such boundaries, gaining vision by passing through them. The more normal paradigm would be to focus on the boundaries. Suffice to say at this point that one of the primary focuses of bioregionalism is to foster an understanding of what these natural boundaries are through the human association with place (Flores, 1999).

The focus of bioregionalism can be summarised by three points. The first is the inclusion of humanity in the environmental equation. The second is a sense of scale that shifts the emphasis from global to regional. The third important factor is reconnection. The focus of bioregionalism is to link theory and practice so that humans are embedded in the environment again, rather than in opposition with it (Aberley, 1999).

2.2.3 The Bioregional Praxis

McTaggart (1993), in his paper comparing bioregionalism to regional geography, puts bioregionalism somewhere between a delineated ideology and a research tool. The bioregional praxis, according to McTaggart, is better described as a set of values that should:

- Recognise that 'society' and 'environment' are integrated elements in a single complex. Such a recognition must be holistic where human society is part of a range of life processes) and that a 'complex' is an entity in its own right.
- Recognise that complex entities are open systems whose functioning is more than a product of their constituent parts. Regions and ecosystems are such complex systems and the networks of communication are multiple and reciprocal. As such, conventional cause and effect analysis is inadequate. Although transitions between local and global systems are normal and necessary for active open systems but humans carry a great deal responsibility for the current rate of transitions.
- Be aware that community responsibility for place operates through the mechanism of a 'collective social or cultural consciousness'. Bioregionalism must work with the collective schema that often needs to be awakened.
- Recognise that a bioregion is more than just a geographical place or a concept but an entity with the capacity for self-modification.

The bioregional praxis can best be summed up in the words of Aberley (1995):

> *"Human cultures thrive best when rooted in relatively small territories that show commonalities of cultural and biophysical identity defined by overlaying information on catchments, land forms, traditional boundaries, patterns of flora and fauna, climate and current transportation linkages."*

2.3 DEFINITIONS OF THE BIOREGIONS CONSTRUCT

A bioregion is defined by characteristics that are usually based on a variety of common physical characteristics including local climatic variation, geomorphology, typical plant and animal communities, watersheds, and local human cultures. However, equally importantly it includes social and economic factors.

There are already definitions for global ecosystem types as defined by the relationship of climate and natural vegetation. These include boreal coniferous forest, temperate deciduous forest, temperate grassland, tropical scrub-forest and desert. These definitions do not include the social or economic elements that are essential for holistic analysis. Important definitions of the bioregions construct (with critical comments) can be seen below:

- Berg (1976) - A geographical province of marked ecological and often cultural unity, its subdivisions, at least ideally, often delimited by watersheds of major rivers or lakes. Berg is almost dismissive of the role of social and economic factors in the definition of bioregionalism. However, in other commentaries Berg (1977; also Berg and Kanz, 1981) does link the study of cultural and biotic regions. This is particularly evident in the former paper (1977) where Berg also introduces the concept of "living in place".

- Sale (1985) - Any part of the Earth's surface whose rough boundaries are determined by natural characteristics rather than human dictate distinguishable from other areas by particular attributes of flora, fauna, water, climate, soil and landforms and the human settlements and cultures. These attributes, and their synergy, give rise to the distinction of the region.

- Holmes (1994) - The plants, animals, and other organisms that make up a distinct biological community in any climatic region. This is descriptive primarily of ecology or possibly biogeographic zones. However, there is no reference to social or economic factors that are important in bioregionalism. This definition is included because it is occasionally the use to which the word "bioregion" is put.

- Tomalty (1994) - defines a bioregion as the geographical area bounded by natural elements that encompasses the significant economic patterns of the region. This definition goes the furthest to promote the importance of economics to a bioregion although the emphasis is lacking from the ecological perspective.

- Shapiro (1996) - A geographical area that has some dominant feature(s), such as landforms, flora and fauna, or water drainage system, which seems to distinguish it from other surrounding areas. This is very similar to and probably based on Sale's (1985) original definition.

- Alexander (1996) - The area drained by a river system, stream or creek. This is closer to a geomormphological definition than a definition of bioregions.

- Diffenderfer and Birch (1997) - The development of a territory's fullest potential through the reliance of systems of production that draw on local resources, do not degrade the ecosphere, and require people to consider the long-term ecological implications of production *versus* short-term economic gain.

- McGinnis (1999b) – Bioregions are constructs of a culture and community rather than a biogeographical certainty. Bioregional boundaries are defined only to be redefined as the physiographic, cultural, ecological characters and patterns of land use change. The boundaries should emerge from the inhabitants' interactions and reactions to their place. Bioregional organisations should exhibit autopoiesis.

Clearly, definitions of what a bioregion is vary from what is better referred to as biogeographic zones (Usher and Balharry, 1996) to more complex definitions that include economics and social factors. It is necessary, therefore, to address the issues raised here when creating any regional zonation.

A full bioregional description will need to encompass elements from more than one of the definitions in the list because none of these definitions quite gives the full picture. The science of managing the environment (and hence global change) cannot be confined to research into natural systems or resultant practice (O'Riordan, 1994). Social and economic factors must be included. There is a general consensus that Sale's (1985) definition encapsulates the essence of bioregions best (Aberley, 1999). Mcginnis's (1999b) definition is somewhat more metaphysical but is very useful nonetheless for establishing where the concept of bioregions might lie on the continuum between objective science and consensual science.

Recent work by Scottish Natural Heritage (SNH) has produced a biogeographic map (Usher and Balharry, 1996) and overlaid it with a cultural definition to produce a natural heritage zonation (Crofts, 1995). While it is probably the best of its kind currently available for Scotland, it is not a full bioregional definition. This is reaffirmed by John Thomson (pers. com.) of SNH's Policy

Directorate who states that their biogeographical zonation would not, in his opinion, be the best starting point for a bioregional definition of Scotland as their work was only indirectly founded on geological or geomorphological factors (and certainly not watersheds). The SNH biogeographic zones were primarily based on biotic communities whose boundaries were later smoothed on the basis of soils and climatic data (Usher and Balharry, 1996) and do not include any societal layers. Usher and Balharry (*op. cit.*) go further to say that, in the field of vegetation mapping, no single zonation is even widely accepted. This suggests that perhaps context, both social and in the use of the map itself, is as important to the mapping process as the perceived patterns of vegetation. The same is true in other fields of regionalisation.

One of the most succinct definitions of true bioregions must be that given by Sale (1985). However, even this definition has its problems because the obvious question is "What kind of human settlements?". Are settlements like London and New York or the scientific research communities in Antarctica bioregional paradigms?

McGinnis (1999b) states that bioregions show the emergent properties of 'mindedness' through autopoiesis. That is, bioregions are self-organising, self-regulatory, natural systems. On this basis, the boundaries of bioregions should be demonstrably of natural origins, so any definition of bioregions must show this self-organisation. McGinnis (*op. cit.*) writes:

> *"Bioregionally-oriented forms of organisations should strive to organise on the basis of self-regulation and autopoiesis. This is not a romantic vision as some critics of bioregionalism propose . . . Rather, the principle of autopoiesis fits well with bioregional science and sensibility."*

2.4 THE FOUNDATIONS OF BIOREGIONAL THOUGHT

The identification of social forces for change linked with environmental concerns predates the emergence of bioregionalism in the 1970s by about a century. This section is a pause for a retrospective look at some of the pre-modern thought on which bioregionalism can be considered to rest. As an aside, it is noteworthy that much of this philosophy was developed during the second half of the last century when the world was undergoing great social and economic change. We are again in a similar position, psychologically, of *fin de siècle* to which the coincident end of the millennium adds poignancy (although, perhaps not weight). As Mason (1987) states, the links between bioregionalism and geography are obvious. In his critique of Parson's (1985) paper on bioregionalism, Mason highlights the gaps in current bioregional thought. One such gap is that, although authors such as Aberley (1995 & 1999) and McGinnis (1999a) cite many geographers such as Lewis Mumford and Carl Sauer. The contribution of the so-called anarchist geographers is sometimes alluded to in the bioregional literature. Five such authors, Elisée Reclus, Peter Kropotkin, Patrick Geddes, Josiah Royce and Lewis Mumford appear to have contributed to the philosophy on which the earliest beginnings of conscious bioregional thought is based. An overview of some of their work is necessary to help understand bioregionalism and demonstrate the link between it and geography. They never referred to their ideas as "bioregional" because they pre-date the term. However, many of their ideas are again in the ascendancy, particularly those of Geddes. The first three authors represent the founding of regionalist philosophy in Europe. The last two represent the move of regionalist thought to America. Other authors, whether pre-modern or current, have and will be referred to as appropriate.

2.4.1 Elisée Reclus (1830 to 1905)

Elisée Reclus was a friend of both Peter Kropotkin and Patrick Geddes. As the son of a devout Christian, Pastor Jacques Reclus, much of his writing is spiritually centred. Such a standpoint may well reduce his modern impact but, whatever the theological leanings of a reader of his works, clearly he should be a reference for in any study of regionalism. As a man who influenced and was influenced by Partick Geddes, bioregionalism's reputed forefather, he is further worthy of at least a passing investigation. Dunbar (1981) provides a good account of his life and a synopsis of his works. Dunbar also cites Reclus as an influence on Lewis Mumford and William Durant.

Like Kropotkin, Reclus was also an anarchist, although possibly less overt in his leanings. Dunbar maintains that anarchy and political geography are not as far removed from one another as may at first appear, even if most geographers prefer to keep politics and geography separate. Bioregionalism, with its need for social change is also not in isolation from politics. Having said this, most anarchists would agree that a society devoid of government is unlikely and unworkable as long as human nature remains human! A more practical vision is of a highly decentralised society and in this Reclus shares much with Kropotkin (Dunbar *op. cit.* and Breitbart, 1981). Reclus has been bedevilled by less than faithful translations that may well have been accidental although some anti-British sentiments were deliberately expunged. Despite this, Dunbar displays some confidence in the integrity of Reclus' central message.

The essence of Dunbar's synopsis of the relevant parts of Reclus' regional philosophy is that hunger and poverty are caused by mismanagement and mal-distribution rather than as a direct result of over-population. At the time he was writing there was a resurgence of Malthusianism in France and Reclus was swimming against the tide but was supported by Kropotkin. Reclus saw the development of large-scale 'bonanza' farms near the Red River Valley of North Dakota and Minnesota as a prime example of mismanagement and over-production that was debilitating environmentally and failing to alleviate hunger. Dunbar goes on to say that, ironically, these bonanza farms were soon replaced by smaller, privately owned enterprises. Another example can be drawn from the cataclysm of the American dust bowl, a result of over production and large-scale farming. Whatever examples he chose and whatever we know subsequently happened from history, Reclus joined Kropotkin in a discussion of the notion of the human responsibility to the environment and that natural and social processes are interwoven. Reclus even went as far as to assert that the development of society is driven in many ways by the surrounding environment (Mason, *op. cit.*). Granö (1981) brings this notion up to date when he writes:

> *"Man together with the environment constitutes an intertwined entity from which neither man nor the environment can be separated. Attempts to break the unity because of the subjective elements involved, and to make man and his environment quite separate objects of logico-empirical study, have led to considerable problems for geography as a discipline. These problems in turn have been reflected in the often posed question . . . does geography as a discipline have an internal cognitive unity . . . This problem is most clearly seen in the dualism between physical and human geography."*

Of course, the same question can be levelled at bioregionalism although, in fairness, the bioregional standpoint is exactly this, that humankind and the environment should not be considered separately.

Dunbar commends Reclus as a source of "morally uplifting as well as scientifically sound geography". Furthermore, he provides a clear indication that social progress lags far behind technological advancement. Mason (1987) cites Reclus as a significant contributor to bioregional philosophy.

2.4.2 Peter Kropotkin (1842 to 1921)

Kropotkin is not normally acknowledged as a founding father of bioregionalism but he is important in that his writings overlapped those of Patrick Geddes and he formulated a regional philosophy. He provided a more coherent vision of what might be now called bioregionalism than many current thinkers. Admittedly, his vision was a Marxist-cum-anarchist[2] one that would tend to make it less favourable today. In any event, Kropotkin was a geographer of note in his day. Breitbart lists his credentials including a banquet held by the Royal Geographical Society of Britain where all the guests rose to honour him for his contributions to physical geography. His political activities seem to have been ignored or forgiven by his peers who showed concern at his frequent imprisonment. As a geographer Kropotkin believed that geography could provide a holistic view of nature as a whole and society in it, acting as an 'integrator of knowledge' through its interdisciplinarity (Breitbart 1981). Of course, geography was not and still is not such an idealistic holistic discipline, having many factions, branches and fashions like any other area of study but this unification theory of man and the environment is very much a part of bioregionalism.

Myrna Brietbart (*op. cit.*), in setting the scene in her discussion of Kropotkin's life, states early on that he soon discovered that his studies could not be conducted in a social vacuum. The landscape cannot be studied, in his opinion, without also accounting for the people and their social situation. As his studies were conducted at the turn of the century (a three year sojourn in a French prison between 1883 and 1886 aside), just before the Russian revolution, the social and economic conditions of the Russian peasants would certainly have been a pressing factor for a man such as Kropotkin. He writes in his *Memoirs of a Revolutionary* (1899, pp.237-41):

> *"Science is an excellent thing. I knew its joys and valued them - perhaps more than many of my colleagues did . . . But what right had I to these highest joys when all around me was misery and struggle for a mouldy bit of bread; . . ."*
>
> (quoted by Breitbart, 1981)

It is important to understand where Kropotkin is starting from in the formulation of his regionalist philosophy. Many might argue that, while some things have improved in the lot of rural people there is still a basis for social concern. On the other hand, bioregionalism is coming to the fore almost a century after Kropotkin penned those words, in a world that has seen great changes in science, technology and especially geography.

There are many interesting overtones in socialist thought which are echoed in bioregionalism today (although, whether bioregionalists consider themselves to be socialist or anarchist is another question). In brief, the socialist schema is one where people have a great capacity for self-determination and co-ordination from the level of the family to the level of an economy on a

2 Kropotkin (1842 – 1921) was also a contemporary of Engels (1820 – 1895)

co-operative basis. The socialist dogma of "from each according to their ability, to each according to their need" will also be well known to most people[3]. Inherent in this dogma is the idea of common ownership of the means of production and distribution to give freedom from repressive authoritarian regimes. Whether this is workable or not is a question for social historians and politicians. Bioregional writings contain many similar idealist statements, if couched in language that is more appealing considering the failings of communism (as practised in the Soviet Republics). Most bioregionalists are not of an academic or scientific background and come from pursuits that are more traditionally anarchio-social such as poetry, art and environmental activism (Parsons, 1985). Bioregionalists can be outspoken about deference to 'experts' and official bodies. This is a theme that can also be found in Kropotkin's writing. Breitbart reports that he states in "*Scientific bases for anarchy*" (*The Nineteenth Century* 18, pp. 940-56; 1887) that such traits can limit individual expression, pre-empt imagination and encourage passivity.

Kropotkin also saw society as being in evolution. Mutual aid between members of a community, in this process, is vital and to be encouraged. However, Kropotkin lists politics, economic social and spatial organisation as being forces that can hinder the emergence of mutual aid (Breitbart, *op. cit.*). In short he believed that centralisation has a deleterious effect on progress and the resolution of social concerns. Compare this to the bioregionalist standpoint that decentralisation is necessary to re-establish a sense of place and hence social justice and an environmentally benign way of living. Again, a similar echo is found in the bioregionalist call for a return from cities to village societies when Kropotkin writes in "*Ethics: origin and development*" (1924, pp. 28):

> "*. . . to speak of the natural death of the village communities in virtue of economical law is as grim a joke as to speak of the natural death of soldier slaughtered on the battlefield.*"
>
> (quoted in Breitbart, *op. cit.*)

According to Kropotkin, associations and co-operatives did not disappear naturally but were systematically outlawed and Britain is cited as an example. He concludes from this that discipline and extreme specialisation (as found in modern society) is not necessary for the efficient functioning of agriculture or even industry. If this is the case, then there seems hope

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3 The quote is most famously found at the end of the first section of the 'new' Soviet Constitution that was accepted on 11 June 1936. The words derive from Karl Marx's famous formula in "Das Kapital" (1867). More information about this can be found at the web site http://csf.colorado.edu/prs/marx (accessed at 12.20pm 12/8/99).

that a workable economic system might yet be able to emerge from the bioregional debate. Economics is one of the weaknesses of bioregional thought as it stands at present (Mason, 1987).

Following this idea that spatial organisation is a social and economic ill, Kropotkin continues his critique of capitalism by suggesting that it also ignores ecological balance. This view is appealing in the current situation of multinational companies and their apparent disregard for ecological issues or the damage they seem to cause (*e.g.* Bhopal, the Exxon Valdez and closer to home the Brayer oil disaster). Kropotkin's theory of 'mutual aid' lays the foundation for his theory of human ecology. This is where Kropotkin's work becomes of real interest to the bioregionalist. Breitbart expounds how he saw nature and people living in nature as an 'organic and interrelated whole'. Imbalances in nature are reflected by imbalances in society. A balanced position in nature is only achievable by discovering the processes that govern the environment and adapting behaviour accordingly. Most importantly, Kropotkin believed that it was necessary to:

> *"re-establish a sense of community and love of place where rootedness in a particular environment would foster a greater human interaction and a more intimate relationship with ones surroundings."*
>
> (Breitbart *op .cit.*).

Kropotkin's social community was based on the commune, a self-governing group of rural and urban dwellers that formed a natural and local partnership. This socio-economic grouping would be able to operate in harmony with its surroundings within the theory of 'decentralism'.

> *"Kropotkin did not believe that modification of the built environment could be a substitute for radical change in the fabric of social life. To eliminate the constraints which certain environments place on personal growth and communal expression, and to insure a supply of natural resources for the future, societies had to rid themselves of capitalism, the state and the basic attitudes which underlie all hierarchical institutions. To harmonise the relationships between people and nature, it was necessary first to create a human community which lived in harmony with itself"* (so writes Reclus in "The Progress of Mankind", *Contemporary Review*, 70; 1896 - paraphrased by Breitbart *op .cit.*).

It can be seen from this that Kropotkin's ideas preceded today's bioregionalism by nearly a century. They would seem to be better reasoned and less spiritualistically inclined and thus possibly more palatable in many quarters. Indeed, Kropotkin spoke more like a bioregionalist than many do themselves and it is appropriate to finish with another quote from *Memoirs of a Revolutionary* (pp. 97):

> *"The infinite immensity of the universe, the greatness of nature, its poetry, its ever throbbing life, impressed me more and more, and never ceasing life and its harmonies gave me ecstasy of admiration which the young soul thirsts for, while my favourite poets supplied me with an expression in words of that awakening love of mankind and faith in its progress which make up the best part of youth and impress a man for life."*
>
> (quoted by Breitbart, *op. cit.*)

Kropotkin had much to say on regionalism. His thesis in this respect anticipated many later works including that of Geddes (in particular *Cities in Evolution*, 1968). Breitbart also cites the works of Lewis Mumford (*The City in History*, 1961) and Ebenezer Howard (*Garden Cities of Tomorrow*, 1965) as successor theories. In essence regions should have a self-sufficiency that obviates their dependence on other regions and encourages co-operation within and between regions. All the authors mentioned put forward a vision of a disappearance of the distinction between industrial and agricultural land-use leading to a less concentrated pattern of population. Kropotkin believed that, within this framework a more environmentally sensitive economic structure could emerge. However, his key to the development of such a system was through social change on a grand scale, a paradigm shift in social structure. This has never been realised as he envisioned and Breitbart reports that he died a disappointed man in the emerging communist Soviet Republic.

2.4.3 Patrick Geddes (1854 to 1932)

Geddes is acknowledged by many as one of the founding thinkers of bioregionalism. He did not use the term himself, of course, as it was to be coined many decades after his death. Born in Ballater in 1854, he published his ideas around the turn of the century but many believe that he still has much to teach us (King, 1990; Robson, 1981 and Aberley, 1995). Possibly one reason why Geddes has not been brought more to the fore is that he was never clear in the articulation of his ideas often leaving his audiences 'dazed and confused' (Robson *op. cit.*). Even so, whatever his place in modern social and geographical thought, he certainly had a considerable influence on Kropotkin and Reclus (Breitbart, 1981 and Dunbar, 1981 respectively). This is important because the three of them form a body of thought that is not referred to as often as it should be in the context of bioregionalism. A look at their collective works should form the starting point for any bioregional study particularly in view of Geddes' resurgence in the field of geography.

Geddes seems to have been a polymath, but particularly a town planner and social scientist with environmental leanings and a biological training. One of the main contributions of Geddian thought is that it is holistic[4]. He draws on all aspects of his experience overlaid with phenomenological interpretation to produce complex idea networks. At the core of many of these networks was the theme of evolutionary dynamics, a unification of social science and the place of the community in and inseparable from the environment, an idea promoted by H. J. Fleure in the French regional geography movement of the time (Robson, 1981). Drawing on the views of Le Play that the environment and mode of living in an area influences the local structure and culture of a society[5], from this framework emerged Geddes' trilogy of place/work/folk. It is perhaps here that we see the beginnings of the vitalist and mystical tradition that often appears in bioregionalist literature. In this schema, intellect takes second place to intuition and instinct[6], or to put it in the language of phenomenology, it is how we 'feel' about a place is more important than how we understand about it through study. Geddes produced classifications by a process of cross-tabulation within the matrix of his place/work/folk trilogy to explain it better. Thus work-FOLK gives the social structure based on an occupational classification of the region's people and folk-PLACE tells us something about 'home' (Robson *op. cit.*). Analysis of these constructs was to be achieved through Geddes' surveys but these were poorly defined. Geddes saw the framework of geography to be the region with the survey as its research tool. Presumably it is the piecing together of the surveys that identifies the region and, if so, the research of bioregionalism seems to share this commonality. If Geddes' survey techniques were obscure then the bioregionalist would be well advised to build on the numerous, in-depth surveys from the fields of geography, ecology, economics and social structure that already exist today and avoid time-consuming repetition.

Education of the people was at the heart of Geddes' vision of a new, regionalist civilisation. Inhabitants would be enabled to learn for themselves about their place in their local environment and to act accordingly. Here, there are some parallels with the thinking of Kropotkin and Reclus. Graham King (1990) quotes Geddes thus:

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4 Sadly his multidisciplinary approach, though almost *de rigueur* today, was ahead of his time (Robson, 1981) and he was forced to leave his native Scotland in order to support his family (Aberley, 1995). Furthermore, like Kropotkin, most of Geddes' vision was unrealised in his lifetime and largely remains so even now and his most obvious contribution is the coining of the term 'conurbation' that succinctly sums up his analysis of the growth of cities (Robson, *op. cit.*).

5 Geddes' took a structuralist view that these social formations were in competition and progression. The social formation of a given region at a given time is the result, or product, of all the preceding formations. This is an example of Geddes' evolutionary principles.

6 The *elan vital* - a concept that still remains, for the most part, a poorly defined concept even in bioregionalist literature.

> *"What is so often missed by scientific and philosophic minds, that the synthetic vision to which they aspire may be reached more simply from the aesthetic and emotional side, and thus be visual and concrete."*[7]

There is much to be said for this approach but scientific study should not be ignored altogether. Suffice it to say now that the stance of 'the local people know best' is part and parcel of bioregionalism[8] (see Sale, 1984).

The essence of Geddes' community construct is decentralisation and small-scale rehabilitation of the social and ecological environment (Robson, *op. cit.*). His mistrust of large-scale, utopian plans for reform have been vindicated in the failure of many of the 'Brave New World' style post-war (WW II) developments such as Manchester's Moss Side and Hulme areas. In short, Geddes is an advocate of small-scale rehabilitation. Robson (*op. cit.*) quotes from *Geddes (Cities in Evolution*, 1915):

> *"the true city . . . is that of a burgher people, governing themselves from their own town halls and yet expressing also the spiritual ideals which govern their lives . . . We have to live in towns: and on the whole, with respect to Garden Cities and Garden Suburbs, we have to make the best we can of the existing towns."*

In a similar vein to Kropotkin and Reclus, Geddes also mistrusts central government and advocates regional planning. This is particularly poignant considering the recent devolution referenda for Scotland and Wales.

2.4.4 Josiah Royce (1855 to 1916)

Josiah Royce, born in California, published at the turn of the century and thus overlapped with Geddes and, to some extent, Kropotkin and Reclus. Royce was an idealist philosopher and not greatly referred to by geographers because most of his writings are concerned with socio-religious philosophy. However, although not strictly speaking an anarchist geographer, his thinking is of interest in the context of the sociological side of bioregionalism. Royce and Mumford demonstrate the American connection as the philosophical movement, started in Europe, moved across the Atlantic.

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7 This is better understood by looking again at King (1990) who describes Geddes', his 'Camera Obscura' as being closely in line with Jung's threefold active imagination of "an active will, an interpretative understanding plus the artistic imagination" - note there is no mention of philosophy or science here.

8 Geddes is often accused of being an 'anti-intellectual' (Robson, 1981) a charge that can be levelled at many bioregionalists (see Aberley, 1999).

In Nicolas Entrikin's revue (1981) of Royce's 'Provincialism' he suggests that the concepts such as 'community', 'milieu' and 'region' are hard to define. This is, in part, due to their holistic nature. As such they cross many traditional boundaries of academia. However, Royce potentially provides another piece in the puzzle that forms the foundation of bioregionalist thought. Of course, this raises the question whether humanist, social geography is so very different from bioregionalism. Possibly not, but it may be that the environmental imperative has a greater presence in bioregionalism. Entrikin lists a number of geographers from the seventies (Buttimer, Ley, Samuels, Relph and Tuan) who argued that a phenomenological and existential approach to understanding man in the environment are more appropriate than positivism. In other words, one should not separate the object of observation from the context in which it is observed. This philosophy is also found in bioregionalism. Relph and Tuan were influential authors on the notion of place during the 1970s (e.g. Relph, 1976 and Tuan, 1977), which ties in with the incorporation of a sense of place to bioregionalism, as it too emerged in the 1970s.

Entrikin (*op. cit.*) continues his introduction to Royce's work by quoting Royce's definition of a province as:

> *". . . a social and geographic 'whole', and loyalty to this unit was termed 'provincialism' . . . Royce's province is an illustration of the linkage of concepts of social organisation and spatial organisation or place, a familiar theme in social geography."*

Royce has been criticised for the import of an essentially 'Hegelian idealism' to America without regard to how appropriate it might be for the new context (Entrikin, *op. cit.*). This is of course poignant for bioregionalism in that to the bioregionalist context and regional appropriateness of both understanding and action is of paramount importance. With this in mind, caution is necessary in the application of various philosophies. However, this said, Royce's provincialism has a great relevance for bioregionalism because he advocated a local community focus and a move away from centralisation. Entrikin (*op. cit.*) puts it like this:

> *"In his work . . . can be found many of the topics which concern contemporary social geography, such as social constitution of reality, the significance of local community. linkages of man to place man's, relationship to the physical environment . . . an orientation similar to that of contemporary humanist geographers emerges."*

But he warns:

"How the humanist social geographers will be able to retain this 'wholeness' and avoid the pitfall of idealism is an issue they have yet to resolve."

Many authors on bioregionalism fall into this trap. The question this poses is whether bioregionalism has sufficient central coherence to be taken seriously or is it a romantic idealist philosophy with the intellectual weakness of vague 'New Age' tendencies to ill-defined, humanist, 'Earth-mother' spirituality? If bioregionalism shows weaknesses, then what of the bioregion construct? These questions need to be addressed.

To sum up, to Royce, the community was everything. What he lacks in the bioregional context is the environmental dimension. The interest here is what he can potentially offer to the important social side of bioregionalism.

2.4.5 Lewis Mumford (1895 to 1990)

No discussion of the early foundations of bioregional thought would be complete without mention of Lewis Mumford. Mumford was famous for his writings on architecture, New York city and technology (Novak, 1995). Later, through his other writings and association with Patrick Geddes he earned a reputation as a regional planner and theorist (McGinnis, 1999a). Mumford was one of the first proponents of an ecoregionalism that he based on an alternative phenomenology of place and his ideas for a regional geography, which recognised the integration of the natural and cultural environments (McGinnis, *op. cit.*). Sale (1985) makes the ties between early American regionalism and, in particular, Lewis Mumford, with the birth of bioregionalism. In this way, bioregionalism inherited a rich legacy of ecocentric tradition and thought.

One of the important issues of Mumford's ecocentrism was a reaction to the vicariousness of human experience in a technocentric environment (McGinnis, 1999b). This is most clearly illustrated in the modern city where even the soil is rarely visible and such 'natural' features that do exist (*e.g.* amenity trees) are controlled and tamed. Mumford's point was that people are divorced from the place in which they live. They are divorced from its natural rhythms and have no understanding of capabilities of limitations. McGinnis (1999b) quotes Mumford[9] thus:

"Though man has become the dominant species in every region . . . partly because of the knowledge and the system of public controls over both man and nature he

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9 (1955) "The Natural History of Urbanisation" in Thomas, W L (Ed.) *Man's Role in Changing the Face of the Earth, Proceedings of International Symposium*, Chicago, University of Chicago Press.

> *exercises, he has yet to safeguard that position by acknowledging his sustained and inescapable dependence upon all his biological partners."*

Mumford believed that place-based knowledge held the key to resolving the problem outlined in the quote above. However, Goldstein (1999) states that, while place-based knowledge has gained some respectability, technocentrism has successful circumvented regional cultural communitarianism and reciprocity with the natural systems that support it.

Mumford was one of the founders of the Regional Planning Association of America (Novak, 1995), which began as a small group of architects, engineers, landscape architects, community planners and journalists[10] who shared a belief in regionalism. The Regional Planning Association of America commissioned a series of leaflets from Mumford on regionalism and the regional city. The decentralist notion is one that is very strong in bioregionalism. Possibly one of the biggest contributions Mumford made to bioregionalism was to brought Geddes' ideas across the Atlantic to America where bioregionalism would be born.

2.4.6 Summary of "Anarchist" Geographic Thought

The outline of some of the main lines of thought for these "anarchist" geographers is instructive if only to demonstrate that the concept of bioregions has a long tradition in the literature. Both Kropotkin and Reclus were advocates of decentralisation of social organisation. These two in particular stressed the responsibility of humankind to care for nature as both dwelling place and provider. Kropotkin called this "mutual aid". An extension of this idea which creates another link between geography and bioregionalism was "la tradition vidalienne" (Mason, 1987) or the geographic region where, according to Vidal de la Blanche, culture, social institutions, technology and the physical environment intersect. Bioregionalism takes another step by including the natural environment and Parsons (*op. cit.*) discusses how Carl Sauer was wont to speculate on how different the world and our perceptions of it might have been if geography had grown, not out of geology, but biology. Geddes' adherence to this philosophy can be clearly seen in his "valley plan of civilisation" (Marshall, 1972) which also draws upon Kropotkin and Reclus. In a nutshell, the valley plan for civilisation was a concept for regional land use in which the river valley, or "watershed" in modern parlance, is the organisational unit. The final link that brings us back to modern bioregionalism is through people like Lewis Mumford and the Regional Plan Association of America. As has already been mentioned, Mumford is often a

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10 The Regional Planning Association of America began life in the 1920s under the name of "Whitaker's Group", so called after one of the principal founders (along with Mumford), Charles Harris Whitaker who was, at the time, editor of the Journal of the Institute of Architects.

source of inspiration to many bioregional thinkers as they promoted the use of natural units as the basis for planning. However, Mumford and other members of the Regional Plan Association of America drew heavily on Geddes' "valley plan of civilisation" and Vidal de la Blanche's "tradition vidalienne" (McGinnis, 1999a).

2.4.7 The Biosphere Reserve

A short break from the discussion of bioregionalism will be taken to mention Biosphere Reserves because their formulation shares some philosophical ground with the bioregions construct. The concept of the biosphere reserves was popular with conservationists in the 1960's and 70's and grew out of the "Man and the Biosphere" (MAB) programme (Batisse, 1982). MAB was a product of the United Nations Educational, Scientific and Cultural Organisation (UNESCO). The biosphere reserve lies halfway between conventional conservation and bioregionalism. Although it is still oriented towards research, UNESCO stressed the reserves' logistical role. The crucial difference between the biosphere reserves and bioregions is the occupancy and utilisation of the resources within the areas by human inhabitants in the case of the latter. Although the biosphere reserves do not preclude the presence of humans it is stressed that there should be an undisturbed core area (Batisse, *op. cit.*). However, the reserves should be set up with a buffer zone in which "traditional land-use" can take place. These traditional land-uses are, essentially, less intensive agriculture or uses of the land which have lower impact by virtue of the traditional (as opposed to modern) methods employed. In particular, land uses that preserve a certain type of habitat are encouraged, for instance the maintenance of heather moorland or woodland composed of coppice with standards. The buffer zone acts as a transition between what is effectively the ecocentric landscape and the technocentric modern industrial landscape. The stated purpose of this buffer zone is to ensure the proper integration of the reserve into the geographical region that it represents and serves (Batisse, *op. cit.*). From an ecocentric standpoint this is the wrong way round. The buffer zone should surely ensure the integration of the unnatural into the more natural.

Bioregionalism is not the development of large nature reserves as are found in Africa or even the proposed Scottish National Parks. Its aims are more diverse. While there does seem to be correlations between area, species richness and extinction rate (MacArthur and Wilson, 1967[11])

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[11] The MacArthur-Wilson theory captured the imagination of the ecological world in the sixties as it showed the dynamics of nature through straightforward mathematics. The main tennet of the theory is that there is an equilibrium between immigration and extinction, produced by a turnover of species. At first sight the theory holds but closer inspection, particularly in the eighties, showed that, at the timescale of generations, the turnover consists mainly of casual species and not

this is not necessarily the best arrangement for a nature reserve. There is much debate, and in particular during the 1970's and 80's, whether nature reserves should be organised into single large or several small areas. The dilemma is usually referred to by ecologists as "SLOSS" (Single Large Or Several Small reserves). Although some have argued in favour of a single large area (Wilson and Willis, 1975), there seems to be a move in favour of several small areas with the caveat that increasing distance between the areas can increase their island effect and so negate any other advantages for species composition (Simberloff, 1986).

The bioregion suggests itself as a possible unit for integration of local communities with the aims of conservation by enabling a balance between several small reserves within a region that is more akin to the biosphere reserves' buffer zones. Larger areas might possibly benefit from habitat protection through bioregionalism, should it be proved to have potential. One of the main virtues of bioregionalism is to bring greater land areas under more sympathetic management. This does not mean that there would not be a role for nature reserves. Even if the whole of Britain were to be converted to a bioregional system overnight, there would still be many fragile sites in need of special care. There would also still be Sites of Special Scientific Interest (SSSI).

2.5 THE THEORY OF BIOREGIONALISM

The definitions that were given towards the beginning of this chapter explain a lot about bioregions but they are weaker in their elucidation of bioregionalism and this distinction between bioregions as entities and bioregionalism as an ecosophy has already been alluded to. Therefore, it is necessary to look at the theory of bioregionalism. This is more difficult territory than understanding bioregions as entities because of a lack of consensus on specifics that necessitates a considerable amount of interpretation. As a starting point, Aberley (1999) describes bioregionalism as:

> *"A body of thought and related practice that has evolved in response to the challenge of reconnecting socially-just human cultures in a sustainable manner to the region-scale ecosystems in which they are irrevocably embedded. Over nearly twenty-five years this ambitious project of 'reinhabitation' has carefully evolved far outside of the usual political or intellectual epicentres of our so-called civilisation."*

---

established populations and no ecological relationship has been established between imigration and extinction (Williamson, 1981).

2.5.1 Restoration Through Bioregionalism

One of the *raisons d'être* of bioregionalism is ecological and environmental restoration. If there were no ecological problems and no environmental crises facing us there would be no reason to discuss bioregionalism. Table 2.2 compares two possible paths for ecological restoration and the ways in which they operate. The first two columns, which show the restorative paths, are drawn from McGinnis *et al* (1999). The final column has been added to demonstrate how a visioning process fits closely with bioregional ideals. It is added here because it is essential to make the links between process and practice

Table 2.2: A comparison of restoration paths (McGinnis *et al*, 1999) including the process of visionary environmental planning.

	Bioregional restoration	**Isolate restoration**	**Environmental visioning**
Function	Communion	Observation	Planning
Relational basis	Community practice. High degree of interpretation between cultures and places.	Management based on expertise. "Nature" studied in isolation from human influence.	Involvement of all stakeholders. Community participation. Expertise as a tool to be used by visionaries
Technology	Focus on locally appropriate technology	Coexistence with industrial production	Mind-mapping, free thought, scenarios
Science	Experimental	Data-based	Values, beliefs and principles supported by data
Activity	Preservation Co-operation	Replacement Domination	Envisioning Communication Co-operative restoration

There are many schemes for restoration or, more usually, preservation. There is a big difference between restoration and preservation that should be acknowledged. The former is a process that moves forward through the stabilisation of the pendulum swing between technocentrism and ecocentrism with the express purpose of undoing accumulated past environmental damage. As such it must, perforce, employ a visioning process if it is to have any hope of achieving restoration. Preservation, on the other hand, is better thought of as trying to maintain the *status quo*. Preservation is a process of present state extrapolation and, as such, can only ever hope to keep pace with change. It can never hope to initiate change or move ahead of the rate of change. This is why environmental future state visioning is so important for ecological restoration and why bioregionalism, as an ecosophy, should never be the process but the lens through which the visioning process should take place. A second review of Table 2.2, paying particular attention to comparisons between the three columns across the rows will demonstrate this point.

2.5.2 Re-inhabitation and 'living in place'

Local culture and a sense of "living in place" are as important to sustainable development as is 'pure' ecological protection (Sale, 1985). 'Pure' ecological protection is used here to mean measures taken to sustain and nurture individual species and tracts of the natural environment as opposed to issues such as recycling and energy from renewable sources, both of which are important but lie outwith the scope of the term as used here.

> *"The phenomenon of universalisation, while being an advancement of mankind, at the same time constitutes a sort of subtle destruction, not only of traditional cultures, . . . but also of the creative nucleus of great cultures, the nucleus on the basis of which we interpret life . . ."*
> Frampton (1983) quotes from Paul Ricoeur's *Universal Civilisation and National Cultures*, History and Time (1961, original not sourced).

Possibly the most important aspect of bioregionalism that emerges from the literature is that of 're-inhabitation' (*e.g.* Sale, 1984; Aberley, 1993; Berg, 1977). At first sight the word 're-inhabitation' can appear a somewhat bizarre notion. In essence it is all about reversing the divorce of humans from their local natural environment. Re-inhabitation focuses on developing and connecting with a regional ecologically based identity:

> *". . . if the life-destructive path of technological society is to be diverted into life-sustaining directions, the land must be reinhabited. "Reinhabitation means developing a bioregional identity. It means learning to live-in-place in an area that has been disrupted and injured through past exploitation. It involves becoming native to a place through becoming aware of the particular ecological relationships that operate within it. Simply stated it involves becoming fully alive in and with such a place. It involves applying for membership of a biotic community and ceasing to be its exploiter."*
>
> (Berg and Dasmann, 1977)

This powerful statement describes the meaning of re-inhabitation. Importantly it refers to an ecocentric *versus* technocentric dichotomy. At this point in the discussion it is very clear that bioregionalism has more in common with Deep Ecology than other ecological philosophies (Figure 2.1). Until now, the guiding principle of environmental management has been a defensive attitude of saving what remains of dwindling natural and semi-natural areas. This is the natural conclusion which is reached through a 'progressional' strategy but bioregionalism proposes a 'strategy by vision'. Bioregionalists advocate that the time has come to stop merely trying to save what is left but to expand the ideals of the nature reserves to be more inclusive; for people to 'step inside' the reserves' so to speak; to reinhabit the land and no longer be separated from it (Berg, 1983). A glimpse of such bioregionalism might be seen in the buffer zones of the biosphere reserves.

2.5.3 Comparing the Bioregional and the Industrial Paradigms

To understand the theory of bioregionalism it is useful to compare it to the current indusrial-scientific paradigm. Leading on from Berg's (*op. cit.*) quote above a comparison of the bioregional paradigm with the current industrial-scientific paradigm is appropriate. Table 2.3 summarises the essential points for comparison between the two paradigms.

Table 2.3: Comparison of the bioregional paradigm and the current industrial-scientific paradigm according to Sale (1985).

	Bioregional Paradigm	Industrial-scientific paradigm
Scale	Region; Community	State; Nation/World
Economy	Conservation; Stability; Self-sufficiency; Co-operation	Exploitation; Change/Progress; World Economy; Competition
Polity	Decentralisation; Complementarity; Diversity	Centralisation; Hierarchy; Uniformity
Society	Symbiosis; Evolution; Division	Polarisation; Growth/Violence; Monoculture

The bioregional paradigm can be considered to be ecocentric and, what Sale calls, the industrial-scientific paradigm can be considered to be technocentric. It is clear from the table that bioregionalists favour a decentralised, disseminated model of authority with a regional environmental and social scale of activity that emphasises ecocentric ideals.

2.5.4 Importance of Local Phenomenological Knowledge and Cultural Diversity

The bioregionalist prizes local phenomenological knowledge (Aberley, 1999). The wealth and worth of local knowledge as opposed to 'distance' scientific knowledge is also recognised in the area of rural development (Chambers, 1983). This is a departure from modern geography. A phenomenological approach to geography was dropped at the time when geography achieved the status of an institutionalised academic discipline (Granö, 1981). It was also around this time that the response of geographers to this contextual development within their discipline moved from the study of regionalism and environmentalism to quantification and later to social humanism (Granö, *op. cit.*). Kropotkin and Geddes can be considered representative of the regionalist, phenomenological approach.

The importance of this split is twofold. The first point is that global or scientific knowledge can not always provide satisfactory answers at the local scale. Both Goldstein (1999) and Chambers (1983) list examples of how scientific enquiry has resulted in poor decision making because the outsider scientists either did not perceive localised micro-variations or asked the wrong questions through a lack of cultural understanding. The second point is the issue of empowerment. Goldstein (*op. cit.*) puts it thus:

> *"Reliance on scientific expertise exclusively has the tendency to concentrate power in the hands of the technically and scientifically adept, transforming a democracy into a technocracy* (Fisher, 1990). *Technocracy does not simply discount place-based knowledge but also fosters the illusion of objectivity that facilitates the transformation of moral and political questions into technical issues."*

The way in which the environment is understood and the reliance on any particular knowledge base has implications for environmental planning, particularly in the formulation of future strategy because that strategy is developed out of the way in which the knowledge is interpreted. The ideal, which Goldstein (*op. cit.*) supports, is that local knowledge and scientific knowledge should be wed. Jacobs and Mulvihill (1995) are in concordance with Goldstein on this point and they point to the success of joint institutions that incorporate both native and non-native members and knowledge bases, particularly in Canada but elsewhere too.

The foregoing can be summed up in the words of Batisse who writes, in connection with biosphere reserves, about how social inclusion and integration are necessary in a bottom-up approach to planning, which is a visionary step in itself as is clear from the following quote:

> *"It cannot be over-stressed that conservation measures – especially those which involve productive lands – will not succeed without the agreement, support and participation of the population directly concerned. Unless administrative habits of most countries, which tend to dictate from above what has to be done in the field of nature conservation – and indeed in other fields – are radically modified, and unless major efforts are made to explain the value of protected areas and to associate the local people with their management, all conservation measures will be bound to collapse sooner or later."* (Batisse, 1982)

It is axiomatic of bioregionalism that the exercise of political power is most effective at the local level (Diffenderfer and Birch *op. cit.* and Sale, 1984). This is the basis of the principal of stakeholder participation. Two of the cornerstones that underpin nearly all the social principles are empowerment and education. It is on both of these issues that a person's ability to participate in the debate and processes of environmental preservation are based. Over the centuries, but particularly this century, there has been a concentration of power in urban areas and a centralisation of government. Although some power has been retained in rural areas of Scotland by wealthy landlords the trend of urbanisation, and the consequent urban focus, cannot be denied. Even knowledge and values have become increasingly concentrated in urban areas from which they dominate (Chambers, 1983). Chambers goes on to describe the two cultures of academics and practitioners (each of C P Snow's two nations, arts and science, can be expected to have within it these two cultures). He describes the former as a negative culture engaged in unhurried analysis and criticism and the latter as a positive culture. Such a distinction, while possibly having some founding, is very value-laden and rather unhelpful.

Social anthropologists recognise the importance and validity of indigenous local knowledge systems (Chambers, *op. cit.*). However, gaps exists between the practitioner, the academic and the politician (see also Harrison, 1989). The latter two are conditioned to be suspicious of "rural people's knowledge"; a term coined by Chambers, in preference to "local knowledge" or other similar terms, to be more inclusive and signify that it is the knowledge within the people and not necessarily, exclusively of the place.

The gap is considerably less wide in Scotland than it might be in some so-called third world countries. There, the outside knowledge comes from aid and extension workers who are often foreigners, conditioned with a different set of values and practices that are appropriate in their own region but not to their current location. Harrison (1989) and Chambers (1983) give numerous examples from Africa. Outside knowledge is deemed modern and scientific and traditional rural people's knowledge is marginalised as, at best, quaint and, at worst, backward.

The importance of local and, particularly, indigenous cultures is that the bioregionalist sees them as repositories of local or 'place-based' knowledge (Goldstein, 1999). The bioregionalist recognises that social customs and religious practices help to cement the connection between many cultures and their surroundings (Parsons, 1985). It stems from this that cultural diversity is, almost *de facto*, desirable. As Parsons (*op. cit.*) writes:

> "[Bioregionalists] *have a special sympathy for separatist, home-rule movements (Quebec, the Basques, The Lapps, the Celtic fringe of Europe, Australian Aborigines, American Indians).*"

The recent developments in political devolution make this all the more poignant. Regional planning has made some progress towards overcoming the disempowerment of local citizens but there are still concerns about the structure of regional planning organisations and the institutionalisation of citizen output (Diffenderfer and Birch, *op. cit.*). There is a danger of environmental planning becoming utilitarian. The regional perspective must support a healthy relationship between individuals and their natural world through their attachment to it (Diffenderfer and Birch, *op. cit.*). Viewing the world in terms of bioregions and ecosystems is potentially a major step on the road to building a co-operative sustainable relationship with our surroundings and the environment. However, bioregionalism differs from most forms of regional planning by putting its primary focus on the development of an integrated self-reliant economic, social and political system (Diffenderfer and Birch, 1997). As such it demands a detailed understanding of a region's geography, ecology and resources.

2.6 A SYSTEMIC AND HIERARCHICAL LOOK AT BIOREGIONALISM

Bioregionalism tries to recognise, through holism, the 'minded' systemic nature of the environment.

2.6.1 A Simple Systems Model of Bioregionalism

Bioregionalism can be re-interpreted by a systems model. Within this model there are three readily identifiable systems that will be referred to as the biophysical, network and local systems. Between them, these systems cover the core areas of 'culture', 'governance and ecopolity', 'economy' and the 'ecosystem'. Each system operates interactively within a geographic region and its environment. As such they can be considered to be autopoietic. These systems are the biophysical system, the inhabiting system and the network system and are represented diagrammatically in Figure 2.2 below.

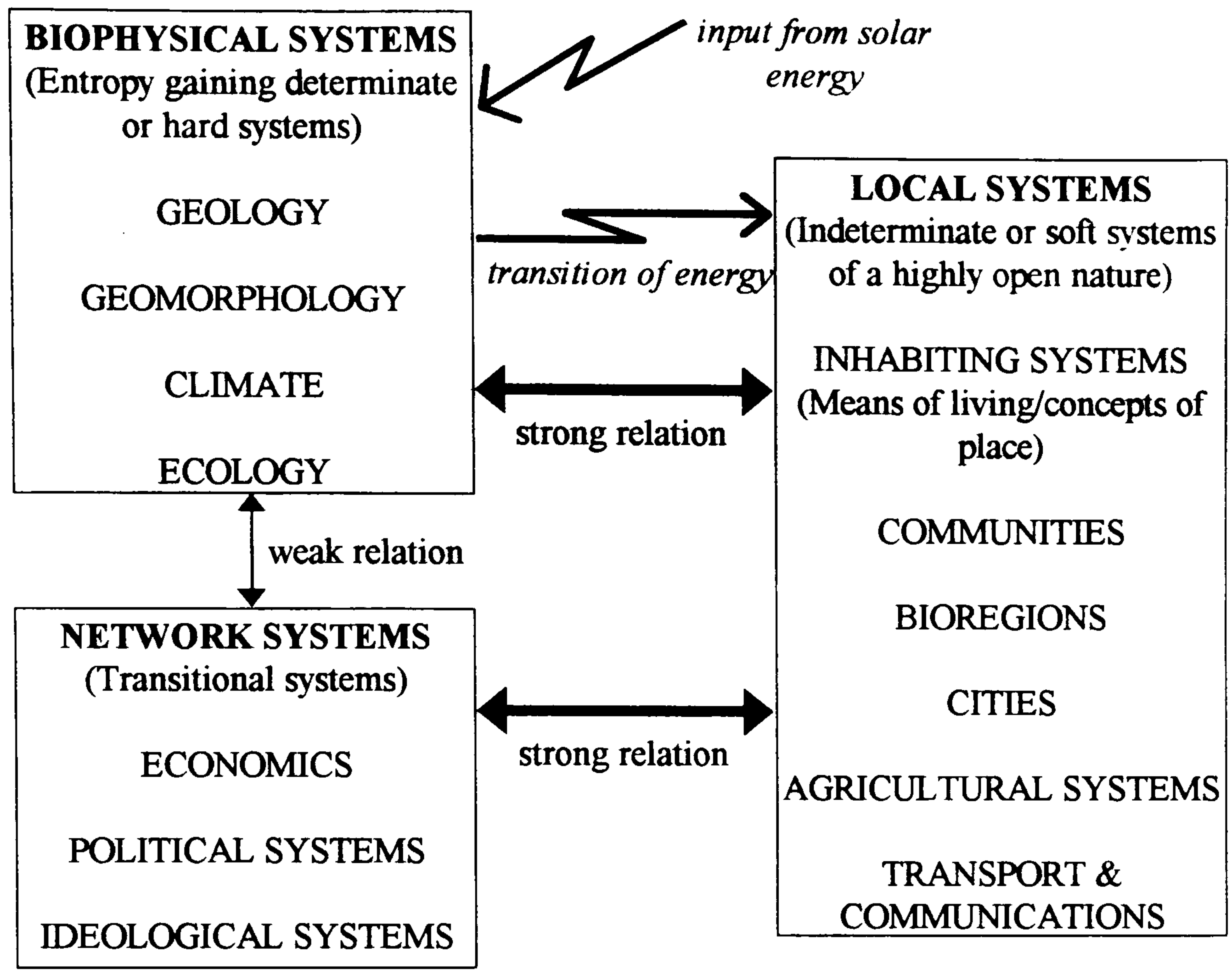

Figure 2.2: Relationship of system components in a region. Adapted from McTaggart (1993) to show bioregions

2.6.2 The Hierarchical Context of Bioregions

As all parts of the environment interact, a bioregion must be a system that operates as part of and within a hierarchy of scale. To locate a sub-system within a hierarchy it is necessary to be able to describe the higher and lower levels between which the system of interest is located. If a level above cannot be described then the system in question is the highest. If the reverse is true and a lower system can not be described then the system in question is the lowest. The hierarchy as a whole is comprised of nested systems. The scale of observation determines the relevant level of consideration within the hierarchy. Figure 2.3 represents the location of bioregionalism in the hierarchy of environmental systems.

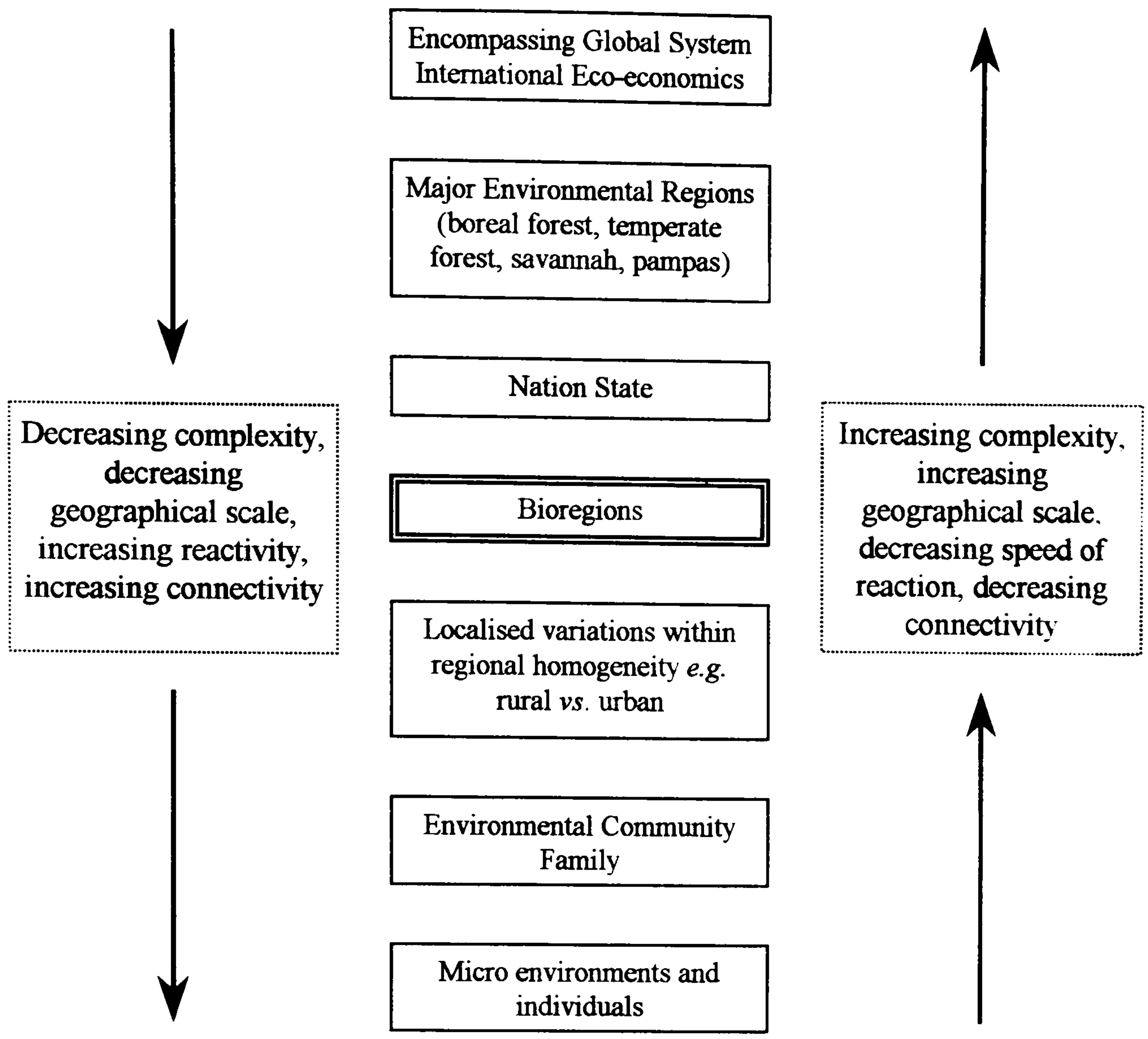

Figure 2.3: Locating bioregions in the hierarchy of environmental systems.

Locating bioregions in the hierarchy in this way is instructive because it begins to reveal one of the possible strengths of bioregionalism. Because it operates at a lower level within the hierarchy, closer to the individual, it is much more likely to command greater loyalty than either the nation state or even meta-regions such as the European Union or even the planet as a whole (Keating, 1997). There is a cohesive strength, which loyalty fosters, in small groups that is powerful enough to run counter to the huge political power which currently tends towards universalism (Hardin, 1988). Patriotism depends to a greater extent on intellectual arguments than 'cronyism', as Hardin (*op. cit.*) calls it. The latter is closer to the egocentric predicament of minimising the risk of trusting others (Figure 2.4). Having said that, there is no point where the head outweighs the heart in a matter of loyalty. There can be no intellectual arguments alone that form the basis of patriotism. This loyalty is one of the potential strengths of bioregionalism.

In a similar vein, Batisse (1982) states that "if the biosphere reserve is set up and managed in the right way, the surrounding population can become its best protector."

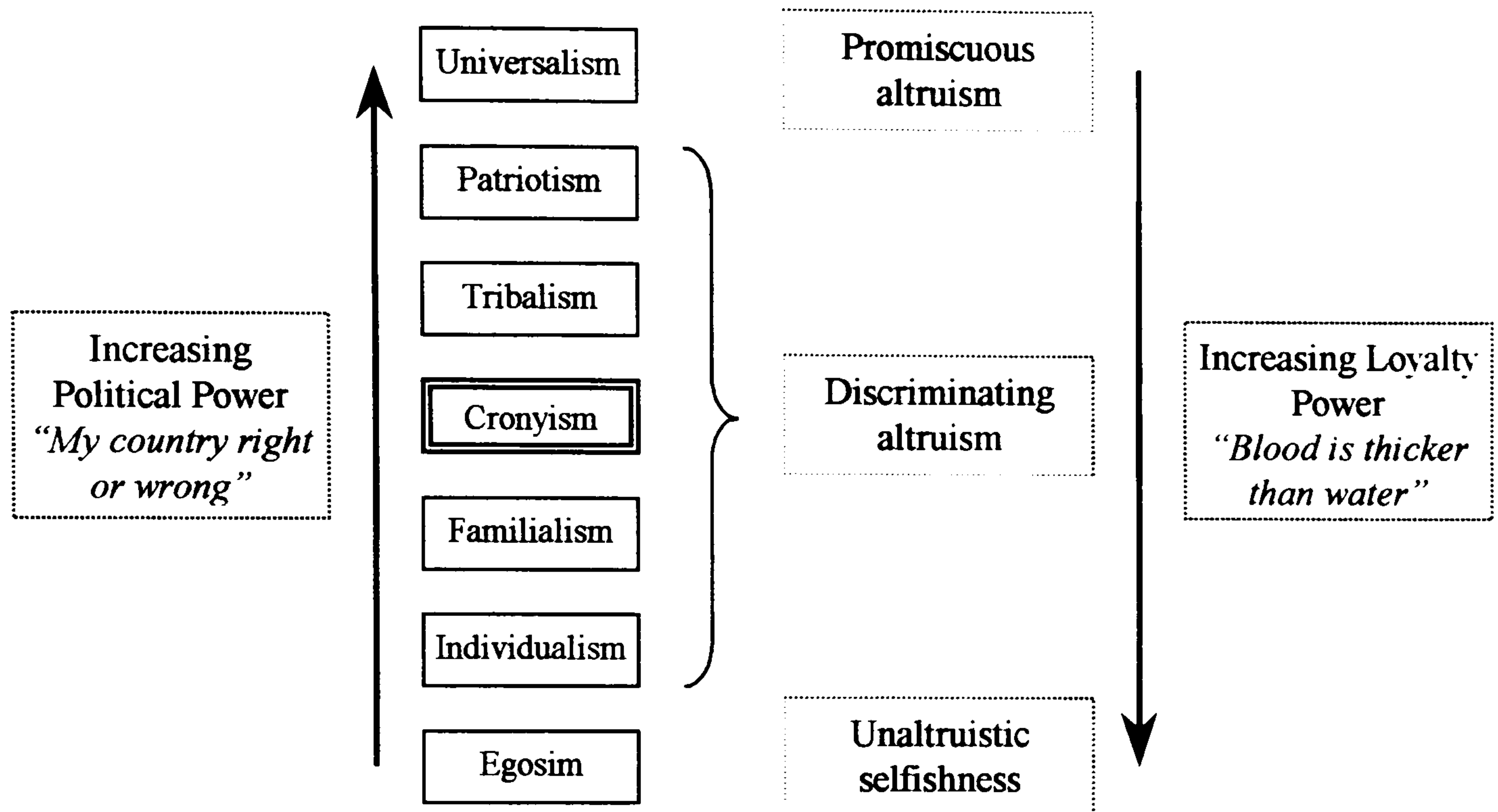

Figure 2.4: The conflict of powers that works against stabilisation at any single level of altruism (adapted from Hardin, 1988)

The similarity between Figures 2.3 and 2.4 is interesting, noting the relative positions of parts of the two hierarchies. If another diagram of economies of scale were to be placed alongside these two figures there would be a clear representation of the ecological, socio-political and economic strengths and weaknesses. The opportunity for bioregionalism is to play to the strengths of its position in the middle of these hierarchies and claim the 'prize' of the best of both worlds. On the other hand, the threat for bioregionalism is to act and be seen to be 'neither one thing nor another', an unhappy compromise.

2.7 IS BIOREGIONALISM SIGNIFICANTLY DIFFERENT TO DEEP ECOLOGY?

The Deep Ecology platform can be summarised by the following points (Naess, 1988 and 1989; Devall and Sessions, 1985):

- The well-being and flourishing of human and non-human life on earth have intrinsic value.
- Richness and diversity of life forms contribute to the realisation of these values and are values in themselves.
- Humans have no right to reduce this richness and diversity except to satisfy vital needs.
- The flourishing of human life and cultures is compatible with a substantial decrease in human population. The flourishing of non-human life requires such a decrease.
- Present human interference with the non-human world is excessive and is worsening.
- Policies must therefore be changed. These policies affect basic, economic, technological and idealogical structures. The resulting state of affairs will be deeply different from the present.
- The ideaological change is mainly that of appreciating life quality (dwelling in situations of intrinsic value) rather than adhering to an increasingly higher standard of living.

The Deep Ecologist believes that those who subscribe to the foregoing points have an obligation, directly or indirectly to try to implement the necessary change. It can been seen that there are very many points of similarity between the Deep Ecology platform and bioregionalism. It is also evident that, there are different 'depths' to both Deep Ecology and bioregionalism. The one thing that does set bioregionalism apart from Deep Ecology and other ecosophies is the concept of the bioregion. It would seem that the important part of bioregionalism is the bioregional concept which should remain valid whatever ecocentric philosophy is used to inform management decisions once the bioregions have been identified and mapped. Therefore, it is doubtful whether bioregionalism is sufficiently unique to warrant being considered distinct from, or better than, other ecocentric philosophies.

The problem faced by bioregionalism is mirrored by permaculture. In both cases a sound practicality has become the focus for a philosophical movement that embraces much more than the original notion of the bioregion or permaculture as *perma*nent agri*culture* (Harland, 1997). It would appear that, in both cases, an unnecessary weakness has been introduced. This note is resonant with what can be learned from the Australian and Californian examples of bioregionalism in action. That is, in both cases, bioregionalism has been accepted up to the point that environmental governance ought to follow natural boundaries and that community involvement is imperative for the success of any environmental planning (Press, 1995). Press (*op. cit.*) states that:

> *"Not surprisingly, bioregionalism is not a major movement, even in California. Its principles of frugal self-sufficiency, holistic ecocentrism and radical decentralisation have not yet found expression in mainstream environmental rhetoric, let alone society at large."*

It would appear that one of the strengths that bioregionalism has for the formulation of mainstream policy, is that is a non-threatening way to enable environmental policy to blur resource management distinctions (Press, *op. cit.*). The concept of watershed management is very familiar to most natural resource managers. Sustainability and stakeholder participation are popular political concepts. The adoption of an ostensibly bioregional strategy achieved a more holistically interactive management strategy, in California and Australia, than was otherwise possible with traditional 'demarcation points' between regional and rural resource planning bodies. This might be put as "'joined-up government' by the back door". Bioregionalism would appear to have a role in environmental policy and management if only for the reasons stated above. However, there is greater potential in bioregionalism through the way it embraces decentralisation and community involvement, not least in a phenomenological understanding of 'their' watershed and it is partly for this reason that an importance is ascribed to bioregional mapping.

2.8. EXAMPLES OF BIOREGIONS

Bioregionalism is finally emerging from being a counter-cultural movement to almost respectable acceptance in some mainstream areas. There are a number of regional organisations and even states, particularly in North America, which use bioregionalism as a land use management tool (Holmes, 1994). More specifically there are bioregional efforts in the form of watershed councils centred on areas such as the Greater Yellowstone ecosystem and the Colorado Plateau (Kemmis, 1999).

2.8.1 Development of a Bioregional Planning Framework in Australia

There have been many significant trends in nature conservation in Australia in response to the problems that faces a national strategy which include the diversity of characteristics of both the physical geography and the natural community structures. Thackway (1997) discusses these trends. To compound the problem there are a further two problems. The first is the distinct cultural differences between the Aboriginal peoples and European descendants. The second is the continental scale at which any national nature conservation strategy must work.

In Australia there has been a change in community attitudes away from the expectation that central government will manage nature reserves through legislation. The move has been towards a community-based embracing of greater community participation in conservation management, unconstrained by a defined reserve boundary through the acceptance of the principles of ecologically sustainable development (Thackway and Cresswell, 1997). This is a positive move because national parks often fail to reflect local and regional community needs and attitudes which is important for the success of any scheme (Batisse, 1982).

The bioregional framework grew out of the Interim Biogeographic Regionalisation for Australia (IBRA; Thackway and Cresswell, 1995). The IBRA framework was based on a hierarchy of environmental data that were specific to a particular state or territory. In this way, Australia was divided into 80 natural regions, each of which reflects an identifiable assemblage of characteristics of landform, climate, geology, flora and fauna. Some similarities can be seen between the IBRA and the Heritage Zones devised by Scottish Natural Heritage (Crofts, 1995) although the IBRA seem to be a little closer to bioregionalism but it still lacks the societal element.

A similar initiative which appears to be an extension of the IBRA is the Indigenous Protected Areas (IPAs) which does involve communities directly, but specific indigenous peoples, the Aborigines (Thackway, 1997). The IPA framework has a specific task of fostering co-operation between Aboriginal peoples and nature conservation agencies. Through the IPA scheme, indigenous people can voluntarily enter a partnership to manage their lands for nature conservation. Other initiatives exist to address the problems of conservation of biodiverity in agricultural landscapes, regional forest assessments, and regional species recovery planes. There seem to be many successes (Thackway, 1997).

The foregoing sets the scene for Australia's bioregional planning initiative. Despite the success of the schemes mentioned there were still deficiencies in the national system of protected areas and a need for greater flexibility. The result was a recommendation at the parliamentary level that a bioregional framework be introduced to help cover the gaps and assist integration. The stated aim of the bioregional framework is to reflect not only the natural environment in the way the IBRA does but also to reflect the human society that lives within it (Thackway, 1997). The process of setting up the bioregional framework began with the parliamentary report in 1993 and is still under implementation, a fact that is not surprising in the light of the enormity of the task.

The first step in the implementation was to establish a consistent national biogeographical regionalisation (the IBRA) which was begun in 1994 and involves a Geographic Information System (GIS) mapping process. The next step was to develop Conservation Planning Attributes (CPAs) for each region. The CPAs defined what gaps there were in the IBRA data and the national system of protected areas. In addition to a top-down approach, a bottom-up approach was initiated to gain community participation in the development of an ecological framework for appropriate resource use and conservation. The bottom-up approach subdivided the bioregions so that the greatest participation by the communities could be ensured and to maximise the integration of local, indigenous knowledge. During this process, three key tasks were identified as necessary for the successful integration of local communities into the bioregional planning process. Thackway and Cresswell (1997) list them as follows:

- Development of model projects in bioregional planning at a finer scale
- Initiation of an education and public relations programme
- Development of a programme of collaboration with indigenous people for them to manage their lands in a way consistent with nature conservation.

To this list can be added the synthesis of culturally meaningful criteria for planning. Public comment, invited on the IBRA from stakeholders who included industry groups, approved of the regional divisions. Various small-scale regional projects have been initiated and the indications are promising. An education programme is now in place. It is clear that the Australian government have understood the concept of bioregionalism and applied the principles in a pragmatic and forward thinking way. Some more time will need to elapse before the true success of the scheme can be determined. The main obstacle that was encountered was the narrow focus of the many and disparate conventional management and planning regimes. Divisions of focus and domain exist between management and planning systems that are based on ecosystem management, watershed management, wildlife management, community projects and rural development. Integrated planning must overcome this obstacle of narrow discipline focus and departmental jealousies. The Australian experience will be revisited in the discussion towards the end of this thesis.

2.8.2 Bioregional Basis for the Enhancement of Biodiversity in California

Another example where the concept of bioregions has been officially recognised comes from California. In 1991 the California Biodiversity Council (CBC[12]) was formed to facilitate better co-ordination and co-operation between the many organisations with interests in natural resource management and environmental protection (CBC, 1999). Unlike the example from Australia, the aim of the council was neither to start new projects nor to add a new layer of administration. It had the expressed purpose of assisting the development of strategies and complementary policies for conserving biodiversity.

It was decided that the environment of California was too complex to understand and manage as a single unit and a way of breaking it down into more manageable units was needed. Moreover a system that recognised important assemblies of ecosystems, landscapes and the people living within them. Members of California's Interagency Natural Areas Co-ordinating Committee (INACC) drew up the original bioregional map in 1988 (Figure 2.5), which divided California into 10 bioregions (Wheeler, 1996). Wheeler reports that the INACC discovered that

> *"Despite development over the years and the imposition of superficial Subdivisions, the strength of natural systems remains evident, and the logic of their alignments compelling . . . Thus no matter what lines may have been superimposed, or alterations to the landscape made, we return inevitably to the enduring reality of California's bioregions as a guide to the management of natural resources, including the land itself."*

They found that the state's watersheds and mid 19th century settlement patterns bore a remarkable similarity to the bioregional divisions of California. The early settlers would have been very heavily dependent on the natural resources of timber, fish, and agriculture and, perforce, had to work with the natural environment not against it.

One of the first steps in the process to officially instituting a bioregional approach to biodiversity management was the drafting of a Memorandum of Understanding (MOU[13]). It was through the MOU that the CBC was established (Press, 1995). The MOU required its signatories to make the maintenance and enhancement of biodiversity a pre-eminent goal and to work in co-

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12 The California Biodiversity Council has a web site that contains this information plus additional material. At the time of writing the Internet address for this site was: http://ceres.ca.gov/biodiv. The '.gov' within the address denotes this site to be an official North American government web site.

