A Suitability Assessment of Farms for Inclusion in a UNESCO-Approved Biosphere Reserve: The Case of the Itala Biosphere Reserve, KwaZulu-Natal.

Andrew John Moffat

Submitted as the dissertation component (which counts for 50% of the degree) in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE IN ENVIRONMENT AND DEVELOPMENT

in the

School of Environment and Development,

University of Natal

Pietermaritzburg

1997

Abstract

This project describes and evaluates a method of assessing the suitability of 161 farms for inclusion in a biosphere reserve. Farms were chosen as a basic study unit over more ecologically based units because the decision to participate in the biosphere reserve rests with the landowner. The study area is located in northern KwaZulu-Natal, between Hlobane, near Vryheid, and the Itala Nature Reserve where local landowners are exploring the possibility of establishing a biosphere reserve. A brief review of the natural, social and economic contexts is given in order to identify local dynamics relevant to the establishment of a biosphere reserve.

Farm suitability for inclusion was assessed with respect to its capability to fulfil the three main roles of a biosphere reserve as defined by the Man and Biosphere Programme of UNESCO. These are conservation, sustainable development and research. Ten factors were identified to determine farm suitability: vegetation, fauna and soil conservation, present land use, agricultural potential, tourism potential, education, settlement density and location. These were prioritised using the Analytical Hierarchy Process according to their impact on the main roles of the biosphere reserve. Each farm was given a factor score according to the expression of that factor on that farm. Overall farm suitability was taken as the sum of the weighted factor scores. The final scores for each farm were grouped into suitability classes and these were mapped. This map was then used to make recommendations on which farms should be considered for inclusion in the reserve.

This method of assessing farm suitability for inclusion in a biosphere reserve, involving scoring the factors determining suitability and prioritising these factors was evaluated with respect to its efficiency in identifying suitable properties. This was achieved by comparing the results of the assessment with the suitability class of farms with known suitability. The conceptual approach to the assessment was reviewed against published guidelines for integrated regional planning and rational resource planning. The accuracy of the project method in correctly identifying suitable farms was assessed against two other simplified methods of assessment, involving no weighting between factors, and a limited number of factors.

Based on these analyses, conclusions have been drawn as to the strengths and weaknesses of both the method of farm assessment and the method of evaluation itself. Recommendations were made for further research into and development of methods of assessing farm suitability for biosphere reserves. A procedure for the establishment of the proposed Itala Biosphere Reserve was suggested.

Declaration

The research work described in this dissertation was carried out at the School of Environment and Development, University of Natal, Pietermaritzburg, and in northern KwaZulu-Natal, from July 1996 to August 1997, under the supervision of Dr. JE Granger, Dr. F Ahmed, and Mr. JR Klug.

These studies represent original work by the author and have not otherwise been submitted in any form for any degree or diploma to any other University. Where use has been made of the work of others it is duly acknowledged in the text.

AJ Moffat

Table of Contents

List of Tables

List of Figures

List of Maps

Acknowledgements

I would like to thank the following for their help and input into this project:

- Ed Granger, Fethi Ahmed, John Klug, my supervisors, for the direction and feedback provided.

- Kelston Camp, Barry Smith, and Ron Bennett, at Cedara, for maps, advice, and pointers.

- Atholl Marchant at the Natal Parks Board, for organization of the project and for discussion on the regional role of the Itala Biosphere Reserve.

- Chris Pullen at Weenen Nature Reserve, for perspective on biosphere reserves in South Africa.

- Trevor Wolf and Don Yunnie at Itala Nature Reserve - for accommodation at Itala, and discussion on the implications of the establishment of the Itala Biosphere Reserve.

- Cheryl Cameron and the staff at the Hlobane Community Complex, for assistance at Hlobane and for enthusiasm for the project.

- Stoffel de Jager in Vryheid, for information on potential conservation management of farms in the study area and for a record of previous discussions on the development of the reserve.

- Hector Urquhart at the Department of Agriculture in Vryheid, for the use of an office, orthophotos, aerial photos and a stereoscope and for a perspective on agriculture in the region.

- Roger Harris at the Surveyor General's Office in Pietermaritzburg, for permission to use digitised cadastral information from the Surveyor General's Office.

- Helena Margeot from Geomap and the Cartographic Unit of the University of Natal, for help with Microstation, for provision of digital data for the project, for the use of her computers and for many cups of coffee and many suppers.

- Stuart Morrison from Geomap, for help with SQL queries and MapInfo 4.1, and for making problems into challenges.

- Susan Brittain and Karl Stielau from the Department of Statistics and Biometry and Dr. Faulds from the Department of Psychology for help with nonparametric methods of statistical analysis.

- Richard Thompson and Kathy Haig from Chengelo Secondary School, Zambia, for transporting my hard drive and all my references and project data up to Zambia.

- Ruby, Tim and Luke Solomon - for bringing my project back again

- My family, for providing financial and moral support over the last year.

- Brad Steyn and the Scottsville Baptist Church Link-up group, for prayer and moral support.

Glossary of Terms and Abbreviations

Definitions of terms for some of the concepts used in this project have been adopted from the definitions used by the Department of Environment Affairs for the Integrated Environmental Management process (Department of Environment Affairs, 1992) and from the definitions used by Noss and Cooperrider (1994) in 'Saving Nature's Legacy - Protecting and restoring biodiversity'. Definitions of terms used to describe the soil characteristics of the study area are adapted from 'Soil Classification - A taxonomic system for South Africa' (Soil Classification Working Group, 1991).

Authority - National, regional or local authority which has a decision-making role in the development of the biosphere reserve.

Catena (*pl.* catenae) - A sequence of soils of similar age, derived from similar parent material, and occurring under similar macroclimatic conditions but having different characteristics due to variation in relief and drainage.

Conservation - The act of maintaining all or part of a resource (whether renewable or non-renewable) in its present condition in order to provide for its continued or future use.

Cutanic - Soil horizons with cutans as a dominant diagnostic characteristic. Cutans occur on the surfaces of peds or individual particles (sand grains, stones). They consist of material which is usually finer than, and that has an organisation different to the material that makes up the surface on which they occur.

Decision-maker - The person(s) entrusted with the responsibility for allocating resources.

Development - The act of altering or modifying resources in order to obtain potential benefits.

Environment - The external circumstances, conditions and objects that affect the existence and development of an individual, organism or group. These circumstances include biophysical, social, economic, historical, cultural and political aspects.

Farm - A cadastral property or collection of cadastral properties owned by a single body and managed as a single management unit.

Farm suitability - The suitability of a cadastral property, whether it is a farm, a rural settlement, a mine, or a township, for inclusion in a biosphere reserve.

HCC - Hlobane Community Complex

Hotspot (of endemism) - An area with high species richness (usually plant species); or where plant communities have high proportions of endemic plant species, or which are of importance to conservation.

Itala - Itala Nature Reserve (NPB)

IBR - Itala Biosphere Reserve

IUCN - International Union for the Conservation of Nature

KZN - KwaZulu-Natal

Local people or local communities - People directly affected by the establishment of a biosphere reserve in the study area.

MAB - (UNESCO) Man and Biosphere programme

Mitigation - Practical measures implemented to reduce adverse impacts or enhance beneficial impacts of an action.

Natural resources - Any resource provided by the biophysical environment.

NPB - Natal Parks Board

ODA - Overseas Development Administration (of the UK)

Plinthic - Used to describe soils with a plinthite horizon. Plinthic horizons develop when periodic saturation with water causes accumulation and localisation of iron oxides and hydroxides. The resulting mottles and concretions become the predominant feature of the horizon.

The reserve - The proposed Itala Biosphere Reserve, unless otherwise stated.

Role players - refers to any person or organisation who will need to be involved in setting up the biosphere reserve.

SA - South Africa

Subjective - A condition relating to or arising from oneself or one's mind (as opposed to objective phenomena which are independent of the mind).

UNESCO - United Nations Educational, Scientific and Cultural Organisation.

UNP - University of Natal, Pietermaritzburg

Value judgement - A statement of opinion or belief which is not capable of being falsified by comparison with fact.

Computer Disk - Covering Note

It is hoped that the information on this disk will provide a useful tool for viewing the data under discussion. Viewing data in the text can be a clumsy procedure as it may involve text, a table, a map, and an appendix, all of which are on different pages. The simplest way to view the data used in this project is to use a computer and to view the maps and tables on screen in a GIS. The workspaces provided on the computer disk allow a reader to view a section of map under discussion and the associated data on the computer screen, while reading the relevant text. In addition, further information about the surrounding areas may be accessed using the 'MapInfo Info Tool' allowing for comparisons between farm scores and their composition. All data used for the project are provided in hard copy in this document either as maps or appendices. The disk is provided purely as a tool for ease of viewing. Readers without access to the specialised software needed to view the disk may reference information in the maps and appendices through each farm's individual identification number.

MapInfo for Windows 2.1.1 was the main software used in this project, and the data on the disk are provided in the format suitable for this software. Later releases of 'MapInfo' software are able to view the data with no conversion necessary. The data are also provided in AutoCAD DXF format (File 'Scores.dxf'). This can be imported into most GIS or CAD systems, without losing the data associated with the map.

The MapInfo workspaces provide maps created specifically for particular sections of text. These are referenced in the text as: (Workspace: 'WorkX'), where X is the Workspace number. These maps are accessed by using the 'File \ Add Workspace' command. Information can be retrieved for each particular farm by activating the 'Info' tool, and clicking on the desired farm. Where a particular group of farms is being discussed, the 'Browser' window contains the information for the farms. Individual farms can be selected from the map or the browser, using the 'Select' tool.

Chapter 1: Introduction

1.1 Introduction

'I'm truly sorry Man's dominion
Has broken Nature's social union,
An' justifies that ill opinion,
that makes thee startle,
At me, thy poor earth-born companion
An' fellow mortal.'

(from 'To a Mouse', by Robert Burns, 1745-1796)

In the eighteenth century, Robert Burns (1785) commented how humankind's stewardship of the environment was not in accord with nature's own progression. Two hundred years have passed and people are only now beginning to consider how to bring land management practices into tune with nature's processes. The biosphere reserve concept is an attempt at restoring the balance between man and his environment or more specifically, the balance between conservation and development.

The term 'biosphere reserve' is a designation awarded by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) through its Man And Biosphere (MAB) programme. It is awarded to areas where a good balance between conservation of valuable natural resources and sustainable development has been achieved in land management policies and practice (Francis, 1996). In addition to conservation and development, biosphere reserve management is concerned with: (a) research; (b) international cooperation between biosphere reserves; (c) local cooperation with regional organisations and administrations; and (d) education. A biosphere reserve consists of a legally protected core conservation area, a surrounding buffer zone, and a transition area between the biosphere reserve and the surrounding area (Batisse, 1984).

Biosphere reserves provide international recognition of natural characteristics that are worthy of conservation. They also provide coordinated management for a region and a framework for settling disputes over land use or resource preservation (Francis, 1996). The establishment of a biosphere reserve in a region means a policy and management focus on sustainable development in the region and on conservation practices in land use.

Alternative approaches which have been used to combine conservation and development include nature reserves, conservancies and community conservation programmes. Of these, nature or game reserves give the highest degree of protection as they are usually fenced off from neighbouring land. Land use is limited to game viewing or hunting; human habitation is only allowed at lodges or staff camps and land management may be based on economic rather than conservation principles.

Conservancies are areas where neighbouring landowners enter an agreement to protect the naturally occurring wildlife in their area. This includes the employment of game guards, cooperation in anti-poaching measures, and the establishment of formal links with the district conservation officer. There are no restrictions on land uses within conservancies, and human habitation is at a level normal to farming areas (Young, 1992).

Community conservation programmes have become popular in recent years as a method of instilling a sense of ownership of wildlife into rural Black communities. The CAMPFIRE programme in Zimbabwe has been successful through the return of revenues to the community earned from sustainable use of wildlife in the area (Child and Peterson, 1991). This approach to conservation and development allows for human settlement within conservation areas and allows for multiple land uses. However, where land is privately owned, it is preferable to have a system where benefits and responsibilities are linked directly back to the landowner.

The MAB approach to conservation and development has been adopted for this project because it allows for private ownership and management of land, with associated human settlement, and a choice of multiple land uses. While doing this, it still affords legal protection to the core conservation areas and formalises the management focus within the reserve onto conservation and sustainable development. This open approach to conservation allows for larger areas of land to be dedicated to conservation while still satisfying the needs of a larger human population than would be found in traditional nature reserves.

There is need for this type of focus and framework in northern KwaZulu-Natal. The collapse of the local coal mining industry, a poor economic outlook for agriculture and a history of being ignored both by the government of the day and by outside investors has led to a situation where the region is poorly developed relative to the rest of the province[1]. The Itala Nature Reserve provides a possible core conservation area for a biosphere reserve, and hosts several species of rare and endangered flora and fauna. The distribution of these is, however, not limited to the confines of the reserve and many of the farms surrounding Itala have potentially valuable natural resources which could form the basis of the conservation role in a local biosphere reserve.

This project seeks to provide and evaluate a method for determining the suitability of cadastral properties for inclusion in a biosphere reserve. It is hoped that the results of the project will be useful in determining strategies for the establishment of a biosphere reserve in the region. It is also hoped that the methodology developed could be used for land use planning exercises elsewhere.

1.2 Aim

The aim of this project is to present and evaluate a method of suitability assessment of farms for possible inclusion in a biosphere reserve using data derived from Geographic Information Systems (GIS) and value judgements. From this assessment, maps showing the relative suitability of each farm in the study area will be produced. The actual decision of whether the farm will be included in the reserve rests with the landowner and will depend on his/her management priorities. Final biosphere reserve boundaries will be drawn up by the participants of the reserve, though the composition of this group will be determined in part by the suitability of their land for inclusion in the reserve.

---

[1] pers. comm. Mrs. S Henderson, Local Historian, Ladysmith, KZN (1996).

The hypothesis of this project is that value judgements used together with GIS-derived information can aid in bringing clarity to land use planning. The suitability of each farm for inclusion in a biosphere reserve will be determined through subjective scores for a variety of factors. These scores will be spatially referenced by linking the scoring database to digital maps.

1.3 Objectives

In the process of assessing suitability, the project aims to provide a realistic model, that could be used in other land use planning exercises. This model should be simple enough for planners to understand and adjust, yet able to provide accurate results in differing situations. The model will be evaluated against this criterion, and with respect to its accuracy and repeatability compared with two alternative methods.

The project aims to provide a holistic approach to development, taking into account all natural, social, cultural and economic factors that will play a role in determining land suitability for a biosphere reserve. This is achieved by linking database records to spatial areas using GIS software. The importance of preserving simplicity is all the more evident considering the multi-faceted approach used in the project.

Such an integrated approach to land use planning corresponds with the objectives of the MAB programme, which oversees biosphere reserves approved by UNESCO. MAB reserves are based on three main criteria (Batisse, 1984): sustainable development, conservation and research. The project aims to incorporate planning for these three points through:

- identifying key biological resources in the region to be targeted for conservation;
- identifying resources of economic value in the area upon which development will depend;
- identifying potential fields for research in the region.

As the philosophy of sustainable development demands a socially responsible approach to planning a biosphere reserve; all efforts have been made during this project to work in cooperation with the main role players in the region, and to ensure that the project is transparent in its motivation. This should enhance the possibility of success in the development of the biosphere reserve.

1.4 Alternative approaches to reserve design

Most existing conservation areas are a result of opportunism, i.e. when land was available for conservation it was declared a conservation area, or of planning based on biodiversity conservation principles (Pressey *et al.*, 1993). Where areas were identified as being in need of conservation, the focus was on either the representation of all ecological types in need of conservation (e.g. vegetation communities, habitat types, or animal home ranges) or on the representation of plant or animal species that had been identified as being particularly important for conservation (Van Jaarsveld, 1995).

There have been three main approaches used to determine suitable reserve areas: algorithms (Pressey *et al.*, 1997), gap analysis (Strittholt and Boerner, 1995) and environmental diagnosis (Cendrero *et al.*, 1993). Algorithms used to identify reserve boundaries can be heuristic or optimal. Heuristic algorithms use a stepwise selection of sites until all the reserve requirements are met (Pressey *et al.*, 1996). Sites are chosen according to their complementarity to those sites already conserved. Two main criteria are used in the selection of sites: richness and rarity. When richness is used as a criteria, a site is chosen if it has a rich representation of the species or communities that are targeted for conservation. The rarity criteria will select sites that contain the rarest species or community that it not already included in reserve areas (Pressey *et al.*, 1996). Heuristic algorithms can be simple to define and can be run interactively because of the fast processing times, but may result in more than one possible solution (Pressey *et al.*, 1997).

Optimal algorithms result in a single optimal solution which should be the most efficient design for the proposed reserve area (Pressey *et al.*, 1996). These algorithms have a processing time of days rather than minutes, are more complicated to design, and require large databases of dependable information (Pressey *et al.*, 1996).

Gap analysis operates by identifying gaps in the conservation status of key characteristics in a region (Strittholt and Boerner, 1995). This is achieved through spatial analysis, usually on a GIS. Key environmental characteristics are mapped along with present conservation areas and known constraints for conservation targets. From these maps, gaps in conservation coverage are identified. These maps may be overlaid with cadastral maps and used to identify priority areas for land acquisition (Strittholt and Boerner, 1995). This technique has become increasingly popular with the increased power and availability of desktop GIS systems. Gap analysis is a proven practical method of prioritising areas for conservation, but requires large amounts of known information to be effective, and can be very labour intensive and expensive if this information is not immediately available in digital format (Ehrlich, 1996).

The environmental diagnosis technique was used by Cendrero *et al.* (1993) to plan the Biosphere Reserve of Pozuelos in Argentina. This technique maps different 'morphodynamic units' (MDUs) which are units with essentially homogenous environmental features for land use purposes. A variety of approved land use activities are identified, and a list of the characteristics that determine the MDUs suitability for each land use activity is compiled. Each MDU is then given a score for each characteristic according to the suitability of each land use. For example, MDU1 may have plant species that have been identified as being rare or endangered. This MDU would therefore have a high score for conservation land use for the vegetation characteristic, but lower scores for other land uses, such as implantation of pastures, for vegetation. Land use activities are given a priority ranking. High priority land use activities are assigned to the MDUs most suited to them. When the high potential MDUs are filled, the next highest priority land use is assigned to remaining MDUs according to their potential. This use of ecologically defined units to determine land use activities does not allow for privately owned land and the right of the landowner to determine land use and management strategies. This technique can be used as a tool to identify most appropriate land uses but cannot be used as a prescriptive method for determining reserve boundaries.

The environmental diagnosis method of reserve planning uses class data from relatively small-scale maps (1:100 000) to determine the suitability of land for conservation. This minimises the time and financial requirements for the assessment. The procedure itself is simple to set up provided the land use activities and environmental criteria used are clearly defined. Suitability classes are based on an aggregate score of the characteristics of the area. Land uses are prioritised according to their role in a biosphere reserve. This type of approach combines simplicity and efficiency with flexibility in the choice of information studied. As such, it achieves the objectives specified for this project (Section 1.3). This type of approach to data capture and a similar approach to data manipulation were adopted for this project.

The focus of the environmental diagnosis method is on determining the most appropriate land use for different ecological units. This focus differs from the project focus in that it uses ecological rather than cadastral units as the decision making unit. The environmental diagnosis method also goes further than indicating suitability for conservation alone, and is more a method of determining land capability for a various land uses rather than a suitability assessment alone. Results therefore can be used for more than one planning scenario. The method of assessment used in this project assesses the suitability of land for a specific purpose (inclusion in a biosphere reserve) and defines the constraints for this purpose at the outset of the project.

The algorithm and gap analysis methods of conservation planning also determine suitability of an area for a specific purpose, conservation, rather than assessing the more general capability of the land for the most appropriate land use. These methods have previously been used to focus primarily on biodiversity conservation requirements alone, and have not accounted for social or economic aspects when defining the constraints of the project. These constraints would have to be written into the algorithms used for analysis. This may require a quantitative knowledge of relationships between the social, economic and environmental factors. These relationships are difficult to quantify or even estimate. What is needed is a method where the contribution of social and economical data can be directly compared to the contribution of ecological or environmental data to the suitability of an area for conservation. This project attempts to resolve this conflict by assigning ordinal values to the impact on suitability of a wide range of factors determining suitability for inclusion in a biosphere reserve.

Algorithm and gap analysis methods need a lot of detailed information and are thus expensive and slow (Ehrlich, 1996). Collection, collation and digitising of information can be worthwhile if there is a certainty of the need for this information in the future. However, if it is likely that it will be used solely for the suitability assessment of an area, the cost and time involved may not be justified. Algorithms do not always produce the most efficient reserve boundaries as sites are chosen for the presence or absence of a characteristic and do not take into account the quality of the expression of that characteristic (Woinarski *et al.*, 1996). The final reserve boundaries produced by algorithms and gap analysis do not reflect the whole picture but usually depend on few characteristics which have been given high priorities by the planners. The accuracy of the suitability scores produced by algorithms is probably higher than the accuracy of suitability scores from the more subjective scores from environmental diagnosis, especially when only a few constraints are considered. However, when some characteristics are not accounted for in gap analyses or algorithm methods of assessment, overall accuracy of the suitability indications may not be so high.

The method used in this project to assess suitability of farms for a biosphere reserve has been developed to take a holistic view of the relevant dynamics and to account for all of these in the final suitability grading. In addition, the objective was to produce a method of assessment that was cheap and easy to repeat, and would provide an accurate reflection of the suitability of diverse areas for the inclusion in a biosphere reserve.

An underlying assumption made in this project was that cadastral properties will be the deciding unit when determining the reserve boundaries. This is a fundamental difference between the method of assessing land suitability for conservation areas developed for this project, and other more commonly used methods. A property will either be wholly included in or excluded from the reserve. The focus on a cadastral unit is a departure from the usual approaches to reserve design which focus on ecological units (Pressey *et al.*, 1993). It is felt that this approach is justified as it promotes connectivity within the reserve, by promoting the inclusion of whole farm properties rather than fragmented islands of particular conservation value. This connectivity is especially important for the conservation of faunal species (Noss and Cooperrider, 1994).

The assumption of the farm as the basic decision unit is based on the premise that the decision to participate in a biosphere reserve rests with the landowner. Compulsory participation or pressure exerted on landowners to participate is unacceptable and the reserve structure would be unstable from the start. The decision to participate would be a free choice made by the landowner, based on the overall suitability of his/her farm.

1.5 Fundamental concepts of a MAB reserve

The term 'biosphere reserve' is a designation awarded by the UNESCO MAB programme to reserves where a good management balance between conservation and development has been achieved (Francis, 1996).The long term goal of the MAB programme is to develop a worldwide network of these reserves where all the earth's ecosystem types and all human land uses will be represented. Research within these reserves and comparative research between these reserves will lead to a better understanding of man's interactions with nature, and through this will provide an indication of how the balance between man and his environment can be restored. The three fundamental roles of a biosphere reserve are: conservation, sustainable development, and research (Von Droste zu Halshoff, 1982).

MAB reserves are designed according to a model that allows for effective research, effective development of local communities, and for effective protection of fragile natural resources (Batisse, 1986). This model zones land in the reserve according to the intensity of land use permitted. There are three zone types: protected 'core' areas, buffer zones and transition areas (Figure 1.1).

The core areas consist of examples of pristine or minimally disturbed ecosystems. The boundaries of these are strictly defined and they are legally protected as conservation areas. Land uses are limited to non-consumptive, non-disruptive land uses such as research, environmental monitoring or low impact tourism (Figure 1.1). Strict protection of these areas does not necessarily exclude human intervention, particularly if it is considered protective management such as burning. MAB approved reserves will contain at least one of these core areas (Batisse, 1986).

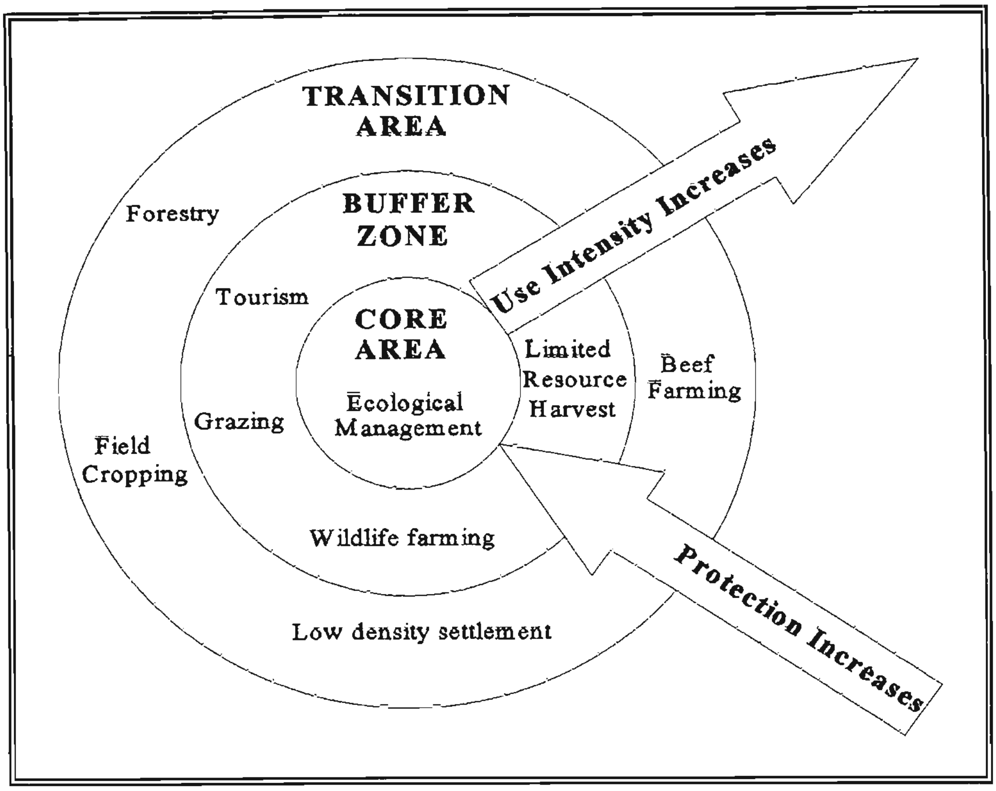


Figure 1.1 Schematic diagram of the components of a biosphere reserve (with some examples of permitted land uses)

The buffer zone, as its name suggests, acts as a buffer for the core area. It protects the core area from edge effects such as invasion by exotic weed species, noise, agricultural chemicals and wind effects associated with high intensity land uses. It gives the core area a degree of temporal stability should there be a change in ecological conditions. For example, a change in mean annual temperature due to global warming would change the characteristics of the core area, decreasing the habitat available to key protected species. In this case, suitable habitat may now be found in the buffer zone, and measures would be taken to include this in the core area. Buffer zones also act as a laboratory for research into the integration of human activities with conservation as more intensive land use is permitted in these areas. More intensive land uses are permitted in the buffer zone than in the core area, but the main management focus in the buffer zone is on conservation (Noss and Cooperrider, 1994). Permitted activities would include e.g. game farming, tourism, hunting, and sustainable harvest of firewood, thatching grass and medicinal plants (Figure 1.1). The buffer zone has definite boundaries and both the buffer zone and core area must have a clearly defined legal or administrative status, even when there are many land owners and administrative bodies involved in management of these areas (Batisse, 1986). Most biosphere reserves registered with UNESCO have depended on informal agreements between landowners and managers for the administration of the reserve. This type of agreement may be insufficient, and it has been recommended that biosphere reserves have legal protection at a national level (Batisse, 1993).

The transition area surrounds the buffer zone and acts as a further buffer for the reserve. However, land uses within the transition area are not heavily restricted (Figure 1.1) and the boundaries of the transition area are not necessarily definite (Batisse, 1986). Land management in the transition area is not directly controlled by the biosphere reserve administration. Conservation, sustainable development and research are practised in the transition area through cooperation between the local land managers and the biosphere reserve authority. The transition area is sometimes known as 'buffer zone II' (Noss and Cooperrider, 1994), or 'zone of cooperation' or 'zone of influence' (Batisse, 1984; Francis, 1996).

The Biosphere Reserve Nomination form (UNESCO, 1994) identifies the factors taken into consideration by UNESCO in determining whether an area meets biosphere reserve requirements. These factors include:

- Ecosystem/habitat type; Particular emphasis is placed on the inclusion of 'centres of endemism', which are rich in endemic, rare, or endangered plant or animal species. Other ecosystem considerations include: suitability for research into sustainable development; examples of a history of good land management, and examples of poor land management suitable for rehabilitation research.
- Human population of reserve; As people are an integral part of the biosphere and human development is one of the key roles of a biosphere reserve, human habitation of the reserve is essential. For biosphere reserves to be a success, people living in and adjacent to the reserve must be assured of a living without having to resort to theft, poaching or destructive land use practices (Von Droste zu Hulshoff, 1982).
- Tenure; The land tenure system, and the number of people holding tenure within the biosphere reserve will impact on the long term security and stability of the reserve.
- Legal protection; It is important that the core area is a legally protected conservation area in order to give some assurance of long term security for the reserve. Some level of legal protection within the buffer zone is also required. It has been suggested that

membership of a biosphere reserve should be registered over the title deeds of each property (Sandwith and Forrest, 1992).

- Administrative structure; The type and number of administrative bodies overseeing the land included in the biosphere reserve will have logistical implications for the management of the reserve. There are legal implications for conservation areas if the reserve falls under different provincial or local administrations.
- Physical characteristics; The physical characteristics of the reserve will help determine individuality of the reserve and comparability with other biosphere reserves. They will also be vital in determining the characteristic biological composition, and hence the levels of diversity.
- Characteristic species in the area; These will determine the ecosystem types that the reserve will represent and will determine the comparability of research within the biosphere with research from surrounding areas and from other biosphere reserves in similar biomes or ecosystem types.
- Climate; Climate has similar effects to the above property in that it will determine comparability of research data.
- Conservation value; Areas with high conservation values need the protection and conservation management associated with a biosphere reserve.
- Research and monitoring history and present or potential programmes; Availability of past data will make research within the reserve all the more valuable as it will be easier monitor changes over time. A clearly defined regional research agenda will help to target research needs both in this reserve and in other comparable biosphere reserves.
- Environmental education and training programmes; Environmental education enhances the chances of the long term success of the reserve by publicising the concepts behind conservation and sustainable development.
- Land use in the reserve; Land use is important for research and must also be compatible with the biosphere reserve objectives.
- Development and income generation opportunities; If the economic opportunities within the biosphere reserve do not have the potential to support the human population in a sustainable manner, the reserve is likely to fail.

- Management plan and implementation mechanisms; Without a carefully considered management plan, the full potential of the reserve will not be realised, and it may fail altogether.
- Networking; Part of the biosphere reserve concept is local and international networking. Successful development of sustainable management techniques in some reserves may motivate managers of other reserves to adapt these techniques for their own situation. Dissemination of research and monitoring results to local parties and to other reserves will lead to more informed management decision making. Structures for networking should be in existence or be in the process of development before UNESCO approval is given (UNESCO, 1994; Batisse, 1984; Noss and Cooperrider 1994).

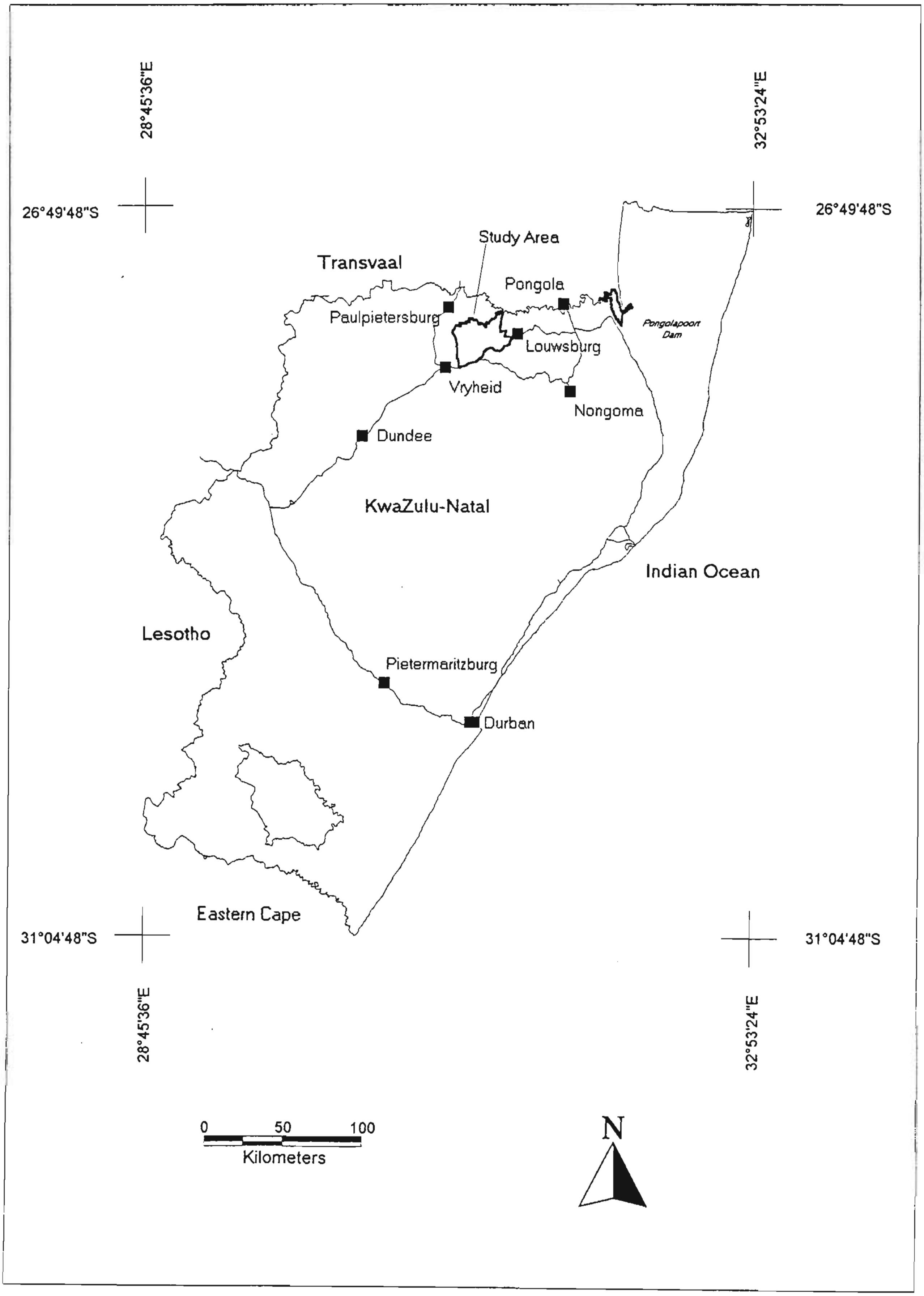
These factors were used as guidelines when identifying factors that would determine a farm's suitability to be included in a proposed biosphere reserve. This was done to ensure that suitability scores from this project reflected a farm's suitability according to UNESCO's own guidelines.

Chapter 2: Study Area

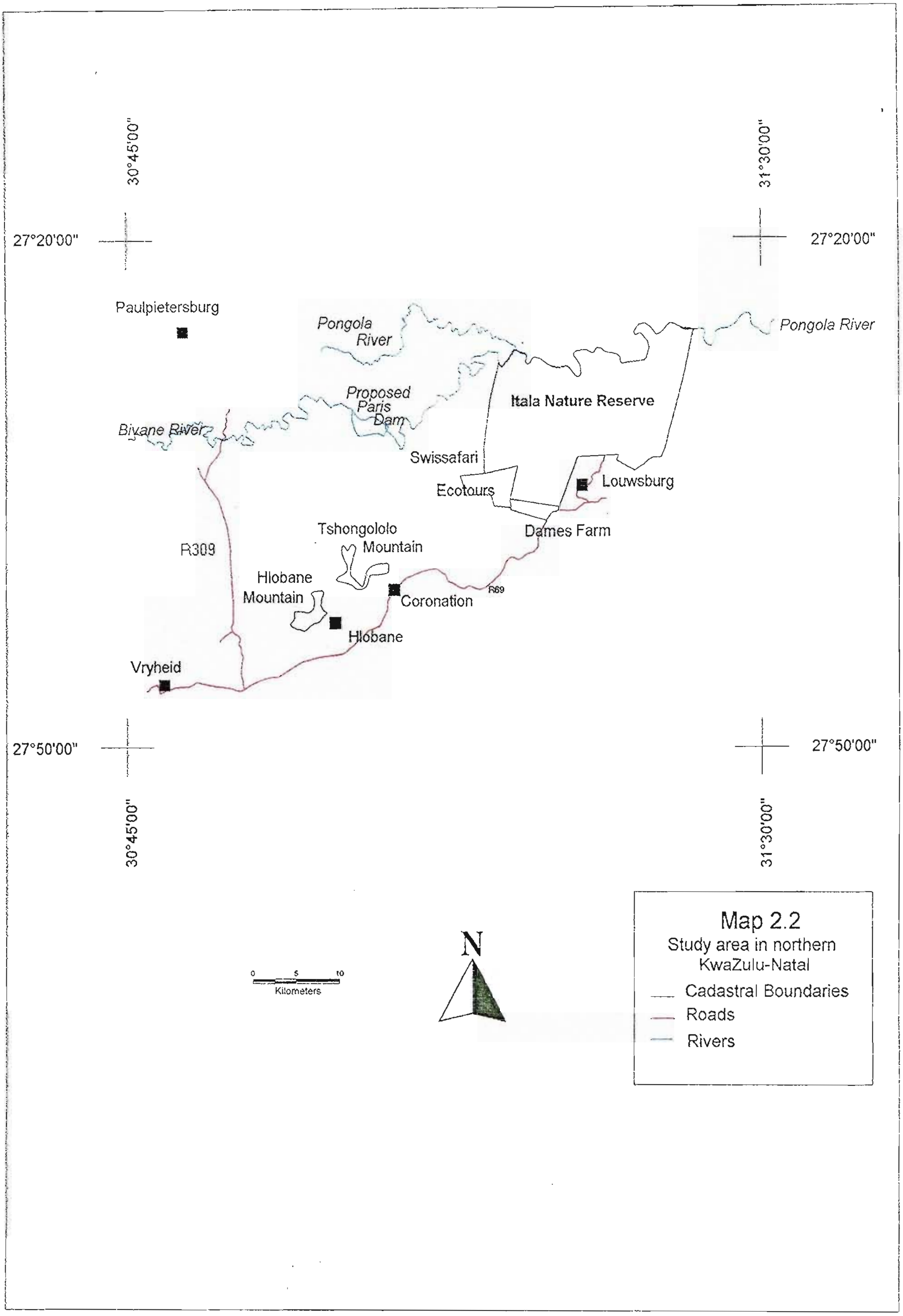
To ensure that all the relevant local dynamics are accounted for in this project, the historical and current contexts of the area must be examined. History plays a key role in determining the present settlement patterns; present land use, floral and faunal composition, present management strategies and the state and characteristics of the economy in the region. These factors all affect the suitability of a farm to be included in the buffer zone of a biosphere reserve.

2.1 Location of Study Area

The area chosen for this project is shown in Map 2.1. It is found on the 'Chief Directorate; Surveys and Land Information 1:250 000 series' sheet 2730 Vryheid and on the '1:50 000 series' sheets 2730BD Paulpietersburg, 2730DB Hlobane, 2730DD Vryheid, 2731AC Hartland, 2731CA Coronation and 2731CB Louwsburg. It is bounded to the north by the Bivane River; to the south by the R69 tar road from Vryheid to Louwsburg; to the west by the R309 tar road between Paulpietersburg and the R69 and to the east by Itala Nature Reserve (Map 2.2). Ideally, a project of this type, should examine a large area of all surrounding farms, with boundaries based on geographic or ecological boundaries (Garett, 1982). On discovering the number and variety of farms included in a 15 km radius of Itala, it was decided that this approach would be too time consuming for the scope of this project. A decision was made to cover a smaller area at a higher level of detail.



Map 2.1 Location of project study area.



Map 2.2 Northern KwaZulu-Natal region, including features relevant to the proposed Itala Biosphere Reserve.

This particular study area was chosen because the possibility of creating a biosphere reserve in this area has been considered by some of the local land managers [1,2,3] (Lowe *et al.*, 1996) . The researcher had a familiarity with the *status quo* in the study area in particular from a previous project undertaken by the School of Environment and Development (Barbosa *et al.*, 1996).

The tar roads on the western and southern borders of the study area were chosen as boundaries as they would constitute a major management complication were they to run through the reserve[4]. The Bivane river was an obvious natural boundary to the north. A river is more suited to inclusion in a reserve than a tar road, but was used as a boundary because the properties to the north of the Bivane were densely settled. The river provides a convenient natural boundary between these settlements and the more extensively managed land to the south.

2.2 Natural Context

2.2.1 Geology and Soils

The study area includes a wide range of geological formations ranging from the Pongola Supergroup, which dates back over 3000 million years BP, to the rocks of the Karroo Supergroup which formed 250 million years ago (Department of Mineral and Energy Affairs, 1988).

Geology is a determinant influence in many of the factors examined in this project. For example, geology plays a role in determining the economic potential of the land through contributions to the geomorphology of the landscape and to soil fertility and drainage characteristics. In particular, the Pongola and Mozaan Formations have given rise to very

---

[1] pers. comm. Ms. C. Cameron, Managing Director, HCC, Hlobane (1996).

[2] pers. comm. Mr. S. De Jager, District Conservation Officer, Vryheid, NPB (1996).

[3] pers. comm. Mr. D. Yunnie, Chief Conservator, Itala Nature Reserve, NPB (1996).

[4] pers. comm. Mr. C. Pullen, Officer in Charge, Weenen Nature Reserve, NPB (1996).

irregular topography, as they are extremely resistant to weathering[5]. The distinctive environment on these quartzite ridges has allowed unique plant communities to develop[6]. Such communities have a high proportion of rare and endangered plant species, and as a result, the ridges have been identified as a conservation 'hot-spot' by the Natal Parks Board[7].

The other economically important geological feature in the region is the presence of the Vryheid Formation of the Ecca Series. This is the coal bearing geological formation and is responsible for the coal mining industry in the region.

A wide variety of soil types is found in the area due to the variety of soil forming factors - in particular climatic variation with altitude and geology. According to the Land Type Unit (LTU) classification (MacVicar, 1986) nine different groups of soils are found in the study area; varying from deep well drained soils to shallow infertile soils (Map 2.3). The distinguishing soil characteristics of each LTU are included in Appendix 1. From Map 2.3 it can be seen that the majority of the study area is dominated by Mispah and Glenrosa soil forms (LTUs Fa and Fb). These shallow, infertile soils occur on hill tops and topslope areas. Because these soils do not have high agricultural potential this would tend to indicate land that might be more suitable for wildlife management (Manson *et al.*, 1995).

Structured soils, such as those found in type E land type units are indicative of dry conditions, where weathering of the clay minerals in the soil is slow. This type makes up a relatively small proportion of the study area and is found on flat, low altitude plateaux (MacVicar, 1986).

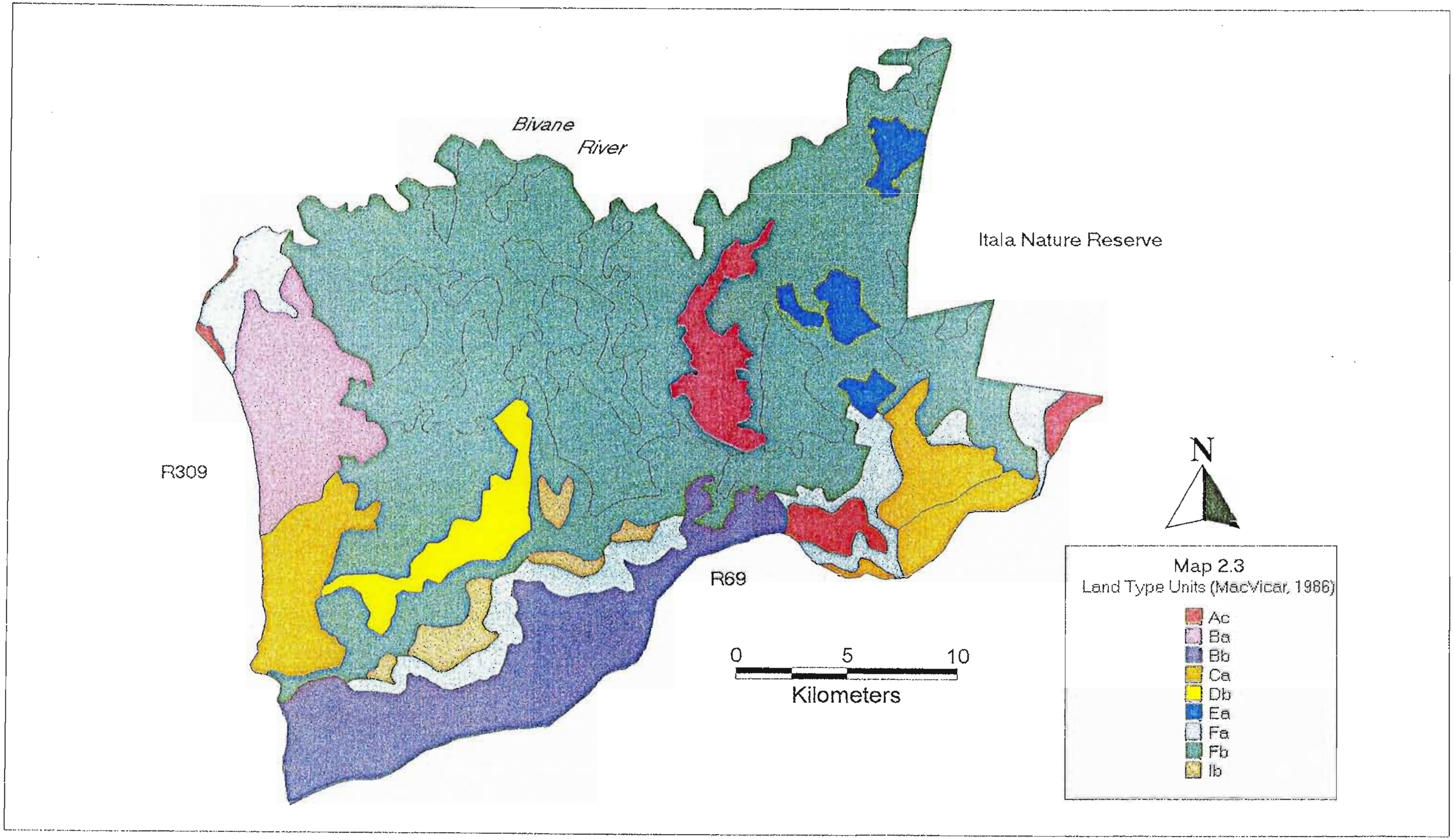
Cutanic soils (LTU Db) dominate only in a very small proportion of the study area, along the northern footslopes of Hlobane and Tshongololo mountains. These soils have an insignificant effect on farm suitability (Manson *et al.*, 1995).