13 A copy of the MOU can be found on the Internet through a link from the California Biodiversity Council web page or directly at http://ceres.ca.gov/biodiv/text/mou.html. This address was correct when the site was accessed at 12.54 on 9th August 1999.

ordination with the other parties to adopt a regional strategy that ensures the protection of biodiversity and the maintenance of economic viability throughout California. The MOU recognised the importance of community and public support. It was recognised that local communities and their economies formed part of the important attributes that define a region. The involvement of the community was seen to include education.

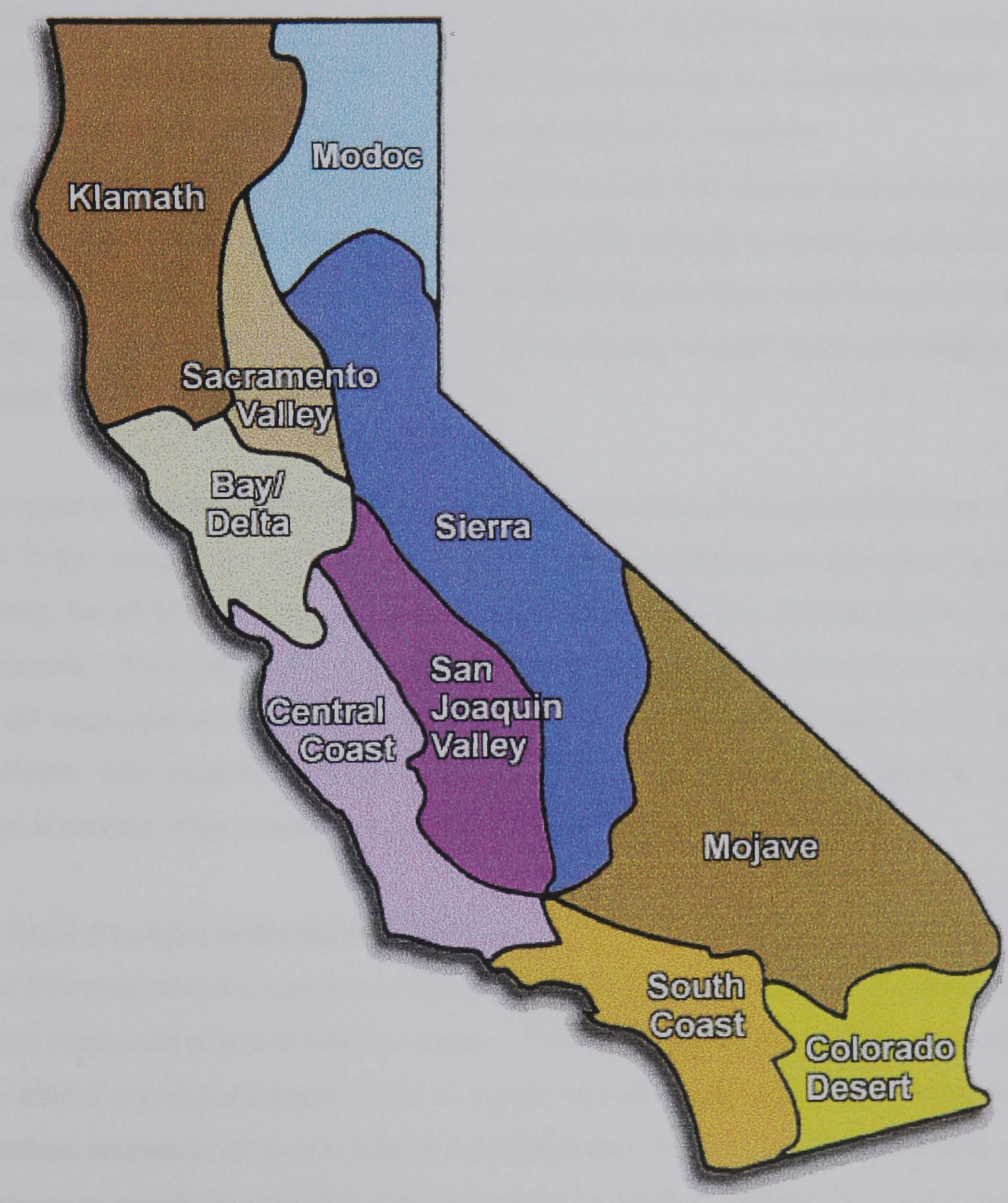


Figure 2.5: The bioregions of California (CBC, 1999)

Administration of California's bioregions was to be achieved by a hierarchical organisational structure that represents the scale of operation. In, brief the organisation was as follows:

- State-wide Executive Council – responsible for setting state-wide goals for biodiversity enhancement, educational outreach, land use strategies, monitoring, research and co-ordination between all levels within the hierarchy.
- Sponsors – includes special interest groups or organisations that support the MOU and have a particular responsibility to promote strategies that meet and further the aims of the MOU.
- Bioregional Councils – work with local and regional authorities to implement biodiversity policies. The councils include local industry, community and environmental groups. They have a responsibility for fostering watershed and landscape associations.
- Watershed and Landscape Associations – act at the local level directly with landowners and private organisations to develop specific co-operative projects to address local needs and meet the over-arching goals identified by the MOU and the State-wide Executive Council. The associations are the primary fori for the resolution of local issues and conflicts that relate to biodiversity issues.

There appears to be some promise in the Californian experience of bioregionalism in the way in which it has managed to pull together a number of very different environmental agencies. However, one of the real powers of bioregionalism, that of enabling community participation, was ignored. The agencies did little analysis of local self-sufficiency and made no attempt to raise the consciousness of the inhabitants of the regions to environmental issues (Press, 1995). Nonetheless, little could be expected in the way of significant change in the political climate current at the time of the inception of the MOU (Press, *op. cit.*).

2.8.3 Other Examples of Bioregional Intent

All the following cases are examples of mapping exercises that have been carried out by some of the local inhabitants of their respective regions. These areas have not necessarily been adopted in any official or political capacity. This is, in part, because bioregionalism divorces itself from the artificial limitations of current political boundaries but can cause a conflict of interest where a bioregion or significant watershed crosses a political boundary. Without the forward thinking of a ruling power on the scale of the case in Australia, they are unlikely ever to be adopted officially. Australia has another advantage of being an island with one government (albeit divided into states). Such a set-up can only facilitate the adoption of bioregionalism. Apart from a comparatively short border with England, the Scottish situation is (now) not too dissimilar. Further they are predominantly defined by their watersheds with other natural features mapped within them rather than these other features serving to help inform the boundaries and little reference has been made to indigenous peoples by and large. As such, it must be debatable whether they are truly bioregions, not taking into account all the principles.

1. The Sonoran Desert Bioregion

   The Sonoran Desert covers three Mexican States (Sonora, Baja Norte and Baja Sur) and parts of two US states (Southern California and Southern Arizona). The Sonoran Desert has a greater diversity of plants and plant communities than any other New World desert and many of the indigenous cultures survive (Nabham, 1981).

2. Cascadia

   "Cascadia" is one of the most prominent bioregionally defined areas in the literature and on the Internet. It can be found on the north Pacific Rim, America. Cascadia is an area of 750,000 square miles (McCloskey, 1996) and includes the states of Oregon, Washington, Idaho, north-western California, Montana to the West of the divide, two-thirds of British Columbia and south-east Alaska.

3. The Wild Onion Bioregion, Chicago

   The Wild Onion Bioregion lies at the south-western end of Lake Michigan. It is within a glacial lake plain within the watersheds of four rivers including the Chicago. The bioregion was given its name from the once common wild onion that used to grow on the original prairie and oak savannah that is now greater metropolitan Chicago (Briggs, 1993).

4. Nortansjski National Park, Solvania

   Bioregionalism has been a driving force in the ecological thinking of the Nortansjski National Park project (Aberley, 1993 and Alexander, 1996). Following independence from the former Soviet Union, the new government of Solvania leant its support to the protection of the area and adopted a bioregionalist approach to community involvement in the mapping process.

5. Dartia

   The bioregion called Dartia is centred on Schumachar College in Dartington, near Totnes and Plymouth. The principal river is the Dart that flows out into the English Channel at

Dartmouth. Kirkpatrick Sale (1993), guided an exercise in bioregional identification at the college. The mapping of Dartia was, however, a training exercise.

2.9 THE PURPOSE OF MAPPING BIOREGIONS

In summary, there is a common denominator to all the bioregional mapping exercises that are listed here. It is, in essence, to produce a visually integrative approach to the presentation of information for environmental policy & management. The intent, although not always stated, is to consider the environmental planning of the area in question in a new way, consciously divorced from the constraints of the past. In every case there is the important element of participation in the mapping process either directly by, or on behalf of, local communities.

However, mapping of bioregions is not the final aim of the exercise. The bioregional map is a vehicle for the expression of local community values, needs and knowledge. It is a step along the road to the creation of a shared vision of the future. The bioregional map is also vehicle by which a shared vision can be expressed and communicated to other non-specialist community groups. It is for this reason that Berg (1988) is an advocate of 'barefoot mapping', or community oriented, qualitative mapping.

3 ENVIRONMENTAL FUTURE STATE VISIONING

"Vision without action is useless. But action without vision does not know where to go or why to go there. Vision is absolutely necessary to guide and motivate action. More than that, vision, when widely shared and firmly kept in sight, brings into being new systems."

(Meadows *et al.*, 1992)

3.1 INTRODUCTION

It is clear from earlier chapters, that bioregionalism is not a part of the structure of modern society or current planning principles. Indeed, it could be argued that the philosophy of bioregionalism is unworkable in the present economic and social climates, particularly considering the current environmental problems. There may be indicators of past bioregional-like activity or even a present desire in some circles to move towards bioregionalism. However, bioregionalism is still, at the moment, a vision of a possible future state.

There are several ways of looking at the future but two methods predominate. The first is by prediction and the second is 'visioning'. Prediction is, perforce, based on extrapolation of past trends. Through this process the future can only be viewed as though along a corridor of constraining possibilities. The corridor might widen along its length but the process of prediction is essentially a restrictive one. Visioning, on the other hand, is a process that begins with the desired future state and then looks backwards to the present (building a new corridor between the states). Visioning is a tool that, under various guises, has been developed by the business community to help corporate planning. The present state can be a difficult barrier to what could be - the future state (Stewart, 1993). Therefore, visioning is radically different from conventional futurology which is predictive, prophetic and tends to offer pictures of exaggerated optimism or pessimism (McRae, 1994).

In this chapter the rationale and process of visioning will be explored with examples of its use. The definitions and processes of visioning will be adapted from the predominantly corporate-oriented literature to the novel process of 'bioregional visioning'. The argument will be made that environmental planning needs a visionary process. Furthermore it will be argued that bioregionalism must adopt visioning if it is to maintain logical consistency and become more acceptable to mainstream academic thought. Most importantly, bioregionalism must adopt visioning if it is to ever become a useful tool in the planning process. The problem is how to get to the future vision from the present and a visionary process provides the answer. First, it is necessary to understand something of the process of visioning. Following an examination of environmental Future State Visioning (FSV) the process of building up a bioregional vision through bioregional mapping will be discussed as a prelude to performing a bioregional mapping exercise on Scotland (in Chapters 4 and 5).

3.2 WHAT IS A VISION?

3.2.1 Defining 'Vision'

The question posed in the heading of this section initially seems like an obvious one but the definition of the term 'vision' as used here must be clear. Reference to a dictionary will reveal a number of definitions for the word. Along with the obvious definitions of the faculty of sight, dreams, trances and apparitions, the Oxford dictionary describes 'vision' as having the meaning of "power of discerning future conditions, sagacity in planning, foresight". The popular perception of 'vision' is that of something desirable in the leadership process but 'soft' or vague (Wilson, 1992). Furthermore, a quick look at Roget's Thesaurus reveals how the word 'visionary' is linked in popular perception with ideas of 'inexistence', 'unsubstantialness', impossibility and heterodoxy. (In the case of bioregionalism the charge of heterodoxy must be accepted even if the other meanings are not). The definition of 'vision' in business circles is much 'harder', more concrete and more akin to the definition of "sagacity in planning". Wilson (*op. cit.*) defines a strategic vision, in corporate terms as:

> *"'A coherent and powerful statement of what the business can and should be (ten) years hence' (the time horizon varies, of course, with the nature of the business)."*

Westley and Mintzberg (1987) have summarised the literature on the definition of what a vision is. From their review it can be seen that "envisioning" is the process of "creating an image of a desired future organisational state . . . [which is] . . . the basis of empowering others when it is coupled to the ability to communicate with others". It is only recently that visioning has been associated with the process of transformation in organisations, particularly through its ability to lead people rather than manage them (Westley and Mintzberg, *op. cit.*). Westley and Mintzberg (*op. cit.*) suggest that "strategic visions are complex, novel images which may be more or less conscious, articulate, and realistic".

Westley and Mintzberg (*op. cit.*) state that the techniques and process of visioning as a transformational tool have been only scantily addressed in the literature of administration. This would appear to be the case in environmental planning and related fields. Since publication of this work in 1987 however, there has been an increase in interest in the subject. For the purposes of this thesis, the business and corporate oriented definitions need to be translated into terms more relevant to the environment. Therefore Wilson's definition above can be redefined to state that:

An environmental strategic vision is a coherent and powerful statement of what the condition of the environment should be (25) years hence (the time horizon varies, of course, with the nature of the environment in question).

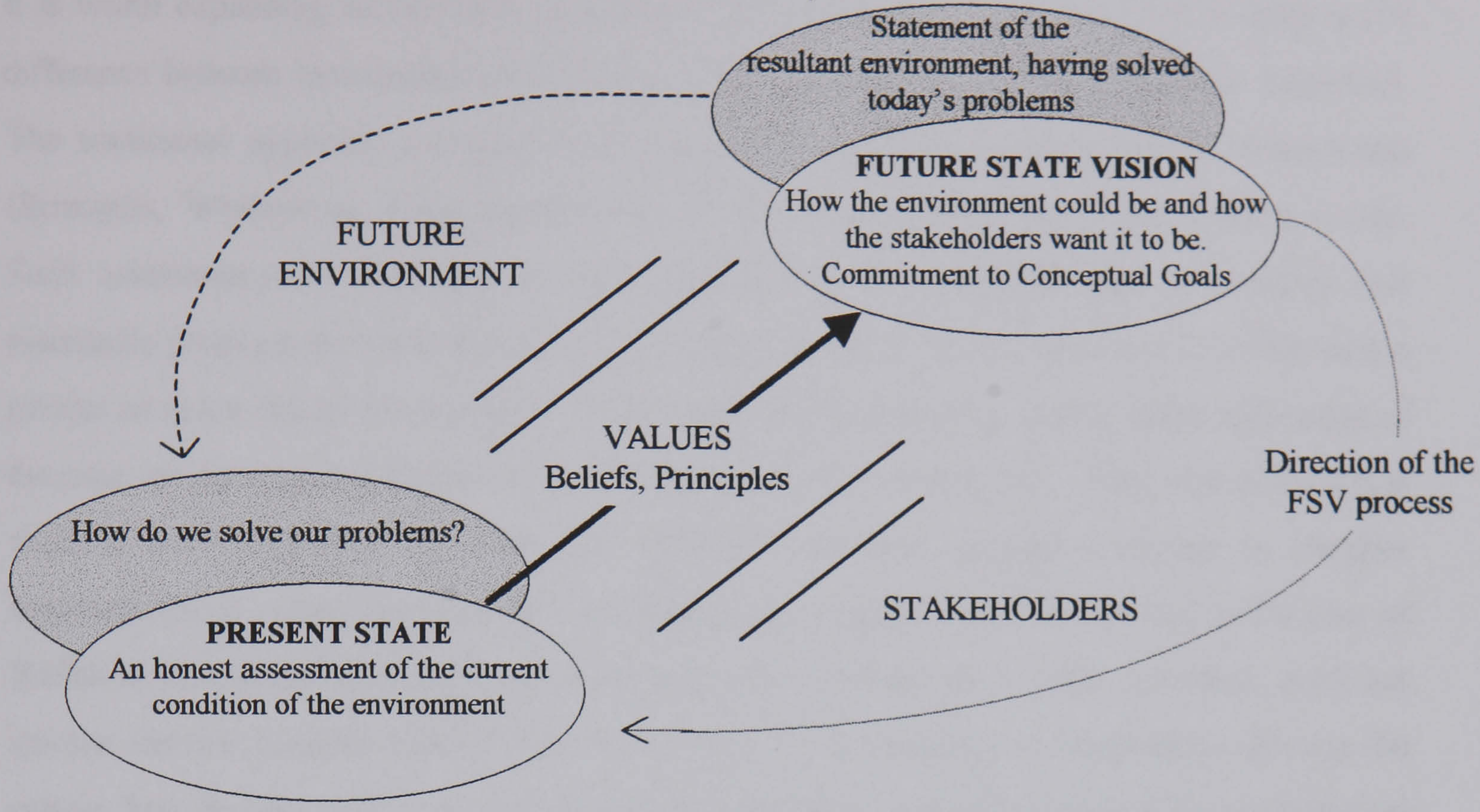
This definition is not entirely satisfactory because it is difficult to conceive a statement that would satisfy all parts of the global environment and still contain a certain amount of rigour and clarity. A similar problem might be faced by a multinational corporation with many subsidiaries. The definition becomes much more satisfactory if it is applied to a region, particular area or even a particular type of ecological community. Wilson (*op. cit.*) expands upon the definition by further exploring some of the terms. His points are presented below and are annotated or altered to give additional relevance to the field of the environment (comments and words that substantially differ from the original corporate-oriented meaning are denoted by square brackets):

1. A vision must be *coherent*, integrating goals, strategies, and action plans into a complete and recognisable picture of the future [region] in its entirety.

2. The vision must be *powerful*, to generate commitment and motivate performance [from within a region's stakeholder groups and external but interested bodies *e.g.* environmental quangos].
3. [The above] definition emphasises what the [environment of a region] *can be*, because a vision must be realistic about the [pollution], [environmental degradation imposed by neighbouring regions], [global environmental change], [social], economic, and regulatory conditions which the [region] is likely to encounter.
4. A strategic vision must clarify what the [region] *should be*, because it should reflect the values and aspirations of [regional government], [local inhabitants] and other stakeholders [within the limits and bounds of the carrying capacity of the region and principles of sustainability].
5. [Additionally, a vision must define the geographical extent of a region so that it includes a suitable sufficiency of natural resources consistent with the harmonious coexistence of the region's human inhabitants with their natural environment allowing for communication within and between regions.]

The word 'region' is used in this new environmentally oriented interpretation of Wilson's original definition because this thesis is concerned with bioregionalism.. However, the definition could be made applicable to other aspects of the environment by substituting words such as 'ecosystem' or 'habitat'. At an even more specific level, the definition could make reference to a particular water catchment or a certain area of woodland (for instance).

Wilson (*op. cit.*) makes the analogy that a vision is like a preview of a company's desired annual report for a given year in the future. In environmental terms a vision is a description of the region or habitat (*etc.*) in question as the stakeholders would like to see it a some time in the future regardless of its present condition. It is then down to the planning process to chart a course to the vision from the present. Figure 3.1 is a pictorial representation of the visioning process where the dotted arrow shows the direction the *visioning process* takes and the bold solid arrow shows the direction in which the *action* moves.



- **Future State Vision** - how the environment should be in the future
- **The Present State** - what exists and what the environment is like at present
- **Values** - the beliefs and principles which provide a foundation for the vision
- **Stakeholders** - inhabitants in and dependants on the environment, biological communities

Figure 3.1: The process of environmental Future State Visioning. Adapted for the environmental context from Stewart (1993).

It is important to remember the following two things about 'visioning':

1. A visionary planning process is lead by the vision of the desired future state and not driven by the present. This difference will be explored in the next section.
2. A vision represents the current target or goal based on current desires and knowledge. It is not an immutable 'holy grail'. A vision can and should be changed with increasing knowledge and changing understanding of relevant events or processes. Furthermore, the inter-connectivity of natural systems may mean that external influences force or encourage a change in the vision. As the goal is approached new targets must be set to avoid falling into the pitfall of obsolescence of the vision through its own success (Wilson, 1992).

3.2.2 Incremental Planning & Visionary Planning

It is worth expanding on the ideas developed in the previous section (3.2.1) by looking at the difference between incremental planning and visionary planning. The difference is important. The traditional approach to corporate planning is to use tools such as SWOT assessments (Strengths, Weaknesses, Opportunities and Threats) and assessments of the relevant trends. Such assessments are important for any business but will inevitably lead to planning that essentially proposes the maintenance of the present course into the future (Stewart, 1993) with a greater or lesser degree of deviation. This process is incremental planning where each stage of the plan, as it progresses through time is based on what has preceded it. Often this is all that is required but the process is weak and inappropriate when significant change in complex organisations or systems is required. This weakness is a charge that has been laid at the door of British environmental planning that has been accused of being not so much 'planning' at all but merely reactive negative control (Allison, 1975). It is necessary to temporarily divorce the system from its past and present to define its desired future state unencumbered by any historical legacy. This is the start of the process which Stewart (*op. cit.)* calls Future State Visioning (FSV).

FSV is a method for conceptualising significant change by creating a description of what is desirable in the future (how things *could* be) before becoming cognitively trapped by exhaustive analysis of present conditions, how things *are* now (Stewart, 1993). Stewart has contributed much to the development FSV both in academia and originally as part of a team trying to transform Du Pont Canada in the 1980s. Then, a need was identified in Du Pont to develop a tool by which people could divorce themselves from conventional thinking and enhance their problem solving abilities to implement discontinuous change within a highly complex organisation. Wilson (1992) describes how a similar process took place in General Electric at around the same time.

3.2.3 Why Should Time and Energy be Invested in Formulating a Vision?

Both businesses and the environment face pressing problems that need to be addressed urgently. In such a climate it would be a reasonable response to question why time, effort, money and energy should be invested in formulating a vision when action is needed immediately. After all, a vision is something of a chameleon, changing as it does through time. The level of uncertainty facing all sectors of enterprise means that the creation of a vision may seem like a process of, at best, dubious worth. Flexibility is usually lauded as the best response to uncertainty but flexibility sets no goals, describes no processes that may prove necessary and sets no direction.

A vision sets both direction and destination (even if it is one that, through constant reappraisal, is never reached). Wilson (*op. cit.*) poetically likens a vision to a star by which a company (or bioregional planners) can steer.

3.3 KEY CONCEPTS OF VISIONING

Understanding the deep structures within the visioning process is important when considering an intangible phenomenon such as a vision. Westley and Mintzberg (1987) identify that a vision contains elements of strategy (*e.g.* pollution, habitat protection, intra region organisation, *etc.*) and is embedded in external contexts (*e.g.* current environmental crises, prevailing cultural attitudes to the environment, *etc.*) and internal contexts (the life experiences and expectations of the participants in the formulation of the vision). Visions are contained in and should be expanded through time. As such they are tied to their own evolutionary process (Westley and Mintzberg, *op. cit.*). Within the process of creating a vision there is an iterative process of justification by which meaning is imparted to the vision and communication is achieved. Figure 3.2 is a representation of the foregoing and is a closer look at the visioning process portrayed in Figure 3.1.

There are eight key concepts for visioning, which are described by both Wilson (1992) and Stewart (1993) with reference to the corporate world. These concepts make up the vision's evolutionary process (see Figure 3.2). Strategic Visioning and FSV, although very similar in many ways are slightly different in content and are presented together in Table 3.1 so that these differences may be seen. Stewart (*op. cit.*) draws the distinction between the two when he says that FSV goes well beyond what is normally thought of as visioning. The final column in Table 3.1 is a translation of these visioning processes for use in environmental planning. Wilson and Stewart both stress that the order of the steps in the process is important.

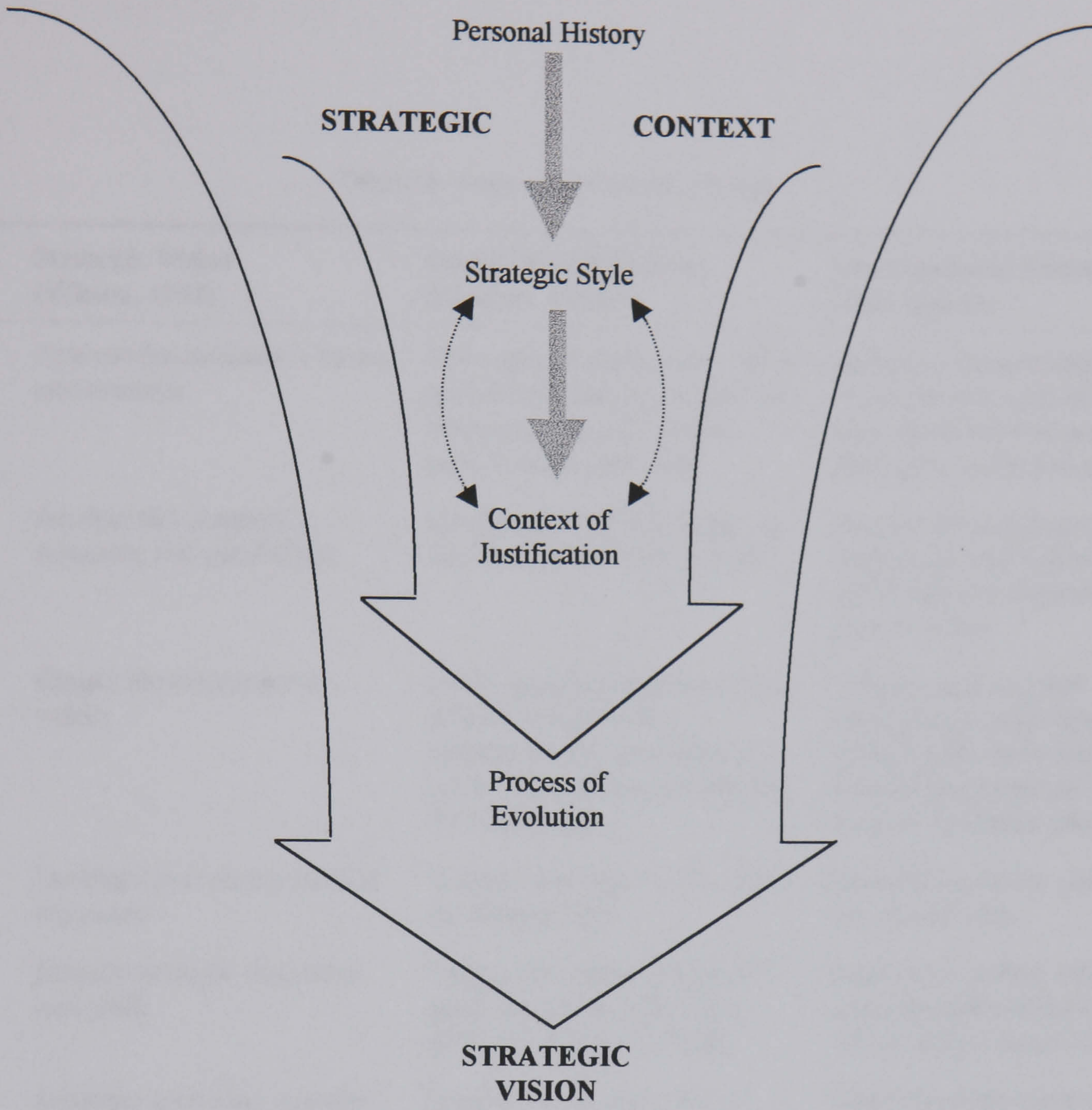


Figure 3.2: The Elements of Strategic Vision (Source: Westley and Mintzberg, 1987)

Some differences are apparent between the three columns of Table 3.1. Wilson (1992, summarised in column 1) is very focused on the particular problems for visioning in the corporate boardroom. Stewart (1993, column 2) takes a somewhat broader view. Although he is primarily interested in the visioning process as originally developed for corporations, he couches his definitions in more generally applicable terms. My transformation in the final column regains more focus, but this time on the environment, although some generality has deliberately been retained to allow for different ways of viewing the environment (whether in bioregional terms or not).

Table 3.1: Steps in the Visioning Process

Step	Strategic Vision (Wilson, 1992)	Future State Visioning (Stewart, 1993)	Environmental Visioning (This author)
1)	Analyse the company's future environment	Develop a comprehensive list of stakeholders and try to view the future state and the present state through their eyes	Compile a comprehensive list of stakeholders and identify representatives who are able to participate in the process
2)	Analyse the company's resources and capabilities	Develop a broad description of the likely future environment	Assess the likely future environment and identify topics which must be addressed in any plan or vision.
3)	Clarify the management values	Create a comprehensive vision of what we could be - disassociated from the barriers of the today, before considering the present state	Create a vision of how the environment could (should) be including the definition of the relevant geographical limits of a region or habitat specification
4)	Develop (or revise) a mission statement	Contrast the future vision with the present state	Contrast the future vision with the present state
5)	Identify strategic objectives and goals	Express the values which will guide the organisation as it seeks to achieve its vision	Express the values which will guide the stakeholders as they seek to achieve their vision
6)	Generate and select strategic options	Ensure that the vision is expressed in terms of actionable concepts	Ensure that the vision is expressed in terms of actionable concepts which are achievable at the local level.
7)	Develop the vision statement - the vision statement usually emerges in a series of stages often by iteratively going through the six key elements of strategic vision: business scope, scale of activities, product and market focus, competitive focus, image and relationships, organisation and culture	Develop the vision in a participative way by involving the main stakeholders (people inside the organisation and, if appropriate, outside stakeholders)	Develop the vision through the participation of the main stakeholders (inhabitants and exploiters of the area). This is an iterative process involving these key elements: ecological or geographical scope, scale of activities, natural resource distribution, shortfalls in natural resources, environmental ethos, management and social issues.
8)	Conduct 'sanity checks' to ensure that the vision is grounded in practicality	Avoid planning strategy or action until the vision values have been created	Ensure the vision is practical and desirable environmentally, socially and economically

3.3.1 The Vision's Stakeholders

Both Table 3.1 and Figure 3.1 demonstrate the importance of the involvement of stakeholders in the visioning process. The involvement of stakeholders is no less important in the process of environmental FSV and was expressly urged by the Rio Summit (United Nations, 1993). Stakeholder participation is important for bioregionalism, particularly in the mapping process that identifies the boundaries of the region (Sale, 1985 and McCloskey, 1993). Every region, area or habitat will have its own unique set of stakeholders although there will be certain groups which might reasonably be expected to occur in most situations. The main groups of stakeholders are shown in Table 3.2. The table is divided into those who should be directly involved in the environmental visioning process and outside bodies or groups who have an interest but are not directly connected to the proposed region[1].

Table 3.2: Major Bioregional Stakeholders who must be considered in the FSV Process

Directly Involved	Indirectly Involved
• Residents	• Absentee landlords
• People dependent on the region's natural resources	• National authoritative bodies (e.g. water or agriculture regulatory bodies)
• People who derive their livelihood from other activities dependent on the region (e.g. tourism)	• National government (in as much as it has the power to officially recognise a bioregion as an operational entity)
• Local government and political groups	• Inhabitants 'upstream' of the region
• Floral and faunal communities	
• Inhabitants 'downstream' of any outputs from the region	

It is very difficult to involve all stakeholders at all levels of the visioning process but it is essential that their needs are always considered. It is for this reason that floral and faunal

1 Note: the word 'region' is used here, as elsewhere in preference to 'habitat' or 'environment' because this thesis is about bioregionalism. The context of this piece can be widened by substituting the appropriate word in place of region, particularly for a more specific visioining task such as a vision for a village common.

communities are included in the list above. It may, at first sight, seem rather bizarre that biological communities should be listed as stakeholders. Building on the concepts of the rights of nature and the imperatives for humankind to respect and preserve the natural environment through stewardship, particularly of environmental services, it becomes clear that components of the natural environment must be considered as stakeholders if the environmental visioning process is to avoid becoming overly anthropocentric and utilitarian. Although, who should or could act on behalf of the biotic communities with impartiality is a separate issue.

A second imperative for ensuring the participation of stakeholders is that action is only achievable through the motivation of interested parties (Stewart, 1993). People have a sense of ownership in a vision that they helped to create and a shared vision is a much more powerful force for change than one that has been imposed. Although participation is stressed by many commentaries on planning and visioning, Stewart (*op. cit.*) warns against falling into the usual trap where visionning is portrayed as the sequential process:

Vision ⟶ **Communication** ⟶ **Action**

As Stewart states "Such a separation of action from the visioning is hierarchical and *disempowering*". By which he means that the stakeholders have no sense of ownership of the vision and that, effectively, it has been imposed in a top-down manner. The above sequence is, unfortunately, advocated in Westley and Mintzberg's (1987) working paper comparing the strategic vision styles of Levesque and Iacocca[2].

An effective vision must 'cover all the angles' and engender a sense of common ownership in the people it effects. There is also a third imperative of participation to ensure that all sources of knowledge are tapped and given due consideration. It is a truism that knowledge is power but equally importantly different groups within the list of stakeholders will have different perceptions and knowledge, often about the same aspect. A full picture can only be built when all the

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2 Rene Levesque was the creator of the political group 'Parti Quebecois' whose vision was for government of Quebec. Lee Iacocca became president of the Ford Motor Company in 1970, was fired and later became president of the Chrysler Corporation in 1978 when he was responsible for a dramatic turnaround in the company's fortunes (Westley and Mintzberg, 1987).

sources of information have been brought together and the importance and value of local or 'native' knowledge should never be underestimated (Chambers[3], 1983).

3.3.2 Science by Consensus

The literature by social anthropologists and environmental historians shows that practically all human societies have and are in negotiation with their worlds to try and guarantee the society's future continuation (O'Riordan, 1995). However, modern Western society seems to have reached a stage of dysfunction in this respect (McBurney, 1990).

> *"But in order to take part in modern civilisation it is necessary at the same time to take part in scientific, technical and political rationality, something which very often requires the pure and simple abandon of a whole cultural past. It is a fact: every culture cannot sustain and absorb the shock of modern civilisation. There is a paradox: how to become modern and return to sources; how to revive an old dormant civilisation and take part in universal civilisation."*
> from Paul Ricoeur (1961) *Universal Civilisation and National Cultures*, History and Time, (quoted in Frampton, 1983)

The extent to which the urban-centric majority lack any feeling of direct links with "The Environment" may preclude them from meaningful negotiation in this way. Early societies, on the other hand, with a more intimate knowledge of the resistances and opportunities afforded them by their local environment, enabled them to evolve rules of social behaviour and mechanisms for contending with difficulties in times of hardship (O'Riordan, 1995). To restore this process of negotiation we must reassert the notions of "living in place" and of human stewardship of the earth. The basis of this stewardship is enshrined in most culture and religions, for example Christianity and hence much of the Western world (Genesis 1.26, 29; 2.15. The Bible) or Greek mythology (Xenophon writes in the fourth century BC that the earth is a goddess who provides good things according to the care and service accorded to her; Sale, 1984). It is only more modern economic-based philosophies such as Socialism and Capitalism that disregard stewardship.

Clearly there is a difficulty in resolving the differences between belief systems and fields of study. However, the important point is that a community's response to the environment, and hence its response to environmental management proposals, is culturally driven. In the example of Easter Island an extreme example was shown of how cultural forces completely overrode any thought of environmental protection, even to the Islanders' own detriment. Understanding a

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3 Chambers (*op. cit.*) devotes a whole chapter in his book "Rural Development: Putting the last first" to the subject of knowledge, its sources and the relative values of those sources.

place in scientific terms is not necessarily meaningful to the place's inhabitants. Therefore, a consensus must be sought between the scientific community and the local population.

3.3.3 Describing the Likely Future Environment

The development of a broad description of the likely future environment is an important and sometimes difficult task. There is a tendency to simply turn to outside experts in relevant fields for direction. Both Stewart (1993) and Chambers (1983) warn against this because of the tendency for the vision to then follow the agenda of the expert and not the stakeholders.

Exploration of the possible future state of the environment should not be a brainstorming session. There needs to be some organisation around clearly identified topics (Stewart, 1993) on which information is sought from the accumulated knowledge of the stakeholders and, if necessary, other additional expert sources (for *advice* not direction; as Wilson, 1993, puts it: "Considerable value can be added by the judicious use of diverse contributions, including those of informed outsiders"). The identification of the topics is, itself, part of this step. The list of topics will vary depending on the situation. The list of topics for, say, a certain area of countryside might include 'imported' pollution, 'exported' pollution, ecological community composition, tourism, the type and extent of agriculture, its associated practices and other forms of enterprise which the area supports. This list is by no means exhaustive but serves to illustrate some of the topics which might be considered important. Participants should then produce visions about the desired future. It is important that these are indeed visions and not trends. The predictions help to form the basis of discussion in the preparation of the vision. Assessing the future environment in this way helps to sensitise participants for the next step and the identification of topics and issues helps provide direction to what could otherwise become a chaotic experience when an attempt is made to create the vision.

3.3.4 Creating the Vision

Creating a vision of how the environment could (should) be is the step in the visioning process which sets it apart from traditional planning (Stewart, 1993). During this step the participants need to clear their minds of current trends. By doing so, the scope of the potential vision is expanded, flexibility is increased and the imagination is released. Wilson (1992) cites failure of the imagination and a lack of flexibility as two of the major pitfalls in the path of participants in the visioning process. Consider the traditional question posed to many an applicant in the course of a job interview "Where do you see yourself in five years?". The answer will be based on extrapolation from the current situation in which the applicant finds themselves. Now consider the subtly different question "Where would you *like* to see yourself in five years?". In answer to this question, the applicant might make a leap of imagination and present the interview board with a vision.

When creating a vision it is often more successful if the system in question (the corporation, the bioregion, the ecosystem) is broken down into sub-systems (Stewart, 1993). The vision can then be expressed in terms of actionable concepts in the form of "What must happen to subsystem X for it to produce the desired feedback to subsystem Y that is necessary for achieving the desired future state". To maintain the advantages of a holistic approach the components must be 'reassembled' before constructing the final vision. It is helpful at this point to consider a slightly more specific environmental example used by Baxter and Fraser (Centre for Environmental Studies, 1994) in an exercise for Tweed Forum:

Imagine an area (a section of a watercourse, say) and how it would be ideally. This gives the macro-level vision. The macro-level vision will include the definition of the relevant geographical limits of a region or habitat specification. From this picture there proceeds three questions:

1. What needs to happen within the area for it to become the vision?
2. What must happen upstream of the area to achieve the desired state?
3. What must happen downstream of the area to achieve the desired state?

The words 'upstream' and 'downstream' can either be taken literally as in this example or they can be taken to mean neighbouring subsystems within a hierarchical structure.

3.3.5 Contrasting the Vision of the Future with the Present

Stewart (*op. cit.*) warns against the temptation to skip this step and move straight to planning. The faults in the present state readily become clear in contrast to the better future vision. The future vision and the present state are like the two ends of a piece of string, or the start and finish lines in a race. It is only by first knowing exactly where these two points are that it can ever be hoped to chart a course between them.

A vision should draw out of the stakeholders the desirable future, or what they want. It is at this stage where the visioinaries can see whether their vision is negative or positive. The desired future will often differ from the predicted future. It is tempting to create a vision by identifying those aspects of the predicted future that are undesirable and to be avoided if possible. This is a negative vision (Centre for Environmental Studies, 1994). Negative visions do not build and are not creative of a new future. The purpose of negative vision is to constrain the future by directing effort into preventative action. A negative vision is one to be avoided as it is responsive only and not proactive, disappearing when the threat which conceived the negative vision has gone (Senge, 1990).

3.3.6 Developing the Vision by Underpinning it With Values

There is a strong need to articulate the values that will guide the stakeholders as they seek to achieve their vision. A vision might be very far-sighted and inspirational but, if its values are at odds with the values of the stakeholders, it will never become reality. Both Stewart (1993) and Chambers (1983) warn of the dangers of such a conflict. Values are made up of beliefs, philosophy and principles. Most commentators agree that visioning is a values-laden process which, in itself, can be unsettling for managers who are more conventionally trained to avoid value judgements.

Sometimes it may be necessary to formulate new philosophy and principles to achieve the vision. This is why it is important to formulate the vision first, unfettered by the constraints of potentially inappropriate values (Stewart, *op. cit.*). For instance, when the European Ecolabelling Scheme was formulated there was no mention of reclamation because it is not part of the prevailing culture. However, it may be considered a laudable value for sustainability (Stevenson and Ball, 1998). Reclamation would need to be expressed as a value by the bodies formulating the Ecolabelling Scheme if it is ever to be included. Stevenson and Ball (*op. cit.*) also discuss how values and meaning (particularly of materials) can vary from culture to culture. In a similar way, it is to be expected that values will differ between stakeholder groups and a common framework of values must be developed through a shared philosophy as is shown in Figure 3.3.

In Figure 3.3 the different sets of values of four imaginary stakeholder groups are represented. The dark shaded area shows the extent to which the values overlap. Group C might be considered to represent the prevailing culture's values in that its values are almost entirely shared by one or more of the other groups. Group D might represent a pressure group which has a specific focus (and hence the narrow definition of its values). The vision, as formulated by the combined efforts of the groups may enter territory which has not previously been a part of the culture of any of the groups and the light shaded area shows this. The groups must now combine to articulate the range of values which they all hold for the sake of the vision.

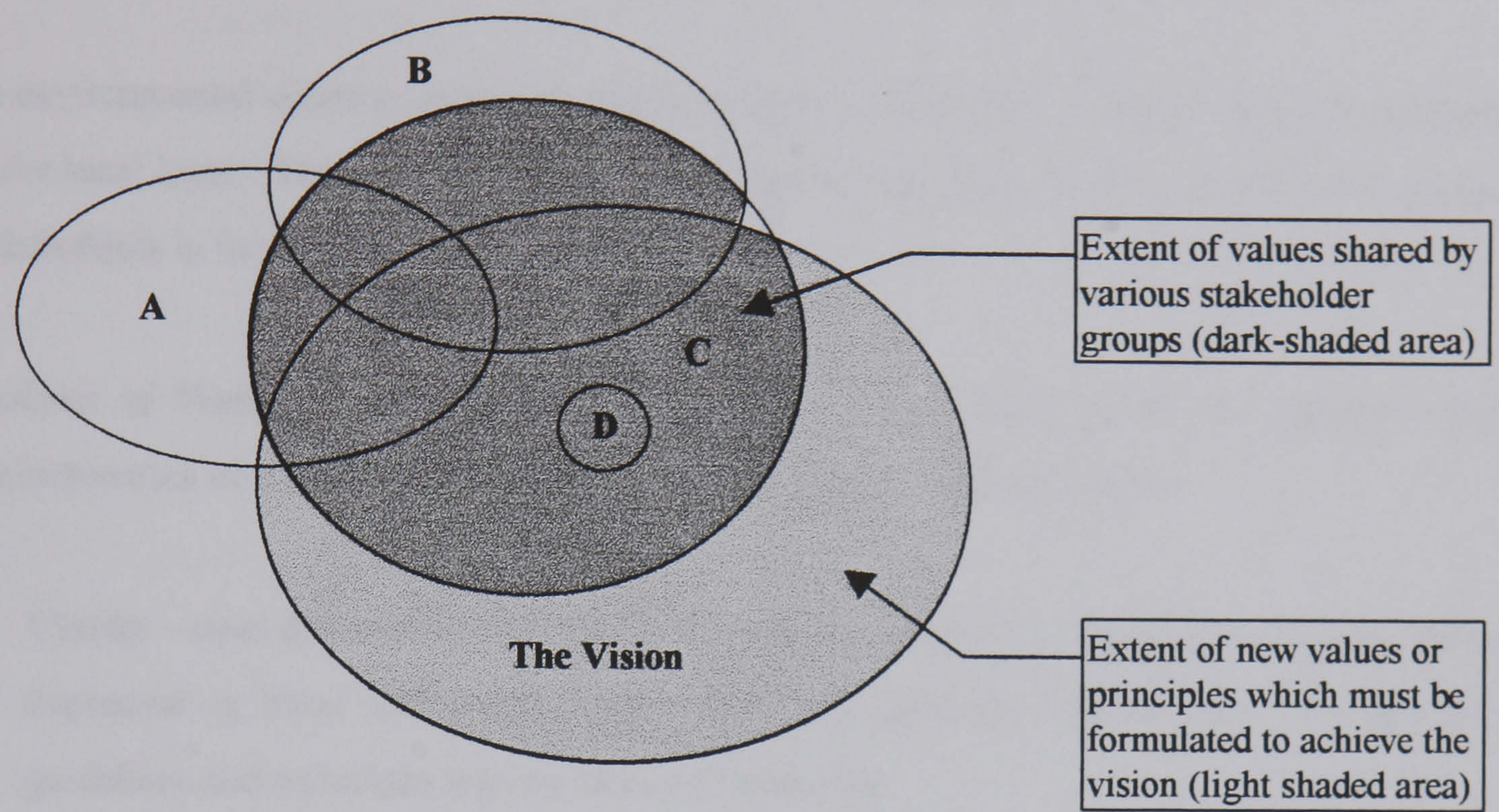


Figure 3.3: Overlapping sets of values of the stakeholder groups (A, B, C and D) showing the degree of coincidence and the extent to which new values may need to be formulated to achieve the vision.

A final note on the subject of expressing the values and principles on which the vision is based is to say that they must be expressed, like the vision itself, in actionable terms. To be powerful and meaningful it must be possible to act upon the principles. Consider the following two similar principles:

1. Pollution is a bad thing
2. Where ever possible, the harmful emissions of activities in the area will be minimised

The first statement is crude and not actionable. The second is much more powerful and is directly actionable.

3.3.7 A Vision Must Become Action

Wilson (1992) identifies a failure to implement a vision as the ultimate pitfall faced by the visioning process. A vision is only as good as its implementation. Without action a vision remains nothing more than an interesting statement of an imaginary future.

An environmental vision must be expressed in terms of actionable concepts which are achievable at the local level. There can be nothing more empowering than the capacity for direct action by stakeholders in the furtherance of their own vision.

Analysis of Westley and Minztberg (1987) and Wilson (1992) reveals the following paired characteristics of a successful vision (keywords are denoted by bold type):

1. **Clarity** - even if the underlying analysis is highly complex, it is important that the vision is expressed in clear and precise terms if it is to generate commitment. A clear set of guidelines and intentions into the future form a **plan**.
2. **Coherence** - a good vision must have internal consistency but also must be able to relate to the world as it is. If a vision lacks coherence then it will not be able to stand up to scrutiny. Coherence is based on a clear understanding of the system's **position** in an environment (whether the business environment or the natural environment).
3. **Communications Power** - A vision needs to be able to 'speak' to the stakeholders and the proposers of the vision need to be able to articulate the importance of successful completion of the vision. Without communication a vision will remain a mystery if it is known of at all. Good communication is the key to the presentation of the **perspective** of the combined 'culture' of the participating stakeholders.
4. **Consistency** - The actions that are taken by people guiding the execution of the vision must be consistent with the original aims and objects of the vision. Consistency can be seen in and dictates the **pattern** of actions as they are realised. Inconsistency with the vision statement is a destructive force to be avoided.
5. **Flexibility** - flexibility is a caveat to consistency. Slavish adherence can be equally destructive to the furtherance of a vision if it becomes unable to respond to new situations arising from unforeseen change in a neighbouring system. Flexibility can be seen in the **ploys** that are used to overcome short term obstacles in achieving the long term objectives of the vision.

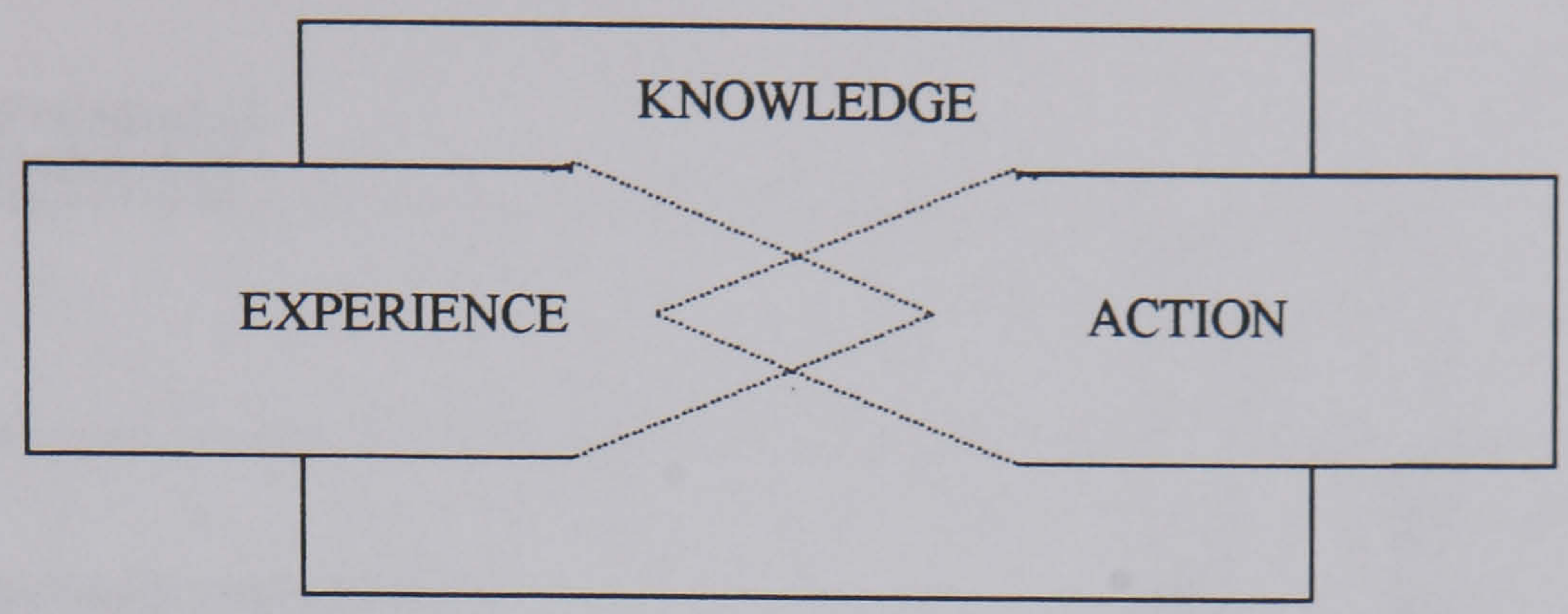
3.4 WHY IS FSV IMPORTANT FOR ENVIRONMENTAL PROBLEM SOLVING?

The way in which we understand and relate to the environment is important for how we interact with it. Granö (1981) suggests a phenomenological basis of geographical science and how experience, knowledge and action form a unity with the environment (Figure 3.4). However, experience, knowledge and action are not seamlessly intertwined because they each operate at a different level of understanding the environment. Experience is the direct sensation of the environment and this provides some basis in fact for the bioregionalist's asertion that, only through 'living in place' can the environment be truly understood and sympathetically managed. This is the level of the perceived environment. At another level is the way in which we understand the environment from a scientific standpoint, or knowledge base. This is a much less immediate understanding of the environment and is subject to change according to prevailing scientific and geographic theories. Finally, there is the level of the real environment and mankind's true ecological relationship with it. It is at this level, of course, at which action takes place. Action transforms the environment to a greater or lesser degree. Changes in the environment return feedback, through their perturbations, to the experience-knowledge-action trinity.

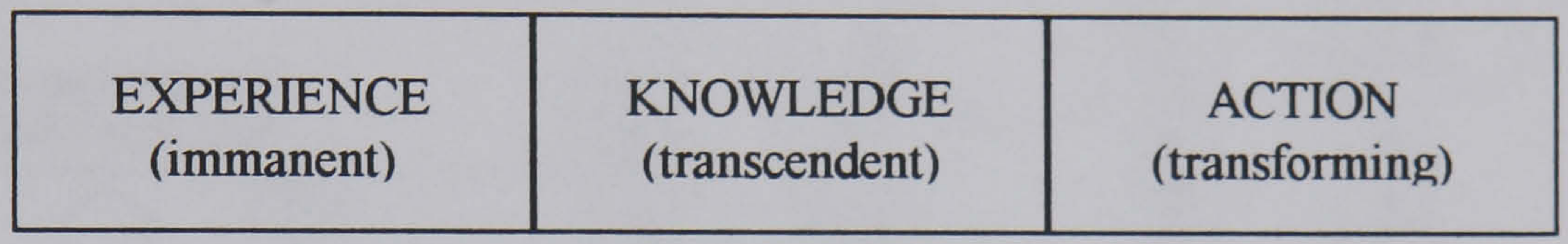
Figure 3.5 is a development of Granö's (*op. cit.*) representation of how the environment is understood but shows how visioning, through the application of an appropriate lens can break the iterative cycle of reactive planning and move towards a new future state. To do this, however, a concept of the desired future state must first be formulated. This must first be at the experiential level, not least because of the involvement of non-expert stakeholder groups. This is the 'lens' through which the future environment is viewed and by which that future may be communicated back to the stakeholders. The important point is that this process looks forward to the future. All other planning techniques look backwards to the current perceived environment.

The vision needs 'fleshing out' and it is here that expert assistance can be brought in. By acting through the lens, this maintains the link between the cultural context of the stakeholder social groups and the factual content of the environment. Additionally there must be action to move towards the desired future environmental state. However, it should be clear from Figure 3.5 that action is initiated at the same level as the experience that creates the lens and knowledge, which develops the vision. In this way the sequential hierarchy which can sometimes separate action from vision (Stewart, 1993) is avoided.

(a)



(b)



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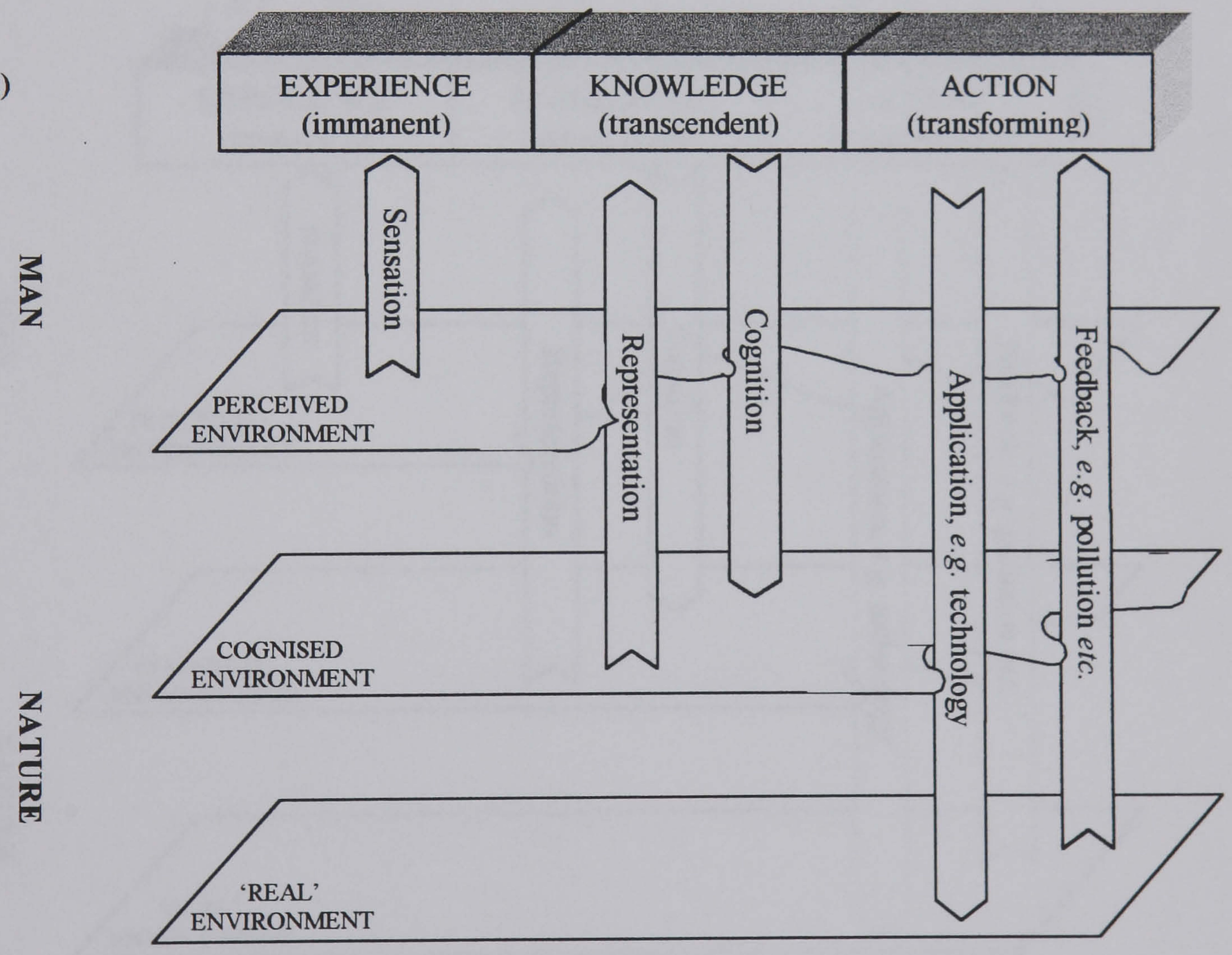

Figure 3.4: Structure and process of geographical enquiry (Granö, 1981). Experience, knowledge and action form a unity with the environment.

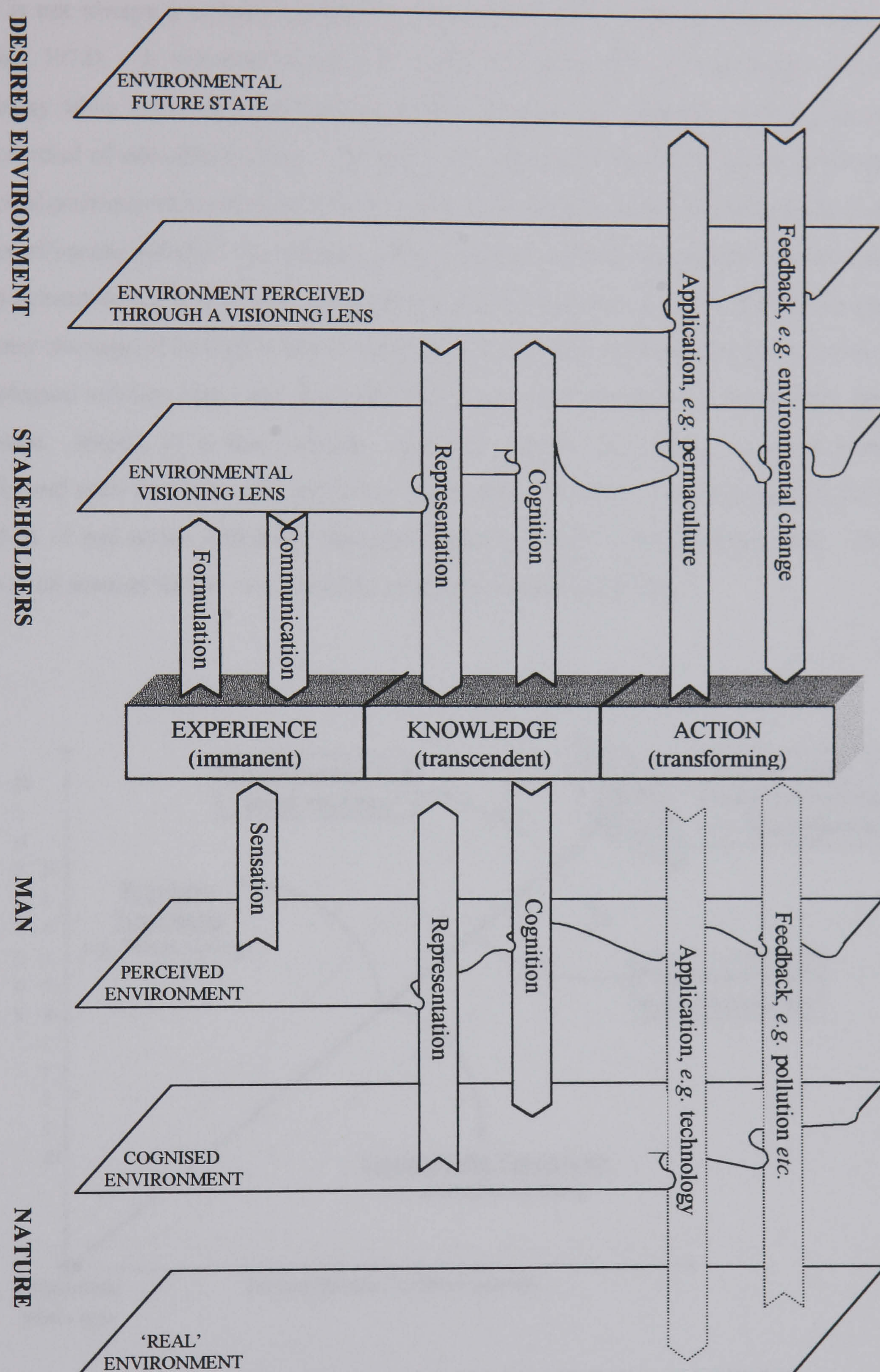

Figure 3.5: Visioning, through an appropriately formulated lens, can break the cycle of repetitive incremental planing and allow transition to a new desired future state. This diagram builds on Granö's (1981) thesis of the human logico-functional relationship with the environment.

There is not always a technical solution to the environmental problems faced in many areas (Hardin, 1978). A visioning exercise is needed to see beyond current trends focused on technology while acknowledging that it is neither practical nor desirable to try to return to a pastoral ideal of subsistence living. The latter more often treat the symptoms of environmental and social problems rather than the causes, many of which result from the perturbations between spheres of human activity. For instance, efficient water transfer with equitable distribution may satisfy present demands of an area and even alleviate the symptoms of a drought but the cause of the water shortage, if through a lack of rainfall, is not treated. Seeding clouds may seem like a technological solution that treats the cause but the cause of the lack of rain has still not been addressed. Indeed, as in this example, maybe the cause of a problem cannot be addressed directly and such an eventuality requires a vision of a new future. In this example the vision would be of one where a naturally plentiful supply of water is not an expectation. The new vision must account for the new, lowered, carrying capacity of the area.

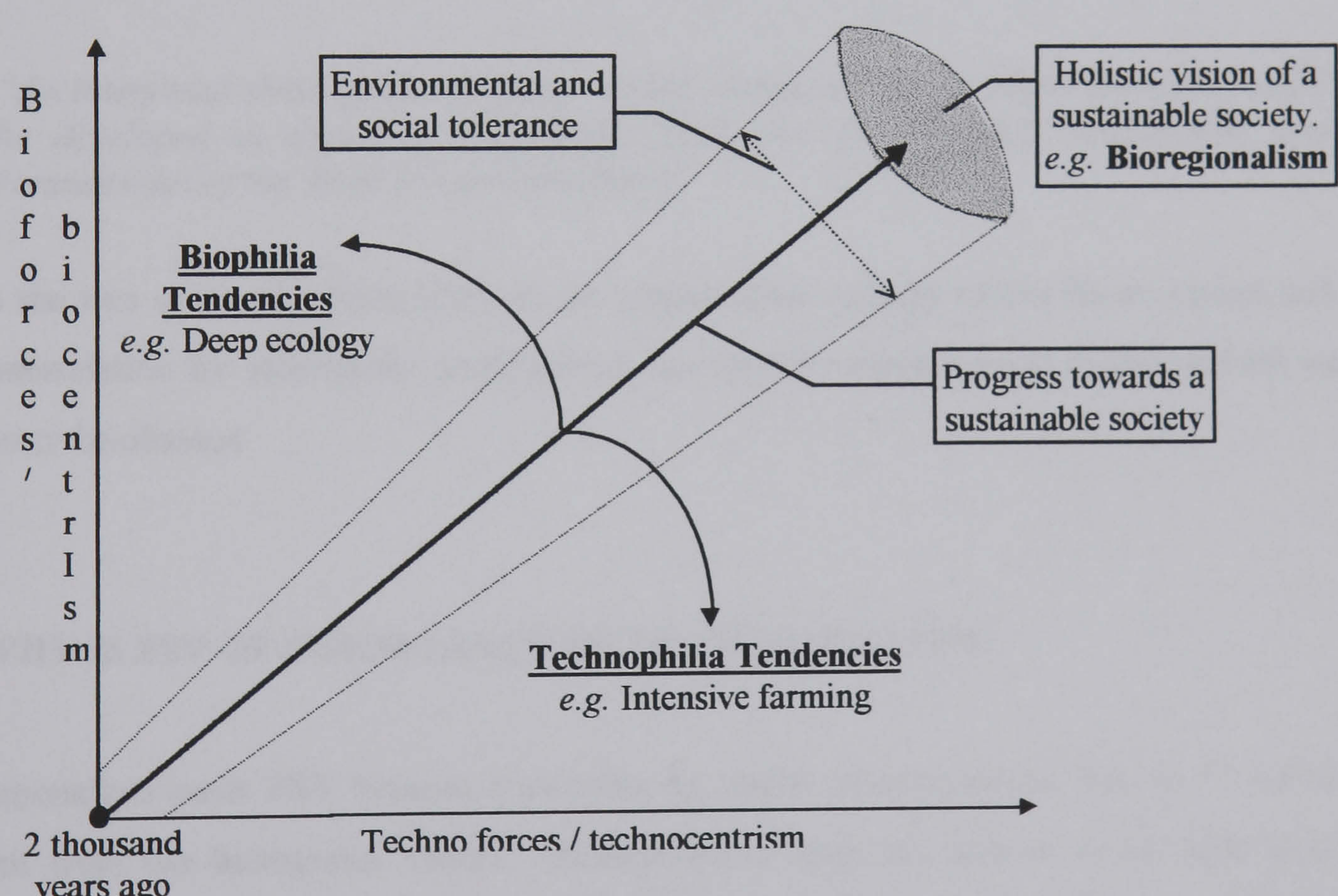

Figure 3.6: Progress towards the vision of a sustainable society such as bioregionalism is a balance between the opposing forces of biocentrism and technocentrism (after Baxter, 1996).

There are benefits to be gained from a balance of technology and a more biophilic approach. A visionary process is necessary to achieve the balance of these, essentially opposing, forces. These forces, as represented in Figure 3.5 are just one (particularly important) pair of opposing forces which could effect the vector of an environmental vision. Environmental planning rarely starts with the creation of future vision and is usually of an incremental nature. The interconnectivity of environmental systems and the potential for current actions to have consequences which reach far into the future means that visioning is necessary for powerful environmental planning. In 1994, the UK/North American Countryside Stewardship Exchange Team was invited by Tweed Forum[4] to look at its conservation and interpretation strategy (Centre for Environmental Studies[5], 1994). The team found that the, then, current arrangements were vulnerable for two reasons:

- responsibilities and leadership are vested in a relatively small number of people
- there is no shared vision and integrated written strategy for the future

Furthermore, the CES report (*op. cit.*) quotes the Exchange Team recommendations that:

> *"An integrated strategy based upon a broad consensus among major interests should be developed to ensure a sustainable future for the economy, environment and communities of the River Tweed Catchment."*

From the two areas of vulnerability of the conservation strategy of the River Tweed and the recommendation for stakeholder participation, the case for visioning and bioregionalism would appear to be obvious.

3.5 WHY IS FSV OF IMPORTANCE TO BIOREGIONALISM?

Bioregionalism needs FSV because it provides the means of defining the 'corridor' back to the present from the bioregional vision. Bioregionalism does not appear to be achievable by incremental change from the present and can, therefore, only be truly conceived through the

4 Tweed Forum is an organisation which was formally set up in 1990 to encourage the sustainable development of the River Tweed and its catchment area. The membership of Tweed Forum was composed, at the time of the workshop, largely of land owner/user federations, quangos, environmental protection agencies and Councils.

5 The Centre for Environmental Studies (CES) was a research group within the Faculty of Design at the Robert Gordon University (RGU), Aberdeen. CES has ceased to exist as a body in its own right although many of CES's research interests are continued within various Schools at RGU.

visioning process. A look at the FSV process gives a strong suggestion of how the process of bioregional visioning might be achieved. Bioregionalism defines the vision. Environmentalism shapes the principles.

To propose bioregionalism is to propose a vision of the future which is not based on extrapolation from the present but is a new state based on principles which are considered desirable for a holistic way of living which is consistent with environmental sustainability. A criticism often levelled at bioregionalism is that proponents are strong on the vision but weak on the process (*e.g.* Frenkel, 1994 and Parsons, 1985). In a way their criticism is justified because most of the bioregional literature can be divided into three camps. The first is the purely visionary *i.e.* *'A bioregional world will look like this and contain these elements and here is why this is good'*. The second camp is made up of more pragmatic descriptions of how a particular group is trying to make bioregionalism work in their locality. The former camp is vision without process. The latter camp appears on initial inspection to contain both vision and process but the vision is almost invariably retrospective, and in American literature the vision is usually grounded in a perceived state of harmony achieved by American Indians with their environment before European settlement (*e.g.* Brown and Tobias, 1988 or McGinnis *et al.*, 1999). There is a third camp or group of bioregional literature which concerns itself with the important process of mapping and defining a bioregion. Most of this literature is rooted in the present.

A problem with much of the bioregional literature is that it lacks internal consistency. The broad vision is usually conceived in terms of Kirkpatrick Sale's (1985) definition and taxonomy of bioregions. Articles often then proceed, particularly during the mapping process, to ignore parts of what constituted the vision. That is not to say that the spirit of bioregionalism is necessarily lost but the pattern is distorted (see section 3.3.6) but consistency and clarity are essential to credibility. Conscious bioregionalism is a comparatively new philosophy. Some might argue it is a very old philosophy which is being rediscovered but, whichever standpoint is adopted there is considerable communication to be done to elucidate both the generalities of the philosophy as a whole and the specific of bioregionalism to a given area and its inhabitants.

Social and economic change is important for bioregionalism and any FSV exercise where the vision is located in the distant future. Cultural change was achieved through the visioning process by Rene Levesque in Canada to put Quebec in the position we know today (Westley and Mintzberg, 1987). Figure 3.7 shows the progression that must take place to achieve a bioregional ideal. Bioregionalism is not alone in its calls for social and economic change. These are themes which are current through all deep ecology philosophies (see Naess, 1989) which require a paradigm shift within the structures of society, land use, political and economic policy (Dobson, 1990).

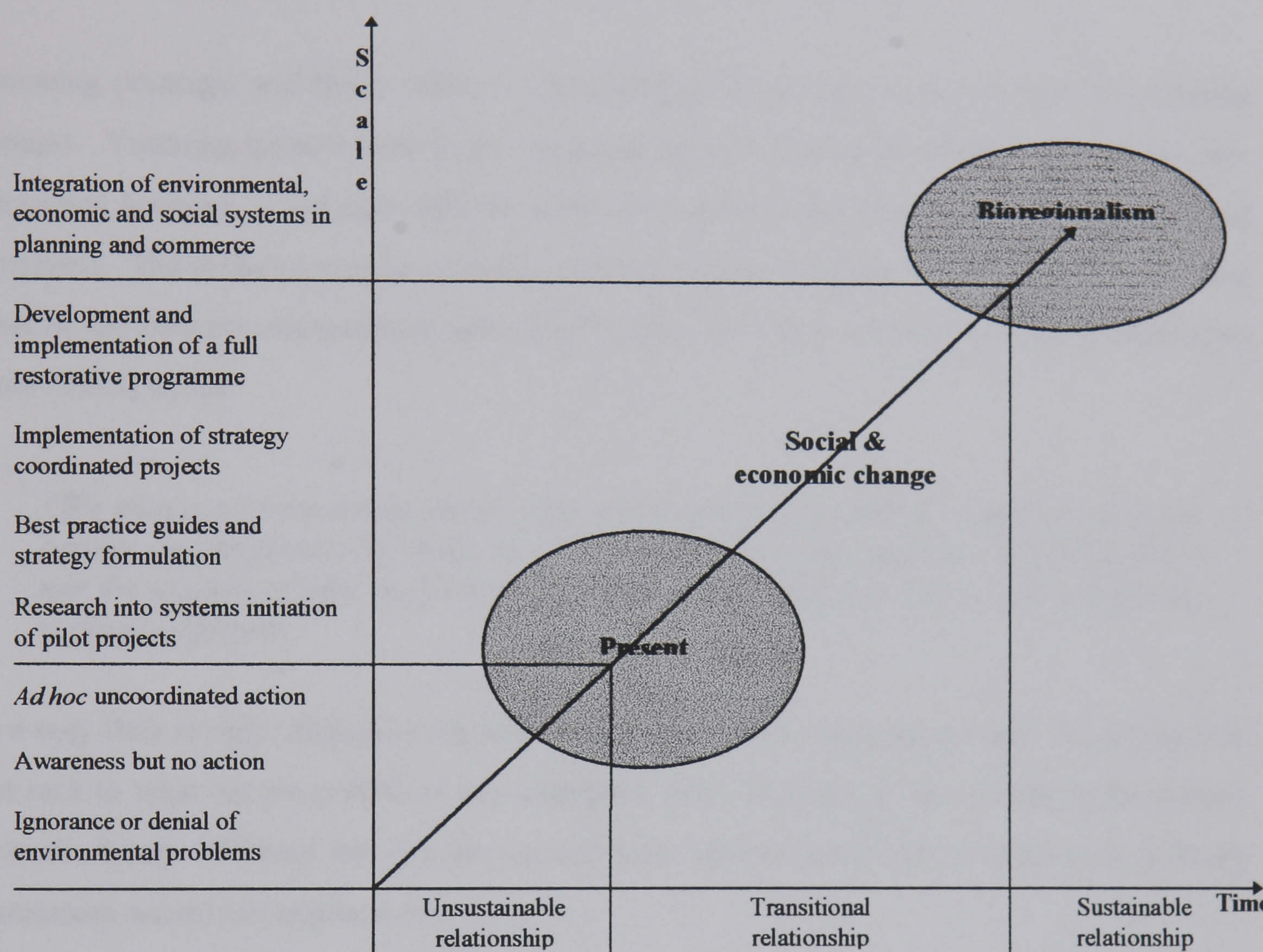

Figure 3.7: A representation of social and economic change towards sustainability through bioregionalism. Adapted from Alexander and Talbot (1996).

Bioregionalism needs concerted community action and participation at all levels. FSV can provide the guidance and foster group cohesion for this. FSV is a powerful tool that can help to bring about the change through the process of participation in the exercise and the community implementation of the action plan. Boggs (1986) writes in his appraisal of a number of important environmentalist texts thus:

> *"Surely none of the Green-inspired writers*[6] *being reviewed here would quarrel with Andre Gorz's injunction* [in "Paths to Paradise", 1985] *that "There are times when because the social order is collapsing, realism consists not of trying to manage what exists but of imagining, anticipating and initiating the potential transformations inscribed in present change.""*

3.6 FSV REDEFINED FOR ENVIRONMENTAL VISIONING

Visioning (strategic and future state) is a powerful tool that can be used to help the planning process. Visioning appears to be highly regarded but little assessed (and often not understood). Visioning, however, is radically different from conventional futurology, which is predictive and prophetic. The evidence suggests that the visioning process is clearly not understood or utilised even by the very environmentalists who need it most. This fact is thrown into stark relief when Daly (1988) writes:

> *"We must start from where we are, these historically given initial conditions, and not assume an unrealistically clean slate. We have neither the time, nor the leadership, nor the wisdom to wipe out existing institutions and start over again with something radically different."*

In a way Daly is right, despite having missed the point of the visioning exercise. Visioning does not seek to wipe out the present in any unrealistic way. It charts a course back to the present from the future. Without this process we will never have the leadership or wisdom to radically restructure society in positive ways.

It can be concluded that a bioregional vision is unlikely to arise out of incremental planning based on current trends (*e.g.* globalisation) although there are signs that a shift of power to the regional level is becoming recognised as potentially desirable (McRae, 1994), a trend which may also be perceived in the field of planning (Haughton, Rowe and Hunter, 1996; Alexandra, 1996 and Diffenderfer and Birch, 1997).

A process of 'Environmental Visioning' can now be drawn out of the preceding material, following the translations from the corporate business world. If the diagrams throughout this chapter are drawn together and their ideas distilled the process emerges and is shown in the Figure 3.8.

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6 The writers in question are Rudolf Bahro, Fritjof Capra and Charlene Spretnak, Petra Kelly. Jonathan Porritt, Kirkpatrick Sale

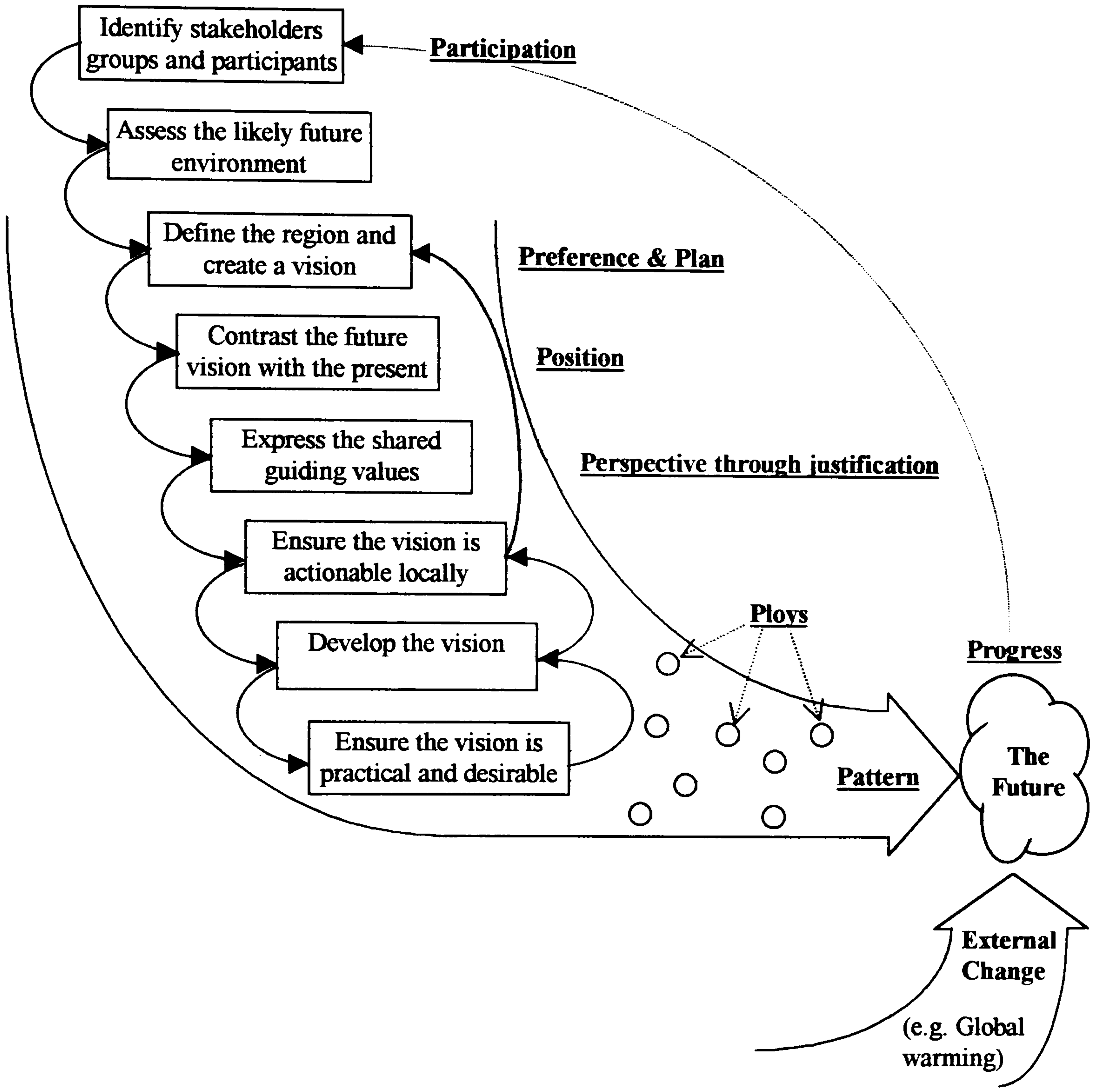

Figure 3.8: The Process of Environmental Visioning

Any environmental visioning process must begin by identifying the stakeholder groups. What follows is a cascade of the eight steps (Figure 3.8). There are some retrograde steps in the cascade which illustrate that certain steps may prove to be iterative.

Once a workable, desirable vision has been created, progress towards it is not necessarily a simple linear conception-implementation process and short-term ploys may need to be employed to overcome difficulties (localised in time or space). Ploys are strategies that are localised either geographically or temporally and are instigated to overcome a local obstacle to progress towards the vision. So long as these ploys can be clearly identified as being consistent with the aims and principles of the vision, the pattern of the vision can be maintained and its progress sustained along the lines originally conceived for it.

This means that any visioning process must be cyclical (Figure 3.9), with periodic reassessment of the vision and creation of new visions to meet the current perception of future needs.

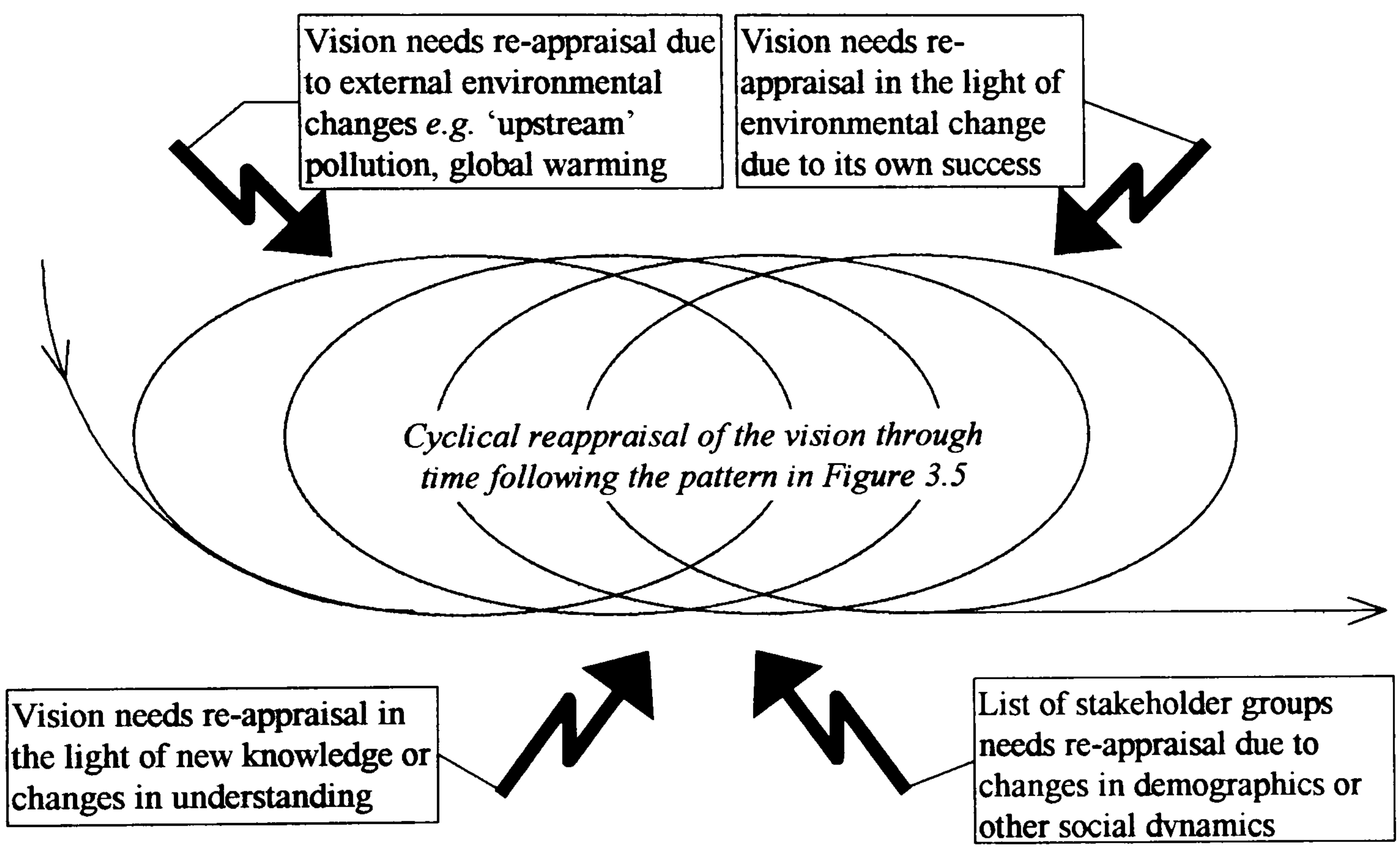

Figure 3.9: The Environmental Vision must be constantly re-appraised through time due to external influences, sometimes identifying new stakeholder groups.

The future, as it actually will be, is obscured from the visionaries because it must always be remembered that forces of external change may often be more powerful than the forces for change which arise from the vision. Furthermore, external change may be beyond the control of the visionaries. The way the future state, when it has been reached, is viewed depends on the stand point of the people assessing it. That standpoint is unlikely to be the same as that of the original visionaries as knowledge, understanding and cultural attitudes change through time.

The power of the visioning process comes from its ability to free the thinking processes of stakeholder groups, to address the needs of those stakeholders at the local level in a way that is appropriate to them and following principles which are held, as part of the vision, commonly by all the stakeholders. The visioning process then 'opens a corridor of possibilities for change' back to the present. Such freedom of thought and powerful impetus to action is essential to environmental planning in general, beleaguered as it is by the current technocentric short-term financially oriented gestalt. It is even more important to bioregionalism which is still new enough that it must prove itself before acceptance into mainstream thought.

3.7 THE OVERARCHING BIOREGIONAL VISION

Social and ecological crises are deepening. Fundamental change is essential sooner rather than later to ensure the preservation of biodiversity. Without such change in attitudes and practices such preservation, including survival of the human species, is in doubt. The immediacy of the situation, in global terms, is evidenced by events such as the Earth Summit in Rio actually taking place. Coupled with this, are the findings of the Club of Rome in their controversial publication "The Limits to Growth" (Meadows *et al*, 1972 and Naess, 1989). Bahn and Flenley (1992) elaborate on these findings in their prediction of the future of this planet, assuming no alteration of attitudes, using the fate of Easter Island as a parable.

Berry (1988; pp. 166 - 168) has proposed six functions that are necessary for bioregional living. This provides the necessary worldview of bioregionalism. In the following section all the quotes are from Berry's exposition of the functions of bioregional living (unless stated otherwise).

3.7.1 "Self-propagation"

> *"The first function, self-propagation, requires that we recognise the rights of each species to its habitat, to its migratory routes, to its place in the community. The bioregion is the domestic setting of the community just as the home is the domestic setting of the family."*

This is a laudable ideal particularly when we think of examples of power lines, roads and cities that take up the traditional ranges of many species. A simple but graphic example of both the problem and the response is the frequency of cases where special toad-tunnels and badger crossings have been put under roads up and down British roads.

3.7.2 "Self-nourishment"

> *"The second bioregional function, self-nourishment, requires that the members of a community sustain one another in the established patterns of the natural world for the well-being of the entire community and each of its members. Within this pattern the expansion of each species is limited by opposed lifeforms or conditions so that no one lifeform or group of lifeforms should overwhelm the others."*

Berry falls deeply into the trap of environmental anthropomorphism with his second function of the bioregion. It is impossible for humans to "require" that nature behaves is any particular way and it is both gross arrogance to attempt to phrase such a requirement and contradictory to bioregionalism's tenet of the equality of the rest of nature with humans (i.e. what right do humans have, bioregionally speaking, to articulate requirements of Nature). On a more practical note, there are other flaws in the presumed intent of Berry's statement. The first is that, by "the established patterns of the natural world" presumably Berry means ecological competition that is often far for being "for the well-being of the entire community". Mutualism and symbiosis both do exist in the natural world (the former much more so than the latter according to the strict definition of the words in ecology). However, altruism and the sacrifice of an individual's or a species' growth are traits which are restricted to humans (Dawkins, 1976) and some would say, even then, rarely. It is hard to accept the notion of species within a community actively sustaining each other "world for the well-being of the entire community and each of its members". Traditional ecologists see the situation more akin to an arms race where the relationships between the predator and the prey are stable because the prey is always one step ahead (Krebs and Davies, 1981). It must be so; otherwise the prey rapidly becomes extinct. Furthermore, that "no life-form should overwhelm the others" is in direct contradiction of the established principal of ecological succession (for an explanation see Begon *et al*, 1986). Ecological succession is an "established patterns of the natural world" and there is no logical reason why or how it could be suspended without massive human intervention which would go against the spirit of bioregionalism. Berry must therefore be referring only to climax communities because the progress to a region's natural climax community is precisely by groups of "life-forms" overwhelming each other but this excludes communities which have not reached climax as being somehow un-bioregional. Alternatively, Berry may be suggesting a curb on human excesses in which case he should say so because it is not possible and entirely pointless to try to legislate or moralise the natural environment.

3.7.3 "Self-education"

> *"The third function of a bioregion is its self-education through physical, chemical, biological and cultural patterning. Each of these requires the others for its existence and fulfilment. The entire evolutionary process can be considered a most remarkable feat of self-education on the part of the planet Earth and of its distinctive bioregional units . . ."*

This presupposes that the planet Earth is to some degree self-aware and that evolution is an almost conscious process. Berry's third function of bioregionalism requires acceptance of a Gaia-centred spiritualism or, at the very least, animism. There is not space here to do justice to the complicated subject of environmental theology and 'eco-spirituality'. Suffice to say that "self-education" is a long way from "self-organisation" although, even disregarding entropy, evolution, whether it is taken to be self-education or organisation, is indeed a most remarkable feat! It would, perhaps have been better to phrase this sentiment as a requirement on humans to appreciate the necessary interplay between the biological and physical worlds. In other words, to understand ecology and minimise interference with it.

3.7.4 "Self-governance"

> *"The fourth function of the bioregional community is self-governance. An integral functional order exists within every regional life community. This order is not an extrinsic imposition, but an interior bonding of the community that enables each of its members to participate in the governance and to achieve that fullness of life expression that is proper to reach . . ."*

A certain degree of self-governance is essential for the fulfilment of a place-based restorative ecological philosophy. The problem here is not so much with bioregionalism but with the current climate of globalisation. Far from the current trend being towards self-governance and regional independence, the trend is towards what is somewhat euphemistically called 'harmonisation'. Globalisation challenges even what regionalism remains in some ways (Williams, 1997). However, the counter to this pessimism is that there is scope for many minorities and groups, particularly within the developing European Union, to appeal to the super-structural organisations for legitimacy which was previously denied to them (Williams, *op. cit.*). As Williams points out, this might not be the dawning of a "Europe of the Regions" but "in one of the ironies of history it could be that the expanded super-structural organisations and the emerging regional-level actors both contribute to the renewal of a reformed, decentralist nation-state posing as the only truly representative instrument of a multi-cultural civil society". This may not go far enough for the dedicated bioregionalist but, at least, it must be a salve to the concerns over excessive centralisation. Indeed it might be argued that a super-state could only operate effectively with greater autonomy of its constituent parts. The bioregionalist's enthusiasm for regional self-governance is not often matched by practical suggestions for the practicalities. Much progress has been made in the development and understanding of the regional dynamic but Wannop (1997) offers a salutary pause for thought when he says

> *". . . no sooner are planning or administrative arrangements fixed for any region than new regional issues arise around its borders. Regional issues are often political in origin and are certainly political in their implications. Thus no perfect system can be devised for regional planning and governance, and any regional planning arrangements tend to be flawed."*

This is not to say that the increased regional autonomy which biregionalism requires is impossible. It is simply that it is difficult to attain at the political level even before the economic implications are considered.

3.7.5 "Self-healing"

> *"The fifth function of the bioregional community is self-healing. The community carries within itself not only the nourishing energies that are needed by each member of the community; it also contains within itself the special powers for regeneration. This takes place, for example, when forests are damaged by great storms or when periods of drought wither fields or when locusts swarm over a region and leave it desolate. In all these instance the life community adjusts itself, reaches deeper into its recuperative powers, and brings about a healing . . ."*

Within the statement above, *de facto*, is the balance to the restorative "powers" of bioregions in that they must also contain within themselves some of the agents of their own damage, or that of their neighbours. This can be seen in Berry's list of "desolations". While it is convenient for many purposes to consider bioregions in isolation it is also necessary to constantly keep in mind the interconnectivity of the environment and all living systems. It is interesting that the environmental disasters that Berry lists are all natural. Surprising omissions from the list are major oil spill such as the Exxon Valdese disaster or even global climate change. It is true that the great versatility of natural life has an immense ability to exploit almost any vacant niche, particularly where the niche became vacant as a result of some natural cataclysmic event. The variety of plant and animal species in even the most inhospitable locations on the Earth's surface is testimony to this fact. However, to call this a "healing power" which the region somehow activates is, again, to be overly anthropomorphic and an adherent of the spiritual dimension of the Gaia gestalt.

3.7.6 "Self-fulfilment"

"The sixth function of the bioregional community is found in its self-fulfilling activities. The community is fulfilled in each of its components in the flowing fields, in the great oak trees, in the flight of the sparrow, in the surfacing of the whale, and in any of the other expressions of the natural worlds. . . . In conscious celebration of the numinous mystery of the universe expressed in the unique qualities of each regional community, the human fulfils its own special role. This is expressed in religious liturgies, in market festivals, in solemnities of political assembly, in all manner of play, in music and dance, in all the visual and performing arts. From these come the cultural identity of the region."

Berry's sixth function of the bioregion has two clear parts. The first is a definite spiritual dimension whose fulfilment depends greatly on the spiritual inclination of the individual and their capacity to appreciate beauty. The second part is the attainment of quality of life and it is telling that no mention is made of standards of living.

3.7.7 Summary of the "World View"

From Berry's list we can see a number of threats to sustainability emerge which it is hoped that a place-centred ecologically restorative philosophy will address. The principal causes of these threats can be condensed into ignorance and greed whether it is manifested in direct monetary gains or for indicators of improved standard of living:

"The root cause of these threats is the inability of the nation-state and industrial capitalism - patriarchal, machine-based civilisation rising from the scientific revolution - to measure progress in terms other than those related to monetary wealth, economic efficiency or centralised power." Aberley (1999)

"But if we have food and clothing, we will be content with that. People who want to get rich fall into temptation and a trap and into many foolish and harmful desires that plunge men into ruin and destruction. For the love of money is a root of all kinds of evil . . ." The Bible, 1 Timothy 6:8-10

To the bioregionalist, as well as to many other ecophilosophies, it is clear that the combination of ignorance and greed are primarily (although not exclusively) responsible for most of the ecological degradation of the planet. Greed can take many forms whether it is for power or money, with the consequent disenfranchising of particular cultural groups or future generations (or even, the bioregionalist would argue, other species). This may seem an extravagant statement but the evidence is readily available (*e.g.* Moran, 1988; Bahn and Flenley, 1992; Naess, 1989; McBuney, 1990).

3.8 BIOREGIONAL MAPPING: A TOOL FOR ENVISIONING THE ENVIRONMENT

The challenge is to translate the overarching bioregional vision into a realistic construct 'on the ground' and allow scope for stakeholder interpretation of the vision as it relates to their specific situation. Bioregionalism claims that sustainability is better gained within a more decentralised structure of governance and development. Where sustainability is defined as equitably distributed achievement of social ecological and economic quality of life such a view might be supported by the ecocentric branches of environmentalism, of which bioregionalism is one. Scale is important to the success of a decentralised approach to ecological restoration. If the scale is too small the region has little capacity for autonomous action or continuance. If the scale is too large then its reactivity is lost. Defined as a territory revealed by similarities of biophysical and cultural phenomenon, the bioregion suggests itself as a scale of decentralisation best able to support the achievement of ecological integrity while maintaining cultural and social progress.

From the conceptual side of visioning the process of defining the bioregions themselves will be studied. The process of mapping bioregions is important for environmental FSV for two reasons. Firstly, the act of mapping provides a forum of community participation and the expression of their needs and perceptions of themselves and their environment. Secondly, the mapping exercise establishes a shared knowledge base that marries specialist or quantitative, scientific knowledge with local or qualitative, intuitive cultural knowledge; from this shared knowledge base a shared vision of the future can be created and a shared plan of action be established.

The process of mapping bioregions has a third important consideration. If bioregions can be shown to be demonstrable entities then there is a basis for their use in environmental management. If it appears that bioregions cannot, in some manner, be demonstrated to be self-evident realities then there is no basis for bioregionalism and bioregions would not prove to be a satisfactory environmental management construct.

3.8.1 Broad Guidelines

Any given bioregion must be shown as part of a bigger picture, where the bigger entity is outside the system, otherwise it can not be logically represented as internally complete. In defence of the charge that it is impossible to address absolutely every system or association when looking at bioregions (and therefore any bioregional model must be flawed), Goedel's incompleteness theorem (explained in Salthe, 1985) states that if the representation of something is to be sufficiently rich as to adequately describe it, the representation must remain incomplete if it is to be internally consistent. This does not mean that a holistic approach can not be taken (which would destroy the argument for bioregionalism before it started) but that certain limitations need to be recognised in the description of any bioregional system. In other words, absolutely every ramification or eventuality can not be covered and other researchers advocate one theme for mapping, often biogeography (e.g. Welsh, 1994). Suffice it to say at this point that, even if the integration proves to be a close match (supporting the theory of bioregionalism) it is extremely unlikely that an exact match will be found. This leads to the concept of "fuzzy boundaries".

McCloskey (1993) argues against fuzzy boundaries when he says that natural divides often tend to be sharp. However, he is specifically discussing ecological boundaries and not bioregional boundaries (as the term is used here). Furthermore, it would appear that there are only three such sharp boundaries in Scotland, namely The Great Glen, the Grampian-North-East Coastal lowlands divide and the sea between the mainland and the islands. Since a bioregion is composed of a series of natural boundaries superimposed on each other, it is inevitable that there will be a certain degree of fuzziness. Therefore, bioregional boundaries are really gradations, whether sharp or gentle, from one region to another.

The concept of fuzzy boundaries is important for the logical consistency of bioregionalism (McGinnis, 1999b and Stevenson and Ball, 1996). When SNH were preparing to conduct their zonation study, they came to a similar conclusion that there can be no one "right" zonation pattern or system and that the intended end-use of a zonation was a prime factor in affecting the type of zonation required (Thomson, 1996). Indeed, the type of questions that are asked in the formulation of a zonation system will greatly affect where the gradations between zones occur.

Bioregions can be built up as a series of overlays that give both the subjective zone of cultural values as well as objective boundaries. Sale's taxonomy of bioregions (1985) is comprised of an **ecoregion**, which is the broadest distribution of vegetation and soil types; a **georegion** which is defined by land topology and physiographic features such as water catchments; a **morphoregion** which is identified not only by the collection of life-forms which are peculiar to it but also to the lifestyles of the people within the region. Lifestyles impact on land use and habitation patterns and both impact upon the environment. These definitions give a bioregionalist a starting point for exercises in overlaying. However, it is proposed here that they need some re-interpretation (Table 3.3).

Table 3.3: Proposed new hierarchy of overlaying regions, from the most fundamental to the most human-centric, on which bioregions can be built.

Type of Region	Description
Georegion	Geology and soil substrate of the region providing the parent material
Climactic region	Level and type of precipitation, temperatures and wind all of which is partly dependent on the shape of the land masses of the region
Toporegion	Clear physiographic features such as water catchments, mountain ranges which are dependent largely on the local geology and climate
Ecoregion	Distinct composition of the floral and faunal communities. The flora is dependent on the substrate and climate. The fauna is dependent on the plant life.
Economic Region	Economy of the region is defined historically by its agriculture and the availability of minerals. The type of economy that a region can support and therefore the density of human population (its carrying capacity) is dependent on the preceding distinctions of a region.
Socioregion	Cultural distinction of a region. Bioregionalism is nothing without the communities. The behaviour of communities is guided by their culture and social heritage. This is the final level.

Elements of each of the regions identified above do not necessarily appear to be in their most logical categories. For instance, the term "life-forms" for the morphoregion presumably must mean animal life, as vegetation is already included in the ecoregion. The interaction between flora and fauna is one of the most important in shaping the ecology of a region so these two elements should go together. The georegion should come first in the list as the defining substrate for the other two. As such soils should come in this definition and not the ecoregion. The importance of humans and the potentially extreme nature of their impact requires particular attention which should give a fourth region as a subset of the morphoregion. A new taxonomy is proposed (Table 3.3).

It is proposed here that there be six layers forming a hierarchy as follows: a georegion, a climactic region, a toporegion, an ecoregion, an economic region and a socioregion. The order shows how one builds upon another to give the bioregion. Table 3.3 is a re-examination of this with the addition of a "socioregion" which seems implicit but is missing. The table has also been arranged into a more logical order to show how the regions are interdependent and build upon each other.

If overlays of maps such as biogeographic zones, economic boundaries, cultural heritage zones and other catchments demonstrate regions of coincidence, leading to the identification of bioregions, these regions will have fuzzy boundaries. They will be fuzzy in two ways; firstly because the boundary is not a discrete line but a two directional gradient (like a valley, it is a boundary zone) between two adjacent bioregions; secondly some types of zones can be expected not to be concentric but cut across each other. They way in which the latter type of fuzziness is handled and the "goodness of fit" between different types of zone will determine the validity of a bioregional definition of an area on the one hand and the validity of bioregionalism on the other.

The dynamic nature of bioregional boundaries is important. Intertwined with this is the affirmation by bioregionalists that bioregions are natural and self evident, free from the impositions of human dictates (Sale, 1985). McGinnis (1999b) explains how bioregions are "self-organising systems". There is a growing quantity of literature which supports the self-evident nature of bioregions (McGinnis, 1999b). McGinnis adds emphasis for the inclusion of culture within the bioregional systems when he quotes Zeleny and Hufford from their paper "The Application of Autopoiesis in Systems Analysis: Are Autopoietic Systems also Social Systems?" which was published in the International Journal of General System (21: pp. 145 - 160):

> *"It is both improper and unscientific to consider engineered social designs as social systems. Concentration camps, jails, command hierarchies, totalitarian orders, and so on, are not social orders but dictatorial, rule-based systems: everybody is put in place, told what to do and how to respond, where to go and when. Whatever social system characteristics do emerge, do so only in spite and in defiance of the imposed order. There is nothing spontaneously social about them. As soon as the boundaries (the imposed rules, order, fear) are dissolved they do not reassemble themselves spontaneously: rather everybody goes home."*

It can be seen from the range of factors above that the process of environmental FSV needs a 'lens' through which the visioning takes place. Different lenses could be used but it is proposed that a bioregions lens provides a holistic approach to environmental visioning. The nature of the factors that need to be accounted for in Sale's (1985) taxonomy also demonstrates the need for a balance between scientific input and interpretative, stakeholder input so that boundaries are not seen to be imposed from outside the community, community needs can be met, local community knowledge can be tapped. At the same time, an educative process is initiated for the stakeholders which raises their awareness of the scientific issues. To be successful, a bioregional mapping process should include a two-way exchange of knowledge between the scientific community and the stakeholder community if all the issues of Sale's (1985) taxonomy are to be dealt with satisfactorily.

This brings the thesis to the point at which the theory of bioregionalism will be tested as far as the existence of bioregions is concerned. Up to this point the theory of bioregionalism, some of its practicalities and the surrounding issues have been discussed along with an outline for identifying bioregions. The following two chapters will look at this aspect in more detail by trying to apply the theories of identification in practice to Scotland.

4 MAPPING METHODOLOGY

"Detection is, or ought to be, an exact science, and should be treated in the same cold and unemotional manner. You have attempted to tinge it with romanticism, which produces much the same effect as if you had worked a love-story or an elopement into the fifth proposition of Euclid."

Sherlock Holmes[1]

4.1 INTRODUCTION

It is good and right that the horizons of science are sometimes broadened with a little romanticism but too much can make fact out of fiction. Bioregionalism has attracted many thinkers from disparate spheres including poets and artists. They make a valuable contribution to the progress of bioregional thought but, whatever one's inclinations towards a subject, there must come a time when the question "Is it true?" is inevitably asked. In the foregoing chapters an overview of bioregionalism and visioning has been built up from a philosophical standpoint. It has been demonstrated that bioregionalism has a degree of attractiveness as a philosophical construct.

A philosophy is only as good as its applicability and, therefore, the ideas should be tested in a more direct way. The definitions of bioregionalism that have been given in preceding chapters suggest that bioregions are demonstrable entities. To test the concept, then, it was determined that an attempt should be made to identify the bioregions of Scotland. If the attempt was to prove successful it could be concluded that bioregions are demonstrable entities. If the attempt was to fail, then the basis for claiming that bioregions are entities whose determination is free of

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1 Sherlock Holmes chastises Dr Watson in the "Sign of Four" (Chapter 1) by Sir Authur Conan Doyle (1890)

human dictates (see Sale, 1985) is considerably less likely to be acceptable. There is little evidence that bioregions have been tested in this way before. The literature, and such discussion that is available via the Internet, all start from the premise that bioregions are observable, natural phenomena. In the normal sphere of human experience, for something to be observable is for it to be measurable and to be measured is to have one's existence proved (although there is the proviso that "absence of evidence is not evidence of absence"; a truism, but nonetheless valid). The methods that were used will be discussed in this chapter.

4.2 TOOLS FOR CONSTRUCTION AND ANALYSIS OF BIOREGIONS

The main analytical tool used in this study of bioregionalism, was a Geographical Information System (GIS). This section begins by looking briefly at the merits of the GIS in the context of this study and outlines why the technique was chosen. The actual use of the technique will be described in detail throughout later sections of this chapter.

4.2.1 Brief Overview of GIS

GIS is a rapidly growing field of computer-based tools designed to capture, store, manipulate, analyze and display spatial data. GIS can give abstract representations of the geographic features of real world locations. There are three groups of typical applications of GIS which are inventory, analysis and modeling for management decisions (ESRI, 1994a).

Examples of inventory applications can include the mapping of forest types, soil properties and ownership of parcels of land. (ESRI, 1993; see also the magazines *GeoEurope* or *Mapping Awareness* which regularly have articles about these aspects of GIS). Analysis applications can include the use of GIS to identify better choices for the location of landfill sites for instance. Examples of the support of management decisions are the graphical representation of optimum use of land, the siting of new structures (*e.g.* power plants, hospitals, pylons *etc.*), modeling (*e.g.* risk from fire dispersion, flood risk, road construction costs *etc.*).

There are two common types of spatial data structures. These are vector data (points, lines and polygons) and raster data (rows and columns of grid cells having a uniform size). In either data structure, extra information about the feature, over and above its basic geographic location and size, can be stored as attribute data (descriptive data which describe the feature with which they are associated *e.g.* street names and pipe flow rates).

At its most basic, vector data can be used to identify point features like man-hole covers, pylons, wells *etc.* or linear features such as streams and railway tracks *etc.* Raster data are best used to represent continuous data such as elevation, soil type, temperature etc.

GIS was considered a suitable tool for developing and delimiting bioregions because it provides:

- a method of identifying regional patterns
- a means of combining regions to study new possible patterns by overlays
- statistical tools for analysis
- a capability for graphical re-interpretation of data for Scotland

One of the great advantages of GIS is its ability to deal with layering of datasets. There are a number of statistical methods for handling layered data and looking for patterns within it. Figure 4.1 graphically represents the process with reference to the adaptation of Sale's taxonomy of bioregions. During the course of the next six subsections the way in which Figure 4.1 was constructed will be shown as a graphical aid to understanding the layered mapping process.

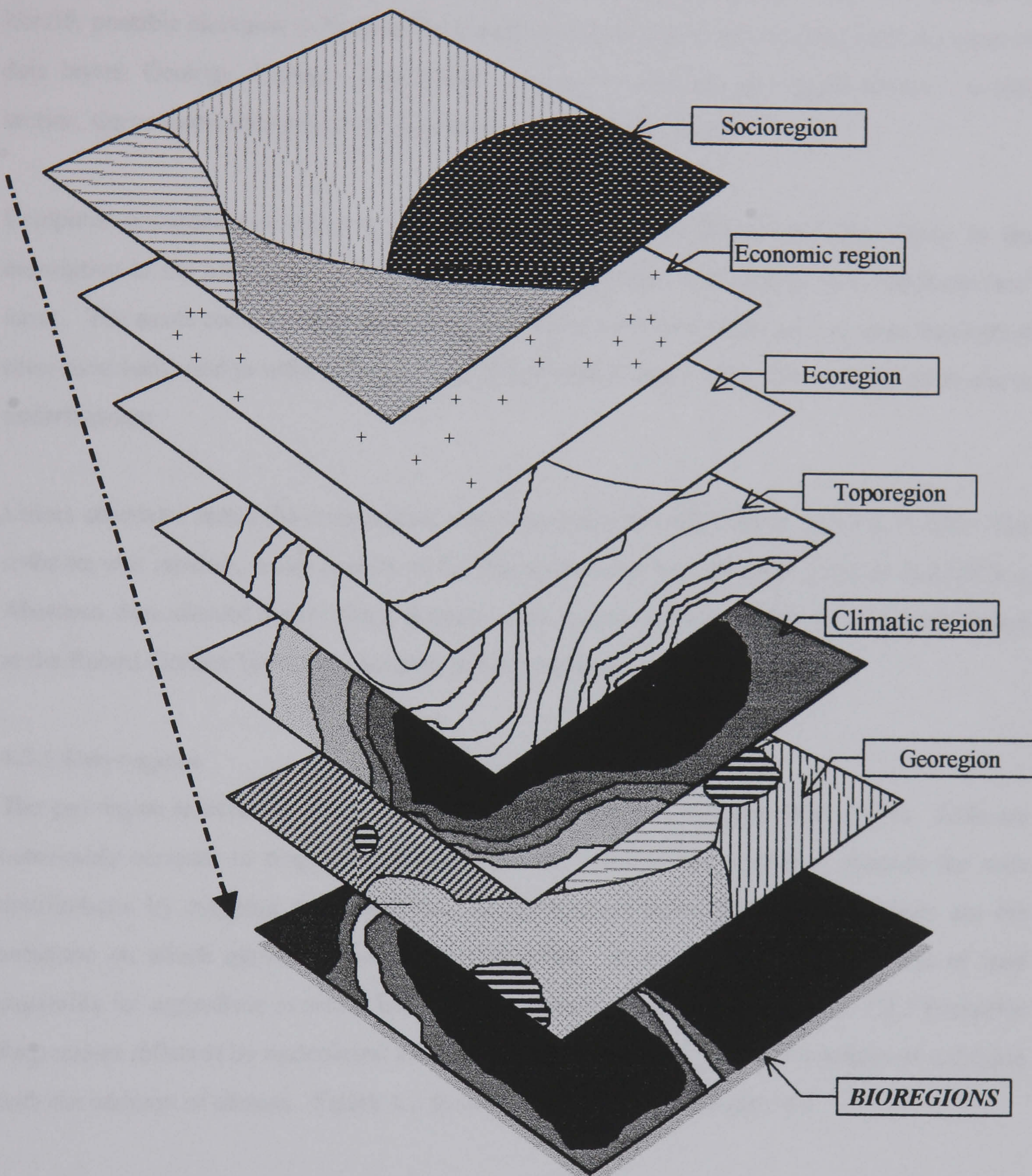

Figure 4.1: Representation of the layers which, together, make up the definition of the bioregions. The classification of the clustering of values within the layers is more important than the layering process (see Figures 4.2 and 4.5). The layers shown above are indicative only.

4.3 PREPARING THE DATA LAYERS

Following the alternative to Sale's (1985) taxonomy of bioregions, it was decided to attempt to identify possible bioregion in Scotland by identifying coincidences between the following types of data layers: Geology, Climate, Topography, Ecology, Economics and Social factors. In this section, the procedure for preparing the data layers will be described.

Computer command-line input is given in some places to help maintain the clarity in the description of the processes. It was not considered necessary to reproduce each command-line[2] input. The exact command-line annotation has not always been followed but more descriptive titles have been used to refer to certain files or commands where it has been considered an aid to understanding.

Unless otherwise stated the computation was done using the ARC/INFO (Version 7) GIS. The software was resident, under licence, at the Macaulay Land Use Research Institute (MLURI) in Aberdeen who allowed access either directly or by remote login via an Apple Macintosh, based at the Robert Gordon University, running in Unix terminal emulation mode.

4.3.1 Geo-regions

The geo-region is basically a map of the varieties of soils in the region (Sale, 1985). Soils are notoriously complex to map, being highly variable, and it is appropriate to simplify the soils distributions by mapping the distribution of agricultural types (Berg, 1988). Soils are the substrate on which agriculture is largely dependent. It was decided to use a map of land capability for agriculture to mirror both soils and primary economic activity (see 4.3.5 Economic Regions) as reflected by agricultural activity because they closely reflect the pattern of soil types with the addition of climate. Figure 4.2 shows the first layer from Figure 4.1.

---

2 When considering any mathematical functions in command-line input it should be noted that Arc/Info does not automatically follow the 'BODMAS' rule. By convention, mathematical functions should be performed in the following order: Brackets, Orders, Division and Multiplication, Addition and Subtraction. Arc/Info performs these mathematical functions in the order they are presented to the compiler but allowance is made for brackets.

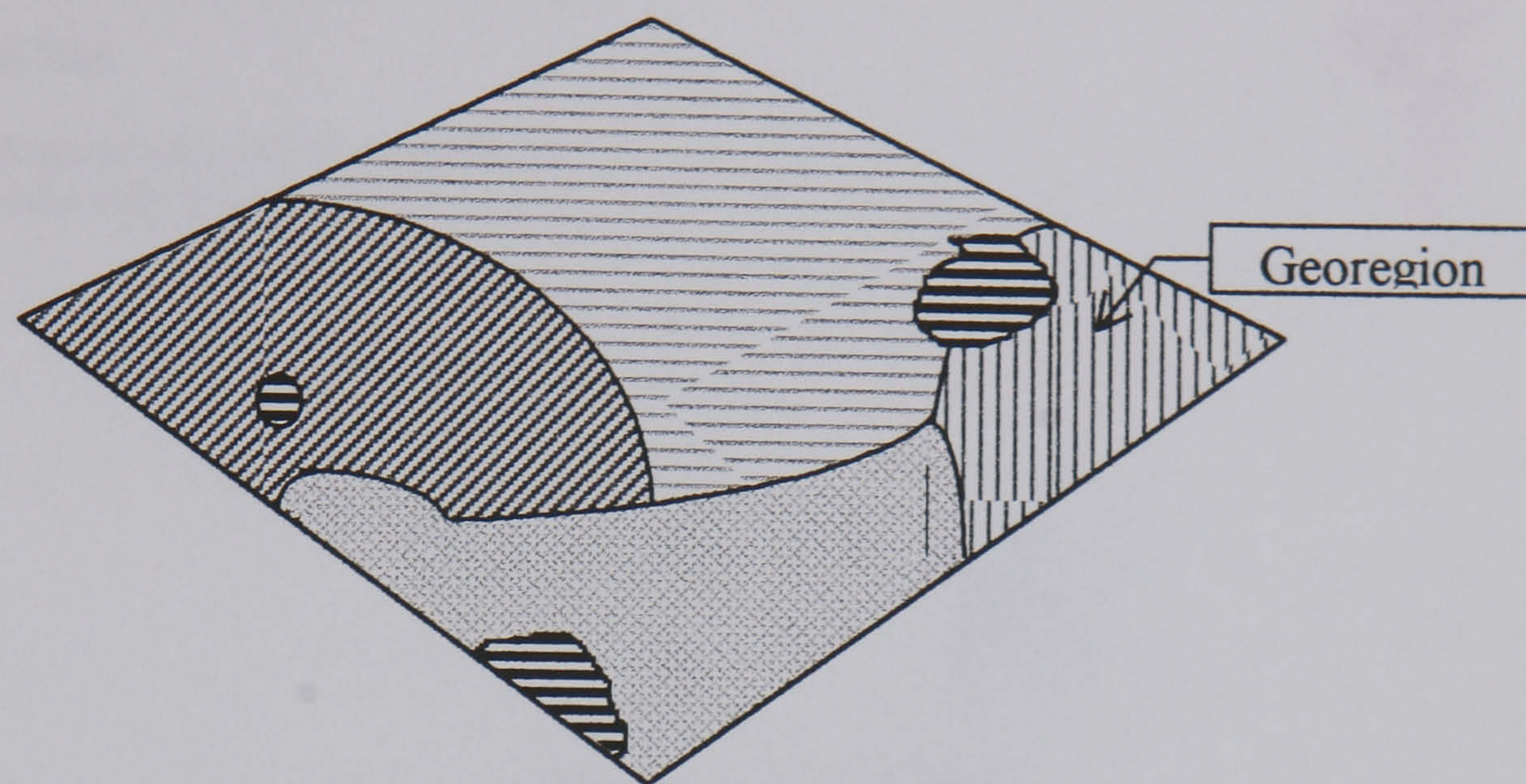

Figure 4.2: Representation of the first layer of the definition of the bioregions according to Sale's (1985) taxonomy.

The land capability classification for agriculture in Scotland developed by the MLURI (1983) was used for this purpose. From the perspective of a future bioregional state, the current patterns of agricultural activity are not as important as the possible distribution of agricultural potential. Figure 4.3 shows the distribution of agricultural land classes in Scotland.

4.3.2 Climatic regions

It was decided that climate could be adequately identified by patterns of rainfall and temperature, particularly in light of the fact that the ecological, and to some extent the economic, layers will also be influenced by climate. The economic layer will be affected by climate in as much as climate affects agriculture and forestry (or primary economic activity) but climatic patterns also affect patterns of human habitation as evidenced by the style and location of dwellings. Figure 4.4 shows the addition of the second layer in the mapping process.

The climate layer is a synthesis of temperature, rainfall and range of rainfall figures. These figures were derived from the Climate Change Project (MLURI, 1993). A coverage of the mean annual temperature for Scotland was computed from 12 mean monthly temperature coverages as below (Equation 1 - each of the monthly coverages is prefixed by the letters "mt" to denote mean temperature and suffixed by the abbreviated month name):

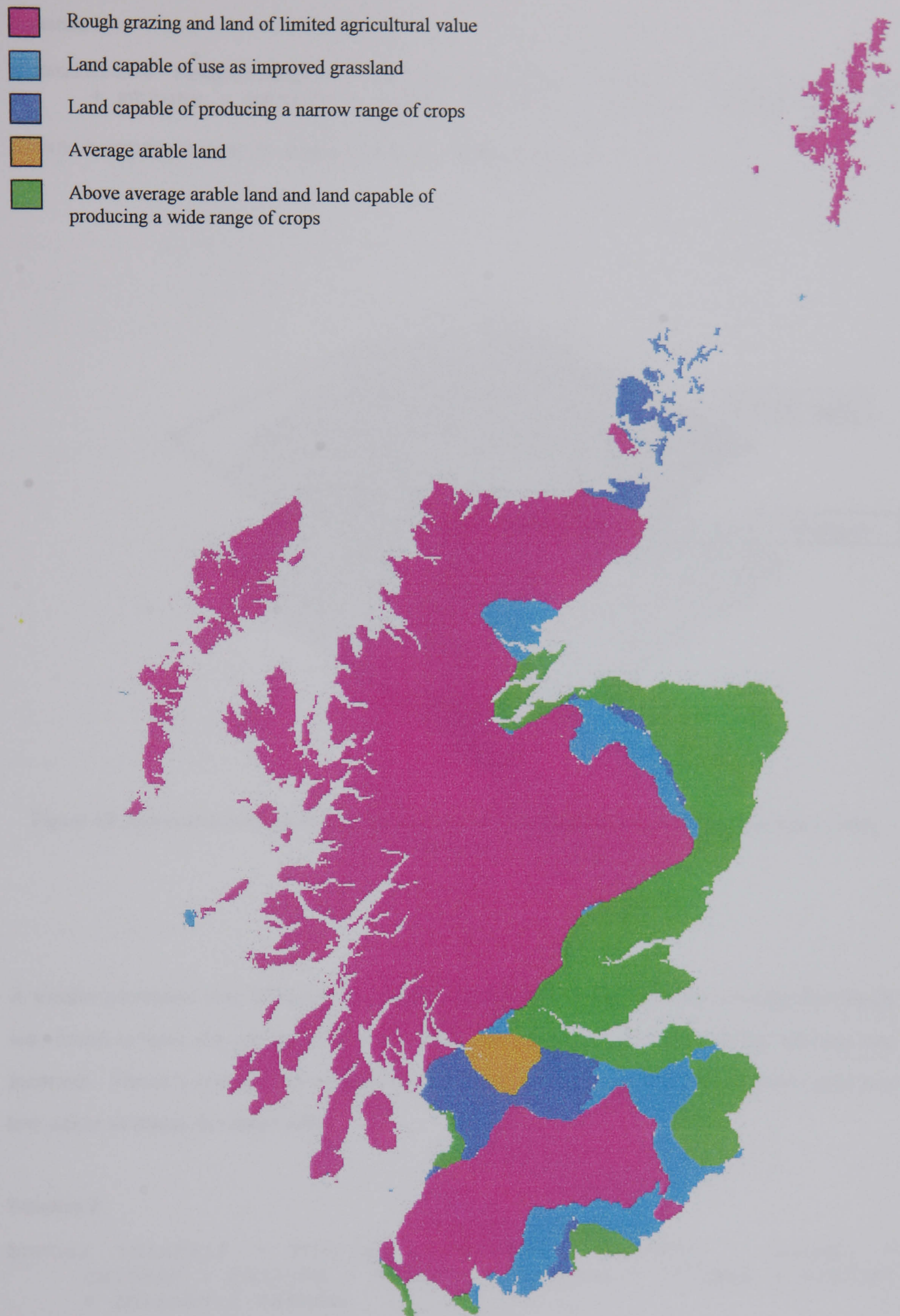

Figure 4.3: Agriculture Land Classes in Scotland (adapted from MLURI, 1983. Note that the resolution of the map as printed here is not sufficient to show some of the finer graduations between classes).

Equation 1:

```
cumulative temperature = mtjan + mtfeb + mtmar + mtapr + mtmay
     + mtjune + mtjuly + mtaug + mtsep + mtoct + mtnov + mtdec

mean temperature = cumulative temperature / 12
```

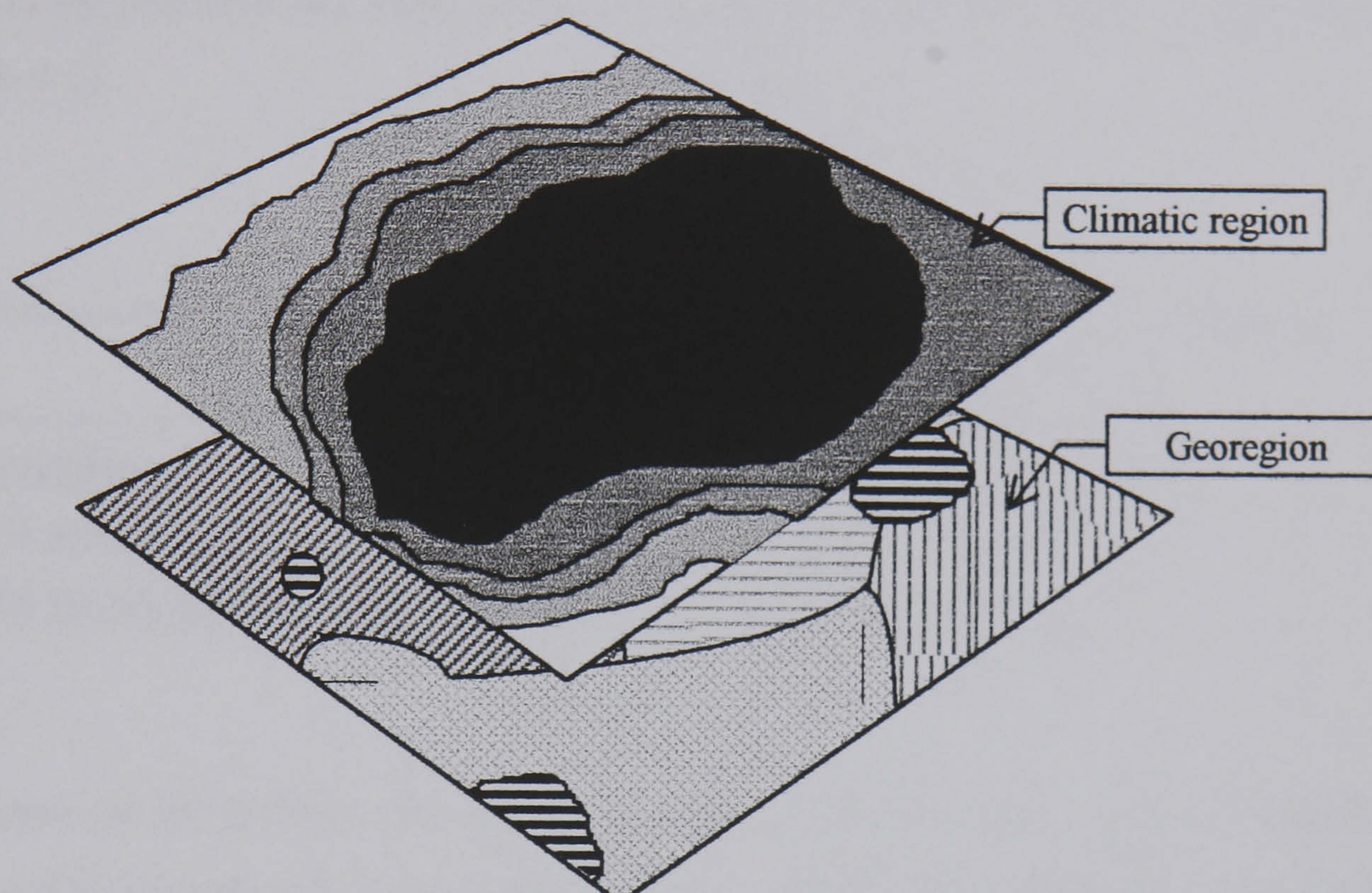

Figure 4.4: Representation of the first two layers of the definition of the bioregions according to Sale's (1985) taxonomy.

A similar procedure was followed for rainfall (Equation 2) except that the coverage for March was found to have the correct number of rows and columns in the grid but the cell-size was incorrect. March's coverage for rainfall was adjusted manually by editing the cell-size value in a text editor to match the other cells.

Equation 2:

```
annual rainfall = rainjan + rainfeb + rainmar + rainapr +
     rainmay + rainjun + rainjul + rainaug + rainsep + rainoct
     + rainnov + raindec
```

To get a more complete picture of climate it was considered necessary to include values not only for rainfall and temperature but also for the annual range in rainfall. This is because two areas may have the same mean annual rainfall but considerably different ranges with one area, say, having completely dry summer months and a deluge in winter, while rainfall in the other area is more evenly distributed throughout the year. Obviously these two areas can be considered to be different climatically despite identical means. A coverage for the annual rainfall range was acquired from the same Climate Change Project (*op. cit.*). First it had to be made compatible with the coverages for mean temperature and total annual rainfall. The suitability of various methods of combining the three data layers were investigated by finding how well the data were correlated (Table 4.1).

Table 4.1: Pair-wise correlation (Pearson's 'r') between coverages contributing to the climate definition of Scotland

Correlation (r)	Annual rainfall range	Mean temperature
Mean temperature	-0.0042	-
Total annual rainfall	-0.036	0.837

Of primary interest are the patterns that are to be found in the data rather than any specific value. To this end the coverages for temperature and total rainfall were smoothed to reduce the level of 'noise' in the raw data and to better show the patterns. It is a basic tenet of geography that there is a tendency for things which are closer together to have greater similarity than things which are further apart. This is known as spatial auto-correlation (ESRI, 1994b). On this basis it was important to assess the degree of spatial auto-correlation of the two coverages to provide a guide to the degree of smoothing which was appropriate. ARC/INFO is capable of calculating spatial auto-correlations for grids depending on user-provided off-sets. The higher the off-set value the greater the distance within the grid over which the correlation is calculated. Various off-sets were tried for the total rainfall and mean temperature coverages until $r = 0.75$[3] was achieved or surpassed (the two figures at the end of the first in each pair of command-lines, Equations 3 and 4, indicates the x-y offsets).

Equation 3:

```
correlation total-rainfall  total-rainfall  7  7
correlation coefficient (r): 0.759
```

3 Where a value of r is equal to 0 there is no correlation. A value of 'r' close to 1 is indicative of a high degree of correlation

Equation 4:

```
correlation mean-temperature  mean-temperature  7  7
correlation coefficient (r): 0.753
```

From these values it can be seen that, beyond a radius of seven cells (i.e. 7 km) in each grid the spatial auto-correlation becomes increasingly less significant as the value of 'r' falls. In other words, for a given cell, the surrounding cells in each grid may be assumed to be well correlated with in a radius of 7 cells. This value was then used to smooth the data. New coverages were constructed by calculating the mean value of the original coverage's cells within a circular neighbourhood having a radius of seven cells (Equation 5). This is an iterative process where the output has no effect on the input.

Equation 5:

```
smoothed-rainfall = focalmean (total-rainfall, circle, 7)
smoothed-temperature = focalmean (mean-temperature,circle,7)
```

The above process can result in the output of analysis of a coverage of an island, like Scotland, to 'spill' over into water features such as the sea. This is corrected by 'trimming' the new coverage of the smoothed values back to the correct coastline before continuing by using an outline of the land area like a 'cookie cutter'.

As can be seen from Table 4.1, there is a very strong correlation coefficient between temperature and rainfall as might be expected. However, there is virtually no correlation between the range of rainfall and either temperature or total rainfall. This is not an unexpected phenomenon as there is no obvious reason why such correlations should exist. These results have implications for data processing nonetheless. Regression analysis is inappropriate because, although the data are continuous, only temperature and rainfall are highly correlated. However, it is for this very reason that the multivariate analysis tool of classification cannot be used on the whole set of three coverages. Classification is a tool that looks for clusters of values that commonly occur together in the various input layers and creates classes based on these clusters. More discussion will be entered into overleaf.

The coverage for annual rainfall range is related to total annual rainfall in that both coverages are measures of certain qualities of the same variable (namely rainfall). The two coverages are not correlated and therefore it is meaningful to classify these coverages to produce a new coverage of Scotland classified for variability and accumulated totals of rainfall. Classification requires that all coverages involved in the process have the same ranges of data (e.g. 1 to 100). Table 4.2 shows the ranges of the data and the multiplication factor used to harmonise the ranges of values for the purposes of classification of the smoothed total rainfall and rainfall range coverages.

Table 4.2: Adjustment factors used to normalise cell values to the range 0 - 100

	minimum value	maximum value	adjustment factor
total rainfall	0	191.408	0.5224
rainfall range	117	201	subtract 117 then multiply by 1.1905

The above coverages were then subjected to the ARC/INFO unsupervised classification procedure. In unsupervised classification the computer defines the classes of values based on naturally occurring values found in the stack of coverages (ESRI, 1994b). These classes are then used to assign each cell, as seen through the layers of the stack, to a cluster (class) to which it most probably belongs. This is an important technique that needs to be understood for future discussion of decisions in which guided the methods. Figure 4.4 represents how clusters might be viewed in multidimensional computer space. It is not possible to suggest more than three dimension here, however the total number of dimensions that such an area may have is equal to the number of input files which are stacked for calculation (in this current case - two).

Each variable (coverage) can be considered as an axis in the graph shown in Figure 4.4. Each axis equates to a layer in Figure 4.1. Classes are regions calculated statistically by ARC/INFO from clusters found in the multivariate attribute space which minimise the distance between a set of plotted points. As can be seen, therefore, the actual values of any of the variables are of secondary relevance to the near coincidence of groups of values. The less classes overlap, the more satisfactory the classification procedure can be considered to have been. Classes that overlap to a great extent can be considered to be non-unique and should be considered as candidates for being merged.

It was determined that the best strategy was to classify the smoothed total rainfall and rainfall range coverages into an initial nominal 12 classes with the expectation that some classes would probably need to be merged (see the explanation in the previous paragraph). ARC/INFO provides various methods for analysing the classification process which were used to reduce the classes to nine based on those which were suggested as the most suitable for combination and were found to geographically adjacent.

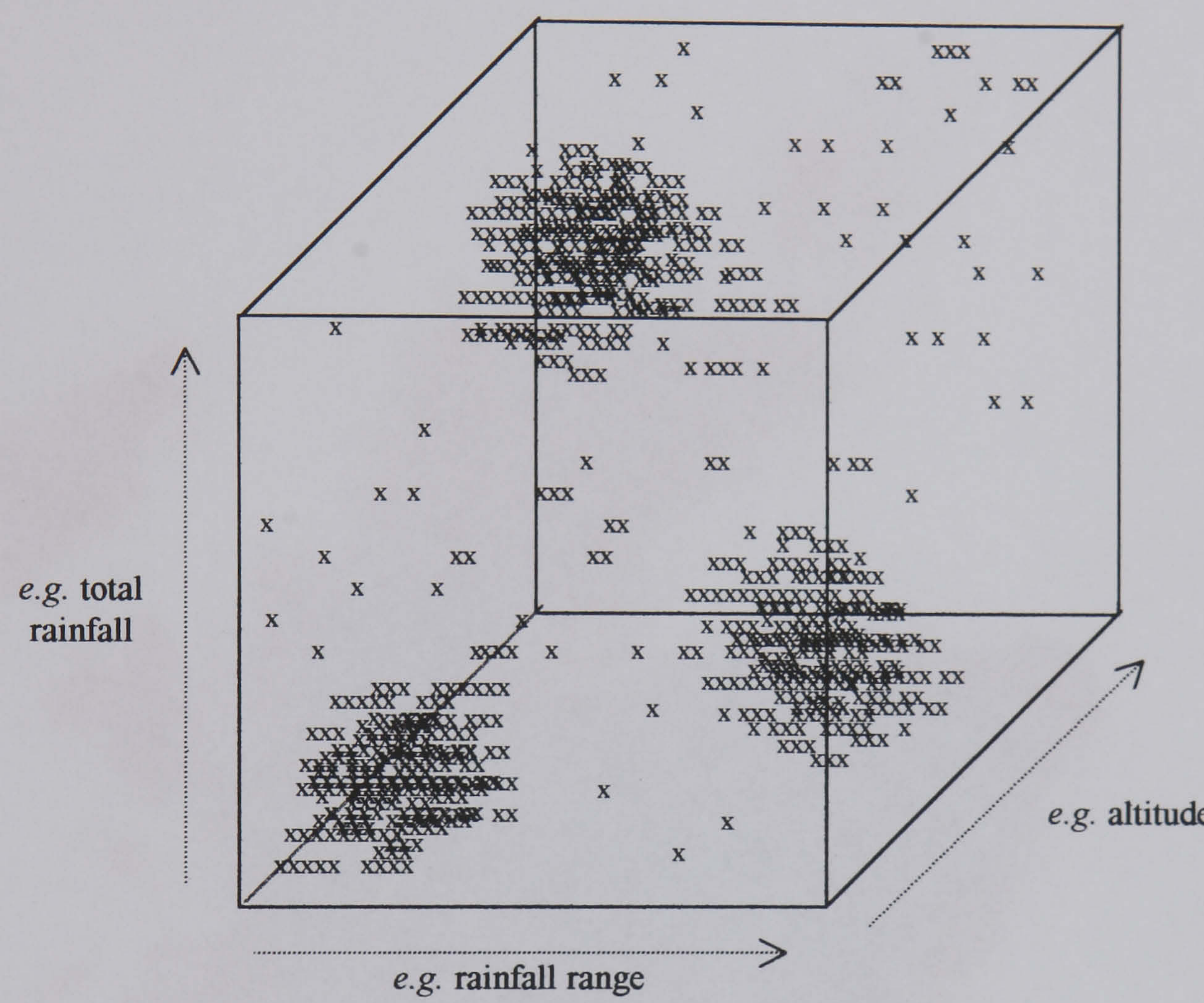

Figure 4.5: A representation of clustering of points within multivariate attribute space.

The new coverage of classified rainfall could no longer be considered as being composed of continuous data. It was therefore inappropriate to attempt to reclassify the rainfall coverage with that for mean temperature. This used the 'combine' function in ARC/INFO. This acts in a similar way to classification by finding combinations of values in the input grids and assigning them arbitrary values in the output grid. The coverage for mean temperature was remapped at two degree intervals to give eight classes by slicing the range (Equation 6).

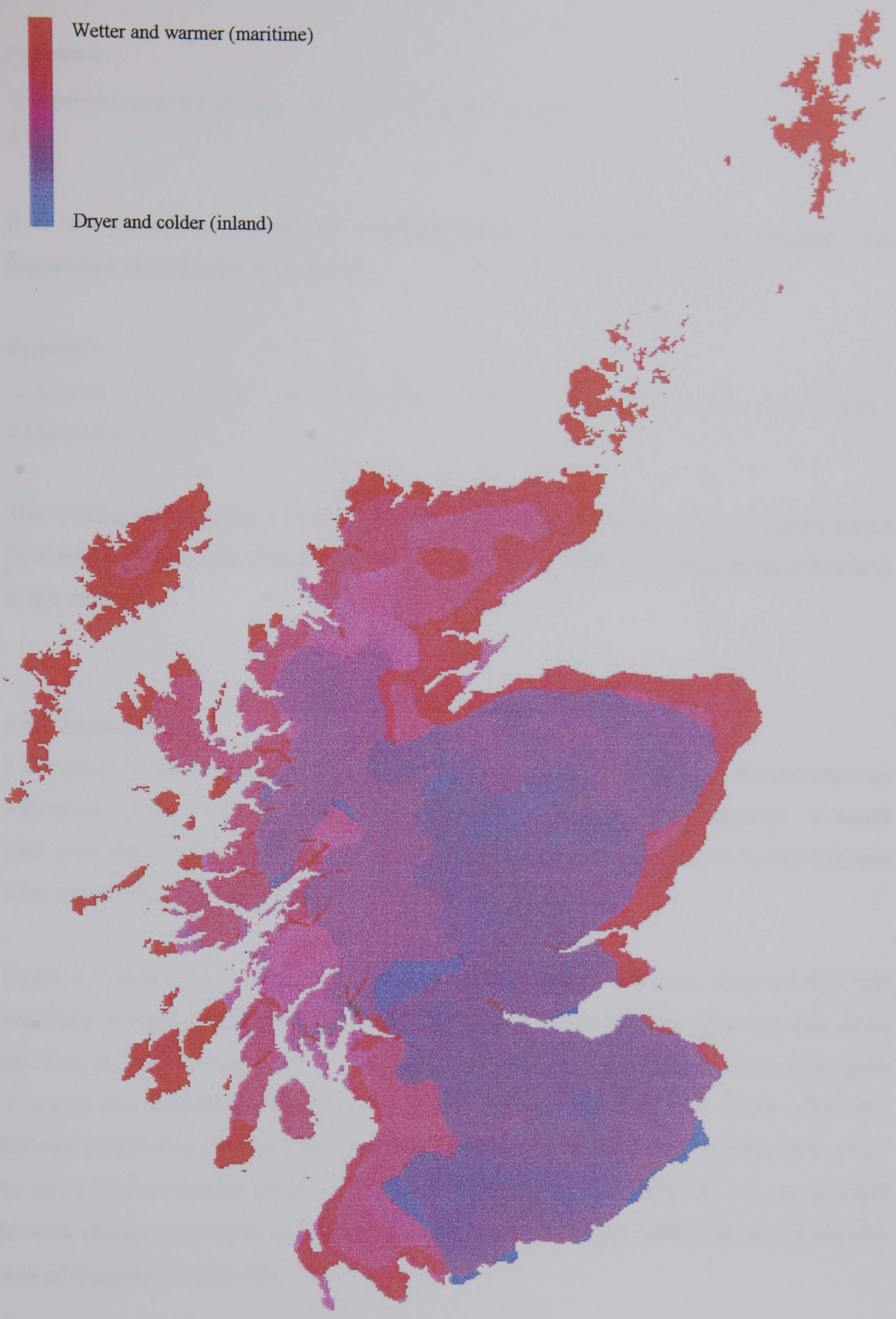

Figure 4.6: Main climatic zones of Scotland. The map is a combination of rainfall and temperature

Equation 6:

```
temperature-classes = slice(mean-temperature, equalinterval, 8)
```

It is now possible to combine the smoothed rainfall classification with the smoothed mean temperature classification (Equation 7).