---

[5]pers. comm. Prof V Von Brunn, Department of Geology, UNP (1996).

[6]pers. comm. Mr. R. Scott-Shaw, Botanist, NPB (1997).

[7]pers. comm. Mr. R. Scott-Shaw, Botanist, NPB (1997).



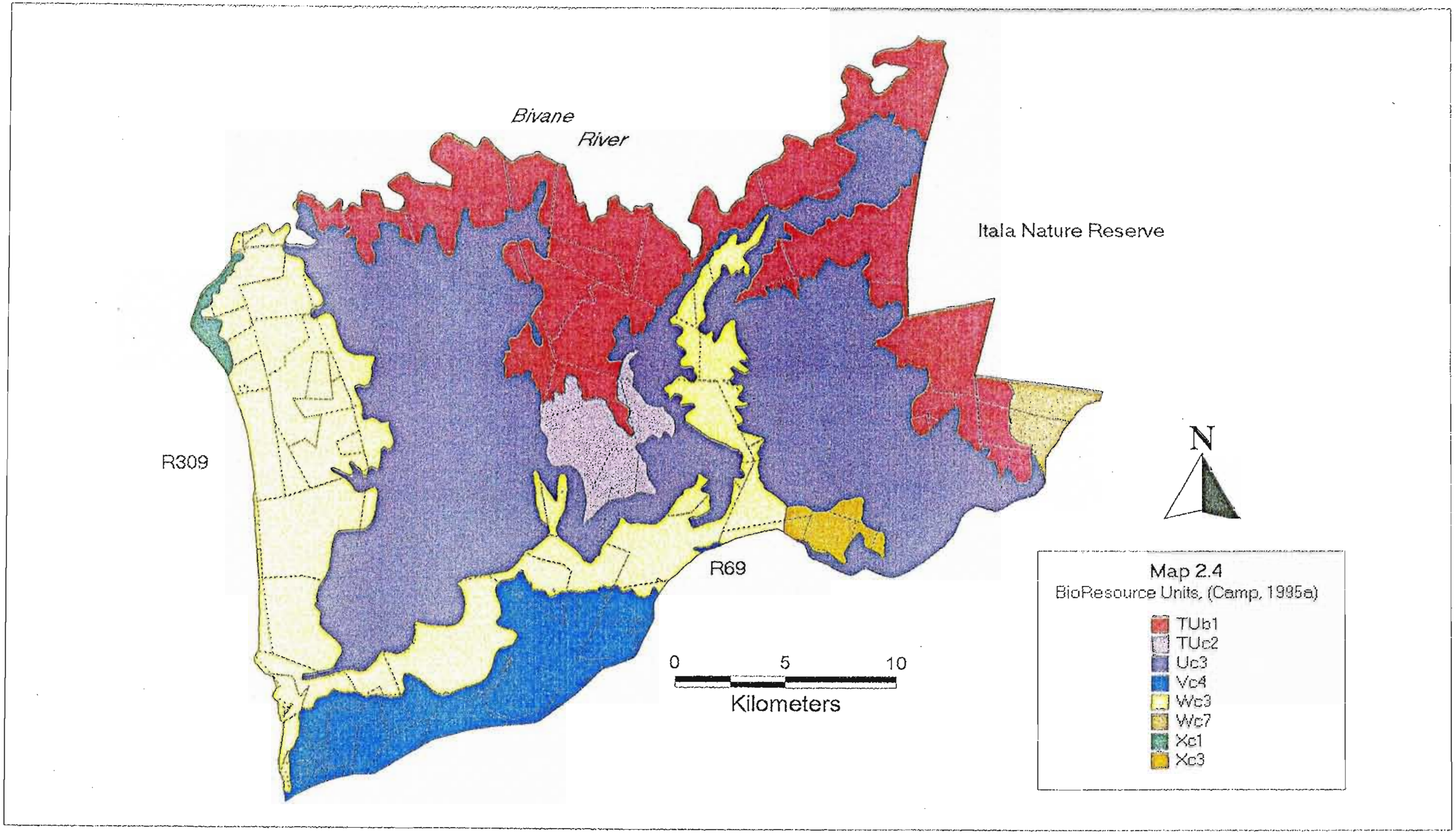
Map 2.3 Land Type Units for project study area (northern KwaZulu-Natal), (after MacVicar, 1986).

The plinthic catenae associated with LTUs B and C are found on the higher altitude flat areas. Large proportions of these classes are arable or support timber. LTUs Ac and Ae also tend to be arable, with deep well drained soil forms. In the study area, LTU A is limited to the Louwsberg plateau and the relatively flat bottomslope land between Yorkshire and Paris farms (Map 2.3). These arable areas would be less suited to inclusion in the biosphere reserve due to the high opportunity cost associated with inclusion (Young, 1992).

2.2.2 Climate and Hydrology

The study area falls into eight BioResource Units (BRUs). According to Camp (1995a) BRUs are areas where the primary ecological conditions will lead to relatively uniform biological expression, i.e. similar climate, soils and topography within each BRU will lead to similar vegetation physiognomy, animal carrying capacity and agricultural potential. Map 2.4 shows the BRUs for the study area and Appendix 2 gives the climatic characteristics for each BRU. BioResource Units are named according to the altitude and annual rainfall range in each BRU. Table 2.1 shows the system used for BRU acronyms. A double letter code for rainfall indicates BRUs with a wide rainfall range, e.g. VW would indicate a rainfall range of 750 to 850 mm *per annum*. The BRUs are numbered progressively through the province for reference purposes and to distinguish between units with similar altitude and rainfall characteristics but markedly different biological expression due to differences in factors other than altitude and rainfall (Camp, 1995a).

Mean Annual Precipitation (MAP) varies from 869 mm for Xc1 to 678 mm for TUb1. Similar altitude related trends are seen for temperature and evaporation: i.e. high altitude BRUs have higher rainfall, lower temperatures and lower evaporation figures. Altitude varies from 1624 m on the top of Hlobane mountain to 480 m at the confluence of the Bivane and Pongola rivers (Map 2.2).



Map 2.4 BioResource Units for project study area (northern KwaZulu-Natal), (after Camp, 1995a).

Table 2.1.a Key to BioResource Unit code acronyms (Rainfall range) (*after* Camp, 1995a)

Rainfall range (mm/y)	Code
<600	R
600-650	S
650-700	T
700-750	U
750-800	V
800-850	W
850-900	X
900-1100	Y
>1100	Z

Table 2.1.b Key to BioResource Unit code acronyms (Altitude range) (*after* Camp, 1995a)

Altitude range (m)	Code
0-450	a
450-900	b
900-1400	c
1400-1800	d
1800-2000	e
>2000	f

The majority of the study area falls into the Bivane catchment system (Schulze *et al.*, 1996). The Bivane is an important source of water for the Pongola sugar farming industry. The catchment is characterised by low winter flows, partly because of the broken topography of the region and the relatively small size of the catchment itself. Environmental concerns over the proportion of the Bivane catchment planted to forestry have recently lead to a moratorium on the issue of afforestation permits[8]. A study by the Department of Agricultural Engineering, University of Natal, Pietermaritzburg (Schulze *et. al.*, 1996) using the ACRU (Agricultural Catchments Research Unit) model has shown that abstraction for irrigation has a far higher impact on flows than forestry, and that further afforestation is not expected to have a significant effect on median low flows.

[8] pers. comm. Mr. T. Wolf, Research Technician, Itala Nature Reserve, NPB (1996).

2.2.3 Vegetation

Although there is little research on floral composition before humans started to impact on the vegetation, it is likely that the study area would have been dominated by forest or woodland. In the high flat areas grassland would dominate, and in valley bottoms riverine bush would be found (Hall, 1987). The high variation in climate and slope leads to a high variation in plant diversity within the study area. Vegetation lists compiled for Itala Nature Reserve, Hlobane Mountain and the proposed Paris Dam show that there is a notable difference in the composition of the vegetation communities. For example, there are 72 species of trees and shrubs found along the upper cliffs of Hlobane, and only 15 of these are found at Paris Dam[9]. This diversity of vegetation in the study area provides a further motivation for the establishment of a biosphere reserve in the region.

The study area extends over five of Acocks veld types (Acocks, 1988):

- North Eastern Sourveld (Veld Type 8), which Acocks (1988) expects to have been characterised by tropical forest in its climax state. The present vegetation in this veld type is mainly sour grassveld on the mountain tops and a scrubby thornveld on the escarpment and slopes;
- Lowveld, (Veld Type 10) which is categorized by Acocks (1988) as a 'tropical bush and savannah type' and occurs in low rainfall (500 - 750 mm per annum), low altitude areas (150 - 600 m);
- North Eastern Sandy Highveld (Veld Type 57) which is a grassland veld type found at high altitudes (1600 - 2150 m);
- Northern Tall Grassveld (Veld Type 64), which is a patchwork of *Hyparrhenia*-dominated old lands and *Tristachya leucothrix* dominated grassland with scrub forest relics merging into Lowveld in the valleys;
- and Natal Sour Sandveld (Veld Type 66), which occurs on badly drained shallow, sandy soils and is characterised by open savannah in a poor sourveld (Acocks, 1988).

[9] pers. comm. Dr. JE Granger, Department of Botany, UNP, (1997).

Because of the range in altitude and climate, there is considerable ecological variation between the relatively sweet, woody Lowveld and the high rainfall, high altitude, grassy sourveld of the North Eastern Sandy Highveld (found on the mountain plateaux) (Map 2.5).

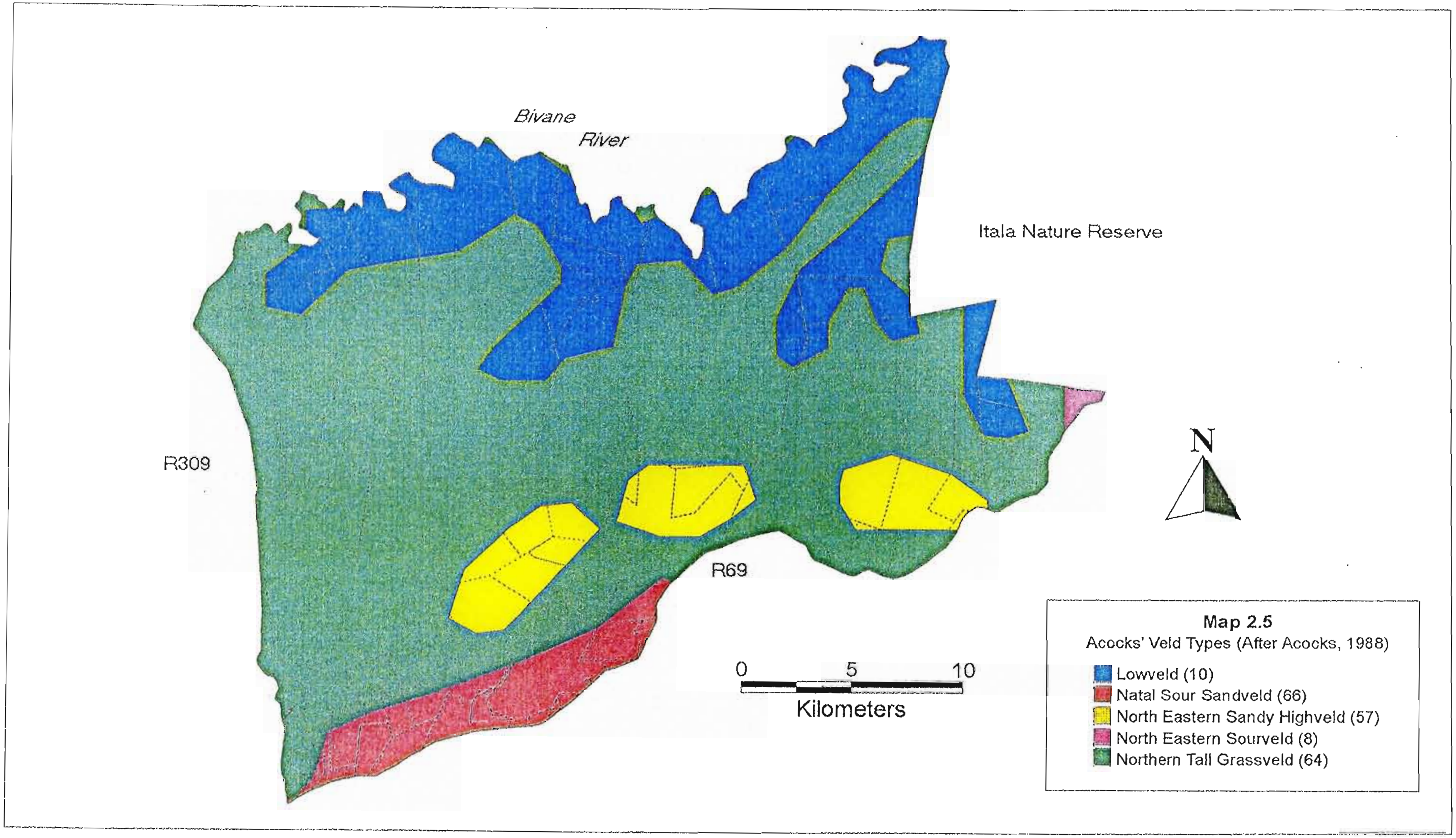
The recently published 'Vegetation of South Africa, Lesotho and Swaziland' (Low and Rebelo, 1996) presents vegetation types based on more accurate ecological criteria than were available to Acocks when he wrote his memoir. These ecological criteria would determine dominant vegetation types in each unit, in the absence of man's interference[10]. The study area includes three of these vegetation types, namely: North-eastern Mountain Grassland (Type 43), Natal Lowveld Bushveld (Type 26) and Natal Central Bushveld (Type 25).

North-eastern Mountain Grassland is part of the grassland biome and incorporates parts of Acocks Veld Types 8 (North-eastern Mountain Sourveld) and 57 (North-eastern Sandy Highveld). This vegetation type is found on shallow soils in relatively high rainfall areas (700 - 1100 mm *per annum*) and low temperatures (average of 15°C). The area has many rare and endemic plant species and, although it is predominantly a grassland veld type, forest patches do occur. The main threat to this veld type is the expansion of the forestry industry (Low and Rebelo, 1996).

Natal Lowveld Bushveld is part of the savannah biome and falls within Acocks Veld Type 10 (Lowveld). Grazing and fire are the two parameters which determine the expression of this veld type. It is warmer than North-eastern Mountain Grassland (mean annual temperature of 24°C) and has an MAP of 800 - 900 mm. The conservation status of this veld type is good, with areas characteristic of this veld type found in Hluhluwe-Umfolozi, Ndumu and Mkuzi Nature Reserves (Low and Rebelo, 1996).

---

[10] pers. comm. Dr. JE Granger, Department of Botany, UNP (1997).



Map 2.5 Acocks' Veld Types for project study area (northern KwaZulu-Natal), (after Acocks, 1988).

Natal Central Bushveld is also part of the savannah biome. It incorporates parts of Acocks Veld Types 64 (Northern Tall Grassveld) and 66 (Natal Sour Sandveld). The MAP is 600 to 900 mm and mean temperatures range from 22°C for January and 10°C for July. Soils for this veld type are shallow and with low rainfall are duplex and highly erodible, or are dominated by black clays. Where the soils are highly erodible, grazing and fire regimes require careful management. Very little of this veld type has been conserved, the majority being used for forestry and agriculture (Low and Rebelo, 1996).

The present state of the vegetation in the region is reflected by an average a veld condition score of between 60% and 75% (Camp, 1995b). Hlobane mountain top has not been subject to high grazing pressures, and many steep slopes still support woody vegetation communities [11]. It is therefore expected that this area will be in good ecological condition. It is probable that the majority of the flatter land has been overgrazed or cropped, especially on old labour farms [12].

2.2.4 Fauna

A large number of fauna species that are considered rare or endangered have previously been found in northern KwaZulu-Natal (Rowe-Rowe, 1992; 1994). This region has large areas of undeveloped land which have the potential to support these species. Many of the farms to the east of the Itala Nature Reserve are already managed as purely game enterprises[13]. The Pongolapoort Biosphere Reserve, surrounding the Pongolapoort Dam (Map 2.1) is well established and many of the participants are finding game farming to be a more profitable option than traditional beef farming[14].

The study area has the potential for a wide variety of game, from plains game on the high grasslands to browsers and bushveld game in the Lowveld (Rowe-Rowe, 1992; 1994). There

---

[11] pers. comm. Dr. JE Granger, Department of Botany, UNP (1996).

[12] pers. comm. Mr. H Urquhart, Agricultural Extension Officer, Department of Agriculture, Vryheid (1996).

[13] pers. comm. Mr. S De Jager, District Conservation Officer, Vryheid, NPB (1996).

[14] pers. comm. Mr. H Urquhart, Agricultural Extension Officer, Department of Agriculture, Vryheid (1996).

is little game remaining outside of Itala Nature Reserve, but reintroductions to Itala have been successful and there is potential to reintroduce game to the wider area in future (NPB Communications, 1994).

The 'classic game country'[15] of the Lowveld covers only a small percentage of the study area (Map 2.5). Nevertheless there is good potential for the introduction of many of the commercial game species such as impala (*Aepyceros malempus*), reedbuck (*Redunca arundinum)* and blesbok (*Damaliscus dorcas phillipsi*), into the higher altitude grasslands. Kudu (*Tragelaphus strepsiceros)* and nyala (*Tragelaphus angasi*) could be re-introduced to the more woody areas (Rowe-Rowe, 1994). Of the ungulate species listed in the South African Red Data Book (Smithers, 1986): black rhinoceros (*Diceros bicornis*), oribi (*Ourebia ourebi*) and possibly tsessebe (*Damaliscus lunatus*) would have occurred naturally in the study area (Rowe-Rowe, 1994). Of the carnivores in the Red Data Book (Smithers, 1986): wild dog (*Lycaon pictus*), ratel (*Mellivora capensis)*, brown hyaena (*Hyaena brunnea*), leopard (*Panthera pardus*), serval (*Felis serval*) and aardwolf (*Protelis cristatus*) all have the potential to occur in this area should the area be developed as a biosphere reserve (Rowe-Rowe, 1992).

Over 300 bird species have been recorded in the Itala Nature Reserve (NPB Communications, 1994), including some uncommon birds such as bald ibis (*Geronticus calvus*), goliath heron (*Ardea goliath*), baillon's crake (*Porzana pusilla*), half-collared kingfisher (*Alcedo semitorquata*), and the blue swallow (*Hirundo atrocaerulea*) (NPB Communications, 1994). Bald ibis have also been seen at Hlobane[16]. The establishment of a biosphere reserve in the region would lead to a more in depth study of local birdlife, and possibly to the more positive identification of rare bird species.

Detailed research into the entomological species found in the region may also reveal other rare and/or endemic species.

---

[15] pers. comm. Mr. D Yunnie, Chief Conservator, Itala Nature Reserve, NPB (1996).

[16] pers. comm. Prof. R Edgecombe, Department of History, UNP (1997).

2.3 Social Context

Figure 2.1 shows the progression of inhabitants of the area and the main events that have determined the government of the area in the last two centuries. The earliest human inhabitants of the study area date back to the Middle Stone Age (120 000 years ago to 30 000 years ago) (Anderson, 1996). Evidence, in the form of rock shelter paintings and artefacts, has been found in both the archaeological surveys that have been done in the region: at the Paris Dam site (Anderson, 1996), and in Itala Nature Reserve (Whitelaw, 1989) (Map 2.2). This is evidence of habitation of the area by Middle and Late Stone Age people (30 000 years ago to the last century). San relics and rock art which are still present today, are an important part of the cultural, historical and archaeological heritage of the area. These are valuable for education and research purposes, and if well preserved, easy to reach or in large quantities, would also be a boost to the tourist attractions of the area[17].

These Stone Age people were hunter gatherers and their major impact on the present vegetation would have been an increase in veld burning. It has been hypothesized that the main use of fire by the Stone Age peoples was to combat bush encroachment, and to improve grazing for game animals[18]. Clearing of timber for firewood would have had a more selective effect on present day species of vegetation communities.

The people who settled in this area in the Late Iron Age (1000 years ago to 1830 AD) were mainly agro-pastoralists, though there is evidence of iron mining and smelting at Ntabayensimbi in Itala itself (Whitelaw, 1989). As agro-pastoralists they apparently existed in harmony with their environment. Degradation of the grazing land appears to have started only when these people were crowded onto much smaller areas of land with the colonisation of KwaZulu-Natal[19].

---

[17] pers. comm. Mr. G Whitelaw, Archaeologist and Cultural Resource Manager, Natal Museum (1996).

[18] pers. comm. Dr. JE Granger, Department of Botany, UNP (1996).

[19] pers. comm. Dr. JE Granger, Department of Botany, UNP (1996).

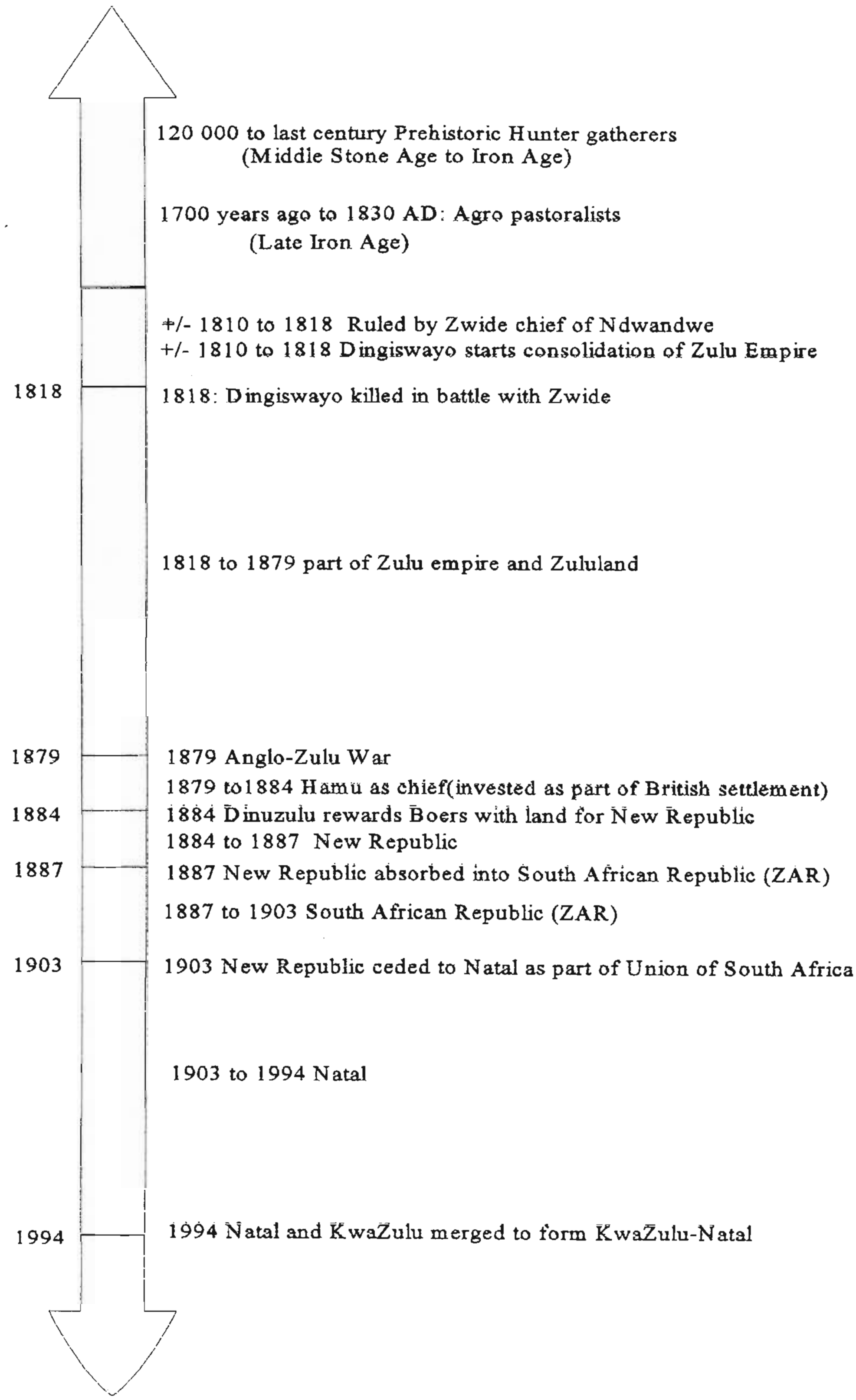


Figure 2.1 Summary of the history of northern KwaZulu-Natal

During the latter stage of the late iron age the area was inhabited by people of the Ndwandwe group of tribes under Zwide while Dingiswayo started consolidating Zulu empire. Dingiswayo was killed in a war with Zwide and Shaka took over the Zulu chieftainship. The lands of the Ndwandwe were incorporated into the Zulu empire, and remained as part of Zululand during the formation of the Natalia Republic and later the Natal Colony (Brookes and Webb, 1987). Many of the present black inhabitants of the region stem from the Ndwandwe people[20].

The decline in power of the Zulu throne and the growth of the neighbouring colony of Natal eventually lead to the Anglo-Zulu war of 1879. During this war, the northernmost of the three British columns that crossed into Zululand with the intention of marching on Ulundi, was active in the Hlobane region. Their supply column was ambushed at Ntombe river and consequently they decided to raid Hlobane mountain top, which had some 2000 Zulu cattle hidden there from the British. Unknown to the British, the chief of the area was in contact with the main Zulu army nearby. The cattle raid escalated into the Battle of Hlobane where the British were defeated and had to retreat to Khambula. The British however won the decisive Battle of Khambula shortly afterwards, and went on to shatter the Zulu army at Ulundi, (Brookes and Webb, 1987; Edgecombe, 1996; Laband 1996).

After the Anglo-Zulu war, the British divided Zululand up between subordinate chiefs, in an effort to return to the fragmented tribal system found before the *mfecane* and the consolidation of the Zulu empire. The Ndwandwe people were settled in most of their old lands under a direct descendant of Zwide. Hamu, a son of Mpande, who had defected to the British was made chief of a large area near Itala (Whitelaw, 1989). The arrangements made by the British were not popular and there was much tension between the chiefs, effectively leading to a Zulu civil war. Hamu was defeated by the royalist Usuthu under Dinuzulu who allied himself with the Boers. As payment for their alliance, Dinuzulu granted his Boer allies 800 farms in north western Zululand with a total area of 800 000 morgen (over 10 000 square kilometres) (Brookes and Webb, 1987).

[20]pers. comm. Prof. J Laband, Department of History, UNP (1996).

The Boers who settled these farms formed the New Republic in 1884. In 1887, the New Republic was absorbed into the South African Republic (ZAR). After the Anglo Boer war, the land was ceded to Natal (1903) and has been part of Natal, more recently KwaZulu-Natal, ever since (Brookes and Webb, 1987). The majority of the white farming population in the region remains Afrikaans. Some of these families have ties to the New Republic settlers[21].

Over the years, northern KwaZulu-Natal has not been a priority area for investment or development initiatives. Factors contributing to this include: distance from major centres, low population densities, and relatively poor potential for economic growth. As a result, regional education levels are low, leading to a lack of skilled manpower. A population growth rate of 4% per annum in recent years has meant that the generally rural based economy has been unable to keep up with population growth. Unemployment is high, with a regional average of 40.16% and levels of up to 78% in some magisterial districts. Consequently, poverty within the region is rife, with urban blacks earning an estimated per capita income of R 153 per month and farm workers earning approximately R 120 (Cameron, 1996). (The poverty datum line for Pietermaritzburg is R 153 per person per month. It is theoretically not possible to survive below this income level).[22]

The Land Reform (Labour Tenants) Act 3 of 1996 is aimed at providing land rights to labour tenants. As many of the farms in the area have been labour farms, it is likely that the implementation of this bill will have significant impacts on land tenure in the region. It is hoped that secure tenure for these communities will encourage wise land management on these farms.

2.4 Economic Context

The exploitation of the coal resources at Hlobane, the oldest coal mine in the study area, was started by Carl Birckenstock, one of the founders of the New Republic. In 1908, the Vryheid (Natal) Railway, Coal and Iron Company was founded, and mining on a commercial scale was

---

[21] pers. comm. Mrs. S Henderson, Local Historian, Dundee (1996).

[22] pers. comm. Dr. N McKerrow, Edendale Hospital (1996).

started at Hlobane (Edgecombe, 1996). Other coal seams were found at Coronation and in the Tshongololo mountain (Map 2.2), and the coal industry grew to be a major economic force in the region. Iron ore deposits were also found at Parijs and Ntabayensimbi, but these have never been mined on a large scale. Gold was mined in the region for a period at the Ngotshe and Wonder mines. The gold resources in the region are no longer commercially viable, and the mines have been abandoned (NPB Communications, 1994).

The coal mines which, for the last eight decades, have provided a mainstay for the economy of the region, are coming to the end of their economic lives, as it has become uneconomic to mine the remaining deposits. The mines themselves are faced with the enormous expenses associated with rehabilitating their land in order to obtain their closure certificates, and therefore cannot afford to keep paying large labour forces while they streamline operations. Some mines have closed down already, while others have started downsizing[23].

Agriculture has always been a major industry in the region. Timber and maize have been grown in the areas capable of supporting cultivation, while beef has been the chief livestock industry. Many farms have been used as labour farms[24]. Land owners settle their labour on these farms, and demand free labour for a certain number of months per year in return for the right to live on the farm. This has lead to the formation of communities who have lived on a farm for up to two or three generations but who have not had any rights to that land. Tenants land rights to tenure of these farms has been established through the Land Reform (Labour Tenants) Act 3 of 1996.

The agricultural industry does not seem to be in any position to provide growth to cover the loss of turnover caused by the decrease in mining. Beef farmers held a field day on 'Survival Strategies for Beef Farmers in Northern Natal' in September 1996, as beef prices are dropping, and input prices rising[25]. Two of the farms within the study area are exploring commercial game farming as an alternative to beef. Swissafari EcoTours own and operate a game farm on the

---

[23] pers. comm. Mr. CR Edwards, Mine Manager, Hlobane Colliery (1996).

[24] pers. comm. Ms. M Curry, Department of Land Affairs, Vryheid (1996).

[25] pers. comm. Mr H Urquhart, Agricultural Extension Officer, Department of Agriculture, Vryheid (1996).

western border of the Itala Nature Reserve (Map 2.2), and have stocked the farm with grazing and browsing animals such as zebra (*Equus burchelli*), impala (*Aepyceros malempus*) and kudu (*Tragelaphus strepsiceros*) [26]. The Dames' farm (Map 2.2), which lies to the south west of Itala has also been stocked with buck. The game species on this farm are run with the cattle and are used for private hunting[27]. A survey of the suitability of the Hlobane property for game farming has been conducted (Map 2.2) (De Jager, 1996) and although costs of implementation are considered too high for the expected returns, game farming remains one of the possible development options for that property[28]. A survey of the land surrounding Itala Nature Reserve estimated that consumptive wildlife management could earn revenues of between R 57.00 and R 67.00 per hectare, while non-consumptive tourist revenues could bring between R 180.00 and R 398.00 per hectare (Anon, 1996a). These are crude figures based on a superficial preliminary survey of the region.

The soil and slope characteristics of the area, as well as the great distances from markets, seem to indicate that timber is the crop with the best economic potential for the area. However, a moratorium has been declared on afforestation in the Pongola catchment. A large percentage of the catchment is already under timber, and it is suspected that this has had a negative effect on the groundwater level[29]. The forestry industry is not labour intensive, and requires little skilled or managerial labour. Development of the industry would not have a significant effect on employment and income values at present. Most arable land has been planted to maize but there is insufficient arable land for maize to provide a back-bone industry for the region[30].

---

[26] pers. comm. Mr. S De Jager, District Conservation Officer, Vryheid, NPB (1996).

[27] pers. comm. Mr. S De Jager, District Conservation Officer, Vryheid, NPB (1996).

[28] pers. comm. Mr. S Swart, Manager, Ferroland Grondtrust, Hlobane (1996).

[29] pers. comm. Mr. T Wolf, Research Technician, Itala Nature Reserve, NPB (1996).

[30] pers. comm. Mr H Urquhart, Agricultural Extension Officer, Department of Agriculture, Vryheid (1996).

Northern KwaZulu-Natal does not have the long history of conservation that Zululand has. Itala Nature Reserve is the major game reserve in the region, and was only taken over by the NPB in 1973 (NPB Communications, 1994). Since then, other game farming initiatives have started, but there is still very little area under legal protection as conservation areas[31]. The Itala Biosphere Reserve could therefore prove to be a key factor in the development of the region.

[31] pers. comm. Mr S De Jager, District Conservation Officer, Vryheid, NPB (1996).

Chapter 3: Methods

3.1 Overview

As stated in Chapter 1, one of the objectives of this project was to develop a method whereby different classes of data could be compared directly with each other in respect of their effect on farm suitability. For this reason, and because of the limited time allocated to the project, maximum use was made of standard classifications and existing data for the region. As a result, a 'coarse filter' measure of suitability is provided (Noss and Cooperrider, 1994) and various farms are identified from the results where a more 'fine filter' type of analysis is applied.

The method used to obtain farm scores reflecting the suitability of the farm for inclusion in a biosphere reserve is outlined in Figure 3.1. The factors used to determine the study area have been discussed in Section 2.1. The area was assessed with respect to suitability for inclusion in a biosphere reserve on a farm by farm basis. Farms were defined as cadastral units of land bounding on each other and with a common owner. Farm units were identified using data from the Registrar of Deeds and from the Surveyor General's Office as of August 1996.

At the outset of the project, factors affecting the establishment of a biosphere reserve were identified by the researcher in workshops with the project supervisors and role players in the study area. A list was compiled of the types of information affecting the suitability of each farm, and likely sources for that information. The people on this list were contacted, briefed on the project, and asked for any data which would contribute to the project. In this manner, interested and affected parties were made aware of the potential development and were able to make contributions from their particular viewpoints. In cases where no suitable data could be found on a particular factor, the influence of this factor was accounted for by other related factors. For example, there were no social indicator data available at a suitable level of detail for this project. Social indicators such as employment and poverty levels were therefore assumed to be related to settlement type such as formal towns, rural communities and commercial farm labour settlements.

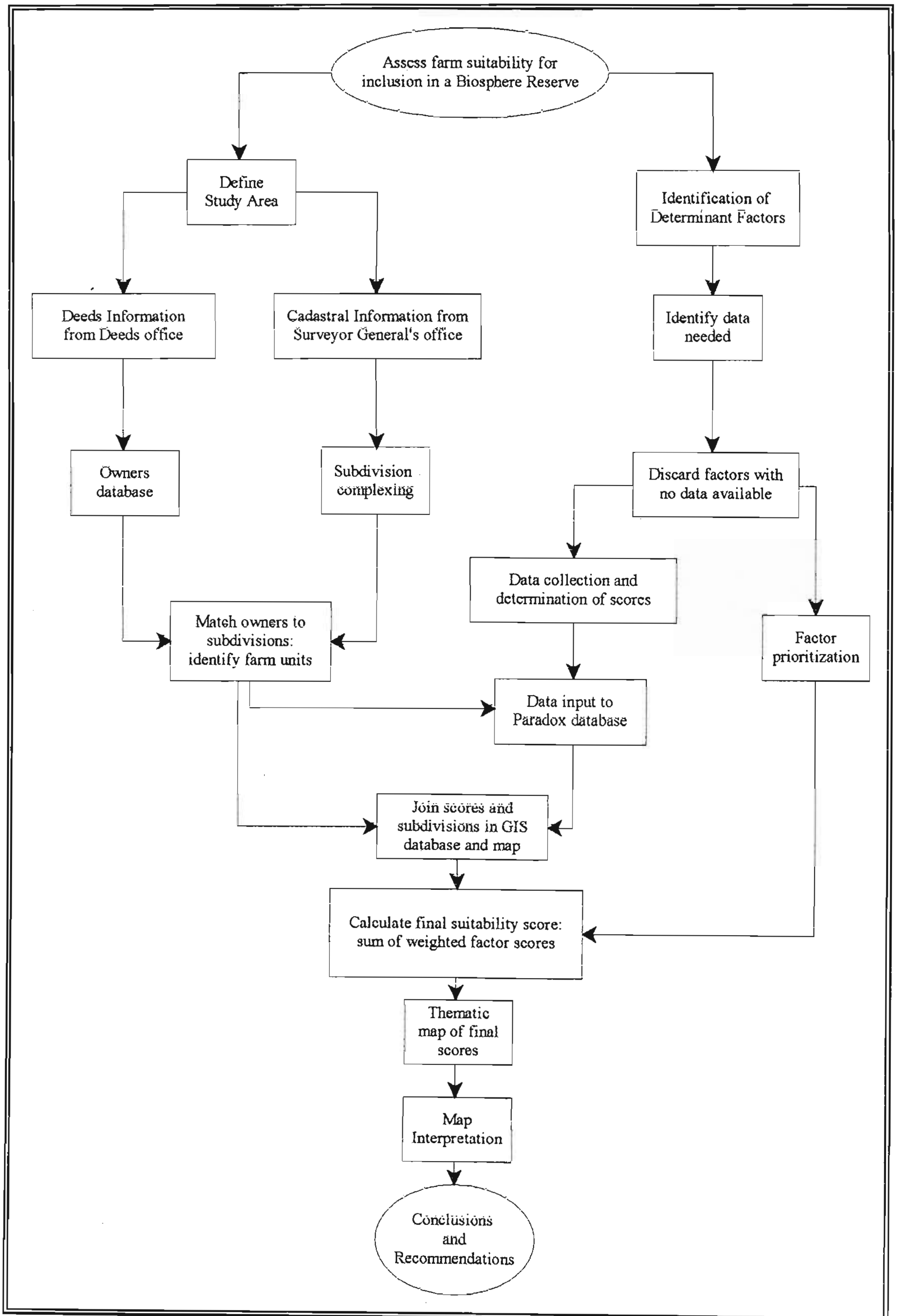


Figure 3.1 Flow diagram of procedure followed in determining farm suitability for inclusion in a biosphere reserve.

Each farm was allocated a score for each factor, according to that factor's impact on the farm's suitability for inclusion in a biosphere reserve. Scores were allocated on an ordinal verbal scale, although numbers were used to represent the intensity of suitability for inclusion.

The Analytical Hierarchy Process (AHP) (Saaty, 1990) was used to determine the relative weighting of each factor in determining overall suitability. The individual factor scores for each farm were entered into a computer database in a GIS system. The final farm score was determined by multiplying the factor scores by the factor weightings and summing the product. The final score gave a reflection of the suitability of that farm for inclusion in the biosphere reserve.

The final scores were classed into suitable farms and non-suitable farms. These were thematically mapped with the GIS and conclusions and recommendations were drawn from the thematic maps.

3.2 Identification of Farm Units

The underlying assumption of this project is that a particular farm within the study area will be included or excluded from participation in the reserve on the basis of the farm's average suitability. This decision will be based on the characteristics of the entire property rather than on the characteristics of each subdivision. Farm units were determined from the deeds and cadastral information.

Original grant and subdivision boundaries were acquired in digital format with the permission of the Surveyor General's Office in Pietermaritzburg[1]. These boundaries were imported into 'Microstation' CAD software. The Bivane River and the R69 and the R309 (from Vryheid to Paulpietersburg) roads were added to this map to complete the study area boundaries. The data were cleaned and complexed so that each farm subdivision within the study area was now defined as a polygon with a fixed area rather than as a set of boundary lines (Map 3.1). It was

[1] pers. comm. Mr. R Harris, Surveyor General's Office, Pietermaritzburg (1996).

now possible to link data to each farm subdivision within a GIS. The map was exported as an AutoCAD DXF file and imported into 'MapInfo 2.1' (MapInfo, 1992), a GIS package.

Deeds information was purchased from the Deeds Office in Pietermaritzburg in order to determine actual management units. The information included the name of the owner of each subdivision. A database was created in 'Paradox for Windows 5.0' (Borland, 1994) which held the original grant name and number for each farm, the subdivision number, the name of the owner and the identification number of the subdivision for the 'MapInfo' database (Appendix 3). The 'Paradox' database software was used because the database functions available in 'MapInfo 2.1' are very limited and it was more convenient to sort and manipulate data in 'Paradox' and then export it to 'MapInfo' in DBF (dBASE) format.

Farms were sorted according to owner name in 'Paradox'. Where farms with a common owner had a common boundary, the farm subdivisions were merged into single units in 'MapInfo'. The final map showed a total of 161 farm units within the study area (Map 3.2, Appendix 4, Workspace 'Work1'[2]). These farms were used as the basic units for the project. Scores for each factor determining farm suitability were given to each farm unit.

3.3 Identification of Determinant Factors

Identification of the factors to be used in this project to determine the suitability of a farm for inclusion in a biosphere reserve was achieved through discussion with the project supervisors and with potential role players in the region such as the Natal Parks Board[3], the Hlobane Community Complex[4], and the local Development Facilitators office[5].

---

[2] Farms are referred to by their farm identification number (Farm ID) from the 'MapInfo' database. This method of referring to farms was chosen because many of the farm units were made up of a number of subdivisions from different original cadastral grants. The farm owner could not be used as an identifier as some organisations or people owned more than one farm unit within the study area.

[3] pers. comm. Mr. A Marchant, Regional Ecologist, North, NPB (1996).

[4] pers. comm. Ms. C Cameron, Managing Director, HCC (1996).

[5] pers. comm. Mr. J De Villiers, Development Facilitator (1996).

Map 3.1 Cadastral property units: grants and subdivisions between Vryheid and Itala Nature Reserve (labelled by 'MapInfo ID').

Map 3.2 Project farm units: neighbouring cadastral subdivisions with a common owner (labelled by 'MapInfo ID').

The following sections list the factors identified and explains why they were or were not used in the assessment of farm suitability.

3.3.1 Sensitive Hydrological Catchments

South Africa is an arid country and wise management of water resources is imperative if the country is to develop in a sustainable manner. Huntley *et al.* (1989) identify water as 'the most critical resource for socio-economic development'. It is important that both water quality and quantity are conserved to ensure the country's future stability (Coetzee and Cooper, 1991). A biosphere reserve would offer protection to hydrological catchments where changes in land use may have serious effects on the water quality or quantity supplied by that catchment. Catchments that have had previous water quality problems due to unrestricted land uses may also benefit from being included in a biosphere reserve.

The hydrological impacts of land use practices in the Pongola/Bivane catchment have been examined in a study by the Department of Agricultural Engineering of the University of Natal, Pietermarizburg, commissioned by Forest Industries Association (Pietermaritzburg) (Schulze *et al.*, 1996). This study found that the Bivane/Pongola catchment is already under stress from the amount of irrigation water extracted for the Pongola sugar estates. This stress is enhanced by the low winter flows characteristic of this catchment (Schulze *et al.*, 1996).

However, the report did not give individual model results for the various sub-catchments. The hydrology of the area was not useful as a criterion in the assessment of individual farm suitability as hydrological data were not available at a sufficient level of detail to differentiate between farms within the study area. It can be assumed, however, that irrigated arable land constitutes an unsuitable land use for a biosphere reserve because of the effects it has on the hydrology of the region. Irrigated arable land is classed as intensively managed farm land and is given a negative score.

3.3.2 Soil Conservation

Soil, along with rainfall, is perhaps the most important factor in determining the agricultural and therefore economic potential of the land (Manson *et al.*, 1995). Soil is also very sensitive to mismanagement and once degraded through erosion, is not easily rehabilitated (Soil Classification Working Group, 1991). KwaZulu-Natal is especially prone to erosion as it is characterised generally by steep slopes and relatively frequent heavy rainfall (Van Der Eyk *et al.*, 1969). As a result, soil conservation practices are important throughout the province, and especially in areas where land management is geared towards conservation and sustainable land use.

There are many farms within the study area where severe gully erosion is already evident. Not only is it wise management practice to institute soil conservation measures in these areas, there is also a legal obligation of the landowner to do so in terms of the Conservation of Agricultural Resources Act 43 of 1983. It would be beneficial to areas affected by severe gully erosion to be afforded the formal protection associated with inclusion in a biosphere reserve.

3.3.3 Vegetation Conservation

Specific priorities for the conservation of vegetation types and communities were identified on the basis of either poor representation of that vegetation type in conservation areas, or the presence of plant species with specific conservation value in plant communities. Conservation value was determined with reference to rare and/or endangered species; or valuable habitat for rare or endangered fauna; or social or cultural value. These priorities are in accord with the conservation priorities for vegetation set by the NPB.[6]

3.3.4 Fauna Conservation

It is likely that in an area with a high representation of endemic floral species, there will be some level of specialised fauna that has developed to take advantage of the unique habitats. At

---

[6] pers. comm. Mr. R Scott-Shaw, Botanist, NPB (1996).

present, no such species are known, although the Natal Red Rock Rabbit (*Pronolagus crassicaudatus*) has been sighted on Hlobane mountain top[7]. No data are available on the distribution of rare and endangered fauna in the study area. This is a field with high research potential and once the area is under conservation management associated with a biosphere reserve, any such species should be identified. Habitat for endangered macro-fauna such as rhinoceros and buffalo, will also become available for populations of these animals. Any rare or endangered fauna found within the area will have positive effects on tourism potential.