Equation 7:

```
climate coverage = combine (temperature-classes, rainfall classification)
```

The resulting coverage has a range of 41 values that describe coherent zones of climate across Scotland (see Figure 4.6). Hereinafter, when a coverage for climate is mentioned the reference is to this coverage.

4.3.3 Topo-regions

Throughout all the bioregional literature there is a theme which closely links bioregionalism to watersheds. Indeed, watersheds are sometimes used as a short-hand for bioregions. It would seem more appropriate, therefore, to use a definition of the major watersheds of Scotland for this layer instead of only altitude data.

Figure 4.7 shows this coverage in the context of building up the stack of layers that will eventually be used to define the bioregions. In a bioregional context the value of height above sea level, in itself, is meaningless. A bioregion can be expected, typically, to cover a wide range of heights as a watershed drains from its source on high ground to the sea. If two areas have different heights this does not affect their comparative 'bioregionalness'. An additional reason for converting the Scottish datum data to watersheds is that a close correlation can be expected between climate, agriculture and height data. Therefore, including altitude would increase the level of redundancy in the data.

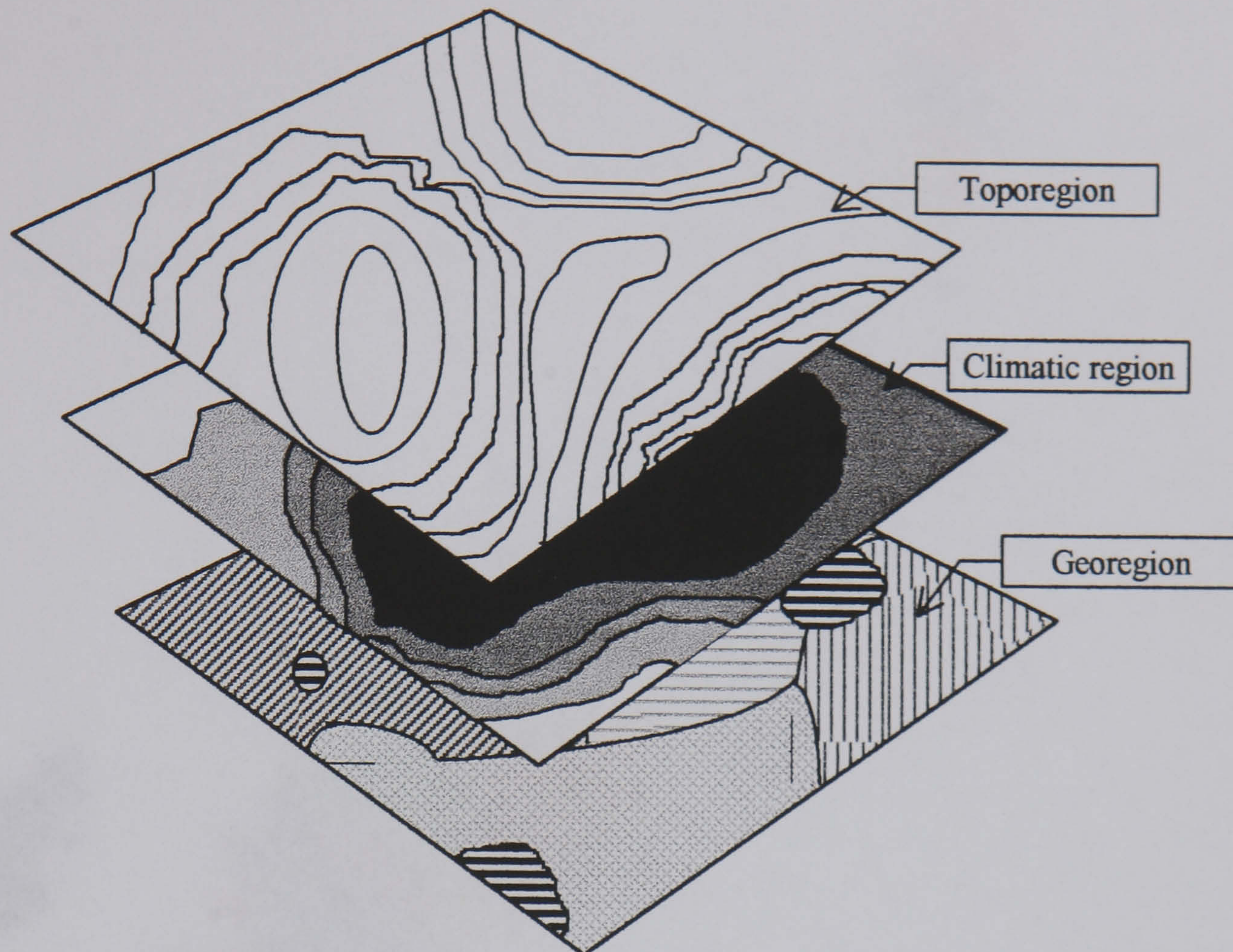

Figure 4.7: The addition of the toporegion (or watersheds) adds another layer to the definition of the bioregions.

Before any conversion could be made it was necessary to ensure that the coverage of height above sea level (HASL) has the same spatial resolution as all the other coverages, *i.e.* a nominal ground resolution of 1km (Equation 8).

Equation 8:

```
Resampled Scottish datum = resample (HASL, 1000, bilinear)
```

(The bilinear function is the best option for changing cell size)

Having normalised the altitude data coverage, it was subjected to a series of transformations in order to identify the watersheds as follows:

- The resulting surface coverage was refined to remove any errors in the data resulting in false sinks - a cell with undefined drainage (ESRI, 1994b). The false sinks were identified by analysing the data to identify isolated 'depressions' in the height data. The value of these

Figure 4.8: Topo-region. These regions are represented by the main watersheds of Scotland.

cells is then increased to their 'pour-point' (the point at which water would flow naturally out of such a cell, that is, the height of the lowest neighbour).

- A flow direction grid was calculated from the hydrologically corrected coverage. The direction of flow is always towards a cell's steepest down-slope neighbour.
- It was now possible to calculate the major river watersheds of Scotland[4].

Each watershed was assigned a discrete and arbitrary numerical identification during the above process. The computer analysis resulted in numerous very small watersheds around the coast. However, it is the major patterns of watersheds that were of importance, particularly as it was believed that a number of smaller watersheds can make up a bioregion. Therefore, it was considered appropriate to eliminate minor coastal watersheds from further analysis (Equation 9).

Equation 9:

```
major_watersheds = focalmajority (all-watersheds, circle, 7)
```

The 'focalmajority' command of ARC/INFO was used. It conducts its calculations on a focal neighbourhood in the same way as the 'focalmean' command used in Equation 5 (here, a circle of radius 7 cells) except that the result of the calculation is the value which occurs most often in the neighbourhood. The 'focalmajority' command was used because the data is comprised of discrete values, acting as unique identifiers for each the watershed to which each cell belongs. Therefore a mean value is meaningless. As with the 'focalmean' command there is some 'spill over' of the new values outside the real-world coastline. This is corrected as before by 'clipping' the coverage back to the true coast. The final coverage is shown in Figure 4.8.

4.3.4 Ecologic-regions

It was determined that there was unlikely to be a better data set for the ecological layer than the Natural Heritage Zones of Scottish Natural Heritage (SNH). This view was supported by Mr. John Thompson (pers. comm.) of SNH's Policy Directorate, who suggested that the work of SNH, both their natural heritage zones and their biogeographical zones would provide important supplementary layers to a bioregional definition. The report on the structure of these biogeographic zones for Scotland can be summarised in Table 4.3.

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4 ARC/INFO distinguishes between basins and watersheds for the purposes of command-line instructions. The 'watershed' command only delineates those basins whose pour points are specified by the user. The command 'basin', on the other hand, may be used to delineate all basins in the current coverage and assumes that the ultimate pour points (the terminal point of the accumulated flow within the basin) are all assumed to be at the edge of the coverage.

Table 4.3: Basic details of the 12 SNH Heritage Zones (Usher and Balharry, 1996). The Preference Index (PI) is a measure of the strength of association between the ten most characteristic species of a zone and the areal definitional of the zone.

N°	Name	Area (km^2)	PI	Mean Altitude (m)	Mean Rainfall (mm)		Mean Temperature (°C)	
					July	Jan	July	Jan
1	Central and Southern Lowlands	66129	0.88	126	88.6	97.9	13.7	2.5
2	Grampian Fringe and Southern Uplands	59900	0.23	259	105.4	125.3	12.6	1.5
3	East Coast	17263	2.27	80	81.4	77.7	13.2	2.4
4	Cairngorms	14598	2.51	532	129.4	175.6	11.0	0.0
5	Western Highlands	20224	3.19	425	187.1	284.1	11.0	1.2
6	Western Highland Fringe	43661	0.80	227	161.7	231.5	12.1	2.0
7	Western Isles (North) and North Mainland	50594	0.62	130	110.4	153.7	11.9	2.3
8	Barra and Tiree	972	1.82	16	103.4	140.2	13.2	4.7
9	Western Isles (South)	6086	2.52	40	112.9	167.2	12.4	3.9
10	Northern Isles	3959	2.60	46	66.1	113.8	11.9	3.3
11	Argyll and the Inner Hebridies	27559	0.80	112	144.4	197.4	12.8	3.3
12	Gallaway Coast	2467	4.04	45	91.4	121.5	13.9	3.7

Usher and Balharry (1996) defined a number of biogeographic zones for Scotland based on a method for associating species with zones. SNH's hertiage zones were a development of this. However, the method used by Usher and Balharry (*op. cit.*) is not subject to statistical analysis. Nonetheless, an attempt was made to gauge the strength of association of the ten most characteristic species in a given zone with the zone in question. This was called the 'Preference Index' (PI). It would appear from the PI values in Table 4.3 that zones 3, 4, 5, 8, 9, 10 and 12 have the best associations (average values of PI over 1.5; *viz.* 2.27, 2.51, 3.19, 1.82, 2.60 and 4.04 respectively). Caution is advised when looking at these values as this is not a true statistical comparison. Interestingly, zone 1 is also the most densely populated area of Scotland and its low PI score is, perhaps, symptomatic of this through hard urban landscaping, disturbance and pollution. The other low scoring zones tend to be either dissected or linear, in a north-south direction, suggesting that they span a number of habitat ranges. This suggests that there may be some reallocation of areas between these zones when other factors such as cultural or economic catchments are considered.

The actual dataset that was used was an earlier version from which the final zonation was created. This earlier version has more zones (20 as opposed to 12) than the final version produced by SNH. The earlier version was used because it was available in digital form. Figure 4.9 represents the addition of the ecoregions to the bioregional definition stack of coverages.

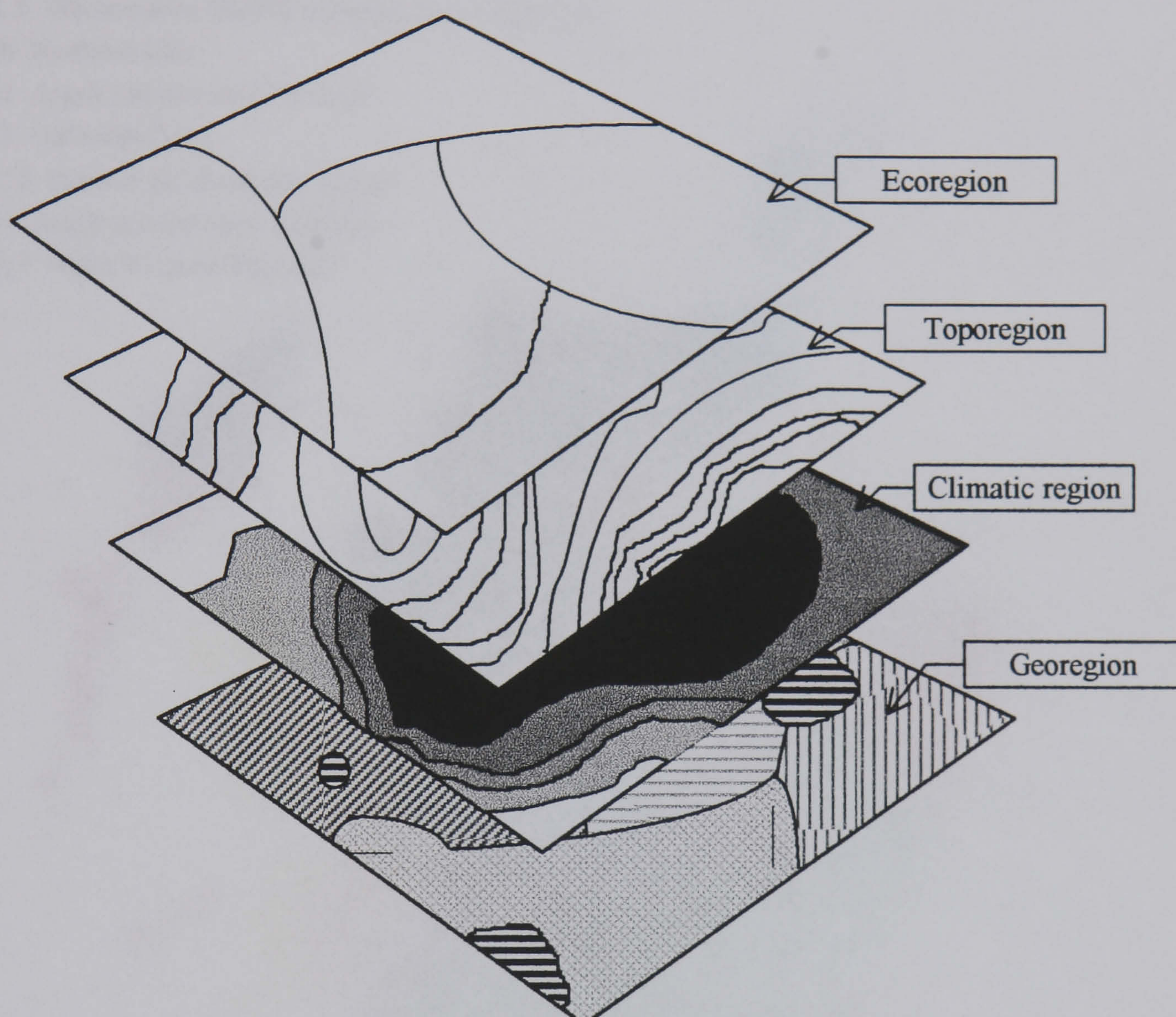

Figure 4.9: The ecoregion is added to the stack for the definition of the bioregions.

The only format that the final biogeographic version was available in was paper form with all the attendant scope for errors this might introduced into the data had it been used. Furthermore, some of the twelve regions are not geographically contiguous even in SNH's smoothed version (Usher and Ballharry, 1996, pp 18). This is particularly the case for zones 2, 5 and 7. These zones are split by other intervening classes of zone. Some other zones (1, 6 and 11) although contiguous were particularly convoluted.

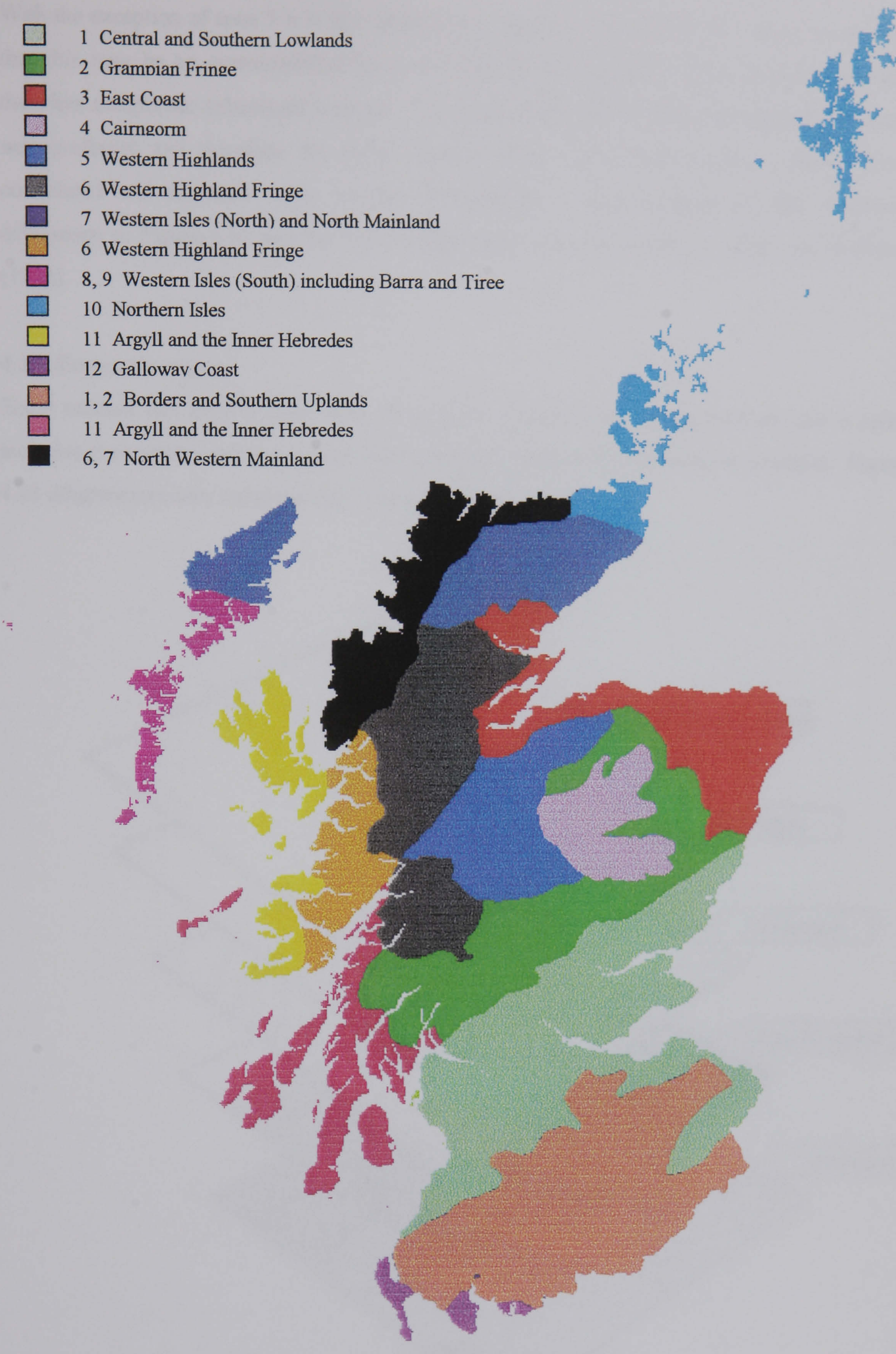

Figure 4.10: Ecoregions. After Usher and Balharry (1996), excluding the climatic factors that were added at a later stage of the Scottish Natural Heritage's zonation. The key relates this version of the species distribution data to the SNH Heritage Zones. The additional zones allow for fragmentation of the SNH zones.

With the exception of zone 5 it is also these zones which have the lowest PI scores. It was felt that this may be an oversimplification of the data for the purposes of the analysis here and therefore complicate subsequent analysis. A categorisation that avoided this potential anomaly was preferred and therefore the earlier categorisation was chosen because it keeps these convoluted and dissected zones in their sub-divisions. This accounts for any boundary differences in Figure 4.10 and the final biogeographic zones produced by Usher and Balharry (1996).

4.3.5 Economic-regions

Some account has already been taken of primary economic activity (agriculture) but a more inclusive representation of the spatial distribution of economic activity needs to be added. Figure 4.11 diagrammatically represents the inclusion of land use.

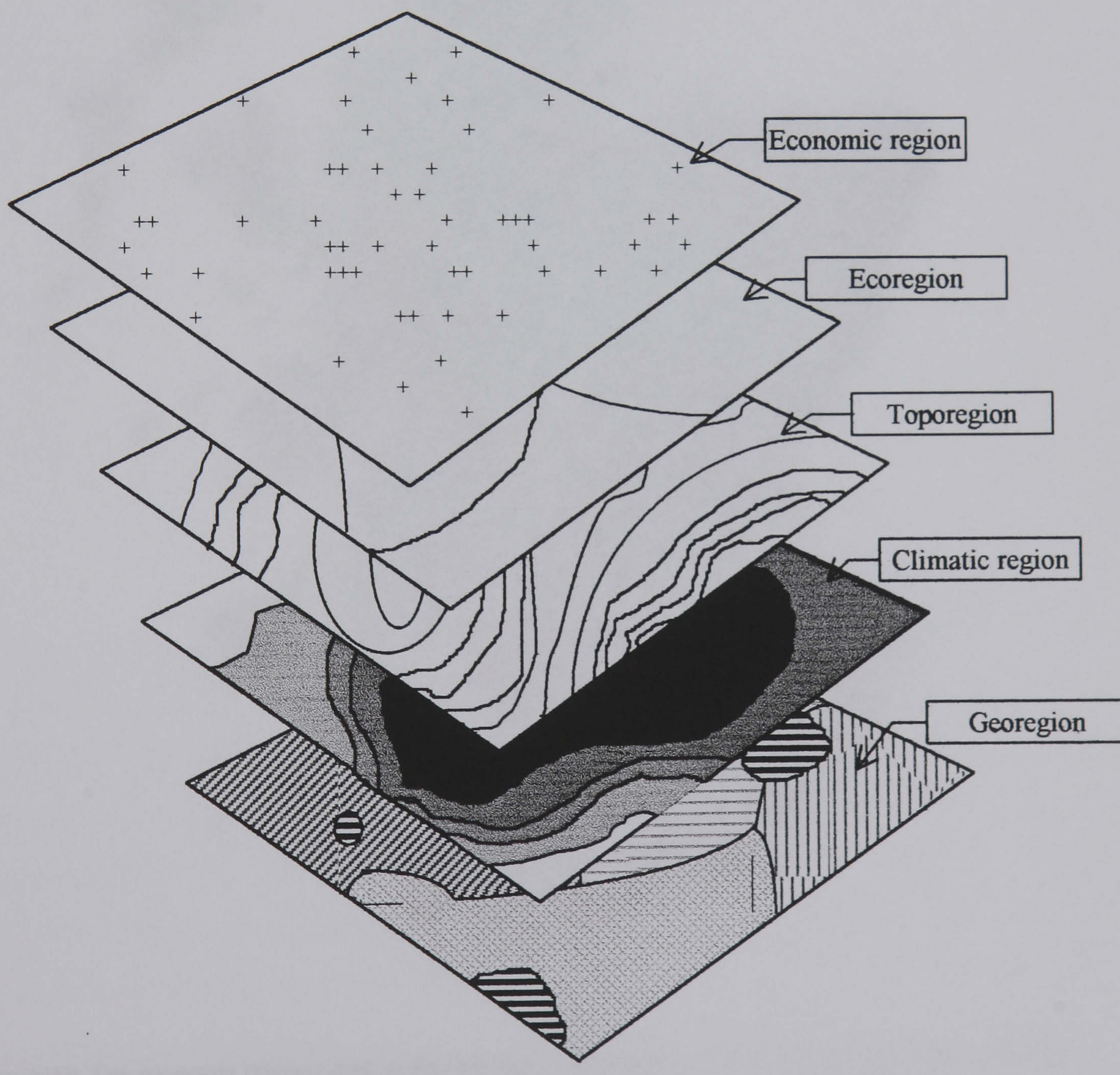

Figure 4.11: The economic regions layer is added to the stack for the definition of the bioregions.

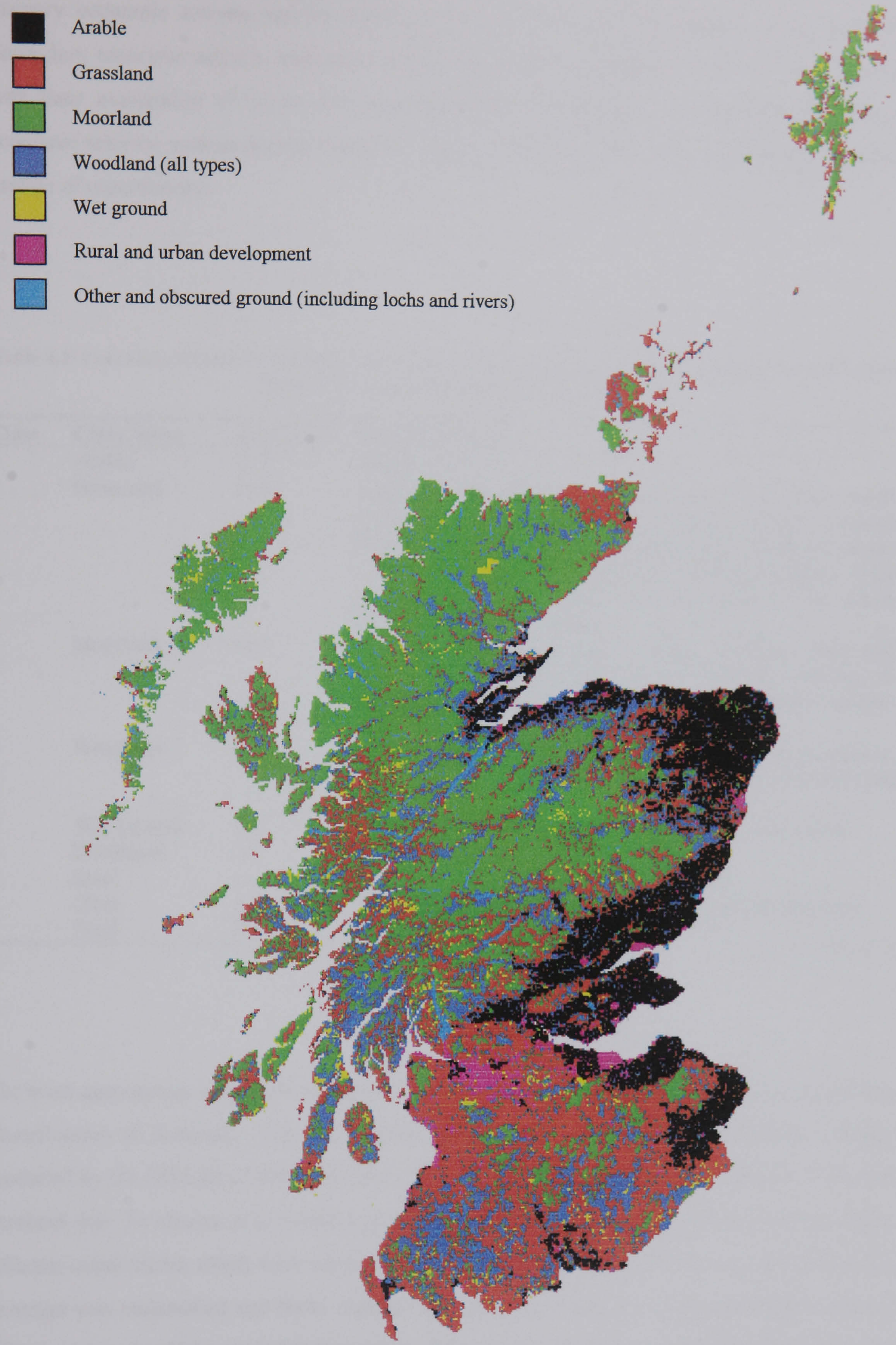

Figure 4.12: The economic regions layer is derived from a smoothed version of the LCS88 dataset (MLURI, 1993). More information about the categories in the key can be fond in Table 4.3

Primary economic activity can be considered to closely follow the patterns of agriculture. Secondary economic activity, such as manufacturing, can be considered to be centred on towns with their availability of labour and good transportation networks. The pattern of tertiary economic activity, such as service industries, can be considered to be even more dependent on the pattern of conurbations.

Table 4.4: Final reclassification of Scotland's land cover based on the major cover types identified in report on the Land Cover of Scotland 1988 (MLURI, 1993).

Class	Class Name	Area (%)	Original Classes
1	Arable	11.2	Arable
2	Grassland	20.8	Improved grassland, Good rough grassland, Poor rough grassland, Good rough grassland & poor rough grassland mosaic, Improved grassland & good rough grassland mosaic Poor rough grassland & heather moorland mosaic, Good rough grassland & heather moorland mosaic, Poor rough grassland & peatland mosaic
3	Moorland	44.7	Bracken, Heather moorland, Peatland, Montane, Rock and cliffs, Heather moorland & peatland mosaic, Peatland & montane mosaic, Good rough grassland & bracken mosaic, Heather moorland & montane mosaic
4	Woodland	14.7	Felled woodland, Recent planting, Coniferous plantation, Semi-natural coniferous, Mixed woodland, Broad-leaved woodland, Scrub
5	Wet Ground	2.4	Fresh waters, Marshes, Salt marshes, Dunes, Tidal waters
6	Developed Land	2.4	Rural development, Urban
7	Other	3.5	Missing photography, Obscured land, Unspecified mosaics
	Total	99.7	With 0.3% rounding errors = 100%

The most appropriate way of mapping the economic layer of bioregionalism is to use a land use classification of Scotland. For this purpose the Land Cover, 'lcs88', of Scotland coverage produced by the MLURI (1988) was used. The original 'lcs88' coverage of Scotland classified Scotland into 34 classes at a nominal ground resolution of 50m. The classes included many different subdivisions which were considered to be too detailed for this study's purposes and the coverage was reclassified into fewer classes. For instance, it was not considered relevant that a differentiation should be made between types of woodland. Therefore deciduous, coniferous and mixed woodland were all classed as 'woodland'. The final reclassification is shown in Table 4.4 and Figure 4.12. For the most part this reclassification follows the major groupings into which the sub-classes are allocated in the Executive Summary, which accompanies the 'lcs88' dataset (MLURI, 1993; pp. 15).

Some areas of Scotland have a land cover that does not fall easily into a single category. In some cases these combinations, or mosaics, of land cover are important to the characteristics of the area such as a mosaic of heather moorland and peatland. The question of how to handle these nationally significant mosaics arose. These cover types comprise 27.3% (21486.9 square kilometres) of Scotland's land area. At over a quarter of the total area of Scotland for this survey it was considered that the categories were too diverse to leave nationally significant mosaics as one category. Two alternatives were considered. The first divided the nationally significant mosaics between the moorland and grassland classes according to the primary cover type within the mosaic. The second classification looked at the characteristics of the mosaic as a combined entity. If it contained communities that are associated with moorland, such as bracken and heather, or are montane areas, the whole mosaic was classed as being moorland. After reclassification the new coverage was re-sampled to match the lowest cell size of the other layers. The final coverage had a nominal ground resolution of 1km.

4.3.6 Socio-regions

Mapping the socio-region was probably one of the most challenging aspect of this research. The inherent problem is that bioregionalism really calls for community participation. In a project of this nature it is not possible to do so, not least because of the scale of the project which covers the whole of Scotland. Despite this, it was decided that the whole of Scotland should be used as a major part of the exercise was to test whether the bioregional construct is demonstrable. The use of an area small enough to engage stakeholders effectively would probably have reduced the number of identified bioregions to one. It was decided that such participation could be left a future project if and when the validity of bioregions had been demonstrated. It is at this stage that Future State Visioning (FSV) is recommended as a tool that should be employed. However, certain aspect of the FSV process provide guidance through the stipulation that potential stakeholders should still be considered even if they are unable to be consulted directly.

At this stage it is not necessary to be concerned with gathering opinions on operational qualities of bioregionalism. That can also be reserved for a later stage in the process. This leaves the problem of how people identify areas they consider as their 'home territory' without consulting them directly. Figure 4.13 is representative of the addition of this final layer in the stack of coverages which go together to allow the definition of the bioregions. A guiding factor in the choice of cultural distinction was that the definitions of areas or regions must be natural patterns, rather than external, government imposed administrative boundaries.

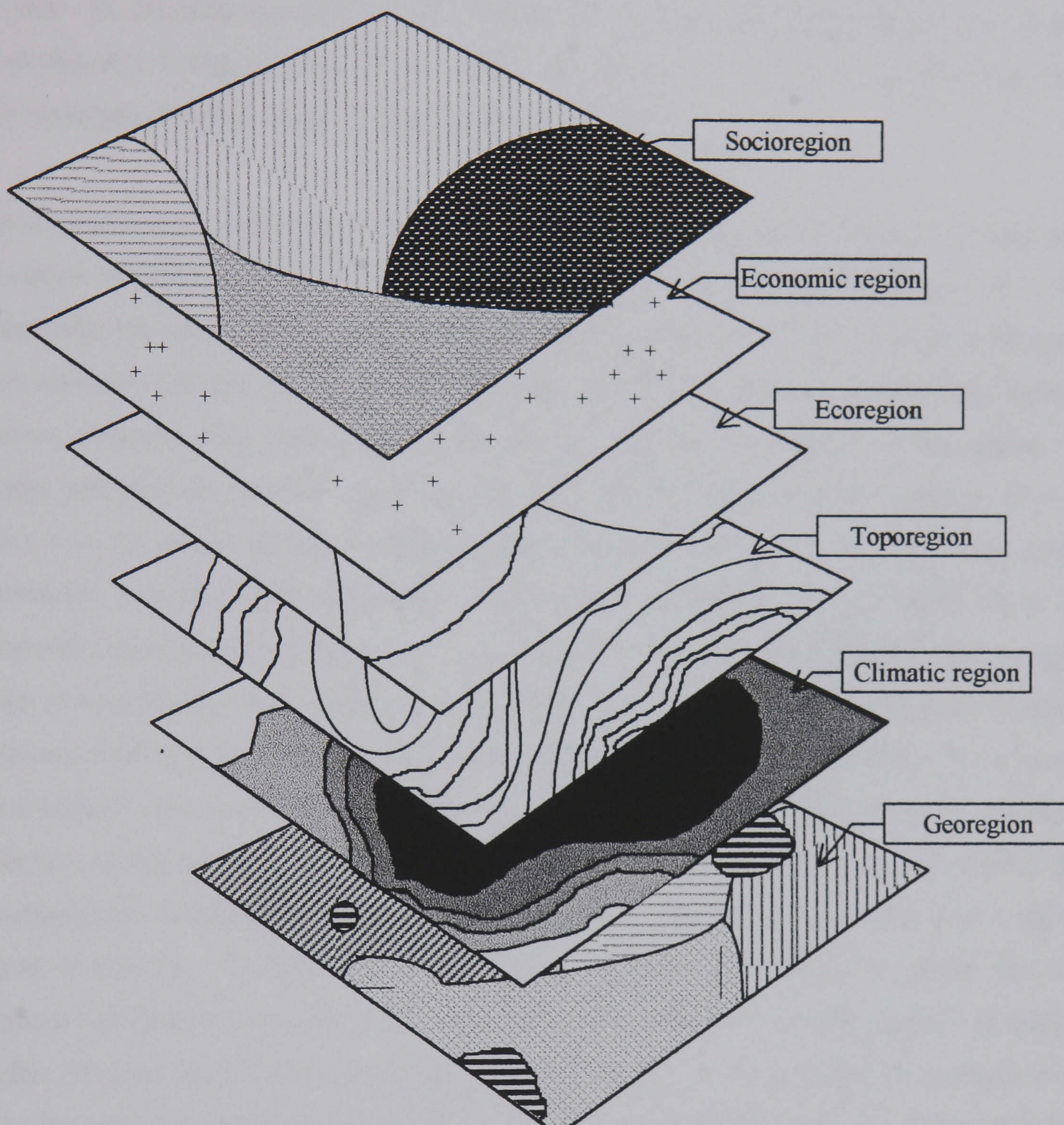

Figure 4.13: The addition of the socioregions layer completes the stack for the definition of the bioregions.

4.3.6.1 Ancient District Names and Clan Territories

The choice of suitable regional definitions proved a challenging task. It was decided that two definitions of cultural regionality in Scotland would be used. The first would be to use ancient regional names which are still in common usage but have not been adopted officially. It can be argued that the persistence of such names is indicative of the strength of association between the people and the place. A second definition is readily available for Scotland and that is the traditional Clan homelands or territories. Although these were never territories in the sense of a modern state they were identifiable 'home ranges' associated with particular clans. By the reign of James VI, the areas occupied by various clans were well defined, albeit liable to some degree of waxing and waning with the fortunes of the clan (Nicol *et al*, 1998). It was determined that two coverages should be created along these lines.

The ancient district names (Dorward, 1995; Moncrieffe and Pottinger, 1998) were plotted onto an outline of Scotland using the interactive editing feature of ARC/INFO (Figure 4.14). The ancient districts do not have certain, distinct and definitive boundaries. The centroid of the areas were identified and used as label points for the area. When all the relevant points were entered thiessen polygons were constructed to identify the most likely boundaries of the regions. A similar procedure was used for identifying the clan territories (Moncieffe and Pottinger, *op. cit.*; Nicol *et al*, *op. cit.*) to produce a second coverage for Scotland (Figure 4.15). In each case, the identifiable area associated with either a clan name or a district was often found not to be adequately represented by a single point at its centroid. This was particularly the case for large areas surrounded by smaller areas. In such a situation, the method used to construct thiessen polygons would tend to underestimate the larger area in favour of the smaller ones. Extra points were added to the cover before the thiessen polygons were constructed to help in the better definition of the shape of areas. Such points could be added strategically to restrict the 'encroachment' of smaller outlying areas on larger areas, or to help define areas with a higher degree of linearity. To define the ancient districts 93 points were used. To define the clan territories 429 points were used. Each point was associated with its relevant name. The higher number of points for the clan names is indicative of the fact that many clans can be associated with one area and that the territories were often of more complex shapes. Not every clan territory was plotted because some of the clans held very small areas of land. Such clans are likely to be dependants of a larger clans and it is more important that the patterns of principal areas are mapped than the detail of the smaller areas. The resulting definition of clan districts is a compromise between the high level detail of Moncrieffe and Pottinger (*op. cit.*) and the lower level of detail, but extra clarity, of Nicol *et al* (*op. cit.*).

Figure 4.14: Distribution of districts as identified by thiessen polygons whose centroids were based on ancient district names still in current usage (Dorward, 1995; Moncrieffe and Pottinger, 1998)

Figure 4.15: Distribution of major clan territories during the reign of James VI as identified by thiessen polygons whose centroids were based on territory centroids derived from Moncrieffe and Pottinger (1998) and Nicol *et al* (1998)

The thiessen polygons constructed in this method stretched to the edge of the grid or, in other words, beyond the coast and out to sea until the map limits were reached. In addition, the extra points used to help define complex areas also have polygons because the process automatically creates a polygon for each point. This results in areas where there were a number of polygons all with the same name attribute. Before continuing it was necessary to rectify these two artefacts of the mapping process.

The polygon coverage was 'clipped' as before back to the correct coastline. The process of clipping the thiessen polygons is that some are subdivided into more than one polygon where the coastline separates one part of an area from another. This can happen particularly around river mouths and in the definition of offshore islands. Adjacent polygons having the same attribute were then merged together by dissolving the boundaries between them to give single polygons which are a better definition of the larger areas identified in the process described above. The result was two coverages, one for ancient district names composed of 447 polygons and another for clan territories composed of 610 polygons (excluding the 'universe polygon' in each case).

One last transformation is required to enable comparisons to be made with the other grid coverages listed in the preceding paragraphs. The coverages of ancient district names and clan territories must be converted from a vector into a raster format. A final note of caution is necessary here to state that both these cultural maps are of discrete data, not continuous, which has implications for the statistical analysis.

4.3.6.2 Regional Variation in Vernacular Buildings

Probably one of the best non-participative stakeholder definitions of regionalism must be the variations in the local response to the environment and its resources (Stevenson and Ball, 1998). These are brought together in the prevalence and distribution of styles of vernacular buildings. The vernacular builder is unlikely to have extensive financial resources to import exotic materials and must, perforce, make do with what is to hand (Rackham, 1987). This imparts, in conjunction with local proclivities of stylistic detail, regional distinctiveness (Scottish Office, 1998) into vernacular buildings (Jackson, 1984). Bioregional definitions have implications for any study into building materials where availability of timber, slate, aggregates, stone and thatch (for instance) is important. The subject of materiality and the investment of local culture in the built environment through the expression of the natural environment, or responses to it, as evidenced by the distinctiveness of regional vernacular buildings is an area that is in need of further research (Ball *et al.*, 1996). That research must be left to others at this moment while recognising the importance of the subject by its inclusion here.

A survey was carried out during the early 1980s, on behalf of the then Countryside Commission for Scotland, of 23,500 small buildings, randomly selected, across Scotland (a ratio of about 1:10) excluding large buildings such as mansions and churches (which might be expected to have employed exotic materials and more prestigious non-local architects). The result of this detailed survey was a regional classification of Scotland into 12 mainland and 3 island-group character zones (Naismith, 1989).

Naismith's (*op. cit.*) map of character zones was scanned into the computer using a flat-bed scanner at a resolution of 300 dots per inch. The data were stored as a TIFF picture file which was subsequently edited using Adobe PhotoShop. Editing of the TIFF file was done to prepare it for conversion to an ARC/INFO raster coverage of Scotland (Figure 4.16). The procedure was as follows:

1) All non-essential data were removed. Such data included all town and island names, boundaries of former counties, all non-essential cartographical items and the numbers of the zones so that all remained were the boundary lines and the coastline.
2) The boundary lines for the zones were then extended beyond the coast to the edge of the picture and additional lines were inserted to group the islands in accordance with Naismith's text (*op. cit.*). Extending the zones' boundary lines allows for a greater degree of tolerance in subsequent matching of the coastline.
3) The picture was cropped to fit Scotland. The outline of the coastline was then removed, being redundant. To save space in the original map, Shetland had been included in an inset box, denoting that it was not in its correct geographical relationship to the rest of Scotland. Shetland emerges from the cartographic process, without the need to correctly repositioning it, as will be shown.
4) Each major zone was assigned a unique colour. The colour was a means of assigning a code to each zone. Because the type of data was discrete, the zones being non-hierarchical, the actual colour assigned to each region was irrelevant so long as it was unique to one region. The zones were filled with colour so that they overwrote the zone boundary line to its midway point and the edges of the area, now defined solely by colour, were not anti-aliased (i.e. they were crisp, with no fade-out), the division between regions being represented by a Boolean change in colour.

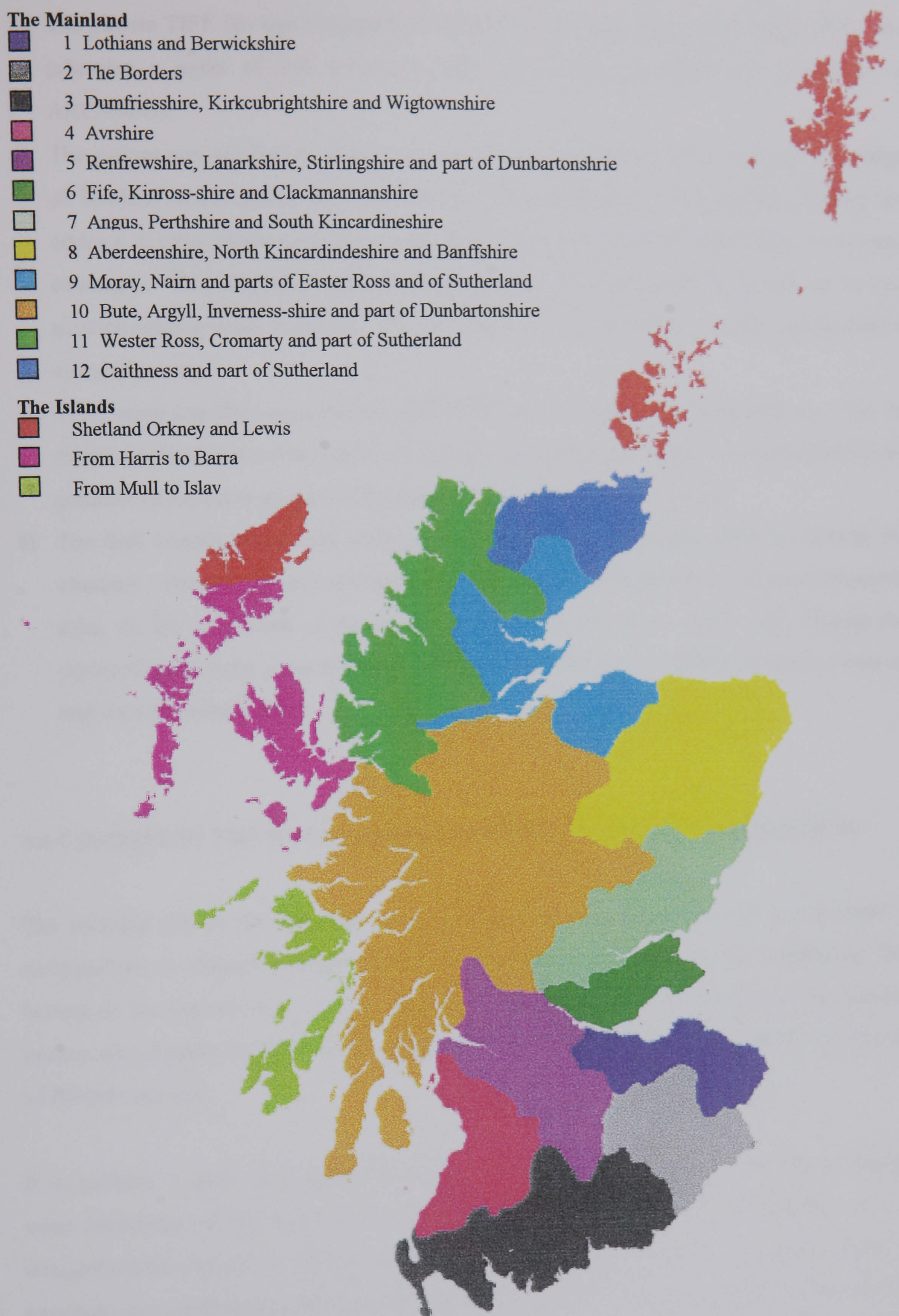

Figure 4.16: Character zones of vernacular rural buildings in Scotland (after Naismith, 1989).

5) The picture TIFF file was converted to indexed colour mode with a pixel depth of 16 bits (allowing a pallet of 256 colours to give good colour separation on translation in ARC/INFO).
6) The picture was rectified to match the resolution and dimensions of existing grid coverages of Scotland to co-register the data with the existing datasets. This process included the addition of extra area around three sides of the picture to match the total extent of existing coverages. This additional area also created space for Shetland to be located in its true position relative to the mainland. The additional area was coloured according to the nearest coloured zone(s).
7) The picture was then imported into ARC/INFO and converted to a raster data set. The xy minima and cell size could now be set to match the existing coverages of Scotland using the gridshift command to give a usable registered grid with a cell size of 1km.
8) The final transformation was made to remove all the coloured area which lay outside the coastline. Because Orkney and Shetland were classed by Naismith in the same character zone, all the area north of the mainland was given the same colour. On clipping the registered grid (using a coastal outline of Scotland) Shetland is located in its correct location and correctly colour coded.

4.4 COMBINING THE DATA LAYERS TO IDENTIFY POSSIBLE BIOREGIONS

The ultimate aim of the preceding work on preparing the data layers was to use them in combination, to identify possible bioregions in Scotland, working on the assumption that bioregions are demonstrable entities. Figure 4.17 represents the final outcome of the layering process and suggests the fuzziness or transitory nature of the bioregional boundaries with the use of shaded contours.

It is, perhaps, a more usual approach to define an area by identifying its boundaries through some knowledge of the extent of the area or some identifiable boundary features. It is a straightforward process to identify areas of similarity or homogeneity in stacked layers of coverages in a sophisticated GIS package such as ARC/INFO. However, herein lay the problem for identifying bioregions using GIS. Even a cursory consideration of the layers that go to make up the stack of seven layers (described in the preceding sections) will reveal that clear-cut patterns of homogeneity are unlikely to emerge by a simple combination of the layers. However, such an outcome would not be expected given the nature of a bioregion.

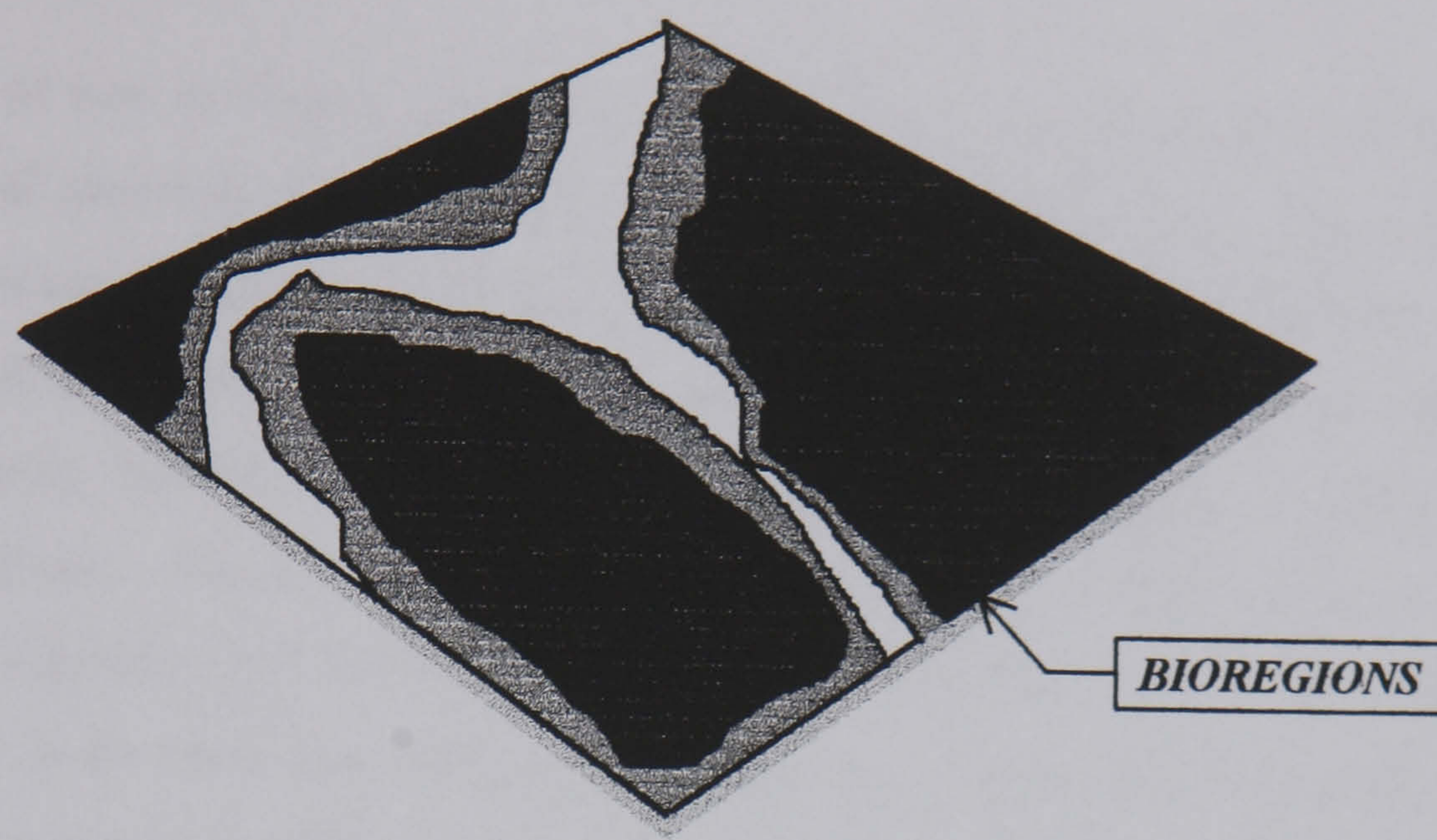

Figure 4.17: Representation of the bioregions showing the fuzzy nature of their boundaries.

A bioregion, if closely associated with the 'signature' of watersheds, can be expected to have variation inherent in almost all of the factors that go into its definition. For instance, a bioregion might be expected to extend inland along watercourses within a basin. This implies wide variation in height, but closer inspection reveals that, over such an area, there might also be an expected variation in rainfall, and particularly temperature, as the ground rises to higher inland summits and plateaux. A variation in height also is associated with a variation is soil type as is evident from the classification in the Land Capability for Agriculture data (MLURI, 1993). A variation in land use is also not unexpected in the sequence from coast through lowland areas to uplands. In short, it is not the homogeneity of the values of attributes but the attributes themselves that define the 'bioregionalness' of an area. Therefore, to identify bioregions, it is not relevant or meaningful to look for areas which can be classified neatly by a particular range of values for height or specific characteristic of land use because a bioregion will contain a number of ranges of these values. Therefore, regardless of the actual values within any cartographical layer, the quality of 'bioregionalness' of an area remains unaffected. It would seem a logical procedure to try to map some quality like 'bioregionalness' but, as has been demonstrated, bioregionalness is not quantifiable, at least in numerical terms. Since all locations are equally bioregional, belonging as they must to one or another of the globe's identifiable bioregions, any map of 'bioregionalness' will be uniform despite containing boundaries. In addition, the practicalities are that the data in the coverage layers, as prepared in the previous section, are discrete and categorical. This rules out most of the conventional statistical techniques available in ARC/INFO.

The problem of how to identify bioregions using GIS can be resolved by reversing the usual epistemological construct of geographical area identification. Instead of trying to identify areas by their boundaries, it should be equally possible to identify boundaries by their areas. The former procedure can be expected to give rise to more tightly defined-regions, and therefore sharp boundaries, because the question which is effectively being asked, if subconsciously, is Boolean in nature. The question can be phrased as "Is this location inside or outside the boundary?" Whereas, if it is the quality of 'boundariness' (see Figure 4.18) which is being considered, as in the latter case, there is a higher degree of uncertainty. Even features such as rivers are only sharp divides in the human imagination. In ecological terms they can be considered to be transition zones. However, this degree of uncertainty is not a problem for bioregionalism, which accepts that natural boundaries are fuzzy.

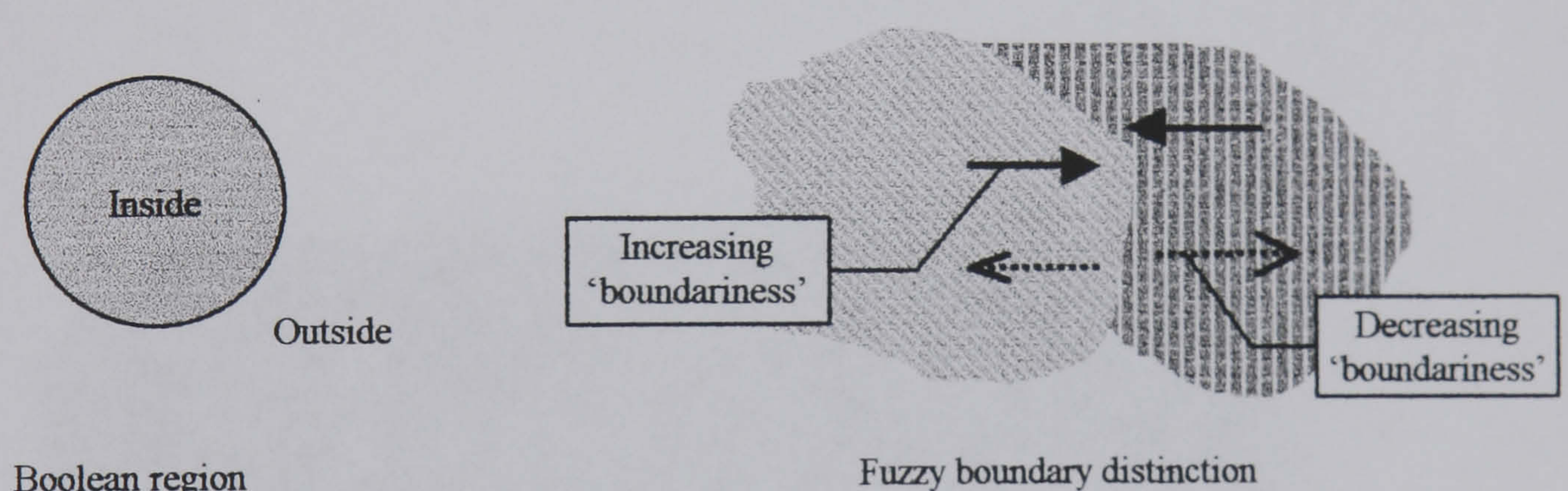

Figure 4.18: Defining area by their boundaries compared to defining boundaries by their areas. The former giving rise to sharp boundaries and the latter to less certain, or fuzzier, boundaries.

Having determined that the most appropriate method of identifying bioregions in GIS is a definition of boundaries through their areas, there are two principal practicalities of the procedure to consider. These can be summarised as follows:

- how will the boundaries be identified in practice from coverages of discrete data?
- having identified the boundaries in separate layers how will possible bioregions be identified when the layers are combined?

A boundary in any coverage of discrete data lies at the intersection between two areas which have different values. The values in themselves, being categorical, are of no relevance here other than to identify any given cell in the cartographical data matrix as belonging to a certain region or area. Therefore, a location in such a grid can be considered to have a greater degree of 'boundariness' the greater the number of different value which surround it. If a location is surrounded by cells which all have the same value then it is clearly not near a division between areas and consequently has no degree of boundariness. If, on the other hand, a location had three or four different values surrounding it, then it is evident that it is close to the convergence of more than two areas. Such a location has a high degree of boundariness. ARC/INFO provides another 'focal' command which assesses the variety of values within a neighbourhood. The 'focalvariety' command was used with a circular neighbourhood, having a radius of three cells (equivalent to a nominal ground resolution of 3km), on each of the seven coverages whose preparation was described in the preceding section. This resulted in a stack of seven coverages in which the value of a cell was a measure of its quality of boundariness as shown in Figure 4.19.

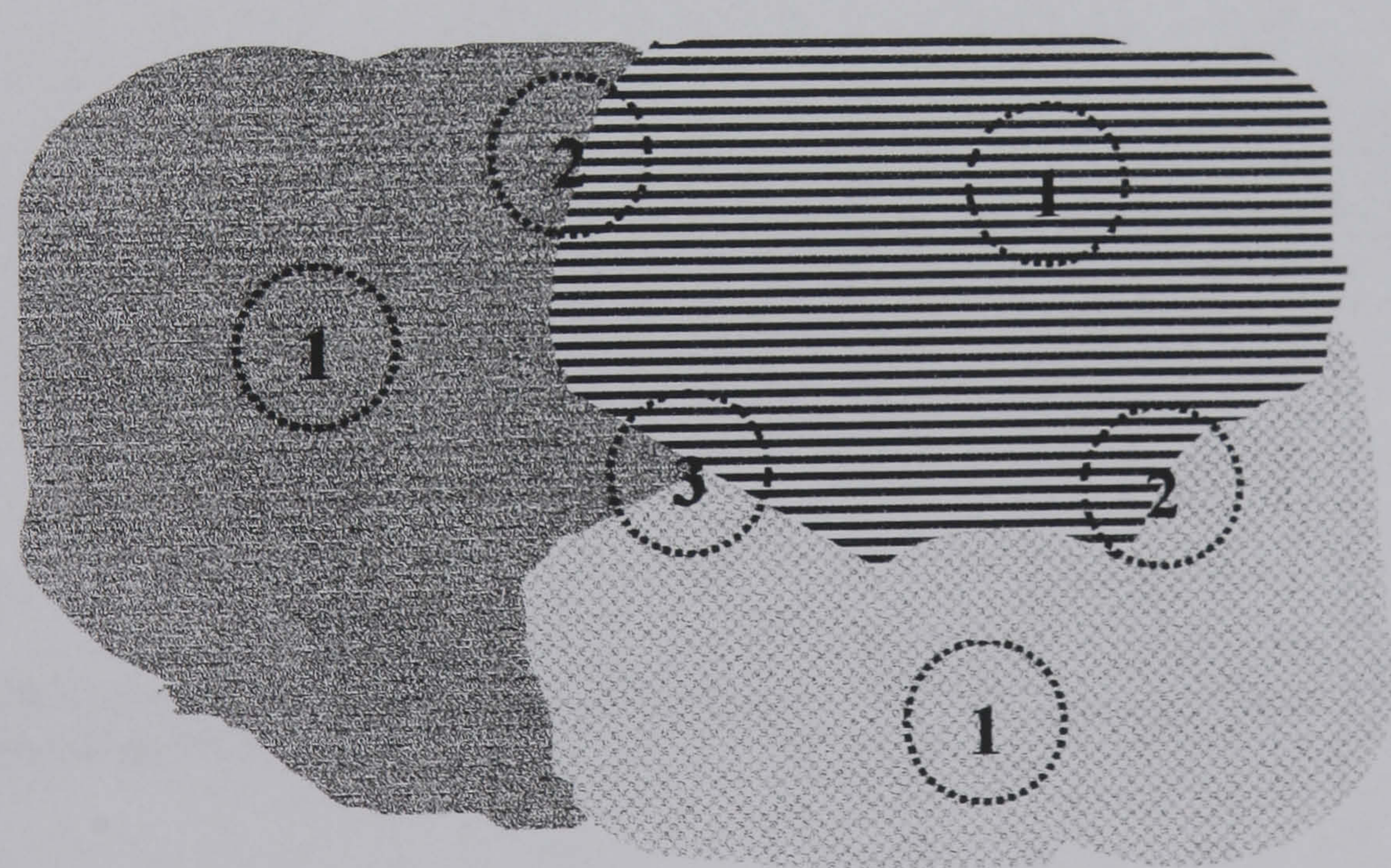

Figure 4.19: Values in the boundary definition grid refer to the boundariness of cells within the specified neighbourhood.

If the seven coverages are considered in a stack, the interesting areas are those where the sum of the values approaches a maximum. In each layer, the values of cells in the grid relate to their degree of boundariness. Therefore, if it was possible to look down through the layers, areas of the greatest coincident boundariness could be identified as the boundaries of bioregions if they appear to show enough distinction above the level of the anticipated background 'noise'. Such an effect can be achieved if the value of the layers are added together (Figure 4.20).

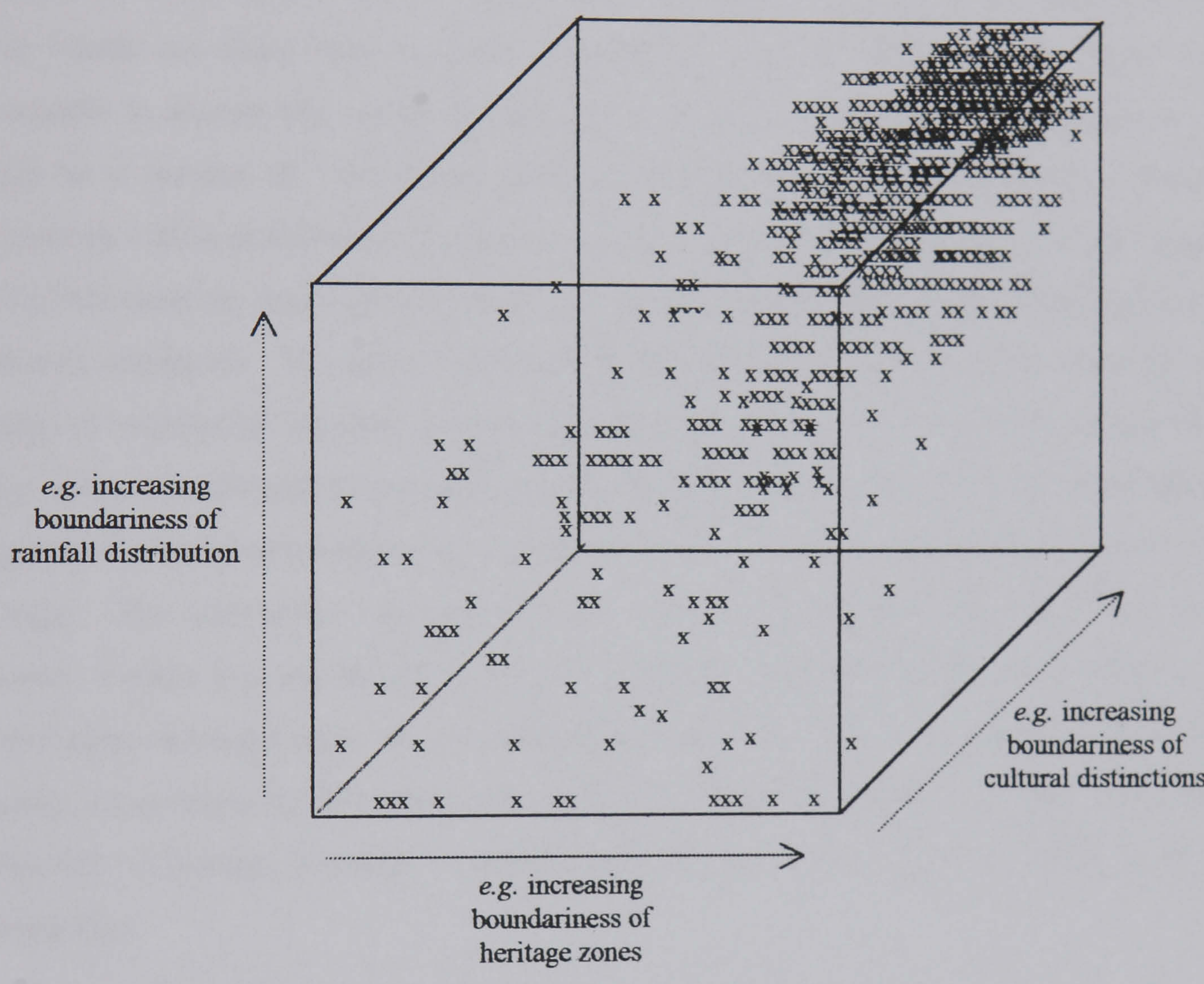

Figure 4.20: Coincidence of 'boundariness' in multivariate attribute space. If bioregions exist their boundaries will be defined by the repeated coincidence of areas with a high degree of 'boundariness' in each layer.

The minimum value in the output grid will be seven which represents the sum of those areas in which there is only one value and, consequently are towards the centres of their regions (see Figure 4.20). For a clearer understanding of the processes at work, compare Figure 4.20 and Figure 4.5.

4.4.1 Converting From a Coverage of Boundaries to a Coverage of Areas

To enable comparisons to be made with other coverages of regional definitions for Scotland it was necessary to convert the bioregional coverage, developed in the description above, from a coverage of degrees of 'boundariness' to a coverage of regional areas.

With seven layers, the values for the cells in the bioregional boundary coverage ranged from 7 to 18, where the higher the number the higher the degree of boundariness. The base value was seven because there were seven input layers and any cell which correspond as areas in all seven layers gives a cumulative value of seven. It is reasonable to assume that bioregions have core areas which are away from the main boundaries with other bioregions. It might also be reasonable to assume that, given the high degree of internal heterogeneity of bioregions, there might be a number of 'core' areas within one bioregion. This would create a mosaic of boundaries within and between bioregions. It was assumed that values up to and including one and a half times the base value could be considered to have a high degree of confidence as the centre of bioregions. The values from seven to ten inclusively were identified as having a high degree of 'regionality' because, in each input layer the value '1' is assigned to a region and all other values are assigned to increasing degrees of boundariness. Therefore, where the degree of regionality is high and the degree of boundariness is low, the area can be assumed to be a core of a region. The value of ten was chosen as the cut-off point for identifying core regions for two reasons. Firstly, it is one and a half times the base value. In other words, at least 50% or more of the input coverages agree on the regionality of the area. The score for land area by value reaches a maximum for the value nine indicating a threshold point in the data. The result is effectively a Boolean coverage of certain regional cores and areas of uncertainty (or fuzzy boundaries).

The bioregional boundary coverage was re-classed to contain two values, where all certain regions were assigned the value of '10' and all uncertain or boundary regions were assigned the value of '1'. The values were chosen arbitrarily, which is acceptable owing to the categorical nature of the reclassification. Table 4.5 shows the division of areas by value.

Table 4.5: Range of values and corresponding land areas in square kilometres of the bioregional boundary coverage.

	← Increasing confidence of area belonging to regional core											
	Increasing degree of 'boundariness' →											
Value	7	8	9	10	11	12	13	14	15	16	17	18
Area	707	4856	12850	20329	19290	12159	5648	2133	599	144	33	5
	← *categorical value '10'* →				← *categorical value '1'* →							

The conversion to a coverage of areas was not, at this stage, complete and still required the absorption of the boundary zones into the most appropriate bioregions. The data also contained spurious or 'sliver' regions which needed to be eliminated. Such areas were considered to be so small as they could be absorbed directly into their surrounding region. On absorption of the boundary zones the definition of the coverage would be lost into singularity unless a means of identifying the regions was devised beforehand. To achieve this the following process was followed:

1. The raster coverage of boundaries and regions was first converted to a vector coverage producing a coverage where areas were represented by polygons.
2. Next the sliver polygons were eliminated by dropping the arc which defines the longest border of polygons whose internal areas were less than or equal to 5 km^2 (this reduced the number of polygons from 470 to 455) except for those sliver polygons whose longest boundary defines part of the coast line. The latter polygons were retained.
3. The vector coverage was then converted back to a raster coverage (Equation 10). This process results in a slightly less noisy coverage where the value of the cells in the new raster coverage reflects the polygon number assigned by ARC/INFO during the conversion process.

Equation 10:

```
polygrid cleaned-vector-coverage raster-coverage1
```

4. A second raster coverage is also made but the original Boolean region/not-region definition was retained (Equation 11). The result is a coverage which can be used to distinguish the region cores from the less-certain boundary areas (or non-core zones).

Equation 11:

```
polygrid cleaned-vector-coverage raster-coverage2 grid-code
```

5. From these coverages a third coverage was constructed by assigning all the region cores in the second raster coverage the value of 1, with all other areas receiving a value of 0, and then multiplying it by the first raster coverage to give a coverage where all region cores retained their unique identifier number (assigned during the vector to ratser conversion) but the non-core areas all have the value of zero (Equations 12 & 13).

Equation 12 & 13:

```
region-cores = raster-coverage2 eq 10
numbered-regions-&-boundaries   =   region-cores   *   raster-
coverage1
```

6. The next step was to minimise the none-core areas, allowing the region-cores to grow into the non-core areas. As the non-core zones shrink away from the edges of the various region-cores which they touch, those region-cores expand to fill the void and retain their unique identifier value on meeting another expanding region-core. At such a point, when two expanding region cores meet, the expansion stops with neither core overwriting the other. ARC/INFO was instructed to shrink the non-core areas by up to 10 cells to ensure complete removal of the non-core areas.
7. The resultant coverage was trimmed using the 'cookie-cutter' technique described earlier (Equation 14), because expansion can take place into areas of no-data (*i.e.* the sea).

Equation 14:

```
regions-only  =  shrink  (numbered-regions-&-boundaries,  10,
list, 0)
latticeclip regions-only coastline regions-clipped
```

Where the non-core areas existed previously there were also islands of regionality within them. It can be assumed by the fact that these islands of regionality lay close together and that they shared the characteristic of being surrounded by non-core areas, that they were more alike to each other than they are to perhaps larger regions. Clearly, the islands of regionality were not bioregions in themselves, but did retain a distinction from those areas which could be considered as bioregions in their own right. These small areas tended to be found together in clusters. These clusters may be representative of the concept of 'bioplaces'. Bioplaces may be the local community scale subdivision of a bioregion. This is a new concept. Nevertheless, they need to be assigned to a bioregion of their own. These small areas appeared to have more in common with each other than with their larger neighbours. With this in mind, it became clear that the conventional wisdom in ARC/INFO of simply dropping either the longest arc or merging with the biggest neighbour was not necessarily appropriate. Furthermore, there still remain some sliver polygons on the edge of the coast. A set of rules were devised to reduce the degree of subjectivity during the process of merging the islands (it was considered easiest to reconvert to a vector dataset for this process). Those rules were as follows:

1. all off-shore islands are considered to be bioregions in their own right
2. all off-shore archipelagos are to be considered as one bioregion
3. in-shore islands are considered to be part of the nearest mainland bioregion but are not merged until the whole of the mainland has been considered
4. where a small island lies equidistant between the mainland and an off-shore island it is assigned to the off-shore island's region.
5. where a small island lies equidistant between two off-shore islands, it is assigned to the one which lies closest to the mainland because, in the absence of any other information, it is assumed that the normal course of colonisation is from the mainland out.
6. small isolated polygons are assumed to be 'bioplaces' within their surrounding bioregion. Such polygons are merged into their 'parent' polygon directly.
7. small polygons on the mainland are always merged with their smallest neighbour so as to aggregate the fragmented areas (or transition regions) unless . . .
8. . . . they are more than three-quarters surrounded by a larger neighbour (*i.e.* they are clearly and enclave of the larger polygon and more rightly belong to it rather than their nearest 'transition' region).
9. merging of regions has direction and proceeds in chains:
    - a polygon which has not been merged with any other polygon or used in any part of the merging process will be referred to as a 'virgin' polygon
    - merging proceeds as a chain which is only broken when a rule would be violated

- a chain may only be started by a 'virgin' polygon and stops when it links to a 'non-virgin' polygon or where there are no other neighbours except for the sea.
- a chain should start at the coast and work in-land (up watersheds) or start with a 'cul-de-sac' virgin polygon inland
- if polygon, proposed as the start of a new chain, has a smaller 'virgin' neighbour, the chain must start with the small 'virgin'.
- a chain cannot be started by merging a larger polygon into a smaller one.
- a chain proceeds always to the smallest adjacent virgin polygon
- once a chain has been broken, all the polygons of which it is comprised are merged and the resultant polygon is no-longer 'virgin' and may never be used to start a new chain. It is assumed that such a polygon has attained a self determined 'critical mass'.

10.there can be no 'virgin' regions left on the mainland at the end of the process.

A coverage of bioregions was constructed using these rules. During the merging process it was realised that there were occasional conflicts of direction depending on the choice of legitimate start points. Additional rules for merging were devised to overcome these conflicts and a second bioregional coverage was constructed with these additional rules (supplemental to point '9').

- a new chain starts from the next nearest legal neighbour to where the last chain stopped. in this way, if the new chain loops back into the old one, it confirms the neighbouring small polygons belong to the newly created region nut if the new chain terminates without joining the newly created region, it confirms that the termination of the old polygon was, indeed, at the limits of that region. The smallest legal neighbour is preferred.
- if a chain ends with a virgin polygon, the process is attempted in the opposite direction by starting with that virgin. If the resulting second attempt chain ends with a non-virgin region, then this is the preferred direction and is accepted.
- if a number of alternative routes in possible alternative chains agree as to which polygons are to be merged then the routes which are in agreement are assumed to indicate the strongest relationships and the polygons which lie on those routes (having all been identified by all agreeing routes) are merged.
- if a conflict still remains then the start of the next chain is moved away completely to a clear and unambiguous virgin. It is assumed that the conflict will be resolved by new chains working their way back to the disputed polygons from which new direction they are not in conflict.

The polygon merging process is represented graphically in Figure 4.21 to clarify the points above and help show how the region cores were merged in practice.

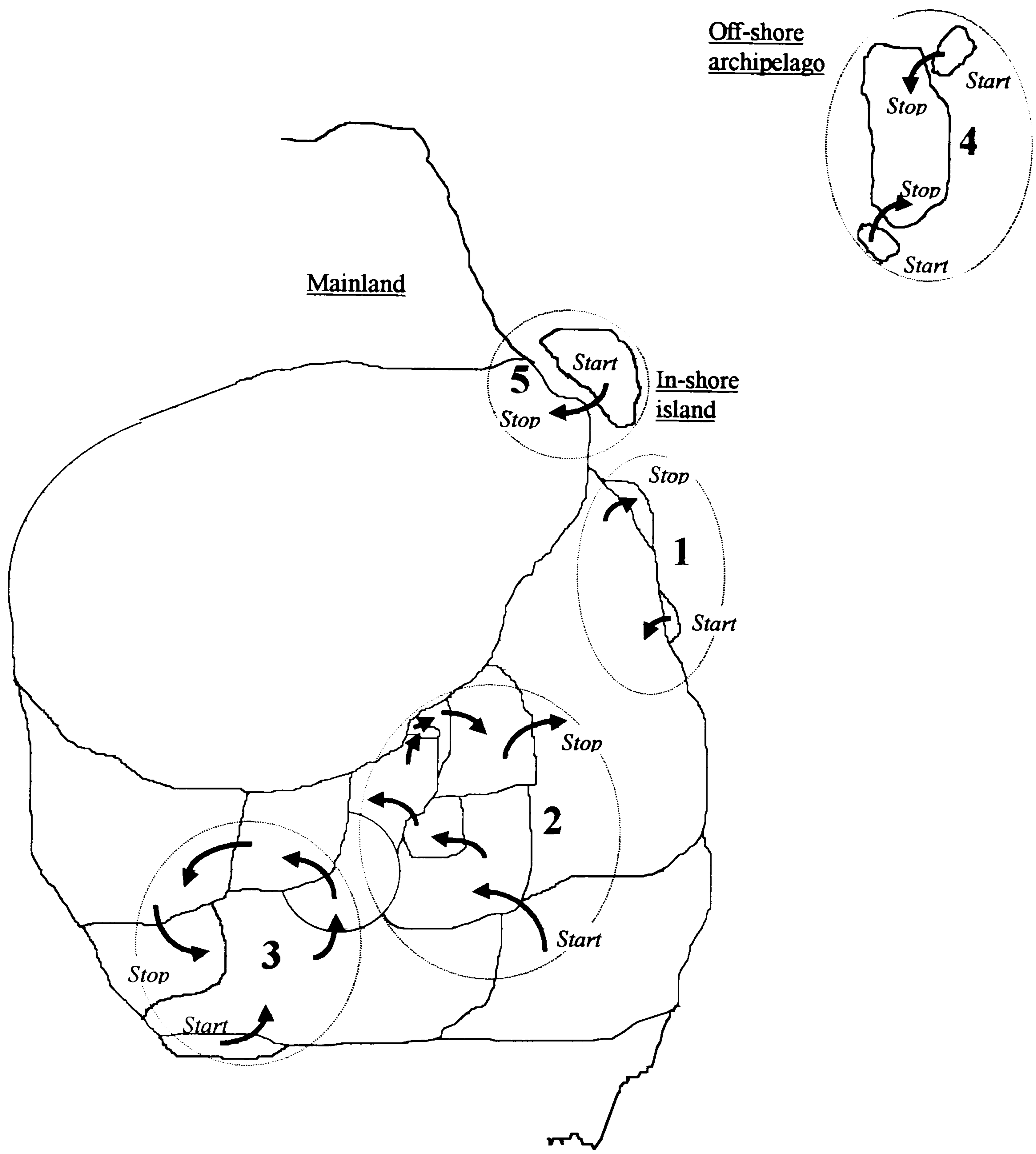

Figure 4.21: A graphical representation of the polygon merging process. The dotted circles show the grouping of the polygons to be merged and the arrows show the direction in which the chains move. Polygons are only merged once the start and the stop points of a chain have been established. The diagram is based on the extended 'conflict resolution' set of rules.

At this stage there were two coverages of possible bioregions for Scotland. One was constructed using the first, intuitively designed, rule-base (Figure 4.22) and the second was constructed using the expanded conflict-resolving rule-base (Figure 4.23). The expanded rule-base was found to give a process which was free from further conflict. A comparison of these two proposals for the bioregions of Scotland should be indicative of the robustness of the merging process described above. Producing two alternatives allowed for sensitivity analysis, the results of which are shown in the next chapter. If the agreement between the two proposed bioregional coverages is poor then the process is susceptible to conflicts and there can be little faith placed in the internal consistency of the process' logic. If the agreement between the two proposed bioregional coverages is good, then the process can be considered to be robust. Agreement should not be expected to be complete because conflicts were identified (hence the extension of rule '9'). If agreement were found to be complete despite the conflicts, then the suspicion of an undetected error would be justified. Failing that the results might be considered in some way to be an artefact of the computational process rather than an observable phenomenon.

4.5 COMPARISON OF THE COVERAGES

All the coverages of Scotland were now ready to be compared. It was determined that three variants on the theme of frequency matrices would be used to provide comparisons between each coverage. These were Mean maximum probability, Chi-squared (Rees, 1995) and Cohen's Kappa tests (Cohen, 1960). ARC/INFO does not have the facility to conduct these tests automatically. Therefore, the data had to be extracted in such a way that these tests could be performed.

4.5.1 Statistical Techniques for Analysis of Frequency Matrices of Categorical Data

Categorical data can present particular problems for analysis. The category identifiers are not necessarily numerical and, where they are, they are not necessarily susceptible to ranking. Many of the numerical identifiers used in the data for the various coverages in the comparisons under consideration were arbitrarily assigned, sometimes based on the numerical equivalent of a colour that was used to code an area. Such numbers in themselves have no meaning.

Figure 4.22: 'Bioregions 1' – the first representation of the bioregions of Scotland

Figure 4.23: 'Bioregions 2' – the second representation of the bioregions of Scotland using the extended set of rules.

The simplest method of handling a frequency matrix is merely to report the observed probability (p_o) of coincidence between two categories. In itself this value is fairly meaningless (Cohen, 1960), if not potentially misleading (Fisher and van Belle, 1993). The inadequacy of this value lead to the formulation of the concept of the twin values of mean maximum probability and mean cross-representation, described in Section 4.5.1.1.

It is only the attribute of uniqueness that is important for differentiation from other regions. The three tests that were chosen to handle the comparisons represent increasing levels of statistical sophistication. However, they also represent increasing levels of pre-processing required to enable the test to be conducted. Each step of pre-processing inevitably introduces the chance of error and often an element of subjectivity. It is for this reason that the results of all three methods will be presented in the following chapter. A brief description of the techniques follows in section 4.5.1.1 through to 4.5.1.3.

4.5.1.1 Mean Maximum Probability and Mean Cross-Representation

Mean maximum probability, is the mean of the highest frequency observed between each columnar category and row category in the frequency matrix. This is a truer measure of the level of association between two categorisations than simply quoting the value of p_o (see section 4.5.1 above). The mean cross-representation is the average number of categories of the row categorisation that are represented by each category in the columnar categorisation. This is a measure of the level of fuzziness between categories. In most situations there would be no purpose to the calculation of this value. The comparison of geographical regionalisations, where all members of region are contiguous is a special case where it is anticipated that there may be many impossible associations. For example, a region that is confined to the North of Scotland can never show agreement with a region of another category that is confined to the South of Scotland however good or bad the overall agreement between the two categorisations is. This leads to a frequency table with many zero entries that is a simplified variation of the possible relationships between two 'egg-yolk' pairs of regional representations[5] (see Cohn and Gotts, 1996). The difference between the analysis here and egg-yolk analysis is that, in this case, the fuzziness is not pre-defined but is 'discovered' by virtue of the 'spill-over' between areas (Figure

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5 Cohn and Frank (1996) suggest that geographical objects with indeterminate boundaries can be represented by a zonation of concentric subregions which the 'yolk' is indicative of certain membership and 'white' is indicative of vague membership. A complex version of this model might have several sub regions like Russian dolls to represent increasing certainness. In the basic 'one-yolk' model, two regions can be related in 46 different ways.

4.24). The value of mean cross-representation is a 'rule-of-thumb' gauge and must always be considered in relation to the number of categories in the 'comparator' categorisation.

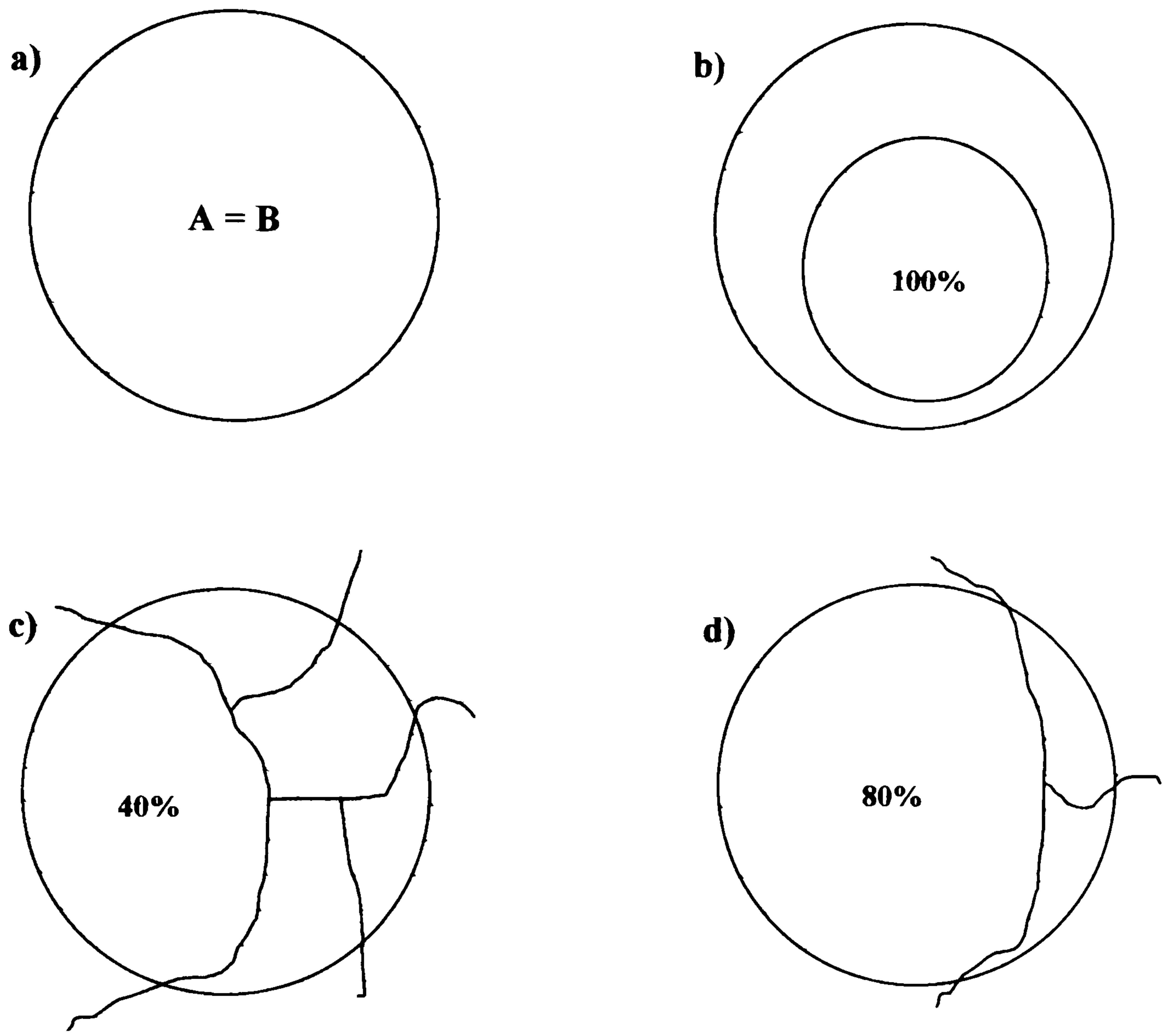

Figure 4.24: A graphical illustration to assist interpretation of the value of mean maximum probability and mean cross-representation. The goodness of fit is determined by the maximum probability of coincidence in conjunction with the number of categories across which the comparator lies.

Either value, if taken in isolation, is not very helpful. Together, however, the two values give a picture of the 'resolution' and 'noise' within the frequency table. For instance, a comparison of two sets of identical categories will give a value for mean maximum probability and mean cross-representation of p_o = 1 in both cases (Figure 4.24a). A similar result can be found if all the categories in one categorisation are contained wholly within the categories of the other categorisation (Figure 4.24b). This could happen if one categorisation had more values.

A situation where, say, a square frequency matrix of 10 rows and columns gives a mean maximum probability of 0.4 and a mean cross-representation value of 5 would suggest a weak association and considerable noise within the matrix (Figure 4.24c). In other words, this would be regarded as a poor 'fit' where any given columnar category is likely have only 40% of its area coincident with a single row category with the remaining 60% 'spilling over' into four additional surrounding categories. A good association might be indicated if the results of a similar comparison gave a mean maximum probability of, 0.8 and a mean cross-representation of 3. In this case any given columnar category is likely to have 80% of its total area coincident with a corresponding row category (Figure 4.24d). The remaining 'spillage' of 20% is divided between another two other categories.

4.5.1.2 Chi-Squared Test of Association

Chi-squared (χ^2) is a standard technique for testing the degree of association between two categorisations and is well described in many texts (*e.g.* Rees, 1995) therefore, only a brief description will be given here. It is more sophisticated than the previous simple method and requires some pre-processing. χ^2 actually tests whether a pair of categorical variables are independent were the null hypothesis states that there is no significant association between the categories. For association to be shown the null hypothesis must be rejected. The basis of the χ^2 test is a comparison between a two-way contingency table of observed counts and a similar, calculated, table of expected counts assuming the two categorisations are independent. The expected contingency table entries are calculated using the formula

Equation 15:

$$E = \frac{\text{row total} \times \text{column total}}{\text{grand total}}$$

The above formula is used iteratively to fill a table of expected frequencies. The observed frequencies are denoted by O and the expected frequencies are denoted by E. The general formula for calculating χ^2 is given by

Equation 16:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

It is necessary to scrutinise the contingency table of expected values to check whether any value of E is less than 5. If any one value of E is less than 5 then a χ^2 test cannot be performed as the table stands (Rees, *op. cit.*). If it makes sense to do so, either the rows or columns may be collapsed until all values of E are at least equal to 5. Such a case will only occur in the data under consideration here where the regions defined by a particular categorisation are either very small or the agreement is very bad (or where both possibilities exist). If it is accepted that neighbouring small regions may represent subdivisions of a larger unit then either rows or columns may be legitimately collapsed into their nearest geographical neighbour (which is not necessarily the neighbouring column or row in the contingency table – this problem will be dealt with later). To be clear, it must be stated that it is an entire row or, an entire column, which is collapsed into its neighbour and not a single value, *i.e.* an entire region is merged with a neighbour or not merged at all.

The value of χ^2 is used to determine the probability that there is no difference between the observed frequencies and the expected frequencies (*i.e.* the phenomenon that is being observed is no different to what might be expected by chance). The number of categories in the rows and columns play a part in determining the significance of the χ^2 result. This is accounted for by the degrees of freedom which is calculated from the general formula

Equation 17:

$$\text{degrees of freedom} = (r-1)(c-1)$$

The values r and c are the numbers of categories in the rows and columns respectively. The degrees of freedom automatically are reduced (restricting the likelihood that the test will be significant) when rows and columns are collapsed. There exist standard tables for finding the probability based on the value of χ^2 for given degrees of freedom. In practise these are usually inadequate for the size of tables that result from this type of analysis. However, there is a standard formula for calculating the probability and many on-line calculation sites exist on the world wide web[6].

---

6 The Internet is constantly changing but, at the time of writing, there were a number of statistical sites that provided χ^2 probability calculators. Two in particular, which were used for this thesis, had the following URLs http://www.fourmilab.ch/rpkp/experiment/analysis/chiCalc.html and http://www.swin.edu.au/tafe/insci/wakeup/stats/surfstat/tables.html

4.5.1.3 Cohen's Kappa Test of Agreement

The problem remains that χ^2 tests a null hypothesis that 'there is no association between two categorisations'. However, association does not necessarily equate to agreement (Cohen, 1960). It would be possible to obtain a significant value for χ^2 which suggests a strong association but where that association is based on a level of *disagreement* that is greater than chance. In the situation under consideration it might be expected that there would be a high degree of association simply by virtue of the nature of regionalisation. Regions are defined by sets of contiguous cells in the raster matrix and so, any region that is vaguely in the vicinity of a region in another categorisation will show association. The association cannot be used as a gauge of agreement because it does not take proper account of the amount by which regions overlap. Indeed the validity of this statement can be seen from a second look at Figure 4.7. It is indisputable that the agreement between the area defined by the circle and the regions over which it lies varies between each of the four parts ('a' through 'd') of the figure. However, it is can be argued that the association between the circle and the regions it overlies is very strong for all cases. Clearly, association alone is not adequate to describe the differences that are seen in the four parts of the diagram.

'Cohen's Kappa' is a test of agreement based on an observation frequency matrix (in a similar way to χ^2). Kappa is the most sophisticated technique that was used for the analysis but it also required the highest level of pre-processing of the data primarily because of the requirement that there be the same number of rows as columns in the observation frequency matrix. This difficulty will be dealt with below. Cohen's Kappa is a less well known statistical technique than the two mentioned previously and so more detail will be provided because an understanding of how Kappa is calculated is essential to interpreting the results of the test. There are only two relevant quantities for a test of agreement (Cohen, 1960):

1) p_o = proportion of units showing agreement (observed) which is calculated by Equation 18.

Equation 18:

$$p_o = \sum_{i=1}^{r} \frac{n_{ii}}{N}$$

where r is the number of categories (for kappa $r = c$) and N is the grand total. In words, this formula is translated as the proportion of observed agreement being equal to the sum of the diagonal values within the contingency table, divided by the grand total of values within the contingency table.

2) p_e = the proportion of units for which agreement is expected by chance (expected) which is calculated by Equation 19.

Equation 19:

$$p_e = \sum_{i=1}^{r} \frac{n_{io} n_{oi}}{N^2}$$

In words, this formula is translated as the proportion of agreement expected by chance being equal to the sum of the product of pairs of row and column totals divided by the square of the grand total of all the values within the contingency table.

From these formulae it follows that the amount of observed agreement that is not attributable to chance is given by the difference of the two values above. The proportion of disagreement is predicted by 1 - p_e. Kappa (κ) is the proportion of chance-expected disagreements that do *not* occur. This equates to answering the question "Having removed the effects of chance, how strong is the agreement between the two categorisations?". The coefficient κ can be calculated from the formula in equation 20.

Equation 20:

$$\kappa = \frac{p_o - p_e}{1 - p_e}$$

Before calculating the value of κ, the contingency tables produced in the analysis were first reordered to make the on-diagonal values highest (*i.e.* minimise the marginals). This was because the categories represent geographical entities. The marginals are an estimation of the degree of overlap with neighbours. The category codings are arbitrary and independent between the various coverages.

The order of the rows and columns in the contingency table is of little interest. The interest is in whether category A of the columns agrees with category X of the rows. Since all the cells of any given region are contiguous, not only is it expedient to reorder the contingency table for the

Kappa test but it is essential that it is done. Reordering the contingency table would not be legitimate if the rows and columns were identical categorisations (e.g. specific clinical conditions presented for diagnosis to two separate doctors). In this case like would not be compared with like if reordering was carried out. However, in the case of contiguous geographical categories that can only exist in one location, re-ordering does not change the relationship between two regions but merely accounts for the arbitrariness of the numerical coding of the categories. By definition, if category A of the rows has a high value when compared with category B of the columns they must be geographically coincident (with some degree of mismatch at the borders which is accounted for by the marginals). In this case, failure to re-order the columns would result in bias against agreement and would mean that like was not compared with like because the process of kappa looks for agreement on the diagonal and the cell showing agreement would be off-diagonal. Only whole columns may be reordered and not individual cells.

The value of κ does not run from zero to one (Fisher and van Belle, 1993) as with most probability statistics but runs between the limits shown in Equation 21.

Equation 21:

$$- p_e/(1 - p_e) \leftrightarrow 1$$

Because κ is a measure of agreement, the numerical value and meaning of its lower limit are of little interest in practical terms (Cohen, 1960). If the value of κ is equal to zero there is no agreement. If the value of κ is less than zero then there is less observed agreement than would be expected by chance and it is futile to pursue the comparison any further. It should be noted that one is the theoretical maximum for perfect agreement. In this case the value of all the off-diagonal cells within the contingency table must be zero. It is these cells that show the level of disagreement. Obviously this is a special case and most studies will have a proportion of disagreement that will be shown by positive, non-identical marginal (off-diagonal) values. These marginal distributions set a practical maximum to κ (κ_m). Sense can only be made of the calculated value of κ if it can be compared to κ_m. It is of particular interest to this study, dealing as it does with geographical regions with indeterminate boundaries to be able to calculate the fuzziness between the categorisations because bioregions have fuzzy boundaries. The proportion of potential agreement which cannot be achieved, having excluded chance, as a consequence of differing marginals serves as a measure of fuzziness (Cohen, 1960). This value is given by 1 - κ_m. The value of κ_m can found by Equation 22.

Equation 22:

$$\kappa_m = \frac{p_{om} - p_e}{1 - p_e}$$

The value of p_{om} is found by pairing the row and column totals, selecting the smaller of each pair and summing them. The value of κ_m is important when considering the meaning of the outcome of κ. Additional aids to understanding the meaning of κ are the confidence limits and the *Z* factor, or level of significance. The 95% confidence interval is calculated in a similar way as in many other statistical techniques and is equal to $\kappa \pm 1.96\sigma$. The 99% confidence limit is given by the standard formula of $\kappa \pm 2.58\sigma$. The standard error (σ) of κ can be approximated by Equation 23.

Equation 23:

$$\sigma_\kappa = \sqrt{\frac{p_o(1-p_o)}{N(1-p_e)^2}}$$

This generalisation for the standard error suffices for most purposes but a variation is needed to test the significance of κ. To test the significance of κ the null hypothesis is assumed that $\kappa = 0$ (*i.e.* all observed agreement is attributable to chance). In this case $p_o = p_e$ which, when substituted into the equation for the standard error of κ gives Equation 24.

Equation 24:

$$\sigma_{\kappa o} = \sqrt{\frac{p_e}{N(1-p_e)}}$$

This allows the significance (*Z*) to be calculated by Equation 25.

Equation 25:

$$Z = \frac{\kappa}{\sigma_{\kappa_o}}$$

To be significant at the 5% level Z must exceed 1.645. Finally, the test of significance of the difference of two independent values of κ is given by an expansion on the above equation. However, because it is the difference of the actual values of κ that are being compared the values of the general standard error and not that for testing the null hypothesis are used, giving the alternative value of Z in Equation 26.

Equation 26:

$$Z = \frac{\kappa_1 - \kappa_2}{\sqrt{\sigma_{\kappa_1}^2 + \sigma_{\kappa_2}^2}}$$

There are a number of points for consideration when the meaning a value of κ is being evaluated. The first is that Cohen's Kappa is a test of agreement and so any positive value of κ demonstrates some level of agreement beyond mere association. Even small values of κ can be both significant and meaningful when understood in conjunction with κ_m. The lower the value of κ_m the more the apparent proportion of disagreement is due to discrepancies in the marginals (Cohen, *op. cit.*). On the other hand, a low value of κ_m also means that the fuzziness between the two categorisations is high and that raises the question of resolution.

The question of resolution does not seem to have been dealt with in the literature. It would seem reasonable to assume that there would be a point at which the amount by which the fuzziness exceeds the value of κ_m is great enough to cast doubt on the significance of κ irrespective of the actual value of Z. In simple terms, the picture is so 'blurred' that the content cannot be identified. The importance of this issue is, because the amount of pre-processing required to be able to perform Cohen's Kappa is sometimes large, this is likely to introduce a considerable amount of fuzziness. For the purposes of interpretation the following limits will be placed on the results that will be reported in the next chapter:

1. a positive result will be rejected, regardless of either the value of κ or Z if the fuzziness exceeds the value of κ_m by one and a half times (following the same reasoning in the identification of the region cores, Section 4.4.2)
2. if the fuzziness is equal to or exceeds κ_m by less than one and a half times, κ will only be accepted as significant if Z is very much greater than 1.645

3. if κ at least one third the size of κ_m, Z is significant and κ_m exceeds the fuzziness then the result will be accepted without equivocation.
4. an arbitrary cut-off of 0.15 will be applied to the acceptability of all values of κ irrespective of their levels of significance, κ_m or fuzziness and despite the fact that such a value might be proof of agreement. This restriction is introduced as a 'safety measure' because, even though very low values of κ can be significant, it is the purpose of this thesis to determine whether bioregions are *clearly* demonstrable and very low values of κ simply lack credibility. The very high number of sample points (from a nominal ground resolution of 1km squares gives 74,802 data points per coverage with water excluded) can be expected to enable the detection of even very low-level agreement. It was anticipated and, indeed found to be the case, that some very small values of κ have very high levels of significance. However, it was decided when formulating this last restriction on interpreting κ that such results would lack weight and not be credible by virtue of how blurred distinctions would be. The purpose of this exercise to show whether bioregions are demonstrable entities. If the distinctions are so blurred that only analysis of tens of thousands of sample points by sophisticated statistical techniques can reveal them, the level of demonstrability is negligible.

4.5.2 Creation of an Analytical Database

The first stage was to sample the coverages to build a table of values for each coverage at given geographical locations. Since all areas under consideration are the same, namely the whole of Scotland, it was considered legitimate to ignore all areas of water and thus reduce the amount of processing. More importantly though, removing water areas also reduces the chance of unintentional bias in favour of finding agreement between coverages because the water areas make up a substantial proportion of the total coverage area and their inclusion would inevitably lead to the suggestion that there was very good agreement. Sampling was carried out using the ACR/INFO `sample` command. The mask used for sampling was simply the entire land area, including the islands, of Scotland. The data were extracted to a text file.

The text file was arranged so that each column represented a separate coverage and each row represented a single raster cell. Included in the text file were two additional columns that stored the Eastings and Northings of each cell. The text file contained nearly 75 thousand rows (as already mentioned) and fifteen columns (thirteen coverages and two co-ordinates). The standard statistical packages that were readily available, such as SPSS and Minitab, were not able to cope with this quantity of data (over one million separate items). The relational database package 4th

Dimension (ACI, 1997) was used to store and process the data. 4th Dimension was chosen because it was available, familiar to the author and had a level of sophistication in excess of ARC/INFO's database engine. 4th Dimension also has a structured query language in which routines could be developed to handle the data and perform the statistical comparisons. Listings of the routines that were developed for analysis are supplied in Appendix XX. The text file mentioned above was imported into 4th Dimension having prepared a table with fifteen fields (one for each coverage and one each for the Eastings and Northings). The database structure was simple and restricted to a single table. Each field equated to a column in the text file and each record equated to a row in the text file (*i.e.* a single raster cell, giving 74,802 records). All the fields except for the two co-ordinate fields were indexed to improve queries on the database.

4.5.3 Pre-processing

From the description of the statistical techniques in Section 4.5.1 it is clear that a certain amount of pre-processing was necessary for the analysis of the data. Pre-processing was handled in a systematic way by routines specifically developed for the task using 4th Dimension's query language (ACI, 1997). The first routine (referred to as a 'method' in 4th Dimension parlance) in Appendix XX is a listing of the pre-processing method. The pre-processing can be split into two parts for the sake of clarity. The first part is concerned with re-coding the entries in the database and the second part is concerned with reducing errors.

4.5.3.1 Pre-processing: Part I

The re-coding of the database was performed to ensure that, if the contingency table columns or rows needed to be collapsed during the calculation of either χ^2 (to eliminate values below 5) or κ (to ensure that $r = c$), the most appropriate columns or rows would amalgamate preferentially. This meant that the contingency table had to be constructed in such a way that adjacent columns and adjacent rows where not only adjacent in the table but adjacent geographically. Obviously there is the potential for the introduction of error during pre-processing. Therefore it was decided to conduct the pre-processing in three different ways thus providing an element of sensitivity analysis to the pre-processing methods. The three ways were

1. re-code according to the most Northerly representative of a category (region) and merge contingency columns or rows with the smaller of the adjacent tabular category, as and when required by the statistical analysis
2. re-code according to the most Northerly representative of a category and merge contingency columns or rows with the smallest and geographically nearest category, as and when

required by the statistical analysis. The nearest geographical neighbour was defined by a comparison of the Euclidean distances between the centroids of the neighbouring regions. The centroids were defined by the mean of the Eastings and the mean of the Northings

3. re-code according to the ranking of the centroids of the regions on a North-South axis and merge contingency columns or rows with the smaller of the adjacent tabular category, as and when required by the statistical analysis

The logic for the emphasis on using a North-South ranking system is that Scotland is elongated along its North-South axis. Ranking regions in this direction gives a better differentiation than using the East-West axis. A two-way ranking system would introduce unnecessary complications both analytically and computationally. The East-West factor is taken account of by the re-ordering process that is part of the final pre-processing for the Kappa test and was explained above. After re-coding, categories that have codes that are close numerically are *de facto* close geographically, if not adjacent. A refinement on this is the identification of nearest geographical neighbours based on the assumption that neighbours which have their centroids closest together will be most alike out of a number of surrounding alternatives and therefore should be first candidates for amalgamation should it become necessary. Finally, by always merging with the smallest of any possibilities (where more than one exists as in the case of adjacency based on tabular position) the risk of error is further reduced. Each re-coding operation was performed using a 'virgin' copy of the original database to ensure no spurious effects from previous re-coding operations.

4.5.3.2 Pre-processing: Part II

The second part of pre-processing was introduced as an attempt to reduce the effect of original coding errors due to minor inaccuracies in the colour coding of the original coverages. This was of particular concern where coverages had been created by conversion from TIFF[7] format to ARC/INFO format such as those data representing clan territories or Naismith's (1989) regions of vernacular building styles. It was noticed that the translation of areas at the edges of regions where two colours met was not always perfect. The resulting coding errors produced very small regions, sometimes only one cell in size, but their presence not only complicated analysis, reducing significance, but also dramatically increased the already lengthy processing time. A cut-off threshold of 0.1% was used as the acceptable resolution. In practical terms this equated

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7 A TIFF file is a standardised file format for storing pictures and graphics. TIFF files are readily transportable between computer platforms although some minor differences do exist in the bit-ordering between Macintosh and IBM TIFF files. It would appear that ARC/INFO uses the IBM bit-order for TIFF conversions.

to 75 records (out of 74,802). Any category that was found to have fewer than 75 records was merged with the smaller of its immediate neighbours. Apart from reordering the kappa contingency table this concludes the pre-processing.

4.5.4 Processing

The processing was carried out using the remaining two routines listed in Appendix XX. Each coverage was taken in turn, starting with the final bioregional definition of Scotland, and compared against all other coverages. Duplication of analysis was avoided and processing time reduced by removing a coverage from the list of 'comparatees' once it had been used as a 'comparator' on the assumption that the result of 'A' compared to 'B' is the same as 'B' compared to 'A'. On each pass the procedure was as follows

1. create a contingency table of observed frequencies between the comparator and each comparatee coverage remaining available and store this as a two dimensional array and create a text document to which the table of observed frequencies is written along with a title to clearly identify which comparison the text file results from;
2. calculate the mean maximum probability and mean cross-representation values and write them to the text file;
3. conduct Cohen's Kappa test (using the equations listed in section 4.5.1.3), checking that the requirement that $r = c$ is met and compensating appropriately depending on the current parameters for the set (of three) within the sensitivity analysis. Send the kappa table to the text document followed by all the values associated with the kappa statistic;
4. use the two dimensional array to create a similar array for the expected values for the Ch-squared test. Follow the current rules for collapsing columns based on the statistical requirement that no expected value may be less than five (see section 4.5.1.2). Automatically adjust the tables and send both the amended tables of observed and expected frequencies to the text file. Perform the Chi-squared test and send the results, including the degrees of freedom to the text file;
5. close the text file, loop back to the beginning, taking the next comparatee coverage in the set of comparisons with the current comparator. Create a new text file for each comparison and repeat the above steps until no more comparatee coverages are available;
6. disallow the current comparator coverage from further comparisons and loop back to the start, taking the next coverage as the new current comparator.

Sending the all contingency tables to the text file allowed visual checks to be made on the computer output, additional manual recalculations were also made to validate the computer routines. The text files were all delimited to allow them to be opened in a variety of packages such as Microsoft Excel. Although all possible comparisons were made not all of them were considered to be relevant. It was more expedient to allow the computer program to run uninterrupted over the course of a number of days than either to stop and start execution or to exclude certain comparisons by programming complex rules for exclusion into the code. Therefore, in the next chapter, only those that were considered to be relevant are reported.

4.6 ASSESSMENT OF THE BIOREGIONAL DEFINITION

The methods described in Section 4.4 were designed to enable the detection of potential bioregions in Scotland following the received bioregional wisdom about their identification. This produced two alternative versions. These were compared using standard statistical techniques available in ARC/INFO where appropriate and the methods described in Section 4.5. The two variations on the bioregional definition of Scotland were also compared to the layers that went into their make-up to test their robustness.

However, assessment of the bioregions would not be complete without comparing them to other regionalism in Scotland. At the time of writing there were no other bioregional definitions of the whole of Scotland apart from the proposal that was produced by Aberley (1995; Figure 4.25). This was used as a comparator in the absence of any better alternative. Aberley divided his diagram into what he considered to be bioregions and subdivisions that he referred to as cultural sub-divisions (Figure 4.26). Both versions were used for comparison partly to make allowance for the roughness of Aberley's proposal and partly because the cultural subdivision is ore similar in its number of categories to the two variants of the bioregional definition that was produced here.

Figure 4.25: Aberley's (1995) intuitive assessment of the bioregions of Scotland

Figure 4.26: Aberley's (1995) intuitive assessment of the bioregions of Scotland showing the subdivision into Community Regions

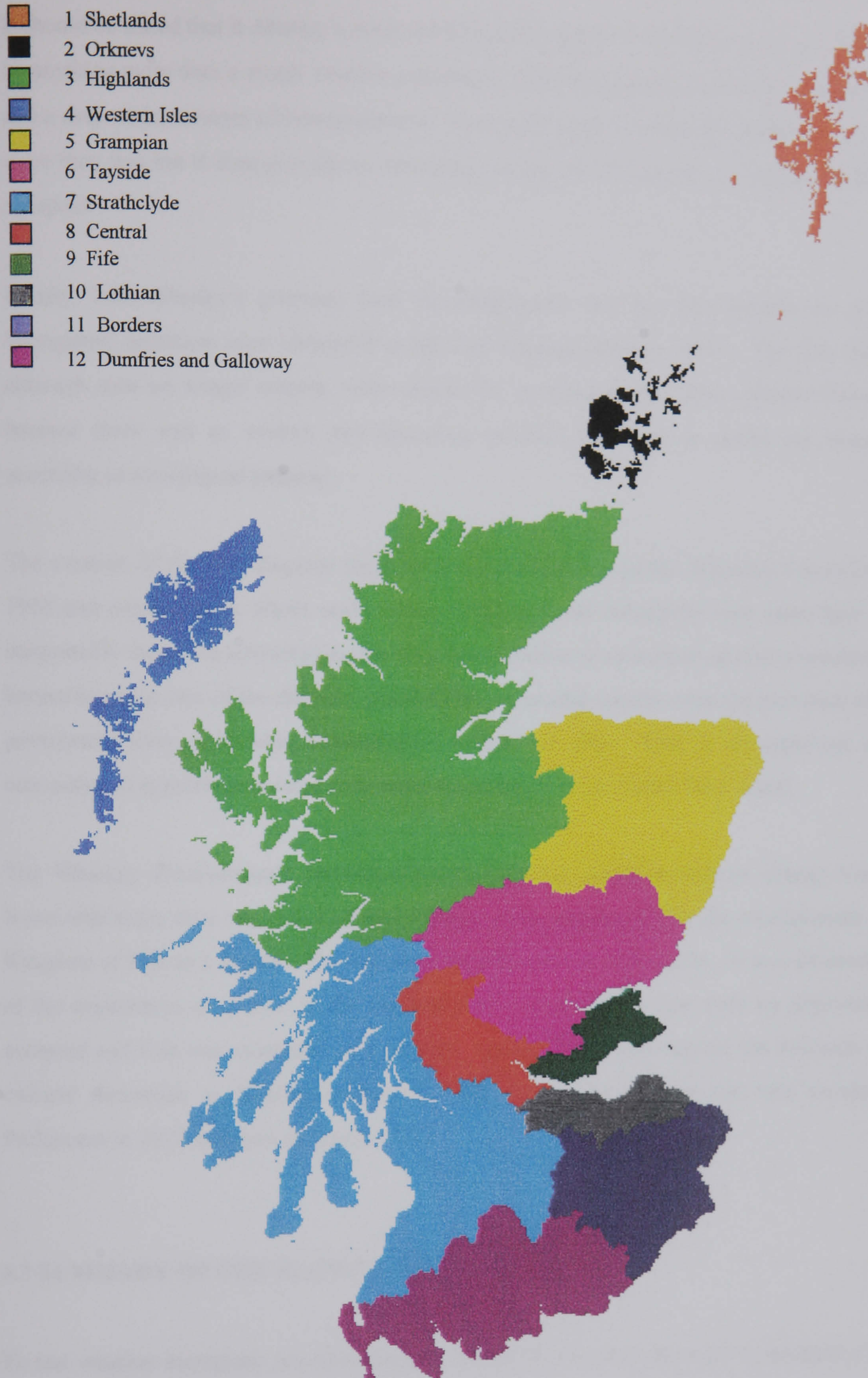

Figure 4.27: The City Regions that arose from the Wheatley Commission, including parliamentary ammendments (Honey, 1976).

It should be stated that it Aberley's proposal for the bioregions of Scotland was never intended to be anything more than a rough intuitive assessment based on personal knowledge and experience and a deep understanding of bioregionalism. It would be unfair to judge his proposal as anything more than this but it does provide an interesting comparison if a certain amount of fuzziness is accepted.

Finally, both Aberley's proposal (and its subdivision) and the two variants on the new bioregional definition were compared to the City Regions (Honey, 1976). The City Regions, although now no longer current, were chosen for comparison over other political boundaries because there was an evident and conscious rationale that tried to define the boundaries according to sociological patterns.

The creation of the City Regions began with the appointment of the Wheatley Commission in 1966 and culminated in whole scale reform of the political boundaries nine years later. The commission was more interested in matching the provision of services to spatial orientation than harmonising the size of the districts' populations. A second criteria waas the provision of local government from a suitable administrative centre, *i.e.* city. This is an important spatial concession to sparsely populated rural areas (particularly on the North West coast).

The Wheatey Commission's recommendations were not accepted without change however. Some objections were raised and notable amongst these was the call for the reinstatement of the Kingdom of Fife as a region. The argument for this was one of tradition. It is a demonstration of the importance of culture in the regional fabric of a country that such an argument was accepted and Fife was reinstated as a separate region. This helps support the inclusion of the cultural dimension in defining bioregions. The final regionalisation that was accepted by Parliament in 1975 is shown in Figure 4.27.

4.7 SUMMARY OF THE MAPPING METHODOLOGY

To test whether bioregions are demonstrable entities, it was first necessary to produce a set of possible bioregions for an area and then compare the results to existing regionalisations. Scotland was chosen because of its familiarity to the author, the availability of data and the fact that it is part of an island thus limiting the study area naturally.

Sale's (1985) taxonomy of bioregions was used to determine what layers should contribute to the definition of the bioregions. The layers were overlaid using the GIS ARC/INFO. The bioregions were determined by first converting all the layers into coverages of 'boundariness' and then adding them together so that areas with low values in the output coverage correspond to areas of high correspondence (and consequently high bioregional certainty). Areas with high values in the output coverage correspond to areas of uncertainty, which is indicative of the boundary or transition zone between one bioregion and its neighbour. A mosaic of region cores was produced by the above process. These region cores were then merged together to form the most likely bioregions, based on a set of rules, that was created for the purpose, to ensure consistency and objectivity in the merging process. A second version of the bioregions was produced from an amended set of rules that sought to eliminate any possible conflicts in the merger method.

The GIS data were converted to a database format that was used to perform statistical queries which were not possible in ARC/INFO. These statistical queries looked for agreement between the two bioregional definitions and various regional definitions of Scotland. In addition, the bioregional definitions were compared to another pair of bioregional definitions for Scotland to investigate the differences between them.

By means of these tests it was hoped to determine whether bioregions are demonstrable entities and which bioregional definition was the best. The results of these test are given in the next chapter.

5

MAPPING RESULTS

"This combination of natural environmental and human influences gives rise to a complex and intricate landscape. Any search for simple clear-cut patterns of zonation in Scotland is likely to fail."

Usher and Balharry, 1996

5.1 INTRODUCTION

This chapter will first look at the success (or otherwise) of the process of creating the bioregional definition of Scotland. The quote above (Usher and Balharry, 1996) gives an indication of the complexity of the process and the capacity for ambiguity. It will have been a successful enterprise if some agreement can be found between the two variations of the bioregional definitions. Although some agreement would be expected between the bioregions and the coverages that went into their creation, back-comparison is a valid assessment because it is the level of agreement that is of interest.

Particular comparisons that appear to be of special interest will be explored in more detail including comparing the bioregions that were produced in Chapter 4 by an almost mechanistic process, compared to those that were defined solely on an understanding of bioregionalism, the Scottish environment and the Scottish culture. This latter definition was created without any map overlay process and is largely intuitive. The question here is, how well do the two approaches compare? Considering the quote at the beginning of this chapter, how far can sophistication of the regionalisation process be taken before it becomes over complicated and meaningless? This has important implications for the environmental visioning process because it impinges on the autonomy of the stakeholders in the self-determination of their vision and the role of expert direction.

5.1.1 Description of the Coverages

For ease of descriptions a shorthand nomenclature was developed and used for computer file names of the coverages. It is reproduced in Table 5.1 to enable easy reference to coverages, which are composed of different combinations of the layers in the table. A coverage is named by simply listing the single-letter designations of the layers of which it is composed. The source, or method of derivation each layer, is described in the previous chapter.

Table 5.1: Single letter shorthand designation for naming layers, which compose any given coverage.

designation	layer name	description of layer	Sale's corresponding layers[1]
a	'agriculture'	Land capability for agriculture (MLURI, 1983)	soils and primary economic activity
b	'basins'	major watersheds of Scotland	geo-region
c	'clans'	computer generated theissen polygon clan territories	socio-region
d	'districts'	computer generated theissen polygons of ancient district names	socio-region
l	'land-use'	land-use classification ('lcs88')	economic region
n	'architecture'	architectural regionalism (Naismith, 1989)	socio-region
s	'SNH zones'	natural heritage zones (Usher and Balharry, 1996)	ecological region
w	'weather'	climate zones	climate region

In addition to the coverages listed in Table 5.1 above there are five more coverages that are important in the analysis. Two result from the development of the new bioregions using the methods from the previous chapter. Two are derived from the work of Aberley (1995) and the last is the Wheatley Commission's (1976) City Regions. All have been described in the previous chapter and will be referred to henceforth as follows

1. Bioregions 1 – the first new objective set bioregions based entirely on the rules
2. Bioregions 2 – the second of the new objective set of bioregions with the extended set of rules

1 Sale's (1985) taxonomy of bioregions is described and discussed in Chapter 3 ('Bioregionalism').

3. Aberley's Bioregions – an intuitive set of bioregions based on the amalgamation of Aberley's Community Regions (below)
4. Community Regions – a set of intuitively defined bioregions split according to perceived societal divisions within Aberley's Bioregions (above)
5. City Regions – developed by the Wheatley Commission including the amendments requested by the government of the day.

Table 5.2 shows the details of the coverages and the layers used to make the bioregional coverages. The eight coverages above the dotted line in the table are the versions of the coverages before they are converted to coverages of boundaries to be used as layers in the construction of the bioregional coverages, which are listed below the dotted line.

Table 5.2: Details of basic meta-data for the layers and bioregional coverages. The table is divided in two. Above the dotted line are the layers used to make the bioregions. Below the dotted line are the bioregional coverages.

Layer or coverage	cell-size (m)	N° of values	min	max	mean	s.d.
'agriculture'	1000	6	3	8	-	-
'basins'	1000	104	3	4304	-	-
'clans'	1000	117	1	133	-	-
'districts'	1000	102	3	446	-	-
'land-use'	1000	7	1	7	-	-
'architecture'	500	14	2	15	-	-
'SNH zones'	1000	20	2	21	-	-
'weather'	1000	35	1	41	-	-
ablnsw (coverage of boundariness)	1000	12	6	17	9.62	1.53
reclassified ablnsw	1000	2	1	10	5.43	4.50
unmerged bioregions (areas)	500	199	0	454	-	-
merged bioregions	500	20	2	21	-	-
merged bioregions (extended rules)	500	21	2	22	-	-

The first two coverages below the dotted line, denoted by the code 'ablnsw', in the table are the result of combining six of the boundary versions of the layers. All the coverages in the table, except the two, which have just been mentioned, are categorical and, therefore, there are no entries for the mean and standard deviation columns. The two versions of the 'ablnsw' coverage are not categorical because they are coverages of degrees of 'boundariness'.

5.2 COMPARISONS BETWEEN DATA LAYERS

A series of comparisons was made between all possible pair-wise combinations of data layers, which were used in the final bioregional definition of Scotland. High correlations were not expected between all, or even most pairs. The results of all the comparisons are presented in Table 5.3. The discussion of the results will begin with the first column of results and proceed across the columns towards the right-hand side of the table. A cursory examination of the table as a whole shows that, apart from one or two notable exceptions, there is little or no correlation between the individual data layers.

Table 5.3: Pair-wise correlation (Pearson's 'r') between the data layers which contribute to the bioregional definition of Scotland.

'r'	agriculture	watersheds	clans	districts	land use	architecture	SNH zones
watersheds	-0.148	-					
clans	-0.100	0.388	-				
districts	-0.125	0.956	0.369	-			
land use	0.317	-0.069	-0.045	-0.060	-		
architecture	-0.218	-0.161	-0.201	-0.201	-0.055	-	
SNH zones	-0.049	-0.383	-0.066	-0.403	-0.012	0.220	-
climate	-0.070	0.423	0.221	0.445	-0.045	-0.162	0.008

In the first column of figures the strongest correlation is between the agriculture and the land-use classification coverages. The correlation (r = 0.317) is weak. A stronger correlation might be expected but the nature of the categories in the two coverages explains the weakness of the correlation. Firstly the agricultural layer is 'land capability for agriculture' and not necessarily the actual use to which the land is being put. All areas are classed according to their capability of supporting different levels of agriculture. Secondly, the land-use layer contains non-agricultural classes such as woodland, urban and rural development, moorland and wetland. Within any one category there may be land which could be classed as suitable for more than one level of agriculture.

Scale also has a significant part to play in the outcome of the correlation comparisons in Table 5.3. The original scale of the land cover data (lcs88) was a nominal ground resolution of 25km.

The scale of the original coverage of agricultural land capability classes was 250km. These differences will inevitably impact on 1km cells. Later comparisons use a unified scale of 1km in all cases to overcome this difficulty. A finer scale was not considered appropriate to analyse Scotland at the regional level.

5.3 THE EFFECT OF DIFFERENT LAYERS OF CULTURAL DEFINITIONS

Of all the data layers which go to make up the bioregional definition of Scotland, the layer that is most open to debate must be the regional definition of culture. It is almost impossible to give any one definitive regionalisation of culture for any area. The three layers which were identified in the methods section (Chapter 4, Sections 4.3.6 and 4.3.7) were the distribution of traditional Clan territories, computer generated districts based on ancient names which are still in use and Naismith's (1989) regional analysis of vernacular buildings. It was determined that the robustness of the bioregional model to different cultural definitions be tested and that the cultural definitions be compared with each other.

For all comparisons Pearson's correlation coefficient ('r') was calculated using ARC/INFO's in-built statistical package. Five different maps were produced. One was a standard, or base-line map, which contained all the non-cultural elements and was composed of the layers for agriculture, watersheds, land-use classification, SNH's heritage zones and climate. Another three maps were produced having one each of the three cultural definitions. The fifth map was the base-line map combined with all three cultural definitions. The correlations are shown in Table 5.4. A cursory look at the values in the table suggests that the final bioregional definition of Scotland is extremely robust with respect to the three choices of cultural definition. From the comparisons in Table 5.4 it can be seen that there is a very high degree of concurrence between the three different methods of defining culture for Scotland. It is appropriate to use Pearson's 'r' correlation for these comparisons because all the coverages are continuous being coverages of degrees of boundariness.

Table 5.4: Pair-wise correlation (Pearson's 'r') between coverages containing different cultural definitions of Scotland where each coverage is based on the provisional bioregional classification, or base-line coverage, which contains all the elements of the others except any cultural elements.

'r'	Provisional bioregional classification	with districts	with clans	with architecture
with districts	0.939	-		
with clans	0.911	0.861	-	
with architecture	0.976	0.922	0.894	-
with all cultural maps	0.845	0.904	0.935	0.872

The first column of figures is the most instructive of the comparisons. In this column it can be seen that the strongest correlation is found when the coverage containing the architectural regionalisation of Scotland is compared to the provisional bioregional classification. This suggests two possibilities.

1. The architectural regionalisation produced by Naismith (*op. cit.)* is 'weaker' than the other elements, which make up the provisional bioregional classification. This hypothesis can be rejected because the technique of mapping boundaries rather than areas means than all coverages contributing to the final out-put map are of equal 'strength' having values naturally in the same range and being unweighted.

2. Naismith's architectural regions so closely follow the boundaries which emerge from the combination of the individual elements which go to make up the provisional bioregional classification that the resultant pattern of values in the two coverages is concurrent. The final figure in the first column of figures is the lowest. This is expected because the small variations in each of the cultural definitions are all contained within this final coverage. This possibility is the favoured explanation.

Although the correlations are still good, comparisons with the coverage that contain the map of clan territories result in the lowest scores. This is to be expected given that the clan territories coverage is probably the least reliable of the three cultural datasets. Therefore, considering the level of redundancy with three layers for culture, the clans coverage will be dropped from the final bioregional definition of Scotland as being unnecessary and the least trustworthy.

5.4 TESTING THE INTERNAL ROBUSTNESS OF THE BIOREGIONS

The preceding sections confirm the choice of the following layers as being the most appropriate and robust definition of bioregionalism for Scotland: land capability for agriculture, watersheds, land-use classification, regional distribution of major building vernaculars, SNH heritage zones, climate. The robustness of the model was tested by selectively removing one layer at a time and determining the correlation between the resultant coverage and the base-line coverage which, in this case, was the full bioregional definition of Scotland. The six incomplete coverages were then compared to each other to investigate the effect of particular layers within the bioregional make-up. The results of this process are given in Table 5.5. As before, the data in these coverages are continuous so a test of correlation is appropriate.

The values for Pearson's 'r' correlation coefficient are arranged in descending order in the first column óf figures. The columns for cross-tabulation were then given the same order as the vertical ordering of the entries in the first column. This arrangement was devised to see if any pattern might emerge from such an ordering. Inspection of Table 5.5 shows a pattern across the columns and down the rows, which follows the same pattern that was imposed on the first column by the ordering described earlier.

The pattern is that, any of the 'incomplete' coverages that are highly correlated with the base-line coverage (ablsnw) can be expected to be highly correlated to each other as well, if to a slightly lesser degree. This should, and on the whole does, produce a reduction in the tabular values from the top left to the bottom right of the table. Any result, which deviates dramatically from this pattern, would be anomalous and in need of further explanation if the baseline bioregional definition of Scotland was not to be rejected outright.

The first column of figures shows that removing the land-use classification ('l') from the final coverage causes the biggest reduction in the value of 'r' followed by the removal of the climate ('w') layer. Therefore, the bioregional definition, as produced here, is most sensitive to changes in land-use and changes in climate. This is confirmed by comparing the layer without land-use directly with the layer without climate, as in the case of the last figure in the last row and column of the table (which, following the pattern is, as expected, the lowest value in the table). There is little correlation between the two coverages ($r = 0.478$).

Table 5.5: Pair-wise correlation (Pearson's 'r') between coverages containing different combinations of the layers which go to make up the bioregional definition of Scotland (ablnsw) to test the robustness of the model and identify the layers of greatest sensitivity.

'r'	ablnsw	ablsw	blnsw	alnsw	ablnw	ablns
ablsw	0.976	-				
blnsw	0.971	0.945	-			
alnsw	0.932	0.905	0.893	-		
ablnw	0.928	0.900	0.895	0.846	-	
ablns	0.893	0.863	0.847	0.807	0.834	-
abnsw	0.715	0.658	0.664	0.564	0.613	0.478

A further test of the robustness of the final bioregional definition is to conduct a series of chi-squared tests to look for the reverse correspondence between the final definition and the layers out of which it is composed. It should be expected that there be a high level of correspondence because the original layers were the source of the data out of which the final bioregional definition was created. However, the purpose of looking at the degree of correspondence between the source data layers and the resultant bioregional definition is to test the acceptability of the merging process which was used to handle the region cores (see Section 4.4.2 to the end of the chapter). Although rules were developed to reduce the subjectivity of the process, the validity of those rules is still open to question.

A chi-squared test may be used where data are categorical. As was described in section 4.5.1.3 chi-squared (χ^2) is a non-parametric test with a null hypothesis that there is no difference between the observed membership of pairs of categories and the membership that would be expected by chance. In this case the categories are the regions within each layer. The question under consideration here is what degree of correspondence is there between the regions in the two data sets that are being compared? It is acceptable in a χ^2 for there to be different numbers of categories in the data sets. In fact this is a common occurrence.

Few published tables of χ^2 probabilities ('p') are available which go as high as the number of degrees of freedom that were obtained in these tests. On-line routines are available over the Internet which automatically calculate values of 'p' based on provided values for the number of degrees of freedom and χ^2. As has been said, these high values are a result of the large numbers of categories (or regions) within the coverages.

A couple of these calculators were used and the value of 'p' was accepted if the results agreed. It was found that, in all cases, the probability of detecting associations between the regions in the final definition, and the regions in the layers which were used in its production, approached zero ($p << 0.001$). Table 5.6 gives the results of the χ^2 tests. This result suggests that there is a very strong association between the final bioregional definition and its composite parts.

Table 5.6: Test of the robustness of the rule base which was developed for merging the regions cores – results of χ^2 tests comparing various coverages with the final bioregional definition of Scotland.

Comparator (Layer name)	Degrees of freedom	χ^2 value	'*p*'
Agricultural regions (a)	80	95519.8	<< 0.001
Principal watersheds (b)	900	598554.7	<< 0.001
Clan territories (constructed coverage - c)	805	247907.1	<< 0.001
Ancient district names (constructed coverage -d)	1220	757689.6	<< 0.001
Land use cover of Scotland (lcs88 - l)	120	54435.1	<< 0.001
Architectural regions (Naismith, 1989 - n)	260	451609.0	<< 0.001
Scottish Natural Heritage zones (s)	360	605376.7	<< 0.001
Main climate zones (w)	400	207013.0	<< 0.001
Bioregions (rule base n° 1)	380	1092839.6	<< 0.001

For most research the above result would have been considered conclusive proof of the 'correctness' of the bioregional definition that was developed as a result of the mapping process. However, while the association between the bioregions and various other regional definitions of Scotland is in no doubt, no agreement has yet been proven. Indeed, Cohen (1960) puts it much more forcefully when he states that

"It is readily demonstrable that the use of χ^2 for the evaluation of agreement is indefensible."

Therefore, as discussed in section 4.5.1.3 the χ^2 test is inadequate for understanding the comparisons between coverages. Many more χ^2 tests were conducted but the results will not be reported in any more detail than to say that unequivocal association was conclusively proven in all comparisons made irrespective of what coverages were used for the comparator and comparatee fields. Since all coverages describe the whole land area of Scotland it is not surprising that they should all be strongly associated! This problem of analysis demonstrates not only the complexity of the factors that go to make up a regional definition but also the care that is needed in interpreting certain types of geographical data.

Table 5.7 shows the results of the tests for the mean maximum probability and the mean cross-representation. These two values were described in the previous chapter and, despite their crudeness, they become more useful in light of the failure of the more sophisticated χ^2 test to yield meaningful results. A couple of comments are necessary to interpret the meaning of Table 5.7. Firstly, columns two and three must be read together and not in isolation. One category from the comparatee coverage matches one category in the comparator layer by the proportion shown in the second column. This means that the residual proportion is accounted for by one less than the value in column three. This is an indication of the fuzziness of the fit is between the two coverages. A high value here is not necessarily bad if the value in column two is high. For more information refer back to Section 4.5.1.1 and Figure 4.7 in particular.

Table 5.7: Results of the tests for the mean maximum probability and the mean cross-representation.

Comparatee (Layer name)	**Mean maximum probability**	**Mean cross-representation (out of 21)**	***Number of comparatee regions***
Agricultural regions (a)	0.47	11.80	5
Principal watersheds (b)	0.83	2.27	104
Clan territories (c)	0.75	2.86	117
Ancient district names (d)	0.84	2.49	102
Land use cover of Scotland (l)	0.29	19.29	7
Architectural regions (n)	0.60	4.79	14
Scottish Natural Heritage zones (s)	0.69	4.15	20
Main climate zones (w)	0.52	6.32	35
Bioregions (rule base n° 1)	0.82	3.70	20
City regions (Honey, 1976)	0.52	6.07	14
Aberley's Bioregions (1995)	0.53	3.87	15
Aberley's regional subdivisions	0.66	4.17	18

It is clear from the above table that the best fit was found with coverages of the watersheds, the clan boundaries and the districts. To a certain extent this confirms the results presented in Tables 5.3 and 5.4. A caveat is added here with respect to the relative size of the regions in the bioregional definition and these three comparatee coverages. The disparity between the sizes can be seen by looking at the number of regions in the comparatee coverage (column four of Table 5.7) and comparing that to the number of regions in the bioregional definition (21). Therefore, it is likely that the very much smaller regions of the comparatee coverages will have a higher probability of being entirely contained within on of the larger bioregional regions.

Close agreement is found between the two variations of the bioregional definition (rule base number 1 being the rule base without the sophistication of the conflict resolution). This is an important result because it is confirmation that the two are variations by degree rather than by quality. It also means that the earlier definition cannot be rejected at this stage and will be retained for future comparisons.

Other values of interest are the levels of agreement found between the bioregions and the coverages of SNH's Heritage Zones, Naismiths's (1989) architectural regions and the subdivision of Aberley's intuitive bioregional definition. The first two of these results confirms the inclusion of these layers in the make up of the bioregions and is also, consequently, supportive of Sale's bioregional taxonomy. A poor result here would have raised the possibility that the derived bioregions were an artefact of the layering process rather than demonstrable entities. The last of these three results suggests that there is some correspondence between two independent bioregional definitions of Scotland. On the one hand this is a serendipitous confirmation of the technique that was used to define the bioregions. On the other hand it calls into question the need for the level of sophistication that was used. The degree of agreement between Aberley's regions and those developed here will be looked at in more detail later in Section 5.7.

So far the analysis has shown the weakness of some statistical techniques that are common in the analysis of categorical data and should therefore be treated with caution, if not rejected altogether, whether in this or other geographical studies. The analysis has also supported the use of Sale's (1985) bioregional taxonomy and suggested that the bioregions are more than mere artefacts of the process that identified them. However, the analysis has also raised a question mark over the level of sophistication used in identifying the bioregions and they will now be contrasted by comparison with other regionalisations.

5.5 COMPARING THE TWO CALCULATED BIOREGIONAL DEFINITIONS

An attempt was made to rationalise the process of assimilating various neighbouring 'region cores' into bioregions (described in Section 4.4). It has been shown (Tables 5.5 and 5.6) that there is a strong association between the two alternative bioregional definitions that result from the rationalisation of the rules base. In this section answers will be sought to the questions of which, if any, is better and how sensitive the result is to the pre-processing that was undertaken to enable the tests to be performed. The previous Section indicated that the less sophisticated definition cannot be rejected at this stage despite its lack of conflict resolution.

5.5.1 Test of agreement between bioregional rule base variants

Table 5.8 shows the results of Cohen's Kappa tests for each region and its constituent coverages, including the additional cultural layers. Also included are tests of agreement with the City Regions (Honey, 1976) and the two variants of Aberley's bioregions. As was explained in Section 4.5.1.3, the value of κ by itself is not conclusive. A clearer picture can be obtained if the values for the maximum achievable agreement allowable by the marginals (κ_{max}), the significance ($Z > 1.645$ for significance at the 5% level) and the fuzziness are taken into account (bearing in mind the restrictions on accepting a value of κ which are set out at the end of Section 4.5.1.3).

The last column in Table 5.8 is the significance between the κ values for each of the two bioregional definitions for a given comparatee coverage and a given method of pre-processing. A negative value in this column indicates that the bioregional definition without the extra (Bioregions 1) stage of conflict resolution shows better agreement with the comparatee coverage than the bioregional definition with conflict resolution (Bioregions2). For each comparatee coverage there are three rows of values, which are labelled 'N Cols', 'N Cent' and 'Cent Cols'. These labels denote the three methods of pre-processing that were described in Section 4.5.3.1. The labels are concatenations of 'category re-coded by North-most region cell and contingency table collapsed by nearest columns', 'category re-coded by North-most region cell and contingency table collapsed by nearest neighbour determined by the Euclidean distance between region centroids' and 'category re-coded by North-South order of region centroids and contingency table collapsed by nearest columns' respectively. The order in which the pre-processing was presented in Section 4.5.3.1 is maintained here for ease of understanding.

Table 5.8: A comparison of the levels of agreement between the two variants of the bioregional definitions of Scotland identified by the methods used in this thesis. 'Bioregions 2' includes the conflict resolution. 'N Cols', 'N Cent' and 'Cent Cols' are the different methods of pre-processing.

Comparatee coverage	Pre-process	Bioregions 2				Bioregions 1				Z_{12}
		K	K_{max}	Z	Fuzz	K	K_{max}	Z	Fuzz	
Agriculture	N Cols	0.05	0.42	23.39	0.58	0.16	0.41	89.24	0.59	-35.56
	N Cent	0.20	0.60	82.20	0.40	0.22	0.46	87.03	0.54	-5.23
	Cent Cols	0.02	0.32	9.59	0.68	-0.07	0.66	-28.34	0.34	27.90
Watersheds	N Cols	0.27	0.63	75.40	0.37	0.22	0.62	244.01	0.38	7.02
	N Cent	0.25	0.60	64.46	0.40	0.23	0.62	219.21	0.38	2.07
	Cent Cols	0.27	0.63	75.40	0.37	0.20	0.64	214.22	0.36	9.25
Clans	N Cols	0.21	0.57	256.10	0.43	0.24	0.57	293.38	0.43	-13.44
	N Cent	0.20	0.60	222.81	0.40	0.20	0.59	221.50	0.41	0.63
	Cent Cols	0.16	0.57	190.05	0.43	0.25	0.57	280.76	0.43	-36.26
Districts	N Cols	0.30	0.60	358.70	0.40	0.28	0.61	319.11	0.39	10.08
	N Cent	0.14	0.56	167.82	0.44	0.14	0.56	165.17	0.44	-0.96
	Cent Cols	0.30	0.60	358.70	0.40	0.24	0.51	286.60	0.49	26.61
Land use	N Cols	0.19	0.51	115.78	0.49	0.17	0.57	104.03	0.43	6.87
	N Cent	0.15	0.62	81.60	0.38	0.11	0.55	62.24	0.45	11.58
	Cent Cols	0.10	0.76	48.02	0.24	0.18	0.64	102.84	0.36	-25.27
Architecture	N Cols	0.25	0.59	248.94	0.41	0.26	0.63	254.21	0.37	-2.93
	N Cent	0.26	0.56	272.03	0.44	0.31	0.61	330.37	0.39	-20.47
	Cent Cols	0.19	0.64	182.10	0.36	0.20	0.67	188.18	0.33	-3.27
SNH	N Cols	0.24	0.65	269.40	0.35	0.28	0.67	303.37	0.33	-12.69
	N Cent	0.24	0.64	262.44	0.36	0.28	0.67	303.37	0.33	-15.40
	Cent Cols	0.24	0.51	316.22	0.49	0.27	0.67	300.85	0.33	-13.35
Climate	N Cols	0.14	0.55	148.86	0.45	0.17	0.62	169.27	0.38	-11.19
	N Cent	0.13	0.62	132.31	0.38	0.16	0.62	161.49	0.38	-14.42
	Cent Cols	0.14	0.56	148.12	0.44	0.19	0.49	224.13	0.51	-19.75
City region	N Cols	0.22	0.64	161.43	0.36	0.35	0.54	309.38	0.46	-48.33
	N Cent	-0.08	0.47	-61.15	0.53	0.28	0.48	203.56	0.52	-33.82
	Cent Cols	0.20	0.46	146.59	0.54	0.30	0.39	351.04	0.61	-41.10
Aberley 1	N Cols	0.18	0.45	139.49	0.55	0.20	0.44	159.20	0.56	-7.46
	N Cent	0.20	0.47	146.56	0.53	0.28	0.50	206.17	0.50	-29.21
	Cent Cols	0.20	0.46	146.59	0.54	0.25	0.51	181.52	0.49	-19.22
Aberley 2	N Cols	0.37	0.67	379.64	0.33	0.38	0.70	388.92	0.30	-4.28
	N Cent	0.25	0.61	265.37	0.39	0.38	0.70	390.49	0.30	-50.58
	Cent Cols	0.33	0.67	335.43	0.33	0.38	0.70	386.97	0.30	-19.81
Bioregion 1	N Cols	0.56	0.69	590.70	0.31					
	N Cent	0.56	0.68	586.96	0.32					
	Cent Cols	0.55	0.68	574.56	0.32					

5.5.2 Sensitivity analysis of pre-processing

The three methods of pre-processing were used to enable the process' sensitivity to the manner in which pre-processing was carried out to be determined. Table 5.9 shows the results of this sensitivity analysis. Each method of pre-processing was compared to the other two and the significance of the difference between the pairs of methods of pre-processing, the Z values are shown first for the bioregional definition with the conflict resolution (Bioregions 2) and secondly for the bioregional definition with the conflict resolution (Bioregions 1). The levels of significance of the differences are then ordered so that the highest level of agreement is presented first of the three letters in the columns labelled 'Order of significance'. In this way, the method of pre-processing that yields the best levels of agreement can be determined and then evaluated. Using this ranking, a numerical value can be applied to the order such that first place receives three points, second place receives two points and last place receives one point. Under this regime it can be seen that pre-processing method 'A' ('N Cols' – pre-processing method 1 in Section 4.5.3.1) performs best with a score of 49. Pre-processing method 'B' ('N Cent') performs second best with a score of 42 and method 'C' ('Cent Cols') performs least well with a score of 40.