3.3.5 Agricultural Potential

Agricultural potential affects suitability of the farm for inclusion in the biosphere reserve by providing an opportunity cost, or best alternative use for the land. As the type of biosphere reserve considered for this project is based on extensive land use practices, high potential agricultural land will not be suitable for the reserve as it would be more beneficial to farm it more intensively. Therefore, the higher the agricultural potential of the farm, the less suitable it will be for biosphere reserve purposes.

3.3.6 Major Dam Sites

The presence of major dam sites was considered to be an insignificant factor and required a three dimensional digital model of the area. Creating this was found to be impractical in the time allocated for the project.

3.3.7 Infrastructure

Detailed information of infrastructure such as electrical reticulation, minor road networks and state and extent of fencing was not available. It was decided that infrastructure would not be included in the list of decisive factors for this project. Tourism infrastructure has been accounted for under tourism potential, as have cultural and archaeological characteristics (Section 3.3.10).

---

[7] pers. comm. Dr. JE Granger, Department of Botany, UNP (1997)

3.3.8 Present Land Use

The present land use of each farm will determine the scale of change needed in management to make it comply with biosphere reserve requirements. Farms with high proportions of irrigated or cropped land would be less suitable for inclusion than farms where little change has been made to its natural state. Farm size is taken into account in this factor as intensity of management is usually related to farm size.

3.3.9 Location - Distance From Core Area

For logistical reasons, the further away a property is from the core conservation areas (Section 1.5), the less it is likely to stand out as an obvious property to be included in the reserve, and the greater the likelihood for there to be natural or physical barriers between it and the biosphere reserve.

3.3.10 Tourism Potential

Tourism potential was used as a bucket category where tourism related characteristics of each farm could be reflected, if they were not accounted for elsewhere. Factors such as tourism infrastructure, historical sites, archaeological sites and scenic beauty were taken into account in assessing this factor.

3.3.11 Economic Circumstances

The economic information for each farm was only available from the owners themselves. The suggestion that each land owner or manager should be contacted and canvassed on their perceptions of a biosphere reserve and their economic status was abandoned for logistical and ethical reasons. The time required to contact and interview 161 different landowners, tenants or representatives was more than was available for this project. Moreover the establishment of a larger conservation area in the region is a sensitive issue with some landowners. It was found that the NPB was in the process of canvassing local opinion on this topic [8] and if interviews for this project were to be carried out at the same time, it could lead to misunderstandings between role players in the potential biosphere reserve. For these reasons economic information was not included as one of the factors contributing to the final farm suitability score.

3.3.12 Land Tenure

Secure land tenure is necessary for both social and economic development. It is doubtful that anyone will invest in improvements or in major changes to management, if the right to the land is uncertain (Erskine, 1995). The land reformation pilot programme has had an impact on the security of tenure on some of the farms in the study area. Claims have been made on these farms either as examples of restitution under the Restitution of Land Rights Act 22 of 1994, or under the Land Reform (Labour Tenants) Act of 1996. Until these claims have been processed, no dramatic changes in management and no concrete plans for inclusion in the biosphere reserve should be made.

3.3.13 Environmental Education

Environmental education is a key concept behind the development of a biosphere reserve (Batisse, 1993). All schools in the reserve are likely to benefit from exposure to the policies guiding the management of the reserve. In turn, the reserve is likely to benefit, in the long run, from a close association with local schools.

3.3.14 Social Indicators

Biosphere reserve policy stresses the need for the development of disadvantaged communities (Von Droste zu Hulshoff, 1982). This is especially important for South Africa today in it's present stage of nation building and affirmative action.

---

[8] pers. comm. Mr. D Yunnie, Chief Conservator, Itala Nature Reserve, NPB (1996).

The social indicators required to map social and economic need on a farm by farm basis were unavailable at a suitable level of detail. In the 1991 census, data were collected on an enumerator subdistrict level, each subdistrict containing more than one farm, and in many cases giving average figures for an area with both extensively managed farm land, and densely populated communities (Van Wyk *et al.*, 1994). A comparison of sub-unit boundaries and farm boundaries showed that in some cases farms fell into more than one sub-unit. The decision was made not to use data from this census since the 'enumerator subdistricts' did not allow accurate assumptions to be made regarding the population of each farm unit and because social data is dynamic and may have changed radically in the five years since the data were collected. This is especially true when there are fundamental changes to the economy, as there are occurring in this region. Data from the census undertaken while this project was underway were not available to the public at the time of writing.

A recent community profile of the area was undertaken at a magisterial district level (Cameron, 1996). This is too coarse a parameter to be able to identify priority areas within the study area. A review of the two magisterial districts relevant to this project showed that while the Vryheid magisterial district has relatively high employment and income levels, unemployment in Ngotshe is significantly higher and more than 80% of people in Ngotshe earn less than R1000 per month (Cameron, 1996). The Vryheid figures tend to be skewed by the relative affluence of Vryheid itself and the mines in the district. It is suspected that the situation in the rural areas surrounding Vryheid would be similar to that in Ngotshe[9]. The development of a biosphere reserve in the region with the emphasis on upliftment and integrated development should be a welcome addition to development initiatives. Although the coarse figures available do not allow prioritisation of individual farms, the need for development in the region is recognised. All social indicators were assumed to be related to settlement density for the purpose of suitability assessment.

---

[9] pers. comm. Ms. C Cameron, Managing Director, HCC, Hlobane (1996).

3.3.15 Settlement Density

The dilemma concerning farm suitability and settlement density is that a biosphere reserve of the kind discussed in this project supports, almost exclusively, extensive land uses, while the people who need most to benefit from development associated with a biosphere reserve live in areas where settlement density precludes extensive land uses. Consequently, densely settled land has been taken as being unsuitable for biosphere reserve development. Logically, for sustainable development to work, the land has to be able to support the population under the management techniques applied. Neighbouring communities can benefit from policies such as priority employment of local people, access to indigenous resources in the reserve and access to recreational and educational activities within the reserve.

3.4 Determination of Weightings

The Analytical Hierarchy Process (AHP) was recommended by Dr. Petkov of the Department of Computer Studies and Business Information Systems (UNP) for determination of the relative contributions of each factor to the final score. This process was developed by Saaty (1990) in the 1970's as a method of multi-criteria decision making. The AHP was chosen because it is based on simple concepts, is relatively easy to learn and use, and has a proven track record of multiple-criteria decision making. A software package, 'Expert Choice' (Expert Choice, 1990) was provided by Dr. Petkov to perform the analysis. This version of the software provided was able to consider only eight factors at each level, while this project considered ten. The final prioritisation was done in a 'Quattro Pro' (Corel, 1996) spreadsheet after familiarisation with the procedure using 'Expert Choice'.

3.4.1 Hierarchy Construction

The decision to be made through the AHP is whether or not the farm is suitable for inclusion in the biosphere reserve. This decision had to be made with regard to all the factors identified as affecting farm suitability. The AHP was designed to break criteria into a hierarchy and to determine priorities or weightings based on pairwise comparisons of individual factors (Saaty 1990). The hierarchy drawn up for this project is shown in Figure 3.2.

All factors were assessed with respect to their importance in determining the suitability of each cadastral property for inclusion in a MAB biosphere reserve. The principal functions of a biosphere reserve, namely, conservation, sustainable development, logistical role in research and local, regional and international cooperation were considered for the first level of the hierarchy. Although the cooperation of landowners and tenants is vital to the success of the project, it did not impact directly on the suitability of each farm for inclusion in the reserve and thus, the cooperative component was discarded as a determinant factor of suitability (Section 3.3). The logistical component was discarded for similar reasons.

There are two aspects of this international network of comparative research between biosphere reserves worldwide: the international network component and the research component. The NPB has excellent connections worldwide and is already an internationally recognised conservation organisation and indispensable research has been done in their reserves. No other organisations in the study area are well known. However, the role of networking will be more relevant once the biosphere reserve is established. It does not directly affect the farm suitability for the biosphere reserve.

The existence of research opportunities is perhaps more relevant to farm suitability. However, there has been no research agenda established specifically for this region. The study area is divided into three crude types of land: mines and associated land; commercial farms; and labour farms and rural communities. Each of these groups are associated with specific research priorities, each of them arguably as important as the others with respect to biosphere reserve research. The demise of the coal mining industry in the region has led to a wealth of research opportunities into the rehabilitation of mines and the safeguarding of their surrounding communities. Commercial farmers in the region face daunting difficulties with the collapse of the beef market[10] and the moratorium on afforestation in the Bivane/Pongola river catchment[11].

---

[10]pers. comm. Mr. F Norbert, Stockowners Ltd, (1996).

[11]pers. comm. Mr. H Urquhart, Agricultural Extension Officer, Department of Agriculture, Vryheid (1996).

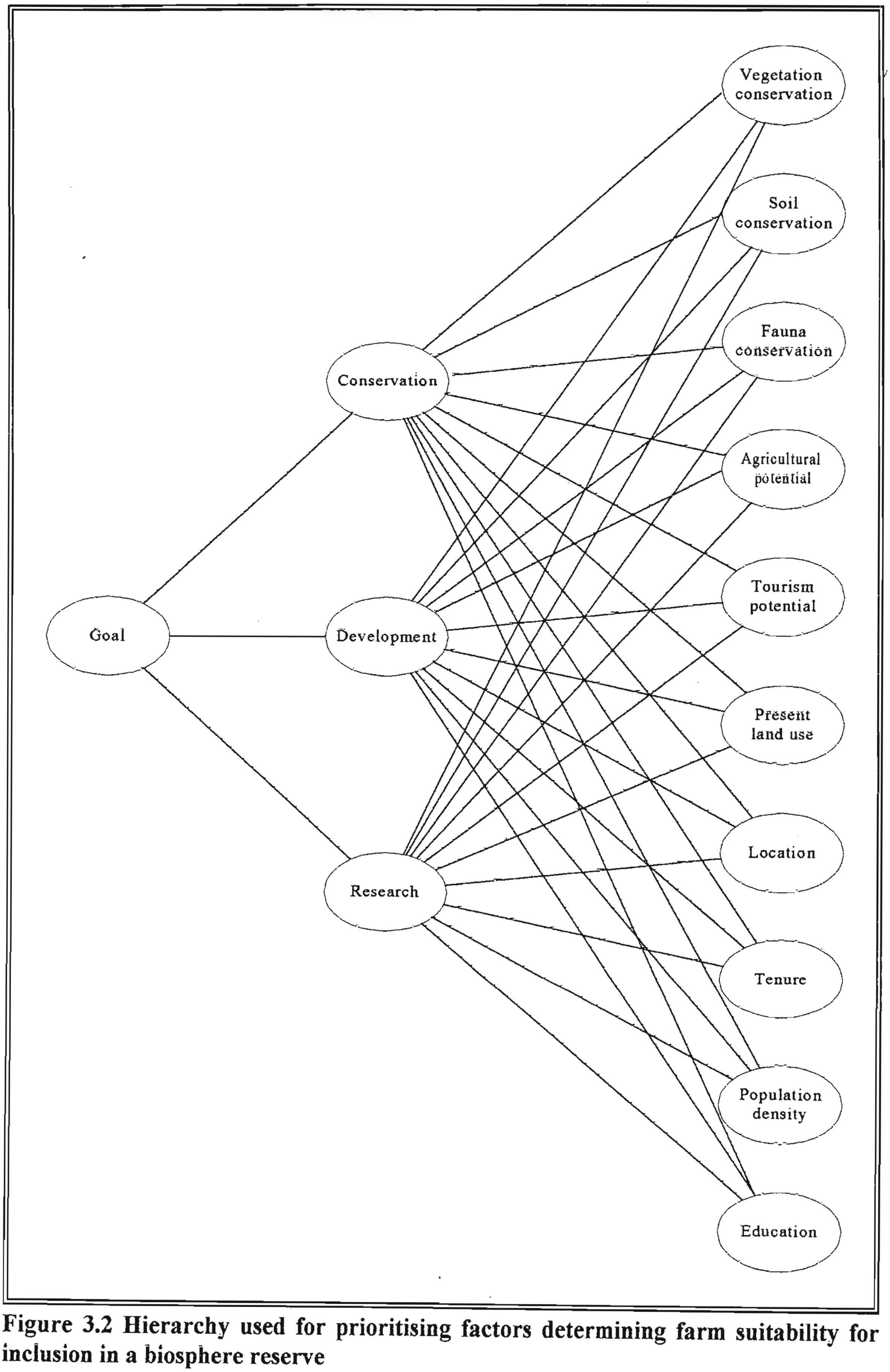


Figure 3.2 Hierarchy used for prioritising factors determining farm suitability for inclusion in a biosphere reserve

Research is needed into alternative yet sustainable farming techniques in the new South Africa. Old labour farms in turn present challenges in land use management systems, as well as opportunities for social research into the effects of a changing land tenure system. The research component was included in the determination of factor weightings, though conservation and development issues were both taken to be strongly more important than research.

The factors being used to identify suitability were placed below the biosphere reserve functions. In the prioritisation stage pairwise comparisons were made between factors to ascertain the relative influence each factor had on the suitability of the farm.

3.4.2 Prioritisation

Priorities are determined in the AHP by making judgments of relative importance between pairs of factors in each level. Before individual judgements were made, the factors were ranked with respect to their impact on suitability. This aids in making consistent judgements comparing factors.

Once a rank order was generated, a matrix was constructed listing the factors along the top and the side (Appendix 5). Each value in the matrix represents the relative importance of the horizontal factor with respect to the vertical factor. The scale used for the comparisons was developed expressly for the AHP by Saaty (1990) (Table 3.1). Where numerical relationships of the intensity of importance between factors exist, it is possible to use this relationship in the prioritisation of factors. In situations such as this project, where there are no simple numerical relationships between the factors identified as affecting farm suitability for inclusion in the biosphere reserve, it is necessary to use the verbal scale for comparisons between factors.

Values of 1 were placed by default in the diagonal positions of the column representing the comparison of each factor with itself. Where the horizontal factor is less important than the vertical factor a reciprocal score is given. For example, if the horizontal factor 'research' is considered strongly less important than the vertical factor 'conservation', a value of 1/5 or 0.2 will be entered in the matrix.

Table 3.1 Definition of scoring system used for Analytical Hierarchy Process (*after* Saaty, 1990)

Intensity of Importance	Definition	Explanation
1	Equal importance	Both factors have equal priority
3	Moderate importance	Experience and judgement assign slightly higher priority to one factor
5	Strong importance	One factor has strong higher priority over the other
7	Very strong importance	One factor has very strong higher priority over the other
9	Extremely strong importance	One factor has extremely strong higher priority over the other
2,4,6,8	Intermediate values	Used when compromise is needed between two judgements

Priorities were calculated through normalising the matrix. This allowed for meaningful comparisons between judgements by bringing all judgements to a common level. The values for each factor in the normalised matrix were summed and presented as a proportional figure. This gave the prioritisation score. These could be directly compared between factors.

The consistency of the value judgements was monitored by means of the consistency ratio. This ratio took the number of factors into account and the difference between the observed values and those that would be expected if the judgements were random. Average consistencies from random matrices were obtained from Saaty (1990). A value of over 0.1 for the consistency ratio indicates that the judgements made in the matrix are relatively inconsistent and should be revised. Table 3.2 shows that the consistency ratio values for judgments made in this project are well below 0.1, indicating a high level of consistency in making comparisons.

Table 3.2 Consistency ratios for the prioritisation of biosphere reserve functions and of factors with respect to biosphere reserve functions

Prioritisation	Consistency ratio
Prioritisation of biosphere reserve functions	0.0000
Prioritisation of factors with respect to conservation	0.0027
Prioritisation of factors with respect to sustainable development	0.0092
Prioritisation of factors with respect to research	0.0053

The AHP is an iterative process and depends on observation, experience and intuition to confirm the results of the process. Saaty (1990) recommends that comparison values should be adjusted until both the desired level of consistency is reached and the user feels intuitively that the results reflect the real priorities of the situation. This procedure has been followed for this project. Higher levels of accuracy might have been achieved if experts in regional planning were to review the comparisons, though even these may be subject to bias towards the experts' particular fields.

3.4.2.1 Prioritisation of Biosphere Reserve Functions

The second level of the prioritisation hierarchy includes the three foundations of the biosphere reserve concept: conservation, sustainable development and research. Although these are equally important functions of the reserve, their relative priority may differ in determining the suitability of areas for inclusion in the reserve. As a main function of biosphere reserves, research is as important as sustainable development and conservation. Neither the study area, nor the region it is situated in, has a clearly set research agenda. Research priorities can only be used as a very general guide to determine farm suitability.

Sustainable development and conservation priorities in this region are more thoroughly defined than research and it is therefore possible to make more accurate judgments regarding farm suitability based on these factors. Conservation and sustainable development were considered to be strongly more important than research (Table 3.3) in determining suitability. The 'Expert Choice' software (Expert Choice, 1990) was used in determining these priorities as there were only two levels in the hierarchy and three factors under consideration (Appendix 5).

Table 3.3 Priorities of biosphere reserve functions in determining farm suitability for inclusion in a biosphere reserve

Biosphere reserve function	Priority
Conservation	0.455
Sustainable Development	0.455
Research	0.090

3.4.2.2 Prioritisation of Factors with Respect to Conservation

Appendix 5.1 shows the full prioritisation matrix for conservation, and summarised results are presented in Table 3.4. Each priority figure was arrived at through the Analytical Hierarchy Process described in Section 3.4.2. A detailed worked example for the determination of the priority rating for soil conservation is provided in Appendix 5.1, where reference to the actual prioritisation matrix is more convenient.

Table 3.4 Factor priorities for the determination of farm suitability for conservation

Factor	Priority
Soil conservation	0.1926
Vegetation conservation	0.1926
Fauna conservation	0.1926
Land tenure	0.1362
Present land use	0.0686
Agricultural potential	0.0497
Education	0.0497
Tourism potential	0.0492
Settlement density	0.0492
Location	0.0197

Soil, vegetation and fauna conservation factors are environmental resources which comprise the cornerstone of conservation philosophies. These were therefore considered to be the most important factors determining conservation priorities with respect to farm suitability. Farms which are known to have these important conservation characteristics will be highly suitable from the conservation viewpoint.

Land tenure is an important factor in determining the conservation aspects of farm suitability as there can be no long term security for conservation areas without secure land tenure. It is assumed that this is a fundamental feature of a stable biosphere reserve, and is considered to be more important than present land use. Present land use (PLU) determines the present conservation status of the land. For example, the necessity of soil conservation measures or the protection of vegetation communities is determined by PLU.

Although agricultural and tourist potential, and settlement density are unlikely to impact directly on the conservation priorities for the region, they may represent a threat, or at least an alternative land use to conservation practices. The presence of these forms of land use in areas which have been targeted for conservation will impact on the suitability of those sites. However it is the natural characteristics of the area that will single it out as a conservation priority and not its land use.

Education is considered to be of equal importance to agricultural and tourist potential. It is recognised that in the long term, education of local people on the importance of conservation and its role in the biosphere reserve will be critical, as they will be responsible for the long term stability of the reserve. However, in the short term the presence of schools on farm properties will have little effect on the conservation suitability of that farm. Additionally, conservation education would be expected to be included in schools in the transition zone to the biosphere reserve as well as in the buffer zone. Therefore education cannot be valued highly as a criterion for suitability for inclusion in the buffer zone as opposed to the transition area.

The location of the farm with respect to the core conservation area will only impact on the conservation suitability of a farm in that funding and personnel for conservation and protection measures will be easier to access on farms closer to Itala Nature Reserve. If a limit is to be placed on the number of participants in the reserve, farms close to Itala are likely to be chosen first, as it is more desirable to have a solid land mass as the reserve than to have a reserve consisting of a number of 'islands'. Logistical and administration influences are the only factors which determine why farms should be located close to Itala - there are no conceptual clashes with farms separated from the rest of the reserve, provided they include a core conservation area (Batisse, 1984).

3.4.2.3 Prioritisation of Factors with Respect to Sustainable Development

Table 3.5 shows the ranking of factors according to their importance in determining a farm's suitability for a biosphere reserve, with respect to sustainable development. The full prioritisation matrix for this level is presented in Appendix 5.2. The method used to derive these priorities is described in Section 3.4.2 and a detailed worked example for the priority 'Soil Conservation' in determining the conservation aspect of farm suitability for inclusion in a biosphere reserve is presented in Appendix 5.1.

Table 3.5 Factor priorities for the determination of farm suitability for sustainable development

Factor	Priority
Settlement density	0.2037
Agricultural potential	0.1986
Land tenure	0.1126
Present land use	0.1105
Soil conservation	0.0822
Vegetation conservation	0.0678
Fauna conservation	0.0678
Tourism potential	0.0678
Education	0.0678
Location	0.0212

The economic potential of the area (represented primarily by agricultural potential) is a key factor in determining the economic limitations and setting the capacity of the area to support different population sizes. Settlement density is essential in determining the needs of the local community. The core principle of sustainable development is to meet present needs without compromising the capacity of the area to meet future needs (World Commission on Environment and Development, 1987). These two factors are therefore the most important elements determining suitability for sustainable development and hence for inclusion in a biosphere reserve.

One of the requirements for UNESCO approval of a biosphere reserve is legal protection of the conservation areas. It is impossible to set this protection in place without the owner being assured of secure land tenure. In addition, there will be no motivation of tenants or landowners to develop their properties and to manage sustainably unless there is land tenure security (Erskine, 1995). Tenure security is therefore important in determining suitability of a farm for inclusion in the biosphere reserve.

Present land use and soil conservation factors are as important as land tenure, as they determine the limitations of the present environment for sustainable development. They may also be key factors in setting priorities for management techniques for further development.

'Our Common Future' - the report from the World Commission on Environment and Development (1987) names conservation of the resource base as a fundamental requirement for sustainable development. However conservation factors have been considered to be less important than land tenure, agricultural potential and the other above mentioned factors because managers will look to those factors before examining conservation options. For example, an area with high population numbers and low agricultural potential will result in a high level of pressure on the vegetation and fauna resources. Against these pressures, conservation management will have a low priority.

Although tourism potential will assist in determining the limitations of the local environment by being a measure of economic potential, the indicators of tourism potential used in this project are not accurate enough to include it at a high priority level. It has been included at the same priority level as the conservation factors because the development of the tourism industry in the region is linked closely to the conservation of its resources. Tourism may benefit conservation by publicising the unique characteristics of the region and the need for their conservation and may be linked with education in the region.

Education of the local population on the principles of sustainable development will be necessary for the long term sustainability of the biosphere reserve.

Location is expected to impact only slightly on the suitability of each farm for sustainable development. The main effects of location are expected to be logistical and administrative, as was the case for conservation suitability (Section 3.4.2.1).

3.4.2.4 Prioritisation of Factors with Respect to Research

Factors were ranked according to their relative importance with respect to research. Priorities were determined according to how each factor would impact on research opportunities in the reserve. The results of the prioritisation exercise for factors with respect to research are presented in Table 3.6. Appendix 5.3 shows the entire matrix of comparisons and the process used to determine priorities. The final priority figures are results of value judgments made in the Analytical Hierarchy Process described in Section 3.4.2. A worked example for the priority of 'Soil Conservation' in determining the research aspect of farm suitability for inclusion in a biosphere reserve is presented in Appendix 5.1.

Table 3.6 Factor priorities for the determination of farm suitability for research

Factor	Priority
Soil conservation	0.1518
Vegetation conservation	0.1518
Fauna conservation	0.1518
Settlement density	0.1518
Land tenure	0.1518
Agricultural potential	0.0541
Present land use	0.0541
Tourism potential	0.0541
Education	0.0541
Location	0.0248

Land tenure changes in South Africa are occurring under the government's 'Land Reform Pilot Programme'. Research into the social and economic effects of these changes and monitoring of the process is essential guidance for further reforms. In the same way, the effects of settlement density on the function of the biosphere reserve, and *vice versa*, are essential points for research. Awareness in this field will aid in developing other biosphere reserves, or other projects combining conservation with sustainable development, which should prove valuable on a worldwide scale. Ecological research into soil, vegetation and fauna conservation in the biosphere reserve is not only one of the stated purposes of the reserve, but is likely to benefit the surrounding region as well. Research into the effects of past and present land use and the monitoring of land rehabilitation measures will be valuable for the management and rehabilitation of similar regions worldwide. Economic research for development will depend on agricultural and tourism potential. The effect of these on farm suitability is expected to be slight as is the effect of education facilities on the property. Research into the long term effects of environmental education and awareness of the principles behind the biosphere reserve concept will be valuable, but do not affect farm suitability as such, as this research can be done in the buffer and transition zones. The location of the farm with respect to the core conservation areas will have a negligible impact on the suitability of the farm for research purposes.

3.4.3 Summary of Final Priorities

The final results of the prioritisation process are presented in Table 3.7. Final priorities were calculated by taking the weighted sum of the conservation, sustainable development and research figures for each factor. For example, the priority value of 0.1387 for 'Soil Conservation' is attained by multiplying: the conservation priority of 0.1926 by the conservation weighting of 0.455 from Table 3.3 to give 0.087633; the development priority of 0.0822 by the development weighting of 0.455 (Table 3.3) to give 0.037401; and the research priority of 0.1518 by the research weighting of 0.09 (Table 3.3) to give 0.013662. When these products are added together they give the final weighting of 0.138696, which is rounded off to give the figure of 0.1387 found in Table 3.7.

The sum of all the final priorities was equal to one. This is important for the determination of final suitability scores for each farm, and also enables comparisons to be made between suitability scores from this project and other similar projects.

Table 3.7 Final Priorities of factors determining farm suitability for inclusion in a biosphere reserve

	Conservation	Development	Research	Final
Soil conservation	0.1926	0.0822	0.1518	0.1387
Vegetation conservation	0.1926	0.0678	0.1518	0.1321
Fauna conservation	0.1926	0.0678	0.1518	0.1321
Settlement density	0.0492	0.2037	0.1518	0.1287
Land tenure	0.1362	0.1126	0.1518	0.1269
Agricultural potential	0.0497	0.1986	0.0541	0.1178
Present land use	0.0686	0.1105	0.0541	0.0864
Education	0.0497	0.0678	0.0541	0.0583
Tourism potential	0.0492	0.0678	0.0541	0.0581
Location	0.0197	0.0212	0.0248	0.0209

Figure 3.3 presents a summary of the relative rankings for each biosphere reserve function. It is evident that location plays a minor role in determining farm suitability. Conservation and sustainable development carry equal weightings as functions of the biosphere reserve (Table 3.3). The factors which are most important for each of these functions are different: soil, vegetation, and fauna conservation factors are most important for conservation while agricultural potential and settlement density are most important for sustainable development. As a result of this disparity, final priority weightings are relatively balanced. The top six of the ten factors, that is the three conservation factors, settlement density, land tenure and agricultural potential have weightings between 0.11 and 0.14 (Table 3.7). The priority difference between the most important factor (0.1387 for soil conservation) and the least important (0.0209 for location) is less than one order of magnitude.

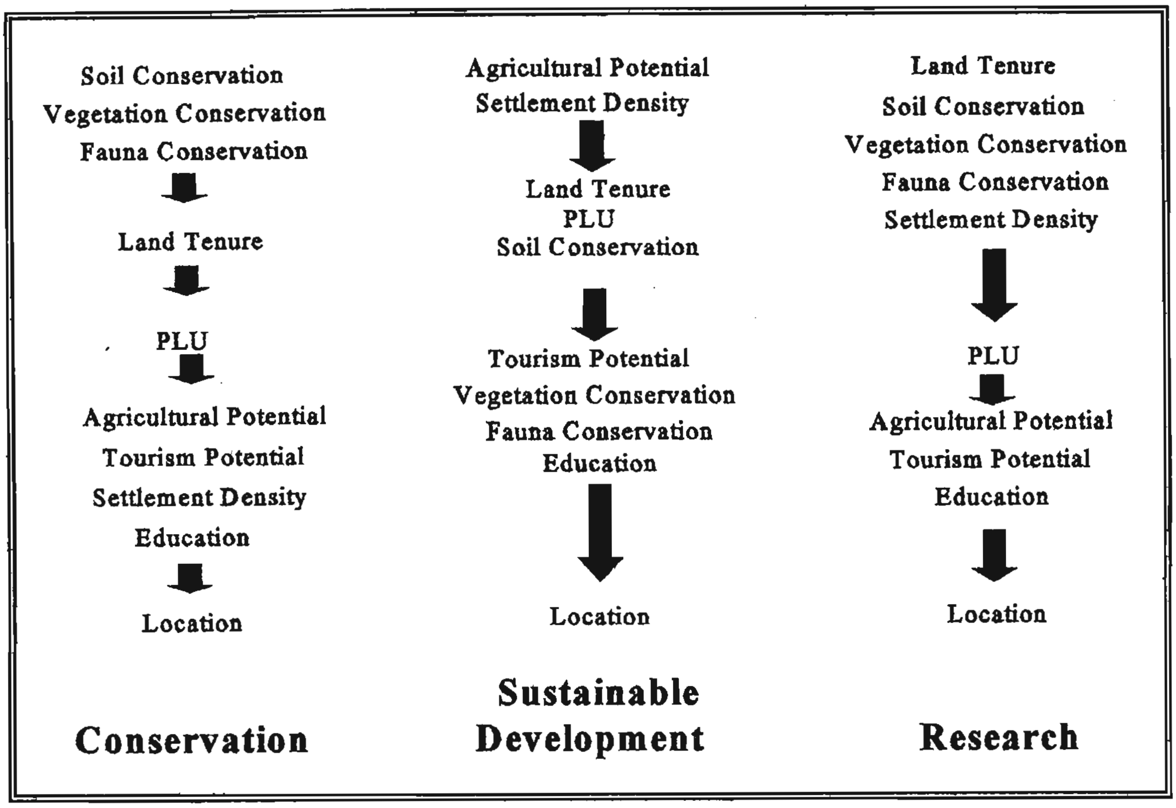


Figure 3.3 Priority ranking of factors affecting farm suitability for inclusion in a biosphere reserve, with respect to the functions of a biosphere reserve (in descending order of importance).

3.5 Data Gathering and Processing

Factors were scored according to the characteristics of each factor on each particular farm. The score depended on the effect on farm suitability which the factor had on that farm. Judgments are made from the viewpoint of the MAB/UNESCO guidelines - i.e. with a focus on the suitability of a farm for conservation, sustainable development and research. The landowner's motives for inclusion in the reserve have not been taken into account.

The scoring system used was an adaptation of the value judgement system used for the AHP (Section 3.4). The neutral score was changed to zero (Table 3.8) instead of one (Table 3.1) so that when factor scores were summed to obtain the final score, factors which had a neutral effect on suitability would not affect the final score.

Table 3.8 Scoring system for factor suitability

Score	Effect on Suitability
8	Extremely strong positive effect on suitability
6	Very strong positive effect on suitability
4	Strong positive effect on suitability
2	Moderate positive effect on suitability
0	Equal or neutral effect on suitability
-2	Moderate negative effect on suitability
-4	Strong negative effect on suitability
-6	Very strong negative effect on suitability
-8	Extremely strong negative effect on suitability

Odd numbers were used when scores were considered to be intermediate in their effect on suitability, e.g. a factor with a weakly positive effect on suitability that was not pronounced enough to be scored as a moderate effect would have been given a score of one.

This system of scoring was chosen because it is only slightly adapted from the scoring system used for the Analytical Hierarchy Process (Saaty, 1990) used to determine the relative priorities of the different factors (Section 3.4).

A database had been created in 'Paradox' which held the identification numbers for the farm units in 'MapInfo' and columns for scores (Appendix 4). Scores for present land use, settlement, erosion, quartzite ridges and cliffs were derived from the aerial and orthophotograph survey and were entered into this database. The records in this database were linked to the owners database through the 'MapInfo' ID number. Other factor scores were derived from other GIS data and were entered directly into the 'MapInfo' database.

The 'MapInfo' ID number in the database allowed scores determined from the aerial photographs and from other sources to be imported into 'MapInfo' and linked straight to the map. The final map was then attached to a table listing the scores for each factor. Final scores were calculated by multiplying each factor score for each farm by the score's weighting:

$$FinalScore = \sum (FactorScore * Weighting)$$

Factor weightings were determined using the Analytical Hierarchy Process (Section 3.4: Determination of Weightings) (Saaty, 1990).

3.5.1 Soil Conservation

Gully erosion is clearly visible on both the aerial and the orthophotographs (Surveyor General's Office, 1990). These were used to identify the degree of erosion on each farm. The presence of eroded areas on a farm indicates past mismanagement through overgrazing or non-conservation tillage. There is a need for formal legal protection of these sites, research into rehabilitation of the gullies and monitoring of the extent of erosion. These needs can be met through the inclusion of the property in the buffer zone of a biosphere reserve, where land use is limited to conservation practices. The presence of gully erosion was given a positive score towards suitability for inclusion in the reserve.

An estimate of the area covered by gully erosion for each farm was made from a survey of the aerial and orthophotographs of the area. The assumption was made that no significant changes in the extent of eroded areas will have occurred since the aerial photographs were taken in 1987 and 1991. Erosion scores depended on the estimated percentage of the farm land covered by gully erosion. The percentage estimate was recorded in the main database of scores (using 'Paradox 5.0 for Windows'). Final score classes were:

Score	
6	over 10 % erosion;
4	5 - 10 % erosion;
2	up to 5 % erosion;
0	no erosion.

3.5.2 Vegetation Conservation

Vegetation conservation priorities within the study area were identified by the Natal Parks Board botanist, Mr. R Scott-Shaw, and his colleagues at the NPB Itala Nature Reserve and in Vryheid. Plant conservation was approached at three levels: species conservation, community conservation and veld type conservation.

Four plant species have been identified as being important to vegetation conservation in the study area. These species have either limited distributions, or are classified as rare, threatened or endangered in the Red Data List of South African Plants (Hilton-Taylor, 1996). This included species such as: *Protea comptonii* found at Itala Nature Reserve [12], *Melanospermum italae* found on the Louwsberg plateau [13] and *Erica austroverna* (Hilliard and Burtt, 1986) and *Jamesbrittenia silenioides* (Hilliard and Burtt, 1985) found on top of Hlobane Mountain. *Protea comptonii* is associated with communities found on steep slopes and rocky outcrops which are generally inaccessible to man and domestic animals. Unnaturally high burning frequencies and high browsing pressure from game animals are considered to be possible threats to this species [14]. Little is known about the response of *Melanospermum italae* to altered grazing and burning regimes although indications are that heavy selective grazing by domestic livestock and the altered fire regime that this brings about could be a serious threat [15]. Since this species is found in areas of relatively high grazing potential and veld condition score (BRU Wc7 (Camp, 1995b)) it can be assumed that if *Melanospermum* is sensitive to grazing and burning, the potential threat to the species in the study area is real. The conditions of high rainfall, shallow soils and high insolation which are prevalent on the top of Hlobane Mountain would imply that *E. austroverna* and *J. silenioides* would be sensitive to inappropriate grazing, or fire

---

[12] pers. comm. Mr. T Wolf, Research Technician, Itala Nature Reserve, NPB. (1996).

[13] pers. comm. Mr. R Scott-Shaw, Botanist, NPB (1996).

[14] pers. comm. Mr. R Scott-Shaw, Botanist, NPB (1997).

[15] pers. comm. Mr. R Scott-Shaw, Botanist, NPB (1997).

regimes or to man made disturbances such as roads or cropping. The genus *Erica* is known to be very sensitive to fire frequency, and requires irregular fire for seeding to occur[16].

With the exception of the mountain top and the corner of the Louwsberg plateau represented on the farm Mooiklip, specific sites of Red Data Book species have not been mapped in the study area. Intensive vegetation surveys have focused on the Itala Nature Reserve and Hlobane Mountain top[17], and have not been done on the whole study area. It is possible to identify potential sites for species of conservation importance by identifying the necessary conditions for their occurrence. Two particular sets of conditions were taken to be important in the study area[18]: the quartzite ridges associated with the Pongola Supergroup geology; and cliffs, a potential habitat for the cycad *Encephalartos lebomboensis* which occurs in this region. The distribution of these cycads is limited to north eastern Swaziland and within a radius of 20km of the confluence of the Bivane and Pongola rivers. It is estimated that the total population of this species numbers only a few thousand plants, and it is listed in the South African Red Data Book as rare[19]. The 1:250 000 series geology map (Department of Mineral and Energy Affairs, 1988); the 1981 orthophotographs of the region; and the 1991 aerial photographs were used to locate these ridges.

Scott-Shaw (1996) has identified certain areas as 'hotspots of endemism' in KwaZulu-Natal. These hotspots are areas of high species richness; or areas where plant communities have high proportions of endemic plant species; or areas which are of importance to conservation (Noss and Cooperrider, 1994). Two of these hotspots are found within the study area: Northern Natal Mountains, represented by Hlobane and Tshongololo mountains, and Ngome/Louwsberg, represented by the Louwsberg plateau. Key vegetation communities have been identified from the Environmental Atlas for KwaZulu-Natal (Anon., 1996b) (Map 3.3). Farms where these vegetation communities are found were given a strong positive score for suitability.

---

[16] pers. comm. Mr. R Scott-Shaw, Botanist, NPB (1997).

[17] pers. comm. Dr. JE Granger, Department of Botany, UNP (1997).

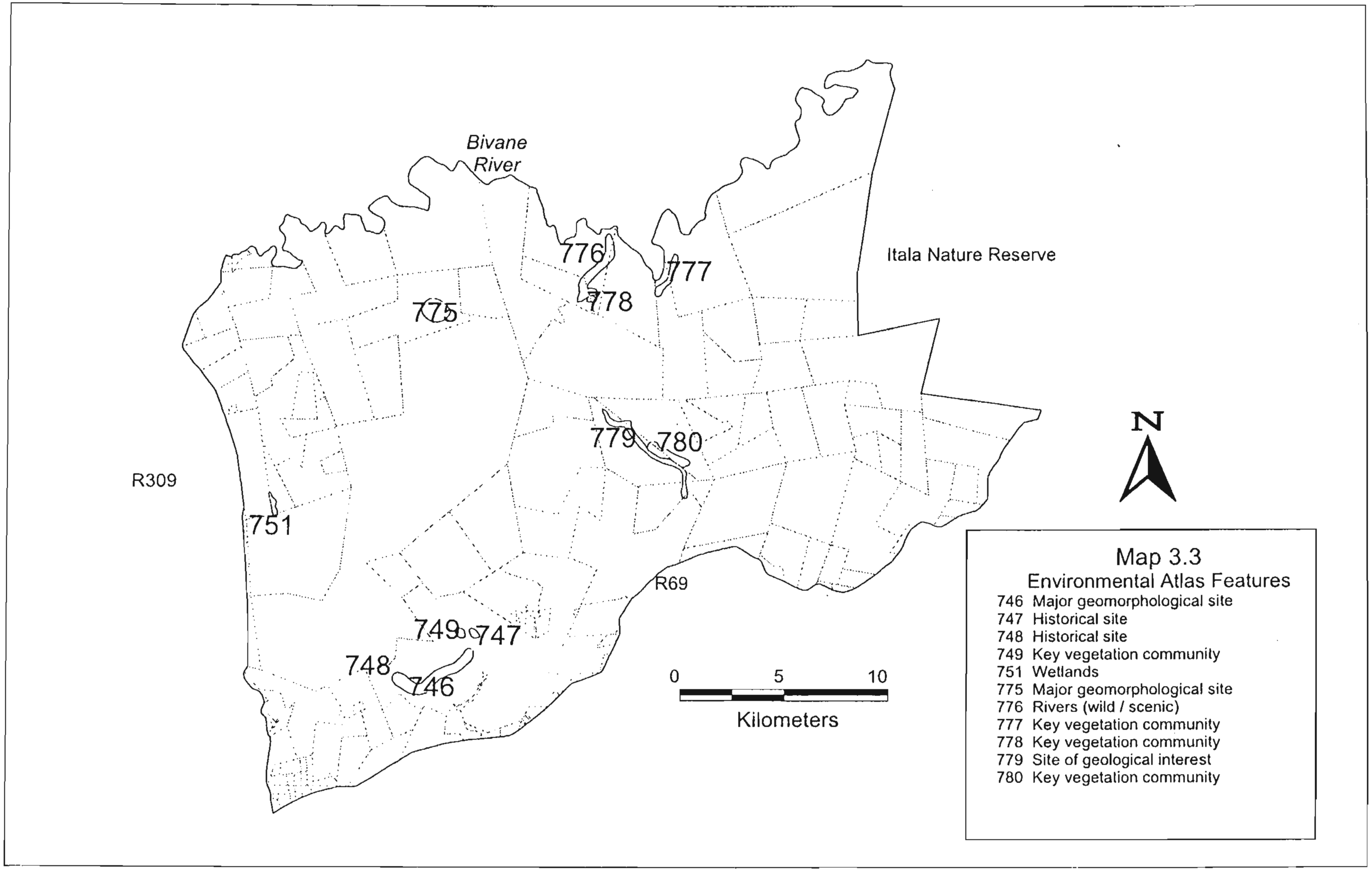
[18] pers. comm. Mr. R Scott-Shaw, Botanist, NPB (1996).

[19] pers. comm. Mr. R Scott-Shaw, Botanist, NPB (1997).

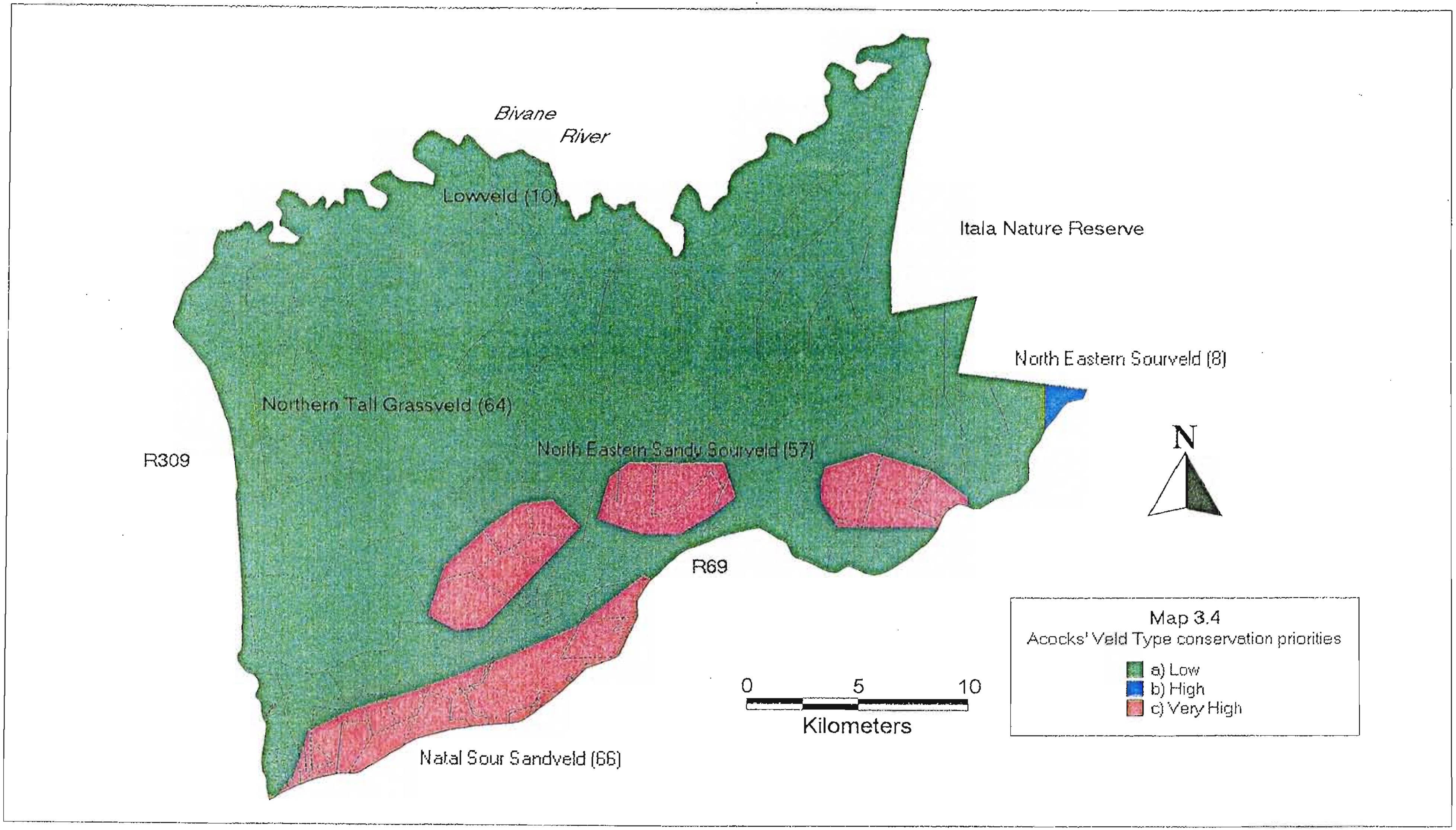
On a wider scale, certain of Acocks Veld Types (Acocks, 1988) have been identified as being important targets for conservation. The biodiversity conservation value in KZN of each Veld Type has been determined from: the percentage of the original extent of the Veld Type that occurs in the province; the percentage of the Veld Type in KZN that has been destroyed; and the percentage of the original Veld Type that is under formal conservation (Scott-Shaw and Bourquin, 1996). Acocks Veld Types 57 (North Eastern Sandy Highveld) and 66 (Natal Sour Sandveld) have been identified by the NPB as being of highest conservation importance (Map 3.4). Only a small proportion of Veld Type 66 is left in its natural state, and very little of this has been placed in protected areas. Veld Type 57 is also considered to be poorly represented in conservation. Similarly, Veld Type 8 (North Eastern Sourveld) is poorly represented in conservation areas, and is especially rich in plant diversity, and endemic species and has been classed as being of high conservation value (Scott-Shaw and Bourquin, 1996). The conservation priority ratings of these veld types were reflected in each farm's score for vegetation conservation.