Table 5.9: Analysis of sensitivity of κ to different methods of pre-processing. A ='N Cols', B ='N Cent' and C = 'Cent Cols'. A, B and C are the different methods of pre-processing. 'Aberley 1' is Aberley's (1995) intuitive bioregional definition of Scotland. 'Aberley 2' is the cultural subdivisions of that bioregional definition.

Comparatee coverage	**Bioregions 2**				**Bioregions 1**			
	Z A *vs.* B	Z B *vs.* C	Z C *vs.* A	Order of significance	Z A *vs.* B	Z B *vs.* C	Z C *vs.* A	Order of significance
Agriculture	-42.55	50.19	-8.85	B A C	-16.2	78.96	-72.18	B A C
Watersheds	2.56	-2.56	0	A/C B	-4.19	10.46	-6.72	B A C
Clans	5.64	15.33	-21.13	A B C	19.62	-21.43	1.94	C A B
Districts	69.60	-69.60	0	A/C B	58.01	-41.76	-16.43	A C B
Land use	12.64	16.38	-29.15	A B C	18.08	-20.66	3.01	C A B
Architecture	-2.98	25.34	-22.23	B A C	-20.34	42.25	-21.79	B A C
SNH	2.71	-2.05	-0.70	A/C B	0	0.21	-0.21	A/B/C
Climate	5.65	-5.30	-0.35	A/C B	2.26	-10.15	7.88	C A B
City regions	68.12	-62.92	-9.09	A C B	7.43	-2.44	-18.71	A C B
Aberley 1	-4.06	-0.27	4.33	C B A	-26.03	9.54	16.28	B C A
Aberley 2	45.77	-29.92	-15.67	A C B	-0.47	0.60	-0.126	A/B/C
Bioregions 1	0.08	5.25	-5.34	A/B C	-	-	-	-

Clearly the method of pre-processing does have a significant effect on the outcome of the tests of agreement, despite nearly 20% of the comparisons in the table above not yielding a significant result (13 out of 69). For the sake of brevity and in the absence of any clear preference from the results in Table 5.9, results for pre-processing methods 'A' and 'C' will be presented in future tables. Method 'B' is dropped from further consideration as it is favoured least from the results of the tests for significant differences between the pre-processing methods. Method 'A' is to be preferred with 52% of the results of comparisons of method 'C' *vs.* 'A' in favour of 'A'. Of these comparisons, however, more than a quarter (26%) show that there is no significant difference between 'A' and 'C' and the remainder favour method 'C'.

5.6 COMPARING STRICT RULES TO INTUITIVE MAPPING

It was decided that an independent definition of bioregions in Scotland was required to allow a test to be carried out between rules-based mapping and intuitive mapping of bioregions. Although the independent definition must have been developed following a qualitative rationale, must also have been produced by somebody who understands the nature of bioregions and is making a genuine attempt to portray what they believe to be the correct bioregional boundaries for Scotland.

There are very few bioregional definitions that relate to Scotland in the literature. At the time of writing there was only one that covered the whole of Scotland (other than the two variations developed here). Both bioregional definitions developed by Aberley (1995) were used to test agreement firstly with the other bioregional definitions and secondly with the coverages (layers) that were used to created the rules-based bioregions. The limitations of this map have been discussed elsewhere but, despite these, kappa provides a very powerful tool to make meaningful comparisons with other regional definitions of Scotland. Good agreement between Aberley's intuitive bioregions and the coverages that were used to represent Sale's (1985) taxonomy of bioregions will add weight to the veracity of Aberley's regions or allow them to be discounted as too inaccurate. Having ascertained that the original variant of the rules-based bioregions (Bioregions 1) is more accurate it will be used as the comparator. Table 5.10 shows the extent of agreement between Aberley's regions and the coverages with the values for Bioregions 1 listed, to allow comparisons between the levels of agreement to be made. Two variations of the pre-processing are also retained.

Table 5.10: Agreement of Aberley's intuitive regions with various coverages of Scotland. A = 'N Cols' and C = 'Cent Cols'. A and C are the different methods of pre-processing (PP). 'Aberley 1' is Aberley's (1996) intuitive bioregional definition of Scotland. 'Aberley 2' is the community region subdivisions of that bioregional definition. Values in bold exceed their counterparts for 'Bioregions 1'.

Comparatee	**P**	**Bioregions 1**		**Community regions (2)**			**Aberley's Bioregions (1)**		
coverage	**P**	K	K_{max}	K	K_{max}	Z	K	K_{max}	Z
Agriculture	A	0.16	0.41	0.16	0.46	77.25	0.01	0.33	4.08
	C	-0.07	0.66	**0.19**	0.49	69.11	-0.02	0.42	-8.71
Watersheds	A	0.22	0.62	**0.33**	0.74	361.10	0.20	0.42	170.96
	C	0.20	0.64	**0.40**	0.69	446.46	**0.21**	0.43	181.87
Clans	A	0.24	0.57	0.24	0.75	266.07	0.16	0.39	138.15
	C	0.25	0.57	0.25	0.75	273.25	0.18	0.38	174.43
Districts	A	0.28	0.61	0.28	0.75	310.72	0.14	0.39	121.28
	C	0.24	0.51	**0.42**	0.75	453.88	0.17	0.43	145.41
Land use	A	0.17	0.57	0.07	0.54	45.15	0.05	0.59	26.12
	C	0.18	0.64	**0.19**	0.45	121.10	0.08	0.51	44.91
Architecture	A	0.26	0.63	**0.32**	0.77	286.09	0.16	0.48	126.86
	C	0.20	0.67	**0.32**	0.68	319.71	-0.05	0.53	-32.92
SNH	A	0.28	0.67	**0.36**	0.80	388.14	0.23	-0.09	59.37
	C	0.27	0.67	**0.41**	0.83	433.10	0.07	0.01	717.35
Climate	A	0.17	0.62	**0.18**	0.73	192.50	0.10	0.48	76.53
	C	0.19	0.49	0.16	0.76	169.89	0.11	0.48	81.73
City region	A	0.35	0.54	**0.43**	0.59	382.66	0.27	0.50	184.78
	C	0.30	0.39	**0.43**	0.59	382.66	0.27	0.46	223.21
Aberley 1	A	0.20	0.44	**0.30**	0.38	272.59			
	C	0.25	0.51	**0.36**	0.40	317.75			
Aberley 2	A	0.38	0.70						
	C	0.38	0.70						

Instances where Aberley's intuitive regions have better agreement (κ) than the rules-based objective regions are highlighted in bold. It is very clear that Aberley's Community Regions provides good agreement with all coverages and is clearly a better bioregional definition than the rules-based objective definition. This result suggests that, at the community level there is much to be gained by an intuitive, consensual science approach to bioregional definition. This is, of course precisely what bioregionalist like Aberley or McGinnis (1999) would say. However, rising a level in Aberley's hierarchy has the effect of creating very poor agreement between the intuitive bioregions and the individual coverages. In this case (Aberley 1) over half of the κ values are rejected either because their Z values are not significant or because they do not meet the requirements for acceptance in Section 4.5.1.3. Indeed there is better agreement and less fuzziness between the Community Regions (Aberley 2) and Bioregions 1 than between Aberley 2 and Aberley 1. For these reasons Aberley's bioregional definition is rejected. Allowing for both the crude nature of the original map, and the entirely intuitive way in which it was created, it lacks any credible agreement with the Scottish countryside. On the other hand the Community Regions (Aberley 2) have excellent agreement with some of the highest absolute values of κ in the entire run of 192 κ tests that may be found in the Appendix.

The observations above suggest that goods results can be obtained where an intuitive approach is guided by expert knowledge. This is precisely the approach that was advocated in Chapter 3 for the best method of achieving good stakeholder participation whilst maintaining scientific credibility and objectivity.

5.7 COMPARING BIOREGIONAL MAPPING TO THE CITY REGIONS

The City Regions (Honey, 1976) provide a good compromise between purely political boundaries and the rationale of bioregional mapping. The City Regions took into account centres of population and social factors although there was little reference to the natural or physical environments. It is, therefore, of considerable interest to assess how this style of mapping compares with the two bioregional definitions that have been established here ('Bioregions 1' and 'Aberley 2') and whether it has better or worse agreement with the natural, physical and cultural environments of Scotland. Table 5.11 presents the values of the kappa tests in a similar form to the previous two tables. As before, values of κ that are in bold exceed their 'Bioregions 1' counterpart. Where City Regions κ values are presented in italics, they exceed their Aberley 2 (Community Regions) counterparts. Consequently values that are presented in bold and italics for the City Regions are the highest for that category in the table and exceed both their 'Bioregions 1' and 'Aberley 2' counterparts. A majority of values for the City Regions in bold and italics would indicate that it surpassed the bioregional definitions.

It can be seen from Table 5.11 that for the City Regions, although in some cases they have good agreement with the various coverages, a quarter of the kappa tests where the City Regions coverage is the comparator are not significant. Even a cursory inspection of the κ values will show that they do not provide a better solution than the bioregional definitions. Overall the latter display more agreement to Scotland's various characteristics than the politically motivated City Regions. The City Regions also have a greater degree of fuzziness associated with each comparison, which reinforces any decision to reject the City Regions in favour of the bioregions. The City Regions might have been expected to display very good agreement with the three coverages that attempt to define socio-cultural aspects, namely the districts, clans and

Naismith's architectural regions. Although the agreement that the City Regions have with these coverages is significant it is not as strong as either of the bioregional definitions or Aberley's Community Regions. Since this was supposedly one of the strengths of this regionalisation and given the proportion of results that were not significant coupled with the fact that in all but one case the bioregions had better agreement the City Regions must be rejected in favour of the bioregions.

Table 5.11: Agreement of the City Regions with various coverages of Scotland compared with 'Aberley 2' and 'Bioregions 1'. Values of κ in bold exceed the Bioregions 1 counterpart. City Regions κ values in italics exceed their Aberley 2 (Community Regions) counterparts.

Comparatee	P	Bioregions 1		Community regions (2)			City Regions		
coverage	P	K	K_{max}	K	K_{max}	Z	K	K_{max}	Z
Agriculture	A	0.16	0.41	0.16	0.46	77.25	***0.23***	0.51	91.53
	C	-0.07	0.66	**0.19**	0.49	69.11	***0.23***	0.40	86.03
Watersheds	A	0.22	0.62	**0.33**	0.74	361.10	**0.23**	0.54	214.34
	C	0.20	0.64	**0.40**	0.69	446.46	**0.23**	0.54	214.34
Clans	A	0.24	0.57	0.24	0.75	266.07	0.17	0.55	153.83
	C	0.25	0.57	0.25	0.75	273.25	0.17	0.55	153.83
Districts	A	0.28	0.61	0.28	0.75	310.72	0.21	0.51	200.13
	C	0.24	0.51	**0.42**	0.75	453.88	0.21	0.51	200.13
Land use	A	0.17	0.57	0.07	0.54	45.15	*0.15*	0.59	84.79
	C	0.18	0.64	**0.19**	0.45	121.10	***0.20***	0.79	91.10
Architecture	A	0.26	0.63	**0.32**	0.77	286.09	0.10	0.55	92.34
	C	0.20	0.67	**0.32**	0.68	319.71	0.07	0.62	59.16
SNH	A	0.28	0.67	**0.36**	0.80	388.14	0.28	0.54	261.11
	C	0.27	0.67	**0.41**	0.83	433.10	**0.28**	0.54	261.11
Climate	A	0.17	0.62	**0.18**	0.73	192.50	0.10	0.54	95.12
	C	0.19	0.49	0.16	0.76	169.89	0.10	0.54	95.12
City region	A	0.35	0.54	**0.43**	0.59	382.66			
	C	0.30	0.39	**0.43**	0.59	382.66			

A final note must be made that the original Wheatley Commission's recommendations for the city regions, successful amendments notwithstanding, were not accepted by the Labour Government of the day in their entirety. The political process that approved the final format of the regional reforms distorted the pattern from the City Region norm (Honey, 1976) so while the City Regions, as they passed into legislation, are rejected the principles on which they were originally formed are not necessarily rejected. These principles are a reflection of the social dimension of bioregionalism and merely lack the environmental dimension.

5.8 CAN WATERSHEDS BE USED AS A SHORT-HAND FOR BIOREGIONS?

A question that was asked early on was whether there was any justification in simply using watersheds to define bioregions or whether the inclusion of the other factors in Sale's (1985) taxonomy of bioregions is necessary. Obviously it would make the process of identifying bioregions much simpler if the other factors could be omitted and this is often done in the literature. The strength of agreement that is found between the bioregional definitions and the major watersheds of Scotland are promising ($\kappa = 0.27$ with Bioregions 2, $\kappa = 0.22$ or 0.20 with Bioregions 1 and $\kappa = 0.33$ or 0.40 with Aberley's Community Regions depending on pre-processing method; values are from Tables 5.7, 5.9 and 5.10). If the agreement that the watersheds are found to show with the other coverages that comprise the bioregions is comparable to the agreement shown by the bioregions, then the hypothesis that watersheds can be used as a simple short-hand for bioregions can be accepted. The results of these comparisons are presented in Table 5.12. For consistency of presentation, and to allow comparisons to be made, the values of κ and κ_{max} for Bioregions 1 and the Community Regions ('Aberley 2') are included. The two preferred methods of pre-processing (PP) are also shown. As before, all the values of κ for the Community Regions and the Watersheds that exceed their counterparts in Bioregions 1 are highlighted in bold. No κ values for the watershed comparisons exceed the κ values for the equivalent comparisons made with the Community Regions, so no values are displayed in italics.

The first point to note when considering these figures is that just under half of all the κ values for comparisons with the watersheds are either not significant, or are rejected according to the criteria set out in Section 4.5.1.3. In addition, there are only three instances where the κ values for comparisons involving the watersheds exceed the Bioregions 1 comparisons. It is clear that the watersheds do not have as good agreement with their overlying geographical and environmental characteristics as either of the sets of bioregions. Therefore, the hypothesis that watersheds, by themselves, can be used as a surrogate for bioregions must be rejected. It is inappropriate to use watersheds by themselves to identify bioregions because they are part of the definition but are insufficient to provide the whole picture. Despite the strong agreement between the bioregions and the watersheds (see last two rows of Table 5.12) it would not be expected from all the preceding discussion of holism and bioregions for the hypothesis to have been accepted. It would be a negation of the whole *raison d'être* of bioregions to reduce them to mere correspondence with watersheds[2].

Table 5.12: Agreement of the major Scottish watersheds with various coverages of Scotland compared with the Community Regions ('Aberley 2') and 'Bioregions 1'. Values of κ in bold exceed the Bioregions 1 counterpart.

Comparatee coverage	PP	Bioregions 1		Community regions		Major Scottish Watersheds		
		K	K_{max}	K	K_{max}	K	K_{max}	Z
Agriculture	A	0.16	0.41	0.16	0.46	0.09	0.46	40.88
	C	-0.07	0.66	**0.19**	0.49	**0.12**	0.42	50.00
Clans	A	0.24	0.57	0.24	0.75	0.05	0.44	141.17
	C	0.25	0.57	0.25	0.75	0.05	0.44	146.50
Districts	A	0.28	0.61	0.28	0.75	0.26	0.64	588.00
	C	0.24	0.51	**0.42**	0.75	**0.26**	0.64	585.54
Land use	A	0.17	0.57	0.07	0.54	0.11	0.54	68.18
	C	0.18	0.64	**0.19**	0.45	0.12	0.61	72.56
Architecture	A	0.26	0.63	**0.32**	0.77	0.22	0.74	203.37
	C	0.20	0.67	**0.32**	0.68	0.19	0.75	172.36
SNH	A	0.28	0.67	**0.36**	0.80	0.26	0.79	298.65
	C	0.27	0.67	**0.41**	0.83	**0.32**	0.72	376.39
Climate	A	0.17	0.62	**0.18**	0.73	0.14	0.63	187.67
	C	0.19	0.49	0.16	0.76	0.15	0.60	201.22
City region	A	0.35	0.54	**0.43**	0.59	0.23	0.54	214.34
	C	0.30	0.39	**0.43**	0.59	0.23	0.54	214.34
Watersheds	A	0.22	0.62	**0.33**	0.74			
	C	0.20	0.64	**0.40**	0.69			

There are some interesting points to emerge from the results above. The first is corroboration of the dramatic result in Table 5.3 that shows an extremely high correlation between the watersheds and the districts ($r = 0.956$). There is also highly significant ($Z > 580$) agreement between them ($\kappa = 0.26$). Another area of corroboration of Table 5.3 can be seen for comparisons of the watersheds with the SNH Heritage Zones where there is even better agreement ($\kappa = 0.32$), that is also highly significant ($Z = 376$). This lends some weight to the moderate correlation shown in Table 5.3 ($r = -0.403$). However there is no basis for reading any meaning into the correlation for either climate or clan territories beyond geographical association because their agreement is so poor or not significant.

2 No statement about the veracity or efficacy of watershed management *per se* is intended by these comments which are limited to whether watersheds are inclusive enough to equate to bioregions.

5.9 REAPRAISING THE CHOICES FOR CULTURAL REGIONS

Certain decisions were made relating to the choice of coverages that would represent social and cultural regionalism in Scotland at the beginning of this and the previous chapter. Tables 5.7 to 5.10 inclusive already show the degree to which the bioregions agree to the cultural definitions of Scotland. The test of agreement can be used to see how well the cultural regions correspond to each other. Table 5.13 shows the levels of agreement between the three cultural coverages.

Table 5.13: Comparison of the levels of agreement between the three cultural definitions of Scotland and also with the major watersheds.

Comparatee coverage	P	Districts			Watersheds			Architecture		
	P	κ	κ_{max}	Z	κ	κ_{max}	Z	κ	κ_{max}	Z
Watersheds	A	0.26	0.64	588.0	-	-	-	-	-	-
	C	0.26	0.64	585.5	-	-	-	-	-	-
Architecture	A	0.24	0.71	246.5	0.22	0.74	203.4	-	-	-
	C	0.29	0.75	298.1	0.19	0.75	172.4	-	-	-
Clans	A	0.06	0.54	173.7	0.05	0.44	141.1	0.25	0.66	250.5
	C	0.05	0.51	151.2	0.05	0.44	146.5	0.24	0.63	241.0

The coverage of the major watersheds is also included in Table 5.13 to help comparisons although these data have been seen before in Table 5.12. It can be seen from the table that Naismith's architectural regions have the best agreement between the different methods of identifying cultural regions. The coverage of clans regions has the worst levels of agreement, which is often not acceptable as significant.

5.10 SUMMARY OF THE RESULTS

The results of the mapping exercise can be summarised as follows:

- bioregions are demonstrable entities having good agreement with underlying biogeographic and geomorphological characteristics of the land;
- bioregions have better agreement with the characteristics of an area than political regional definitions;

- culture, although sometimes difficult to map, is important to bioregions and regional variations of vernacular building styles would appear to give a good approximation to cultural zones;
- watersheds are important to bioregions but are insufficient by themselves to substitute for as bioregions;
- a balance needs to be struck between objective, quantitative and intuitive, qualitative methods of analysis to achieve the best results;
- Aberley's (1995) Community Regions provided the best agreement and is promoted as the best definition of Scottish bioregions in the absence of an extensive, stakeholder participatory exercise. However, both versions of the objective, quantitatively generated bioregions that result from the mapping exercise, showed significantly better agreement than all other regionalisations including Aberley's Bioregions.

6

MAPPING DISCUSSION

"In order to continue his astonishing adventure on Earth, Man must continue to balance two basic imperatives – the need to innovate constantly in order to meet the growing challenges of development and progress and the need to preserve carefully his cultural and natural heritage upon which he depends for his spiritual and biological survival."

(Batisse, 1982)

6.1 INTRODUCTION

The discussion in this chapter will focus on the mapping process and results found in Chapters 4 and 5. The mapping process was concerned with investigating the degree to which credibility can be invested in the existence of bioregions as demonstrable entities through the practical application of the published rules in the literature, with adaptations developed in this thesis, for identification of bioregions.

During the course of the mapping it became clear that additional rules were needed to amalgamate 'region cores' into bioregions without resorting to subjective choices. The newly derived rules reduce the chance of conflicts in the merger of the 'region cores'. The result was two similar, but alternative, bioregional definitions for Scotland. These definitions were compared, for agreement with two other bioregional definitions (Aberley, 1995) and with the City Regions of the Wheatley Commission (Honey, 1976). The levels of agreement between the constituent layers of the new bioregions were compared back to the new bioregions to assess the possibility that the bioregions were artefacts of the process that produced them. These comparisons also allowed a more detailed assessment of the comparisons between the new bioregions, Aberley's bioregions and the City Regions which could not have been achieved by comparing the level of agreement between the five regional definitions. This chapter will explore the results of the mapping process, looking at its strengths and weaknesses and assess whether the concept of bioregions is acceptable.

6.2 LIMITATION OF METHODS FOR IDENTIFYING BIOREGIONS IN SCOTLAND

In a true bioregional mapping exercise, the involvement of the community at an early stage is important to agree the brief, identify the areas of analysis, agree the appraisal framework and finally map the bioregion. In the context of this study public consultation was difficult for a three reasons:

- a greater level of participation was not feasible as the whole of Scotland was to be considered and thus the number of people which would have been required for a full bioregional analysis with stakeholders from all regions of Scotland was prohibitively large, the logistics of such a venture notwithstanding, within the limits of time and resources available.
- bioregionalism is not as well known about in Scotland as it would appear to be in North America (for instance). A high level of public consultation was not deemed to be possible with out an accompanying campaign of awareness-raising and public education about bioregionalism. This was outwith the realms of possibility for this study.
- A more theoretical approach was adopted, the aim was to investigate bioregionalism itself. At a theoretical level, public consultation is less important.

A less theoretical study on bioregionalism should try to include an element of public consultation. Therefore, it may be considered feasible that a limited appraisal of public opinion might be undertaken by means of a questionnaire. Such a questionnaire survey could be used as a pilot study of Scottish opinion on bioregionalism. The results of a suitably worded questionnaire could then form a comparison with the results from GIS analysis. The constraints of time and resources prevented such a survey being a part of the research for this thesis. Future work, either as a continuation of this thesis or in a new study, would benefit from first a questionnaire survey of opinion and knowledge followed by, more in-depth mapping workshops at a number of locations throughout Scotland.

A second limitation of the mapping system described in Chapter 4 was that it was entirely quantitative. From one standpoint this is a positive attribute. However, a thread that has been running through this thesis has been one of consensual science (O'Riordan, 1995), particularly in

Chapters 3, bioregionalism introduces a cultural dimension which puts a qualitative perspective on interpretation of the environment (Aberley, 1999). The consultative process that is discussed above would have added a greater qualitative element to the mapping process through, for instance, the identification of key community objectives. The strength of the argument for the inclusion of qualitative aspects in the mapping process can be seen from the strength of agreement shown by Aberley's Community Regions (Table s 5.9 and 5.10).

A final limitation of the mapping process is one that is common to all attempts at regional mapping and is summed up by the quotation at the start of Chapter 5. There is a great deal of inherent variability associated with nearly all natural systems including both ecological and cultural systems that means all attempts at mapping ultimately require a degree of interpretation. This point highlights the need for consensual science through community involvement as the interpretation is best done by the people who are most effected by it.

6.3 EXPLAINATION OF THE 'LCS88' RECLASSIFICATION

The use of the widely acknowledged 'lcs88' data set is important in providing a frame of reference with many other studies which used this data set. In Section 4.3.5, the reclassification the land cover of Scotland dataset was described. Two alternative methods of dealing with the nationally significant land cover mosaics were discussed and Table 6.3 shows the reclassification for the favoured method of dividing the nationally significant mosaics. Before discussion of the results of the mapping exercise is continued, it is important to discuss why the favoured method of reclassifying the 'lcs88' dataset was chosen because what emerges from the lcs88 data impinges on bioregional mapping and consideration of the boundaries.

To recap, the two reclassifications of the 'lcs88' dataset differed in terms of how the nationally significant mosaics were allocated. One reclassification used the primary land cover type to determine the class to which the mosaic should belong. The other classification allocated all areas, which contained moorland features, as moorland, and all mosaics, which were a combination of different types of grassland, as grassland. The two resultant coverages were found to be very similar. They were found to have a correlation coefficient ($r = 0.977$) and could be considered, for most purposes, to be almost identical. However, when the two reclassifications of the 'lcs88' dataset were used in trial bioregional mapping exercises it was found that the correlation between the two otherwise identical bioregional maps was positive ($r = 0.762$) but not as significant as the reclassifications of 'lcs88'.

At first sight this is a surprising result. It might be expected that using two nearly identical coverages, while keeping all other components of the mapping process unchanged, would result in two output maps with the same degree of variation as the differences in the input layers. This is expected because the actual area of land whose classification differs amounts to only 7.5% in one of seven layers (all other layers being identical. See Figure 6.1).

However, the original correlation was based on areas and spatial coincidence whereas the final output maps were derived from mapping boundaries. This can have a profound effect on minor differences in area. For example, consider two areas, which are identical in all respects and are totally devoid of features. Into one introduce a small homogeneous feature. Into the second area also introduce a feature which is very similar, but not identical, to the feature in area one (see Figure 6.1). The spatial correlation between these two areas is expected to be very close to 1.

The two areas (A^1 and A^2 in Figure 6.1) have no internal boundaries apart from the boundaries between the features (F^1 and F^2) and the rest of the space labelled area A^1 or area A^2. Therefore an almost negligible difference in the contents of two otherwise identical areas, can produce a much larger difference in the distribution of boundaries within the two areas. This was found to be the case when comparing the effect of using the two different reclassifications of the 'lcs88' dataset in practice.

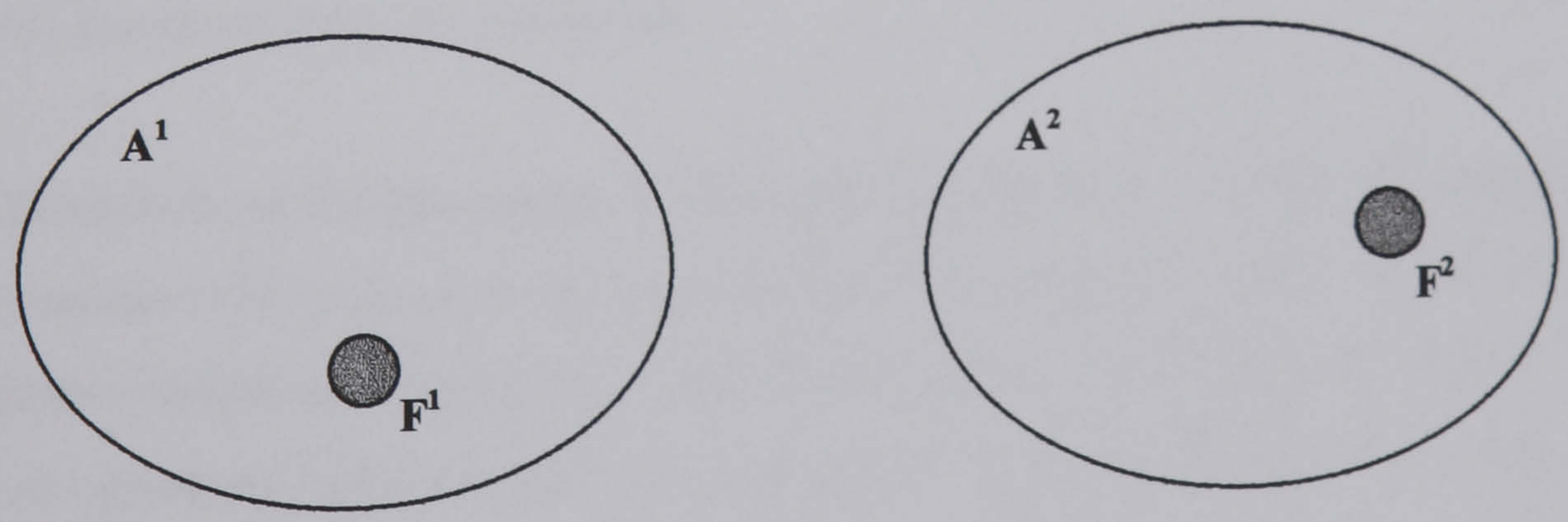

Figure 6.1: Two identical areas 'A^1' and 'A^2', having no internal boundaries, each have a small feature introduced into them ('F^1' and 'F^2'). F^1 and F^2 are similar but not identical. A^1 and A^2 can be expected to have a spatial correlation close to $r = 1$ but a lower correlation of their internal boundaries.

For the land cover data, the method of reclassifying the nationally significant mosaics by the nature of their primary cover type, because it is less subjective and the magnitude of error is likely to be less. The total area of all types of 'pure' grassland is 20.8% of the total land area of Scotland. The total area of moorland (including bracken, peatland and montane) is 37.3%. The area of minor mosaics is 7.5%, which is a larger proportion of the total grassland area than the moorland area.

A poor result for agreement was expected, and found, in the comparison of the various regional definitions with land cover (lcs88) (see Tables 5.6 and 5.7). This is because most types of land cover are found in most of the bioregions. In fact, it could be argued that bioregions should show a balance of different types of land cover so no particular correlation should be expected. Indeed, this is a minor weakness in the analysis because the extent of land-use differs subtly in its character from the other coverages. All the other coverages have contiguous regions. The coverage of land-use has clusters of identically valued cells but not all clusters of cells of a given value are connected to each other in this case.

6.4 SENSITIVITY ANALYSIS

As part of this research the sensitivity in the results were explored in two stages. The first, was the sensitivity of the final definition of bioregions to small changes in the formulation of the rules for merging the region cores. The second was the sensitivity of the results of analysis to the way in which pre-processing was conducted.

6.4.1 Sensitivity of the Bioregions to Changes in the Rules for the Merger of Region Cores

The extension of the rules that were developed for the merger of region cores resulted in the two bioregional definitions 'Bioregions 1' and 'Bioregions 2'. The bottom of Table 5.7 shows the level of agreement between these two coverages. The agreement is very high ($\kappa \geq 0.55$) particularly in view of the maximum possible agreement allowable by the marginals[1] ($0.7 \leq \kappa_{max} \geq 0.68$). This is proof that, while changes to the rules for merging the region cores does make a difference to the outcome of the definition of the bioregional boundaries that difference is small. In all other comparisons in Table 5.7 the two bioregions both show significant agreement. The

1 The marginals are those values that lie off-diagonal in the κ matrix. These values contribute to the fuzziness. See Section 4.5.1.3.

level of the agreement does differ as can be seen from the final column but in only two cases (< 1%) is there actually disagreement (Agriculture 'N Cols' and City Regions 'N Cent'). This may be explained because 'Bioregions 2' dissects a critical area on the Northwest coast that is not so dissected in either 'Bioregions 1' and nor the two cases from Table 5.7.

6.4.2 Sensitivity of the Results to Pre-Processing Methods

It is inevitable in almost any study that there will be pre-processing prior to the analysis. This study was no exception particularly as certain statistical techniques, such as the kappa coefficient, required a minimum level of pre-processing before they could be applied to the data. The basic rationale in the pre-processing was that, firstly, areas closer together are more likely to be similar and, secondly, that many small regions in one coverage may represent one larger region in another coverage if good agreement was found between them.

The methods used for the pre-processing were described in Chapter 4. Closer consideration of the mechanics of the methods (described in Section 4.5.3.1) suggests why method 'A' (Table 7.8) performed best. A number of factors are relevant:

- method 'A' ('N Cols' – pre-processing method 1 in Section 4.5.3.1) is the simplest method of pre-processing;
- adjacent columns in the contingency table are naturally adjacent geographically as a result of the re-coding of the categories (Section 4.5.3.1);
- the use of centroids to merge with the nearest neighbour may cause several regions to collapse into a single significant column. Theoretically, this should not be a problem but it is likely to bias the marginals of the kappa contingency table. The method of collapsing by columns is likely to maintain a more even distribution of the marginals by an equal spread of mergers. Using a similar scoring method for fuzziness as was used for ranking the significance, it can be seen from Table 5.7 that pre-processing methods 'A' and 'C' rank equal top (scoring 49 out of a possible 69) and method 'B' comes a close second (46). Admittedly, this result is weak because the difference between the rankings is small but pre-processing methods 'A' and 'C' both collapse kappa contingency table columns based on adjacent columns;
- the use of polygon centroids masks the effect of particularly dominant axes and so there is no differentiation between compact and elongated regions. This can be expected to make a slight difference to the way in which the kappa contingency table is collapsed. The use of

the most northerly cell does not differentiate directly but, because Scotland is elongated along its North-South axis and is comparatively narrow, a particularly elongated region will 'push' more Southerly ones 'down' giving a greater differentiation between their respective most Northerly points than would be found between their centroids.

The choice of pre-processing method does not effect the definition of the bioregions, only their interpretation. It is reassuring that all three pre-processing methods yield significant results for the tests of agreement (Table 5.7), in most cases. This means that, although Table 5.8 shows that there are significant differences between the levels of agreement for each pre-processing method in a given test, the process is not so sensitive that, overall, an alternative pre-processing method could change 'agreement' into 'no agreement'. The differences that are shown by Table 5.8 are in the levels of agreement that the methods of pre-processing show, rather than fundamental differences in the results.

6.5 ARE BIOREGIONS DEMONSTRABLE ENTITIES?

One of the most important questions that this thesis seeks to answer is whether bioregions can be demonstrated to exist, in their own right, outside of the philosophical arguments of bioregional*ism* and deep ecology. If bioregions cannot be shown to be demonstrable entities then the arguments of bioregional*ism* are very much weakened. The statistical methods used for analysis of the bioregions are not easy to interpret intuitively but it is on the basis of their results that the acceptance of bioregions is made.

A closer look at the meaning of the statistics shows that the Z values in Table 5.8 represent, in the main, small differences between the κ values (Table 5.7) for the various tests. The reason these small differences are significant is that all the respective standard errors are small. As explained in Section 4.5.1.3, even small values of κ can be highly significant. Since any one value of κ represents the analysis of comparing nearly 75,000 pairs of data even low values of κ can be accepted if shown to be significant.

Table 5.7 demonstrates that the bioregions found by studying the land according to a set of rules are associated with corresponding regionalisations (Table 5.5), since they result, in part, from these coverages and that agreement has been shown (Table 5.7). This suggests that the bioregions are more than merely artefacts of the process of their definition. If they were merely

An intuitive mapping approach can provide as good, if not better, results than a more strictly quantitative method (Table 5.10), where the intuitive approach is informed by an understanding of bioregional taxonomy, the local environment and the local culture. This belief is supported by the high levels of agreement shown by Aberley's community regions with the coverages that were used as precursors of the new 'objective bioregions'. This is an important result for the process of environmental future state visioning because it means that stakeholders are not only able to participate but are necessary for the formulation of a locally meaningful vision and the management strategies that are consequent on and consistent with that vision.

From Tables 5.7, 5.9 and 5.10 it is possible to rank the regional definitions of Scotland that are under consideration, where the coverage with the best agreement is placed first, as follows

1. Community Regions
2. Bioregions 1
3. Bioregions 2
4. City Regions
5. Aberley's Bioregions

Aberley's Bioregions appear to be rather an over simplification and reduce the level of their agreement with the layers in Sale's (1985) taxonomy of bioregions below that which is acceptable as significant. The new 'objective bioregions' have served the purpose to prove the bioregions can be identified according to logic. The number of variables is large as are the assumptions that were required. It is entirely possible that a better result can be achieved through a more qualitative approach, grounded in an understanding of people, place and bioregions although there is an equal danger of being overly simplistic as over being overly sophisticated. This latter situation is seen in the rejection of Aberley's Bioregions. Although these are based on his Community Region, they have simplified the situation to such an extent that the meaning of the bioregions has been lost.

6.7 CAN WATERSHEDS BE USED AS A SHORTHAND FOR BIOREGIONS?

Considering the nature of 'place', the logic of using divisions based solely upon watersheds must be questioned. The research within this thesis and bioregional literature both support the attractiveness of the watershed as a unit for ecological management. Section 5.9 investigated this issue from the point of view of the levels of agreement between the coverage of the major watersheds of Scotland and their agreement with other coverages. It was shown in that section that there was little basis for accepting watersheds as any sort of shorthand for bioregions, particularly in light of Table 5.11. A coda to this is the fact that simple identification of bioregions as watersheds does not permit the inclusion of in-shore islands as part of a mainland bioregion irrespective of the logic based on similarities in culture, flora, fauna, climate *etc*. If the argument that a given in-shore island is "obviously a part of the nearest mainland bioregion" even though it is not in its watershed is accepted then the bioregions are no long being defined purely by watersheds. Table 5.11 should show this argument is not merely pedantry.

The results do support the importance of the inclusion of watersheds in the bioregional make up but, nonetheless, two questions remain

1. Do coastal communities 'look out to sea' (and at each other) more than they do to the mainland?
2. How unified are the communities along the length of the bioregion as it follows the watersheds?

Both questions have consequences for the identification of bioregions. If the answer to the first one is 'yes' then a refinement of the concept of bioregions is necessary to allow for these coastal zones. The limits of this study do not permit a definitive answer to this sociological question. The second question does not affect the nature of a bioregion but means that care is needed in the way in which communities are mapped.

It is justifiable to consider divisions within a watershed which are tangential to the direction of flow. Figure 6.1 attempts to illustrate this in broad-brush terms with the aim of demonstrating how primary economic activity changes along the length of the watershed. The activities in brackets are suggestions only. The figure is not intended as a definitive statement on rural economies and cultures. There is plenty of anecdotal evidence that the nature of communities and their primary economic activity changes along the length of a watershed that supports the findings of Table 5.11. Consider fishing communities with their dependence on the sea for their livelihood and their traditional disdain of 'landlubbers', or more specifically the divisions between Highlanders who tend to fall into the 'Transitional' and 'Upland categories. Here the primary economic activity is either forestry or what geographers refer to as 'hill farming'. The

Highlander traditionally looks askance at the Lowlander and *vice-versa*. Following this train of thought, coastal communities might be expected to have more in common with inshore islands or coastal neighbours from different watersheds than with their more immediate mainland neighbours. Such communities share the same primary economic activity and the same dangers and trials that pursuing that activity brings.

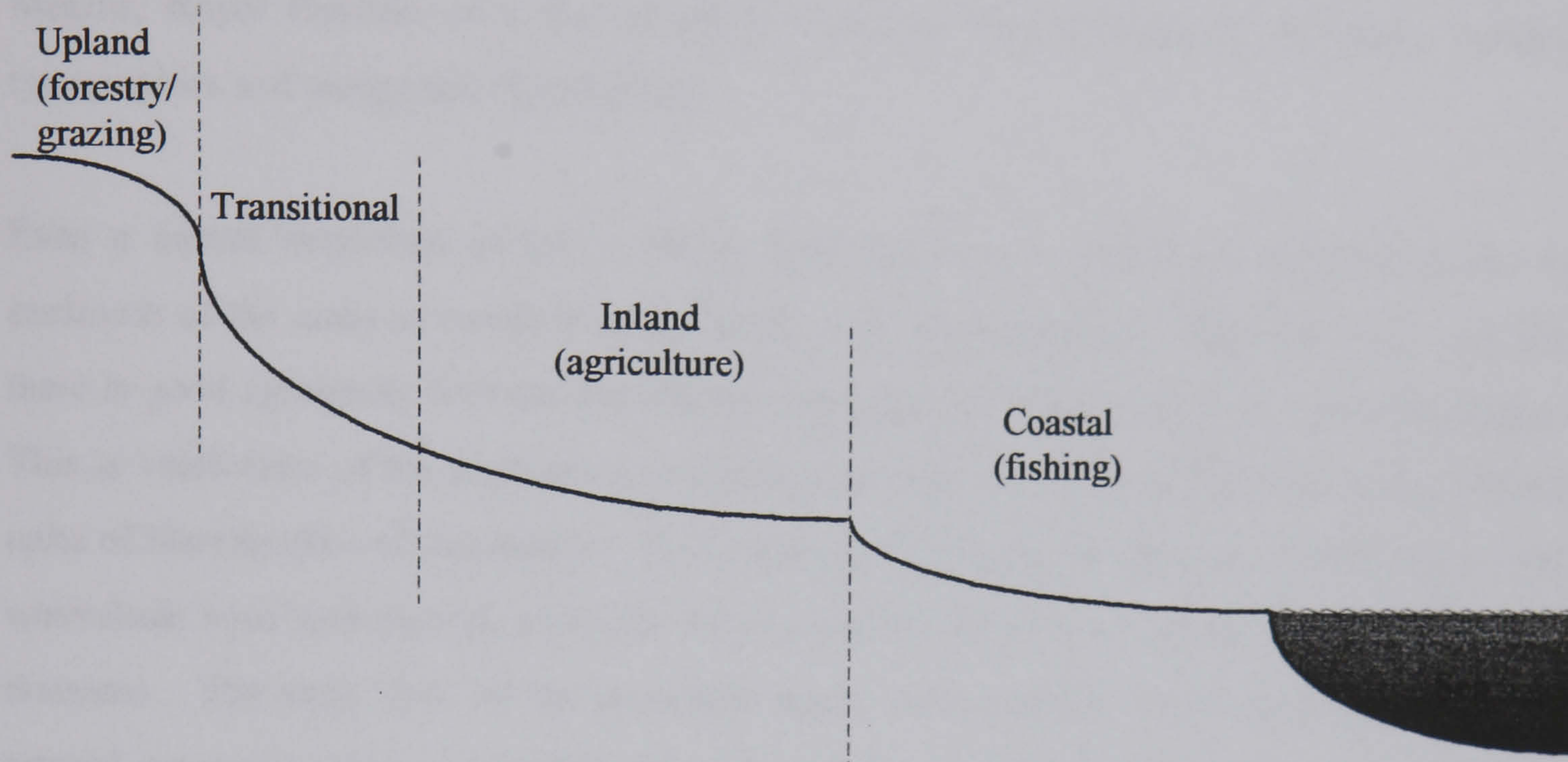

Figure 6.2: Diagrammatic broad brush divisions across a watershed where the nature of the primary economic activity tends to change (suggestions in brackets) and there is anecdotal evidence for cultural changes too.

If communities are aligned along watersheds as bioregionalism predicts but have qualitative difference along the watershed (as suggested in Figure 6.2) then it would be erroneous simply to map types of community. A method of mapping community groupings is needed to show their alignment while allowing for their different qualities. This explains the strength of Aberley's Community Regions over the quantitatively defined bioregions produced from the methodology outlined in Chapter 4. Clearly, any mapping of communities without participation of the stakeholders is speculative. This again points to the need for environmental future state visioning and community participation. Unfortunately it is not possible to do more than speculate as to the answers to the two questions posed earlier in this section without further study. This is an area for future research.

6.8 REAPRAISING THE CHOICES FOR CULTURAL REGIONS

It would be reasonable to expect that there would not be perfect agreement between the different types of cultural region but it would also be reasonable to expect a significant level of agreement because each definition should relate to, broadly, the same cultural groups. To reiterate, the cultural regions that were explored in the development of the bioregions were districts centred on known areas that relate to ancient but still extant district names (*e.g.* Garrioch, Trossachs, The Mearns, Royal Deeside *etc.*), the reflection of culture through regional vernacular building typographies and recognised clan districts.

Even a casual inspection of the κ values from Table 5.12 shows the justification for the exclusion of the clans coverage from the creation of the bioregions. However, it is clear that there is good agreement between the districts coverage and the coverage of major watersheds. This is vindication of the emphasis bioregionalism places on watersheds as one of the primary units of identification of bioregions. This result is not unexpected however. Until recent times watersheds have been natural, albeit not insurmountable, barriers or boundaries between cultural divisions. The main river of the watershed again, until recently, would have been the main arterial transport route. Together these facts help to focus the districts on there nearest watersheds.

The inclusion of Naismith's (1989) architectural regions is also clearly justified by the significance of the agreement that it shows with other cultural regions including, even, the clans. This suggests that the architectural regions are perhaps the best indirect mechanism for identifying cultural differences. However, it must be pointed out that the architectural regions were based on a very meticulous study that was capable of identifying even very minor regional differences in style and, by inference, local cultural influences. It is not a suggestion of this thesis that a cursory investigation of vernacular buildings in other areas would necessarily lead to such a clear identification of minor cultural regional differences. Nonetheless this is a very interesting result with many implications for heritage studies. This is not least because of a recent call by the (then) Scottish Office (1995) for the definition of a neo-svernacular architecture to safeguard regional character in the face of placeless mass-market housing design. Bioregional mapping has an obvious role to play here.

Bioregionalism seeks a divorce from the present trend towards a technocentric 'omni-state' or 'Coca-Cola culture'. As has been discussed in preceding chapters, bioregionalism places importance on cultural heritage in that it is what defines our understanding and interaction with the environment. It is therefore relevant to consider established historical regional divisions of people, but this is only acceptable where those divisions are stable. Unstable and transient divisions are indicative of a state of flux in which it is assumed that there is little sense of 'belonging' to a place. A guiding factor in the choice cultural distinction is that the definitions of areas or regions must be the most natural patterns possible rather than government imposed administrative boundaries. Such boundaries are externally imposed.

6.9 CONCLUSIONS OF THE BIOREGIONAL MAPPING EXERCISE

The bioregional mapping exercise that was described in Chapters 6, 7 and 8 when coupled with the philosophical discussion of bioregionalism in earlier chapters leads to a number of conclusions about bioregions. These can be summarised as follows

1. Bioregions are demonstrable entities.
2. Bioregions are not 'container space' like political regions but are dynamic.
3. As such bioregions are not quantifiable in purely mechanistic terms and allowance must be made for their qualities. Increasing the sophistication of the analysis of the quantities of systems that go together to make bioregions does not necessarily improve their identification and can lead to a loss of agreement between the purported bioregions and their constituents.
4. Conversely, over simplification results in a loss of meaning which is again reflected in reduced agreement.
5. Cultural regions are not susceptible to indirect definition using only one factor. Furthermore care needs to be exercised in the choice of which combination of factors should be used to represent cultural divides if this is to be attempted with participation.
6. Communities are best defined by the people that live in them or have intimate knowledge of them based on qualities rather than by any purely quantitative means as exemplified by the previous point.
7. It follows that proper identification of bioregions, not to mention a true sense of ownership of and co-operation in any ecologically restorative or developmental projects, requires a balance of participation by stakeholders or their representatives and expert input.

8. Watersheds are not legitimate as a 'shorthand' for bioregions. Watersheds are a very important dimension to bioregions but it is not justifiable to use them solely as a substitute for bioregions. If bioregions are to be used as a management tool then they should be properly defined using the other constituents as identified by Sale (1985) and others. Management on the basis of areas defined by watersheds alone is more properly defined as 'Watershed (or 'Catchment') Management' which is a branch of study in its own right. Bioregionalism purports to be a more holistic approach to ecologically restorative environmental management and this fact alone should make it meaningless to define bioregions solely based on watersheds. Moreover, bioregions have been shown to provide better overall agreement with numerous other systems than watersheds alone.
9. Further research is necessary to determine the affiliation of coastal areas, in-shore and off-shore islands. These areas may prove to be special cases.
10. Aberley's Community Regions provide the best-published definition of bioregions for the whole of Scotland followed by 'Bioregions 1', resulting from the bioregional mapping exercise in this thesis. Although the author knows of a number of researchers looking at defining local bioregions there are no other national bioregional definitions of Scotland. It is unfortunate that there was no more rigorously produced version of Scottish bioregions to use as a comparison. It could even be argued that Aberley was wrong twice. The regions that he called bioregions bear no resemblance to any other regional definitions of Scotland as was shown statistically. Aberley's 'Community' regions are clearly at a scale above the level of the community as can be seen by their agreement with the bioregional definitions that were produced in the mapping exercise of this thesis. Although they agree well with many of the layers used to produce the bioregions, they are not at a community scale, being much larger than the region cores used to construct the bioregions.

7

GENERAL DISCUSSION & CONCLUSIONS

"What then is the role of alternative paradigms in environmental thinking? Requisite changes in environmental practices and attitudes will not be achieved by waiting for alternative paradigms to be adopted: indeed they are . . . to be commonly dismissed as 'politically unrealistic' . . . their main function is ideological; they are not where the main focus of action should be . . ."

Routley, 1983

7.1 INTRODUCTION

Bioregionalism has been expanding rapidly since it emerged as an identifiable philosophy in the early 1970's. This rapid growth has resulted in a blurring of purpose (Aberley, 1999). The issues that surround bioregionalism, and the concept of environmental future state visioning were expounded by first looking at the philosophical background of bioregionalism, and then progressively expanding the level of detail and decreasing the scope of discussion. Chapters 4 and 5 moved from the abstract to reality with an investigation of whether bioregions are demonstrable entities, either defined by strictly objective rules or on a more intuitive basis. Scotland was used as a study area. This chapter will expand the focus again, to draw conclusions about bioregions, bioregionalism and environmental future state visioning.

7.2 CAN THE CONCEPT OF BIOREGIONS BE ACCEPTED?

In his presentation to the Macaulay Land Use Research Institute's 10th Anniversary Lectures, Professor John Krebs[1] (1997) told the story of how the distinguished plant ecologist, John

1 At the time of writing Professor Krebs was Chief Executive of the Natural Environment Research Council (NERC).

Harper, argued forcefully against the inclusion of any reference to 'ecosystems' in a new student textbook on ecology. Harper's argument, in opposition to the other two potential authors of the proposed text-book, was that ecosystems are ecologists' constructs of convenience. Nevertheless, the study of biological communities in an area and their physico-chemical environment is a recognised branch of ecology. A similar charge could be levelled against the word 'bioregion', that it is a construct of convenience.

However, the bioregion is, in reality an extension of the ecosystem to include human social, cultural and economic dimensions. As such it is an equally valid construct to that of the ecosystem. Furthermore, constructs of convenience are not undesirable *per se*. For instance, the concept of the ecosystem is invaluable for environmental management particularly in the definition of nature reserves. Constructs are the basis for models in the way that ecosystems can be considered models of the real world. From the point of view of a science of quantities, Harper was right about ecosystems. From the point of view of a science of qualities (Goodwin, 1999) Harper was wrong. The same argument applies to bioregions.

In general, a good model will be economical, but have high predictive validity and will be readily interpretable (Clayton and Radcliffe, 1996). It will include all significant, relevant, factors and cover their range of potential values. Such a model will be a reflection of the way they behave in the real world. It is also important that a model should exclude all insignificant and irrelevant factors. A model, therefore, must be in agreement with what it is modelling.

It was argued in Chapters 4 and 5 that association alone was not acceptable as an indicator of agreement (and hence acceptability of the bioregional model). This is despite the fact that very good association can be shown to exist between the bioregions and the underlying regionalisations that constitute the inputs (Table 5.5). Nonetheless, following the results of the kappa tests, it was shown that the criteria of a good model outlined in the previous paragraph have been met. Therefore, the existence of bioregions as demonstrable entities can be supported.

Furthermore, an intuitive mapping approach can provide as good, if not better, results than a more strictly quantitative method (Table 5.10) where the intuitive approach is informed by an understanding of bioregional taxonomy, the local environment and the local culture. This is an important result for the process of environmental future state visioning because it means that stakeholders are not only able to participate in, but are necessary for, the formulation of a locally meaningful vision and the management strategies that are consequent on that vision.

7.3 IS BIOREGIONALISM AN ECOPHILOSOPHY OR AN ECOSOPHY?

As argued and presented in the preceding chapters, the concepts of living in place, of watershed management, of catchment-specific ecology and of people belonging in some way to the scene they inhabit are not new. Ecologically oriented philosophies and ecosophies are not new either (see Elliot and Gare,1983; Bookchin, 1996 or Tobias,1988) and it is unlikely that bioregionalists would claim that bioregionalism was either the first, or only, such philosophy. Where, then, is the originality of bioregionalism?

The description in Chapter 2 of an ecosophy, and the derivation of the word, suits bioregionalism well. The bioregionalist places much store in local knowledge and indigenous, if sometimes intuitive, wisdom (Aberley, 1999). Bioregions, themselves, appear from the research in this thesis, to be demonstrable entities. However, the extension from bioregions to bioregion-*alism* enters areas of subjectivity, position statements and points of view. So, bioregionalism is not a self-evident philosophy. Indeed, Naess (1989) emphasises the point home with the damning remark that:

> *"In debate, to label a standpoint an 'ism' often means that it generalises the concepts of a science too much, for example: sociologism, historicism etc."*

Naess' comment is a truism but it is apt because bioregionalists themselves admit to a great diversity of opinion and voices that clamour to be heard, where consensus is an uneasy truce. The new bioregionalist is invited to choose the alternative of a science of qualities over the impartiality of the scientific approach (McGinnis, 1999). There is even open hostility to academic probing of the subject (Aberley, 1999) and an ecosophy is, essentially, added onto the very attractive concept of bioregions. This is not to say that bioregionalism has nothing positive to offer. However, it does mean that bioregionalism falls into the category of an over-generalisation as suggested by Naess (*op. cit.*). To maintain a balanced argument, it is appropriate at this point to quote Aberley (1999) when he says that:

> *"To those who hear only a part of the bioregional story or who attempt to analyse bioregionalism only through the filters of academic on institutionalised specialities, it may seem to suffer from a host of apparent weaknesses, contradictions or unresolved conflicts. For those who take the time to listen to more of the voices that are speaking about bioregionalism, or better yet, participate in the bioregional movement itself, chaos transforms itself into something that is properly perceived as an elegant, persistent and organic growth of purpose."*

Aberley, as an activist (see 'Contributors' listing in McGinnis, 1999) might be expected to take an overly enthusiastic view even though he himself admits that there are areas where consensus is lacking. The author of this thesis has not only pursued bioregionalism in an institutionalised, academic fashion, but has also listened to many of the voices of bioregionalism from a variety of sources, including published literature, and bioregional discussions on the Internet and still feels justified in levelling criticism at bioregionalists. Aberley is right about the weaknesses, if only because the disparity and quantity of the 'many voices', if taken together as he suggests, makes bioregionalism an over generalisation that its suffix "-ism" suggests that it is. Bioregionalism is, therefore, perhaps best seen as a loose bundle of ecophilosophies that are centred on the concept of the bioregion under an umbrella of place-centred ecological restoration (Aberley, *op. cit.*).

7.3.1 Can Bioregions be Accepted without Bioregionalism?

At first sight this might seem to be a pointless question. After all how can bioregions be accepted if bioregionalism is not to be accepted also. The answer lies in the foregoing discussion of whether bioregionalism is an ecophilosophy or an ecosophy. Clearly it is an ecosophy but as such it is based on the concept of bioregions, with the adoption of some of the themes that are normally associated with Deep Ecology, varying in extent depending on the commentator. The one core principle of bioregionalism that holds, however deep the ecological inclinations of the commentator, is their taxonomy. This has been expressed in a number of different ways but has been shown here to produce demonstrable bioregions with significant agreement with the landscape that they describe. As such, the process of understanding could stop there and the bioregions could then used for whatever purpose, *e.g.* as units of management, with or without accepting any more of the ecosophy of bioregionalism. It has been shown through the mapping exercise that bioregions are demonstrable entities and are therefore acceptable as a management, or research, construct. The philosophy or cultural connotations that might be attached to such a construct should come after the proof of existence of bioregions and not before it. First, there must be bioregions, and only then can there be bioregionalism. Therefore, a better question would be "Can bioregionalism be accepted without bioregions?". The answer to that question is, obviously, "No". The dichotomous split between bioregionalism and the bioregions construct is better understood when the difference between them is expressed in terms of the idealistic and pragmatic halves of the philosophy (Alexander, 1990 and Nichols, 1991).

The split between the visioning tool of bioregions and the ecosophy of bioregionalism must be stressed. The latter needlessly constrains the usefulness of the former as an adjunct to an extremely heterodox end of the ecocentric-technocentric continuum. Divorced from this unnecessary baggage, bioregional mapping can become a useful tool in strategic planning from any perspective on the ecocentric-technocentric continuum. The identification of bioregions in Scotland did not require a detailed synthesis of bioregional ecosophy, but was achieved by a comparatively mechanistic mapping process.

7.3.2 The Practical Role of Bioregionalism as an Alternative Paradigm

The challenge that was laid down in Routley's (1983) quote at the beginning of this chapter requires that there be some actionable outcome of a philosophical construct if it is to be more than just ideological. Yet, it has just been suggested that bioregionalism is an ecosophy and therefore subject to intellectual negotiation. Aberley's comments above, and the dichotomy between bioregions and bioregionalism, hold the solution to this conundrum. If bioregionalism is accepted as an ecosophy there is room for many voices within the subject area of the ecosophy.

The practical application of bioregions is through the community mapping process. This is in line with the package of policies from the Rio Summit (United Nations, 1993) and the implications of participation from Local Agenda 21. It is essential to understand that bioregional mapping does not provide the "answer" but a framework for the answer, which comes from the visioning process. The framework that bioregional mapping provides is a more sensitive way of handling the environment and its integration with social planning. This is, again, a goal that is set out in Agenda 21. The consideration of upstream and downstream effects of planning, both in the literal hydrological sense and a metaphorical sense, are part of the mapping process through the integration of spatial factors, such as watersheds, and temporally fluid factors such as social data. Part of the framework that bioregions help to establish is the basis for collaboration between neighbouring political units (e.g. regional councils) through the establishment of commonalities. In fairness, though, there is the limitation of the willingness of such groups to co-operate. It is diplomacy and not bioregions that must overcome any institutional partisanship.

Bioregionalism focuses the ecosophies onto real communities, in real locations, facing real ecological problems and this is the unique and important contribution which bioregionalism makes to ecophilosophy. The unit of management, or the object of focus, is the bioregion. One may also consider bioregionalism as a 'coat-rack philosophy', on which a number of scientific and community-based studies can be hung, in organised combination to create a place-based, restorative, future vision. Bioregionalism, as an ecosophy, is better regarded as a lens through which the future should be viewed. As a visioning lens, bioregionalism brings many ecophilosophies and ecosophies into focus and shows their relationships (Figure 7.1).

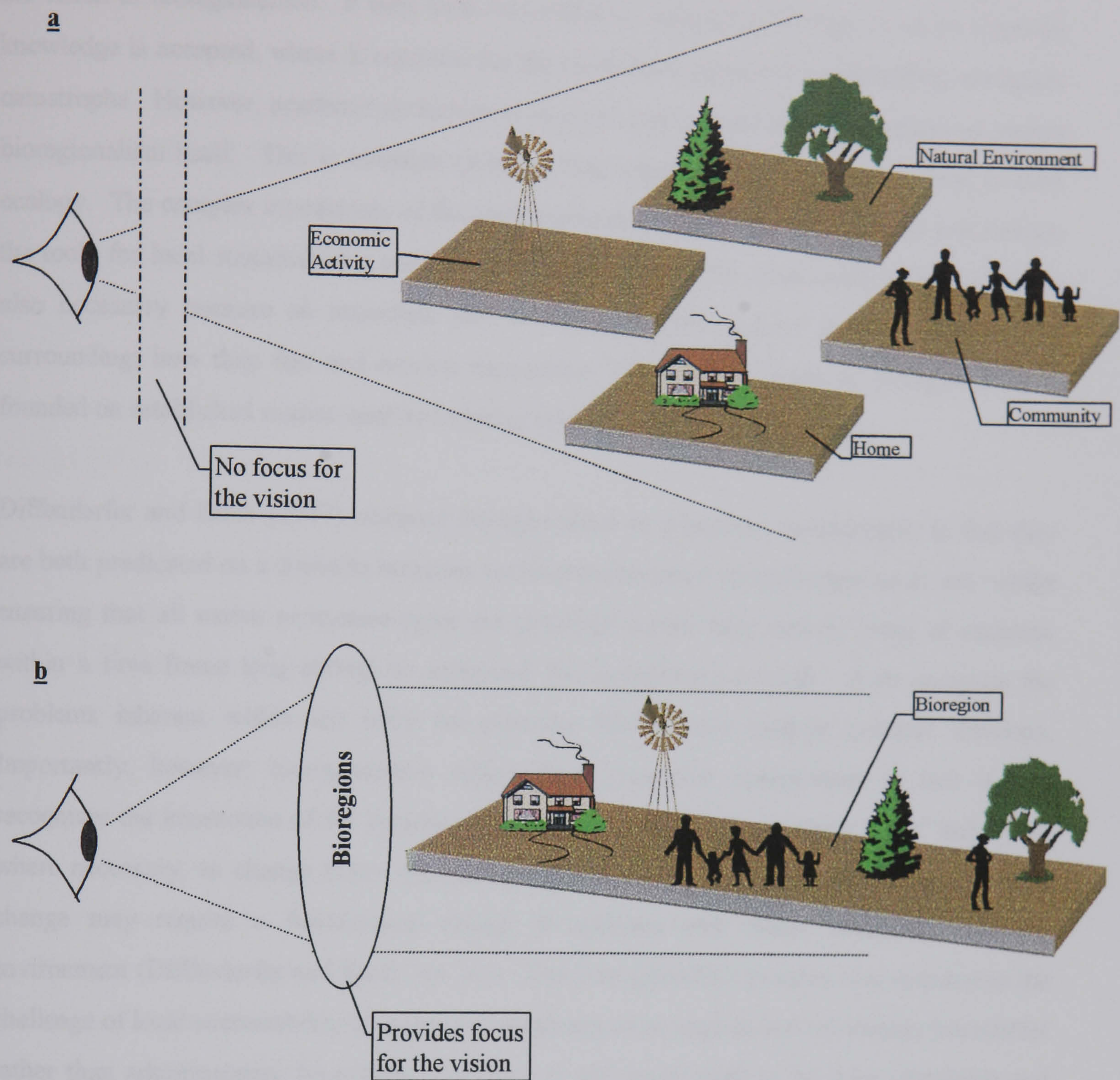

Figure 7.1: Graphical representation of how bioregions provide a focus for place-based environmental visioning

One of the biggest inconsistencies of bioregionalism is that bioregions are demonstrable entities which are not created out of human dictates (see Sale, 1989) and, at the same time, the final boundaries of a bioregion are . . .

> *" . . . best described by people who have lived in it, through human recognition of the realities of living-in-place."*
>
> (Berg and Dasmann, 1977)

This ambivalence to academic and scientific study is a problem that, fortunately, does not limit the vision of bioregionalism. It does limit its credibility, because of the way in which scientific knowledge is accepted, where it supports the bioregionalist argument by highlighting ecological catastrophe. However, academic endeavour is shunned and scorned when it questions or probes bioregionalism itself. This is evidence of how young bioregionalism is in comparison to even ecology. The complex interactions of the components that give a region its identity, and provide the tools for local sustainability, need practical study. However, some study of philosophy is also necessary because an important part of bioregionalism is how people relate to their surrounding; how they feel and express themselves. The scientific basis of bioregionalism is founded on established studies such as biogeography, ecology and cartography.

Diffenderfer and Birch (1997) compare bioregionalism to ecosystem management, in that they are both predicated on a desire to maintain viable populations of all native species *in situ*, whilst ensuring that all native ecosystem types are protected across their natural range of variation within a time frame long enough to safeguard the evolutionary process. Both recognise the problems inherent within the need for planning that crosses modern political divisions. Importantly, however, bioregionalism differs from ecosystem management in that it also recognises the interaction of the systems of production with their supporting "base" and seeks, where necessary, to change those systems to try and promote a sustainable future. Such a change may require a fundamental change in attitudes and values associated with the environment (Diffenderfer and Birch, *op. cit.*). The bioregionalist's position is a response to the challenge of local sustainability by putting an emphasis on ecological and community boundaries rather than administrative boundaries, but there is still much work to be done (Agyeman and Evans, 1996). Bioregionalism is, in essence, the transition to a proactive, holistic approach to environmental problems from the *ad hoc* and largely reactive response to date.

Bioregionalism offers geographers a possible response to the changes contemporary scientific culture is undergoing (McTaggart, 1993). From the discussion in this thesis it is suggested that the strongest contribution that bioregionalism can offer planners and geographers is the construct of the bioregion where this is used in conjunction with a participative, future state visioning process, by drawing together human, bio- and regional geographies. Furthermore, it would seem that technology has progressed faster than social understanding since Kropotkin's or Geddes' time. For this reason a more biocentric and environmentally conscious society needs a more holistic and visionary process. Therefore, in the context of Local Agenda 21, the approach of integrating the bioregional mapping approach with environmental future state visioning is not only valid but highly relevant.

7.4 'BIOREGIONS' OR 'REGIONS OF SUSTAINABILITY'?

> *"What's in a name? That which we call a rose by any other name would smell as sweet;"*
>
> Romeo and Juliet, II. ii. 45

The problem with the name 'bioregions' is threefold. Firstly, it has a strong association with bioregionalism, the ecosophy, which has been rejected as not only unoriginal but also unnecessary to the validity of the bioregions construct. Secondly, the term 'bioregion' is not unambiguous, either in its intuitive sense or in the ways in which it has been used in the literature (see Section 2.3). Thirdly, if it is accepted that bioregions are a construct (see Section 7.2) for the purposes of management (see Section 7.5), then a term that sums up both the purpose and the way in which the regions are derived (see Figure 4.1) would be more apposite.

'Sustainability' was introduced in Chapter 1 to enable the term to be defined in its modern context, which encompasses the natural environment, the social and cultural environments, including their economic dimension and the physical environment. If the modern meaning of the term 'sustainability', as expounded in Chapter 1 (Holdgate, 1997), is used then it is suggested that the term 'Regions for Sustainability' is better than 'Bioregions' because it sums up the holistic nature of the definitions of bioregions (see Chapter 2 and Figure 4.1). The question of sustainability is significant particularly at the policy level. Likewise, bioregions, or Regions for Sustainability, which would appear to be too large for planning to be directly actionable, are concluded to provide their most significant contribution at the strategic level, or level of policy making.

At the level where direct action takes place, *i.e.* the level at which community involvement in a project can operate, the notion of 'bioplaces' comes to the fore. Bioplaces were first introduced in Chapter 6 where it appeared that bioregions were made up of a number of smaller, possibly community-scale, regions. This would be a more appropriate level for action, informed by policy at the bioregional level.

The use of the word 'for' in Regions for Sustainability is used advisedly, in preference to the word 'of'. The latter might be the more obvious choice but there is an important, if subtle, semantic difference. The act of identifying the regions does not make them sustainable any more than drawing a political boundary would. The regions are units that are identified as being the most naturally cohesive and, therefore, susceptible to policy aimed at sustainability where that term is taken to include environmental, ecological and community issues in the spirit of the Rio Summit (United Nations, 1993).

7.5 REGIONS – PLACES – MY PLACE – 'BIOPLACE'

Bioregions are clearly part of a hierarchical system. Easter Island was used at the start of the thesis because its singularity provided a metaphor for Earth Island (or the Earth seen as a singularity). However, Easter Island is a part of the surface of the Earth and, therefore, it is a subsystem of the total Earth meta-system. In a similar way, Scotland was shown to consist of a number of bioregions and each bioregion consists of a number of communities. When a move is attempted from theory to praxis, where bioregional mapping is concerned, some consideration of hierarchies and scale of observation is necessary.

7.5.1 Hierarchies, Systems and Scale of Observation

The world as a whole can be considered as a very large and complex system. It contains many complex sub-systems such as climatic systems, ecological systems and human social and economic systems (Clayton and Radcliffe, 1996). Some subsystems like the human social and economic systems are open systems (which exchange energy or resources with the environment, as will be discussed in more detail with relation to bioregionalism in the next chapter, see Figure 3.1). The economy is a highly open system because it interacts with many other systems in a great many different ways. This becomes important when developing policy to regulate the interactions between such open systems.

A system formally, is a set of components that interact with each other. Changes in one component of the system will usually induce changes in another linked component and the changes at one level of the hierarchy can promote changes at other levels in the system. Any one interaction of this kind is causal and directional. This may include feedback loops which can be positive (*i.e.* excitatory or developmental) or negative (*i.e.* inhibitory or restrictive). Clayton and

Radcliffe (*op. cit.*) identify three particularly important characteristics that define systems which are emergence, hierarchical control and communication:

- Emergence - This means that at any given level of complexity, there are emergent properties that cannot be readily explained solely by reference to lower level ('emergence' was first described by von Bertalanfy - see Radcliffe and Clayton, 1996). The construct of bioregions can be considered to be an emergent property itself. It is this emergence that allows the mapping of bioregions.
- Hierarchical control - A hierarchy consists of the effective structures, defined by levels of emergent properties, within which systems are constituted by and constituent of other systems. Hierarchies are different levels of relative complexity within a system. Hierarchical control refers to the imposition of new functional relationships by each level on the detailed dynamics of neighbouring levels (particularly those in lower levels). A level in a hierarchical system may operate differently if uninfluenced by other levels. In other words there is a synergistic effect as a result of membership of a hierarchy out of which new properties emerge.
- Communication - This refers to the transfer of information in some form that effects regulation and feedback. Positive and negative feedback loops are therefore the core of the process of communication. A more recent extension of systems theory to include social communication, has required an evolution of the concept of communication. It is the communication of meaning rather than the information that is important in human systems.