The Acocks Veld Type classification is currently being completely revised with the aim of producing a comprehensive description and mapping of vegetation in South Africa. While this revision is in progress, an alternative map has been produced by Low and Rebelo (1996). The vegetation units on this map are based on more accurate ecological boundaries and more substantiated evidence of the effect of past land uses on the vegetation, than was available to Acocks when he developed his classification[20]. Conservation priorities for the units from Low and Rebelo have not been determined, thus Acocks' original classification was used.

[20]pers. comm. Dr. JE Granger, Department of Botany, UNP (1996).



Map 3.3 Attributes of the "Environmental Atlas of KwaZulu-Natal" falling within the project study area.



ap 3.4 Conservation priority Acocks' Veld Types for project study area (northern KwaZulu-Natal), (Scott-Shaw and Bourquin, 1996; after Acocks, 1988).

Farms were assigned a vegetation score in the database on the following criteria:

Score

8 confirmed presence of Red Data Book species;

6 hotspots of endemism, key vegetation communities, potential cycad habitat, quartzite ridges;

4 priority veld types for conservation;

0 all others.

3.5.3 Fauna Conservation

The potential for fauna conservation was determined from the BRU characteristics of each farm. Vegetation pattern or physiognomy and indicator vegetation species for each BRU were ascertained from the BRU database (Camp, 1995b). These were used to determine the suitability of the BRU as habitat for fauna species that have been identified as being of conservation importance in KZN.

Rowe-Rowe (1992; 1994) lists the conservation importance ratings of the carnivores and ungulates of Natal. These ratings are based on: habitat specificity, distribution range, endemism, commonness, protection in reserves and threats. The ten most important carnivores and ten most important ungulates were examined with respect to original home range and to habitat requirements. Of these, only species which were likely to be native to the region were considered. The habitat requirements of each of these species was matched to the dominant habitat type provided by each BRU (Appendix 2). Habitat requirements and original distributions were taken from Rowe-Rowe (1992, 1994) and were cross checked with Stuart and Stuart (1988).

The BRU's identified were assigned scores according to their ability to provide habitat for wildlife species identified as being a focus for conservation efforts (Table 3.9). BRU scores were calculated by normalising the number of species supported by the BRU, to give a score out of ten. For example, BRU TUb1 was capable of supporting six of the thirteen fauna species considered. This count of six was divided by thirteen (the number of species considered) and multiplied by ten to give a score of 4.6.

Table 3.9 Fauna Conservation scores for each BRU determined from habitat requirements for 'Conservation Priority Mammals' in KwaZulu-Natal and the BRU's ability to meet these requirements

	Habitat	TUb1	TUc2	Uc3	Vc4	Wc3	Wc7	Xc1	Xc3
Wild Dog	Open savannah, moderately dense bush, open grassland. Avoids long grass.	✘	✘	✘	✔	✘	✘	✘	✔
Ratel	Dry, well wooded, low altitude, bushveld	✔	✔	✘	✘	✘	✘	✘	✘
African Wildcat	Grassland with good cover	✔	✔	✘	✘	✘	✘	✘	✘
Brown Hyaena	Dry savannah with good cover	✘	✘	✘	✘	✘	✘	✘	✘
Leopard	Forest, thicket, closed woodland, rocky wooded hills.	✔	✘	✘	✘	✘	✘	✘	✘
Serval	High rainfall, vleis and long grass	✘	✘	✘	✘	✘	✘	✔	✔
Aardwolf	Dry, upland, open country	✘	✘	✔	✘	✘	✘	✘	✘
Cheetah	Dry open plains and savannah	✘	✘	✘	✔	✘	✘	✘	✘
Klipspringer	Rocky outcrops with browse	✔	✘	✔	✘	✘	✔	✘	✘
Waterbuck	Permanent water, long grass, dense wood	✔	✔	✘	✘	✘	✘	✘	✘
Elephant	Closed and open woodland, needs shade and water	✘	✘	✘	✘	✘	✘	✘	✘
Black rhino	Semi-arid to moist thickets and closed woodland	✔	✔	✘	✘	✘	✘	✘	✘
Oribi	Flat to gently undulating grassland, both tall and short grass	✘	✘	✘	✔	✘	✘	✔	✔
Count		6	4	2	3	0	1	2	3
Score		4.6	3.1	1.5	2.3	0	0.8	1.5	1.5

The score for each BRU reflects the estimated potential of each BRU, in pristine ecological condition, to support these animals which have been identified as being important for conservation efforts. The actual capacity of each farm to support these animals will depend on the past land management and the actual vegetation or habitat type on the farm. This may not be representative of the dominant vegetation type for the BRU.

To get an accurate depiction of the fauna potential for each farm, an area proportional score was used which was calculated from the proportion of the farm falling within different BRU's. This was the first time that the vector capabilities of the GIS were tested. All other factors (except agricultural potential which also depended on BRU values) were assigned a score for each farm, which was treated as an individual entity.

A 'MapInfo' file was created where the project BRUs were allocated scores according to the above procedure. This map was overlaid onto the map of the farms. The farms were split up so that each unit represented a unique farm-BRU combination. The proportion of the original farm area that each unit represented was used to determine the proportion of the overall fauna potential score for that farm. For example, Draaiom (Farm 1) falls within two BRUs; Uc3 and TUB1. Two units would have been identified: Draaiom-TUB1 and Draaiom-Uc3. These two units had areas of 2397 ha and 747 ha respectively. In other words 76% of the Draaiom property falls into BRU TUb1, and 24% of the property falls into BRU Uc3. The score for TUB1 was 4.6 (Table 3.9) and for Uc3 was 1.5 (Table 3.9). These scores were multiplied by the proportion of the farm that fell into that BRU (for TUB1: 4.6 x 0.76 = 3.496 and for Uc3: 1.5 x 0.24 = 0.36). These were added together to give a total farm score for fauna conservation potential (3.856). It was necessary to use 'MapInfo 4.1 Professional' (MapInfo, 1996) as 'MapInfo 2.1' does not have the capability to split the polygons of one map using another map's polygons.

3.5.4 Agricultural Potential

Crop and livestock agricultural potentials have been determined for the whole of KwaZulu-Natal on an ecotope basis (Camp, 1995a). Ecotopes are sub-units of BRU's developed by the Department of Agriculture, and they represent units of land with homogenous agricultural potential. They are based on climatic, altitude, slope and soil characteristics. The original intention in this project was to derive boundaries for each ecotope within the study area using BRU and slope data. Ecotope boundaries were to be determined from a three dimensional slope map or digital elevation model (DEM) of the study area and from Land Type Unit data (Section 2.1.1, Map 2.3).

Contour data for the 1:50 000 series sheets 2730BD, 2731AC and 2731CA were purchased from the Surveyor General's Office as raw material for the DEM. The data purchased included contours, rivers, roads and settlements. All data except contours were removed. The contours were cleaned and major and minor contours were put on different levels. Sheet 2730DB Hlobane was, however, unavailable from the Surveyor General. The contours for this sheet were traced from the 1:50 000 sheet and scanned as a bitmap. 'Geovec', within the Modular GIS Environment in 'Microstation', was used to draw vectors over the bitmap image. Line segments in the vector image of 2730DB were then complexed, so that each contour was an individual entity. When this file was converted to a three dimensional file, and heights were assigned to each contour, it was found that the complexing had not been successful as were all further attempts to complex these contours.

At this point it was decided that the production of the DEM should be abandoned as project time was running short. Although the DEM would have been a useful aid in determining agricultural potential, the time spent on this particular factor was disproportionate to the time and effort needed for more important factors.

Agricultural potential was therefore determined from data associated with each BRU. Camp (1995b) provides estimates for the percentage of arable land within the BRU, the average grazing capacity in ha/AU and the average veld condition score of the BRU (Table 3.10) (Camp, 1995a). Each BRU was given a score for agricultural potential based on Camp's estimates for each BRU. Suitability for the biosphere reserve was assumed to be inversely proportional to agricultural economic potential. It is suggested that land management should be cost effective, and that sustainable cropping of high potential arable land rather than using it for conservation purposes is desirable as cropping will support more people than wildlife. Although there are potential conflicts between livestock farming and biodiversity conservation, for example the conflict between 'predator control' and the 'predator conservation' (Noss and Cooperrider, 1994), areas that are suitable for livestock are assumed to be suitable for inclusion in the buffer zone of the reserve. Mixed livestock /game systems were considered to be a potential activity within this zone.

Table 3.10 Scores for agricultural potential in each BRU determined from percentage of arable land in each BRU, current grazing capacity and average veld condition (VC) score

BRU	Arable %	Grazing ha/AU	VC Score %	Score
TUB1	8	5.3	0.6	4
TUc2	7	4.8	0.6	4
Uc3	11	3.7	0.6	4
Vc4	49	2.8	0.7	-2
Wc3	43	2.3	0.75	-2
Wc7	35	2	0.75	0
Xc1	50	2	0.75	-4
Xc3	66	2	0.75	-4

Some arable areas have also been identified as being important for conservation The trade-off between conservation and agriculture is reached by including both these factors in the assessment process when determining farm suitability for inclusion in a biosphere reserve.

BioResource Units TUB1, TUc2 and Uc3 had low percentages of arable land (less than 20%) and with relatively low grazing capacities and veld condition scores which were considered to have a strong positive effect on the farm's suitability for inclusion in a biosphere reserve.

These BRUs were given a score of 4 (Table 3.10). Nearly 50 % of Vc4 and Wc3 is arable, and the grazing capacity and average veld condition score of these BRU's is high. This high agricultural potential was considered to have a moderate negative effect on farm suitability, earning these BRU's a score of -2. The veld condition and carrying capacity of Wc7 are similar to those of Vc4 and Wc3, but the percentage of arable land is lower. This BRU was not considered to have either a positive or negative effect on farm suitability. High grazing capacities, a high average veld condition score and a high percentage of arable land led Xc1 and Xc3 to be considered as having a strongly negative effect on farm suitability and a score of -4 was awarded to these BRU's.

Area proportional scores for each farm were calculated using the same process as for fauna scores (Section 3.5.3). The resultant scores were attached to the final scores table in the 'MapInfo' database (Appendix 6).

3.5.5 Present Land Use (PLU)

Present land use was determined for each farm from a survey of aerial photographs (Surveyor General's Office, 1990), backed up by the 1979 orthophotographs. The assumption was made that land uses will not have changed significantly since the photographs were taken. Five classes of present land use were identified:

- extensive land uses - cattle, game, or uninhabited/unmanaged land (1);
- timber (2);
- field cropping (3);
- intensive agricultural practices: e.g. horticulture or feedlots (4);
- industrial, mining, transport, or residential areas (5).

The numbers in brackets represent codes used to identify each class in the data. These classes were also used to determine scores reflecting different present land use mixes on the suitability of each farm.

An estimate of the proportion of each farm covered by each land use was recorded in the main database in 'Paradox' (Borland, 1994) (Section 3.2). A logical macro following the steps outlined in the flow chart in Figure 3.4 was created in 'Quattro Pro' to allocate scores according to the total farm area and the relative areas of intensively and extensively managed land on the farm. The full table used to determine PLU scores is given in Appendix 7.

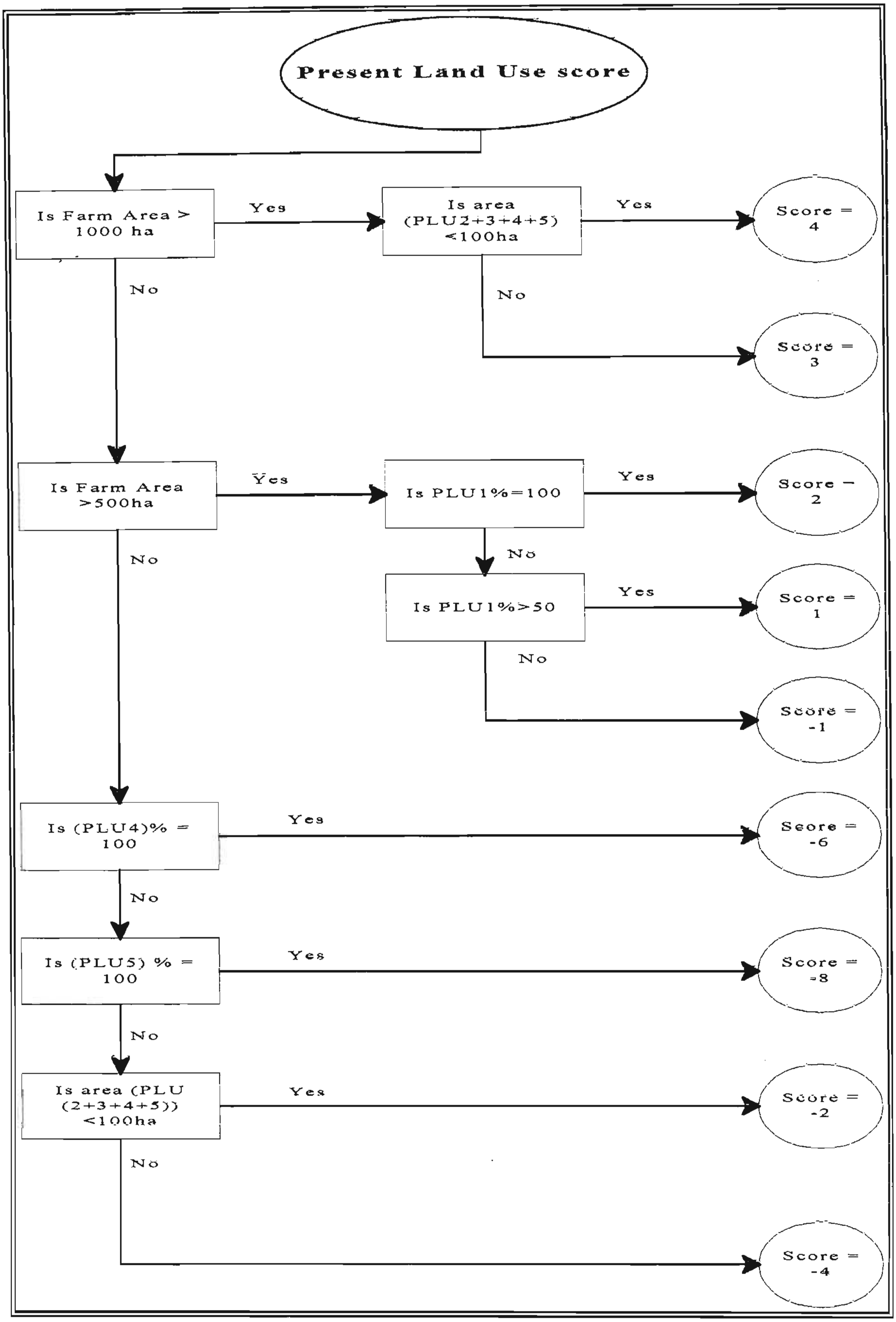


Figure 3.4 Flow Chart used to quantify the effect of Present Land Use on Farm Suitability for inclusion in a biosphere reserve

'Quattro Pro' was used rather than 'Paradox' for this manipulation because the researcher was more familiar with the 'Quattro Pro' macro programming language than the programming language used in 'Paradox'. Scores were allocated as follows:

Score	
4	Total farm area of over 1000 ha with less than 100 ha of this supporting intensive land uses (classes 2 - 5);
3	Total farm area of over 1000 ha with more than 100 ha supporting intensive land uses (classes 2 - 5);
2	Total farm area of between 500 and 1000 ha, managed entirely extensively (class 1);
0	Mixed farming, total area between 500 and 1000 ha, majority of the area managed extensively;
-1	Mixed farming, total area between 500 and 1000 ha, majority of the area managed intensively;
-2	Total farm area of less than 500 ha, with less than 100 ha being intensively managed (classes 2 - 5);
-4	Total farm area of less than 500 ha, with more than 100 ha being intensively managed (classes 2 - 5);
-6	Whole farm used for intensive agriculture such as orchards, chickens, or feedlots (class 4);
-8	Whole farm used for industrial, mining, transportation or residential areas (class 5).

The macro was applied to the percentage and area figures to give final PLU scores. Estimated areas for each land use in each farm were calculated by multiplying the farm area by the percentage of the farm put to that land use. For example, Draaiom (Farm 1) had an area of 3144 ha, an estimated 70 % of which is extensively managed land (PLU class 1) and 30 %, intensively managed land (PLU class 3). This translates to 2201 ha of PLU class 1 and 943 ha of PLU class 3 land.

Once both area figures and percentage figures had been calculated for all land uses for all farms, the logical macro was run to calculate final farm scores for PLU. For Draaiom, this resulted in a score of 3, as the total farm area was over 1000 ha, more than 100 ha of which were intensively managed. Final scores were exported to 'MapInfo' and attached to the scores database.

3.5.6 Tourism Potential

Tourism potential examined factors likely to have positive or negative effects on the tourism industry in the region. Positive factors included: river frontage, tourist accommodation, historical and archaeological sites, sites of specific conservation interest; while negative factors included high levels of erosion, railways and/or mine dumps on the property. These were found from the 1:50 000 topo-cadastral maps; 1:10 000 orthophotographs; through examination of archaeological reports for the region (Anderson 1996, Whitelaw 1989); from the Environmental Atlas of KwaZulu-Natal (Anon., 1996b) and from consultation with local experts[21,22,23]. It is recognised that these factors are not ideal indicators of tourism potential, but it is believed that they do impact on tourism potential and as such are useful approximations for the purposes of this project. It is further recognised that the effect of factors such as railways and mine dumps may be changed, even to the point where they may become attractions. This project is however aimed only at providing a measure of the present suitability of each property for inclusion in the reserve.

Tourism potential was scored as follows:

Score	
4	historical / archaeological sites, sites of specific conservation interest (as found in the Environmental Atlas of KwaZulu-Natal (Anon., 1996b));
2	river frontage, tourist accommodation / facilities in place;

[21] pers. comm. Mr. S De Jager, District Conservation Officer, Vryheid, NPB (1996).

[22] pers. comm. Ms. C Cameron, Managing Director, HCC, Hlobane (1996).

[23] pers. comm. Prof. R Edgecombe, Department of History, UNP (1996).

Score

-2	extensive erosion on property;
-4	railway on property;
-8	mine dumps or infrastructure remaining.

3.5.7 Distance from Core Area

Scores for distance from core area were calculated in 'MapInfo' using the radius tool and update column tool. Five classes of distance were chosen and scores associated with each:

Score

4	<5 km;
2	5-10 km;
0	10-15 km;
-2	15-20 km;
-4	>20 km.

Scores for location or distance from the core area were derived directly from the farm properties map in 'MapInfo'. All farms were given a default score of -4 (i.e. more than 20 km away from the core area). The radius tool was then used to select all farms whose centroid lay within 20 km of Itala and these were allocated a score of -2. This process was repeated for 15 km (score = 0), 10 km (score = 2), and 5 km (score = 4). The resulting column was then attached to the final scores database in 'MapInfo'.

3.5.8 Population

Settlement density was determined from examination of the aerial photographs, backed up by orthophotograph interpretation. In the cases where a farm falls partially into the study area, only the portion of the farm within the study area was considered. This is justified as the only properties that are not fully in the study area are split by arterial roads. These roads can be a hindrance to conservation efforts if included in a biosphere reserve (Noss and Cooperrider, 1994).

Four classes of settlement density were defined (for input to the 'Paradox' database (Appendix 4)), and suitability scores were assigned to each class:

Score	
4	No settlement (class 1);
2	Sparse settlement - commercial farms, sparsely settled communal areas (class 2);
-4	Densely settled rural community (class 3);
-8	Town or township (class 4).

Dense population in rural areas was considered to have a strong negative effect on farm suitability for inclusion in a biosphere reserve because it is assumed that extensive land management practices associated with participation in the biosphere reserve would not be able to support the entire population of these farms. Farms were classified as being 'densely settled rural communities' when there were a more small settlements than would be required for an extensive commercial farming type enterprise. The number of homesteads for each farm were counted from the aerial and orthophotographs. This score was subjective and was based on past experience and on instruction in agricultural economics, agricultural production and range and forage management.

The assumption was made that settlement density has not changed significantly since the photographs were taken. Towns or townships included informal settlements in the vicinity of towns.

3.5.9 Land Tenure

The Department of Land Affairs office in Vryheid provided information on land claims in the study area[24] (Vryheid Land Facilitation Service, 1996a; 1996b). Claims which have already been processed were regarded in a positive light as tenure is now assured on those farms.

There is some uncertainty as to the future of residential land owned by mines which have now ceased production. Because of this uncertainty, residential properties owned by the mines were

[24] pers. comm. Ms. M Currie, Department of Land Affairs, Vryheid (1996).

given a negative score. Farms where the land claim was still awaiting settlement were given a strongly negative score as it is clearly undesirable to include this land in a biosphere reserve, at the point when tenure is most uncertain. Scores for land tenure then were assigned on an individual farm basis using the following criteria:

Score	
4	Recent land claim settled;
-4	Residential land owned by mining house;
-8	Land claim awaiting settlement.

These scores were entered directly into the 'MapInfo' database.

3.5.10 Environmental Education

It was decided that any school on the property would be a benefit to the biosphere reserve as it would certainly include some element of environmental education in its syllabus once the reserve was established. The 1:50 000 topocadastral sheets were surveyed for schools. All properties with a school were given a positive score. Present or proposed educational facilities dedicated purely to environmental education were considered to have an extremely important effect on the farm's suitability to be included in a biosphere reserve:

Score	
8	Environmental education facilities planned or present;
2	School on property.

These scores were entered directly into the 'MapInfo' database.

Once all the scores for all the factors were entered into the database, the total suitability score for each farm was calculated by summing the weighted scores for each factor. Thematic maps were created in MapInfo and the patterns of suitability were examined.

Chapter 4: Results and Discussion

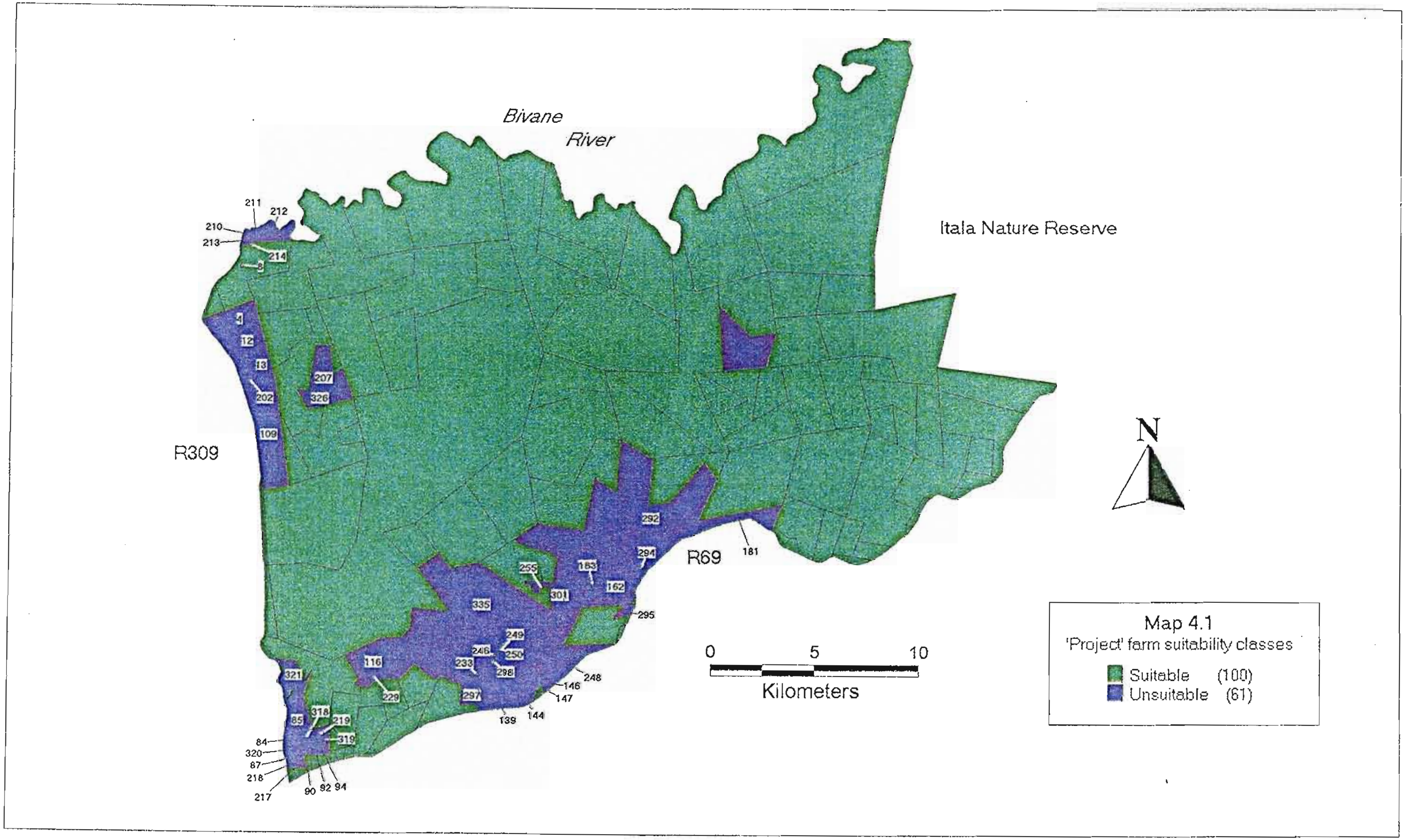
4.1 Results

The object of this project was to develop and evaluate a method of assessing land suitability for inclusion in a biosphere reserve. The method developed has been outlined in Chapter 3 and is referred to as 'the Project Method'. The final results of the assessment shown are in Map 4.1 and Table 4.1. The component factor scores are given in Appendix 6.

Table 4.1 Results of assessment of farm suitability for inclusion in a biosphere reserve

Class	Class boundaries	Number of farms
Suitable	0 - 3.079	100
Unsuitable	-2.72 - 0	61
Mean Suitability Score		0.329
Standard Deviation		+/-1.087

Farms were divided into two classes of suitability: suitable farms and unsuitable farms. Unsuitable farms are those farms whose overall score was found to be less than zero. On these farms, once all the relevant factors have been taken into account, there were more reasons not to include the farm in the biosphere reserve than there were in favour of inclusion. Using the score classes from Chapter 3, the maximum possible suitability score for a farm in the study area was 4.9069, and the minimum possible score was -3.7556. These are theoretical scores for farms where all factors were either given the maximum score to give the maximum possible score, or all factors were given the minimum score to determine the minimum possible score. The actual scores ranged from -2.72 to 3.079. Ideally, the final scores should follow the same scoring scale as was used for scoring the effects of the constituent factors on farm suitability (Table 3.8) so that, for example, a farm with a suitability score of -2 could be said to be moderately unsuitable for inclusion. However, because several factors have no effect on the final suitability score of a farm, this resulted in a more limited range of final suitability scores, causing final suitability scores to be more sensitive to change than factor suitability scores.



Map 4.1 Farm suitability for inclusion in a biosphere reserve. Suitability was determined using ten determinant factors and weightings between the factors.

A farm with a final suitability score of -2 is in practice likely to be very strongly unsuitable for inclusion in a biosphere reserve. Moderately suitable or unsuitable farms are more likely to have a score of the order of 0.5 or -0.5.

The mean suitability score and the standard deviation for the farm scores in the study area (Table 4.1) were used to determine significant differences between sets of farm suitability scores from three methods of suitability assessment (Section 4.2.3).

4.1.1 Discussion from Thematic Map of Final Scores (Map 4.1)

Examination of Map 4.1 reveals three zones where farms have negative suitability scores: farms along the R69, including the mining towns of Hlobane and Coronation; farms in the north-western corner of the study area along the R309 and next to the Bivane river; and in the south-western corner of the study area where farms subdivisions are small and intensively managed.

The largest of these zones is the one that includes the residential and trade areas, and infrastructure previously associated with the coal mines on the Hlobane Colliery property; the Vryheid Coronation Colliery property; and the Duiker mining depot. This zone is found in the southern central part of the study area. Table 4.2 shows the constituent scores for these farms. These can also be examined in the Workspace 'Work2' on disk. The negative final scores on these farms are due to the negative effects on suitability of settlement, agricultural potential, present land use (PLU), tourism, and location scores, which tend to be a result of previous mining activities. Settlement density, present land use, and tourism potential may be mitigated to some extent with the closure and rehabilitation of the mines and the subdivision of residential areas from the main mine properties.

Table 4.2 Constituent suitability scores for unsuitable farms in the vicinity of Hlobane and Vryheid coronation collieries

Farm ID	Soil Cons.	Veg. Cons.	Fauna Cons.	Settlement Density	Land Tenure	Agricultural Potential	PLU	Tourism Potential	Education	Location	Score
116	0	0	0.35	2	0	-1.24	-2	0	0	-4	-0.09
139	0	4	2.29	-8	0	-1.98	-2	-8	0	-4	-1.15
144	0	0	2.32	-8	0	-2.01	-2	0	0	-4	-1.21
146	0	4	2.29	-4	0	-1.98	-2	0	0	-4	-0.17
147	0	4	2.21	-8	0	-1.91	-2	0	0	-4	-0.69
162	0	4	1.82	-4	0	-2.00	-4	0	2	-2	-0.25
163	0	0	2.17	-8	0	-1.89	-2	0	0	-2	-1.18
181	0	0	0.04	2	0	-1.15	-4	0	0	0	-0.21
229	0	0	0.63	-4	0	-1.98	-2	0	0	-4	-0.92
248	0	4	2.47	-8	0	-2.15	-8	0	0	-4	-1.20
255	0	0	2.20	-8	-4	-2.00	-2	-8	0	-4	-2.20
292	0	6	0.75	-8	0	0.52	4	-8	2	0	-0.08
294	0	4	0.00	-8	0	-1.63	-2	0	0	-2	-0.90
295	0	4	2.31	-8	0	-2.00	-8	0	0	-2	-1.16
297	0	4	2.30	4	0	-1.99	-8	-8	0	-4	-0.12
298	0	0	2.34	4	0	-2.03	-8	0	0	-4	-0.19
301	0	0	2.31	-8	0	-2.01	-2	-8	0	-4	-1.68
335	0	8	1.17	-8	-4	-1.49	3	-1	4	-4	-0.15

Farm ID: Farm identification number (Map 3.2)
Soil Cons.: Soil conservation score
Veg. Cons.: Vegetation conservation score
Fauna Cons.: Fauna conservation score
Settlement Density: Settlement density score
Land Tenure: Land tenure score
Agricultural Potential: Agricultural potential score
PLU: Present land use score
Tourism Potential: Tourism potential score
Education: Education potential score
Location: Score for location with respect to core areas
Score: Final score indicating farm suitability for inclusion in a biosphere reserve

The second region of farms that were found to be unsuitable for inclusion in the biosphere reserve was located along the R309 near the Bivane River. The constituent scores for these farms are presented in Table 4.3 or can be seen in Workspace 'Work3'. These farms tend to have high agricultural potentials with a high proportion of cultivated land, resulting in negative present land use (PLU) and agricultural potential scores. In addition, they are situated more than 20km away from Itala Nature Reserve and so have negative scores for location. Although

Table 4.4 Constituent scores for unsuitable farms in the south-western corner of the study area

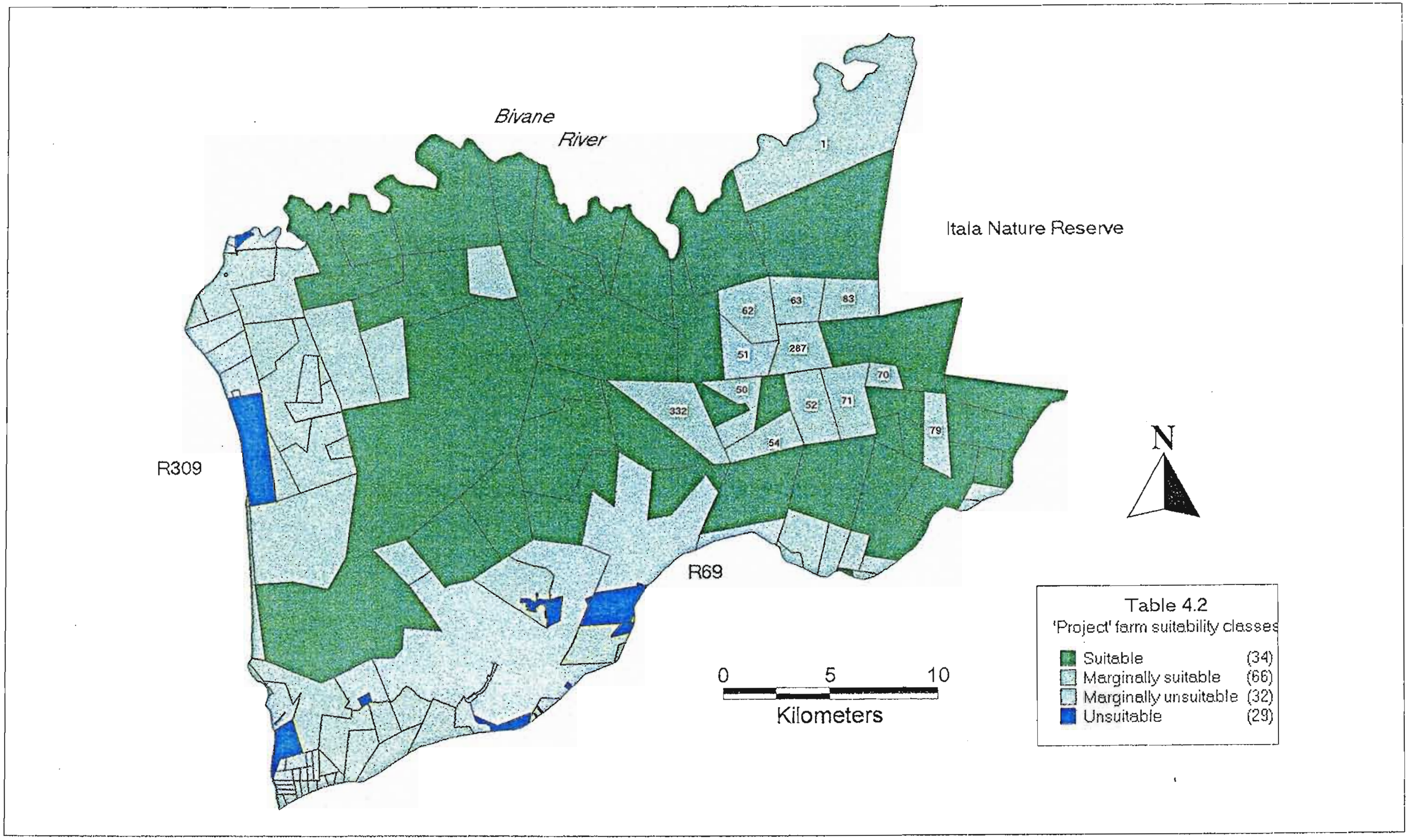
Farm ID	Soil Cons.	Veg. Cons.	Fauna Cons.	Settlement Density	Land Tenure	Agricultural Potential	PLU	Tourism Potential	Education	Location	Score
84	0	0	1.09	2	0	-2.01	-8	0	0	-4	-0.61
85	0	0	0.70	-4	0	-1.99	-4	0	0	-4	-1.08
87	0	0	1.20	2	0	-1.97	-8	0	0	-4	-0.59
90	0	0	2.32	2	0	-2.02	-8	0	0	-4	-0.44
92	0	0	2.30	2	0	-2.00	-8	0	0	-4	-0.44
94	0	0	2.32	2	0	-2.01	-8	0	0	-4	-0.44
217	0	0	1.39	2	0	-2.03	-8	0	0	-4	-0.57
218	0	0	1.33	2	0	-1.96	-8	0	0	-4	-0.57
219	0	0	2.26	2	0	-1.96	-8	0	0	-4	-0.45
318	0	0	2.30	2	0	-1.99	-8	0	0	-4	-0.44
319	0	0	2.29	2	0	-1.99	-8	0	0	-4	-0.44
320	0	0	1.33	2	0	-2.01	-8	0	0	-4	-0.57
321	0	0	0.00	2	0	-2.00	-4	0	0	-4	-0.40

4.1.2 Discussion From Marginal Areas

It was considered necessary to examine patterns of suitable and unsuitable farms using more detailed classes of suitability. This allowed for distinction between farms which are obviously highly suitable or unsuitable and farms which are in a middle class of marginal suitability, where adjustments to the factor scores or factor weightings may change the final suitability score from a positive to a negative score. Factor scores were divided into three classes of equal range:

- -2.2 to -0.44;
- -0.44 to 1.32;
- and 1.32 to 3.079.

Factors falling into the middle of these classes were considered to be marginal. This marginal class was split at zero so that farms with negative scores were considered to be marginally unsuitable and farms with positive scores, marginally suitable. These classes were used to create a thematic map from which spatial suitability trends could be identified (Map 4.2).



Map 4.2 Farm suitability for inclusion in a biosphere reserve. Four classes of suitability are presented, ranging from highly unsuitable farms to highly suitable farms. Suitability was determined using ten determinant factors and weightings between the factors.

In practice this is an arbitrary division made as an aid to interpret changes in suitability within the study area and how these changes may be linked to location or to neighbouring farms. There is no guarantee that farms falling into the marginal class will, in reality, be different in respect of their suitability from those in the outer two classes, however, it should be safe to assume that farms falling more than one class apart would show a significant difference in suitability, i.e. a farm falling into the highly suitable class should in practice be demonstrably more suitable for inclusion in the biosphere reserve than a farm in the marginally unsuitable class or the highly unsuitable class.

Two of the farms bounding directly on Itala are judged to be only marginally suitable for inclusion in the biosphere reserve (Map 4.2; Workspace 'Work 5'). The larger of these two farms (Farm 1, Draaiom 709) is inhabited by a Black community[1]. The arable land on this farm shows signs of extensive cultivation. If this farm were to be included in the reserve, the capacity of the farm to support the present inhabitants under extensive management techniques must first be established. An affirmative action policy within the biosphere reserve to give first option of employment to residents of properties within the reserve may ease the burden on this farm's resources. It is a potentially valuable farm for inclusion in the reserve as it contains considerable habitat for priority conservation vegetation. In addition it is vitally important for local communities to be involved in the reserve if the reserve is to succeed. This property will need a more detailed assessment by a qualified conservation planner before it can be dismissed as unsuitable for inclusion in the reserve. The community on this farm is already working in cooperation with the NPB on innovative methods of deriving revenue from conservation practices[2].

The second marginally suitable farm bounding directly on Itala Nature Reserve (Farm 83, Kliprif 111, Subdivision 4) has only one negative aspect in its constituent scores (Appendix 6). It is a relatively small farm (approximately 500 ha) and has a cultivated area of over 100 ha. This resulted in a PLU score of -2. The positive aspects of this farm are not sufficient to bring

[1]pers. comm. Mr. T Wolf, Research Technician, Itala Nature Reserve, NPB (1996).

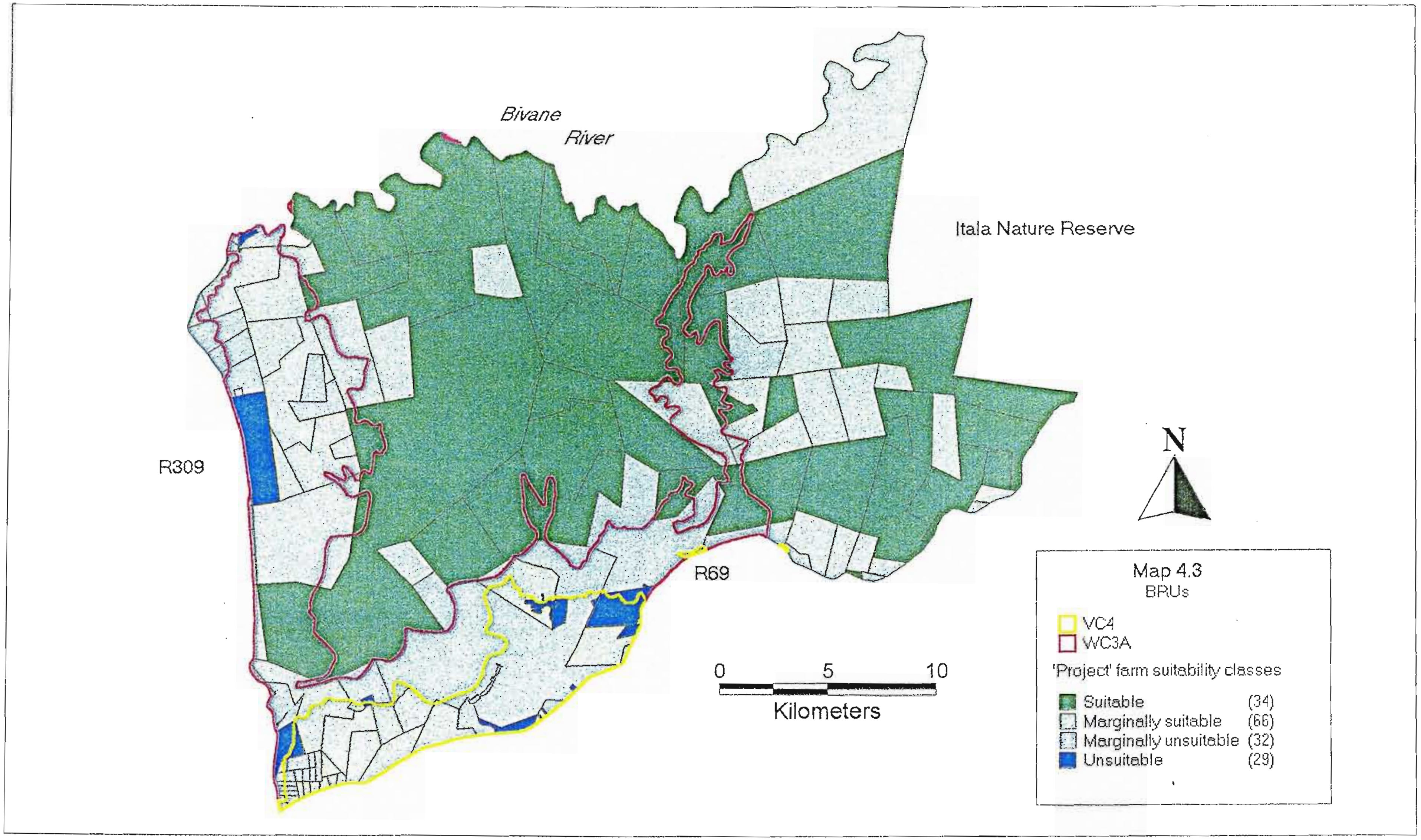
[2]pers. comm. Mr. T Wolf, Research Technician, Itala Nature Reserve, NPB (1996).

the farm into the highly suitable class. There should be little difficulty in incorporating this farm into the reserve should the landowner be amenable.

There are three clear expanses of land where farms are marginally suitable. The first two of these are situated along the R69 and along the R309 and are associated with the areas of unsuitable farms discussed in Section 4.1.1. The first of these, along the R69, includes most of the mining infrastructure and the small plots around the R309-Paulpietersburg turnoff (Map 4.2, Workspace 'Work6'). Some of these small plots fall within veld type 66 (Natal Sour Sandveld) and so have a high vegetation conservation priority. This causes a positive final score for these farms despite the intensive settlement and land use patterns in this area.

Land uses on the properties along the R309 tend to be a mixture of timber, cropping and cattle and the properties are mainly either marginally unsuitable or unsuitable for inclusion in a biosphere reserve (Map 4.2, Workspace 'Work7'). These two areas fall inside BRUs Wc3 and Vc4 which have high proportions of high potential soils and cropping land. Both present land use and agricultural potential of these areas have a impact on suitability for a biosphere reserve. The boundary of these marginally suitable to unsuitable areas correlates well with the ecological boundaries of the BRUs Wc3 and Vc4 (Map 4.3). This correlation supports this method as a valid method of assessment of ecological suitability. The exclusion of intensive land uses is consistent with the objectives of sustainable development linked to conservation.

The last of these marginally suitable to unsuitable areas, situated directly to the west of Itala Nature Reserve (Map 4.2, Workspace 'Work8'), is the most problematic. It obviously has good location and farm size and at first glance should be a highly suitable area. Examination of the constituent scores for these farms (Table 4.5) shows that PLU, population and land tenure have negative scores. Good conservation potential and poor agricultural potential are not sufficient to make these farms highly suitable for inclusion in the biosphere reserve. The suitability of this area of farms is dependent on the balance between social and political factors on one side and conservation and economic factors on the other.



Map 4.3 BioResource Unit boundaries overlaid on suitability classes of farms for inclusion in a biosphere reserve. Suitability was determined using ten determinant factors and weightings between the factors.

Farm 1, for example, is more densely settled than a commercial farm should be and has been heavily cultivated. These two negative factors are sufficient to outweigh the positive aspects of fauna conservation potential and location. The inclusion of this property in the reserve is likely to require mitigatory action on the part of land managers, such as the preferential employment within the wider reserve of residents from densely populated areas. Further investigation into the practicality of including this farm in a biosphere reserve and of limiting land use practices to those consistent with the biosphere reserve concept is needed.

Table 4.5 Constituent scores of marginally suitable and unsuitable farms to the west of Itala Nature Reserve.

Farm ID	Soil Cons.	Veg. Cons.	Fauna Cons.	Settlement Density	Land Tenure	Agricultural Potential	PLU	Tourism Potential	Education	Location	Score
50	0	0	1.8	2	0	3.4	-4	0	0	2	0.53
51	0	0	2.0	-4	0	4.0	-4	0	0	2	-0.15
52	0	0	2.0	2	0	4.0	1	0	0	2	1.06
54	4	0	1.8	2	0	3.5	-2	0	0	2	1.28
62	0	2	2.2	2	-2	4.0	1	0	0	2	1.14
63	0	0	2.0	2	0	4.0	-4	0	0	4	0.68
70	0	2	2.2	4	-2	4.0	-2	0	0	4	1.17
71	4	0	2.0	-4	0	4.0	1	0	0	4	0.88
83	0	0	2.4	2	0	4.0	-2	0	0	4	1.01
287	0	0	2.0	2	0	4.0	1	0	0	4	1.10
332	0	6	0.6	2	-4	0.0	1	4	0	0	0.91

The prevalent pattern of farm suitability showed that highly suitable farms tended to be large with low populations and an extensive present land use system. High scores for conservation priority factors were not always sufficient to cause a highly positive suitability scores, as was seen in the small scale farms in the south western corner of the study area (Map 4.2).

4.2 Evaluation of Method

The following queries were posed to determine the value of this approach in assessing farm suitability for inclusion in a biosphere reserve:

- 'Has this project identified suitable farms correctly?';
- 'Do farms identified as highly suitable agree with the requirements set by UNESCO for land to be included in a biosphere reserve (as summarised by IUCN's Commission on National Parks and Protected Areas, (1982))?';
- 'Does the approach used agree with published requirements for effective natural resource planning (Balzer, 1982) and for integrated regional planning (Garett, 1982)?'.

4.2.1 Classification of Farms

The efficacy of the project in correctly identifying suitable farms was determined through comparison with farm situations where more data regarding the farm were available than were reflected in the scores. The farms used for this comparison are shown in Map 4.4. Workspace 'Work1' provides full information as to owners and factor scores for each of these farms. These farms were examined on the basis of whether they met the biosphere reserve requirements. Biosphere reserve criteria require land with one or more of the following characteristics (IUCN, 1982):

- representative examples of natural biomes;
- unique communities or areas with unusual natural features of exceptional interest;
- examples of harmonious landscapes resulting from traditional land use practices;
- or examples of modified or degraded ecosystems capable of being restored to more natural conditions.

In addition a biosphere reserve requires long-term legal protection and must be approved by UNESCO. With the exception of UNESCO approval, these criteria can be met in Itala itself. Other specific criteria are needed to judge suitability of land for inclusion in a buffer zone. The purpose of a buffer zone is to find ways of integrating development with conservation (Noss and Cooperrider, 1994). The functions of a buffer zone are:

- to shield the core reserves from harmful activities;

- to ameliorate edge effects such as wind effects, weed invasion, and opportunistic predators (including poachers);
- to enlarge effective size of a reserve;
- and to provide some measure of temporal stability to the landscape (Noss and Cooperrider, 1994).

These functions, and the roles of the biosphere reserve (conservation, sustainable development, research and cooperation) have been used as criteria to determine the suitability of the farms examined.

4.2.1.1 Gertges Medisyne (Farm 325)

This is the largest farm in the study area (10 070 ha), owned by Gertges Medisyne of Vryheid. It is managed as a mixed beef and cropping farm. The manager of the farm has been informed of the proposed establishment of the biosphere reserve and sees no obstacle to the inclusion of the farm[3]. Although this farm is relatively far from the core area, its inclusion would significantly enlarge the effective size of the reserve and provide a measure of stability to the reserve. It would also be a viable connecting factor between the proposed conservation areas at Hlobane and the Paris Dam. It is thus considered highly suitable for inclusion in the reserve.

4.2.1.2 Paris Dam - Impala Irrigation Board (Farm 57)

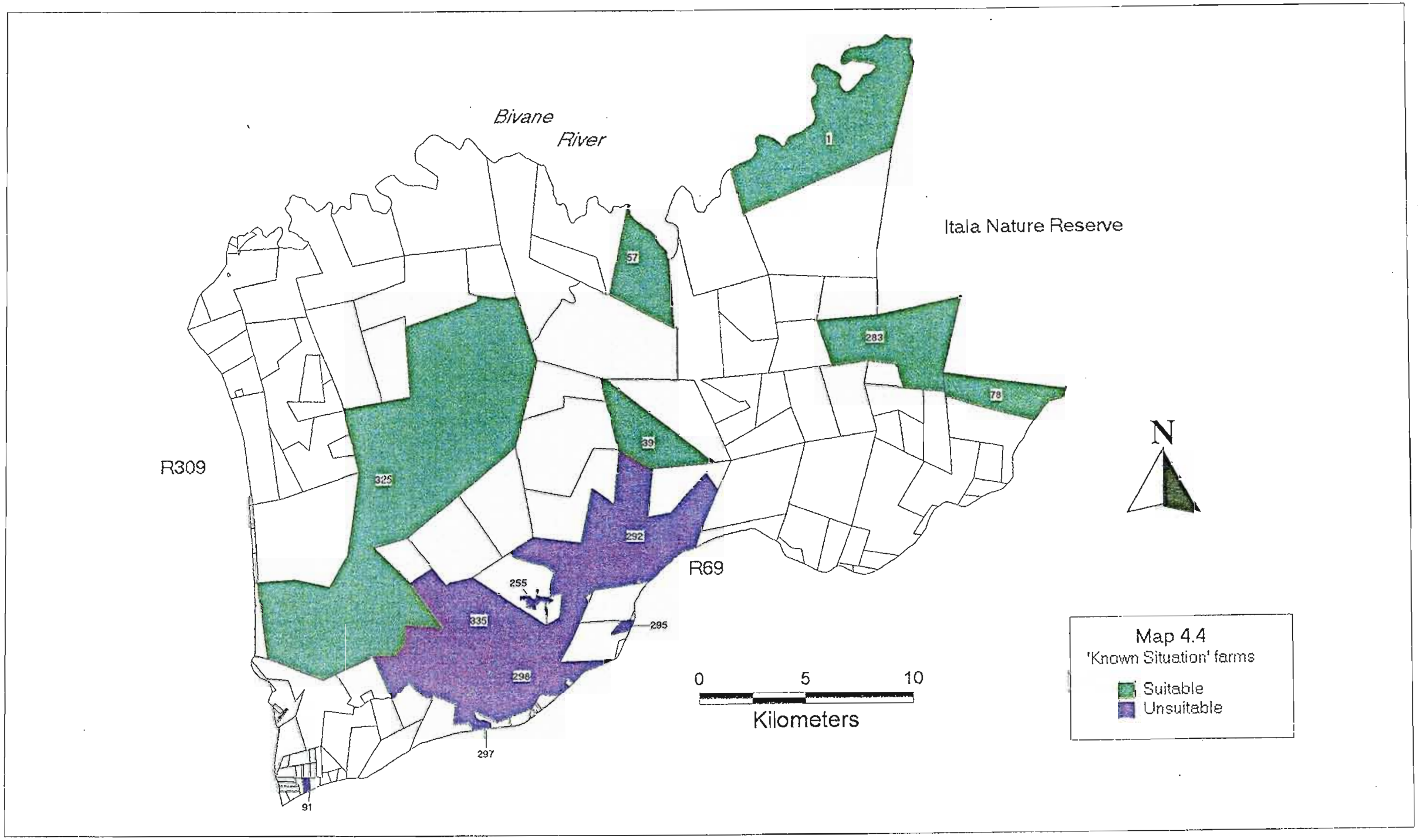
This property has been bought by the Impala Irrigation Board, who are constructing a holding dam on the property to supply irrigation to the sugar estates at Pongola. The Board has fenced off the farm with a game fence, introducing game as well as building lodges and other leisure facilities around the dam[4]. The land is suitable for game farming and has steep hillsides which do have rare and endemic vegetation species[5]. This is a highly suitable farm for inclusion in a biosphere reserve, with no negative impacts on conservation, sustainable development or research.

---

[3] pers. comm. Mr. S De Jager, District Conservation Officer, Vryheid, NPB (1996).

[4] pers. comm. Mr. S De Jager, District Conservation Officer, Vryheid, NPB (1996).

[5] pers. comm. Dr. JE Granger, Department of Botany, UNP (1997).



Map 4.4 Farms units where suitability class for inclusion in a biosphere reserve is known.

4.2.1.3 Draaiom (Farm 1)

This is a large farm inhabited by a Black rural community of approximately 45 families[6]. It appears that all arable land has been intensively cultivated in the past. The community living on this farm have, in the past, been working with the NPB on means of utilizing their natural resources for conservation and development at the same time[7]. The co-operation with the NPB, the relatively large areas of cliffs and quartzite ridges as habitats for vegetation species or communities identified as being priorities for conservation (Section 3.3.3) and the location of this property, would make it a highly suitable property to be included in the biosphere reserve, were it not for the estimated large number of residents on the farm and the relatively intensive land use of the arable parts of the farm. This farm is suitable for inclusion in the reserve, though mitigatory action should be taken to limit land uses.

4.2.1.4 Swissafari and EcoTours (Farm 283)

This is a large game farm with tourist accommodation providing for eco-safaris. It is a suitable farm for inclusion, as sustainable development and conservation management practices are already in place. It bounds on Itala and therefore is ideal as a buffer zone farm, since it could protects the core area against harmful land uses and edge effects. The company running the farm, Swissafari EcoTours, apply conservation management techniques which are in agreement with the principles of the biosphere reserve[8]. This farm is highly suitable for inclusion in a biosphere reserve.

4.2.1.5 Dames' Farm (Farm 78)

The owner of this farm has recently introduced impala to the farm for private hunting purposes. He is interested in expanding this game operation which would fit in well with the type of biosphere reserve recommended for this area[9]. The farm area contains part of the Louwsburg plateau, which has a very high vegetation conservation priority due to the high proportion of

---

[6]pers. comm. Mr. C Buthelezi, Community Development Facilitator, Vryheid (1996).

[7]pers. comm. Mr. T. Wolf, Research Technician, Itala Nature Reserve, NPB (1996).

[8]pers. comm. Mr. S De Jager, District Conservation Officer, Vryheid, NPB (1996).

[9]pers. comm. Mr. S De Jager, District Conservation Officer, Vryheid, NPB (1996).

endemic species found and the low percentage of this type of vegetation under conservation protection[10]. As the farm also bounds on Itala it fulfils the buffer zone protective function. This farm would be considered highly suitable for inclusion in the reserve.

4.2.1.6 Makalusi Community (Farm 39)

This property is inhabited by a Black rural community of about 40 families who farm cattle and cultivate the arable land. The community is aware of the danger of over-grazing the farm with cattle and are interested in exploring possible alternatives [11]. As a part of the biosphere reserve, a more conservation orientated grazing policy can be pursued, introducing a mixture of animals to the farm to utilize different parts of the vegetation. The community's income would not have to be based purely on the products of the land (game meat) but could include income from non-consumptive uses, such as tourism. This is a highly suitable property for inclusion in the biosphere reserve, especially with regards to the sustainable development and research aspects but must be regarded as only marginally suitable until the capacity of the land to support the community as part of the biosphere reserve can be determined. The participation of Black communities in these initiatives is essential if they are to succeed in South Africa in the long term (Jacobsohn, 1991). If this farm can be successfully integrated into the biosphere reserve, it may provide a model for similar rural communities elsewhere.

4.2.1.7 Hlobane (Farm 335) and Coronation (Farm 292) Mines

Hlobane and Vryheid Coronation coal mines have reached the end of their useful lives as mines and are now scaling down operations and seeking their 'Certificate of Closure'. The land is made up of mining infrastructure (dumps, workshops, sheds), transport areas (railways and roads) and residential areas. It is owned by the mining houses, Vryheid Natal Railway Coal and Iron Co. in the case of Hlobane and Anglo American in the case of Coronation. Each property has large tracts of relatively under-utilised land. As a whole the properties are not suitable for inclusion in a biosphere reserve at present. The total population of the properties (over 6000, Addo *et al.*, 1996) is too big to be supported by the land and would need outside industries to give employment on a more intense scale than tourism could provide. Incorporation of these

[10] pers. comm. Mr. R Scott-Shaw, Botanist, NPB (1996).

[11] pers. comm. Mr. C Buthelezi, Community Development Facilitator, Vryheid (1996).

communities into the biosphere reserve and the restriction of land use to extensive conservation management would not be viable. However, should the properties be sub-divided into constituent parts - residential and industrial areas being separated from the more open agricultural areas - it is likely that some of these areas would be highly suitable for inclusion in the biosphere reserve. This inclusion would benefit the whole surrounding community by improving quality of life through increased leisure facilities, providing jobs and spin-off industries from the biosphere reserve activities and encouraging outside investment in the region.

The cadastral boundaries used were correct as of July 1996 at the starting date of this project. It is understood that some of the sub-divisions owned by Vryheid Natal Railway Coal and Iron Co. have since been sold off[12]. The changes have been too numerous and rapid to be included in the project, but it is understood that all residential areas have now been legally subdivided and sold[13]. The Hlobane Mountain, in this case, would make an excellent addition to the Itala Biosphere Reserve as it represents an almost self-contained eco-system conserved in pristine condition and containing a number of documented rare or endangered plant species [14]. This area may even be included in the reserve as an additional core conservation area. The management plans for similar areas owned by Anglo-American at Coronation are unknown.

4.2.1.8 Kongolana Hotel and Filling Station (Farm 295)

The Kongolana Hotel and Filling Station is situated on the R69 from Vryheid to Louwsburg. The property is 38 ha and much of this is taken up by the hotel and filling station buildings. The inclusion of this property in the biosphere reserve would not benefit the biosphere reserve in any way. Whatever benefits the hotel may gain by being part of the biosphere reserve, are likely to be due to the proximity of the biosphere reserve, while inclusion would also mean some restriction of land use practice. This property is therefore considered unsuitable for inclusion in the biosphere reserve.

---

[12] pers. comm. Ms. C Cameron, Managing Director, HCC (1996).

[13] pers. comm. Ms. C Cameron, Managing Director, HCC (1996).

[14] pers. comm. Dr. JE Granger, Department of Botany, UNP (1997).

4.2.1.9 Duiker Mining Depot (Farm 297)

This property has little to recommend it for inclusion in the biosphere reserve. It provides for none of the necessary functions of the biosphere reserve or the buffer zone with the possible exception of offering land in need of reclamation. The land is taken up almost exclusively by mine dumps, coal waste, roads and railways. It is unsuitable for inclusion in a biosphere reserve.

4.2.1.10 Van Aswegen and Viljoen (Farm 91)

This property falls within Acocks' Veld Type 66, which is a priority vegetation type for conservation[15]. This property is farmed as a battery chicken farm. Extensive land use practices could not be expected to give the same return as intensive chicken farming. This farm would be considered unsuitable for inclusion in the biosphere reserve.

4.2.1.11 Hlobane Railway (Farm 298) and Coronation Sheds (Farm 255)

These two properties are unsuitable for inclusion in a biosphere reserve. They are both dominated by infrastructure such as railways, roads, and buildings and have nothing to contribute to the biosphere reserve besides opportunities for reclamation. They are unsuitable because, unless a lot of money is invested, they will be hazardous to game species, may be heavily polluted and have few features worth conserving that are not conserved in museums elsewhere.

4.2.2 Comparison Of 'Project' Method Classes with 'Known' Classes

Table 4.6 summarises the suitability classes for each of the known farms according to the assessment and the known suitability class of each farm. The method of assessment used in this project gives a correct indication of suitability in twelve of the thirteen cases where farm suitability class is known. This is equivalent to a success rate of approximately 92%. A more accurate evaluation of this assessment could be made if the suitability class of more farms were known.

---

[15] pers. comm. Mr. R Scott-Shaw, Botanist, NPB (1996).

Table 4.6 Comparison of 'Known Situation' classes with 'Project' assessment score classes

Property	Known Situation	Score	'Match'
Gertges	✔	✔	+
Paris Dam	✔	✔	+
Welgevonden	✔	✔	+
Swissafari	✔	✔	+
Dames	✔	✔	+
Makulusi	✔	✔	+
Coronation	✘	✘	+
Hlobane	✘	✘	+
Kongolana	✘	✘	+
Duiker/Nyembe	✘	✘	+
Van Aswegen and Viljoen	✘	✔	-
Coronation Sheds	✘	✘	+
Hlobane Railway	✘	✘	+
Matches with known situation			12

✔ = Suitable

✘ = Unsuitable

+ = Match between assessment and known situation

- = No match between assessment and known situation

The only farm showing an unsuccessful match was a small-holding farmed as a poultry farm (subdivision 15 of the farm Dagbreek 786 (Farm 91)) along the R69. The constituent scores for this farm are presented in Table 4.7.

Table 4.7 Constituent scores for Farm 91 (Van Aswegen and Viljoen)

Farm ID	Soil Cons.	Veg. Cons.	Fauna Cons.	Settlement Density	Land Tenure	Agricultural Potential	PLU	Tourism Potential	Education	Location	Score
91	0	4	2.3	2	0	-2.0	-6	0	0	-4	0.251

The difference between the assessed suitability and the known suitability for this farm is due mainly to the relatively low priority given to PLU and the omission of farm area as a suitability criterion. This plot is situated in veld type 66, which is a conservation priority veld type. The positive score associated with this, in conjunction with the positive score associated with fauna conservation potential for BRU Vc4 were enough to outweigh the negative scores for PLU and location. These scores can be rectified through review of the process used to allocate PLU scores and a review of the weightings for PLU and location.

The estimated level of accuracy of 92% is not satisfactory when assessing farms for biosphere reserve suitability. Inclusion of unsuitable farms or exclusion of highly suitable farms in a biosphere reserve may have significant long term effects on the viability of the reserve. This level of accuracy could be improved with refinements of the method used in this project. The results of any similar farm suitability assessment should be reviewed against expected results before any actions based on the results are taken. Suitability assessments are never infallible and common sense must be the final judge in these cases.

4.2.3 Evaluation of Approach with Respect to Published Guidelines.

Further evaluation of this approach was done by comparison with two sets of published requirements for natural resource planning. Garett (1982) outlined an approach to integrated regional planning which included the following components:

- 'definition of extent and boundaries of the planning region in logical geographical, ecological or human terms;
- a system for collecting, storing and retrieving relevant and structured information;
- a system for analysing and inter-relating the various categories information such as computerised land information systems or sieve mapping;
- an ability to define various planning options and assess their consequences;
- systems for full cooperation and input from all relevant disciplines and organisations;
- and effective public participation leading to
- definition of realistic and acceptable regional planning objectives as a consistent framework for more detailed sectoral planning.'

This project meets the first four of these criteria. The planning region was defined in logical geographic terms in Chapter 1. Chapters 2 and 3 describe the system used for collection and storage of data. This system was computer based and included a GIS programme ('MapInfo') and a database programme ('Paradox'). The additional database programme was used because the data manipulation capabilities of the GIS programmes used were not adequate for the project. The system developed for analysing and inter-relating the data is described in Chapter 3. This system also makes use of the database and GIS programmes and includes the use of a spreadsheet for some data manipulation. These programmes include tools for 'what-if' and 'scenario' analyses, which can be used to define planning options and to assess the consequences thereof.

Attempts have been made to work in cooperation with the potential role players in this reserve through communication with agricultural, regional planning, conservation and development specialists in the region. Public participation was avoided in this project at the request of potential role players, since other researchers in the field are currently involved with this aspect. The results of their research were not available at the time when the information was required for this project, and thus were not used. Nevertheless, it is felt that the results of this project provide a tool for the definition of regional planning objectives, which may be used as a framework for further planning. This project does not go all the way to fulfilling the requirements for integrated planning set out by Garett (1982), but is consistent with the first stages of this planning.

Balzer (1982) states that the rational resource planning process should:

- 'Directly address the stresses and tensions which arise when questions of conservation and development are debated;
- be an effective and equitable process which establishes priorities for resource use based upon clearly defined criteria which address the reality of both present and projected needs;
- accommodate the needs of developing nations whose economies are rapidly expanding due to abundant natural resources that are often in areas suitable for varied uses;

- encourage professionals representing all interests to work together in open communication;
- be conducted with the best data and information available for the resource;
- allow policy-makers to make decisions based on sound scientific information and good public policy.'

The stresses and tensions between the concepts of conservation and development have been one of the foci of this project. These have been addressed through the prioritisation of factors affecting farm suitability with respect to both conservation and development, using the Analytical Hierarchy Process. This process is a recognised process and has proved to be an effective tool for multi-criteria decision making. This project does not focus on prioritising resource uses, as required in the third point above, but takes these resource uses from recommendations for biosphere reserve (Batisse, 1984; 1986). A biosphere reserve will accommodate the needs of South Africa as a developing nation. The need in the study area is for conservation of sensitive natural resources and for development of communities that have been previously disadvantaged.

This survey has been done with the most appropriate and best information available at the time. More accurate and detailed information might have been gathered, though this was not consistent with the level of detail examined in this project. As more data were available for the natural and conservation factors than were available for social, political and economic factors, the results are probably biased in favour of farms suitable for conservation, rather than for sustainable development. If more detailed social data were available, it would have been possible to identify the needs of the local people more clearly and to have scored social factors, so that farms were given a high suitability rating if they were able to meet these needs. Similarly, if more financial data were readily available for the properties in the study area, it would have been possible to identify farms with high potentials for alternative land uses, or farms where a change of management strategy is necessary for continued solvency. However, this paucity of data does not invalidate the approach used. Rather the approach is designed to make the best use of the available data to formulate recommendations.

The information presented in this project could be used to support policy decisions made regarding the biosphere reserve. Balzer's (1982) requirements are wide ranging and targeted at a more conceptual level than was examined in this project. However, it was felt that this project was successful in meeting its relevant objectives.

4.2.4 Project Simplicity and Efficacy

The results of the project suitability assessment were compared with results from two simplified methods of assessment to make an evaluation of the simplicity and accuracy of the project method. The suitability scores of the three methods of suitability assessment were subjected to an analysis of variance (ANOVA) test which identified whether the different methods produced significantly different results. The evaluation of the efficacy of these methods was based on a comparison of suitability classes from the methods of assessment, with the known suitability class for the farms discussed in Section 4.2.1.

The first alternative method of suitability assessment, referred to as the 'No Weightings' method, disregarded the weightings of the different factors and calculated a farm's final suitability score by taking a mean factor suitability score. The results of this assessment are given in Table 4.8 and Map 4.5.

Table 4.8 Results from 'No Weightings' farm suitability analysis

Class	Class Boundaries	Count
Suitable	0 - 3.195	67
Unsuitable	-3.18 - 0	94
Mean suitability score		0.004
Standard deviation		1.148

The second alternative (referred to as 'Limited Factors') limited the number of factors used in the suitability assessment. Four factors were chosen for this method: land tenure, settlement density, vegetation conservation and agricultural potential. These were chosen because they had high priority weightings in the main analysis and because they represented a variety of perspectives ranging from natural, to economic, to social. The relative weightings used for these four factors were the same as those determined for the 'Project' method. The results of this analysis are shown in Table 4.9 and Map 4.6.

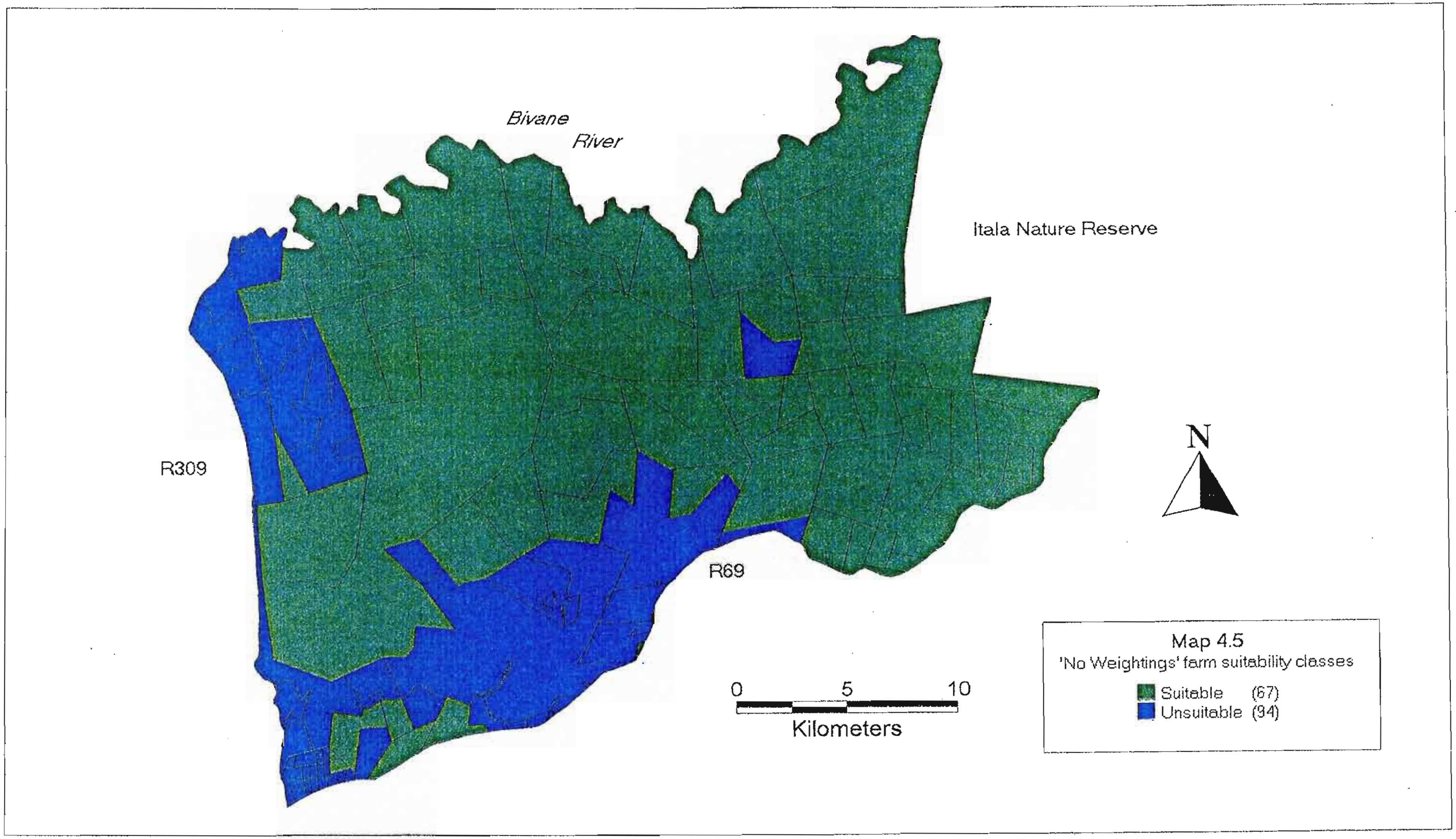
Table 4.9 Results of 'Limited Factors' farm suitability analysis

Class	Class Boundaries	Count
Suitable	0 - 3.519	125
Unsuitable	-3.5 - 0	37
Mean suitability		0.618
Standard deviation		1.324

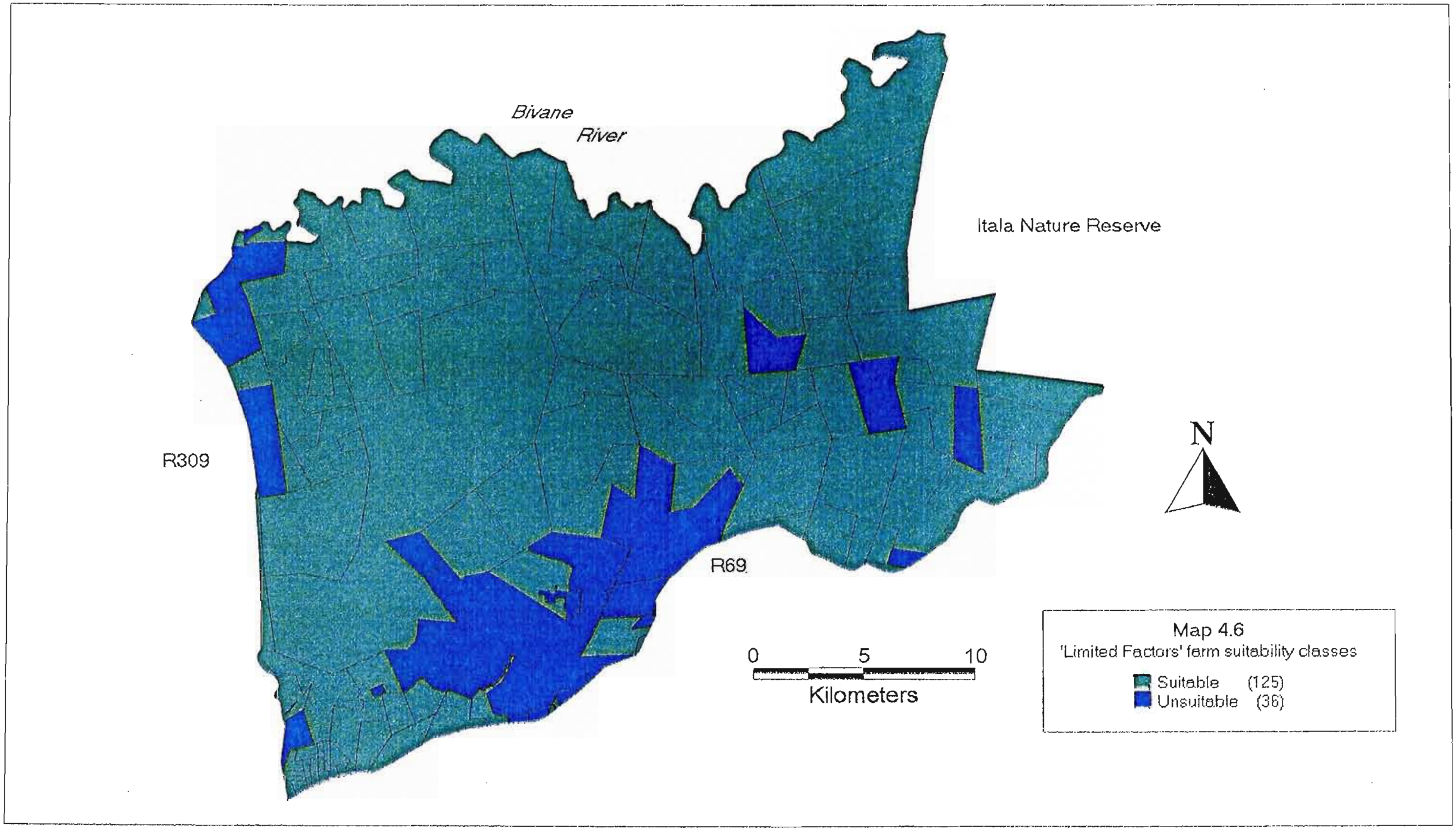
4.2.4.1 Analysis of Variance for 'Project', 'No Weightings' and 'Limited Factors' Methods of Suitability Assessment.

The data examined in this suitability assessment is categorical and discrete, depending on scales of value judgments from 'moderate' through to 'extreme'. There are 'nonparametric' methods of testing these results that do not rely on the assumption of a specific distribution for the data. Although the efficiency of these methods is high for small sample sizes, it decreases as the sample size increases. In addition, these nonparametric tests extract less information than the equivalent parametric test, and if the parent population can be shown to approximate a known distribution, the parametric tests for that distribution may be used (Steel and Torrie, 1980).

An ANOVA was done on the three methods to determine whether they produce the same average suitability score. This would indicate that the sets of suitability scores produced were not significantly different. The ANOVA procedure assumes that the distribution of the data used is normal. The distribution of the results in this project is not normal as it has been derived from discrete and categorical data. However, for the purposes of analysis, a normal distribution may be assumed as sample size is large and the shape of the frequency distribution approximates the bell curve of the normal distribution, even though the parent population is known not to be normally distributed (Reichmann, 1961).



Map 4.5 Farm suitability for inclusion in a biosphere reserve. Suitability was determined with no weighting differences between determinant factors ('No Weightings' method).



Map 4.6 Farm suitability for inclusion in a biosphere reserve. Suitability was determined with four determinant factors ('Limited Factors' method).

Figure 4.1 shows the frequency distribution of the score obtained in all three methods of suitability assessment. It can be seen that the shape of this distribution is similar to the bell-shaped curve of the normal distribution, and it is assumed that statistical tests designed for normally distributed data will give accurate results when used to test the suitability assessment data. The ANOVA test is used where the distribution of data can be shown, or may be assumed to be normal and where significant differences need to be determined between more than two samples or replications (Steel and Torrie, 1980).

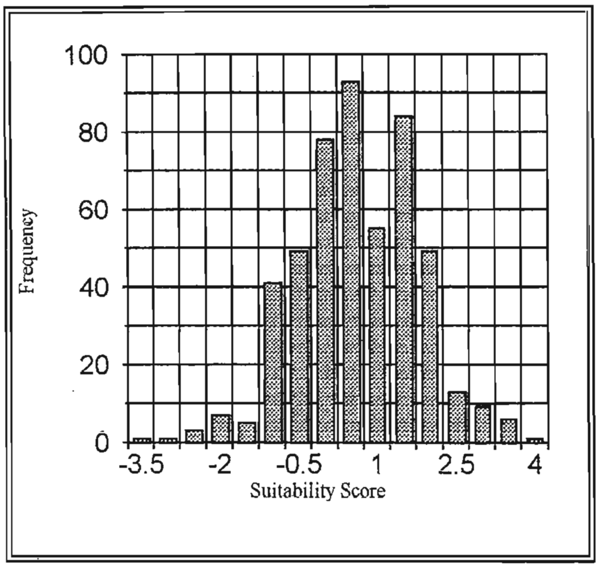


Figure 4.1 Frequency distribution for suitability scores from 'Project' method, 'No Weightings' method and 'Limited Factor' method of suitability assessment

The null hypothesis (H_0) for this ANOVA test is that there are no significant differences between the results of any of the three methods of assessment. The alternative hypothesis (H_1) states that there are significant differences between at least one pair of the three sets of results from the suitability assessments. The level of significance chosen for this test was 0.05. This means that the null hypothesis was rejected if the F-value indicated that the probability of obtaining the observed scores in three random samples from the same population was less than 0.05.

The ANOVA table was computed using 'Minitab' (Pennsylvania State University, 1996). Table 4.10 presents the results of this analysis. The F-value was found to be significant at $\alpha = 0.05$ level and H_0 was rejected.

Table 4.10 Analysis of Variance of 'Project', 'No Weightings' and 'Limited Factors' methods of farm suitability assessment.

Source	df	SS	MS	F	p
Method	2	28.29	14.14	11.15	0.0001
Error	492	623.97	1.27		
Total	494	652.26			

Significant differences between the results from the three methods of assessment were identified using Dunnett's test statistic (Steel and Torrie, 1980). Confidence intervals for the mean based on pooled standard deviation were calculated in 'Minitab' for each method (Figure 4.2). These showed that the scores from the 'No Weightings' method were significantly different to the results from the 'Limited Factors' method at the 0.05 significance level. The 'Project' method of suitability assessment, incorporating factor weightings and all ten determinant factors, did not provide results that were significantly different from either of the two alternative methods, although the lower limit of the 95% confidence interval for the 'Project' method was equal to the upper limit of the 95% confidence interval for the 'No Weightings' method. From Figure 4.2, it would appear that the 'No Weightings' method of assessment shifts the scores towards unsuitability, whilst 'Limited Factors' tends to shift scores towards higher suitability, though this shift is not statistically significant. If any coarser level of significance were chosen, these two methods would have been found to be significantly different to each other.

It is not possible to conclude that the method developed for this project is better or worse than the two alternative methods at appraising farm suitability for inclusion in a biosphere reserve on a statistical basis, since the results of the assessment were not found to be significantly different from either of the two alternative methods of assessment. However, the case for the use of the 'Project' method of assessment over the 'No Weightings' and 'Limited Factor' methods can be argued from a logical viewpoint.

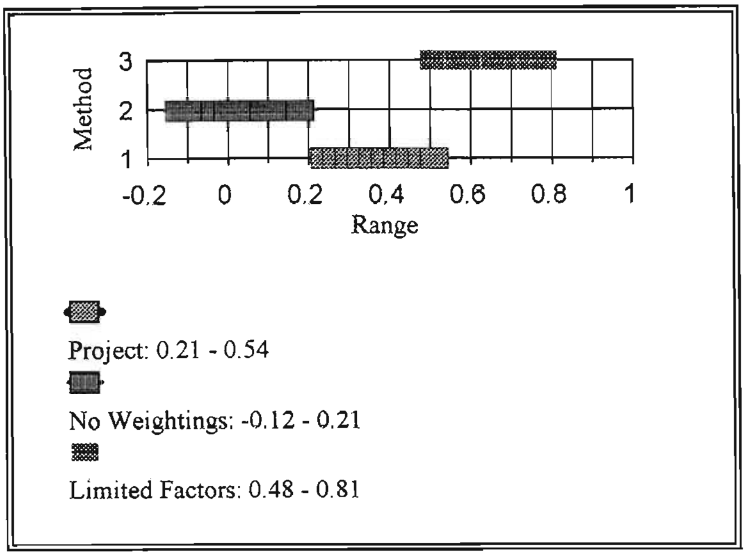


Figure 4.2 Confidence intervals (at 95%) for three methods of assessing farm suitability for inclusion in a biosphere reserve

The weighting of factors is necessary in order to avoid scenarios where farms are marked as highly suitable or highly unsuitable because of relatively unimportant or low priority characteristics. In this particular project, the weightings between factors are relatively even and it may be possible to obtain accurate results without going through the process of weighting the factors. However, factor priorities within the different biosphere reserve functions (conservation, sustainable development and research) were markedly different, and should the balance between these factors be changed for this or for other similar assessments, the differences between factor weightings may become notably different.

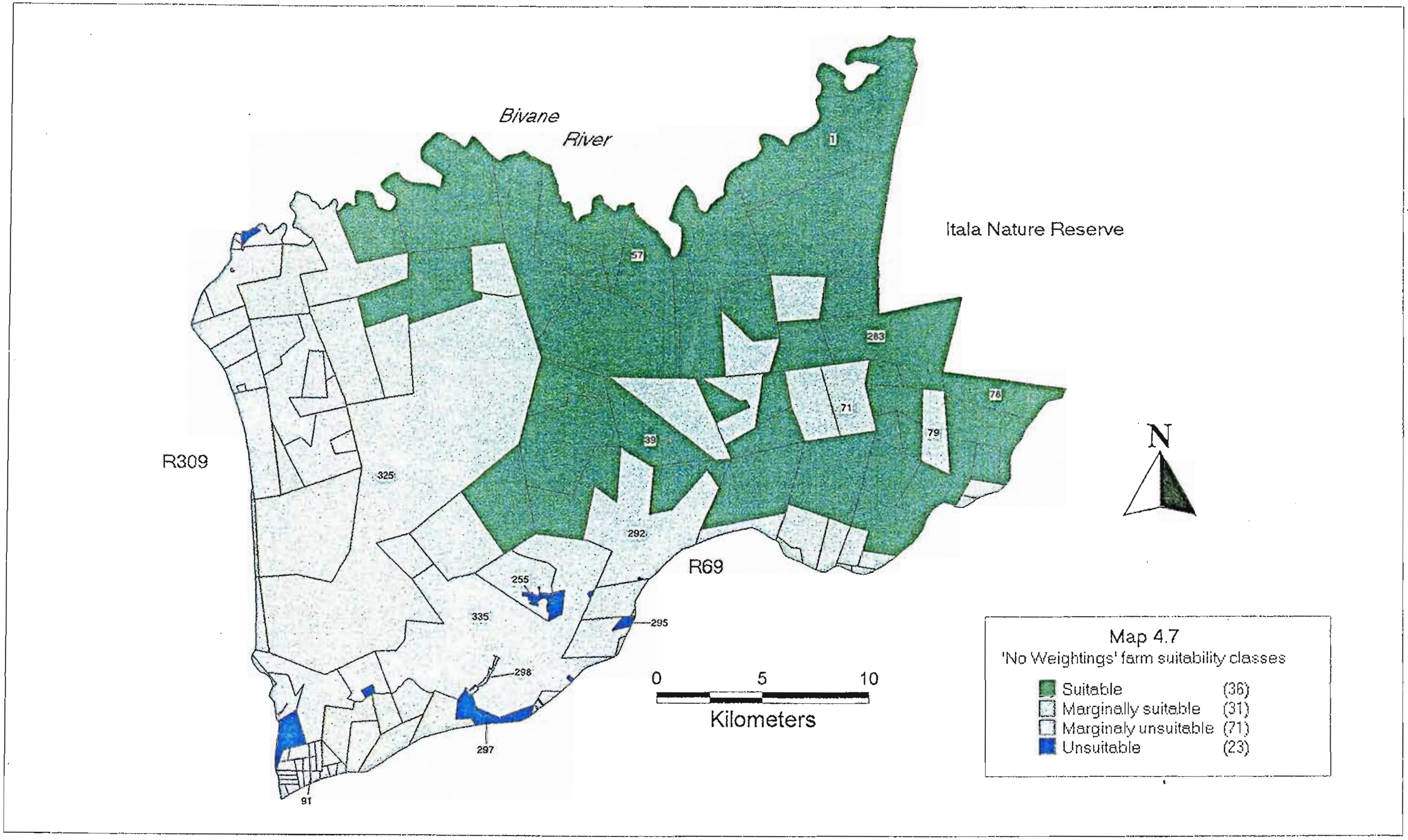
It can also be accepted that as many factors as possible need to be taken into account in the suitability assessment, so that a holistic portrayal of the farm's suitability may be obtained. Situations where farms are wrongly scored because important characteristics have not been accounted for should be avoided. For these reasons, the method proposed in this project, is taken to be the most accurate method of determining farm suitability for inclusion in a biosphere reserve. In order to ensure higher levels of accuracy than have been obtained in this project, it is necessary to have ready access to detailed data and to have value judgements made by experts in the respective fields.

4.2.4.2 Comparison of Maps for 'Project', 'No Weightings' and 'Limited Factors' Methods of Assessment.

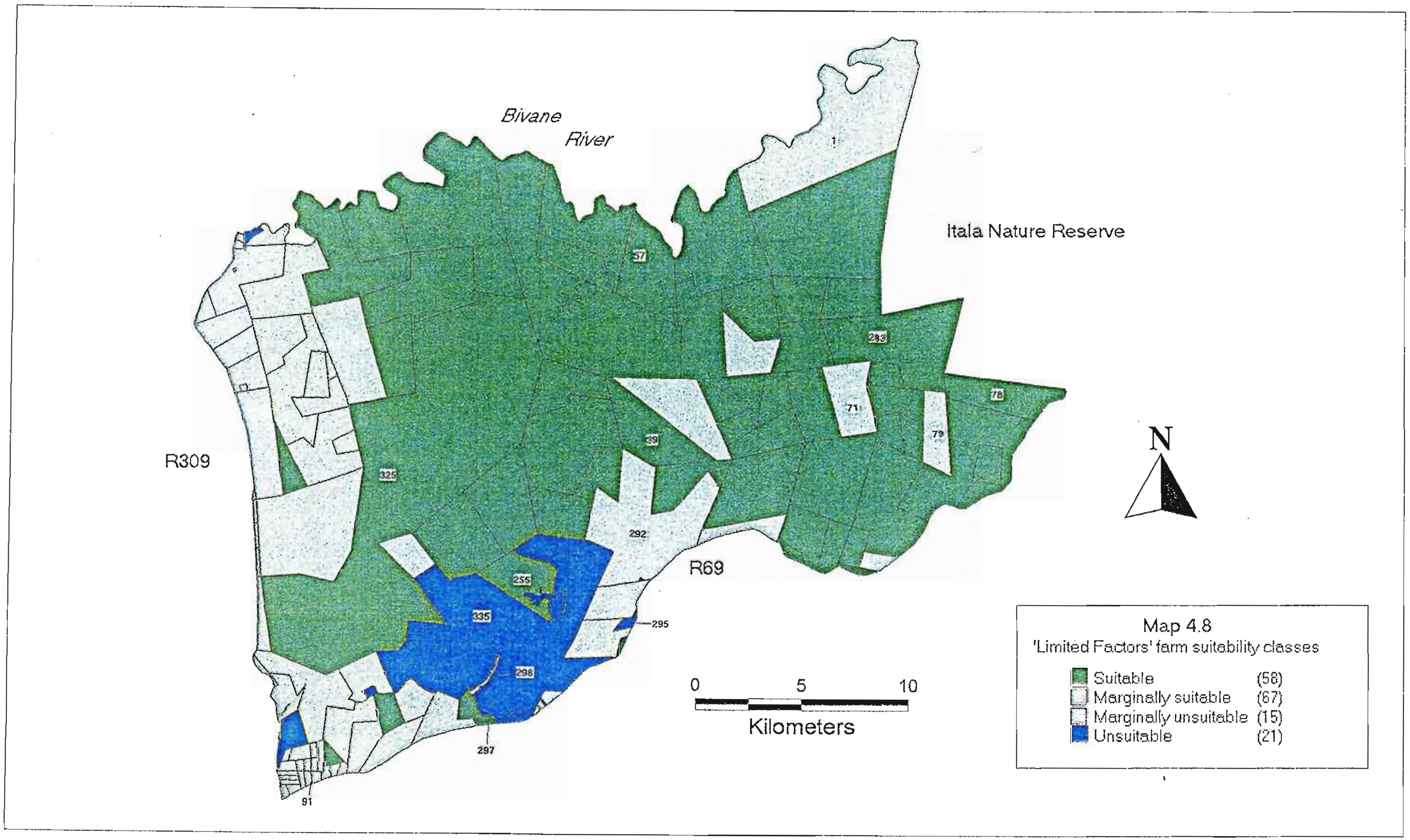
The thematic maps from the three methods of assessment (Map 4.2, Map 4.7, and Map 4.8) were examined with respect to the area of suitable and unsuitable land in each, and the pattern and positioning of these classes. These maps included classes for marginally suitable and unsuitable farms. These classes were determined by dividing the range of suitability values for each method into three equally sized classes. The middle class was taken to include marginal scores. Negative scores in this class were marginally unsuitable and positive scores were marginally suitable. This was an arbitrary division for interpretive purposes, and there is no guarantee that there is in reality a significant difference in suitability between farms in different classes (Section 4.1.2).