Open and closed systems have an important difference. The distinction depends on thermodynamics (first applied to systems theory by von Bertalanfy - see Clayton and Radcliffe, *op. cit.* or McTaggart, 1993). Briefly, the second law of thermodynamics states that, without the input of energy all systems tend to move from organised to disorganised states. The 'run-down' of the system is called entropy. Life is an entropy-decreasing process. Living systems build, and create and reproduce order.

Closed systems have unchanging components. They will eventually arrive at a state of equilibrium, tending to move towards a higher state of entropy, particularly in view of the fact that such systems are often 'donors' of energy and materials to living systems. Open systems exchange materials, information and energy with their environment. Open systems can achieve a steady state, but this depends on a system being able to maintain continuous flows with their environment. The creation and maintenance of a state of low entropy in an open system is enabled by a continuous flow of exchanges. The ability of an open system to maintain its integrity is always at the expense of an increase in entropy in other systems. All living systems, by definition of the needs for life, are open systems. Bioregions, therefore, are also open systems. Furthermore, an understanding of systems requires that all areas designated for environmental protection activities should also be regarded as open systems in dialogue with their surroundings.

7.5.2 Predictability and 'Mindedness'

There are differing degrees of predictability from system to system (McTaggart, 1993). A highly predicable system such as designed engineering systems are known as 'hard systems'. At the other end of the scale are highly unpredictable systems, such as human communities, which are known as 'soft systems'. In between can be found systems that have elements that lie in both camps of predictability and unpredictability. A simple diagrammatic model of a 'minded' system is shown in Figure 7.2.

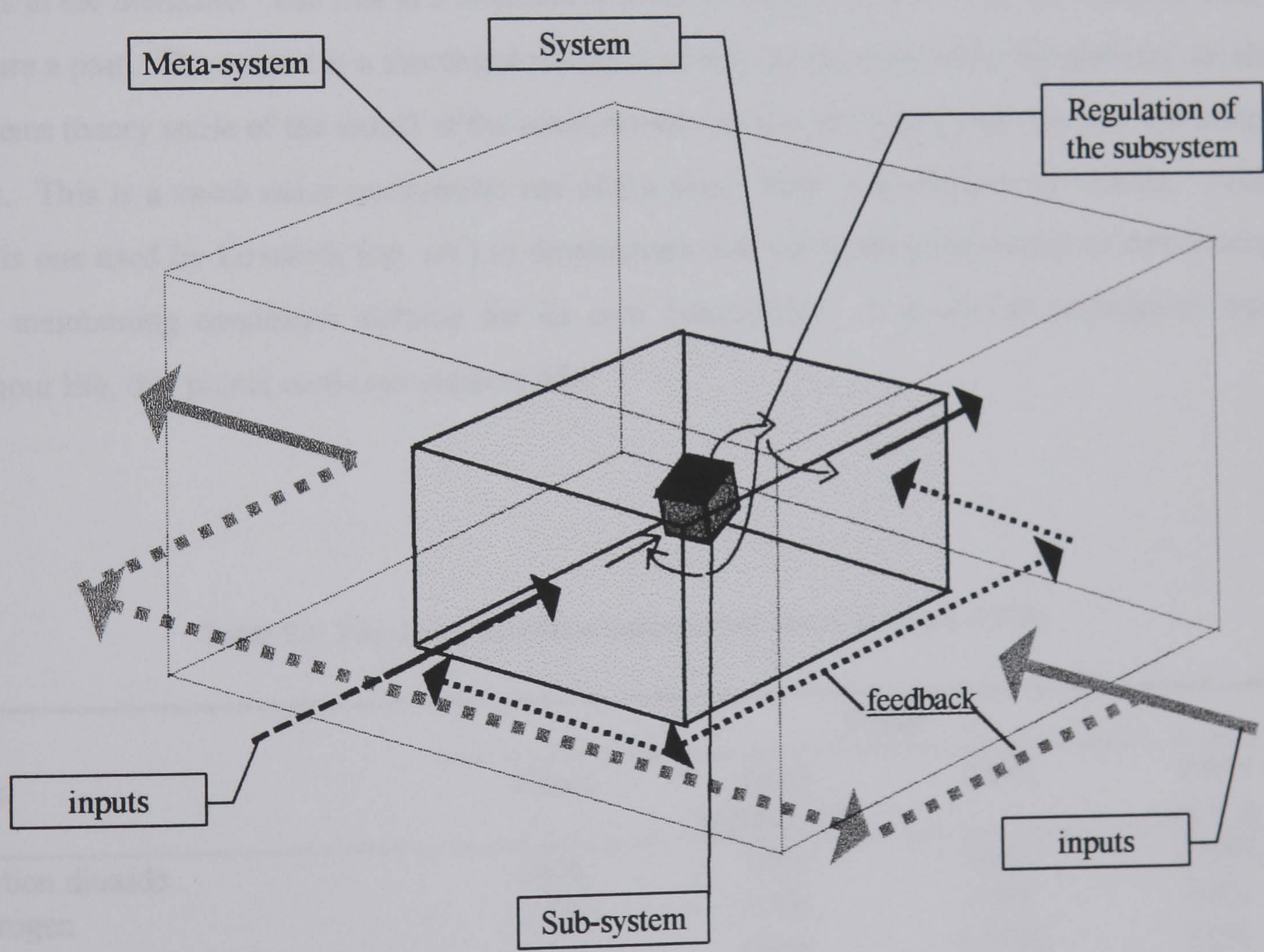

Figure 7.2: A simple model of a 'minded' or self-organising (autopoietic) system (after Baxter, 1996). The problem for planning is to be able to 'see' through the layers of the system, affect control or change in one layer while preserving the functioning of the system as a whole.

Examples of this last kind of system are environmental systems that are often referred to as 'transitional'. Many natural systems exhibit von Bertalanfy's concept of 'emergence' (see above, Clayton and Radcliffe, *op. cit.)* particularly in the co-evolutionary nature of the information content of their transitions. This is sometimes referred to as 'mindedness' (McTaggart, *op. cit.*) or 'cybernetics' (Salthe, 1985). Minded or cybernetic systems must also, almost *de facto*, be autopoietic. This concept is inherent in Lovelock's Gaia theory and, taking the latter description, important in the development of artificial intelligence (an example of a design system entering the realms of a 'transitional' system).

7.5.2.1 Global ecology: A cybernetic system?

To return to ancient Greek philosophy, the Gaia, theory is a useful parallel for bioregionalism. This was a theory that was promoted by Lovelock (1979). To sum up the preceding paragraphs, the Gaia theory is a Heraclian, holistic, hierarchical, cybernetic systems-dependent, process-centric world view (if prone to mysticism) and bioregionalism is its practical, more modern parallel (if it can be steered away from too much metaphysics). The term 'Gaia' is used in two ways in the literature. The first is a reference to Gaia as Mother Earth, a sentient being of whom we are a part. The second is a shorthand reference to sum up the cybernetic 'mindedness' (in the systems theory sense of the word) of the environment and the emergent properties that life brings to it. This is a much more mechanistic use of the word 'Gaia' henceforth in this thesis. Table 7.1 is one used by Lovelock (*op. cit.*) to demonstrate that life is the prime factor in determining and maintaining conditions suitable for its own continuance. It is almost paradoxical that, without life, this planet could not support life!

Table 7.1: Planetary atmospheric compositions, source: Lovelock (1979)

Gas	Planet			
	Venus	Earth without life	Mars	Earth as it is
Carbon dioxide	98%	98%	95%	0.03%
Nitrogen	1.9%	1.9%	2.7%	79%
Oxygen	trace	trace	0.13%	21%
Argon	0.1%	0.1%	2%	1%
Surface temperature °C	477	290 ± 50	-53	13
Total pressure (bars)	90	60	0.064	1.0

Biological processes make a significant contribution to maintaining ecological conditions. Human interaction with biological systems is no less important in this process and often is considered to be a major driving force (as seen in the debate over global warming and the effects of deforestation for instance). Biological activity is responsible, in part, to maintaining the quantity and the balanced proportions of gases that make up the earth's atmosphere (Clayton and Radcliffe, 1996).

7.5.2.2 Spheres of activity

Following on from the theme of the world as a cybernetic system it can be concluded that there is an interconnectivity between different layers, or spheres, of activity which link humans and the environment (Figure 7.3). For every action there is a reaction. Figure 7.3 is not illustrative of a super organism but the links between systems within the totality of Earthly meta-system.

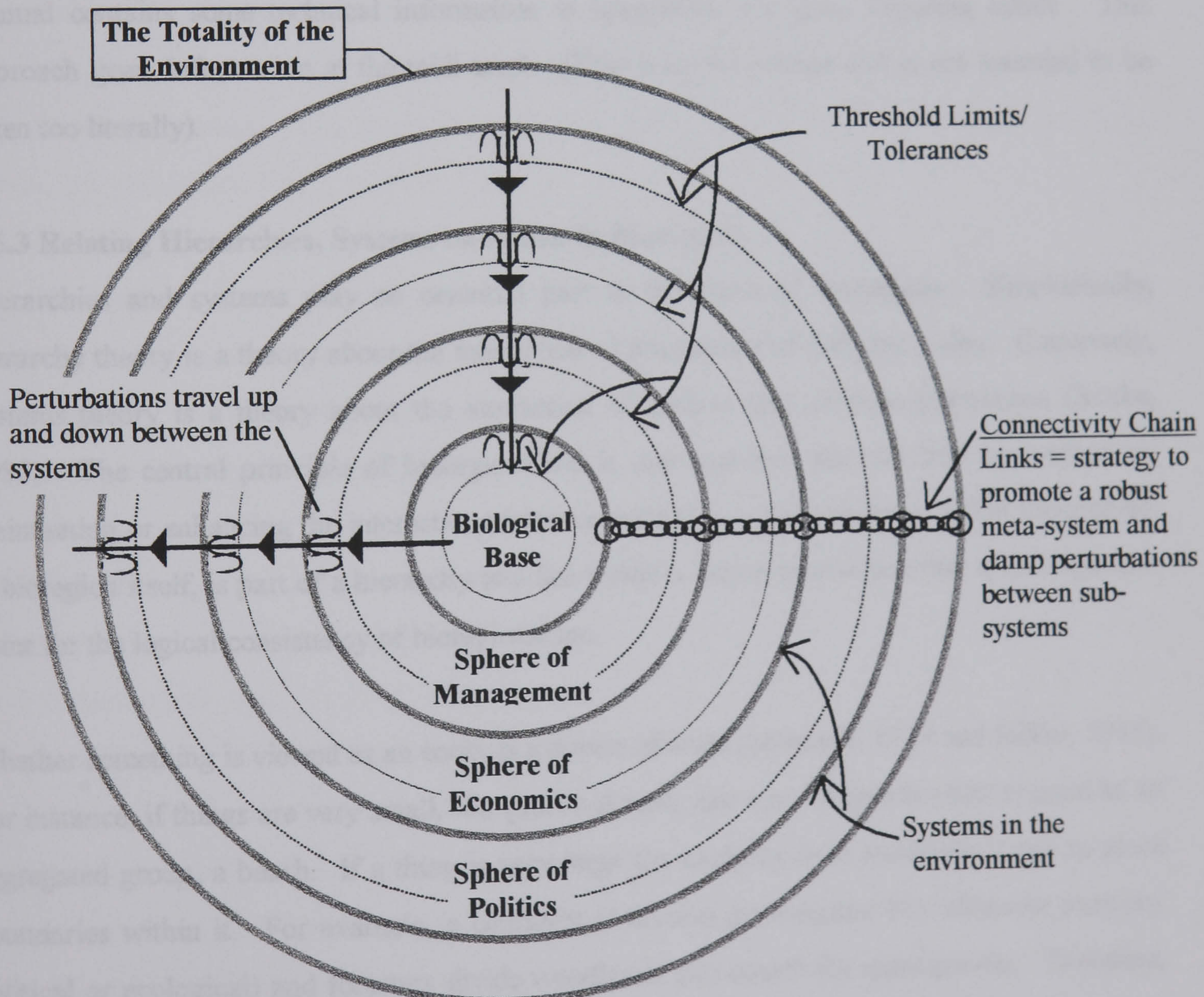

Figure 7.3: The interconnectivity of spheres of activity (Baxter, 1996).

In ecology, super-organism theories of the world have been strongly criticised. The problem is that they are not compatible with a reductionist approach that has been very successful in many areas of science, especially other branches of biology. Where bioregionalism differs from super-organism theories is that it does not propose a theory of how the world works as such but how we can live in it more effectively and less damagingly. A way to understand the differences between super-organism theories, bioregionalism and reductionist world views is to imagine an integrated television, video and hi-fi system. The super-organism theory would take the approach that this is one system and would describe how the components interact together and give sufficient analysis of the black boxes, around their interfaces, to help understand the whole picture. This is information at the macro level. The reductionist approach would analyse the inside of any of the boxes, or spheres, separately and in detail. Different researchers would look at the different boxes but there would be no attempt to link them together. This gives information at the micro level. Bioregionalism is the owner's manual and tells the buyer how to set the system up without electrocuting themselves and then get the best out of it. The owner's manual contains some technical information in appendices for more inquiring minds. This approach gives information at the midi level. (This is an illustration and is not intended to be taken too literally).

7.5.3 Relating Hierarchies, Systems and Scale to Bioregions

Hierarchies and systems play an essential part in the study of bioregions. Simplistically, hierarchy theory is a theory about the interaction of phenomena of different scales. Conversely, systems theory is a theory about the interaction of entities that produce phenomena (Salthe, 1985). The central principle of bioregionalism is that sustainability can best be reached by maintaining or enhancing the interactions between naturally evolved systems within hierarchies. A bioregion itself, is part of a hierarchy and lies within a bigger system and that is an important point for the logical consistency of bioregionalism.

Whether something is viewed as an entity is a matter of scale (Lovelock, 1979 and Salthe, 1985). For instance, if things are very small, like grains of sand, one may frequently refer to them as an aggregated group, a beach. If a thing is very large the tendency is to subdivide it and to place boundaries within it. For example, a continent is divided into regions (for whatever purpose, political or ecological) and foresters divide woodlands into stands for management. Therefore, on the human scale[2] bioregions are entities, a definition based upon their function. On the

2 Sale draws heavily on the idea of 'human scale'. He draws on the theme in his seminal bioregional work "Dwellers in the Land" (1985).

cosmic scale however, the world is an entity and bioregions are networked subsystems that provide internal feedback and control.

Most of the systems that make up a bioregion can be described and behave according to Salthe's (1985) three principle qualities of entities, whatever other qualities they may have. They can be ordered according to scale; they have apparent boundaries and they have apparent stability. Ecological stability is a relative term that is why the word "apparent" is used advisedly.

Consider the stability of a forest ecosystem on the banks of a major river where the only force for change is the river itself. Unless the river is prone to dramatic flooding, this example would appear to have robust stability. That is in terms of human observation and perception of time spans. For the riverside tree community on the other hand, this could be a very unstable environment. During their life span of a couple of hundred years the course of the river can change, destroying their habitat and leaving behind unsuitable sites such as gravel banks, lakes or marshes. Human populations, too, show gross dynamics at a similar scale with societal dynamic at a possibly, smaller scale. The main three qualities of entities are more accurately described as opposing pairs of qualities, namely bigger versus smaller, discontinuity versus continuity and change versus stability.

Individual entities depend on observation for discrimination. Observation effects the observed because it is an interaction between the observer and the subject. This can mean that the observation *is* the phenomenon in certain circumstances (Salthe, 1985). Furthermore, the philosophy of empiricism states that the only way to know is to experience, which compounds the problems for reductionism. The alternative is holism through hierarchy theory where the world would be a field, or metasystem, in which different phenomena interact. Bioregionalism fits with this process-centric view as opposed to the traditional entity-centric reductionist view. Local phenomena can translate into causal mechanisms, often interconnected and often reciprocal (Welsh, 1994). Phenomena are related at different levels of space and time from the microcosms of village ponds right up through broad landscapes and beyond. A dramatic and well-known example comes from the rainforests. The unsustainable utilisation of the primary commercial resource, timber, causes well-documented local habitat destruction (*e.g.* United Nations, 1993). This has other implications such as soil erosion and potential species extinction. The only way in which the soils can support the rainforest communities is through efficient nutrient cycling by the plant species that support the animal communities. As the thin, poor soils become exposed to the sun they quickly lose fertility and will support arable crops or grazing for only a couple of years (Harrison, 1989). The secondary commercial resource is also destroyed. At a larger scale the rainforests, sometimes referred to as 'the lungs of the world', provide a major stabilising force for the global climate but they are being destroyed at an alarming rate (Merchant, 1992). Their destruction is seen as a major contributory factor to current global climate change particularly through the loss of their capacity for carbon sequestration. Social implications include the erosion of local indigenous cultures (Chambers, 1983) and the potential losses of new medicines.

Through each scale of observation stable biological communities can be found. These natural assemblages have spatial and temporal integrity at the chosen scale (Figure 7.4), although if they are viewed at a larger scale fluctuations can be seen which lead to temporally fuzzy boundaries (Welsh, 1994).

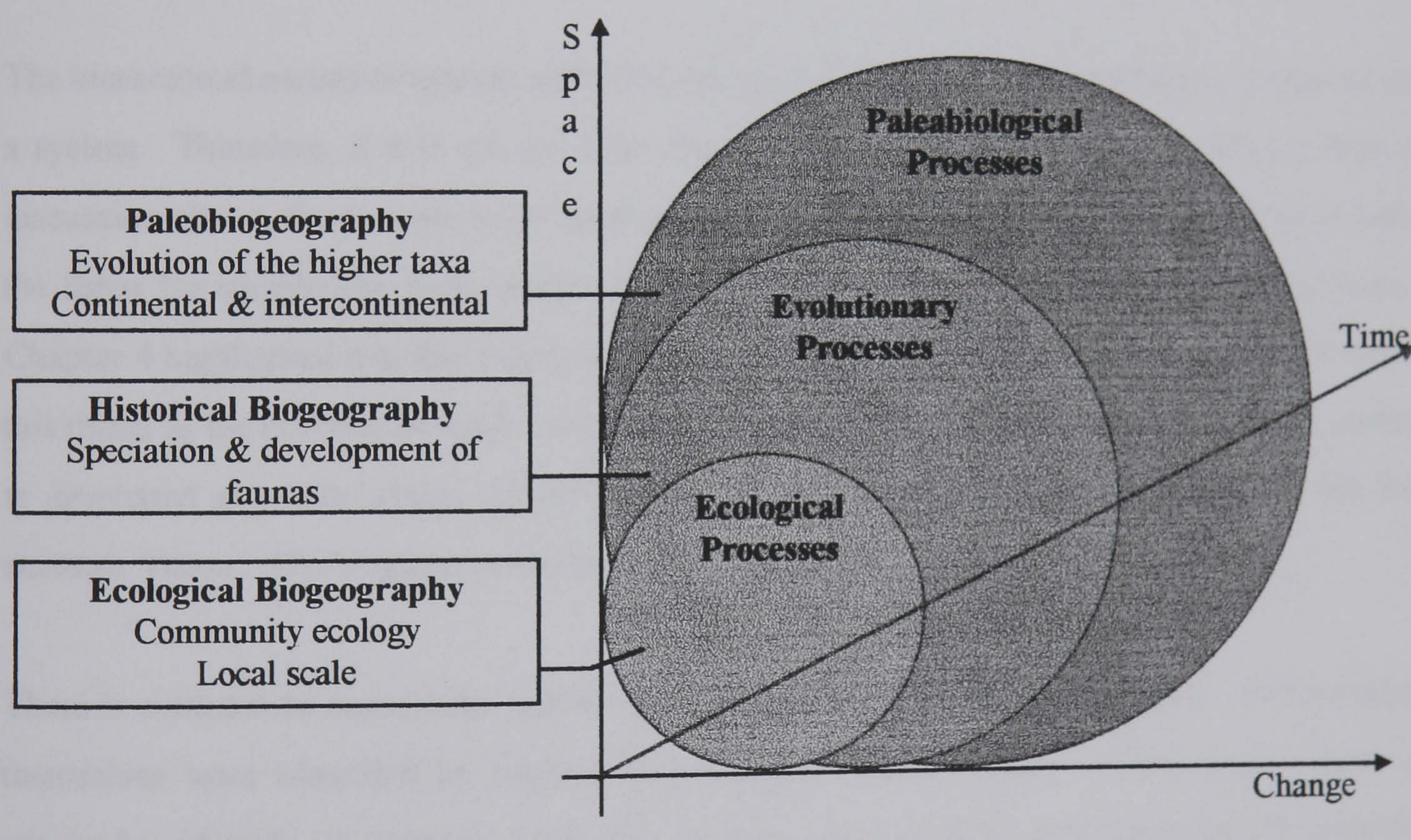

Figure 7.4: There are three main bodies of research by which biogeographical processes may be studied but all are closely interrelated along the scales of space, time and change (Salthe, 1985). Figure adapted from Welsh (1994).

7.5.4 Bioregions or Bioplaces?

The construct of the bioregion provides a suitable scale for strategic planning but the visionary process itself, and the foregoing material, highlight a difficulty that is faced by all strategic planning. This is the difficulty of scale. Action rarely takes pace at the same scale as strategy. It cannot, because strategy is overarching and action is immediate and focussed.

Environmental future state visioning and the mapping of bioregions should involve stakeholder representation. However, stakeholder groups work at a completely different scale than even the scale of a bioregion. Stakeholder groups work at the scale of the community. This is the level of Sale's 'human scale'. This level of cognisance is several levels below the 'Sphere of Politics' in Figure 7.3. Furthermore, the individuals within the stakeholder groups relate to their environment at the scale of the individual. Therefore, a community's sense of place is an agreed composite of individual perceptions. 'Our place' is identifiable by the commonalities in 'my place' and 'your place'. Agreement might be subconscious, having existence through the common inheritance of local traditions and heritage. On the other hand agreement can be fostered through the visioning process. The capacity of the visioning process is particularly valuable where communities are internally fragmented, through the fluid movement of people in modern society for instance.

The hierarchical nature of natural systems must not be forgotten. The bioregion is a part of such a system. Therefore, if it is not the focus for action as is the suggestion that follows from the discussion above, there needs to be another concept to identify that part of the bioregion that is the focus for stakeholder participation in environmental management. The mapping process in Chapter 4 highlighted that this might be the case. The concept of the 'bioplace' is put forward in this thesis as the community-scale sub-units of the bioregion. National and international strategy is developed at scales above the bioregion. The bioregion provides the focus for the local strategic vision. The bioplace provides the human scale for action.

There is evidence to support the notion of bioplaces from the mapping exercise. The bioregions themselves were identified by natural assemblages of region cores. Many region cores are required to identify a bioregion. Therefore, region cores are closer to the community scale than bioregions but share the environmental and economic layers as well as the social layers that make up bioregions. The similarity between the region cores of the mapping exercise and the hypothetical bioplaces is compelling. The practical implications of bioregions and bioplaces, as a result of their respective scales is sumarised in Table 7.2.

Table 7.2: A practical comparison of Bioregions and Bioplaces based on their respective scales

Scale of region	Bioregions	Bioplaces
Scale of foresight	visions	'visionlets'
Scale of planning	strategy	ploys and tactics
Participants	planners	stakeholders

7.6 THE IMPORTANCE OF MAPPING TO MANAGEMENT AND VISIONING

A map is a representation of the real world. However, cartography is open to a great deal of use and abuse and many authors, especially of bioregionalism, discuss the sinister potential of mapping for social homogenisation and political control (*e.g.* Aberley, 1993). On the other hand, mapping is an essential facet of bioregionalism (Berg, 1988), allowing reinterpretation of place, not only in terms of ecological carrying capacity, culture and as a guide towards sustainability, but more importantly, in terms of community specific and culturally relevant interpretation. This importance is summed up by Don Harker[3] (1999) in his discussion about the role of maps in supporting informed community decision making when he writes

> *"As a society, our highest responsibility is to build communities that will sustain current and future generations. To act responsibly, communities need to know as much as possible about their resources and revenue so they can make informed choices. Often, however, communities are the last to know."*

In the light of Chapter 3, the quote above can be seen as a subconscious demand for environmental future state visioning. Community involvement in the mapping process can be an empowering experience, engendering a true sense of ownership and living in place (Aberley, *op. cit.* and Mackie, 1996; see also Chapter 5 for a discussion of the importance of community involvement in environmental visioing). The importance of the mapping process can be summed up by the statement that 'what is not understood cannot be managed and what is not known cannot be understood'. Management in the absence of understanding is specifically countermanded by the precautionary principle. As a phrase "the precautionary principle" has many meanings. In the Rio Declaration (United Nations, 1993) the precautionary principle is defined as stating that where there are threats of serious or irreversible damage, the lack of scientific certainty shall not be used as a reason for postponing measures to prevent environmental degradation. This means that there is a duty of care and maintenance of critical life-support systems in the face of scientific uncertainty but recognising the benefits of anticipatory action and the costs (social, environmental and long-term economic) of irreversibility (O'Riordan, 1995).

A landscape that is not mapped cannot be known, whether the knowing of the landscape is at the philosophical (cognised) or cultural (perceived) level. This knowledge must work in two ways, as demonstrated by Figure 3.5. If appropriate environmental management strategies are to be formulated and action is to be taken to transform the present reality into some future state, that future must also be mapped. The work of SNH in determining the biogeographic zones of Scotland (Crofts, 1995) is demonstrative of a cognised mapping approach. Mapping at the perceived level requires participation and the outcome is likely to be dependant on the make up of stakeholder groups. Therefore, etic cultural regionalism plays its part in the definition of a bioregion and so, more importantly, do emic values of people and place. Revisiting the problems of observation raised by Salthe (*op. cit.*) there is a need for achieving consensus within the community for their perceptions of their region as a whole. For example, consider the different views of a farmer, a forester, a poet and an ecologist all contemplating the same piece of woodland. The idea of people once more considering themselves to be indigenous in a very real sense is important. It engenders of a sense of stewardship.

7.7 LINKING BIOREGIONAL MAPPING AND ENVIRONMENTAL VISIONING

Management requires people, by definition. Moreover, the experience from the management nature reserves (Thackway and Cresswell, 1995), the biosphere reserves (Batisse, 1982; see also Section 2.3.5) and the Australian bioregions (Thackway, 1997; see also Section 3.6.1) shows the importance of local community participation. For environmental management to be successful there must be a common understanding about the local natural and cultural environments.

Bioregions are not only concerned with the quantities of their constituents that were mapped to produce 'Bioregions 1' and 'Bioregions 2' in Chapter 5 but also with their qualities (McGinnis, 1999b). This has two consequences. The first is that it will always be difficult to measure 'bioregionalness', if such a quantity actually does exist. This is supported by Goodwin (1999) in his discussion of the science of qualities when he writes

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3 Don Harker was, at the time of writing, the President of The Mountain Association for Community Economic Development in Kentucky, USA.

> *"[Healthy environments, healthy bodies and healthy communities] cannot be manipulated and controlled in ways that work for mechanical systems such as cars, computers, radios and television sets. [W]atersheds, cows and crops function in terms of emergent, holistic properties, such as health, that we are only beginning to understand; and they require us to adopt a different pattern of relationships from the manipulative, exploitative style of interaction that we have learned from our science of quantities."*

The second consequence is that bioregions are ideally suited to the process of environmental future state visioning. This is not in spite of the first consequence, but because of it. Following on from Goodwin's quote, it should be clear that a mechanism of accounting for the qualities of a place that arise as a result of the emergent properties of, amongst other things, human occupation and exploitation. There is a complimentarity between the needs of environmental future state visioning and the process of bioregional mapping (Table 7.3), which makes the latter ideally suited as a tool for use by the former. Conversely, environmental future state visioning provides a purpose for bioregional mapping.

Table 7.3: A comparison of the qualities of bioregional mapping and environmental future state visioning to show their complimentarity.

Bioregional Mapping	**Environmental Future State Visioning**
Ideally conducted by stakeholder participation	Requires stakeholder participation
Values the environment through participants' choices and emphases	Provides a vehicle for the valuation of non-market commodities (e.g. nature)
Establishes limits while allowing for the inter-connectivity of the environment	Requires the establishment of limits to the scope of understanding while allowing for the inter-connectedness of the environment
Emphasis is placed on qualities more than qualities	Frees participants from the narrow focus of quantities, allowing them to explore the future through its qualities
Provides a learning experience through which different stakeholder groups can come to see each others perceptions of their environment	Provides a learning experience through which different stakeholder groups can come to see each others perceptions of their environment
Provides a means of mapping the natural and cultural environments without the need for complex cartographic skills	Requires that the local natural and cultural environments be mapped by non-expert stakeholders

Without a focus for action, or a goal other than as an end in itself, bioregional mapping is an unnecessary exercise. In isolation, bioregional mapping, at best, provides a different perspective on the local environment. Such an end might be an interesting academic exercise, particularly for teaching purposes for regional and rural resource planning. However, if the mapping process does not feed into the larger picture of strategic planning for environmental management, then its potential remains unfulfilled.

The technocentrism of modern life styles also mean an increasingly large footprint. People are city-centric in their thought which influences policy and planning (Tukel, 1993). The countryside is always put in the urban context. What building materials can it provide the city? What food stuffs can it provide? How can it be used to dispose of the city's effluent and wastes? What land for edge of town shopping and housing development can it provide (while the centre of the city decays)? The modern city is a very hungry animal. It is a nett user of resources and nett producer of waste. Rural areas are nett producers of resources, including food, and a nett sink for waste. A biocentric view of sustainability requires a paradigm shift in thinking from urban-centrism towards rural-centrism if only because rural areas, as the providers and primary sources of supply, must be nurtured. It is short sighted to pollute the source of supply.

> *"Some metropolitan areas extend over the boundaries of several political and/or administrative entities (counties and municipalities) even though they conform to a continuous urban system. In many cases this political heterogeneity hinders the implementation of comprehensive environmental management programmes."*
> Agenda 21 (United nations, 1993, p.58)

A shift of thinking such as this, and the acknowledgement of the interaction between the city (and its stakeholders) and the country (and its stakeholders) requires a participatory mapping process and a visionary exercise to overcome the limitations current thinking.

7.8 RECOMMENDATIONS FOR FUTURE RESEARCH

It is concluded that the bioregional construct can be usefully put into practice. However, from the foregoing chapters it is concluded that there is much work remaining to be done to expand knowledge about bioregions. The potential areas of future research can be summarised in the following list:

1. with respect to the specific study present, a reappraisal of the Scottish bioregions with input from their respective local communities;

2. greater investigation of the concept of 'Bioplaces' and how these combine to form bioregions;
3. community and cultural study to understand the differences between and within bioregions;
4. further development of Environmental FSV to deliver a proven and practical management tool;
5. appraisal of the bioregional mapping process as a tool within a rapid assessment technique of the current environmental state and community needs of, in particular, large estates with varied land uses.

7.9 CONCLUDING REMARKS

Human societies cannot consume more resources than nature produces and they cannot produce more waste than nature can absorb in the long run. Carrying capacity varies from place to place and there is no one value for allowable level of consumption of resources '*per capita* per unit area'. There must be a regional basis for determining sustainable consumption (MacLaren *et al.*, 1997).

The need for a regionalistic approach and recognition of local distinction has become part of political thinking as evidenced by United Nations Agenda 21 in 1992[4] (United Nations, 1993). Key issues include the protection of the physical and ecological environment, promoting local economic stability and enhancement of community involvement and inclusiveness.

Bioregionalism, which tries to address these problems, has been slowly gathering momentum as a movement and no more so than in America, with around 200 bioregional organisations (Alexander and Talbot, 1996). A problem when reviewing the literature has been a certain level of mysticism, a pitfall into which even respected figures in the field sometimes fall. The danger for bioregionalism is a loss of credibility if the somewhat unrealistic zeal of visionaries, propounding utopian ideals, is not tempered with a degree of pragmatism.

We do not live in anything that remotely resembles a society based on the tenets of bioregionalism. This fact alone makes bioregionalism a vision. Some would say that it is a pastoral utopian vision. To be steered by utopia is not necessarily a bad thing as long as the end is not seen as justification of the methods that are used to attain it. We have had many decades that testify to the dangers of that particular trap in the form of the miscarriage of the Socialist and Communist utopian visions. To believe that any utopian vision is attainable is to be mislead, given the innate imperfections of humanity.

Effective holistic environmental management requires to be proactive not reactive, inclusive of communities not exclusive, and restorative not just preservative. The achievement of these objectives, with the full of inclusion of communities needs powerful tools, and environmental future state visioning coupled with the focus of bioregions provides these.

7.10 SUMMARY OF THE CONCLUSIONS

Conclusions specific to mapping of bioregions were given in Section 6.7 at the end of the previous chapter. The following list summarises the broader conclusions of this thesis which are additional to the list in Section 6.7:

1. Environmental problems are too complex and too dependent on community participation to rely on a top-down, imposed, non-holistic approach to environmental management. To be holistic the knowledge base on which the management decisions are made must also be holistic, drawing on the communities that are so vital to the success of conservation and restoration programmes. Incremental management is unlikely to be successful in finding long-term solutions to environmental problems because it lags behind the progression of the problem and fails to account for the big picture. Therefore satisfactory long-term management and change can best be brought about through a process of environmental future state visioning.
2. The notion of bioregions is a construct for sustainable, restorative, environmental management that seeks to re-establish the bond between people and their environment through greater understanding and participation. It is based on demonstrable, naturally occurring assemblages of floral, faunal and human communities in co-existence with their physical, ecological, cultural and economic environments.

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4 Although, the exploitation of environmental and ecological thinking for political motives has the danger of being nihilistic rather than a guiding hand allowing a more harmonised human presence in the natural world (Lovelock, 1979) there scope for optimism (O'Riordan, 1994).

3. Bioregionalism is an ecosophy which is a branch of extremely ecocentric environmentalism and, as such, bioregionalism offers no new guidelines or management strategies that are not better expressed through the concepts of the Deep Ecological movement.
4. Bioregions give a more holistic view of regional land-use and local economic development valuing local environmental goods and services *in situ* in association with the communities they support. National, generic research provides an essential baseline from which bioregional research can build to provide more detailed information that is locally relevant.
5. The true strength of bioregionalism is the bioregions construct, without which bioregionalism is nothing. Therefore, bioregions, being demonstrable entities in their own right, are not dependent on ascribed meanings or personal proclivities of bioregionalists whose lack of agreement risks the credibility of the bioregional construct.
6. To distinguish the meaning from other uses of the word (*e.g.* as a concatenation of the phrase biogeographic regions) the term 'Regions for Sustainability' is proposed.
7. The process of mapping bioregions (or 'Regions for Sustainability') is important for environmental FSV for two reasons. Firstly, the mapping provides a forum for community participation and the expression of their needs and perceptions of themselves and their environment. Secondly, the mapping exercise establishes a shared knowledge base that marries specialist, or quantitative, scientific knowledge with local or qualitative, intuitive cultural knowledge; from this shared knowledge base a shared vision of the future can be created and a shared plan of action be established.
8. The scope of bioregional mapping at the local community level cannot be expected to credibly describe an entire bioregion. At this scale, the mapping process will describe a community's "our place" which equates to a bioplace, which is a sub-unit of a bioregion. Although there should be an overarching vision for the bioregion as a whole, action takes place at the human scale, or community level. The vision must therefore be tempered by local amendments and additions to the parent vision. These are referred to as 'visionlets'.
9. Environmental future state visioning is an important tool for effective environmental management. Bioregional mapping is an important aid for environmental future state visioning. For example, the environmental future state visioning coupled with bioregional mapping could be used to assist in the difficult task of valuing the environment, heritage and amenity in non-monetary terms through the identification of the meaning and importance that the stakeholder groups within the community place on the environment.
10. To move from bioregions (as a demonstrable construct) to 'Regions for Sustainability', (as a management tool) development of both environmental FSV and the mapping process is necessary, requiring an expansion of the work of this thesis.

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GLOSSARY & APPENDIX

GLOSSARY

The definitions given here are the definitions of the various words as they are used in this thesis. Where possible, the word has been used in the standard context with the meaning normally associated with it in a particular discipline. This does not mean that the word, as used in a specialism has the same meaning as in popular usage. The expansion of important abbreviations is also given in this Section.

ARC/INFO, a GIS produced by ESRI and used in this thesis for mapping and analysis

autopoiesis, is the characteristic of self-organisation within a system through positive and negative feed-back loops. This is sometimes known as 'mindedness'.

beliefs, what a person or group holds to be true (compare to 'philosophy' and 'principles').

benign, gracious, gentle; fortunate, salutary; (of diseases) mild, not malignant [L *benignus* prob. = *benigenus* (*bene* well + *-genus* born)]; Concise Oxford Dictionary (fourth edition). In this document benign means an entity or phenomenon which has a nett balance, zero or near-zero impact on the environment. Using best current knowledge and practice the entity or phenomenon is not harmful, although it is not necessarily actually beneficial.

biocentrism, see '**ecocentrism**'

biophilic, see '**ecocentrism**'

Biosphere Reserve, a system of nature reserve design and planning in which core areas are surrounded by buffer zones in which traditional practices of land use are maintained so as to integrate better the reserve into the landscape whilst providing greater protection and reducing edge effects. Integral to the concept of the biosphere reserve is the notion of research and education as well as preservation of species and habitats.

carrying capacity, population densities are regulated by intraspecific competition to a point where birth rate equals death rate. Denoted by 'K', the carrying capacity represents the size of a population which can just be maintained by the environment's resources without any tendency to change (Begon *et al*, 1986, pp. 209-210).

Chi-squared, a statistical test of association

climactic region, is used in this thesis to define a region on the basis of the level and type of precipitation, temperatures and wind (Sale, 1985).

cybernetic system, a self-regulating system, however simple, some of whose constituent parts co-vary through time, assuming a measurable length of existence. A cybernetic-system is one whose output is governed recursively by its subsystems where those sub-systems are connected by networks of feedback loops to make them function as an integrated and in independent whole (Salthe, 1985). Plants and animals are examples of complex cybernetic systems and the Gaia theory (Lovelock, 1979) views the world as a global cybernetic system.

development, in the context of the sustainability of the environment, is a process of human intervention which results in the production of and increasing amount of useful goods and services – including biological products and environmental services (WCED, 1987). Development is undertaken to increase the capacity of the environment to support human communities while giving them a higher quality of life (Holdgate, 1997). See also 'susatinability' and 'sustainable development'.

ecocentrism, is a philosophy in which the environment and its maintenance are at the centre. Nature must be nurtured to ensure mankind's survival. Adverse environmental side effects of economic development can pose long-term threats to its own continuance (O'Riordan, 1981).

economic region, within the bioregional paradigm, the local economy of a region is based historically on its agriculture and the local availability of minerals (bearing in mind the influences of trade, particularly in coastal zones). Derived from the philosophies of Kropotkin and Geddes (Breitbart, 1981 and Robson, 1981 respectively) the economic region is the basis of a regional philosophy.

ecophilic, see '**ecocentrism**'

ecoregion, from Sale's taxonomy of bioregions, an ecoregion is the broadest distribution of vegetation and soil types (Nichols, 1991). In this thesis the term is used to mean a region with a distinct composition of floral and faunal communities.

entity, the theoretical representation of a thing as an individual where the thing is a discrete bounded portion of the world. An entity is something which is identifiable from its surroundings and has given proportions (Salthe, 1985).

environmental determinism, is a theory which was popularised by Ellen Churchill Semple in 1911 and was based on her selective interpretation of Ratzel's implicit nature-culture relationship (Frenkel, 1994). The theory assumes that the environment not only affects but also determines all aspects of societal development. Proponents of environmental determinism used the theory to try and demonstrate the superiority of inhabitants in mid latitudes over inhabitants of the tropics. Although now discredited on scientific and moral grounds, environmental determinism became, for a time, part of mainstream American geography for a time. Bioregionalism is accused by some of being deterministic (e.g. Alexander, 1990). This is not a stance adopted in this thesis. It is argued in Chapter 3 that the environment plays a part in influencing certain aspects of culture and may even force certain constraints on behaviour but is does not, of itself, determine the development of societies and certainly cannot be used as an indicator of a society's "worth".

ESRI, Environmental Science Research Institute are based in Redlands, USA, and are a company that produce GIS equipment, software and related services

freeware, is free software that may be used and distributed usually without being subject to any licence agreement. Such software is frequently freely available from the Internet. Contrast this with 'shareware' which is normally available free of charge for a limited period of time after which the software either ceases to function or a registration fee is then required for continued use.

FSV, future state visioning – a technique pioneered by the commercial sector and proposed in this thesis as a tool for environmental management; hence 'environmental future state visioning'

Gaia (Gaea), a theory which states that the non-biological condition of the surface of the Earth, including the atmosphere and oceans, has been and is actively made fit and comfortable by the presence of life itself (Lovelock, 1979). Lovelock is supported in his theory by evidence that forms of blue-green algae (cyanophytes) transformed the Earth's atmosphere by the release of oxygen as a by-product of their photosynthetic activity (Attenborough, 1980). Gaia was the earth mother of Greek mythology and so the name was considered appropriate by Lovelock for his theory.

georegion, from Sale's (1985) taxonomy of bioregions, a georegion is defined by land topology and physiographic features such as water catchments (Nichols, 1991). The term is used in this thesis to mean a regional classification depending on the geology and soil substrate.

GIS, Geographical Information System(s) are computer-based tools designed to capture, store, manipulate, analyse and display spatial data.

GNP, Gross National Product is an economic indicator

GNH, Gross National Happiness is an alternative indicator of development suggested by the King of Bhutan, a financially poor country (de Jonge, 1999)

Hegelian philosophy, is a system of thought which relates to the German philosopher G. W. F. Hegels and his concept of the dialectic in logic that leads to a resolution of the contradiction between a thesis and its antithesis at a higher level of truth, or 'synthesis'.

integrated land use, is defined by Agenda 21 (United Nations, 1993) as having the objective of facilitating the allocation of land to uses that provide the greatest sustainable benefits and promote the transition to a sustainable and integrated management of land resources.

IPCC, Inter-government Panel on Climate Change

Kappa, a statistical test of agreement developed by Jacob Cohen in the 1960s

LDC, less developed country

mindedness, see 'autopoiesis'

MDC, more developed country

MLURI, Macaulay Land Use Research Institute

morphoregion, from Sale's (1985) taxonomy of bioregions, a morphoregion is identified not only by the collection of life-forms which are peculiar to it but also to the lifestyles of the people within the region (Nichols, 1991). For the purposes of this thesis the term morphoregion has been dived into three new regions; toporegion, economic region and socioregion.

OST, Office of Science and Technology

phenomenon, an immediate object of perception, a thing as it is observed (Salthe, 1985). Phenomena are related at different levels of space and time (Salthe, 1985) from the microcosm of a village pond up through broad landscapes and beyond

philosophy, the composite of beliefs a person or group want to live by (compare to 'beliefs' and 'principles')

principles, are the guidelines by which philosophy is translated into action (compare to 'philosophy' and 'beliefs')

RGU, The Robert Gordon University

SNH, Scottish Natural Heritage

SO, Scottish Office (now known as the Scottish Executive)

socioregion, is the cultural distinction of a region. Founded on the thinking of Geddes, Royce and Reclus (Robson, 1981 Entrikin, 1981 and Dunbar, 1981 respectively) the bioregion is nothing without its communities. The behaviour of communities is guided by their culture and social heritage which is influenced by their understanding and empathy with their surroundings (Sale, 1984).

standards, as indicators of environmental performance are benchmarks either of what is tolerable or what must be achieved in order to make development sustainable. They can be measures of chemical and physical changes, mandates of land use practices and goals for the maintenance or enhancement of biodiversity (Holdgate, 1997). See also 'sustainable development'.

sustainable development, was defined by the World Commission on Environment and Development (WCED, 1987) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". See also 'development' and 'sustainability'.

sustainability, means that developmental processes must safeguard the functional and structural integrity, productivity and resilience of environmental systems. Environmental systems must be safeguarded in such a way as to be certain that they can continue to meet human needs indefinitely in a world that is certain to experience change (Holdgate, 1997). 'Sustainability' should also include the continuance of the environmental systems to meet their ecological community's needs and not just human needs. See also 'development'.

technocentricism, is a philosophy in which economic development is at its heart. Efficiency is the best guide of economic progress and there is a preference for advantages in the foreseeable future. Inherent in technocentricsim is a desire to transform nature to be more certain of its provision of those advantages (O'Riordan, 1981).

technophilic, see **'technocentrism'**

telnet, is software that is used to login to a computer at a remote site. It was used in this case to allow the author to access the MLURI mainframe and run ARC/INFO from outwith MLURI premises

thiessen polygons, are areas defined by a set of points that are used to form the centroid of each polygon. The boundaries of the polygons are constructed such that all points within the boundary are closer to the centroid of that polygons than the centroid of any adjacent polygon.

toporegion, is a term used in this thesis to mean the clear physiographic features such as water catchments, mountain ranges and coast lines which pose potential physical barriers and give the region geographical form.

UN, United Nations

vernacular, of one's native country, native, indigenous, not of foreign origin or of learned formation; hence 'vernacular buildings', which follow the local styles, forms and materiality.

APPENDICES 1 & 2

(Statistical results and computer methods listings)

APPENDIX 1

RESULTS OF KAPPA STATISTICAL TESTS

The following list gives the results of all the Cohen's Kappa tests that were performed. The values of all the parameters are shown in each case. The results are arranged in columns where each column groups the results of comparisons according to the first named data set. The following symbols are used:

Po = Observed proportion of agreement

SE = Generalised standard error of the mean

Pe = Proportion of agreement expected by chance

SEPo=Pe (Standard error of the mean assuming that Po = Pe)

Kappa = Kappa coefficient

Kmax = Maximum value of Kappa allowable by the marginals

BIOREGIONS2

Comparison of Bioregions1 regions with Agriculture

Northmost Columns

Po = 0.309	SE = 0.0023	CL =	0.048	to	0.057	
Pe = 0.271	SE (P(0.0022					
Kappa 0.052	Kmax 0.4202	Z =	23.39		Fuzz=	0.58

Northmost Centroid

Po = 0.445	SE = 0.0027	CL =	0.197	to	0.207	
Pe = 0.304	SE (P(0.0025					
Kappa 0.202	Kmax 0.5999	Z =	82.2		Fuzz=	0.4

Centroid-cols

Po = 0.31	SE = 0.0024	CL =	0.018	to	0.027	
Pe = 0.294	SE (P(0.0024					
Kappa 0.023	Kmax 0.3234	Z =	9.591		Fuzz=	0.677

Comparison of Watershed regions with Bioregions2

Northmost-cols

Po = 0.313	SE = 0.0071	CL =	0.257	to	0.284	
Pe = 0.059	SE (P(0.0036					
Kappa 0.271	Kmax 0.6333	Z =	75.4		Fuzz=	0.367

Northmost-centroid

Po = 0.294	SE = 0.007	CL =	0.231	to	0.259	
Pe = 0.065	SE (P(0.0038					
Kappa 0.245	Kmax 0.602	Z =	64.46		Fuzz=	0.398

Centroid-cols

Po = 0.313	SE = 0.0071	CL =	0.257	to	0.284	
Pe = 0.059	SE (P(0.0036					
Kappa 0.271	Kmax 0.6333	Z =	75.4		Fuzz=	0.367

Comparison of Clans regions with Bioregions2

Northmost-cols

Po = 0.251	SE = 0.0017	CL =	0.209	to	0.215	
Pe = 0.049	SE (P(0.0008					
Kappa 0.212	Kmax 0.5741	Z =	256.1		Fuzz=	0.426

BIOREGIONS1

Comparison of Bioregions1 regions with Agriculture

Northmost-cols

Po = 0.335	SE = 0.002	CL =	0.33	to	0.339	
Pe = 0.203	SE (Po 0.002					
Kappa 0.165	Kmax = 0.411	Z =	89.24		Fuzz=	0.589

Northmost-centroid

Po = 0.449	SE = 0.003	CL =	0.217	to	0.228	
Pe = 0.291	SE (Po 0.003					
Kappa 0.222	Kmax = 0.459	Z =	87.03		Fuzz=	0.541

Centroid-cols

Po = 0.289	SE = 0.003	CL =	-0.079	to	-0.069	
Pe = 0.338	SE (Po 0.003					
Kappa -0.074	Kmax = 0.661	Z =	-28.34		Fuzz=	0.339

Comparison of Bioregions1 regions with Watershed

Northmost-cols

Po = 0.264	SE = 0.002	CL =	0.216	to	0.223	
Pe = 0.057	SE (Po 9E-04					
Kappa 0.219	Kmax = 0.615	Z =	244		Fuzz=	0.385

Northmost-centroid

Po = 0.284	SE = 0.002	CL =	0.226	to	0.234	
Pe = 0.07	SE (Po 0.001					
Kappa 0.23	Kmax = 0.619	Z =	219.2		Fuzz=	0.381

Centroid-cols

Po = 0.254	SE = 0.002	CL =	0.2	to	0.207	
Pe = 0.063	SE (Po 9E-04					
Kappa 0.203	Kmax = 0.643	Z =	214.2		Fuzz=	0.357

Comparison of Bioregions1 regions with Clans

Northmost-cols

Po = 0.282	SE = 0.002	CL =	0.241	to	0.248	
Pe = 0.049	SE (Po 8E-04					
Kappa 0.244	Kmax = 0.566	Z =	293.4		Fuzz=	0.434

BIOREGIONS2

Comparison of Bioregions1 regions with Agriculture

Northmost Columns

Po =	0.309	SE =	0.0023	CL =	0.048	to	0.057
Pe =	0.271	SE (P(	0.0022				
Kappa	0.052	Kmax	0.4202	Z =	23.39	Fuzz=	0.58

Northmost Centroid

Po =	0.445	SE =	0.0027	CL =	0.197	to	0.207
Pe =	0.304	SE (P(	0.0025				
Kappa	0.202	Kmax	0.5999	Z =	82.2	Fuzz=	0.4

Centroid-cols

Po =	0.31	SE =	0.0024	CL =	0.018	to	0.027
Pe =	0.294	SE (P(	0.0024				
Kappa	0.023	Kmax	0.3234	Z =	9.591	Fuzz=	0.677

Comparison of Watershed regions with Bioregions2

Northmost-cols

Po =	0.313	SE =	0.0071	CL =	0.257	to	0.284
Pe =	0.059	SE (P(	0.0036				
Kappa	0.271	Kmax	0.6333	Z =	75.4	Fuzz=	0.367

Northmost-centroid

Po =	0.294	SE =	0.007	CL =	0.231	to	0.259
Pe =	0.065	SE (P(	0.0038				
Kappa	0.245	Kmax	0.602	Z =	64.46	Fuzz=	0.398

Centroid-cols

Po =	0.313	SE =	0.0071	CL =	0.257	to	0.284
Pe =	0.059	SE (P(	0.0036				
Kappa	0.271	Kmax	0.6333	Z =	75.4	Fuzz=	0.367

Comparison of Clans regions with Bioregions2

Northmost-cols

Po =	0.251	SE =	0.0017	CL =	0.209	to	0.215
Pe =	0.049	SE (P(	0.0008				
Kappa	0.212	Kmax	0.5741	Z =	256.1	Fuzz=	0.426

BIOREGIONS1

Comparison of Bioregions1 regions with Agriculture

Northmost-cols

Po =	0.335	SE =	0.002	CL =	0.33	to	0.339
Pe =	0.203	SE (Po	0.002				
Kappa	0.165	Kmax =	0.411	Z =	89.24	Fuzz=	0.589

Northmost-centroid

Po =	0.449	SE =	0.003	CL =	0.217	to	0.228
Pe =	0.291	SE (Po	0.003				
Kappa	0.222	Kmax =	0.459	Z =	87.03	Fuzz=	0.541

Centroid-cols

Po =	0.289	SE =	0.003	CL =	-0.079	to	-0.069
Pe =	0.338	SE (Po	0.003				
Kappa	-0.074	Kmax =	0.661	Z =	-28.34	Fuzz=	0.339

Comparison of Bioregions1 regions with Watershed

Northmost-cols

Po =	0.264	SE =	0.002	CL =	0.216	to	0.223
Pe =	0.057	SE (Po	9E-04				
Kappa	0.219	Kmax =	0.615	Z =	244	Fuzz=	0.385

Northmost-centroid

Po =	0.284	SE =	0.002	CL =	0.226	to	0.234
Pe =	0.07	SE (Po	0.001				
Kappa	0.23	Kmax =	0.619	Z =	219.2	Fuzz=	0.381

Centroid-cols

Po =	0.254	SE =	0.002	CL =	0.2	to	0.207
Pe =	0.063	SE (Po	9E-04				
Kappa	0.203	Kmax =	0.643	Z =	214.2	Fuzz=	0.357

Comparison of Bioregions1 regions with Clans

Northmost-cols

Po =	0.282	SE =	0.002	CL =	0.241	to	0.248
Pe =	0.049	SE (Po	8E-04				
Kappa	0.244	Kmax =	0.566	Z =	293.4	Fuzz=	0.434

Northmost-centroid

Po =	0.244	SE =	0.0017	CL =	0.196	to	0.202
Pe =	0.056	SE (P‹	0.0009				
Kappa	0.199	Kmax	0.5953	Z =	222.8	Fuzz=	0.405

Centroid-cols

Po =	0.208	SE =	0.0016	CL =	0.161	to	0.167
Pe =	0.053	SE (P‹	0.0009				
Kappa	0.164	Kmax	0.57	Z =	190.1	Fuzz=	0.43

Comparison of Ancient Districts regions with Bioregions2

Northmost-cols

Po =	0.338	SE =	0.0018	CL =	0.3	to	0.307
Pe =	0.051	SE (P‹	0.0008				
Kappa	0.303	Kmax	0.6024	Z =	358.7	Fuzz=	0.398

Northmost-centroid

Po =	0.18	SE =	0.0015	CL =	0.136	to	0.142
Pe =	0.048	SE (P‹	0.0008				
Kappa	0.139	Kmax	0.5573	Z =	167.8	Fuzz=	0.443

Centroid-cols

Po =	0.338	SE =	0.0018	CL =	0.3	to	0.307
Pe =	0.051	SE (P‹	0.0008				
Kappa	0.303	Kmax	0.6024	Z =	358.7	Fuzz=	0.398

Comparison of Land Use regions with Bioregions2

Northmost-cols

Po =	0.319	SE =	0.002	CL =	0.183	to	0.191
Pe =	0.163	SE (P‹	0.0016				
Kappa	0.187	Kmax	0.514	Z =	115.8	Fuzz=	0.486

Northmost-centroid

Po =	0.316	SE =	0.0021	CL =	0.145	to	0.154
Pe =	0.196	SE (P‹	0.0018				
Kappa	0.149	Kmax	0.6173	Z =	81.6	Fuzz=	0.383

Centroid-cols

Po =	0.315	SE =	0.0022	CL =	0.094	to	0.103

Northmost-centroid

Po =	0.242	SE =	0.002	95% L.	0.194	to	0.201
Pe =	0.056	SE (Po	9E-04				
Kappa	0.197	Kmax =	0.595	Z =	221.5	Fuzz=	0.405

Centroid-cols

Po =	0.291	SE =	0.002	CL =	0.246	to	0.253
Pe =	0.056	SE (Po	9E-04				
Kappa	0.249	Kmax =	0.572	Z =	280.8	Fuzz=	0.428

Comparison of Bioregions1 regions with Ancient Districts

Northmost-cols

Po =	0.316	SE =	0.002	CL =	0.274	to	0.281
Pe =	0.053	SE (Po	9E-04				
Kappa	0.277	Kmax =	0.613	Z =	319.1	Fuzz=	0.387

Northmost-centroid

Po =	0.185	SE =	0.002	95% L.	0.138	to	0.144
Pe =	0.051	SE (Po	9E-04				
Kappa	0.141	Kmax =	0.564	Z =	165.2	Fuzz=	0.436

Centroid-cols

Po =	0.274	SE =	0.002	CL =	0.233	to	0.24
Pe =	0.048	SE (Po	8E-04				
Kappa	0.237	Kmax =	0.507	Z =	286.6	Fuzz=	0.493

Comparison of Bioregions1 regions with Land Use

Northmost-cols

Po =	0.302	SE =	0.002	CL =	0.163	to	0.171
Pe =	0.162	SE (Po	0.002				
Kappa	0.167	Kmax =	0.571	Z =	104	Fuzz=	0.429

Northmost-centroid

Po =	0.282	SE =	0.002	CL =	0.11	to	0.119
Pe =	0.189	SE (Po	0.002				
Kappa	0.115	Kmax =	0.548	Z =	62.24	Fuzz=	0.452

Centroid-cols

Po =	0.324	SE =	0.002	CL =	0.172	to	0.18

Pe = 0.24	SE (P(0.0021		
Kappa 0.099	Kmax 0.7591	Z = 48.02	Fuzz= 0.241

Comparison of vernacular buildings regions with Bioregions2

Northmost-cols

Po = 0.302	SE = 0.0018	CL = 0.246 *to* 0.253	
Pe = 0.07	SE (P(0.001		
Kappa 0.25	Kmax 0.5873	Z = 248.9	Fuzz= 0.413

Northmost-centroid

Po = 0.304	SE = 0.0018	CL = 0.254 *to* 0.261	
Pe = 0.063	SE (P(0.0009		
Kappa 0.257	Kmax 0.5577	Z = 272	Fuzz= 0.442

Centroid-cols

Po = 0.257	SE = 0.0017	CL = 0.191 *to* 0.198	
Pe = 0.078	SE (P(0.0011		
Kappa 0.194	Kmax 0.6357	Z = 182.1	Fuzz= 0.364

Comparison of SNH Heritage Zones with Bioregions2

Northmost-cols

Po = 0.287	SE = 0.0018	CL = 0.24 *to* 0.247	
Pe = 0.058	SE (P(0.0009		
Kappa 0.244	Kmax 0.6512	Z = 269.4	Fuzz= 0.349

Northmost-centroid

Po = 0.281	SE = 0.0017	CL = 0.233 *to* 0.24	
Pe = 0.057	SE (P(0.0009		
Kappa 0.237	Kmax 0.6431	Z = 262.4	Fuzz= 0.357

Centroid-cols

Po = 0.274	SE = 0.0017	CL = 0.239 *to* 0.245	
Pe = 0.042	SE (P(0.0008		
Kappa 0.242	Kmax 0.5057	Z = 316.2	Fuzz= 0.494

Comparison of Climate regions with Bioregions2

Northmost-cols

Po = 0.197	SE = 0.0016	CL = 0.139 *to* 0.145	

Pe = 0.18	SE (Po 0.002		
Kappa 0.176	Kmax = 0.636	Z = 102.8	Fuzz= 0.364

Comparison of Bioregions1 regions with vernacular buildings

Northmost-cols

Po = 0.31	SE = 0.002	CL = 0.254 *to* 0.261	
Pe = 0.071	SE (Po 0.001		
Kappa 0.257	Kmax = 0.635	Z = 254.2	Fuzz= 0.365

Northmost-centroid

Po = 0.353	SE = 0.002	CL = 0.307 *to* 0.314	
Pe = 0.062	SE (Po 9E-04		
Kappa 0.31	Kmax = 0.614	Z = 330.4	Fuzz= 0.386

Centroid-cols

Po = 0.266	SE = 0.002	CL = 0.199 *to* 0.206	
Pe = 0.08	SE (Po 0.001		
Kappa 0.202	Kmax = 0.671	Z = 188.2	Fuzz= 0.329

Comparison of Bioregions1 regions with SNH Heritage Zones

Northmost-cols

Po = 0.318	SE = 0.002	CL = 0.272 *to* 0.279	
Pe = 0.058	SE (Po 9E-04		
Kappa 0.276	Kmax = 0.668	Z = 303.4	Fuzz= 0.332

Northmost-centroid

Po = 0.318	SE = 0.002	CL = 0.272 *to* 0.279	
Pe = 0.058	SE (Po 9E-04		
Kappa 0.276	Kmax = 0.668	Z = 303.4	Fuzz= 0.332

Centroid-cols

Po = 0.318	SE = 0.002	CL = 0.271 *to* 0.279	
Pe = 0.059	SE (Po 9E-04		
Kappa 0.275	Kmax = 0.668	Z = 300.8	Fuzz= 0.332

Comparison of Bioregions1 regions with Climate

Northmost-cols

Po = 0.225	SE = 0.002	CL = 0.164 *to* 0.171	

Pe = 0.064	*SE (P(* 0.001		
Kappa 0.142	*Kmax* 0.5537	*Z* = 148.9	Fuzz= 0.446

Northmost-centroid

Po = 0.189	*SE* = 0.0015	*CL* = 0.127 *to* 0.133	
Pe = 0.067	*SE (P(* 0.001		
Kappa 0.13	*Kmax* 0.6183	*Z* = 132.3	Fuzz= 0.382

Centroid-cols

Po = 0.197	*SE* = 0.0016	*CL* = 0.139 *to* 0.145	
Pe = 0.064	*SE (P(* 0.001		
Kappa 0.142	*Kmax* 0.5571	*Z* = 148.1	Fuzz= 0.443

Comparison of City Regions regions with Bioregions2

Northmost-cols

Po = 0.316	*SE* = 0.0019	*CL* = 0.217 *to* 0.224	
Pe = 0.123	*SE (P(*0.0014		
Kappa 0.221	*Kmax* 0.6415	*Z* = 161.4	Fuzz= 0.358

Northmost-centroid

Po = 0.045	*SE* = 0.004	*CL* = -0.089 *to* -0.074	
Pe = 0.117	*SE (P(*0.0013		
Kappa-0.082	*Kmax* 0.466	*Z* = -61.15	Fuzz= 0.534

Centroid-cols

Po = 0.291	*SE* = 0.0019	*CL* = 0.192 *to* 0.2	
Pe = 0.118	*SE (P(*0.0013		
Kappa 0.196	*Kmax* 0.4645	*Z* = 146.6	Fuzz= 0.536

Comparison of Aberley's Bioregions with Bioregions2

Northmost-cols

Po = 0.279	*SE* = 0.0019	*CL* = 0.181 *to* 0.188	
Pe = 0.116	*SE (P(*0.0013		
Kappa 0.185	*Kmax* 0.453	*Z* = 139.5	Fuzz= 0.547

Northmost-centroid

Po = 0.29	*SE* = 0.0019	*CL* = 0.192 *to* 0.199	
Pe = 0.117	*SE (P(*0.0013		
Kappa 0.195	*Kmax* 0.466	*Z* = 146.6	Fuzz= 0.534

Pe = 0.068	*SE (Po* 1E-03		
Kappa 0.168	*Kmax* = 0.625	*Z* = 169.3	Fuzz= 0.375

Northmost-centroid

Po = 0.221	*SE* = 0.002	*CL* = 0.159 *to* 0.166	
Pe = 0.07	*SE (Po* 0.001		
Kappa 0.162	*Kmax* = 0.62	*Z* = 161.5	Fuzz= 0.38

Centroid-cols

Po = 0.226	*SE* = 0.002	*CL* = 0.183 *to* 0.189	
Pe = 0.049	*SE (Po* 8E-04		
Kappa 0.186	*Kmax* = 0.485	*Z* = 224.1	Fuzz= 0.515

Comparison of City Regions regions with Bioregions1

Northmost-cols

Po = 0.412	*SE* = 0.002	*CL* = 0.351 *to* 0.358	
Pe = 0.089	*SE (Po* 0.001		
Kappa 0.354	*Kmax* = 0.538	*Z* = 309.4	Fuzz= 0.462

Northmost-centroid

Po = 0.367	*SE* = 0.01	*CL* = 0.26 *to* 0.299	
Pe = 0.122	*SE (Po* 0.001		
Kappa 0.279	*Kmax* = 0.475	*Z* = 203.6	Fuzz= 0.525

Centroid-cols

Po = 0.341	*SE* = 0.002	*CL* = 0.3 *to* 0.308	
Pe = 0.053	*SE (Po* 9E-04		
Kappa 0.304	*Kmax* = 0.394	*Z* = 351	Fuzz= 0.606

Comparison of Aberley's Bioregions with Bioregions1

Northmost-cols

Po = 0.292	*SE* = 0.002	*CL* = 0.201 *to* 0.208	
Pe = 0.11	*SE (Po* 0.001		
Kappa 0.204	*Kmax* = 0.444	*Z* = 159.2	Fuzz= 0.556

Northmost-centroid

Po = 0.361	*SE* = 0.002	*CL* = 0.271 *to* 0.279	
Pe = 0.118	*SE (Po* 0.001		
Kappa 0.275	*Kmax* = 0.496	*Z* = 206.2	Fuzz= 0.504

Centroid-cols

Po =	0.291	SE =	0.0019	CL =	0.192	to	0.2
Pe =	0.118	SE (P(	0.0013				
Kappa	0.196	Kmax	0.4645	Z =	146.6	Fuzz=	0.536

Comparison of Community Regions with Bioregions2

Northmost-cols

Po =	0.411	SE =	0.0019	CL =	0.365	to	0.373
Pe =	0.066	SE (P(	0.001				
Kappa	0.369	Kmax	0.6711	Z =	379.6	Fuzz=	0.329

Northmost-centroid

Po =	0.296	SE =	0.0018	CL =	0.246	to	0.253
Pe =	0.062	SE (P(	0.0009				
Kappa	0.249	Kmax	0.6085	Z =	265.4	Fuzz=	0.391

Centroid-cols

Po =	0.372	SE =	0.0019	CL =	0.323	to	0.331
Pe =	0.066	SE (P(	0.001				
Kappa	0.327	Kmax	0.671	Z =	335.4	Fuzz=	0.329

Comparison of Bioregions1 regions with Bioregions2

Northmost-cols

Po =	0.591	SE =	0.0019	CL =	0.559	to	0.567
Pe =	0.064	SE (P(	0.001				
Kappa	0.563	Kmax	0.6905	Z =	590.7	Fuzz=	0.309

Northmost-centroid

Po =	0.591	SE =	0.0019	CL =	0.559	to	0.566
Pe =	0.064	SE (P(	0.001				
Kappa	0.563	Kmax	0.6806	Z =	587	Fuzz=	0.319

Centroid-cols

Po =	0.577	SE =	0.0019	CL =	0.544	to	0.552
Pe =	0.064	SE (P(	0.001				
Kappa	0.548	Kmax	0.6755	Z =	574.6	Fuzz=	0.325

Centroid-cols

Po =	0.341	SE =	0.002	CL =	0.245	to	0.252
Pe =	0.123	SE (Po	0.001				
Kappa	0.249	Kmax =	0.507	Z =	181.5	Fuzz=	0.493

Comparison of Community Regions with Bioregions1

Northmost-cols

Po =	0.422	SE =	0.002	CL =	0.377	to	0.385
Pe =	0.067	SE (Po	1E-03				
Kappa	0.381	Kmax =	0.697	Z =	388.9	Fuzz=	0.303

Northmost-centroid

Po =	0.423	SE =	0.002	CL =	0.378	to	0.386
Pe =	0.067	SE (Po	1E-03				
Kappa	0.382	Kmax =	0.697	Z =	390.5	Fuzz=	0.303

Centroid-cols

Po =	0.422	SE =	0.002	CL =	0.377	to	0.384
Pe =	0.067	SE (Po	1E-03				
Kappa	0.381	Kmax =	0.697	Z =	387	Fuzz=	0.303

COMMUNITY REGIONS

Comparison of Community Regions with Agriculture

Northmost-cols

Po =	0.367	SE =	0.0023	CL =	0.156	to	0.166	
Pe =	0.245	SEPo=	0.0021					
Kappa	0.161	Kmax	0.4618	Z =	77.25		Fuzz=	0.538

Northmost-centroid

Po =	0.387	SE =	0.0026	CL =	0.193	to	0.203	
Pe =	0.236	SEPo=	0.0022					
Kappa	0.198	Kmax	0.3962	Z =	88.27		Fuzz=	0.604

Centroid-cols

Po =	0.474	SE =	0.0028	CL =	0.181	to	0.192	
Pe =	0.354	SEPo=	0.0027					
Kappa	0.187	Kmax	0.4941	Z =	69.11		Fuzz=	0.506

Comparison of Community Regions with Watershed

Northmost-cols

Po =	0.364	SE =	0.0019	CL =	0.322	to	0.329	
Pe =	0.057	SEPo=	0.0009					
Kappa	0.326	Kmax	0.7398	Z =	361.1		Fuzz=	0.26

Northmost-centroid

Po =	0.422	SE =	0.002	CL =	0.38	to	0.387	
Pe =	0.063	SEPo=	0.001					
Kappa	0.384	Kmax	0.7849	Z =	387.6		Fuzz=	0.215

Centroid-cols

Po =	0.439	SE =	0.0019	CL =	0.401	to	0.408	
Pe =	0.058	SEPo=	0.0009					
Kappa	0.404	Kmax	0.6917	Z =	446.5		Fuzz=	0.308

Comparison of Community Regions with Clans

Northmost-cols

Po =	0.283	SE =	0.0017	CL =	0.236	to	0.243	
Pe =	0.057	SEPo=	0.0009					
Kappa	0.24	Kmax	0.7501	Z =	266.1		Fuzz=	0.25

ABERLEY'S BIOREGIONS

Comparison of Aberley's Bioregions with Agriculture

Northmost-cols

Po =	0.264	SE =	0.002	CL =	0.005	to	0.013	
Pe =	0.257	SEPo=	0.002					
Kappa	0.009	Kmax =	0.327	Z =	4.082		Fuzz=	0.673

Northmost-centroid

Po =	0.315	SE =	0.002	CL =	0.127	to	0.136	
Pe =	0.211	SEPo=	0.002					
Kappa	0.131	Kmax =	0.38	Z =	69.46		Fuzz=	0.62