The three methods showed similar general patterns of suitability. Large extensively managed farms near Itala Nature Reserve had high scores in all three methods, while unsuitable farms tended to be small, densely populated, with intensive land uses or situated far from Itala. All three methods showed regions of unsuitable to marginally suitable land along the R309 and along the R69 near the old mining towns. The 'Limited Factors' method showed the highest number of highly suitable farms (59) and clearly the largest area of highly suitable land.

The distribution of farms in the different suitability classes from the 'No Weightings' method highlights the difference that the weighting or prioritisation of factors makes, especially to those factors with very low or very high priorities. Map 4.7 shows that the majority of highly suitable farms in 'No Weightings' are found near Itala, whilst the highly unsuitable farms are found furthest from Itala. This finding is assumed to be a function of the change in weighting of the location factor. Factors which have very high or very low weightings will experience the greatest change in their influence on final score when weightings are disregarded.



Map 4.7 Farm suitability for inclusion in a biosphere reserve. Four classes of suitability are presented, ranging from highly unsuitable farms to highly suitable farms. Suitability was determined with no weighting differences between determinant factors ('No Weightings' method).



Map 4.8 Farm suitability for inclusion in a biosphere reserve. Four classes of suitability are presented, ranging from highly unsuitable farms to highly suitable farms. Suitability was determined with four determinant factors ('Limited Factors' method).

Location would be the most likely factor to have this effect as it had a very low ranking in the priority listings for conservation, for sustainable development and for research (Section 3.5.2). The standardisation of the weightings will mean that the change in location's effect on final score will be greater than the change in any other factor's score.

The limited factors method of assessment identifies two farms close to Itala Nature Reserve (Farm 71 and Farm 79) as being unsuitable for inclusion in the biosphere reserve, where the other two methods identified them as being suitable. All three methods place these farm in the marginal class, so there is not a high degree of difference in the suitability score. Examination of the constituent scores for these two farms (Table 4.11) shows that the negative score in the 'Limited Factors' method is a result of a negative population density score which is more highly weighted than the positive score for agricultural potential. The other two methods of assessment take into account positive scores for soil conservation, fauna conservation, and location which result in an overall positive score for each farm. This situation provides a justification for using a method of assessment taking as many of the farm suitability determining factors into account as possible.

Table 4.11 Constituent scores for farms close to Itala scored as unsuitable by 'Limited Factors' method but as suitable by 'Project' and 'No Weightings' methods

Farm ID	Soil Cons.	Veg. Cons.	Fauna Cons	Popn	Land Tenure	Agric. Pot	PLU	Tourism Pot	Edu.	Loca.	Project Score	No Weighting	Limited Factor
71	4	0	1.51	-4	0	4.00	1	0	0	4	0.88	1.05	-0.08
79	2	0	3.15	-4	0	4.00	-4	0	0	4	0.39	0.52	-0.08

4.2.4.3 Comparison with 'Known Situation'

Table 4.12 summarises the suitability classes for each of these farms from each of the methods of suitability assessment used (Section 4.2.1).

Table 4.12 Comparison of 'Known Situation' scores with 'Project', 'No Weightings' and 'Limited Factors' score classes

Property	'Known Situation'	'Project'	'No Weightings'	'Limited Factors'
Gertges	✔	✔	✔	✔
Paris Dam	✔	✔	✔	✔
Welgevonden	✔	✔	✔	✔
Swissafari	✔	✔	✔	✔
Benade	✔	✔	✔	✔
Makulusi	✔	✔	✔	✔
Coronation	✘	✘	✘	✘
Hlobane	✘	✘	✘	✘
Kongolana	✘	✘	✘	✘
Duiker/Nyembe	✘	✘	✘	✔
Van Aswegen and Viljoen	✘	✔	✘	✔
Coronation Sheds	✘	✘	✘	✘
Hlobane Railway	✘	✘	✘	✔
Matches with known situation		12	13	10

✔ = Suitable

✘ = Unsuitable

This table shows that the 'Project' method is correct in 12 cases, the 'No Weightings' method in all 13 cases and the 'Limited Factors' method in 10 out of 13 test cases. The significance of the number of successful matches was tested using Cochran's Q test (Siegel, 1956). This is a nonparametric test used to test the null hypothesis (H_0) that the probability of a successful match with known situation is the same for all methods, implying that the three methods of assessment are equally accurate in their prediction of farm suitability for inclusion in a biosphere reserve.

The alternative hypothesis (H_1) states that the probability of a successful match with known situation differs according to method of assessment used, and implies that there is a significant difference in the accuracy of the methods. A significance level of 0.05 was chosen. For H_0 to be rejected, the test statistic had to show that the probability of obtaining the observed number of matches under H_0 was less than 0.05.

Table 4.13 shows the figures used in the Q test. The total number of 'successes', and the total number of successes squared are signified by the expressions L_i and L_i^2 respectively. The distribution of Q is equivalent to the χ^2 distribution and the same tables are used to determine probabilities.

Table 4.13 Successful matches of assessment scores with 'Known Situation', with row and column totals for Cochran's Q test.

	Match with 'Project'	Match with 'No Weightings'	Match with 'Limited Factors'	L_i	L_i^2
Gertges	1	1	1	3	9
Paris Dam	1	1	1	3	9
Draaiom	1	1	1	3	9
Swiss Safari	1	1	1	3	9
Dames	1	1	1	3	9
Makulusi	1	1	1	3	9
Coronation	1	1	1	3	9
Hlobane	1	1	1	3	9
Kongolana	1	1	1	3	9
Duiker / Nyembe	1	1	0	2	4
Van Aswegen and Viljoen	0	1	0	1	1
Coronation Sheds	1	1	1	3	9
Hlobane Railway	1	1	0	2	4
Total	12	13	10	35	99

The Q value calculated was 4.6667. This was looked up in the χ^2 tables in Table A5 in Steel and Torrie (1980). The probability of a greater Q under H_0 was found to be between 0.1 and 0.05. The null hypothesis could not be rejected in this test showing that for the thirteen test cases, there were no significant differences in the accuracy of the three methods of assessment.

The ANOVA table and Dunnett's test conducted on the complete sets of scores showed that there was a significant difference between the mean farm suitability scores of the 'No Weightings' and the 'Limited Factors' methods of assessment. However, this difference was not apparent in the comparison with 'Known Situation' farms. One possible reason for this is the relatively small sample size used in the 'Known Situation' comparison.

It is possible that the differences between these methods and the known suitabilities is due to random error, as sample size was relatively small (13 farms out of a total population of 161).

An alternative explanation for the lack of significant difference between methods in the comparison with 'Known Situation' scores is the lack of power associated with nonparametric statistical tests. One of the disadvantages of using nonparametric tests with data of this type is that it is often difficult to reject the null hypothesis, unless there are strong differences in the data[16].

The choice of farms used for this comparison was limited to those farms about which in-depth information was available on its specific suitability with respect to a local biosphere reserve. All such farms were used in the comparison so that a more accurate interpretation could be made of the efficacy of each method. Furthermore, the farms used for 'Known Situation' tended to be either strongly suitable or strongly unsuitable for inclusion. If the farms were not clearly suitable or clearly unsuitable, they could not have been used as a 'Known Situation' example. However, this degree of suitability usually meant that there were high scores for high priority factors within the constituent scores. Of all the farms in the study area, the farms chosen for 'Known Situation' were therefore the farms where the methods of assessment were most likely

[16] pers. comm. Mr. K Stielau, Department of Statistics and Biometry, UNP (1997).

to give the correct suitability class. There are likely to be more differences between assessment methods and 'Known Situation' for marginally suitable farms.

Examination of the conditions of 'Known Situation' farms (Map 4.4) shows that those properties close to Itala Nature Reserve tend to be suitable and those far from it, unsuitable. Theoretically distance from core area should have little role to play in determining suitability, according to the factor priority weightings (Table 3.7). In reality, either distance from core areas of location with respect to population centres such as Vryheid or Hlobane may play a strong role in determining farm suitability for inclusion in a biosphere reserve. Location with respect to population centres was not considered at the start of the project because the definition of a biosphere reserve, and the requirements for a biosphere reserve do not set a limit on population densities, and specifically require that the human population be involved with the establishment and management of the biosphere reserve (Batisse, 1984; UNESCO, 1994; IUCN's Commission on National Parks and Protected Areas, 1982). By the time that this was identified as a possible factor in determining farm suitability, the time allocated to this project had run out. It was decided that the improvement in accuracy expected through incorporation of this factor into the suitability assessment process was not worth the extra time that would be required.

Location with respect to towns or cities is related to the effect that farm size has on suitability. Game can be run on farms as small as 50 ha (Young, 1992). Farms smaller than this are not excluded from participating in a biosphere reserve if they are depending on tourist activities and accommodation or other more intensive activities associated with the biosphere reserve to provide income. However, farm sizes tend to become smaller as they get nearer a town or population centre. Farms close to Itala are far away from Vryheid and tend to be larger and more extensively managed than those nearer Vryheid. This situation may have been avoided if farm size were used as an individual criteria instead of being treated as part of PLU. Farm size was not considered as a factor on its own as the definition and requirements for a biosphere reserve are broad enough to include almost any farm size provided that management is centred on conservation, sustainable development and research and that the management is networking with the rest of the biosphere reserve participants (Batisse, 1984). A comparison of Map 4.4 with Map 4.5 reveals that this is a further reason why there is little difference between the known situation and 'No Weightings'. Known situation farms that were classed as being suitable for inclusion in a biosphere reserve tended to be large and situated close to Itala Nature Reserve, whereas farms classed as being unsuitable tended to be small and far away from Itala. PLU is the only factor to take farm size into account and the effect of this factor is increased in 'No Weightings'. In addition, the effect of distance on suitability score is increased fivefold in 'No Weightings'.

The factors determining farm suitability had relatively equal priorities in all three methods of assessment. The four highest factors: soil (13.87%), vegetation (13.21%) and fauna conservation (13.21%) and settlement density (12.87%) account for only 53% of the total priority ratings (Table 3.7). In this situation it is necessary to include all relevant factors. This is especially important when the end suitability depends on many different factors which are not dependant on each other, for example economic, social and conservation factors may have conflicting effects on the end suitability and all of these need to be accounted for.

4.3 Possible effects of a UNESCO / MAB reserve in northern KwaZulu-Natal

Having shown that there are farms within the study area which have the potential to be included in a biosphere reserve, the advantages of establishing such a reserve were weighed against some of the disadvantages. This serves to emphasize the need in South Africa for approaches to integrated conservation and development, such as the MAB approach, which allow for human settlement and multiple land uses.

South Africa is advertised to the tourist world as 'a world in one country', and it has a wide range of different climatic and topographic conditions, resulting in biotic diversity as rich as any similar sized region in the world. In addition, South Africa is a developing country and consumption rates are set to increase with empowerment of the Black sector of the economy (Huntley *et al.,* 1989). There is great need in South Africa for methods of ensuring that her natural resources are not destroyed or compromised as populations increase and economic pressure for development intensifies. The biosphere reserve concept is one method where the country's natural resources can be safeguarded without preventing the land from providing for the population.

There may be valuable natural and cultural resources in need of legal and administrative protection in northern KwaZulu-Natal. However, it is not economically feasible to declare these areas as protected conservation areas at a time when economic support is declining due to mine shut downs and problems in the agricultural sector. There is need for an open conservation approach such as the biosphere reserve principle, where protected areas can be incorporated into a mosaic of extensive conservation based land uses and more intensive human based management practices, allowing the land to be economically productive, yet conserving important natural resources.

Conservation of natural resources will not occur in the study area unless the socio-economic development of the local community is seen not to be threatened by conservation activities (Dasmann, 1982). Similarly, regional development will not be sustainable, unless the resource base is conserved (World Commission on Environment and Development, 1987). This balance and co-dependence between conservation and development is a basis of the biosphere reserve concept itself (Batisse, 1993). This project's assessment of farm suitability attempts to reach a balance between these roles of the biosphere reserve through the prioritisation process, where all factors affecting farm suitability were prioritised with respect to conservation and development. Research is included in the prioritisation process as one of the fundamental concepts behind the UNESCO biosphere reserve vision (Batisse, 1984).

The marriage between conservation and development is at times an uneasy one. On the one hand, development demands that people have the economic security necessary to meet their basic needs plus some opportunity to fulfil aspirations for an improved quality of life (World Commission on Environment and Development, 1987). On the other hand, biodiversity conservation demands the preservation of as many species of biodiversity as possible through the representation of these species in protected areas. Conservationists are agreed that this means more and larger protected areas, or more land under land uses limited to those compatible with nature conservation (Noss and Cooperrider, 1994). In many cases this also means a reduction in short and medium term revenues per unit area of land, i.e. financial return in Rand per hectare or Rand per acre (ODA Natural Resources and Environment Department, 1991), which implies a diminished capacity to meet immediate needs. Priorities for biodiversity conservation must be defined which allow for the support of the world's human population (Holdgate, 1996). Ideally, a biosphere reserve seeks to balance conservation and development by ensuring that development occurs within the context of conserving the biodiversity resource base (Batisse, 1993).

The creation of a biosphere reserve in the Itala area that complies with UNESCO specifications would have a number of advantages for the area. The participants in the project would benefit from economies of scale such as the development of a single administrative body for the project. This body would allow for coordination between development initiatives and for more focus in policy making. A more comprehensive list of tourist attractions, and the use of a single body for anti-poaching law enforcement would result from the development of a biosphere reserve. The different properties making up the reserve would each contribute their own characteristics, and each property would build on its neighbours advantages as well as its own. The increased tourism potential associated with this increase in scale should lead to an increase in tourism revenue in the region, which, if wisely invested, should contribute to economic and social development in northern KwaZulu-Natal. The biosphere reserve would provide a large physical area for research and a wide range of research fields.

Cooperation in conservation and especially in the management of wild animal species between landowners and managers has a number of additional advantages. The advantages for common conservation practices between landowners was listed by Young (1992) and include:

- regular contact between role players;
- control of invasive plant and animal species such as wattle or stray dogs;
- a deterrent to stock thieves and the discouragement of firewood theft;
- regular reports concerning strange tracks and suspect persons;
- an increase in game and bird numbers and in viewing opportunities as animals feel more secure in larger conservation areas;
- more effective protection of threatened habitat or rare and endangered plants;
- regular inspection of game fences leading to more effective protection of game animals;

- and more effective control of fire.

Although these advantages are associated with common conservation practices between landowners, it can be assumed that participants in a biosphere reserve would benefit from them.

The recognition of the reserve by UNESCO is significant as a measure of international recognition and credibility. More international organisations would have access to information about the reserve. This exposure may make it easier to access development funding, both inside South Africa and from overseas.

International recognition of features endemic to the region that deserve protection and conservation can reinforce and strengthen the commitment to conservation of these areas at a local level.

In the long term, the emphasis on sustainable development in the area should have economic benefits. Environmental degradation leads to a decrease in the productive capacity of the area. A protected and well managed environment will avoid the costs associated with a diminished productive capacity. Internalisation of external costs is especially important to environmental management (Pearce and Turner, 1990). The emphasis on sustainable development should also lead to economic empowerment of local communities, and thus to sustainable economic growth in the region. This is an important consequence as conservation practices will not succeed in the long run unless they take the needs of local people into consideration (Dasmann, 1982)

Biosphere reserves play an important role in monitoring regional trends (Croze, 1982). This is true of the social and economic trends within the buffer zone as well as natural trends over the whole reserve. A regional representation of climate can be formulated from rainfall, temperature and evapotranspiration records over the whole reserve, whilst the local ecology can be monitored through records of large mammal distribution, large mammal reproduction, fire frequency and extent, and plant productivity (Croze, 1982).

As a UNESCO / MAB recognised reserve, management conditions will have to be met, and these will place restrictions on the type of management that could be applied within the area. While it is hoped that these conditions will benefit the area, farmers and managers used to making their own management decisions may resent the limitations placed on their management by submitting to biosphere reserve guidelines.

Unless carefully planned, the organisation and administration of the biosphere reserve itself may lead to negative perceptions of the reserve by both participants and outside investors. Poor communication, failure to meet targets, and inefficient administration may lead to scepticism and resentment of the reserve by local landowners.

4.3.1 The Proposed Itala Biosphere Reserve

A simple model for the proposed Itala Biosphere Reserve (IBR) is presented which accommodates local constraints such as the lack of large areas of ecologically pristine vegetation for core areas. An open and representative administrative structure is recommended to ensure the long term stability of the reserve.

4.3.1.1 Spatial Organisation

Core areas in the proposed IBR would be situated in the Itala Nature Reserve and possibly at Hlobane. Only a small proportion of Itala itself is in ecological benchmark condition suitable for a core area, but it is ideally suited for research into regeneration of old agricultural land for conservation purposes (NPB Communications, 1994). Other core areas may be identified if there are pockets of undisturbed indigenous vegetation large enough to provide a relatively self contained eco-system.

The buffer zone ideally surrounds the core area and allows for denser settlement and more intensive land uses than for core areas (Figure 1.1) (Noss and Cooperrider, 1994). The IBR buffer zone should be a continuous expanse of land surrounding the core conservation areas, where the landowners are willing to limit land use practices to those in accordance with biosphere reserve principles. The transition area around the Itala Biosphere Reserve would not have to be delineated. The purpose of this area is to allow for local networking which would help to serve the development role of the biosphere reserve (Batisse, 1984).

The suitability assessment performed in this project evaluates each farm's suitability for the three major roles of a biosphere reserve; conservation, sustainable development, and research according to ten determinant factors. Very high suitability scores should indicate areas which are highly suitable for one or more of these biosphere reserve roles, and which have few characteristics which would be an impediment to any of these roles. These areas may be considered for inclusion as core areas. These areas would need legal protection as conservation areas before being approved as core areas for the reserve. Positive suitability scores should indicate suitability for inclusion in the buffer zone of the reserve. These properties would only be included in the buffer zone if the manager of the land wishes to manage the land according to conservation principles and if the land borders on a core area or on another property that is included in the buffer zone. Other highly suitable land that does not border on the buffer zone or on core areas may be included in the transition area. Marginally suitable farms will also be included in the transition area. Marginally suitable farms bounding on core areas may be included in the buffer zone if negative attributes are moderated or positive attributes enhanced.

4.3.1.2 Administrative Organisation

The management of the Itala Biosphere Reserve must be addressed under a single administrative accord. Management of conservation areas overseen by different administrations with different mandates is likely to be impeded by management conflicts (Noss and Cooperrider, 1994). Management of the individual farms in the reserve will still be the responsibility of the landowner or resident, but they will be under the authority of a reserve administration that sets management policy and guidelines. In this way the reserve is managed as an ecosystem, and not as a collection of independent units.

The land included in the study area for this project is privately owned land. There are three ways of achieving conservation on private land: control by regulation; negotiated agreements and voluntary actions by owners (Garett, 1982). Ideally, conservation management will be practised primarily through the latter two of these factors, though core areas will be controlled by regulation. The buffer zone of a biosphere reserve will depend on all three of these methods. Land use practices will be limited by regulation through the legal and administrative status of the reserve. However, participation in the buffer zone will be a voluntary act of the landowner or part of a negotiated agreement. Cooperative efforts between land owners and conservation authorities in the form of negotiated agreements and voluntary actions will determine the conservation management practised on land in the transition zone.

The Natal Parks Board (NPB) has been involved with the creation of the Thukela biosphere reserve, but this has not yet been approved as a MAB reserve[17]. Although the NPB has expressed a willingness to participate in a biosphere reserve in this region, and to allow parts of Itala Nature Reserve to be used as a core area, the motivation and initial action towards developing a biosphere reserve must come from the local land owners and communities [18]. As a potential major participant in the establishment of an Itala Biosphere Reserve, the NPB felt that in order to justify the human and economic cost of creating a biosphere reserve in the area, the biosphere reserve should meet MAB criteria, and so gain the benefits associated with UNESCO affiliation. As a parastatal organisation, the NPB has recently faced severe budget cuts and cannot afford a large financial commitment in the administration of the biosphere reserve. It was felt that, by gaining international approval, additional funding would be more accessible[19].

If landowners are to be persuaded to participate in a biosphere reserve in the region, there have to be tangible benefits associated with their participation, especially benefits associated with being included in the buffer zone as opposed to the transition area. The main benefits of managing the area as a single conservation unit come from sharing access to each others' resources; sharing the costs and responsibilities for wildlife protection; increasing the habitat diversity and availability for keystone animal species such as elephant (Noss and Cooperrider, 1994; Young, 1992). These benefits would only be realised if the core areas and buffer zone

---

[17] pers. comm.. Mr. C Pullen, Officer in Charge, Weenen Nature Reserve, NPB (1996).

[18] pers. comm.. Mr. D Yunnie, Chief Conservator, Itala Nature Reserve, NPB (1996).

[19] pers. comm. Mr. A Marchant, Regional Ecologist, North, NPB (1996).

were able to be managed as a large scale wildlife area. Although it would be impractical to start off by taking down fences between Itala and the neighbouring farms, the biosphere reserve is unlikely to be a success unless this is made a long term aim of the project[20]. In this case, intensive land uses such as timber, arable farming, mining and industry would effectively be excluded as land use activities within the buffer zone as these are not compatible with wildlife management (Noss and Cooperrider, 1994).

[20] pers. comm. Mr. D Yunnie, Chief Conservator, Itala Game Reserve, NPB (1996).

Chapter 5: Conclusions

5.1 Project Overview

The aim of this project was to identify and evaluate a method to assess the suitability of a number of commercial, residential, stock and crop farms for potential inclusion in a biosphere reserve. In doing this, the method sought to achieve a balance between the need for conservation and the need for social and economic security.

Requirements of MAB/UNESCO biosphere reserves are that they focus on conservation, sustainable development and research (Batisse, 1993). This assessment of farm suitability for inclusion into a biosphere reserve has incorporated these requirements as primary criteria in the hierarchy used to prioritise factors determining suitability (Section 3.4.2). Secondary requirements for UNESCO approval of a biosphere reserve (Batisse, 1984; UNESCO, 1994) were taken into account when identifying the factors used to determine farm suitability (Section 3.3).

The method of assessment developed for this project involved identifying the factors that would determine the suitability of each farm for inclusion in the biosphere reserve. These factors were weighted using the Analytical Hierarchy Process (AHP) (Saaty, 1990), according to the extent to which each factor would influence overall farm suitability. Each farm was given a score for each factor according to the expression of that factor on that farm. Scores were awarded on a qualitative ordinal scale (Section 3.5). The individual factor scores for each farm were weighted (using the weights determined through the AHP) and summed to give a total suitability score for the farm. These suitability scores were used to create a thematic map of suitability from which recommendations could be made on which areas would be most suitable for the establishment of a biosphere reserve in the study area.

This method of assessment was evaluated in Chapter 4 from three perspectives. Section 4.2.1 evaluated the efficacy of the method in identifying suitable farms by comparing the results of the assessment with known suitabilities of farms where more detailed information was available than was used in the general assessment. The method's success in following planning guidelines for sustainable land use was evaluated in Section 4.2.2, by comparing the approach used in this project with published guidelines for sustainable land use planning. Thirdly, the method was evaluated with respect to the necessity of assigning priorities to factors determining suitability and the necessity of using as many factors as possible in assessing suitability (Section 4.2.3). This was achieved by comparing the results of the assessment with results from two alternative methods. The first of these alternatives did not prioritise the factors determining suitability and the second assessed farm suitability according to only four of the factors with high priority ratings.

In achieving the aim of this project to develop and evaluate a method of suitability assessment of farms for inclusion in a biosphere reserve, the following secondary objectives defined at the outset of the project were attained. The project provided a realistic model that was simple and easy to repeat for other land use planning exercises. The project developed a holistic approach to planning for a biosphere reserve, taking into account all relevant natural, social, cultural and economic factors. Finally, project work was done in cooperation with local role players and local opinion was taken into account during the formulation of recommendations.

One of the objectives of this project was to ensure that the method developed to assess farm suitability for a biosphere reserve was both simple and repeatable. This has been achieved through the use of Surveyor General's Office maps, aerial photographs and orthophotographs; environmental atlas information (Anon., 1996b), and classifications such as Acocks (1988), Low and Rebelo (1996), and the BioResource Units of KwaZulu-Natal (Camp, 1995a). Similar projects can therefore be undertaken wherever this type of information is available. The Analytical Hierarchy Process is a widely acknowledged process for multi-criteria decision making and can be used to prioritise any criteria considered relevant to biosphere reserve suitability. In addition, it can be adapted to reflect the priorities of a number of experts in the relevant fields and so to reflect a holistic view of the relative priorities (Saaty, 1990).

Natural factors were most strongly represented through soil, vegetation and fauna conservation factors. Data for these factors was more readily available in digital database or GIS formats than social, political or economic factors. In addition, conservation priorities were clearly defined for the study area and could be related to the maps on a farm by farm basis. This was not possible for the social, political or economic data. However, factors such as present land use, tourism potential, agricultural potential, settlement density, land tenure, education and location reflected the logistical, social, and economic context of each farm.

The interests of the local community were considered in this project at two levels: firstly through a sensitivity to the relationship between landowners and conservation and development organisations in the area, and secondly through cooperation with potentially key role players in the Itala Biosphere Reserve. Matters which had the potential for conflict or misinterpretation were clarified in all personal communications and the position of the researcher as an independent party from any of the regional role players was made clear. The decision to participate in the biosphere reserve rests with the landowners. This suitability assessment gives landowners an indication of the potential viability of their farms should they wish to participate in the biosphere reserve.

The results of this assessment show a mosaic of farms suitable for inclusion in a biosphere reserve. Recommendations are made on development strategies for the reserve that will have a reasonable probability of success. The accuracy of these results may be improved through review of scores by accredited experts in each field and review of priorities by people experienced in conservation and development planning.

It is hoped that the results of this project will provide a useful tool for further planning for the establishment of the Itala Biosphere Reserve. The assessment provides an identification of key resources and potential problems within the region where development of the biosphere reserve is being considered. This is one of the first steps in planning for a protected area (Noss and Cooperrider, 1994). Suitability scores reflect these key resources and problem areas through the individual factor scores for each farm. Final suitability scores reflect the overall suitability of a farm for inclusion in the biosphere reserve and accounts for the key factors which may be modified by other farm attributes affecting suitability. The factors and priority weightings used for this method may be used in the assessment of other land surrounding Itala Nature Reserve that is to be considered for inclusion in the Itala Biosphere Reserve. Assessment of the entire area surrounding Itala Nature Reserve will provide a clearer picture of possible biosphere reserve boundaries.

5.2 The Proposed Itala Biosphere Reserve

From the results of this assessment of suitability, it is possible to make recommendations for strategies for the establishment of the proposed Itala Biosphere Reserve in the study area. The establishment of the Itala Biosphere Reserve will depend on the attitude of the local community towards the biosphere reserve. This assessment of suitability provides a reflection of the potential for the development of a biosphere reserve in the region. The driving force behind the reserve, if it is to be successful must come from local residents and land managers (Dasmann, 1982).

The examination of settlement and land use patterns undertaken in this project is based on material that is at least five years old (Surveyor General's Office, 1990). It is recommended that farms which are in a good location, and that present a barrier to the continuity of the reserve should be examined in more detail as to their actual suitability. It may be found that the inclusion of these farms in the biosphere reserve is possible with little mitigation necessary. The CAMPFIRE experience in Zimbabwe (Child and Peterson, 1991) has shown that rural communities can exist in harmony with wildlife, even under present day economic conditions. However, the communities involved in CAMPFIRE and similar programmes (such as ADMADE in Zambia and LIFE in Namibia) have tended to be started in areas where wildlife is already resident and requires management, and where communities are more sparsely settled and remote than those considered in this project (International Institute for Environment and Development, 1994).

This project has not identified all farms with priority conservation areas as being suitable for inclusion in a biosphere reserve. These areas will either need conservation measures that are not associated with inclusion in the biosphere reserve, or will need mitigatory action before they can be considered for inclusion. If the need for conservation is high, these areas may be placed under legal protection through provincial regulations (Dasmann, 1982). This is not ideal as there is no connectivity with the reserve and the advantage of temporal stability is lost (Noss and Cooperrider, 1994). This sort of protection is more likely if the community is separated from the main reserve by some distance. Alternatively, mitigatory actions may include: voluntary movement elsewhere by the residents of the property, or affirmative action employment opportunities within the reserve or land rehabilitation if present land use is the adverse factor.

It should be remembered that this project assesses the suitability of farms for inclusion in a biosphere reserve on the basis of data gathered from previous surveys and from map and aerial photograph interpretation. It provides valuable direction for further detailed studies into the possible mitigation needed for some farms prior to inclusion in the reserve. Initial development efforts should be focused on those areas identified as being highly suitable for inclusion in the reserve. In reality, the reserve may develop in a different sequence than that recommended by this project. This will be a function of landowner preference.

It is recommended that any development of an Itala Biosphere Reserve be a gradual process, occurring as and when properties are able to meet standards with respect to conservation management or to resource protection capability. These may have been set by UNESCO for biosphere reserves, or by the administration of the biosphere reserve itself. For instance, in the Thukela Biosphere Reserve, fences will not be removed between Weenen Nature Reserve and its neighbouring properties until it has been shown that the managers of these properties are able to protect and contain the wildlife that will have access to their land[1]. This is an ethical decision taken to protect the public's interest in these animals. It is assumed that a similar condition will be set for the Itala Biosphere Reserve. Initially, only a few properties surrounding Itala should be included in the buffer zone of the reserve. Although bigger reserve areas are more desirable for conservation, the limited land area and limited number of participants will decrease logistical difficulties associated with the establishment of the reserve, and will increase the probability of long term success of the reserve.

---

[1]pers. comm. Mr. C Pullen, Officer in Charge, Weenen Nature Reserve, NPB (1996).

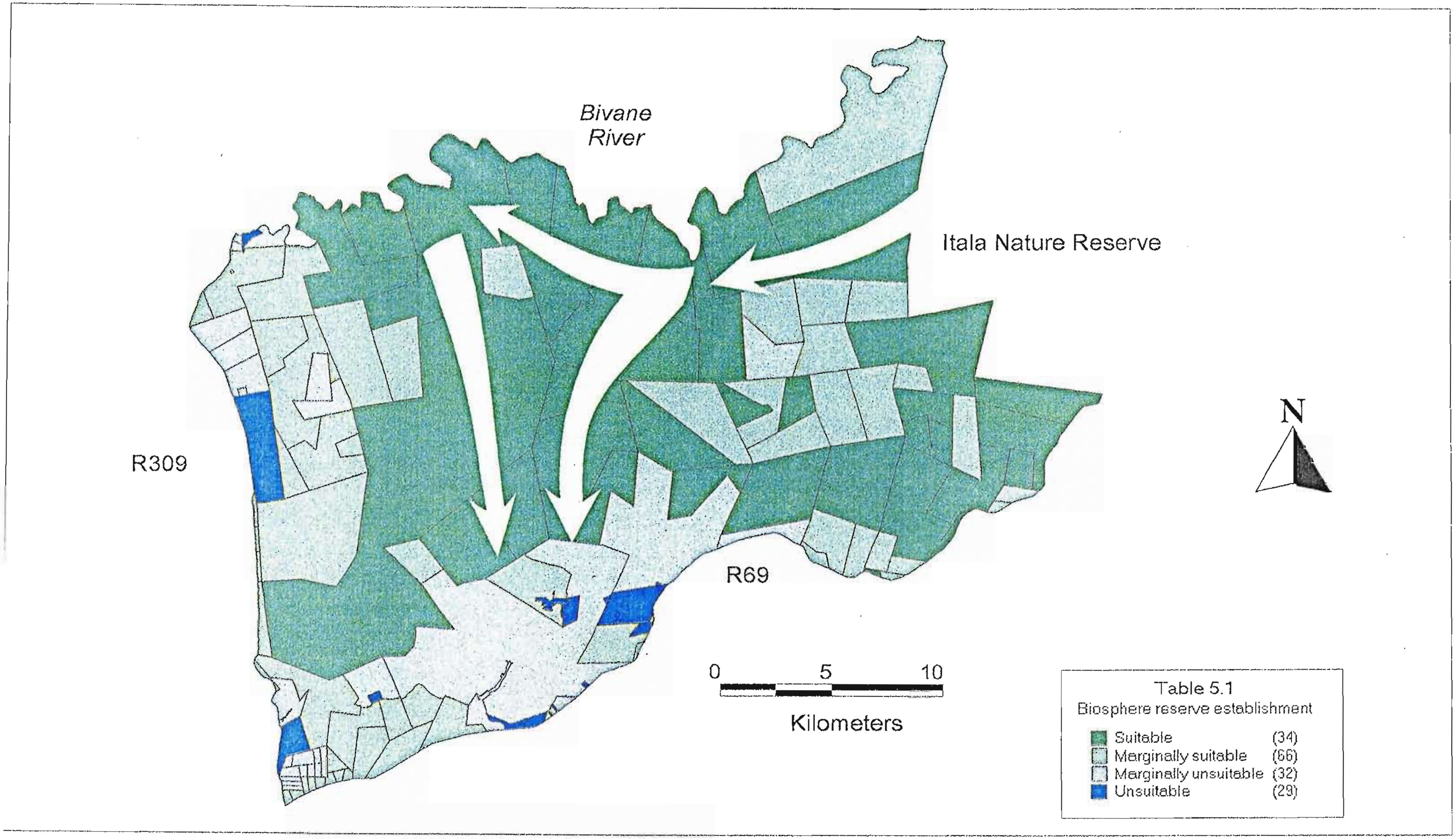
A suitability assessment similar to that performed in this project should be done for all farms within 20 km of Itala Nature Reserve. A researcher who is familiar with the area and who has good access to the necessary information should be able to accomplish this in a relatively short period of time at a small cost. Initial boundaries for the reserve should be drawn up including a buffer zone of suitable farms bounding on Itala Nature Reserve.

It is likely that the most suitable areas for expansion of the reserve beyond those properties adjacent to Itala Nature Reserve will be along the Pongola and Bivane rivers (Map 5.1). These rivers run through steep terrain and have suitable habitats for conservation of priority vegetation and fauna. Perennial water is essential for most game species, and large rivers usually have a positive economic value associated with tourism potential. Perhaps the most important feature of the farms along these rivers is the fact that there are no bridges across them for some way either side of Itala Nature Reserve. Associated with this is a low road density, which is an important criteria for good conservation areas (Noss and Cooperrider, 1994). In addition, the farms along the rivers tend to be larger than those close to the road, and tend to be managed on a more extensive basis. There is a stretch of suitable farms within the study area extending along the Bivane river from Itala Nature Reserve to Farm 307, more than 20km away.

It is recommended that once these river-front properties are included in the reserve, further expansion should occur from the properties surrounding and including the Paris Dam, towards Hlobane Mountain (Map 5.1). Expansion in this direction should be relatively simple as the majority of farms are suitable.

Initial analysis considered farms as units which would either be wholly included in the reserve, or not included at all. However, it is possible that at the outer edges of the biosphere reserve farms may be split by the reserve boundaries. This would be advantageous to farmers who wish to continue cultivation of arable land that would not fall inside the reserve. Reserve boundaries in these cases may be based more on ecological factors than on cadastral boundaries. Unfortunately, this is likely to lead to problems if other farmers beyond the split farm wish to be included in the reserve. In these cases, either the arable land will have to be fenced off which is likely to be too expensive to be viable, or it will have to be included in the reserve and the cropping potential lost, or development of the reserve will be halted as the farmer does not wish to sacrifice his cropping land. Communication between farmers, and a framework for the settlement of such disputes is vital for the long term success of the reserve.

Whilst initial development of the reserve is likely to include only those properties adjacent to or very close to Itala Nature Reserve, there are some highly suitable properties where management is eager to benefit from association with the reserve. An example of this would be Hlobane mountain top. This would be a highly suitable property if separated from the industrial and residential areas of the property. It may be some time until all the properties between Hlobane and Itala are able to meet biosphere reserve criteria and are included in the reserve. Until this time, it is suggested that management strategies consistent with biosphere reserve principles are adopted for this property and that the adjacent properties to Hlobane are approached to form a 'mini-biosphere reserve' and to cooperate in management of their natural resources. It is possible that another biosphere reserve could be formed in this area as Hlobane mountain top could function as a core conservation reserve in itself. These steps can be taken under the auspices of the Itala Biosphere Reserve as 'island reserves' and can be registered as part of the main biosphere reserve. There should be communication between the biosphere reserve administration and properties that wish to bring their management into accordance with the biosphere reserve requirements, ready for such time when they can join the reserve. This should be a part of the networking role of the biosphere with the surrounding community.



Map 5.1 Recommended direction of establishment of the Itala Biosphere Reserve

5.3 Method of Suitability Assessment of Farms for Inclusion in Biosphere Reserves

The identification and prioritisation of factors determining farm suitability for inclusion in a biosphere reserve and the determination of a farm suitability score based on these factors and priorities provide a model assessment procedure that could be used in other cooperative conservation areas, such as biosphere reserves, communal conservation areas, or private game reserve complexes. This approach can be used for non-Biosphere Reserve related land use planning as long as all the relevant dynamics are included as criteria in the prioritisation process. However, if the planning constraints can be clearly defined it would be more accurate to use an algorithmic method of assessment.

This approach to land use planning does not formulate a specific set of boundaries for the planned development but rather presents a full set of suitable farms within the study area. Examination of the suitability scores and individual factor scores gives the land use planner a tool for identifying priority areas, and can be used in determining strategies for future development of, in this case, a biosphere reserve.

This method of assigning suitability scores to farms according to factors identified as affecting farm suitability and the prioritisation of these factors implies that there is a gradient of suitability, from highly suitable or desirable farms to unsuitable or undesirable farms. This assumption has been justified because of the range of factors that affect farm suitability and the range of possible impacts within each factor. The different combinations of these factors lead to a range of different suitability scores. Highly suitable or highly unsuitable farms have highly positive or negative scores, while scores from marginal farms tend to be near zero.

Noss and Cooperrider (1994) strongly recommend that protected area boundaries be based on ecological boundaries. Despite this, this project has used cadastral boundaries to delimit units for inclusion in the Itala Biosphere Reserve. It is argued that this is justified because farms represent the basic unit on which the decision to participate in the biosphere reserve will be made (Section 1.5). In cases where high priority vegetation communities occur on unsuitable properties, it may be possible to protect through direct legal measures, although it would be preferable for these to be buffered from intensive land uses and to be part of a greater reserve. Some possible mitigatory actions were suggested to bring the property in line with biosphere reserve requirements, such as preferential employment opportunities to those families living on communal land within the reserve.

Areas where the sole management focus is on biodiversity conservation are needed, and in the biosphere reserve programme these areas are included in the core conservation areas. There is therefore a need for methods such as algorithms and gap analyses. However, in the case of biosphere reserves, reserve boundaries need to be based on more than purely ecological/biodiversity criteria, especially where the reserve includes private landowners. When planning is limited to a single land use, or when land is to be managed by a single organisation, it is relatively easy to define the constraints that will determine an area's suitability for conservation or sustainable development. When reserves are to be planned which will incorporate a number of land uses and land owners, it is necessary to have a wider definition of suitability, and method of assessment that will still identify highly suitable or unsuitable areas despite the wide definition.

The criteria for suitability for a biosphere reserve need to include social, political and economic factors in order to ensure long term stability. It is difficult to include social, political and economic factors in a suitability assessment using algorithms and gap analyses as it is not always possible to identify the exact constraints that these factors pose, or to directly compare the importance of this type of factor and more traditional conservation priorities. The ability to directly compare the effect of two unrelated factors, for example settlement density and fauna conservation potential, on the suitability of a farm for a biosphere reserve is probably the most important advantage of this assessment technique. The other commonly used method of direct comparison is to assign economic values to each factor. This is difficult and often inaccurate, especially when dealing with political or environmental factors.

Variation in suitability differs when both conservation and sustainable development criteria are used. The use of both these criteria together often has a dampening or balancing effect on areas which may be highly suitable for one of these criteria (e.g areas with high conservation value may not necessarily be highly suitable for sustainable development). Reserves using the method of assessment developed for this project will be based on a holistic view of social, natural, cultural and economic factors and are likely to be more viable in the long term as these factors are all taken into account during the planning phase (Eger *et al.*, 1996).

The way in which this assessment has been carried out also suggests that the most realistic view of farm suitability for inclusion in a biosphere reserve is achieved by including all factors affecting suitability in the assessment; and that the factors determining suitability may not be of equal importance. By accounting for as many factors as possible in the assessment, situations are avoided where farms may be highly suitable in some aspects but may be highly unsuitable in other aspects not included in the assessment (Section 4.2.3).

Although this project found that there were only small differences between the final factor priorities, the differences between these priorities with respect to each of the main biosphere reserve functions (sustainable development, conservation and research) were more marked. In cases where the weighting behind these functions may change, it is likely that there will be much stronger weighting differences between final priorities.

The need for planning and establishment of nature reserves with multiple land use buffer zones is likely to increase in the near future and thus there will be a need for recognised practical approaches to this type of planning. These areas are an essential concept in biodiversity conservation as conservation biologists stress the need for more and larger protected areas (Noss and Cooperrider, 1994). Climatic change due to global warming or the depletion of the ozone layer may also have serious effects on the ability of the worlds existing parks to conserve species and ecosystems (Noss and Cooperrider, 1994). Buffer zones allow for connectivity between protected areas; for larger habitat areas and provide a measure of temporal stability in times of climatic change.

The identification of factors determining biosphere reserve suitability and the prioritisation of these factors in this project provide a multi-disciplinary approach to the identification of suitable land for a biosphere reserve, and especially for the buffer zone areas. This approach could be refined through further research into the effects of different mixtures of extensive, commercial and residential land uses in conservation areas. The issue of particular concern is how to integrate rural Black communities into these reserves particularly where they have previously depended on arable farming or other more intensive land uses.

The accuracy and repeatability of this method of suitability assessment of farms should be checked through statistical analysis once there is more data available for comparison. For example, farms which have been assessed using this approach and then included in biosphere reserves could provide evidence of the success or otherwise of this method of assessment. Comparative data could also be generated by doing a more in depth analysis of the farms in this study area so that known suitability classes can be compared with final scores from the suitability assessment.

Research is needed into the changes in a community's quality of life after inclusion in a buffer zone and a limitation on the permitted land uses. The most pressing issue for examination here is whether economic security can be maintained if intensive land uses cannot be practised. The results of this research will enable more realistic social criteria to be used when assessing the suitability of farms for inclusion in a biosphere reserve. Projects of this kind require clearly defined policies on the balance between conservation objectives and the inclusion of local communities for the sake of development.

The balance in priority between conservation and development on final suitability should be reviewed by the potential role players in the Itala Biosphere Reserve, as the present balance reflects the subjective opinion of an outside party, albeit backed up by reference to documents defining biosphere reserve, sustainable development and biodiversity conservation concepts. This review is the domain of conservation biologists and regional planners and calls for a balance between conservation, social, economic and political objectives. People in these disciplines need to determine how suitability assessment of farms could be more focused on ecological boundaries, while still allowing for the rights of the landowner to make management decisions. This is a contentious issue, but is one which contributes to the balance between conservation and social, economic and political objectives.

Research is needed to determine an appropriate size of the biosphere reserve, and to assess organisational constraints such as administrative structures needed for different types and numbers of landowners or participants. The involvement of more than one government administration or department is a potential area for conflict (Noss and Cooperrider, 1994) and research is needed into the viability and administrative logistics of reserves falling under more than one administration.

It can be assumed that improvements could be made to the accuracy of the assessment if more specialised expertise in regional/conservation planning were available for prioritisation of factors. Similarly, more detailed knowledge of the factors identified and the likely effects they will have on biosphere reserves would mean that scores would give a more accurate reflection of their true effect on farm suitability for inclusion in a biosphere reserve. In particular, the availability of more detailed social data than were used in this assessment would mean that more relevant social dynamics could be accounted for in assessing farm suitability.

This project has presented and evaluated a method of assessment of suitability of farms for inclusion in a biosphere reserve. The method accounts for development and conservation and allows for the different priorities of these two roles of a biosphere reserve. It uses readily available information and technology to demarcate highly suitable areas for biosphere reserve development. It is hoped that this assessment will facilitate the establishment of the Itala Biosphere Reserve; that this method will be useful in developing an approach to biosphere reserve planning and that this project has gone some small way to restoring man to 'nature's social union.'

References

Acocks JPH (1988). Veld types of South Africa (3rd edition). *Memoirs of the Botanical Survey of South Africa.* No. 57. Pretoria.

Addo PK, McKenzie M, Othusitse B, Plaistowe M and Thompson G (1996). Settlement: A way forward for Hlobane. Unpublished student report. School of Environment and Development, University of Natal, Pietermaritzburg.

Anderson G (1996). Archaeological survey of the proposed Paris Dam. Report for Bosch and Associates; Ekokonsult and Impala Irrigation Board. Institute for Cultural Resource Management, Natal Museum, Pietermaritzburg.

Anonymous (1996a). Economic evaluation of wildlife based tourism opportunities within and near the Itala Game Reserve. Unpublished internal report. Natal Parks Board.

Anonymous (1996b). *Environmental Atlas of KwaZulu-Natal.* Town and Regional Planning Commission, Pietermaritzburg.

Balzer JL (1982). Development and Conservation: Co-existence through regional planning. In: *National Parks, Conservation, and Development: The role of protected areas in sustaining society; Proceedings of the World Congress on National Parks, Bali, Indonesia, 11-22 October, 1982.* McNeely JA and Miller KR (eds.) pp. 719-721. Smithsonian Institution Press, Washington DC.

Barbosa F, Dikobe L, Langley N, Lewis F and Moffat A (1996). Quality of Life: Options for Hlobane. Unpublished student report. School of Environment and Development, University of Natal, Pietermaritzburg.

Batisse M (1984). MAB action plan for biosphere reserves. *Nature and Resources.* UNESCO, Paris. Vol. 20, No. 4, pp. 1-12.

Batisse M (1986). Developing and focusing the biosphere reserve concept. *Nature and Resources.* UNESCO, Paris. Vol. 22, No. 3, pp. 2-11.

Batisse M (1993). Biosphere Reserves: An overview. *Nature and Resources.* UNESCO, Paris. Vol. 29, Nos. 1-4, pp. 3-5.

Borland (1994). *Paradox for Windows, Version 5.0.* Borland International Incorporated.

Brookes EH and Webb C de B (1987). *A History of Natal.* University of Natal Press, Pietermaritzburg.

Burns R (1785). To A Mouse, on Turning Her Up in Her Nest with the Plough, November, 1785. In: *Robert Burns Selected Poems.* Penguin Popular Classics, pp. 109-110. Penguin Books Ltd., Harmondsworth, UK (1996).

Cameron C (1996). Community Profile Survey - Vryheid, Paulpietersburg, Ngotshe, Nqutu, Simdlangentsha, Hlobane. Report for Hlobane Community Complex, Hlobane.

Camp KGT (1995a). *The BioResource Units of KwaZulu-Natal.* Cedara Report No. N/A/95/32. Resource and Information Unit, Cedara.

Camp KGT (1995b). BioResource Unit classification database. Resource and Information Unit, Cedara.

Cendrero A, de Teran JRD, Gonzalez D, Mascitti V, Rotondaro R and Tecchi R (1993). Environmental Diagnosis for Planning and Management in the High Andean Region - The Biosphere Reserve of Pozuelos, Argentina. *Environmental Management.* Vol. 17, No. 5, pp. 683-703.

Child B and Peterson JH Jr. (1991). *CAMPFIRE in Rural Development: The Beitbridge experience* (2nd edition). Joint Working Paper Series. Centre for Applied Social Sciences, University of Zimbabwe, Harare.

Coetzee H and Cooper D (1991). Wasting Water - Squandering a precious resource. In: *Going Green: People, politics and the environment in South Africa.* Cock J and Koch E (eds.) pp. 129-138. Oxford University Press, Cape Town.

Corel (1996). *Quattro Pro, Version 6.02.* Corel Corporation Limited, Dublin.

Croze H (1982). Monitoring within and outside protected areas. In: *National Parks, Conservation, and Development: The role of protected areas in sustaining society; Proceedings of the World Congress on National Parks, Bali, Indonesia, 11-22 October, 1982.* McNeely JA and Miller KR (eds.) pp. 628-633. Smithsonian Institution Press, Washington DC.

Dasmann RF (1982). The Relationship Between Protected Areas and Indigenous Peoples. In: *National Parks, Conservation, and Development: The role of protected areas in sustaining society; Proceedings of the World Congress on National Parks, Bali, Indonesia, 11-22 October, 1982.* McNeely JA and Miller KR (eds.) pp. 667-671. Smithsonian Institution Press, Washington DC.

De Jager S (1996). Voorgeselde 5 jaar projeksie vir Ferro Landgoed soos gebaseer op dokument gedateer 28 April 1996. Unpublished report to Ferroland Grondtrust (CC).

Department of Environment Affairs (1992). *Glossary of terms used in Integrated Environmental Management.* Department of Environment Affairs, Pretoria.

Department of Mineral and Energy Affairs (1988). *2730 Vryheid, 1:250 000 Geological Map Series*. Department of Mineral and Energy Affairs, Pretoria.

Edgecombe R (1996). A brief history of Hlobane mountain. Unpublished seminar presented at "Hlobane: a development opportunity for region E33" one day seminar.

Eger H, Fleischhauer E, Hebel A and Sombroek WG (1996). Taking action for sustainable land-use: Results from 9th ISCO conference in Bonn, Germany. *Ambio - A Journal of the Human Environment*. Vol. 25, No. 8, pp. 480-483.

Ehrlich PR (1996). Conservation of temperate forests: What do we need to know and do? *Forest Ecology and Management*. Vol. 85, No. 1-3, pp. 9-19.

Erskine JM (1995). Options for sustainable animal husbandry in South Africa's less developed rural areas. *Bulletin of the Grassland Society of Southern Africa*. Vol. 6, No. 1, pp. 27-28.

Expert Choice (1990). *Expert Choice Textbook Version*. Expert Choice Inc., Pittsburgh, Pennsylvania.

Feely JM (1986). The distribution of iron age farming settlement in Transkei, 470 - 1870. M.A. thesis, University of Natal.

Francis GR (1996). Biosphere Reserves: Frequently asked questions. Http://ice.ucdavis.edu/MAB/ (7 April 1996).

Garett K (1982). The relationship between adjacent lands and protected areas: Issues of concern for the protected area manager. In: *National Parks, Conservation, and Development: The role of protected areas in sustaining society; Proceedings of the World Congress on National Parks, Bali, Indonesia, 11-22 October, 1982*. McNeely JA and Miller KR (eds.) pp. 65-77. Smithsonian Institution Press, Washington DC.

Hall M (1987). *The Changing Past: Farmers, kings and traders in southern Africa, 200 - 1860*. David Phillip, Cape Town.

Hilliard OM and Burtt BL (1985). Notes on some plants of southern Africa, chiefly from Natal: XI. *Notes from the Royal Botanic Gardens, Edinburgh*. Vol. 42, No. 2. pp. 243-244.

Hilliard OM and Burtt BL (1986). Notes on some plants of southern Africa, chiefly from Natal: XII. *Notes from the Royal Botanic Gardens, Edinburgh*. Vol. 43, No. 2. p 217.

Hilton-Taylor C (1996). *Red data list of South African Plants*. Conservation Biology Research Unit, National Botanical Institute, Cape Town.

Holdgate M (1996). The ecological significance of biological diversity. *Ambio - A Journal of the Human Environment*. Vol. 25, No. 6, pp. 409-416.

Huntley B, Siegfried R and Sunter C (1989). *South African Environments into the 21st Century*. Human and Rousseau Tafelberg, Cape Town.

Intergraph (1992). *Microstation GIS Environment PC-1, Version 02.00.02.04*. Intergraph, Huntsville, Alabama.

International Institute for Environment and Development (1994). *Whose Eden? An overview of community approaches to wildlife management*. Report to the Overseas Development Administration of the British Government, London.

IUCN's Commission on National Parks and Protected Areas (1982). Categories, Objectives and Criteria for Protected Areas. In: *National Parks, Conservation, and Development: The role of protected areas in sustaining society; Proceedings of the World Congress on National Parks, Bali, Indonesia, 11-22 October, 1982*. McNeely JA and Miller KR (eds.) pp. 47-55. Smithsonian Institution Press, Washington DC.

Jacobsohn M (1991). The Crucial Link, conservation and development. In: *Going Green: People, politics and the environment in South Africa.* Cock J and Koch E (eds.) pp. 210-222. Oxford University Press, Cape Town.

Laband JPC (1996). *Rope of Sand: The rise and fall of the Zulu Kingdom in the nineteenth century.* Jonathan Ball Publishers, Jeppestown.

Low AB and Rebelo AG (1996). *Vegetation of South Africa, Lesotho and Swaziland.* Department of Environmental Affairs and Tourism, Pretoria.

Lowe K, Lund N, Mabuza L, Muir A and Sutherland S (1996). Proposed Options for Tourism in the Hlobane Region. Unpublished student report, School of Environment and Development, University of Natal, Pietermaritzburg.

MacVicar CN (ed.) (1986). *Land types of the map 2730 Vryheid.* Memoirs on Agricultural Natural Resources of South Africa. No. 7.

Manson AD, Camp KGT and Smith JMB (1995). *Soil Potential and Land Capability.* Cedara Agricultural Development Institute, Cedara.

MapInfo (1992). *MapInfo Desktop Mapping Software for Windows, Version 2.1.1.* MapInfo Corporation, Troy, New York.

MapInfo (1996). *MapInfo Professional, Version 4.1.* MapInfo Corporation, Troy, New York.

Noss RF and Cooperrider AY (1994). *Saving Nature's Legacy: Protecting and restoring biodiversity.* Island Press, Washington DC.

NPB Communications (1994). Itala Game Reserve - Visitors guide. Natal Parks Board, Pietermaritzburg.

ODA Natural Resources and Environment Department (1991). *Biological diversity and developing countries: Issues and options*. Overseas Development Administration, London.

Pearce DW and Turner RK (1990). *Economics of Natural Resources and the Environment.* Harvester Wheatsheaf, Hemel Hempstead, UK.

Pennsylvania State University (1996). *MiniTab for Windows, Version 10.51 Xtra.* Pennsylvania State University, Pennsylvania.

Pressey RL, Humphries CJ, Margules CR, Vane-Wright RI and Williams PH (1993). Beyond opportunism: Key principles for systematic reserve selection. *Trends in Ecology and Evolution.* Vol. 8, No. 4, pp. 124-128.

Pressey RL, Possingham HP and Day JR (1997). Effectiveness of alternative heuristic algorithms for identifying indicative minimum requirements for conservation reserves. *Biological Conservation.* Vol. 80, No. 2, pp. 207-219.

Pressey RL, Possingham HP and Margules CR (1996). Optimality in reserve selection algorithms: When does it matter and how much? *Biological Conservation.* Vol. 76, No. 3, pp. 259-267.

Reichmann WJ (1961). *Use and Abuse of Statistics.* Pelican, Harmondsworth.

Rowe-Rowe DT (1992). *The Carnivores of Natal.* Natal Parks Board, Pietermaritzburg.

Rowe-Rowe DT (1994). *The Ungulates of Natal,* (2nd edition). Natal Parks Board, Pietermaritzburg.

Saaty TL (1990). *Decision making for leaders: The Analytical Heirarchy Process for decisions in a complex world.* RWS Publications, Pittsburgh.

Sandwith TS and Forrest CJ (1992). The uThukela biosphere: A development strategy. Unpublished discussion document. Natal Parks Board, Pietermaritzburg.

Schulze RE, Pike A, Lecler NL, Esprey LJ, Howe BJ and Zammit RM (1996). *Hydrological impacts of land use practices in the Pongola-Bivane catchment, Phase 1: Impacts of present and proposed afforestation on streamflows. Report to Forest Industries Association, Pietermaritzburg.* ACRUcons Report 11. Department of Agricultural Engineering, University of Natal, Pietermaritzburg.

Scott-Shaw CR (1996). Hotspots of endemism in KwaZulu-Natal. Unpublished report. Natal Parks Board, Pietermaritzburg.

Scott-Shaw CR and Bourquin O (1996). The conservation status of Acocks Veld Types in KwaZulu-Natal. *Lammergeyer*, Vol. 44, pp. 50-63.

Siegel S (1956). *Nonparametric Statistics: For the behavioural sciences*, (International student edition). McGraw-Hill Inc., Japan.

Smithers RHN (1986). *South African Red Data Book - terrestrial mammals.* South Africa Natural Scientific Programmes Report 125. CSIR, Pretoria.

Soil Classification Working Group (1991). *Soil Classification - A taxonomic system for South Africa.* Memoirs on Agricultural Natural Resources of South Africa, No. 15. Department of Agriculture, Pretoria.

Steel RGD and Torrie JH (1980). *Principles and procedures of statistics: A biometrical approach,* (2nd edition). McGraw-Hill Inc., Singapore.

Strittholt JR and Boerner REJ (1995). Applying biodiversity gap analysis in a regional nature reserve design for the Edge of Appalachia, Ohio (USA). *Conservation Biology.* Vol. 9, No. 6, pp. 1492-1505.

Stuart C and Stuart T (1997). *Field guide to the larger mammals of Africa*. Struik, Cape Town.

Surveyor General's Office (1990). Surveyor General's Office Aerial Photos, Job 942, 90/08/09, Nos. 2099- 2103 (Strip 14); 2105-2112 (Strip 13); 2174-2182 (Strip 12); 2183-2191 (Strip 11); 2261-2262 (Strip 10).

UNESCO (1994). Biosphere Reserve Nomination Form, March 1994, UNESCO, Paris.

Van der Eyk JJ, MacVicar CN, and De Villiers JM (1969). *Soils of the Tugela basin: A study in subtropical Africa*. Town and Regional Planning Commission, Pietermaritzburg.

Van Jaarsveld AS (1995). Where to with reserve selection and conservation planning in South Africa? *South African Journal of Zoology*. Vol. 30, No. 3, pp. 164-168.

Van Wyk E, Du Preez JA, Delport A, and Korsman NBC (1994). *Northern Natal Regional Development Plan: Development policy, actions and programmes*. Korsman and Van Wyk Town and Regional Planners, Management Consultants, Vryheid.

Von Droste zu Hulshoff B (1982). How UNESCO's Man and Biosphere programme is contributing to human welfare. In: *National Parks, Conservation, and Development: The role of protected areas in sustaining society; Proceedings of the World Congress on National Parks, Bali, Indonesia, 11-22 October, 1982.* McNeely JA and Miller KR (eds.) pp. 689-691. Smithsonian Institution Press, Washington DC.

Vryheid Land Facilitation Service (1996a). *Status Quo* Report. Unpublished internal report.

Vryheid Land Facilitation Service (1996b) Summary of case *status quo*: Vryheid Land Facilitation Service: September 1996. Unpublished internal report.

Whitelaw G (1989). Archaeological survey of the Itala Game Reserve: results and recommendations. Natal Museum, Pietermaritzburg. Unpublished report to Natal Parks Board.

Woinarski JCZ, Price O and Faith DP (1996). Application of a taxon priority system for conservation planning by selecting areas which are most distinct from environments already reserved. *Biological Conservation.* Vol. 76, No. 2, pp. 147-159.

World Commission on Environment and Development (1987) *Our Common Future*. Oxford University Press, Oxford.

Young E (1992) *Game Farming and Wildlife Management*. Eddie Young Publishers, Nylstroom.

Appendix 1: Dominant Soil Characteristics of Land Type Units

The Land Type Unit (LTU) classification (MacVicar, 1986) divides land into units or relatively homogeneous soil catenae. Each LTU is given a code indicating the dominant soil types or horizons to be found within the unit. This appendix describes the definition of the codes for the LTUs found in the study area for this project (Section 2.1.1) (Map 2.3).

A = Red Apedal B horizon / Yellow Brown Apedal B - freely drained

c - red and yellow - dystrophic and/or mesotrophic
e - red - high base status, >300 mm deep, no dunes

B = Plinthic catena; upland duplex and margalitic soils rare

a - dystrophic and/or mesotrophic, red soils widespread
b - dystrophic and/or mesotrophic, red soils not widespread

C = Plinthic catena; Upland duplex and margalitic soils common

a - undifferentiated

D = Prismacutanic and/or Pedocutanic diagnostic horizons dominant

b - B horizons not red

E = One or more of Vertic, Melanic, Red Structured B diagnostic horizons

a - undifferentiated

F = Glenrosa or Mispah forms (others may occur)

a - lime rare or absent in entire landscape
b - lime rare or absent in upland soils, but generally present in low lying soils

I = Miscellaneous land classes

b - rock areas with miscellaneous soils

Appendix 2: Summary of BRU Climatic, Topographic and Physiographic Properties

The properties relevant to determining a farm's suitability for inclusion in a biosphere reserve are presented in this appendix. These were obtained from the BioResource database (Camp (1995b) provides an extended summary of properties for each BRU.

Table A2: Summary of BRU climatic, topographic and physiographic properties

BRU	MAP (mm)	Mean Temp. (deg C)	Max Temp (deg C)	Min Temp (deg C)	A Pan Evaporation (mm)	Altitude (m)	Vegetation physiognomy	Topography
TUb1	678	19.20	25.80	12.70	1922	378 - 1134	Bushed grassland to bushland thicket	Rolling / broken
TUc2	699	18.10	24.70	11.50	1891	866 - 1259	Bushed grassland to bushland	Rolling
Uc3	742	17.80	24.30	11.30	1865	724 - 1388	Grassland	Broken / rolling
Vc4	793	16.80	23.40	10.20	1830	1055 - 1606	Grassland to bushed grassland	Rolling
Wc3	800	17.20	23.90	10.60	1863	850 - 1574	Grassland	Rolling / broken
Wc7	828	18.00	24.10	11.90	1818	740 - 1417	Grassland	Rolling / broken
Xc1	869	16.40	23.00	9.80	1823	1066 - 1700	Grassland	Rolling
Xc3	863	16.90	23.00	10.80	1798	1134 - 1401	Grassland	Rolling

Appendix 3: Database of Farm Owners

This table gives cadastral and owner information for each subdivision of original grants within the study area (Map 3.1). The table is sorted by owner name, and was used to determine the farm units for the project. Subdivisions with a common owner and bordering on each other were combined into single units.

The "ID" column refers to the identification number assigned to the subunit by the Microstation software when the subdivisions were converted to polygons from the line data provided by the Surveyor General's Office. This ID number was kept and used as an identifier in the MapInfo and Paradox databases.

Table A3: Cadastral properties, owners and GIS identification numbers for farms between Itala Nature Reserve and Vryheid

Subdivision ID	Owner	Grant	Subdivision
1	No Registered Owner	Draaiom 709	0
2	Gertges Medisyne	Barofine 716	1
3	Klingenberg, WA	Nooitgedacht 479	1
4	Klingenberg, LO	Welgevonden 1	4
5	Hinze, HH	Eerstelling 690	2
6	Hannes Viljoen Trust	Pivaansbad 533	5
7	Neser, A	Uitzicht 284	4
8	Zululand Diocesan Trusts Board	Pivaansbad 533	10
9	Hinze, HH	Pivaansbad 533	11
10	Neser, A	Uitzicht 284	5
11	Hannes Viljoen Trust	Pivaansbad 533	4
12	Funk-Oertel, I	Welgevonden 1	5
13	Reinstoff, IH	Welgevonden 1	6
14	Dannheimer, WHH	Schurwepoort 216	0
15	Retief, HL	Uitzicht 284	2
16	Dannheimer, MFG	Nooitgedacht 240	1
17	Schurwepoort Boerdery	Schurwepoort 216	1
18	Hannes Viljoen Trust	Zandspruit 488	1
19	Venter, IPL	Uitzicht 284	6
20	Schurwepoort Boerdery	Zandspruit 488	0
21	Frances Development Corp	Zandspruit	3
22	Venter, IPL	Nooitgedacht 240	0
23	de Neckar, JAR	Schurwepoort 216	2

Subdivision ID	Owner	Grant	Subdivision
24	Gertges Medisyne	Express 625	1
25	Gertges Medisyne	Mahlone 524	4
26	Gertges Medisyne	Mahlone 524	1
27	Gertges Medisyne	Mahlone 524	3
28	Gertges Medisyne	Overgespring 312	1
29	Gertges Medisyne	Driehoek 710	0
30	Gertges Medisyne	Overgespring 312	2
31	Gertges, HHM	Express 625	0
32	Vredengeluk Boerdery	Rondspring 137	1
33	Vredengeluk Boerdery	Pietersrust 617	1
34	Vredengeluk Boerdery	Paris 750	4
35	Hannes Viljoen Trust	Pietersrust 617	2
37	Hannes Viljoen Trust	Makalusi 245	1
38	Hannes Viljoen Trust	Pietersrust 617	0
39	Muller, JJ	Belvue 600	1
40	de Neckar, JAR	Mahlone 524	0
41	Neser, A	Alone 814	0
42	Nebbe, F	Rondspring 137	0
43	Gertges, HHM	Palmietfontein 584	2
44	Swart, AH	Belvue 600	3
45	Vercuil, FJJ	Paris 750	9
46	Swart, AH	Belvue 600	2
47	Scheepers, HJB	Basan 382	3
48	Swanepoel, CA	Kalbasfontein	1
49	Swanepoel, CA	Allandale 404	1
50	Aaron Family Trust	Paris 750	3
51	A Y R Boerdery CC	Basan 382	2
52	CJ and JHC Lourens Trust	Allandale 404	0
53	Scheepers HJB	Kliprif 111	2
54	Schalkwyk, CJ	Kalbasfontein 509	0
55	Filmalter, TO	Nooitgedacht 264	0
56	Yorkshire Agric CC	Yorkshire 329	0
57	Impala Irrigation Board	Paris 750	0

Subdivision ID	Owner	Grant	Subdivision
58	Retief, HL	Dipka 590	0
59	Vercuil, FJJ	Paris 750	2
60	Landman FJ	Dwaalhoek 105	2
61	Eyssen AJ, and Snyman ZM	Eensgevonden 582	0
62	Potgeiter, FJ	Basan 382	0
63	van Rensburg, JJJ	Kliprif 111	0
64	Frances Development Corp	Zandspruit 448	2
65	Gertges Medisyne	Helmekaar 631	0
66	Retief, HL	Palmietfontein 584	0
67	Nebbe, F	Palmietfontein 584	1
68	Landman, FJ	Dwaalhoek 105	1
69	van Niekerk, JI	Welverdiend 397	3
70	Potgeiter, TC	Bedrog 217	1
71	Bester, JH	Allandale 404	2
72	van Niekerk, JI	Welverdiend 397	4
73	Swissafari and Eco Tours Pty Ltd	Bedrog 217	3
74	Swissafari and Eco Tours Pty Ltd	Kliprif 111	1
75	Swissafari and Eco Tours Pty Ltd	Bedrog 217	2
76	Steenkamp, JH	Beroofd 107	0
77	Leonard, JD	Welverdiend 397	6
78	Dames, HDP	Mooiklip 239	4
79	Gevers, VH	Welverdiend 397	1
80	Libiena Wentzel Trust	Mooiklip 239	5
81	Potgeiter, EF	Mooiklip 239	0
82	Swissafari and Eco Tours Pty Ltd	Bedrog 217	0
83	Potgeiter TC	Kliprif 111	4
84	No registered owner	Welgevonden 287	23
85	No registered owner	Welgeluk 761	0
86	Lombard, JH	Welgevonden 287	22
87	Sauer, NE	Dagbreek 786	13
88	Lombard, JH	Welgevonden 287	21
89	Barnard, AB	Dagbreek 786	14
90	Taljard, JC	Welgevonden 287	20

Subdivision ID	Owner	Grant	Subdivision
91	van Aswegen HC and Viljoen, VV	Dagbreek 786	15
92	Labuschagne, LJ	Welgevonden 287	19
93	Torino, CM	Dagbreek 786	16
94	Muller, JW	Welgevonden 287	18
95	Foley, A	Welgevonden 287	17
96	van Jaarsveldt, ES	Dagbreek 786	22
97	Foley, JD	Welgevonden 287	28
98	van Jaarsveldt, ES	Dagbreek 786	20
99	Becker, BG	Dagbreek 786	17
100	van Jaarsveldt, ES	Dagbreek 786	21
101	Greyling Welgevonden Trust	Welgevonden 287	3
102	Thring, NE	Welgevonden 287	24
103	Thring, NE	Welgevonden 287	25
104	Thring, NE	Welgevonden 287	26
105	Adila Investments	Welgevonden 287	2
106	Lombard, JH	Dagbreek 786	19
107	Swart, SM	Welgevonden 287	4
108	Wida Investments Pty Ltd	Voorkeurplaats 332	5
109	Dannheimer, WHH	Traktaat 200	4
110	Coetzer, JL	Welgeluk 56	1
111	Myburgh, HJ	Almansnek 114	3
112	Adila Investments	Almansnek 114	13
113	Gertges, HHM	Mooihoek 129	0
114	Adila Investments	Welgevonden 287	10
115	Adila Investments	Almansnek 114	10
116	Insleep Farms Pty Ltd	Welgevonden 287	9
117	Gertges, HHM	Langgelegen 704	1
118	Wida Investments Pty Ltd	Voorkeurplaats 332	4
119	Hein, WE	Goedgeloof 396	2
120	Wida Investments Pty Ltd	Voorkeurplaats 332	3
121	Wida Investments Ltd	Eensgevonden 292	0
122	Gertges, HHM	Doornkloof 425	2
123	Gertges, HHM	Langgelegen 704	9

Subdivision ID	Owner	Grant	Subdivision
124	Gertges, HHM	Langgelegen 704	7
125	Gertges, HHM	Doornkloof 425	3
126	Frances Development Corp	Nooitgedacht 479	2
127	Klingenberg, WA	Nooitgedacht 479	5
128	Gertges Medisyne	Barofine 716	0
129	Klingenberg, WA	Nooitgedacht 479	4
130	Klingenberg, WA	Nooitgedacht 479	6
131	Frances Development Corp	Nooitgedacht 479	7
132	Gunter, JH	Nyembe 184	9
133	Vryheid Natal Railway, Coal and Iron Company Ltd	Hlobane 506	0
134	Vryheid Natal Railway, Coal and Iron Company Ltd	Welgevonden 287	8
135	Swanepoel, JP	Welgevonden 287	7
136	CJ and JHC Lourens Trust	Welgevonden 287	5
137	Duiker Mining	Alpha 765	0
138	Duiker Mining	Nyembe 184	1
139	Barcoal CC	Nyembe 184	4
140	Vryheid Natal Railway, Coal and Iron Company Ltd	Hlobane 506	8
141	Duiker Mining	Alpha 765	1
142	Transnet Ltd	Hlobane 506	19
143	Gertges, HHM	Langgelegen 704	3
144	San Cotona Boerdery CC	Nyembe 184	5
145	Vryheid Natal Railway, Coal and Iron Company Ltd	Hlobane 506	5
146	Phillips and David Tyre Brothers CC	Rietvlei 150	6
147	Hlobane Boerevereneging	Rietvlei 150	36
148	Vryheid Natal Railway, Coal and Iron Company Ltd	Hlobane 506	4
149	van Heerden, HJV	Vaalbank 38	4
150	Vryheid Natal Railway, Coal and Iron Company Ltd	Langgelegen 704	2
151	Vryheid Natal Railway, Coal and Iron Company Ltd	Hlobane 506	2
153	Craig, MW	Langgelegen 704	8
154	Gertges, HHM	Langgelegen 704	6
155	Duiker Mining	Vrede 154	21
156	Amcoal Colliery and Industrial Operations	Vrede 154	3
157	Amcoal Colliery and Industrial Operations	Vrede 154	4

Subdivision ID	Owner	Grant	Subdivision
158	Amcoal Colliery and Industrial Operations	Vrede 154	9
159	Duiker Mining	Vrede 154	6
160	Duiker Mining	Vrede 154	22
161	Vryheid Natal Railway, Coal and Iron Company Ltd	Vrede 154	1
162	Amcoal Colliery and Industrial Operations	Veelsgeluk 171	3
163	Administrator - Natal	Vrede 154	17
164	Amcoal Colliery and Industrial Operations	Vanmekaar 810	0
165	Amcoal Colliery and Industrial Operations	Bymekaar 783	0
168	Amcoal Colliery and Industrial Operations	Veelsgeluk 171	1
169	Vryheid Natal Railway, Coal and Iron Company Ltd	Vrede 154	14
170	Gertges, HHM	Doornkloof 425	1
171	Amcoal Colliery and Industrial Operations	Makalusi 245	3
172	Jefkev Inv Pty Ltd	Makalusi 245	2
173	Jefkev Inv Pty Ltd	Makalusi 245	0
174	van Heerden, HJV	Vaalbank 38	2
175	Dirk Jansen Family Trust	Vaalbank 38	11
176	Dirk Jansen Family Trust	Vaalbank 38	12
177	Zulu, NZ	Veelsgeluk 171	4
178	Amcoal Colliery and Industrial Operations	Diepkloof 152	1
179	Amcoal Colliery and Industrial Operations	Diepkloof 152	4
180	Amcoal Colliery and Industrial Operations	Diepkloof 152	3
181	Lourens, MJ	Waterval 310	0
182	Jefkev Inv Pty Ltd	Makalusi 245	4
183	Dludla, MW	Diepkloof 152	2
184	Amcoal Colliery and Industrial Operations	Diepkloof 152	5
185	Dludla, MW	Diepkloof 152	6
186	Scheepers, HJB	Goudhoek 148	0
187	Scheepers, HJB	Goudhoek 148	3
188	Pretorius, FJ	Skutari 802	0
189	Aucamp, JJB	Goederaden 794	1
190	van Heersen, JJ	Skutari 803	0
191	Steenkamp, CJS	Beroofd 107	1
192	Scheepers, AT	Goudhoek 148	5

Subdivision ID	Owner	Grant	Subdivision
193	Umboghoto Landgoed Pty Ltd	Welverdiend 397	5
194	Steenkamp, JH	Ontevrede 124	1
195	Scheepers, HJB	Goudhoek 148	4
196	Steenkamp, JH	Goederaden 794	2
197	Steenkamp, CJS	Rietfontein 212	3
198	Libiena Wentzel Trust	Beroofd 107	2
199	Libiena Wentzel Trust	Rietfontein 212	4
200	Mthembu, C	Rietfontein 212	5
201	Pieterse AC	Mooiklip 239	1
202	Roman Catholic Mission	Welgevonden 1	1
203	Retief, HL	Nooitgedacht 479	3
204	Retief, HL	UItzicht 284	0
205	Kolbe, FP	Nooitgedacht 479	0
206	Kolbe, FP	UItzicht 284	3
207	Dannheimer, WHH	UItzicht 284	1
208	Hinze, HH	Pivaansbad 533	2
209	Hannes Viljoen Trust	Pivaansbad 533	3
210	Natal Spa Inv Pty Ltd	Pivaansbad 533	8
211	Natal Spa Inv Pty Ltd	Pivaansbad 533	9
212	Fourie, PJ	Pivaansbad 533	1
213	Schwartz, JG	Pivaansbad 533	0
214	Roman Catholic Church - Eshowe	Pivaansbad 533	6
215	Scheepers, P	Dagbreek 786	9
216	Delport, HJ	Dagbreek 786	10
217	Delport, AM	Dagbreek 786	11
218	Hansie and Tina Kilian Trust	Dagbreek 786	12
219	Mhlongo, CN	Welgevonden 287	27
220	van Rensburg, DLJ	Dagbreek 786	18
222	Transnet	Almansnek 114	4
223	Myburgh, HJ	Almansnek 114	15
224	Wida Investments Pty Ltd	Voorkeurplaats 332	1
225	Myburgh, HJ	Almansnek 114	7
226	Mattison, GE	Almansnek 114	9

Subdivision ID	Owner	Grant	Subdivision
227	Greyling Welgevonden Trust	Welgevonden 287	13
228	Apostolic of Vicariate - Eshowe	Welgevonden 287	6
229	Shoba Boerdery CC	Welgevonden 287	16
230	Wida Investments Pty Ltd	Voorkeurplaats 332	2
231	Gertges, HHM	Langgelegen 704	4
232	Gertges, HHM	Langgelegen 704	5
233	R S A	Hlobane 506	23
234	Vryheid Natal Railway, Coal and Iron Company Ltd	Hlobane 506	7
235	Transnet Ltd	Hlobane 506	24
237	Transnet Ltd	Hlobane 506	15
238	Transnet Ltd	Hlobane 506	14
239	Transnet Ltd	Hlobane 506	16
240	Vryheid Natal Railway, Coal and Iron Company Ltd	Hlobane 506	6
241	Transnet Ltd	Hlobane 506	9
242	Vryheid Natal Railway, Coal and Iron Company Ltd	Hlobane 506	6
243	Transnet Ltd	Hlobane 506	25
244	Transnet Ltd	Hlobane 506	1
246	Eskom	Hlobane 506	21
247	R S A	Rietvlei 150	39
248	Dirk Jansen Family Trust	Vaalbank 38	8
249	Telkom SA Ltd	Hlobane 506	22
250	South African Post Office	Hlobane 506	18
251	Old Apostolic Church of Africa	Vaalbank 38	15
252	Hlobane Primary School	Vaalbank 38	13
253	van Heerden, A	Vaalbank 38	5
254	Duiker Mining	Vrede 154	10
255	Amcoal Colliery and Industrial Operations	Vrede 154	16
256	Amcoal Colliery and Industrial Operations	Vrede 154	5
257	Vryheid Natal Railway, Coal and Iron Company Ltd	Vrede 154	13
258	Duiker Mining	Vrede 154	11
259	Amcoal Colliery and Industrial Operations	Vrede 154	12
260	Amcoal Colliery and Industrial Operations	Vrede 154	8
261	R S A	Veelsgeluk 171	7

Subdivision ID	Owner	Grant	Subdivision
262	R S A	Veelsgeluk 171	10
263	van Heerden, JJ	Goudhoek 148	2
264	Scheepers, AT	Goederaden 794	0
265	Wida Investments Pty Ltd	Traktaat 200	5
266	SA Mutual Life Insurance Co	Eerstelling 690	1
267	SA Mutual Life Insurance Co	Eerstelling 690	5
268	Bester, JH	Rietfontein 212	0
269	Lombard, JH	Rietvlei 150	8
270	Transnet Ltd	Hlobane 506	20
272	Vryheid Natal Railway, Coal and Iron Company Ltd	Hlobane 506	3
274	Vryheid Natal Railway, Coal and Iron Company Ltd	Vaalbank 38	1
277	Phillips and David Tyre Brothers CC	Rietvlei 150	28
279	Myburgh, HJ	Almansnek 114	11
282	Myburgh, HJ	Almansnek 114	8
302	Uys, GJvD	Waterval 84	0
303	Moolman, JZ	Waterval 84	1

Appendix 4: 'Paradox' Database of Farm Owners and Factor Scores From Aerial Photos, Orthophotos, Deeds and 1:50 000 Series Maps

This appendix presents the data derived from standard 1:50 000 maps; aerial and orthophotographs from the Surveyor General's Office and from the Vryheid Land Facilitation Service. Scores for fauna conservation potential, agricultural potential and location with respect to core areas were derived in MapInfo from digital maps.

Title abbreviations were used in order to fit the table onto the page. The columns contained the following information:

Farm ID	Identification number for the farm on the 'MapInfo' map of the farms (Map 3.1);
PLU 1%	Percentage of farm under present land use (PLU) class 1 (extensive land uses);
PLU 2%	Percentage of farm under present land use (PLU) class 2 (timber);
PLU 3%	Percentage of farm under present land use (PLU) class 3 (field cropping);
PLU 4%	Percentage of farm under present land use (PLU) class 4 (intensive agriculture);
PLU 5%	Percentage of farm under present land use (PLU) class 5 (industry, residential, transport);
Popn. density	Population density (Section 3.5.8);
Soil cons.	Estimated percentage of the farm unit covered with gully or donga erosion (Section 3.5.1);
Qu. ridges	Indicates the presence (1) or absence (0) of the quartzite ridges identified as being possible habitat for conservation priority plant species (Section 3.5.2);
Cliffs	Indicates the presence (1) of absence (0) of cliffs, which were identified as being possible habitat for cycad species that have been identified as conservation priorities (Section 3.5.2);
Land Tenure	Recently settled or outstanding land claims, or residential properties previously associated with coal mines (Section 3.5.9)
Educ.	Absence (0) or presence of environmental education facilities (4), or schools (2) (Section 3, 5, 10);
Tourism Potential	Score reflecting the tourism potential of each farm.

Table A4: Farm owners and factor scores from aerial photographs, orthophotographs, deeds and 1:50 000 series maps

ırm ID	OWNER	PLU 1 %	PLU 2 %	PLU 3 %	PLU 4 %	PLU 5 %	Popn Density	Soil Cons.	Qu. ridges	Cliffs	Land Tenure	Educ.	Tourism Potential
1	No Registered Owner	70	0	30	0	0	3	0	0	1	0	0	2
4	Klingenberg, LO	65	35	0	0	0	2	0	0	0	0	0	0
8	Zululand Diocesan Trusts Board	100	0	0	0	0	2	0	0	0	0	2	0
12	Funk-Oertel, I	60	25	15	0	0	2	0	0	0	0	0	0
13	Reinstoff, IH	30	0	70	0	0	2	0	0	0	0	0	0
19	Venter, IPL	100	0	0	0	0	1	0	0	0	0	0	0
22	Venter, IPL	100	0	0	0	0	1	0	0	0	0	0	0
33	Vredengeluk Boerdery	90	0	10	0	0	2	5	0	0	0	0	0
39	Muller, JJ	80	0	20	0	0	3	2	0	1	4	0	0
41	Neser, A	80	0	20	0	0	2	0	0	0	0	0	0
43	Gertges, HHM	50	0	50	0	0	1	0	0	0	0	0	0
50	Aaron Family Trust	60	0	40	0	0	2	0	0	0	0	0	0
51	A Y R Boerdery CC	60	0	40	0	0	3	0	0	0	0	0	0
52	CJ and JHC Lourens Tust	90	0	10	0	0	2	0	0	0	0	0	0
54	Schalkwyk, CJ	90	0	10	0	0	2	5	0	0	0	0	0
55	Filmalter, TO	60	10	30	0	0	2	3	0	1	0	0	0
56	Yorkshire Agric. CC	85	15	0	0	0	2	2	0	0	0	0	0

rm ID	OWNER	PLU 1 %	PLU 2 %	PLU 3 %	PLU 4 %	PLU 5 %	Popn Density	Soil Cons.	Qu. ridges	Cliffs	Land Tenure	Educ.	Tourism Potential
57	Impala Irrigation Board	95	0	5	0	0	2	0	1	0	0	0	2
61	Eyssen AJ, and Snyman ZM	98	0	2	0	0	2	0	1	0	-2	0	0
62	Potgeiter, FJ	85	0	15	0	0	2	0	1	0	-2	0	0
63	van Rensburg, JJJ	70	0	30	0	0	2	0	0	0	0	0	0
65	Gertges Medisyne	90	0	10	0	0	2	0	0	0	0	0	2
70	Potgeiter, TC	100	0	0	0	0	1	0	1	1	-2	0	0
71	Bester, JH	90	0	10	0	0	3	5	0	0	0	0	0
77	Leonard, JD	30	0	70	0	0	2	5	0	1	0	0	0
78	Dames, HDP	85	10	5	0	0	2	0	1	1	0	0	0
79	Gevers, VH	70	0	30	0	0	3	3	0	0	0	0	0
81	Potgeiter, EF	100	0	0	0	0	2	8	0	1	0	2	0
83	Potgeiter TC	90	0	10	0	0	2	0	0	0	0	0	0
84	No registered owner	0	0	0	100	0	2	0	0	0	0	0	0
85	No registered owner	0	30	70	0	0	3	0	0	0	0	0	0
87	Lombard, JH	0	0	0	100	0	2	0	0	0	0	0	0
89	Barnard, AB	0	0	0	100	0	2	0	0	0	0	0	0
90	Taljard, JC	0	0	0	100	0	2	0	0	0	0	0	0
91	van Aswegen, HC and Viljoen, VV	0	0	0	100	0	2	0	0	0	0	0	0

arm ID	OWNER	PLU 1 %	PLU 2 %	PLU 3 %	PLU 4 %	PLU 5 %	Popn Density	Soil Cons.	Qu. ridges	Cliffs	Land Tenure	Educ.	Tourism Potential
92	Labuschagne, LJ	0	0	0	100	0	2	0	0	0	0	0	0
93	Torino, CM	0	0	0	100	0	2	0	0	0	0	0	0
94	Muller, JW	0	0	0	100	0	2	0	0	0	0	0	0
96	van Jaarsveldt, ES	0	0	0	100	0	2	0	0	0	0	0	0
98	van Jaarsveldt, ES	0	0	0	100	0	2	0	0	0	0	0	0
99	Becker, BG	0	0	0	100	0	2	0	0	0	0	2	0
100	van Jaarsveldt, ES	0	0	0	100	0	2	0	0	0	0	0	0
106	Lombard,JH	0	0	0	100	0	2	0	0	0	0	0	0
107	Swart, SM	0	0	100	0	0	2	0	0	0	0	0	0
109	Dannheimer, WHH	40	0	60	0	0	1	0	0	0	-6	0	0
110	Coetzer, JL	100	0	0	0	0	1	0	0	0	0	0	0
116	Insleep Farms Pty Ltd	100	0	0	0	0	1	0	0	1	0	0	0
119	Hein, WE	100	0	0	0	0	1	0	0	0	0	0	0
120	Wida Investments Pty Ltd	100	0	0	0	0	1	0	0	0	0	0	0
126	Frances Development Corp Pty Ltd	100	0	0	0	0	2	0	0	0	0	0	0
131	Frances Development Corp Pty Ltd	100	0	0	0	0	1	0	0	0	0	0	0
132	Gunter, JH	95	5	0	0	0	2	0	0	0	0	0	0
135	Swanepoel, JP	40	0	60	0	0	2	0	0	0	0	0	0

arm ID	OWNER	PLU 1 %	PLU 2 %	PLU 3 %	PLU 4 %	PLU 5 %	Popn Density	Soil Cons.	Qu. ridges	Cliffs	Land Tenure	Educ.	Tourism Potential
136	CJ and JHC Lourens Trust	100	0	0	0	0	2	0	0	0	0	0	0
139	Barcoal CC	0	0	0	0	100	4	0	0	0	0	0	0
144	San Cotona Boerdery CC	0	0	0	0	100	4	0	0	0	0	0	0
146	Phillips and David Tyre Brothers CC	0	0	50	0	50	3	0	0	0	0	0	0
147	Hlobane Boerevemeging	0	0	0	0	100	4	0	0	0	0	0	0
153	Craig, MW	40	0	60	0	0	3	5	0	0	0	0	0
162	Amcoal Colliery and Industrial Operations	0	0	0	0	100	3	0	0	0	0	2	0
163	Administrator - Natal	0	0	0	0	100	4	0	0	0	0	0	0
177	Zulu, NZ	100	0	0	0	0	1	0	0	0	0	0	0
181	Lourens, MJ	40	30	30	0	0	2	0	0	0	0	0	0
188	Pretorius, FJ	40	60	0	0	0	2	0	0	0	0	0	0
189	Aucamp, JJB	100	0	0	0	0	1	0	0	1	0	0	0
190	van Heersen, JJ	0	45	55	0	0	2	10	0	0	0	0	0
192	Scheepers, AT	100	0	0	0	0	2	0	0	1	0	0	0
193	Umboghoto Landgoed Pty Ltd	65	0	35	0	0	2	3	0	1	0	0	0
196	Steenkamp, JH	85	0	15	0	0	2	0	0	0	0	0	0
197	Steenkamp, CJS	80	0	20	0	0	2	0	0	0	0	0	0
200	Mthembu, C	95	0	5	0	0	2	0	0	0	0	0	0

arm ID	OWNER	PLU 1 %	PLU 2 %	PLU 3 %	PLU 4 %	PLU 5 %	Popn Density	Soil Cons.	Qu. ridges	Cliffs	Land Tenure	Educ.	Tourism Potential
201	Pieterse AC	90	0	10	0	0	2	3	0	0	0	0	0
202	Roman Catholic Mission	80	0	20	0	0	3	0	0	0	0	2	0
207	Dannheimer, WHH	80	20	0	0	0	2	0	0	0	0	0	0
210	Natal Spa Inv Pty Ltd	70	30	0	0	0	2	0	0	0	0	0	0
211	Natal Spa Inv Pty Ltd	0	0	0	100	0	3	0	0	0	0	0	2
212	Fourie, PJ	30	0	70	0	0	2	0	0	0	0	0	2
213	Schwartz, JG	0	0	0	0	0	0	0	0	0	0	0	0
214	Roman Catholic Church - Eshowe	0	0	0	0	100	1	0	0	0	0	0	0
215	Scheepers, P	0	0	0	100	0	2	0	0	0	0	0	0
216	Delport, HJ	0	0	0	100	0	2	0	0	0	0	0	0
217	Delport, AM	0	0	0	100	0	2	0	0	0	0	0	0
218	Hansie and Tina Kilian Trust	0	0	0	100	0	2	0	0	0	0	0	0
219	Mhlongo, CN	0	0	0	100	0	2	0	0	0	0	0	0
220	van Rensburg, DLJ	0	0	0	100	0	2	0	0	0	0	0	0
221	Myburgh, HJ	0	0	0	0	100	1	0	0	0	0	0	0
222	Transnet	0	0	0	0	100	0	0	0	0	0	0	0
223	Myburgh, HJ	0	0	0	0	100	1	0	0	0	0	0	0
224	Wida Investments Pty Ltd	100	0	0	0	0	1	0	0	0	0	0	0

ırm ID	OWNER	PLU 1 %	PLU 2 %	PLU 3 %	PLU 4 %	PLU 5 %	Popn Density	Soil Cons.	Qu. ridges	Cliffs	Land Tenure	Educ.	Tourism Potential
225	Myburgh, HJ	0	100	0	0	0	2	0	0	0	0	0	0
226	Mattison, GE	100	0	0	0	0	1	0	0	0	0	0	0
228	Apostolic of Vicariate - Eshowe	100	0	0	0	0	1	0	0	0	0	2	0
229	Shoba Boerdery CC	0	80	0	0	20	3	0	0	0	0	0	0
230	Wida Investments Pty Ltd	100	0	0	0	0	1	0	0	0	0	0	0
233	R S A	0	0	0	0	100	4	0	0	0	0	0	0
246	Eskom	0	0	0	0	100	4	0	0	0	0	0	0
247	Phillips and David Tyre Brothers CC	0	0	0	0	100	4	0	0	0	0	0	0
248	Dirk Jansen Family Trust	0	0	0	100	0	4	0	0	0	0	0	0
249	Telkom SA Ltd	0	0	0	0	100	5	0	0	0	0	0	0
250	South African Post Office	0	0	0	0	100	4	0	0	0	0	0	0
251	Old Apostolic Church of Africa	0	0	0	0	100	4	0	0	0	0	0	0
252	Hlobane Primary School	0	0	0	0	100	4	0	0	0	0	2	0
253	van Heerden, A	100	0	0	0	0	1	0	0	0	0	0	0
255	Amcoal Colliery and Industrial Operations Ltd	0	0	0	0	100	4	0	0	0	0	0	0
263	van Heerden, JJ	100	0	0	0	0	2	0	0	1	0	0	0
264	Scheepers, AT	100	0	0	0	0	3	0	0	0	0	0	0
265	Wida Investments Pty Ltd	100	0	0	0	0	1	0	0	0	0	0	0

rm ID	OWNER	PLU 1 %	PLU 2 %	PLU 3 %	PLU 4 %	PLU 5 %	Popn Density	Soil Cons.	Qu. ridges	Cliffs	Land Tenure	Educ.	Tourism Potential
268	Bester JH	20	0	80	0	0	1	0	0	0	0	0	0
269	Lombard, JH	0	0	0	0	100	2	0	0	0	0	0	0
275	Old Apostolic Church of Africa	0	0	0	0	100	4	0	0	0	0	0	0
276	Hlobane Primary School	0	0	0	0	100	5	0	0	0	0	2	0
277	Phillips and David Tyre Brothers CC	100	0	0	0	0	2	0	0	0	0	0	0
278	Phillips and David Tyre Brothers CC	0	0	0	0	100	5	0	0	0	0	0	0
281	Myburgh, HJ	100	0	0	0	0	2	0	0	0	0	0	0
282	Myburgh, HJ	100	0	0	0	0	1	0	0	0	0	0	0
283	Swissafari and Eco Tours Pty Ltd	100	0	0	0	0	2	1	1	0	4	4	0
285	Scheepers, HJB	0	25	75	0	0	2	0	0	1	0	0	0
286	Swanepoel, CA	70	0	30	0	0	2	10	0	0	0	0	0
287	Scheepers, HJB	70	0	30	0	0	2	0	0	0	0	0	0
288	Landman, FJ	80	0	20	0	0	2	0	0	0	-6	0	2
289	Vercuil, FJJ	90	2	8	0	0	2	2	1	1	4	0	2
290	Vredengeluk Boerdery	90	0	10	0	0	2	0	0	0	0	0	0
291	Retief, HL	70	0	30	0	0	2	0	0	0	0	0	2
292	Amcoal Colliery and Industrial Operations	65	5	0	0	30	4	0	0	0	0	2	0
293	Dludla, MW	45	55	0	0	0	2	0	0	1	0	2	0

ırm ID	OWNER	PLU 1 %	PLU 2 %	PLU 3 %	PLU 4 %	PLU 5 %	Popn Density	Soil Cons.	Qu. ridges	Cliffs	Land Tenure	Educ.	Tourism Potential
294	R S A	0	0	0	0	100	4	0	0	0	0	0	0
295	Dirk Jansen Family Trust	0	0	0	100	0	4	0	0	0	0	0	0
296	van Heerden, HJV	20	40	40	0	0	2	0	0	0	0	0	0
297	Duiker Mining Ltd	0	0	0	0	100	1	0	0	0	0	0	0
298	Transnet Ltd	0	0	0	0	100	1	0	0	0	0	0	0
301	Duiker Mining Ltd	0	0	0	0	100	4	0	0	0	0	0	0
302	Uys, GJvD	40	0	60	0	0	3	3	0	0	0	0	0
303	Moolman, JZ	40	0	60	0	0	2	2	0	0	0	0	0
305	Hannes Viljoen Trust	70	0	30	0	0	2	5	0	1	0	0	0
306	Jefkev Inv Pty Ltd	60	0	40	0	0	2	0	0	1	0	2	0
307	Frances Development Corp Pty Ltd	100	0	0	0	0	1	0	0	0	0	0	2
309	Dannheimer, WHH	100	0	0	0	0	2	0	0	0	0	0	0
310	Hannes Viljoen Trust	70	10	20	0	0	2	0	0	0	0	0	2
311	Hinze, HH	90	5	5	0	0	2	0	0	0	0	2	0
312	SA Mutual Life Insurance Co	0	100	0	0	0	1	0	0	0	0	0	0
313	Neser, A	85	15	0	0	0	1	0	0	0	0	0	0
314	Klingenberg, WA	70	20	10	0	0	2	0	0	0	0	0	0
315	Wida Investments Pty Ltd	70	5	25	0	0	1	0	0	0	0	0	0
317	Greyling Welgevonden Trust	85	0	15	0	0	2	0	0	0	0	2	0

rm D	OWNER	PLU 1 %	PLU 2 %	PLU 3 %	PLU 4 %	PLU 5 %	Popn Density	Soil Cons.	Qu. ridges	Cliffs	Land Tenure	Educ.	Tourism Potential
318	Thring, NE	0	0	0	100	0	2	0	0	0	0	0	0
319	Foley, A	0	0	0	100	0	2	0	0	0	0	0	0
320	Lombard, JH	0	0	0	100	0	2	0	0	0	0	0	0
321	Myburgh, HJ	50	50	0	0	0	2	0	0	0	0	0	0
323	Retief, HL	65	25	10	0	0	2	0	0	0	0	2	0
324	Adila Investments Ltd	80	15	5	0	0	2	0	0	0	0	0	0
325	Gertges, HHM	77	5	18	0	0	2	2	0	1	0	0	0
326	Kolbe, FP	90	10	0	0	0	2	0	0	0	0	0	0
327	Libiena Wentzel Trust	75	0	25	0	0	2	12	0	0	0	2	0
328	Nebbe, F	80	0	20	0	0	2	0	1	1	0	0	2
329	Schurwepoort Boerdery	95	0	5	0	0	2	0	0	0	0	0	2
330	de Neckar, JAR	95	0	5	0	0	1	0	1	0	0	0	0
331	Steenkamp, JH	18	2	80	0	0	2	3	0	0	0	0	0
332	Swart, AH	60	10	30	0	0	2	0	0	1	-4	0	0
333	van Niekerk, JI	85	0	15	0	0	2	15	0	0	0	0	0
334	Amcoal Colliery and Industrial Operations Ltd	0	30	40	0	30	0	0	0	0	0	0	0
335	Vryheid Natal Railway Coal and Iron Company Ltd	45	25	0	0	30	-8	0	0	0	-4	4	2

Appendix 5: Matrices Used for Analytical Heirarchy Process Prioritization

This appendix contains the matrices used to determine the priorities of the factors used to assess farm suitability for inclusion in a biosphere reserve. The biosphere reserve functions of conservation, sustainable development and research were determined using Expert Choice (1990) software (Textbook Version), and only the results of this process are presented in this appendix. The weightings of these biosphere reserve functions represent the importance of that function in determining the suitability of a farm for inclusion in a biosphere reserve (Table A5.1). The software was only able to work with eight factors, and this project had ten factors that needed to be prioritised. Saaty (1990) provides instructions on how matrices are used in the Analytical Heirarchy Process, and these matrices were developed according to those guidelines.