Centroid-cols

Po =	0.279	SE =	0.002	CL =	-0.025	to	-0.016	
Pe =	0.293	SEPo=	0.002					
Kappa	-0.02	Kmax =	0.418	Z =	-8.709		Fuzz=	0.582

Comparison of Aberley's Bioregions with Watershed

Northmost-cols

Po =	0.271	SE =	0.002	CL =	0.194	to	0.201	
Pe =	0.091	SEPo=	0.001					
Kappa	0.198	Kmax =	0.424	Z =	171		Fuzz=	0.576

Northmost-centroid

Po =	0.233	SE =	0.002	CL =	0.153	to	0.16	
Pe =	0.091	SEPo=	0.001					
Kappa	0.156	Kmax =	0.351	Z =	129.6		Fuzz=	0.649

Centroid-cols

Po =	0.285	SE =	0.002	CL =	0.209	to	0.216	
Pe =	0.093	SEPo=	0.001					
Kappa	0.212	Kmax =	0.431	Z =	181.9		Fuzz=	0.569

Comparison of Aberley's Bioregions with Clans

Northmost-cols

Po =	0.244	SE =	0.002	CL =	0.161	to	0.168	
Pe =	0.095	SEPo=	0.001					
Kappa	0.165	Kmax =	0.392	Z =	138.1		Fuzz=	0.608

Northmost-centroid

Po = 0.256	*SE* = 0.0017	*CL* = 0.211 *to* 0.217		
Pe = 0.053	*SEPo*=0.0009			
Kappa 0.214	*Kmax* 0.6951	*Z* = 246.8	Fuzz= 0.305	

Centroid-cols

Po = 0.292	*SE* = 0.0018	*CL* = 0.245 *to* 0.252	
Pe = 0.058	*SEPo*=0.0009		
Kappa 0.248	*Kmax* 0.7498	*Z* = 273.3	Fuzz= 0.25

Comparison of Community Regions with Ancient Districts

Northmost-cols

Po = 0.323	*SE* = 0.0018	*CL* = 0.278 *to* 0.285	
Pe = 0.058	*SEPo*=0.0009		
Kappa 0.281	*Kmax* 0.7454	*Z* = 310.7	Fuzz= 0.255

Northmost-centroid

Po = 0.292	*SE* = 0.0018	*CL* = 0.248 *to* 0.255	
Pe = 0.054	*SEPo*=0.0009		
Kappa 0.251	*Kmax* 0.6629	*Z* = 285.7	Fuzz= 0.337

Centroid-cols

Po = 0.453	*SE* = 0.0019	*CL* = 0.415 *to* 0.422	
Pe = 0.06	*SEPo*=0.0009		
Kappa 0.419	*Kmax* 0.7528	*Z* = 453.9	Fuzz= 0.247

Comparison of Community Regions with Land Use

Northmost-cols

Po = 0.218	*SE* = 0.0018	*CL* = 0.068 *to* 0.075	
Pe = 0.158	*SEPo*=0.0016		
Kappa 0.072	*Kmax* 0.5356	*Z* = 45.15	Fuzz= 0.464

Northmost-centroid

Po = 0.175	*SE* = 0.0017	*CL* = 0.017 *to* 0.024	
Pe = 0.158	*SEPo*=0.0017		
Kappa 0.021	*Kmax* 0.5331	*Z* = 12.51	Fuzz= 0.467

Centroid-cols

Po = 0.31	*SE* = 0.002	*CL* = 0.183 *to* 0.191

Northmost-centroid

Po = 0.198	*SE* = 0.002	*CL* = 0.129 *to* 0.136	
Pe = 0.075	*SEPo*= 0.001		
Kappa 0.133	*Kmax* = 0.333	*Z* = 126.1	Fuzz= 0.667

Centroid-cols

Po = 0.246	*SE* = 0.002	*CL* = 0.18 *to* 0.187	
Pe = 0.077	*SEPo*= 0.001		
Kappa 0.184	*Kmax* = 0.376	*Z* = 174.4	Fuzz= 0.624

Comparison of Aberley's Bioregions with Ancient Districts

Northmost-cols

Po = 0.216	*SE* = 0.002	*CL* = 0.136 *to* 0.142	
Pe = 0.09	*SEPo*= 0.001		
Kappa 0.139	*Kmax* = 0.394	*Z* = 121.3	Fuzz= 0.606

Northmost-centroid

Po = 0.153	*SE* = 0.001	*CL* = 0.086 *to* 0.092	
Pe = 0.07	*SEPo*= 0.001		
Kappa 0.089	*Kmax* = 0.284	*Z* = 86.71	Fuzz= 0.716

Centroid-cols

Po = 0.253	*SE* = 0.002	*CL* = 0.17 *to* 0.177	
Pe = 0.096	*SEPo*= 0.001		
Kappa 0.174	*Kmax* = 0.429	*Z* = 145.4	Fuzz= 0.571

Comparison of Aberley's Bioregions with Land Use

Northmost-cols

Po = 0.241	*SE* = 0.002	*CL* = 0.044 *to* 0.052	
Pe = 0.202	*SEPo*= 0.002		
Kappa 0.048	*Kmax* = 0.59	*Z* = 26.12	Fuzz= 0.41

Northmost-centroid

Po = 0.24	*SE* = 0.002	*CL* = 0.044 *to* 0.051	
Pe = 0.202	*SEPo*= 0.002		
Kappa 0.048	*Kmax* = 0.596	*Z* = 25.92	Fuzz= 0.404

Centroid-cols

Po = 0.259	*SE* = 0.002	*CL* = 0.077 *to* 0.084

Pe = 0.152	SEPo=0.0015			
Kappa 0.187	Kmax 0.4466	Z = 121.1		Fuzz= 0.553

Comparison of Community Regions with vernacular buildings

Northmost-cols

Po = 0.373	SE = 0.0019	CL = 0.312	to 0.32	
Pe = 0.084	SEPo=0.0011			
Kappa 0.316	Kmax 0.7737	Z = 286.1		Fuzz= 0.226

Northmost-centroid

Po = 0.405	SE = 0.002	CL = 0.355	to 0.363	
Pe = 0.072	SEPo= 0.001			
Kappa 0.359	Kmax 0.6967	Z = 347.6		Fuzz= 0.303

Centroid-cols

Po = 0.373	SE = 0.0019	CL = 0.321	to 0.328	
Pe = 0.072	SEPo= 0.001			
Kappa 0.325	Kmax 0.6838	Z = 319.7		Fuzz= 0.316

Comparison of Community Regions with SNH Heritage Zones

Northmost-cols

Po = 0.399	SE = 0.0019	CL = 0.357	to 0.364	
Pe = 0.061	SEPo=0.0009			
Kappa 0.361	Kmax 0.8005	Z = 388.1		Fuzz= 0.2

Northmost-centroid

Po = 0.381	SE = 0.0019	CL = 0.336	to 0.343	
Pe = 0.062	SEPo= 0.001			
Kappa 0.34	Kmax 0.8038	Z = 357.3		Fuzz= 0.196

Centroid-cols

Po = 0.45	SE = 0.0019	CL = 0.409	to 0.417	
Pe = 0.064	SEPo= 0.001			
Kappa 0.413	Kmax 0.8266	Z = 433.1		Fuzz= 0.173

Comparison of Community Regions with Climate

Northmost-cols

Po = 0.234	SE = 0.0017	CL = 0.179	to 0.186

Pe = 0.194	SEPo= 0.002			
Kappa 0.081	Kmax = 0.515	Z = 44.91		Fuzz= 0.485

Comparison of Aberley's Bioregions with vernacular buildings

Northmost-cols

Po = 0.256	SE = 0.002	CL = 0.16	to 0.167	
Pe = 0.111	SEPo= 0.001			
Kappa 0.164	Kmax = 0.481	Z = 126.9		Fuzz= 0.519

Northmost-centroid

Po = 0.256	SE = 0.002	CL = 0.16	to 0.167	
Pe = 0.111	SEPo= 0.001			
Kappa 0.164	Kmax = 0.481	Z = 126.8		Fuzz= 0.519

Centroid-cols

Po = 0.085	SE = 0.001	CL = -0.048	to -0.043	
Pe = 0.125	SEPo= 0.001			
Kappa-0.045	Kmax = 0.528	Z = -32.92		Fuzz= 0.472

Comparison of Aberley's Bioregions with SNH Heritage Zones

Northmost-cols

Po = 0.301	SE = 0.006	CL = 0.219	to 0.244	
Pe = 0.09	SEPo= 0.004			
Kappa 0.232	Kmax =-0.091	Z = 59.37		Fuzz= 1.091

Northmost-centroid

Po = 0.276	SE = 0.011	CL = 0.041	to 0.085	
Pe = 0.227	SEPo= 0.011			
Kappa 0.063	Kmax =-0.283	Z = 5.957		Fuzz= 1.283

Centroid-cols

Po = 0.07	SE = 9E-04	CL = 0.067	to 0.071	
Pe = 7E-04	SEPo= 1E-04			
Kappa 0.069	Kmax = 0.007	Z = 717.3		Fuzz= 0.993

Comparison of Aberley's Bioregions with Climate

Northmost-cols

Po = 0.205	SE = 0.002	CL = 0.098	to 0.104

Pe = 0.063	*SEPo*=0.0009				
Kappa 0.183	*Kmax* 0.7336	*Z* =	192.5		Fuzz= 0.266

Northmost-centroid

Po = 0.214	*SE* = 0.0016	*CL* =	0.157	*to*	0.164
Pe = 0.063	*SEPo*= 0.001				
Kappa 0.16	*Kmax* 0.7063	*Z* =	167.7		Fuzz= 0.294

Centroid-cols

Po = 0.217	*SE* = 0.0016	*CL* =	0.16	*to*	0.166
Pe = 0.064	*SEPo*= 0.001				
Kappa 0.163	*Kmax* 0.7557	*Z* =	169.9		Fuzz= 0.244

Comparison of City Regions regions with Community Regions

Northmost-cols

Po = 0.474	*SE* = 0.002	*CL* =	0.421	*to*	0.429
Pe = 0.085	*SEPo*=0.0011				
Kappa 0.425	*Kmax* 0.5931	*Z* =	382.7		Fuzz= 0.407

Northmost-centroid

Po = 0.349	*SE* = 0.0019	*CL* =	0.295	*to*	0.303
Pe = 0.072	*SEPo*= 0.001				
Kappa 0.299	*Kmax* 0.504	*Z* =	291.1		Fuzz= 0.496

Centroid-cols

Po = 0.474	*SE* = 0.002	*CL* =	0.421	*to*	0.429
Pe = 0.085	*SEPo*=0.0011				
Kappa 0.425	*Kmax* 0.5931	*Z* =	382.7		Fuzz= 0.407

Comparison of Aberley's Bioregions with Community Regions

Northmost-cols

Po = 0.361	*SE* = 0.0019	*CL* =	0.299	*to*	0.306
Pe = 0.084	*SEPo*=0.0011				
Kappa 0.302	*Kmax* 0.3832	*Z* =	272.6		Fuzz= 0.617

Northmost-centroid

Po = 0.348	*SE* = 0.0019	*CL* =	0.286	*to*	0.293
Pe = 0.083	*SEPo*=0.0011				
Kappa 0.289	*Kmax* 0.3498	*Z* =	260.6		Fuzz= 0.65

Pe = 0.115	*SEPo*= 0.001				
Kappa 0.101	*Kmax* = 0.482	*Z* =	76.53		Fuzz= 0.518

Northmost-centroid

Po = 0.186	*SE* = 0.002	*CL* =	0.086	*to*	0.092
Pe = 0.106	*SEPo*= 0.001				
Kappa 0.089	*Kmax* = 0.415	*Z* =	70.27		Fuzz= 0.585

Centroid-cols

Po = 0.211	*SE* = 0.002	*CL* =	0.105	*to*	0.111
Pe = 0.116	*SEPo*= 0.001				
Kappa 0.108	*Kmax* = 0.482	*Z* =	81.73		Fuzz= 0.518

Comparison of City Regions regions with Aberley's Bioregions

Northmost-cols

Po = 0.364	*SE* = 0.002	*CL* =	0.262	*to*	0.27
Pe = 0.134	*SEPo*= 0.001				
Kappa 0.266	*Kmax* = 0.501	*Z* =	184.8		Fuzz= 0.499

Northmost-centroid

Po = 0.363	*SE* = 0.002	*CL* =	0.26	*to*	0.268
Pe = 0.134	*SEPo*= 0.001				
Kappa 0.264	*Kmax* = 0.501	*Z* =	183.9		Fuzz= 0.499

Centroid-cols

Po = 0.341	*SE* = 0.002	*CL* =	0.266	*to*	0.273
Pe = 0.098	*SEPo*= 0.001				
Kappa 0.269	*Kmax* = 0.457	*Z* =	223.2		Fuzz= 0.543

Centroid-cols

Po = 0.419	*SE* = 0.002	*CL* = 0.358 *to* 0.366	
Pe = 0.089	*SEPo*=0.0011		
Kappa 0.362	*Kmax* 0.4046	*Z* = 317.8	Fuzz= 0.595

CITY REGIOINS

Comparison of City Regions regions with Agriculture

Northmost-cols

Po = 0.483	*SE* = 0.0027	*CL* = 0.228 *to* 0.238	
Pe = 0.326	*SEPo*=0.0025		
Kappa 0.233	*Kmax* 0.51	*Z* = 91.53	Fuzz= 0.49

Northmost-centroid

Po = 0.493	*SE* = 0.0028	*CL* = 0.265 *to* 0.276	
Pe = 0.305	*SEPo*=0.0026		
Kappa 0.271	*Kmax* 0.47	*Z* = 104.2	Fuzz= 0.53

Centroid-cols

Po = 0.505	*SE* = 0.0028	*CL* = 0.228 *to* 0.239	
Pe = 0.355	*SEPo*=0.0027		
Kappa 0.233	*Kmax* 0.4032	*Z* = 86.03	Fuzz= 0.597

Comparison of City Regions regions with Watershed

Northmost-cols

Po = 0.29	*SE* = 0.0018	*CL* = 0.226 *to* 0.233	
Pe = 0.079	*SEPo*=0.0011		
Kappa 0.229	*Kmax* 0.5448	*Z* = 214.3	Fuzz= 0.455

Northmost-centroid

Po = 0.263	*SE* = 0.0018	*CL* = 0.193 *to* 0.201	
Pe = 0.082	*SEPo*=0.0011		
Kappa 0.197	*Kmax* 0.521	*Z* = 171.7	Fuzz= 0.479

Centroid-cols

Po = 0.29	*SE* = 0.0018	*CL* = 0.226 *to* 0.233	
Pe = 0.079	*SEPo*=0.0011		
Kappa 0.229	*Kmax* 0.5448	*Z* = 214.3	Fuzz= 0.455

BASINS

Comparison of Watershed regions with Agriculture

Northmost-cols

Po = 0.314	*SE* = 0.002	*CL* = 0.082 *to* 0.091	
Pe = 0.249	*SEPo*= 0.002		
Kappa 0.086	*Kmax* = 0.464	*Z* = 40.88	Fuzz= 0.536

Northmost-centroid

Po = 0.287	*SE* = 0.002	*CL* = 0.058 *to* 0.067	
Pe = 0.239	*SEPo*= 0.002		
Kappa 0.063	*Kmax* = 0.397	*Z* = 29.27	Fuzz= 0.603

Centroid-cols

Po = 0.397	*SE* = 0.003	*CL* = 0.118 *to* 0.128	
Pe = 0.312	*SEPo*= 0.002		
Kappa 0.123	*Kmax* = 0.421	*Z* = 50	Fuzz= 0.579

Comparison of Clans regions with Watershed

Northmost-cols

Po = 0.054	*SE* = 8E-04	*CL* = 0.045 *to* 0.048	
Pe = 0.008	*SEPo*= 3E-04		
Kappa 0.047	*Kmax* = 0.442	*Z* = 141.2	Fuzz= 0.558

Northmost-centroid

Po = 0.052	*SE* = 8E-04	*CL* = 0.043 *to* 0.046	
Pe = 0.008	*SEPo*= 3E-04		
Kappa 0.044	*Kmax* = 0.435	*Z* = 134.5	Fuzz= 0.565

Centroid-cols

Po = 0.057	*SE* = 9E-04	*CL* = 0.047 *to* 0.051	
Pe = 0.008	*SEPo*= 3E-04		
Kappa 0.049	*Kmax* = 0.441	*Z* = 146.5	Fuzz= 0.559

Comparison of City Regions regions with Clans

Northmost-cols

Po = 0.239	SE = 0.0017	CL = 0.166 to 0.173	
Pe = 0.083	SEPo=0.0011		
Kappa 0.17	Kmax 0.5499	Z = 153.8	Fuzz= 0.45

Northmost-centroid

Po = 0.211	SE = 0.0016	CL = 0.123 to 0.13	
Pe = 0.096	SEPo=0.0012		
Kappa 0.126	Kmax 0.5841	Z = 105.7	Fuzz= 0.416

Centroid-cols

Po = 0.239	SE = 0.0017	CL = 0.166 to 0.173	
Pe = 0.083	SEPo=0.0011		
Kappa 0.17	Kmax 0.5499	Z = 153.8	Fuzz= 0.45

Comparison of City Regions regions with Ancient Districts

Northmost-cols

Po = 0.273	SE = 0.0018	CL = 0.208 to 0.215	
Pe = 0.077	SEPo=0.0011		
Kappa 0.212	Kmax 0.5077	Z = 200.1	Fuzz= 0.492

Northmost-centroid

Po = 0.203	SE = 0.0016	CL = 0.137 to 0.143	
Pe = 0.074	SEPo=0.0011		
Kappa 0.14	Kmax 0.499	Z = 132.4	Fuzz= 0.501

Centroid-cols

Po = 0.273	SE = 0.0018	CL = 0.208 to 0.215	
Pe = 0.077	SEPo=0.0011		
Kappa 0.212	Kmax 0.5077	Z = 200.1	Fuzz= 0.492

Comparison of City Regions regions with Land Use

Northmost-cols

Po = 0.315	SE = 0.0021	CL = 0.147 to 0.156	
Pe = 0.193	SEPo=0.0018		
Kappa 0.152	Kmax 0.5913	Z = 84.79	Fuzz= 0.409

Comparison of Land Use regions with Watershed

Northmost-cols

Po = 0.252	SE = 0.002	CL = 0.105 to 0.113	
Pe = 0.16	SEPo= 0.002		
Kappa 0.109	Kmax = 0.536	Z = 68.18	Fuzz= 0.464

Northmost-centroid

Po = 0.187	SE = 0.002	CL = 0.061 to 0.067	
Pe = 0.131	SEPo= 0.001		
Kappa 0.064	Kmax = 0.474	Z = 42.96	Fuzz= 0.526

Centroid-cols

Po = 0.279	SE = 0.002	CL = 0.119 to 0.127	
Pe = 0.178	SEPo= 0.002		
Kappa 0.123	Kmax = 0.614	Z = 72.56	Fuzz= 0.386

Comparison of vernacular buildings regions with Watershed

Northmost-cols

Po = 0.286	SE = 0.002	CL = 0.218 to 0.225	
Pe = 0.082	SEPo= 0.001		
Kappa 0.222	Kmax = 0.738	Z = 203.4	Fuzz= 0.262

Northmost-centroid

Po = 0.264	SE = 0.002	CL = 0.195 to 0.202	
Pe = 0.082	SEPo= 0.001		
Kappa 0.199	Kmax = 0.688	Z = 174.3	Fuzz= 0.312

Centroid-cols

Po = 0.261	SE = 0.002	CL = 0.189 to 0.196	
Pe = 0.085	SEPo= 0.001		
Kappa 0.193	Kmax = 0.745	Z = 172.4	Fuzz= 0.255

Comparison of SNH Heritage Zones with Watershed

Northmost-cols

Po = 0.295	SE = 0.002	CL = 0.252 to 0.259	
Pe = 0.052	SEPo= 9E-04		
Kappa 0.256	Kmax = 0.792	Z = 298.7	Fuzz= 0.208

Northmost-centroid

Po =	0.329	*SE* =	0.0022	*CL* =	0.167	*to*	0.175
Pe =	0.19	*SEPo*=	0.0018				
Kappa	0.171	*Kmax*	0.6164	*Z* =	93.17	Fuzz=	0.384

Centroid-cols

Po =	0.406	*SE* =	0.0024	*CL* =	0.193	*to*	0.202
Pe =	0.26	*SEPo*=	0.0022				
Kappa	0.197	*Kmax*	0.7906	*Z* =	91.1	Fuzz=	0.209

Comparison of City Regions regions with vernacular buildings

Northmost-cols

Po =	0.183	*SE* =	0.0015	*CL* =	0.101	*to*	0.107
Pe =	0.087	*SEPo*=	0.0011				
Kappa	0.104	*Kmax*	0.5526	*Z* =	92.34	Fuzz=	0.447

Northmost-centroid

Po =	0.183	*SE* =	0.0015	*CL* =	0.101	*to*	0.107
Pe =	0.087	*SEPo*=	0.0011				
Kappa	0.104	*Kmax*	0.5526	*Z* =	92.34	Fuzz=	0.447

Centroid-cols

Po =	0.17	*SE* =	0.0015	*CL* =	0.071	*to*	0.077
Pe =	0.104	*SEPo*=	0.0012				
Kappa	0.074	*Kmax*	0.6157	*Z* =	59.16	Fuzz=	0.384

Comparison of City Regions regions with SNH Heritage Zones

Northmost-cols

Po =	0.338	*SE* =	0.0019	*CL* =	0.277	*to*	0.285
Pe =	0.08	*SEPo*=	0.0011				
Kappa	0.281	*Kmax*	0.5432	*Z* =	261.1	Fuzz=	0.457

Northmost-centroid

Po =	0.312	*SE* =	0.0018	*CL* =	0.253	*to*	0.26
Pe =	0.075	*SEPo*=	0.001				
Kappa	0.256	*Kmax*	0.5012	*Z* =	244.5	Fuzz=	0.499

Centroid-cols

Po =	0.338	*SE* =	0.0019	*CL* =	0.277	*to*	0.285

Northmost-centroid

Po =	0.269	*SE* =	0.002	*CL* =	0.228	*to*	0.235
Pe =	0.049	*SEPo*=	9E-04				
Kappa	0.231	*Kmax* =	0.704	*Z* =	266.7	Fuzz=	0.296

Centroid-cols

Po =	0.35	*SE* =	0.002	*CL* =	0.312	*to*	0.319
Pe =	0.05	*SEPo*=	8E-04				
Kappa	0.316	*Kmax* =	0.723	*Z* =	376.4	Fuzz=	0.277

Comparison of Climate regions with Watershed

Northmost-cols

Po =	0.172	*SE* =	0.001	*CL* =	0.135	*to*	0.141
Pe =	0.039	*SEPo*=	7E-04				
Kappa	0.138	*Kmax* =	0.627	*Z* =	187.7	Fuzz=	0.373

Northmost-centroid

Po =	0.151	*SE* =	0.001	*CL* =	0.12	*to*	0.125
Pe =	0.033	*SEPo*=	7E-04				
Kappa	0.122	*Kmax* =	0.531	*Z* =	180.4	Fuzz=	0.469

Centroid-cols

Po =	0.179	*SE* =	0.001	*CL* =	0.143	*to*	0.149
Pe =	0.038	*SEPo*=	7E-04				
Kappa	0.146	*Kmax* =	0.596	*Z* =	201.2	Fuzz=	0.404

Comparison of Ancient Districts regions with Watershed

Northmost-cols

Po =	0.269	*SE* =	0.002	*CL* =	0.256	*to*	0.262
Pe =	0.014	*SEPo*=	4E-04				
Kappa	0.259	*Kmax* =	0.639	*Z* =	588	Fuzz=	0.361

Northmost-centroid

Po =	0.268	*SE* =	0.002	*CL* =	0.254	*to*	0.261
Pe =	0.014	*SEPo*=	4E-04				
Kappa	0.258	*Kmax* =	0.63	*Z* =	587.4	Fuzz=	0.37

Centroid-cols

Po =	0.268	*SE* =	0.002	*CL* =	0.254	*to*	0.261

Pe =	0.08	*SEPo*=0.0011					
Kappa	0.281	*Kmax* 0.5432	*Z* =	261.1		Fuzz=	0.457

Pe =	0.014	*SEPo*= 4E-04					
Kappa	0.258	*Kmax* = 0.639	*Z* =	585.5		Fuzz=	0.361

Comparison of City Regions regions with Climate

Northmost-cols

Po =	0.172	*SE* = 0.0015	*CL* =	0.098	*to*	0.104	
Pe =	0.078	*SEPo*=0.0011					
Kappa	0.101	*Kmax* 0.536	*Z* =	95.12		Fuzz=	0.464

Northmost-centroid

Po =	0.138	*SE* = 0.0014	*CL* =	0.062	*to*	0.068	
Pe =	0.078	*SEPo*=0.0011					
Kappa	0.065	*Kmax* 0.5076	*Z* =	60.72		Fuzz=	0.492

Centroid-cols

Po =	0.172	*SE* = 0.0015	*CL* =	0.098	*to*	0.104	
Pe =	0.078	*SEPo*=0.0011					
Kappa	0.101	*Kmax* 0.536	*Z* =	95.12		Fuzz=	0.464

DISTRICTS

Comparison of Ancient Districts regions with Agriculture

Northmost-cols

Po =	0.296	*SE* = 0.0021	*CL* =	0.102	*to*	0.11	
Pe =	0.212	*SEPo*=0.0019					
Kappa	0.106	*Kmax* 0.3673	*Z* =	55.89		Fuzz=	0.633

Northmost-centroid

Po =	0.295	*SE* = 0.0023	*CL* =	0.035	*to*	0.045	
Pe =	0.266	*SEPo*=0.0023					
Kappa	0.04	*Kmax* 0.4514	*Z* =	17.69		Fuzz=	0.549

Centroid-cols

Po =	0.296	*SE* = 0.0024	*CL* =	-0.029	*to*	-0.02	
Pe =	0.312	*SEPo*=0.0025					
Kappa	-0.024	*Kmax* 0.4255	*Z* =	-9.884		Fuzz=	0.575

Comparison of vernacular buildings regions with Ancient Districts

Northmost-cols

Po =	0.291	*SE* = 0.002	*CL* =	0.237	*to*	0.244	
Pe =	0.066	*SEPo*= 1E-03					
Kappa	0.241	*Kmax* = 0.705	*Z* =	246.5		Fuzz=	0.295

Northmost-centroid

Po =	0.256	*SE* = 0.002	*CL* =	0.199	*to*	0.206	
Pe =	0.066	*SEPo*= 0.001					
Kappa	0.203	*Kmax* = 0.717	*Z* =	202.5		Fuzz=	0.283

Centroid-cols

Po =	0.338	*SE* = 0.002	*CL* =	0.287	*to*	0.295	
Pe =	0.066	*SEPo*= 1E-03					
Kappa	0.291	*Kmax* = 0.745	*Z* =	298.2		Fuzz=	0.255

Comparison of Ancient Districts regions with Clans

Northmost-cols

Po = 0.071	*SE* = 0.001	*CL* = 0.061 *to* 0.064	
Pe = 0.01	*SEPo*=0.0004		
Kappa 0.062	*Kmax* 0.5391	*Z* = 173.8	Fuzz= 0.461

Northmost-centroid

Po = 0.066	*SE* = 0.0009	*CL* = 0.055 *to* 0.059	
Pe = 0.009	*SEPo*=0.0004		
Kappa 0.057	*Kmax* 0.5306	*Z* = 160.4	Fuzz= 0.469

Centroid-cols

Po = 0.06	*SE* = 0.0009	*CL* = 0.05 *to* 0.053	
Pe = 0.009	*SEPo*=0.0003		
Kappa 0.052	*Kmax* 0.512	*Z* = 151.2	Fuzz= 0.488

Comparison of SNH Heritage Zones with Ancient Districts

Northmost-cols

Po = 0.266	*SE* = 0.002	*CL* = 0.223 *to* 0.23	
Pe = 0.051	*SEPo*=8E-04		
Kappa 0.226	*Kmax* = 0.763	*Z* = 266.5	Fuzz= 0.237

Northmost-centroid

Po = 0.176	*SE* = 0.001	*CL* = 0.13 *to* 0.136	
Pe = 0.049	*SEPo*=8E-04		
Kappa 0.133	*Kmax* = 0.734	*Z* = 158.6	Fuzz= 0.266

Centroid-cols

Po = 0.361	*SE* = 0.002	*CL* = 0.32 *to* 0.328	
Pe = 0.055	*SEPo*=9E-04		
Kappa 0.324	*Kmax* = 0.784	*Z* = 366.2	Fuzz= 0.216

Comparison of Land Use regions with Ancient Districts

Northmost-cols

Po = 0.197	*SE* = 0.0017	*CL* = 0.075 *to* 0.081	
Pe = 0.129	*SEPo*=0.0014		
Kappa 0.078	*Kmax* 0.4946	*Z* = 55.37	Fuzz= 0.505

Northmost-centroid

Po = 0.172	*SE* = 0.0017	*CL* = 0.032 *to* 0.039	
Pe = 0.142	*SEPo*=0.0015		
Kappa 0.035	*Kmax* 0.5112	*Z* = 23.15	Fuzz= 0.489

Centroid-cols

Po = 0.341	*SE* = 0.0022	*CL* = 0.173 *to* 0.181	
Pe = 0.2	*SEPo*=0.0018		
Kappa 0.177	*Kmax* 0.6569	*Z* = 97.07	Fuzz= 0.343

Comparison of Climate regions with Ancient Districts

Northmost-cols

Po = 0.133	*SE* = 0.001	*CL* = 0.104 *to* 0.109	
Pe = 0.029	*SEPo*=6E-04		
Kappa 0.106	*Kmax* = 0.533	*Z* = 167.2	Fuzz= 0.467

Northmost-centroid

Po = 0.166	*SE* = 0.001	*CL* = 0.137 *to* 0.143	
Pe = 0.03	*SEPo*=6E-04		
Kappa 0.14	*Kmax* = 0.515	*Z* = 216.1	Fuzz= 0.485

Centroid-cols

Po = 0.139	*SE* = 0.001	*CL* = 0.11 *to* 0.115	
Pe = 0.029	*SEPo*=6E-04		
Kappa 0.113	*Kmax* = 0.526	*Z* = 177.2	Fuzz= 0.474

Po = Observed proportion of agreement
Pe = Proportion of agreement expected by chance
Kappa Kappa coefficient

SE = Generalised standard error of the mean
SEPo=Standard error of the mean assuming that Po = Pe
Kmax Maximum value of Kappa allowable by the marginals

CL = Confindence Limits
Fuzz = Fuzziness (due to marginals
Z = Significance

APPENDIX 2a

METHOD LISTING FOR "mRECODER"

"Methods" in the parlance of 4th Dimension are pieces of executable code that are defined by the user. The prefix "m" has been used to denote the name of a method. The method mRecoder applies a consistent logic to the coding of categorical data within the database.

NOTES ON THE LAYOUT OF THE METHODS LISTINGS

In the three methods a standard format has been maintained. To aid understanding of the methods, the main points of the conventions are as follows:

- Text that is prefixed by the character " ` " and in italics denotes non-executable comments for in-program documentation. These are extensive because the 4th Dimension programming language is not commonly known.
- Text in bold capitals denotes commands from the 4th Dimension programming language.
- Variable names appear in plain text. Local process variables are denoted by the character "$". Variable names prefixed by "a" refer to array variables. Variable names prefixed by "vp" refer to pointer variables. Variable names prefixed by "s" refer to sets. The prefix "v" is used to help identify text as a general variable name.
- Nested loops are used extensively and the convention used for loop counter variables was to follow the sequence $i, $j, $k to identify a loop's relative position within a nest. Bracing lines are shown to link the start and end of each loop and each successive loop within a nest is incrementally indented.

```
    `Method mRecoder; (JB; 4th Dimension 6.0.6; 21/5/99). This routine recodes all cells of
    each category for every coverage (field) according to the relative northerly position of
    the centroid of that category. After recoding the command 'DISTINCT VALUES' will
    return an array in GEOGRAPHICAL order irrespective of the arbitary code assigned in
    ARC/INFO. All original codes are categorical and arbitary so this proceedure is valid
    and is helpful in reducing preprocessing for Cohen's Kappa test of agreement. There
    are two main parts to this routine. The first part requires userinput on how the recoding
    should be performed.

    `Declaration of variables
C_INTEGER($i;$j;$k;$vPass;$vCatVal)   `local loop control variables
C_INTEGER($Current_Val;$vX;$vNumber;$vNewValue;$vElem)   `temporary values
C_POINTER(vpFieldPtr)   `field pointer
ARRAY INTEGER($aDValues;0)

    `RECODE PART 1
CONFIRM("Recode the database so that values reflect the regions geographical order
accord";"most northerly point";"relative centroid locations")
If (OK=1)   `Recode the database according to relative northerly position
  For ($i;1;13)   `first field known to be in order (starting from '2', not '1', admittedly)
    $vNumber:=1   `Start coding most northerly cells from '1'
    vpFieldPtr:=Field(1;$i)   `set field
    ALL RECORDS([Sample_new])
    CREATE SET([Sample_new];"sAllThatsLeft")
      DISTINCT VALUES(vpFieldPtr->;$aDValues)   `ascertain the number of different
    values

    For ($j;1;Size of array($aDValues))   `loop for each possible value
      USE SET("sAllThatsLeft")
      FIRST RECORD([Sample_new])
      $Current_Val:=vpFieldPtr->   `find the value of the most northerly cell
       QUERY SELECTION([Sample_new];vpFieldPtr->=$Current_Val)   `find all
       representatives of this category
      CREATE SET([Sample_new];"sDiscard")
      FIRST RECORD([Sample_new])
      For ($k;1;Records in selection([Sample_new]))
        vpFieldPtr->:=$vNumber   `recode all representatives of this category (current
        selection)
        SAVE RECORD([Sample_new])
        NEXT RECORD([Sample_new])
      End for
       DIFFERENCE("sAllThatsLeft";"sDiscard";"sAllThatsLeft")   `discard the processed
       category
      $vNumber:=$vNumber+1   `increment code
    End for
  End for
      `scavange memory
  CLEAR SET("sAllThatsLeft")
  CLEAR SET("sDiscard")

Else   `Recode the database according to relative location of region centroids
  For ($i;1;13)
    vpFieldPtr:=Field(1;$i)   `set field
    ALL RECORDS([Sample_new])
    DISTINCT VALUES(vpFieldPtr->;$aDValues)   `ascertain the number of different
    values

        `The centroid is the  average of the eastings by the average of the northings. The
        centroid is not necessarily the geometrical center but is close enough to
```

```
        distinguish between candidate "closest" neighbours if contingency table columns
        need to be merged (see below).

    ARRAY INTEGER($aCentroid;Size of array($aDValues);2)    `store the centroid
    eastings and northings
    ARRAY INTEGER($aCentval;Size of array($aDValues))    `store the centroid
    eastings and northings
    For ($j;1;Size of array($aDValues))
      QUERY([Sample_new];vpFieldPtr->=$aDValues{$j})
      $aCentroid{$j}{1}:=Average([Sample_new]Northings)
      $aCentroid{$j}{2}:=$aDValues{$j}
      $aCentval{$j}{1}:=Average([Sample_new]Northings)
    End for

    SORT ARRAY($aCentval;<)    `most Northerly has the highest value
    ALL RECORDS([Sample_new])
    CREATE SET([Sample_new];"sRemainder")
    For ($j;1;Size of array($aDValues))    `loop for each possible value
      USE SET("sRemainder")    `ensure no "contamination" between recoded and
      uncoded
      $vElem:=Find in array($aCentroid;$aCentval{$j})
      $vCatVal:=$aCentroid{$vElem}{2}
      QUERY SELECTION([Sample_new];vpFieldPtr->=$vCatVal)    `find all
      representatives of this category
      FIRST RECORD([Sample_new] )
      For ($k;1;Records in selection([Sample_new]))
        vpFieldPtr->:=$j    `recode all representatives of this category (current selection)
        SAVE RECORD([Sample_new])
        NEXT RECORD([Sample_new])
      End for
      CREATE SET([Sample_new];"sDone")
      DIFFERENCE("sRemainder";"sDone";"sRemainder")
    End for
  End for
      `scavange memory
  CLEAR SET("sRemainder")
  CLEAR SET("sDone")

End if

      `-------------------------------------------------------------------
      `RECODE PART 2
      `Normalise any codes errors due to minor spectral inaccuracies in colour coding of the
      original coverages (particularly where conversions between ARC/INFO and TIFF files
      have been conducted.

For ($vPass;3;13)    `start from 3rd field - the first two fields are known to be correct
  vpFieldPtr:=Field(1;$vPass)    `set comparatee field
  ALL RECORDS([Sample_new])
  DISTINCT VALUES(vpFieldPtr->;$aDValues)
  $vX:=Size of array($aDValues)
  ARRAY INTEGER($aValAndSize;$vX;2)
  For ($i;1;$vX)    `fill a 2-dimensional array with the code and cell count for each
  category
    $aValAndSize{$i}{1}:=$aDValues{$i}
    ALL RECORDS([Sample_new])
    QUERY([Sample_new];vpFieldPtr->=$aDValues{$i})
    $aValAndSize{$i}{2}:=Records in selection([Sample_new])
  End for
```

```
`Identify coding errors and normalise to the nearest category which has fewest
members to reduce the risk of accidental bias.   Category code do not need to be
sequential so long as they remain in order (i.e. gaps are permissable).

For ($i;1;$vX)
  If ($aValAndSize{$i}{2}<75)     `use a 0.1% cut-off threshold (i.e. 75 records)
    Case of     `set new value
      : ($i=1)   `first category in array
        $vElem:=$i+1
      : ($i=$vX)     `last category in array
        $vElem:=$i-1
      : ($aValAndSize{$i-1}{2}<$aValAndSize{$i+1}{2})     `previous value has fewer
      records
        $vElem:=$i-1
      : ($aValAndSize{$i+1}{2}<$aValAndSize{$i-1}{2})     `next value has fewer
      records
        $vElem:=$i+1
      : ($aValAndSize{$i+1}{2}=$aValAndSize{$i-1}{2})     `previous and next
      categories are same size
        $vElem:=$i-1
    End case
    $vNewValue:=$aValAndSize{$vElem}{1}
    If ($vNewValue=$aValAndSize{$i}{1})   `selected category has already been
    incorporated into current one
      $vElem:=$i+1    `go the other way
      If ($vElem>Size of array($aValAndSize))     `end of array special case
        $vElem:=$vElem-3     `$vElem exceeds array size AND last two categories
        have already merged
      End if
      $vNewValue:=$aValAndSize{$vElem}{1}
    End if
    QUERY([Sample_new];vpFieldPtr->=$aValAndSize{$i}{1})     `find all members of
    current error category
    FIRST RECORD([Sample_new])
    For ($j;1;Records in selection([Sample_new]))
      vpFieldPtr->:=$vNewValue     `recode to most apropriate value
      SAVE RECORD([Sample_new])
      NEXT RECORD([Sample_new])
    End for
    $aValAndSize{$i}{1}:=$vNewValue     `update category value information
    $aValAndSize{$vElem}{2}:=$aValAndSize{$vElem}{2}+$aValAndSize{$i}{2}
      `update category size information
    $aValAndSize{$i}{2}:=$aValAndSize{$vElem}{2}     `ensure correct recognition of
    size forwards and backwards
  End if
End for

End for

mRegions_compare     `call the next procedure in the process chain
```

APPENDIX 2b

METHOD LISTING FOR "mREGIONS_COMPARE"

The method mRegions_Compare forms the second in the chain of processes. Once all the data have been re-coded, mRegions_Compare performs the statistical tests used in this thesis. The process branches to the method mCohens_Kappa as necessary.

```
    `Project Method mRegions_Compare; JB (4th Dimension 6.06; 21/5/99). This routine
    conducts 78 chi-squared tests across 13 fields for 74802 records in the database. Each
    field was derived from a GIS coverage of categorical data. This routine produces a suite
    of tabular delimited text files. Delimiters are "tab" (9) between columns and "return" (13)
    between rows. This routine calculates the mean maximum probability, the mean cross-
    representation and the Chi-squared value with associated degrees of freedom for each
    comparison. After calculating the observed frequencies the routine branches to a
    separate routine to perform the Cohen's Kappa statistical test before returning.

    `Declaration of variables
C_INTEGER($vControl;$i;$j;$k;$x;$vO_or_E;$vCounter)   `$vControl is master counter
    `$i, $j, $k;$x are counter variables for nested "For-End For' loops and show the
    `level of the loop within the nest where $i is the highest level
C_INTEGER($vRowsNum;$vRowPlus$vTag;$vPosCount;$vSmallest;$vHere)   `array
control variables
C_LONGINT($vGrandTot)   `sum of rows and columns
C_REAL($vChiSq;$vCentProd)   `result of the chi-squared test and Euclidean distance
between two regions
C_REAL($vMaxProb;$vThisProb;$v$BigProb;$vNumOfCats;$vColCats)   `variables for
other measures of association
C_INTEGER($vDegsFree)   `result of the calculation of degrees of freedom
C_TIME(vDocRef)   `computer generated reference for current output document
C_POINTER(vpMainPtr;vpFieldPtr)   `vpMainPtr points to comparator field, vpField Ptr
points to comparatee field
C_STRING(60;$vTitle)   `Title of current output document based on current comparison
C_BOOLEAN(vHowCollaps;$vCorrect)   `array and calculation control variables
ARRAY REAL(aRows;0)   `create "formless" array for comparator values
ARRAY INTEGER(aDValues;0)   `create "formless" array for comparatee values

    `ask user how to handle pre-processing for kappa in this run
CONFIRM("If the kappa contingency table needs to be collapsed, how should it be
done?";"by nearest neighbour";"by columns")
If (OK=1)
  vHowCollaps:=True
Else
  vHowCollaps:=False
End If

    `conduct all possible comparisons
For ($vControl;1;12)   `loop for comparator fields
  ALL RECORDS([Sample_new])
  vpMainPtr:=Field(1;$vControl)   `set pointer to comparator field
  $vControlName:=Field name(vpMainPtr)
  DISTINCT VALUES(vpMainPtr->;aRows)
  $vRowsNum:=Size of array(aRows)

      `produce a separate output file for each comparison (safer & saves on memory)
  For ($i;$vControl+1;13)   `loop for each GIS coverage (comparatee field)
        `prepare for new comparison
    ALL RECORDS([Sample_new])
    vpFieldPtr:=Field(1;$i)   `set comparatee field
    DISTINCT VALUES(vpFieldPtr->;aDValues)   `identify comparatee categories
    $vDocName:=Substring(Field name(vpFieldPtr);1;5)+"_"+$vControlName
    vDocRef:=Create Document($vDocName)   `open new output document
    $vTitle:="Comparison of "+Field name(vpFieldPtr)+" regions with "+$vControlName
    ARRAY LONGINT(aRowTot;0)   `clear old row totals
    $vGrandTot:=0   `clear previous comparison's grand total
        `------------------------------------------------------------
```

```
	`Set up identification headers in output document and prepare calculation arrays
	where the row headers are from the bioregional coverage and the column
	headings are from the particular range of values in the compared coverage
SEND PACKET(vDocRef;"PhD Sampling Exercise on GIS data - Series:
"+String($vControl)+Char(13))
SEND PACKET(vDocRef;$vTitle+Char(13)+Char(13))
ARRAY INTEGER(aObserved;Size of array(aDValues);$vRowsNum) `observed entry
ARRAY REAL(aExpected;Size of array(aDValues);$vRowsNum)   `expected entries
ARRAY LONGINT(aRowTot;$vRowsNum)   `row totals
ARRAY REAL(aColTot;Size of array(aDValues))   `column totals
ARRAY BOOLEAN(aColMerg;Size of array(aDValues))   `do columns need to be
merged for valid chi-squared test?
ARRAY STRING(100;$aHeaders;Size of array(aDValues))   `headers tell user how
columns have been handled
For ($j;1;Size of array(aDValues))   `initialise all array elements (default is no merge)
	aColMerg{$j}:=False
	aColTot{$j}:=0   `clear old column totals
	$aHeaders{$j}:=String(aDValues{$j})   `set default headers
End For
	`-----------------------------------------------------------------------

	`Set up the OBSERVED-values table
	`Find and count all the different instances of categories in the "comparatee"
	'for each specific value in the "comparator" coverage and then create a
	'contingency table in an array. Send output to a text file
SEND PACKET(vDocRef;"OBSERVED"+Char(13)+Char(9))   ` space for row headers
	`First row is the values of the layer
For ($j;1;Size of array(aDValues))   `output column headers
	SEND PACKET(vDocRef;String(aDValues{$j})+Char(9))
End For
SEND PACKET(vDocRef;"Row totals"+Char(13))

For ($j;1;$vRowsNum)   `loop for comparator values
	SEND PACKET(vDocRef;String(aRows{$j})+Char(9))   `output row header
	QUERY([Sample_new];vpMainPtr->=aRows{$j})
	CREATE SET([Sample_new];"sTemp")
	For ($k;1;Size of array(aDValues))   `loop for each category in the coverage
		USE SET("sTemp")
		QUERY SELECTION([Sample_new];vpFieldPtr->=aDValues{$k})
		aObserved{$k}{$j}:=Records in selection([Sample_new])   `fill the array
		SEND PACKET(vDocRef;String(aObserved{$k}{$j})+Char(9))   `output cell entry
		aRowTot{$j}:=aRowTot{$j}+Records in selection([Sample_new])   `row total
		aColTot{$k}:=aColTot{$k}+Records in selection([Sample_new])   `column total
	End For
	$vGrandTot:=$vGrandTot+aRowTot{$j}   `update grand total
	SEND PACKET(vDocRef;String(aRowTot{$j})+Char(13))   `new line in output
End For

	`finish observed table
SEND PACKET(vDocRef;"Column totals"+Char(9))
For ($j;1;Size of array(aDValues))   `output column totals
	SEND PACKET(vDocRef;String(aColTot{$j})+Char(9))
End For
SEND PACKET(vDocRef;String($vGrandTot)+Char(13)+Char(13))
CLEAR SET("sTemp")   `tidy up memory
	`-----------------------------------------------------------------------

	`Calculate the mean maximum probability of coincidence between
```

```
        `comparator and compartatee categories.  Also calculate the mean number of
        `comparator categories represented by each comparatee category.
  $vMaxProb:=0      `cumulative maximum probability
  $vNumOfCats:=0      `representation of comparator by comparatee
  $vThisProb:=0      `current probability
  For ($j;1;Size of array(aDValues))      `loop for comparatee (columns)
    $vBigProb:=0    `bigest probability for this column so far
    $vColCats:=0    `number of categories counted so far
    For ($k;2;$vRowsNum)    `loop for comparator (rows)
      $vThisProb:=aObserved{$j}{$k}/aColTot{$j}
      If ($vThisProb>$vBigProb)
        $vBigProb:=$vThisProb
      End If
      If ($vThisProb>0)
        $vColCats:=$vColCats+1
      End If
    End For
    $vMaxProb:=$vMaxProb+$vBigProb
    $vNumOfCats:=$vNumOfCats+$vColCats
  End For
  SEND PACKET(vDocRef;"Mean Maximum Probability: "+String($vMaxProb/Size of
  array(aDValues))+Char(13))
  SEND PACKET(vDocRef;"Mean Representation in Comparator Categories:
  "+String($vNumOfCats/Size of array(aDValues)))
  SEND PACKET(vDocRef;Char(13)+Char(13))
        `------------------------------------------------------------------------

        `Branch process to perform Cohen's Kappa test of agreement
  mCohens_Kappa
        `------------------------------------------------------------------------

        `Set up the EXPECTED-values table for Chi-squared test
        `Create a new  table of expected values for each cell in the expected table
        `using the formula "cell_value = (row_total * column_total)/grand_total"
  SEND PACKET(vDocRef;"EXPECTED"+Char(13)+Char(9))    `send subheading
        `First row is the values of the layer
  For ($j;1;Size of array(aDValues))      `output column headers
    SEND PACKET(vDocRef;String(aDValues{$j})+Char(9))
  End For
  SEND PACKET(vDocRef;"Row totals"+Char(13))

  For ($j;1;$vRowsNum)      `loop for Bioregions defined with full rules (lowest value = 2)
    SEND PACKET(vDocRef;String($j)+Char(9))      `output row header
    For ($k;1;Size of array(aDValues))    `loop for each category in the coverage
      aExpected{$k}{$j}:=(aRowTot{$j}*aColTot{$k})/$vGrandTot      `expected value
      If (aExpected{$k}{$j}<5)    `check if merger necessary for a valid chi-squre test
        aColMerg{$k}:=True
      End If
      SEND PACKET(vDocRef;String(aExpected{$k}{$j})+Char(9))      `output cell entry
    End For
    SEND PACKET(vDocRef;String(aRowTot{$j})+Char(13))    `start new line
  End For

        `finish expected table
  SEND PACKET(vDocRef;"Column totals"+Char(9))
  For ($j;1;Size of array(aDValues))      `output column totals
    SEND PACKET(vDocRef;String(aColTot{$j})+Char(9))
  End For
```

```
SEND PACKET(vDocRef;String($vGrandTot)+Char(13)+Char(13))
CLEAR SET("sTemp")    `tidy up memory
    `------------------------------------------------------------------

    `Find the centroid of each group of values in the "comparatee" coverage
    `The centroid is theaverage of the eastings by the average of the northings.
    `The centroid is not necessarily the geometrical center but is close enough to
    `distinguish between candidate "closest" neighbours If contingency table columns
    `need to be merged (see below).
ARRAY INTEGER($aCentroid;Size of array(aDValues);2)    `store the centroid
For ($j;1;Size of array(aDValues))
  QUERY([Sample_new];vpFieldPtr->=aDValues{$j})
  $aCentroid{$j}{1}:=Average([Sample_new]Eastings)
  $aCentroid{$j}{2}:=Average([Sample_new]Northings)
End For

    `calculate the nearest neighbouring centroid for each value
ARRAY INTEGER($aNeighbour;Size of array(aDValues))
For ($j;1;Size of array(aDValues))    `loop for each distinct value in 'comparatee"
  For ($k;1;Size of array(aDValues))    `compare centroid with all other centroids
    $vCentProd:=(($aCentroid{$j}{1}-$aCentroid{$k}{1})^2)+(($aCentroid{$j}{2}-
    $aCentroid{$k}{2})^2)
    $vCentProd:=Square root($vCentProd)    `Euclidean distance between centroids
    Case of
      : ($k=1)    `this is the first pass therefore there is no lowest value
        $aNeighbour{$j}:=1
        $vSmallest:=$vCentProd
      : ($vCentProd=0)    `do nothing - this is a 'self-comparison'
      : ($vCentProd<$vSmallest)    `does current pass gives closest neighbour?
        $aNeighbour{$j}:=$k
        $vSmallest:=$vCentProd
    End case
  End For
End For
    `------------------------------------------------------------------

    `If any cell value in the expected table is less than 5 columns must be merged
    `For a valid Chi-squred test.
Repeat    `loop until no columns need to be merged
  $vCorrect:=True    `temporary variable to note if table is correct for chi-square test
  $vLoops:=Size of array(aExpected)
  $vPosCount:=1    `A position counter is needed to keep track of the shrinking array.
      `merge columns
  For ($k;1;$vLoops)    `loop for columns
        `identify if column must be merged
    $vMerge:=False    `temporary variable to note if column needs merging
    For ($x;1;$vRowsNum)    `loop for rows
      If (aExpected{$vPosCount}{$x}<5)
        $vMerge:=True
        $vCorrect:=False
      End If
    End For
        `conduct appropriate merger if necessary
    If ($vMerge=True)    `merge with nearest neighbour
      $vTag:=$aNeighbour{$vPosCount}

      If ($vTag=$vPosCount)    `a column cannot merge with itself so find alternative
```

```
$vHere:=Find in array($aNeighbour;$vPosCount;$vPosCount+1)     `start
looking from NEXT element
If ($vHere=-1)
    $vHere:=Find in array($aNeighbour;$vPosCount)   `start again from
    begining of array
End If
If ($vHere=$vPosCount)     `no other neighbour found (extremely unlikely)
    Case of
        : ($vPosCount<Size of array(aExpected))
            $vHere:=$vPosCount+1     `default to the next column
        : ($vPosCount=Size of array(aExpected))
            $vHere:=$vPosCount-1   `default to the previous column
    End case
End If
$vTag:=$vHere
End If

For ($x;1;$vRowsNum)    `loop and merge for each row
    aObserved{$vTag}{$x}:=aObserved{$vTag}{$x}+aObserved{$vPosCount}{$x}
    aExpected{$vTag}{$x}:=aExpected{$vTag}{$x}+aExpected{$vPosCount}{$x}
End For
DELETE ELEMENT(aObserved;$vPosCount;1)
DELETE ELEMENT(aExpected;$vPosCount;1)
DELETE ELEMENT(aColTot;$vPosCount;1)
DELETE ELEMENT($aNeighbour;$vPosCount;1)
$aHeaders{$vTag}:=$aHeaders{$vTag}+"/"+String(aDValues{$k})
DELETE ELEMENT($aHeaders;$vPosCount;1)
        `NOTE: all the nearest neighbour values must be amended
        `all nearest neighbours to the MERGED column must be able to follow it
        `therefore their neighbour value must become the destination column.
Repeat
    $vElement:=Find in array($aNeighbour;$vPosCount)
    If ($vElement>0)
        $aNeighbour{$vElement}:=$vTag
    End If
Until ($vElement=-1)
        `All neighbour values of higher value than the merging column must be
        `decreased by one to ensure referential integrity within the array
For ($x;1;Size of array($aNeighbour))
    If ($aNeighbour{$x}>$vPosCount)
        $aNeighbour{$x}:=$aNeighbour{$x}-1
    End If
End For
Else    `Position counter incremented ONLY at each complet non-merging pass.
    $vPosCount:=$vPosCount+1
End If
End For
Until ($vCorrect=True)
    `--------------------------------------------------------------------

    `The contingency table is now valid For a Chi-square test
    `send final table to output
    `new column totals must be calculated (row totals are unaffected)
$vChiSq:=0
For ($vO_or_E;1;2)     `loop for Observed then Expected
    $vGrandTot:=0     `recalculate as a check of accuracy
    If ($vO_or_E=1)     `Observed: send new observed table title
        SEND PACKET(vDocRef;Char(13)+"OBSERVED"+Char(13))
```

```
Else    `Expected: send new expected table title
  SEND PACKET(vDocRef;Char(13)+"EXPECTED"+Char(13))
End If
$vRowPlus:=$vRowsNum+1
For ($j;0;$vRowPlus)   `loop for each row including headers and totals
  Case of    `send row headings
    : ($j=$vRowPlus)
      SEND PACKET(vDocRef;"Col Tot:"+Char(9))
    : ($j>0)
      SEND PACKET(vDocRef;String(aRows{$j})+Char(9))
    Else
      SEND PACKET(vDocRef;Char(9))
  End case
  For ($k;1;Size of array(aColTot))   `loop for each column
    Case of    `send column headings or cell contents
      : ($j=0)
        aColTot{$k}:=0    `clear old column value
        SEND PACKET(vDocRef;$aHeaders{$k}+Char(9))
      : ($j=$vRowPlus)
        SEND PACKET(vDocRef;String(aColTot{$k})+Char(9))
        $vGrandTot:=$vGrandTot+aColTot{$k}
      : ($vO_or_E=1)    `Observed: send table observed cell entry
        SEND PACKET(vDocRef;String(aObserved{$k}{$j})+Char(9))
        aColTot{$k}:=aColTot{$k}+aObserved{$k}{$j}   `update column total
      Else    `Expected: calculate chi-squared value and send table entry
        $vChiSq:=$vChiSq+(((aObserved{$k}{$j}-aExpected{$k}{$j})^2)/
        aExpected{$k}{$j})
        SEND PACKET(vDocRef;String(aExpected{$k}{$j})+Char(9))
        aColTot{$k}:=aColTot{$k}+aExpected{$k}{$j}   `update expected column
    End case
  End For
  Case of    `polish up the table
    : ($j=0)
      SEND PACKET(vDocRef;"Row Totals"+Char(13))   `finish headers row
    : ($j<$vRowPlus)
      SEND PACKET(vDocRef;String(aRowTot{$j})+Char(13))
    Else    `finish the table
      SEND PACKET(vDocRef;String($vGrandTot)+Char(13)+Char(13))
  End case
End For
End For
SEND PACKET(vDocRef;"Chi-squared = "+String($vChiSq)+Char(13))
$vDegsFree:=($vRowsNum-1)*(Size of array(aColTot)-1)   `degrees of freedom
SEND PACKET(vDocRef;"Degrees of freedom = "+String($vDegsFree))
  `-----------------------------------------------------------------

  `this document is finished - move on to the next comparison
CLOSE DOCUMENT(vDocRef)
End For
End For

QUIT 4D   `Exit 4D to let the computer shut down automatically when run unattended
```

APPENDIX 2c

METHOD LISTING FOR "mCOHENS_KAPPA"

The method mCohens_Kappa uses the contingency tables that were calculated by the method mRegions_Compare. The former method is called as a branch process by the latter method. The method mCohens_Kappa performs the eponymous statistical test.

```
    `Method mCohens_Kappa; (JB; 4th Dmension 6.0.6; 10/6/99)
    `This routine calculates Cohen's Kappa test of agreement (ordered columns)

    `Initialise local variables
C_INTEGER($i;$j;$k)  `local loop control variables
C_INTEGER($vCounter;$vPosCount;$vPosOrder)  `local process control variables
C_LONGINT($vSmallCat;$vGrandTot)  `local temprory variable
C_BOOLEAN($vCor_or_Cee)  `local array control variable
C_REAL($vProbObs;$vProbExp;$vKappa;$vSEMean;$vSESig;$vLower)  `values
associated with the Kappa statistic
C_REAL($vUpper;$vZ;$vKmax;$vFuzz)  `values associated with the Kappa statistic

    `Preserve the Observed table for future Chi-squared analysis
    `Use local arrays to free up memory when this process ends
COPY ARRAY(aObserved;$aCohenKap)
COPY ARRAY(aRowTot;$aCohenRowT)
COPY ARRAY(aColTot;$aCohenColT)

    `Only find nearest neighbours and 'pivot' array for comparator if it has more categories
    than the comparatee coverage, otherwise skip this section.
If (Size of array($aCohenRowT)>Size of array($aCohenColT))

    `Use $aPivot array as local temporary storage during pivot of Observed (CohenKap)
  ARRAY INTEGER($aPivot;Size of array($aCohenRowT);Size of array($aCohenKap))
  For ($j;1;Size of array($aCohenRowT) )
    For ($k;1;Size of array($aCohenKap))
      $aPivot{$j}{$k}:=$aCohenKap{$k}{$j}
    End for
  End for
  COPY ARRAY($aPivot;$aCohenKap)  `complete rotation of Observed array
  COPY ARRAY($aCohenColT;$aPivot)  `borrow $aPivot array space again to save on
  memory
  COPY ARRAY($aCohenRowT;$aCohenColT)  `pivot row totals
  COPY ARRAY($aPivot;$aCohenRowT)  `pivot column totals
  $vCounter:=Size of array($aCohenRowT)
  $vCor_or_Cee:=True

Else  `no need to pivot array so leave it alone
  $vCounter:=Size of array(aDValues)
  $vCor_or_Cee:=False
End if


    `--------------------------------------------------------------
    `Only conduct pre-processing if 'r' does not equal 'c'
    `Collaps table based on user selection of nearest column or nearest centroid
If (vHowCollaps=True)  `user chose to collaps by centroids
  SEND PACKET(vDocRef;"Contingency table for Kappa was collapsed by reference to
  region centroids"+Char(13))
  If (Size of array($aCohenRowT) # Size of array($aCohenColT))
      `Find the centroid of each group of values to determine the Euclidean distance to a
      neighbour
    ARRAY INTEGER($aCentroid;Size of array($aCohenColT);2)  `store the centroid
  eastings and northings
    For ($j;1;Size of array($aCohenColT))
      If ($vCor_or_Cee=True )
        QUERY([Sample_new];vpMainPtr->=aRows{$j})
      Else
```

```
      QUERY([Sample_new];vpFieldPtr->=aDValues{$j})
    End if
    $aCentroid{$j}{1}:=Average([Sample_new]Eastings)
    $aCentroid{$j}{2}:=Average([Sample_new]Northings)
   End for

      `calculate the nearest neighbouring centroid for each value
   ARRAY INTEGER($aNeighbour;Size of array($aCohenColT))
   For ($j;1;Size of array($aCohenColT))    `loop for each distinct value in 'comparatee' coverage
    For ($k;1;Size of array($aCohenColT))    `compare centroid with all other centroids
      $vCentProd:=(($aCentroid{$j}{1}-$aCentroid{$k}{1})^2)+(($aCentroid{$j}{2}-$aCentroid{$k}{2})^2)
      $vCentProd:=Square root($vCentProd)    `Euclidean distance between two centroids
     Case of
       : ($k=1)    `this is the first pass therefore there is no lowest value
         $aNeighbour{$j}:=1
         $vSmallest:=$vCentProd
       : ($vCentProd=0)    `do nothing - this is a 'self-comparison'
       : ($vCentProd<$vSmallest)    `identify whether the current pass gives the closest neighbour
         $aNeighbour{$j}:=$k
         $vSmallest:=$vCentProd
     End case
    End for
   End for
  End if
End if
   `----------------------------------------------------------

   `Only conduct preprocessing if 'r' does not equal 'c'
While (Size of array($aCohenRowT) # Size of array($aCohenColT))    `loop until no columns need to be merged
  $vPosCount:=1
     `identify category that represents the smallest land area
  $vSmallCat:=74802    `total land area
  For ($j;1;Size of array($aCohenKap))    `loop for categories
   If ($aCohenColT{$j}<$vSmallCat)
     $vSmallCat:=$aCohenColT{$j}
     $vPosCount:=$j
   End if
  End for

  If (vHowCollaps=True)    `user chose to collaps by centroids
      `Identify the nearest neighbour (Euclidian distance)
   $vTag:=$aNeighbour{$vPosCount}
   If ($vTag=$vPosCount)    `a column cannot merge with itself so find alternative neighbour
     $vHere:=Find in array($aNeighbour;$vPosCount)    `look for 'back-comparison'
    If ($vHere=$vPosCount)    `no other neighbour was found (extremely unlikely)
      $vHere:=$vPosCount-1    `default to the next column
    End if
    If ($vHere=-1)    `no proper match found (very unlikely - but fail-safe anyway)
      $vHere:=$vPosCount-1    `default to the previous column (which is the nearest based on coding)
    End if
     $vTag:=$vHere
```

```
End if
    `conduct concatination
For ($j;1;Size of array($aCohenRowT))    `loop and merge for each row
   $aCohenKap{$vTag}{$j}:=$aCohenKap{$vTag}{$j}+$aCohenKap{$vPosCount} {$j}
End for
$aCohenColT{$vTag}:=$aCohenColT{$vTag}+$aCohenColT{$vPosCount}
DELETE ELEMENT($aCohenKap;$vPosCount;1)
DELETE ELEMENT($aCohenColT;$vPosCount;1)
DELETE ELEMENT($aNeighbour;$vPosCount;1)

  `NOTE: all the nearest neighbour values must be amended all nearest neighbours to
  the MERGED column must be able to follow it therefore their neighbour value must
  become the destination column.

Repeat
  $vElement:=Find in array($aNeighbour;$vPosCount)
  If ($vElement>0)
    $aNeighbour{$vElement}:=$vTag
  End if
Until ($vElement=-1)
  `All neighbour values of higher value than the merging column must be decreased
  by one to ensure referential integrity within the array
For ($x;1;Size of array($aNeighbour))
  If ($aNeighbour{$x}>$vPosCount)
    $aNeighbour{$x}:=$aNeighbour{$x}-1
  End if
End for

Else      `user chose to collaps table by neighbouring columns
For ($j;1;Size of array($aCohenRowT))    `loop and merge for each row
  If ($vPosCount=1)    `test for special case of first element in array
    $aCohenKap{$vPosCount+1}{$j}:=$aCohenKap{$vPosCount+1}{$j}+
    $aCohenKap{$vPosCount}{$j}
  Else
    $aCohenKap{$vPosCount-1}{$j}:=$aCohenKap{$vPosCount-1}{$j}
    +$aCohenKap{$vPosCount}{$j}
  End if
End for

If ($vPosCount=1)    `test for special case of first element in array
  $aCohenColT{$vPosCount+1}:=$aCohenColT{$vPosCount+1}+$aCohenColT
  {$vPosCount}
Else
  $aCohenColT{$vPosCount-1}:=$aCohenColT{$vPosCount-1}+
  $aCohenColT{$vPosCount}
End if
DELETE ELEMENT($aCohenKap;$vPosCount;1)
DELETE ELEMENT($aCohenColT;$vPosCount;1)
End if

End while
`------------------------------------------------------------------------
```

```
    `Output the table for visual chec k.
SEND PACKET(vDocRef;Char(13)+Char(13))
For ($i;1;Size of array($aCohenRowT))
  For ($j;1;Size of array($aCohenColT))
    SEND PACKET(vDocRef;String($aCohenKap{$j}{$i})+Char(9))
  End for
  SEND PACKET(vDocRef;Char(13))
End for
    `------------------------------------------------------------------

    `check the order of the columns to ensure maximum diagonal agreement
COPY ARRAY($aCohenKap;$aCohenSacrif)    `create "sacraficial" array
COPY ARRAY($aCohenKap;$aCohenOrder)    `create safety array to receive ordering
For ($i;1;Size of array($aCohenRowT))    `take each row in turn on the diagonal
      `identify frequency table cell with the largest value "on the diagonal"
  $vSmallCat:=0
  $vPosOrder:=1
  For ($j;1;Size of array($aCohenSacrif))
    If ($aCohenSacrif{$j}{$i}>$vSmallCat)    `note position of highest value in the "ith" row
    of the "jth" column
      $vSmallCat:=$aCohenSacrif{$j}{$i}
      $vPosOrder:=$j
    End if
  End for
      `make the column with the highest value in the "ith" row the "ith" column
  For ($j;1;Size of array($aCohenRowT))
    $aCohenOrder{$i}{$j}:=$aCohenSacrif{$vPosOrder}{$j}
  End for
   DELETE ELEMENT($aCohenSacrif;$vPosOrder)    `remove this column from
   consideration
End for
    `restore primacy to "$aCohenKap" and recaluclate new order column totals
COPY ARRAY($aCohenOrder;$aCohenKap)
$vKGrandTot:=0
For ($i;1;Size of array($aCohenKap))
  For ($j;1;Size of array($aCohenKap))
    $aCohenRowT{$i}:=$aCohenRowT($i}+$aCohenKap{$j}{$i}
    $aCohenColT{$i}:=$aCohenColT($i}+$aCohenKap{$i}{$j}
    $vKGrandTot:=$vKGrandTot+$aCohenKap{$i}{$j}
  End for
End for
    `------------------------------------------------------------------

    `Output the table for 2nd visual check.
SEND PACKET(vDocRef;Char(13)+Char(13))
For ($i;1;Size of array($aCohenRowT))
  For ($j;1;Size of array($aCohenColT))
    SEND PACKET(vDocRef;String($aCohenKap{$j}{$i})+Char(9))
  End for
  SEND PACKET(vDocRef;Char(13))
End for
    `------------------------------------------------------------------

    `The table is now ready for Cohen's Kappa to be performed:
$vProbObs:=0
$vProbExp:=0
For ($i;1;Size of array($aCohenKap))
  $vProbObs:=$vProbObs+$aCohenKap{$i}{$i}
```

```
    $vProbExp:=$vProbExp+($aCohenRowT{$i}*$aCohenColT{$i})
End for
$vProbObs:=$vProbObs/$vGrandTot    `on-diagonal agreement
$vProbExp:=$vProbExp/($vGrandTot^2)    `off-diagonal marginals
$vKappa:=($vProbObs-$vProbExp)/(1-$vProbExp)    `Cohen's kappa
$vKmax:=0
    `find the sum of the lowest value for each pair of column and row totals
For ($i;1;Size of array($aCohenRowT))
  If ($aCohenRowT{$i}<$aCohenColT{$i})
    $vKmax:=$vKmax+$aCohenRowT{$i}
  Else
    $vKmax:=$vKmax+$aCohenColT{$i}
  End if
End for
$vKmax:=($vKmax-$vProbExp)/(1-$vProbExp)    `maximum value of kappa allowable by the marginals
$vSEMean:=Square root(($vProbObs*(1-$vProbObs)/($vGrandTot*((1-$vProbExp)^2)))
    `standard error for confidence limits
$vLower:=$vKappa-(1.96*$vSEMean)    `lower value of 95% confidence limit
$vUpper:=$vKappa+(1.96*$vSEMean)    `upper value of 95% confidence limit
$vSESig:=Square root($vProbExp/($vGrandTot*(1-$vProbExp)))    `standard error for significance test
$vZ:=$vKappa/$vSESig    `significance value 'Z'
$vFuzz:=1-$vKmax    `measure of fuzziness
SEND PACKET(vDocRef;"Observed proportion of agreement = "+String($vProbObs)
  +Char(13))
SEND PACKET(vDocRef;"Expected proportion of agreement = "+String($vProbExp)
  +Char(13))
SEND PACKET(vDocRef;"COHEN'S KAPPA = "+String($vKappa)+Char(13))
SEND PACKET(vDocRef;"Standard error of the mean = "+String($vSEMean) +Char(13))
SEND PACKET(vDocRef;"95% Confindence Limits = "+String($vLower)+" to
  "+String($vUpper)+Char(13))
SEND PACKET(vDocRef;"Maximum value of kappa allowable by marginals =
  "+String($vKmax)+Char(13))
SEND PACKET(vDocRef;"Fuzziness = "+String($vFuzz)+Char(13))
SEND PACKET(vDocRef;"Standard error (assuming Po=Pe) = "+String($vSESig)
  +Char(13))
SEND PACKET(vDocRef;"Z = "+String($vZ)+Char(13)+Char(13))
    `This process is over so control is automatically returned to 'mRegions_Compare'. On
    exit all local variables are cleared automatically to save on memory.
```