The factor weightings are a result of assigning a numerical value to comparisons of importance between the factor and all other factors. This was done with respect to all three of the biosphere reserve functions. The final factor weighting was determined by summing the product of the factor priorities for each biosphere reserve function and the weighting for that functions.

For example, the factor weighting indicating the importance of soil conservation in determining the suitability of a farm for inclusion in a biosphere reserve was determined as follows. Soil conservation was given a score for its importance relative to the other factors for each of the biosphere reserve functions. The gradation of scores and their verbal equivalent is explained in Section 3.4.2. Each value in the matrix represents the value of the horizontal factor against the value of the vertical factor. If the horizontal factor is less important than the vertical factor the comparison is given a reciprocal score, ie the reciprocal of the numerical importance of the vertical factor over the horizontal factor.

Matrix A5.1.1 shows the comparisons between factors with respect to the importance of each factor in determining the suitability of a farm for conservation as a biosphere reserve function. Soil conservation was judged to be:

- equally as important as vegetation conservation and fauna conservation (with a score of 1);
- equally to moderately more important than tenure (with a score of 1.5);
- moderately more important than present land use (PLU) (with a score of 3); moderately to strongly more important than agricultural potential, tourism potential and education factors (scoring 4).

Once all the comparisons for conservation were completed the column totals were calculated. Matrix A5.1.2 represents the normalised prioritization matrix where all values in the matrix have been divided by the column total. The sum of these columns is equal to one, and the mean of these represents the priority for that factor.

A measure of the consistency of the judgements is calculated by means of the consistency ratio which compares the observed values with expected values if the value judgements were random. This is calculated by dividing the values in each row by the factor priority and t2hen summing the row. For soil conservation with respect to conservation, this results in values of: 0.1926, 0.1926, 0.1926, 0.1988, 0.1580, 0.2059, 0.1966, 0.1966, 0.2043, and 0.1988 with a sum value of 1.9268 (first row of Matrix A5.1.3) The result is divided by the overall priority for the factor (1.9268/0.1935 = 10.0585 (last value in the first row of Matrix A5.3.3)). The last column of the matrix is summed and divided by the number of factors used (to give 10.0364). The number of factors used (10) is subtracted from this (to give 0.0364) and the result is divided by the number of degrees of freedom in the problem (9) to give (0.040). This value is divided by the random consistency value (1.49) from Saaty (1990) to give the consistency ratio (0.0027).

Matrix A5.2.1 holds the comparison values of each factor with respect to sustainable development as a biosphere reserve function. Soil conservation was judged to be:

- moderately less important than agricultural potential and population density (scoring 1 / 2.5 or 0.4);
- equally important to vegetation conservation, fauna conservation, PLU, tourism potential, land tenure and education factors (with a score of 1);
- and moderately to strongly more important than location (with a score of 4.5).

The priority for soil conservation factors in determining suitability of a farm for the sustainable development role of a biosphere reserve was calculated to be 0.0822. The consistency ratio (0.0092) was determined in the same manner as for conservation.

Matrix A5.3.1 indicates the importance of each factor compared to each other factor with respect to determining the suitability of a farm for research as a biosphere reserve function. Soil conservation was judged to be:

- of equal importance to vegetation conservation, fauna conservation, population density, and land tenure (each comparison scored as 1);
- moderately more important than agricultural potential, PLU, tourism potential and education (scoring 3)
- and strongly more important than location (scoring 5).

The priority for soil conservation factors in determining suitability of farms for research was calculated to be 0.1518. The consistency ratio of these judgements (0.0053) was calculated as was the consistency ratio for conservation.

The overall priority for soil conservation was calculated by multiplying the soil conservation priority for each biosphere reserve function by the priority for soil conservation with respect to that function and summing these. The soil conservation priority for conservation (0.1926) multiplied by the priority for conservation as a biosphere reserve function (0.455) gave 0.0876. The soil conservation priority for sustainable development (0.0822) multiplied by the priority for sustainable development as a biosphere reserve function (0.455) gave 0.0374 The soil conservation priority for research (0.1518) multiplied by the priority for research as a biosphere reserve function (0.090) gave 0.0137. When these three components are added together, the overall priority for soil conservation in determining the suitability of a farm for inclusion in a biosphere reserve is 0.1387.

Table A5.1, Weighting of Biosphere Reserve Functions:

Conservation:	0.4550
Sustainable Development:	0.4550
Research:	0.0900

Table A5.2, Factor Weightings for each Function:

	Conservation	Development	Research	Final
Soil Conservation	0.1926	0.0822	0.1518	0.1387
Vegetation Conservation	0.1926	0.0678	0.1518	0.1321
Fauna Conservation	0.1926	0.0678	0.1518	0.1321
Agricultural Potential	0.0497	0.1986	0.0541	0.1178
Location	0.0197	0.0212	0.0248	0.0209
PLU	0.0686	0.1105	0.0541	0.0864
Tourism Potential	0.0492	0.0678	0.0541	0.0581
Population Density	0.0492	0.2037	0.1518	0.1287
Land Tenure	0.1362	0.1126	0.1518	0.1269
Education	0.0497	0.0678	0.0541	0.0583
Total				1

Appendix 5.1: Conservation Prioritization Matrix

. of Options	10
grees of Freedom	9
ndom Consistency	1.49

trix A5.1.1: Pairwise comparisons for prioritization of factors with respect to conservation

	Soil Conservation	Vegetation Conservation	Fauna Conservation	Agricultural Potential	Location	PLU	Tourism Potential	Population Density	Land Tenure	Education	Priority
l Conservation	1.0000	1.0000	1.0000	4.0000	8.0000	3.0000	4.0000	4.0000	1.5000	4.0000	**0.1926**
getation Conservation	1.0000	1.0000	1.0000	4.0000	8.0000	3.0000	4.0000	4.0000	1.5000	4.0000	**0.1926**
una Conservation	1.0000	1.0000	1.0000	4.0000	8.0000	3.0000	4.0000	4.0000	1.5000	4.0000	**0.1926**
ricultural Potential	0.2500	0.2500	0.2500	1.0000	3.0000	0.7500	1.0000	1.0000	0.3333	1.0000	**0.0497**
cation	0.1250	0.1250	0.1250	0.3333	1.0000	0.2500	0.3333	0.3333	0.1667	0.3333	**0.0197**
U	0.3333	0.3333	0.3333	1.3333	4.0000	1.0000	1.5000	1.5000	0.5000	1.3333	**0.0686**
urism Potential	0.2500	0.2500	0.2500	1.0000	3.0000	0.6667	1.0000	1.0000	0.3333	1.0000	**0.0492**
pulation Density	0.2500	0.2500	0.2500	1.0000	3.0000	0.6667	1.0000	1.0000	0.3333	1.0000	**0.0492**
nd Tenure	0.6667	0.6667	0.6667	3.0000	6.0002	2.0000	3.0000	3.0000	1.0000	3.0000	**0.1362**
ucation	0.2500	0.2500	0.2500	1.0000	3.0003	0.7500	1.0000	1.0000	0.3333	1.0000	**0.0497**
TAL	5.1250	5.1250	5.1250	20.6667	47.0006	15.0834	20.8334	20.8334	7.5000	20.6666	1.0000

ıtrix A5.1.2: Normalised matrix for prioritization of factors with respect to conservation

	Soil Conservation	Vegetation Conservation	Fauna Conservation	Agricultural Potential	Location	PLU	Tourism Potential	Population Density	Land Tenure	Education
il Conservation	0.1951	0.1951	0.1951	0.1935	0.1702	0.1989	0.1920	0.1920	0.2000	0.1935
getation Conservation	0.1951	0.1951	0.1951	0.1935	0.1702	0.1989	0.1920	0.1920	0.2000	0.1935
una Conservation	0.1951	0.1951	0.1951	0.1935	0.1702	0.1989	0.1920	0.1920	0.2000	0.1935
ricultural Potential	0.0488	0.0488	0.0488	0.0484	0.0638	0.0497	0.0480	0.0480	0.0444	0.0484
cation	0.0244	0.0244	0.0244	0.0161	0.0213	0.0166	0.0160	0.0160	0.0222	0.0161
U	0.0650	0.0650	0.0650	0.0645	0.0851	0.0663	0.0720	0.0720	0.0667	0.0645
urism Potential	0.0488	0.0488	0.0488	0.0484	0.0638	0.0442	0.0480	0.0480	0.0444	0.0484
pulation Density	0.0488	0.0488	0.0488	0.0484	0.0638	0.0442	0.0480	0.0480	0.0444	0.0484
nd Tenure	0.1301	0.1301	0.1301	0.1452	0.1277	0.1326	0.1440	0.1440	0.1333	0.1452
ucation	0.0488	0.0488	0.0488	0.0484	0.0638	0.0497	0.0480	0.0480	0.0444	0.0484
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

ıtrix A5.1.3: Matrix for determination of Consistency Ratio for pairwise comparisons made when determining factor priorities with respect to conservation

	Soil Conservation	Vegetation Conservation	Fauna Conservation	Agricultural Potential	Location	PLU	Tourism Potential	Population Density	Land Tenure	Education	Total	Consistency Statistic
il Conservation	0.1926	0.1926	0.1926	0.1988	0.1580	0.2059	0.1966	0.1966	0.2043	0.1988	1.9368	10.0585
getation Conservation	0.1926	0.1926	0.1926	0.1988	0.1580	0.2059	0.1966	0.1966	0.2043	0.1988	1.9368	10.0585
una Conservation	0.1926	0.1926	0.1926	0.1988	0.1580	0.2059	0.1966	0.1966	0.2043	0.1988	1.9368	10.0585
ricultural Potential	0.0481	0.0481	0.0481	0.0497	0.0593	0.0515	0.0492	0.0492	0.0454	0.0497	0.4983	10.0235
cation	0.0241	0.0241	0.0241	0.0166	0.0198	0.0172	0.0164	0.0164	0.0227	0.0166	0.1977	10.0116
U	0.0642	0.0642	0.0642	0.0663	0.0790	0.0686	0.0737	0.0737	0.0681	0.0663	0.6883	10.0306
urism Potential	0.0481	0.0481	0.0481	0.0497	0.0593	0.0457	0.0492	0.0492	0.0454	0.0497	0.4926	10.0198
pulation Density	0.0481	0.0481	0.0481	0.0497	0.0593	0.0457	0.0492	0.0492	0.0454	0.0497	0.4926	10.0198
nd Tenure	0.1284	0.1284	0.1284	0.1491	0.1185	0.1372	0.1475	0.1475	0.1362	0.1491	1.3703	10.0598
ucation	0.0481	0.0481	0.0481	0.0497	0.0593	0.0515	0.0492	0.0492	0.0454	0.0497	0.4983	10.0235

nsistency Ratio **0.0027**

Appendix 5.2: Sustainable Development Priority Matrix

No. of Options	10
Degrees of Freedom	9
Random Consistency	1.49

Matrix A5.2.2: Normalised matrix for prioritization of factors with respect to sustainable development

	Soil Conservation	Vegetation Conservation	Fauna Conservation	Agricultural Potential	Location	PLU	Tourism Potential	Population Density	Land Tenure	Education	Priority
Soil Conservation	1.0000	1.0000	1.0000	0.4000	4.5000	1.0000	1.0000	0.4000	1.0000	1.0000	**0.0822**
Vegetation Conservation	1.0000	1.0000	1.0000	0.3333	4.0000	0.5000	1.0000	0.3333	0.5000	1.0000	**0.0678**
Fauna Conservation	1.0000	1.0000	1.0000	0.3333	4.0000	0.5000	1.0000	0.3333	0.5000	1.0000	**0.0678**
Agricultural Potential	2.5000	3.0000	3.0000	1.0000	7.0000	2.0000	3.0000	1.0000	2.0000	3.0000	**0.1986**
Location	0.2222	0.2500	0.2500	0.1429	1.0000	0.2222	0.2500	0.1429	0.2222	0.2500	**0.0212**
PLU	1.0000	2.0000	2.0000	0.5000	4.5000	1.0000	2.0000	0.4000	1.0000	2.0000	**0.1105**
Tourism Potential	1.0000	1.0000	1.0000	0.3333	4.0000	0.5000	1.0000	0.3333	0.5000	1.0000	**0.0678**
Population Density	2.5000	3.0000	3.0000	1.0000	6.9979	2.5000	3.0003	1.0000	2.0000	3.0000	**0.2037**
Land Tenure	1.0000	2.0000	2.0000	0.5000	4.5000	1.0000	2.0000	0.5000	1.0000	2.0000	**0.1126**
Education	1.0000	1.0000	1.0000	0.3333	4.0000	0.5000	1.0000	0.3333	0.5000	1.0000	**0.0678**
TOTAL	12.2222	15.2501	15.2501	4.8762	44.4980	9.7222	15.2503	4.7762	9.2222	15.2500	1.0000

Matrix A5.2.2: Normalised matrix for prioritization of factors with respect to sustainable development

	Soil Conservation	Vegetation Conservation	Fauna Conservation	Agricultural Potential	Location	PLU	Tourism Potential	Population Density	Land Tenure	Education
Soil Conservation	0.0818	0.0656	0.0656	0.0820	0.1011	0.1029	0.0656	0.0837	0.1084	0.0656
Vegetation Conservation	0.0818	0.0656	0.0656	0.0684	0.0899	0.0514	0.0656	0.0698	0.0542	0.0656
Fauna Conservation	0.0818	0.0656	0.0656	0.0684	0.0899	0.0514	0.0656	0.0698	0.0542	0.0656
Agricultural Potential	0.2045	0.1967	0.1967	0.2051	0.1573	0.2057	0.1967	0.2094	0.2169	0.1967
Location	0.0182	0.0164	0.0164	0.0293	0.0225	0.0229	0.0164	0.0299	0.0241	0.0164
PLU	0.0818	0.1311	0.1311	0.1025	0.1011	0.1029	0.1311	0.0837	0.1084	0.1311
Tourism Potential	0.0818	0.0656	0.0656	0.0684	0.0899	0.0514	0.0656	0.0698	0.0542	0.0656
Population Density	0.2045	0.1967	0.1967	0.2051	0.1573	0.2571	0.1967	0.2094	0.2169	0.1967
Land Tenure	0.0818	0.1311	0.1311	0.1025	0.1011	0.1029	0.1311	0.1047	0.1084	0.1311
Education	0.0818	0.0656	0.0656	0.0684	0.0899	0.0514	0.0656	0.0698	0.0542	0.0656
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Matrix A5.2.3: Matrix for determination of Consistency Ratio for pairwise comparisons made when determining factor priorities with respect to sustainable development

	Soil Conservation	Vegetation Conservation	Fauna Conservation	Agricultural Potential	Location	PLU	Tourism Potential	Population Density	Land Tenure	Education	Total	Consistency Statistic
Soil Conservation	0.0822	0.0678	0.0678	0.0794	0.0956	0.1105	0.0678	0.0815	0.1126	0.0678	0.8330	10.1295
Vegetation Conservation	0.0822	0.0678	0.0678	0.0662	0.0850	0.0553	0.0678	0.0679	0.0563	0.0678	0.6840	10.0910
Fauna Conservation	0.0822	0.0678	0.0678	0.0662	0.0850	0.0553	0.0678	0.0679	0.0563	0.0678	0.6840	10.0910
Agricultural Potential	0.2056	0.2033	0.2033	0.1986	0.1487	0.2210	0.2033	0.2037	0.2252	0.2033	2.0161	10.1529
Location	0.0183	0.0169	0.0169	0.0284	0.0212	0.0246	0.0169	0.0291	0.0250	0.0169	0.2144	10.0921
PLU	0.0822	0.1356	0.1356	0.0993	0.0956	0.1105	0.1356	0.0815	0.1126	0.1356	1.1239	10.1704
Tourism Potential	0.0822	0.0678	0.0678	0.0662	0.0850	0.0553	0.0678	0.0679	0.0563	0.0678	0.6840	10.0910
Population Density	0.2056	0.2033	0.2033	0.1986	0.1486	0.2763	0.2034	0.2037	0.2252	0.2033	2.0714	10.1679
Land Tenure	0.0822	0.1356	0.1356	0.0993	0.0956	0.1105	0.1356	0.1019	0.1126	0.1356	1.1443	10.1622
Education	0.0822	0.0678	0.0678	0.0662	0.0850	0.0553	0.0678	0.0679	0.0563	0.0678	0.6840	10.0910

Consistency Ratio **0.0092**

Appendix 5.3: Research Prioritization Matrix

No. of Options	10.0000
Degrees of Freedom	9.0000
Random Consistency	1.4900

Matrix A5.3.2: Normalised matrix for prioritization of factors with respect to research

	Soil Conservation	Vegetation Conservation	Fauna Conservation	Agricultural Potential	Location	PLU	Tourism Potential	Population Density	Land Tenure	Education	Priority
Soil Conservation	1.0000	1.0000	1.0000	3.0000	5.0000	3.0000	3.0000	1.0000	1.0000	3.0000	**0.1518**
Vegetation Conservation	1.0000	1.0000	1.0000	3.0000	5.0000	3.0000	3.0000	1.0000	1.0000	3.0000	**0.1518**
Fauna Conservation	1.0000	1.0000	1.0000	3.0000	5.0000	3.0000	3.0000	1.0000	1.0000	3.0000	**0.1518**
Agricultural Potential	0.3333	0.3333	0.3333	1.0000	3.0000	1.0000	1.0000	0.3333	0.3333	1.0000	**0.0541**
Location	0.2000	0.2000	0.2000	0.3333	1.0000	0.3333	0.3333	0.2000	0.2000	0.3333	**0.0248**
PLU	0.3333	0.3333	0.3333	1.0000	3.0000	1.0000	1.0000	0.3333	0.3333	1.0000	**0.0541**
Tourism Potential	0.3333	0.3333	0.3333	1.0000	3.0000	1.0000	1.0000	0.3333	0.3333	1.0000	**0.0541**
Population Density	1.0000	1.0000	1.0000	3.0000	5.0000	3.0000	3.0000	1.0000	1.0000	3.0000	**0.1518**
Land Tenure	1.0000	1.0000	1.0000	3.0000	5.0000	3.0000	3.0000	1.0000	1.0000	3.0000	**0.1518**
Education	0.3333	0.3333	0.3333	1.0000	3.0000	1.0000	1.0000	0.3333	0.3333	1.0000	**0.0541**
TOTAL	6.5333	6.5333	6.5333	19.3334	38.0001	19.3334	19.3334	6.5333	6.5333	19.3333	1.0000

Matrix A5.3.2: Normalised matrix for prioritization of factors with respect to research

	Soil Conservation	Vegetation Conservation	Fauna Conservation	Agricultural Potential	Location	PLU	Tourism Potential	Population Density	Land Tenure	Education
Soil Conservation	0.1531	0.1531	0.1531	0.1552	0.1316	0.1552	0.1552	0.1531	0.1531	0.1552
Vegetation Conservation	0.1531	0.1531	0.1531	0.1552	0.1316	0.1552	0.1552	0.1531	0.1531	0.1552
Fauna Conservation	0.1531	0.1531	0.1531	0.1552	0.1316	0.1552	0.1552	0.1531	0.1531	0.1552
Agricultural Potential	0.0510	0.0510	0.0510	0.0517	0.0789	0.0517	0.0517	0.0510	0.0510	0.0517
Location	0.0306	0.0306	0.0306	0.0172	0.0263	0.0172	0.0172	0.0306	0.0306	0.0172
PLU	0.0510	0.0510	0.0510	0.0517	0.0789	0.0517	0.0517	0.0510	0.0510	0.0517
Tourism Potential	0.0510	0.0510	0.0510	0.0517	0.0789	0.0517	0.0517	0.0510	0.0510	0.0517
Population Density	0.1531	0.1531	0.1531	0.1552	0.1316	0.1552	0.1552	0.1531	0.1531	0.1552
Land Tenure	0.1531	0.1531	0.1531	0.1552	0.1316	0.1552	0.1552	0.1531	0.1531	0.1552
Education	0.0510	0.0510	0.0510	0.0517	0.0789	0.0517	0.0517	0.0510	0.0510	0.0517
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Matrix A5.3.3: Matrix for determination of Consistency Ratio for pairwise comparisons made when determining factor priorities with respect to research

	Soil Conservation	Vegetation Conservation	Fauna Conservation	Agricultural Potential	Location	PLU	Tourism Potential	Population Density	Land Tenure	Education	Total	Cosistency Statistic
Soil Conservation	0.1518	0.1518	0.1518	0.1623	0.1242	0.1623	0.1623	0.1518	0.1518	0.1623	1.5321	10.0957
Vegetation Conservation	0.1518	0.1518	0.1518	0.1623	0.1242	0.1623	0.1623	0.1518	0.1518	0.1623	1.5321	10.0957
Fauna Conservation	0.1518	0.1518	0.1518	0.1623	0.1242	0.1623	0.1623	0.1518	0.1518	0.1623	1.5321	10.0957
Agricultural Potential	0.0506	0.0506	0.0506	0.0541	0.0745	0.0541	0.0541	0.0506	0.0506	0.0541	0.5438	10.0530
Location	0.0304	0.0304	0.0304	0.0180	0.0248	0.0180	0.0180	0.0304	0.0304	0.0180	0.2487	10.0151
PLU	0.0506	0.0506	0.0506	0.0541	0.0745	0.0541	0.0541	0.0506	0.0506	0.0541	0.5438	10.0530
Tourism Potential	0.0506	0.0506	0.0506	0.0541	0.0745	0.0541	0.0541	0.0506	0.0506	0.0541	0.5438	10.0530
Population Density	0.1518	0.1518	0.1518	0.1623	0.1242	0.1623	0.1623	0.1518	0.1518	0.1623	1.5321	10.0957
Land Tenure	0.1518	0.1518	0.1518	0.1623	0.1242	0.1623	0.1623	0.1518	0.1518	0.1623	1.5321	10.0957
Education	0.0506	0.0506	0.0506	0.0541	0.0745	0.0541	0.0541	0.0506	0.0506	0.0541	0.5438	10.0530

Consistency Ratio **0.0053**

Appendix 6: Table of Final Scores

This table provides final factor scores for each farm and the final score reflecting the overall suitability of the farm unit to be considered for inclusion in a biosphere reserve.

Table A6.1: Factor and final farm suitability scores "Project", "No Weightings", and "Limited Factors" methods of assessment

Farm ID	Owner	Soil Cons.	Vegn. Cons.	Fauna Cons.	Popn Density	Land Tenure	Agric. Pot.	PLU	Tourism Pot.	Educn.	Locn.	"Project"	"No Weightings"	"Limited Factors"
1	No Registered Owner	0	2	3.865	-4	0	4.001	4	2	0	4	1.277	1.587	0.437
4	Klingenberg, LO	0	0	0.689	2	0	-2.91	-4	0	0	-4	-0.42	-0.82	-0.16
8	Zululand Diocesan Trusts Board	0	0	1.023	2	0	-3.7	-2	0	0	-4	-0.3	-0.66	-0.35
12	Funk-Oertel, I	0	0	0.475	2	0	-2.63	-2	0	0	-4	-0.24	-0.61	-0.1
13	Reinstoff, IH	0	0	0.05	2	0	-2.06	-4	0	0	-4	-0.4	-0.8	0.029
19	Venter, IPL	0	0	0	4	0	-1.98	-2	0	0	-4	0.025	-0.39	0.557
22	Venter, IPL	0	0	1.501	4	0	4.002	2	0	0	-4	1.274	0.75	1.951
33	Vredengeluk Boerdery	4	0	4.014	2	0	3.998	1	0	0	-2	1.858	1.301	1.441
39	Muller, JJ	2	2	2.109	-4	4	4.001	1	4	0	0	1.603	1.511	1.441
41	Neser, A	0	0	2.41	2	0	4.002	-2	0	0	-2	0.833	0.441	1.442
43	Gertges, HHM	0	6	4.599	4	0	4.003	-4	4	0	0	2.273	1.86	3.519
50	Aaron Family Trust	0	0	1.338	2	0	3.35	-4	0	0	2	0.525	0.469	1.29
51	A Y R Boerdery CC	0	0	1.489	-4	0	3.958	-4	0	0	2	-0.15	-0.05	-0.09
52	CJ and JHC Lourens Tust	0	0	1.501	2	0	4.004	1	0	0	2	1.056	1.051	1.442
54	Schalkwyk, CJ	4	0	1.382	2	0	3.525	-2	0	0	2	1.279	1.091	1.331
55	Filmalter, TO	2	6	1.346	2	0	3.591	4	0	0	2	2.316	2.094	2.914
56	Yorkshire Agric. CC	2	4	0.836	2	0	1.453	4	0	0	0	1.69	1.429	1.893

Farm ID	Owner	Soil Cons.	Vegn. Cons.	Fauna Cons.	Popn Density	Land Tenure	Agric. Pot.	PLU	Tourism Pot.	Educn.	Locn.	"Project"	"No Weightings"	"Limited Factors"
57	Impala Irrigation Board	0	2	3.701	2	0	3.375	1	2	0	0	1.611	1.408	1.818
61	Eyssen AJ, and Snyman ZM	0	2	3.398	2	-2	4.002	4	0	0	4	1.617	1.74	1.462
62	Potgeiter, FJ	0	2	2.058	2	-2	4.004	1	0	0	2	1.14	1.106	1.463
63	van Rensburg, JJJ	0	0	1.61	2	0	4	-4	0	0	4	0.679	0.761	1.441
65	Gertges Medisyne	0	0	3.954	2	0	3.98	4	2	0	-4	1.627	1.193	1.437
70	Potgeiter, TC	0	2	2.007	4	-2	4.001	-2	0	0	4	1.172	1.201	1.971
71	Bester, JH	4	0	1.505	-4	0	4.001	1	0	0	4	0.88	1.051	-0.08
77	Leonard, JD	4	2	2.635	2	0	3.992	-4	0	0	4	1.633	1.463	1.962
78	Dames, HDP	0	8	1.825	2	0	1.078	1	0	0	4	1.852	1.79	2.852
79	Gevers, VH	2	0	3.149	-4	0	3.997	-4	0	0	4	0.387	0.515	-0.08
81	Potgeiter, EF	4	2	2.384	2	0	1.865	2	-2	2	4	1.868	1.825	1.467
83	Potgeiter TC	0	0	2.836	2	0	4.003	-2	0	0	4	1.014	1.084	1.442
84	No registered owner	0	0	1.088	2	0	-2.01	-6	0	0	-4	-0.43	-0.89	0.041
85	No registered owner	0	0	0.703	-4	0	-1.99	-4	0	0	-4	-1.08	-1.32	-1.48
87	Sauer NE	0	0	1.2	2	0	-1.97	-6	0	0	-4	-0.41	-0.87	0.05
89	Barnard, AB	0	4	2.259	2	0	-1.96	-6	0	0	-4	0.251	-0.37	1.098
90	Taljard, JC	0	0	2.324	2	0	-2.02	-6	0	0	-4	-0.27	-0.77	0.039
91	van Aswegen, HC and Viljoen, VV	0	4	2.256	2	0	-1.96	-6	0	0	-4	0.251	-0.37	1.098
92	Labuschagne, LJ	0	0	2.303	2	0	-2	-6	0	0	-4	-0.27	-0.77	0.043
93	Torino, CM	0	4	2.333	2	0	-2.02	-6	0	0	-4	0.254	-0.36	1.084
94	Muller, JW	0	0	2.317	2	0	-2.01	-6	0	0	-4	-0.27	-0.76	0.041
99	Becker, BG	0	4	2.276	2	0	-1.97	-6	0	2	-4	0.369	-0.16	1.096

Farm ID	Owner	Soil Cons.	Vegn. Cons.	Fauna Cons.	Popn Density	Land Tenure	Agric. Pot.	PLU	Tourism Pot.	Educn.	Locn.	"Project"	"No Weightings"	"Limited Factors"
106	Lombard, JH	0	4	2.304	2	0	-2	-6	0	0	-4	0.253	-0.37	1.089
107	Swart, SM	0	4	2.301	2	0	-2	-4	0	0	-4	0.425	-0.17	1.089
109	Dannheimer, WHH	0	0	0	4	-6	-2	-1	0	0	-4	-0.65	-0.9	-0.95
110	Coetzer, JL	0	0	0	4	0	-1.8	-2	0	0	-4	0.046	-0.38	0.599
116	Insleep Farms Pty Ltd	0	0	0.349	2	0	-1.24	-2	0	0	-4	-0.09	-0.48	0.22
119	Hein, WE	0	0	0	4	0	-2	-2	0	0	-4	0.023	-0.4	0.552
120	Wida Investments Pty Ltd	0	0	0	4	0	-2.02	-2	0	0	-4	0.02	-0.4	0.548
126	Frances Development Corp Pty Ltd	0	6	0	2	0	-1.99	-2	4	0	-4	0.792	0.401	1.614
131	Frances Development Corp Pty Ltd	0	0	0	4	0	-2	-2	0	0	-4	0.023	-0.4	0.552
132	Gunter, JH	0	4	2.28	2	0	-1.99	-2	0	0	-4	0.596	0.029	1.091
135	Swanepoel, JP	0	4	2.278	2	0	-1.99	-4	0	0	-4	0.423	-0.17	1.091
136	CJ and JHC Lourens Trust	0	4	2.298	2	0	-1.99	-2	0	0	-4	0.599	0.031	1.091
139	Barcoal CC	0	4	2.286	-8	0	-1.98	-8	-8	0	-4	-1.67	-2.36	-1.45
144	San Cotona Boerdery CC	0	0	2.32	-8	0	-2.01	-8	0	0	-4	-1.73	-1.96	-2.5
146	Phillips and David Tyre Brothers CC	0	4	2.287	-4	0	-1.98	-2	0	0	-4	-0.17	-0.56	-0.43
147	Hlobane Boerevereneging	0	4	2.207	-8	0	-1.91	-8	0	0	-4	-1.2	-1.57	-1.43
153	Craig, MW	4	0	1.498	-4	0	3.994	-4	0	0	-4	0.279	-0.25	-0.08
162	Amcoal Colliery and Industrial Operations	0	4	1.822	-4	0	-2	-8	0	2	-2	-0.59	-0.81	-0.43
163	Administrator - Natal	0	0	2.175	-8	0	-1.89	-8	0	0	-2	-1.69	-1.77	-2.47
177	Zulu, NZ	0	4	2.445	4	0	-2.12	-2	0	0	-2	0.902	0.432	1.57
181	Lourens, MJ	0	0	0.037	2	0	-1.15	-4	0	0	0	-0.21	-0.31	0.241
188	Pretorius, FJ	0	0	1.498	4	0	3.994	-2	0	0	0	1.01	0.749	1.949

Farm ID	Owner	Soil Cons.	Vegn. Cons.	Fauna Cons.	Popn Density	Land Tenure	Agric. Pot.	PLU	Tourism Pot.	Educn.	Locn.	"Project"	"No Weightings"	"Limited Factors"
189	Aucamp, JJ	0	2	1.059	4	0	2.825	-2	0	0	2	1.121	0.988	2.199
190	van Heersen, JJ	6	0	1.47	2	0	3.92	-2	-2	0	0	1.457	0.939	1.423
192	Scheepers, AT	0	4	1.001	2	0	2.67	-2	0	0	2	1.102	0.967	2.177
193	Umboghoto Landgoed Pty Ltd	2	2	1.841	2	0	4.004	-2	0	0	4	1.425	1.385	1.965
197	Steenkamp, CJS	0	4	1.493	2	0	3.982	-2	0	0	2	1.321	1.148	2.483
200	Mthembu, C	0	0	1.507	2	0	4.019	-2	0	0	2	0.799	0.753	1.446
201	Pieterse AC	2	0	3.569	2	0	3.915	-2	0	0	4	1.378	1.348	1.421
202	Roman Catholic Mission	0	0	0	2	0	-1.92	-2	0	2	-4	-0.1	-0.39	0.062
207	Dannheimer, WHH	0	0	0	2	0	-1.99	-2	0	0	-4	-0.23	-0.59	0.046
210	Natal Spa Inv Pty Ltd	0	0	0	2	0	-1.96	-2	2	0	-4	-0.11	-0.39	0.053
211	Natal Spa Inv Pty Ltd	0	0	0	-4	0	-2.01	-6	2	0	-4	-1.23	-1.4	-1.48
212	Fourie, PJ	0	0	0.014	2	0	-1.94	-2	2	0	-4	-0.1	-0.39	0.057
213	Schwartz, JG	0	0	0	2	0	-1.99	-2	2	0	-4	-0.11	-0.39	0.046
214	Roman Catholic Church - Eshowe	0	0	0	4	0	-2.59	-8	0	0	-4	-0.56	-1.05	0.415
215	Scheepers, P	0	4	1.357	2	0	-1.97	-6	0	0	-4	0.131	-0.46	1.096
216	Delport, HJ	0	4	2.162	2	0	-2	-6	0	0	-4	0.234	-0.38	1.089
217	Delport, AM	0	0	1.392	2	0	-2.03	-6	0	0	-4	-0.4	-0.86	0.036
218	Hansie and Tina Kilian Trust	0	0	1.334	2	0	-1.96	-6	0	0	-4	-0.39	-0.86	0.053
219	Mhlongo, CN	0	0	2.258	2	0	-1.96	-6	0	0	-4	-0.27	-0.77	0.053
220	van Rensburg, DLJ	0	4	2.313	2	0	-2.01	-6	0	0	-4	0.253	-0.37	1.086
221	Myburgh, HJ	0	0	0	4	0	-1.88	-8	0	0	-4	-0.48	-0.98	0.58
222	Transnet	0	0	0	4	0	-2.01	-8	0	0	-4	-0.49	-1	0.55

'arm ID	Owner	Soil Cons.	Vegn. Cons.	Fauna Cons.	Popn Density	Land Tenure	Agric. Pot.	PLU	Tourism Pot.	Educn.	Locn.	"Project"	"No Weightings"	"Limited Factors"
223	Myburgh, HJ	0	0	0	4	0	0	-8	0	0	-4	-0.26	-0.8	1.018
224	Wida Investments Pty Ltd	0	0	0	4	0	-2	-2	0	0	-4	0.023	-0.4	0.552
225	Myburgh, HJ	0	0	0	2	0	-2.04	-2	0	0	-4	-0.23	-0.6	0.034
226	Mattison, GE	0	0	0	4	0	-1.97	-2	0	0	-4	0.026	-0.39	0.559
228	Apostolic of Vicariate - Eshowe	0	4	2.213	4	0	-1.99	-2	0	2	-4	0.961	0.422	1.6
229	Shoba Boerdery CC	0	0	0.626	-4	0	-1.98	-2	0	0	-4	-0.92	-1.13	-1.48
230	Wida Investments Pty Ltd	0	0	0	4	0	-2.01	-2	0	0	-4	0.022	-0.4	0.55
233	R S A	0	4	2.024	-8	0	-1.76	-8	0	0	-4	-1.21	-1.57	-1.4
246	Eskom	0	4	2.671	-8	0	-2.32	-8	0	0	-4	-1.19	-1.56	-1.53
247	R S A	0	4	1.715	-8	0	-1.49	-8	0	0	-4	-1.22	-1.57	-1.33
247	Phillips and David Tyre Brothers CC	0	4	1.715	-8	0	-1.49	-8	0	0	-4	-1.22	-1.57	-1.33
248	Dirk Jansen Family Trust	0	4	2.473	-8	0	-2.15	-6	0	0	-4	-1.03	-1.36	-1.49
249	Telkom SA Ltd	0	0	0	-8	0	0	-8	0	0	-4	-1.8	-2	-2.03
250	South African Post Office	0	4	0	-8	0	0	-8	0	0	-4	-1.27	-1.6	-0.99
251	Old Apostolic Church of Africa	0	4	0	-8	0	0	-8	0	0	-4	-1.27	-1.6	-0.99
252	Hlobane Primary School	0	4	2.173	-8	0	-1.88	-8	0	2	-4	-1.09	-1.37	-1.42
253	van Heerden, A	0	4	2.356	4	0	-2.04	-2	0	0	-2	0.9	0.432	1.589
255	Amcoal Colliery and Industrial Operations Ltd	0	0	2.205	-8	-4	-2	-8	-8	0	-4	-2.72	-3.18	-3.5
263	van Heerden, JJ	0	2	1.179	2	0	2.925	-2	0	0	0	0.849	0.61	1.714
264	Scheepers, AT	0	0	1.504	-4	0	4.01	-2	0	0	2	0.025	0.151	-0.08
265	Wida Investments Pty Ltd	0	0	0	4	0	-1.86	-2	0	0	-4	0.039	-0.38	0.585
268	Bester JH	0	0	1.48	4	0	3.946	-2	0	0	2	1.044	0.943	1.938

Farm ID	Owner	Soil Cons.	Vegn. Cons.	Fauna Cons.	Popn Density	Land Tenure	Agric. Pot.	PLU	Tourism Pot.	Educn.	Locn.	"Project"	"No Weightings"	"Limited Factors"
269	Lombard, JH	0	4	3.151	2	0	-2.74	-8	0	0	-4	0.104	-0.55	0.916
275	Old Apostolic Church of Africa	0	0	0	-8	0	0	-8	0	0	-4	-1.8	-2	-2.03
276	Hlobane Primary School	0	0	2.173	-8	-4	-1.88	-8	0	2	-4	-2.13	-2.17	-3.47
277	R S A	0	0	2.356	2	0	-2.04	-2	0	0	-4	0.072	-0.36	0.034
277	Phillips and David Tyre Brothers CC	0	0	2.356	2	0	-2.04	-2	0	0	-4	0.072	-0.36	0.034
278	R S A	0	0	1.715	2	0	-1.49	-8	0	0	-4	-0.46	-0.97	0.162
278	Phillips and David Tyre Brothers CC	0	0	1.715	2	0	-1.49	-8	0	0	-4	-0.46	-0.97	0.162
281	Myburgh, HJ	0	0	0	4	0	-2.04	-2	0	0	-4	0.018	-0.4	0.543
282	Myburgh, HJ	0	0	0	4	0	-1.88	-2	0	0	-4	0.037	-0.38	0.58
283	Swissafari and Eco Tours Pty Ltd	2	2	3.953	2	4	4.001	4	2	4	4	3.079	3.195	2.968
285	Scheepers, HJB	0	4	0.198	2	0	0.527	-4	0	0	0	0.528	0.273	1.678
286	Swanepoel, CA	6	0	1.499	2	0	3.998	-2	-2	0	2	1.511	1.15	1.441
287	Scheepers, HJB	0	0	1.499	2	0	3.997	1	0	0	4	1.096	1.25	1.441
288	Landman, FJ	0	6	2.755	2	-6	2.855	4	4	0	2	1.609	1.761	1.237
289	Vercuil, FJJ	2	6	0.81	2	4	0.773	4	4	0	2	2.653	2.558	3.262
290	Vredengeluk Boerdery	0	0	2.996	2	0	3.421	4	0	0	0	1.402	1.242	1.306
291	Retief, HL	0	6	4.601	2	0	4.001	4	4	0	0	2.707	2.46	3.01
292	Amcoal Colliery and Industrial Operations	0	6	0.747	-8	0	0.52	4	-8	2	0	-0.08	-0.27	-0.34
293	Dludla, MW	0	6	0.886	2	0	1.544	-1	4	2	0	1.612	1.543	2.437
294	R S A	0	4	0	-8	0	-1.63	-8	0	0	-2	-1.42	-1.56	-1.37
295	Dirk Jansen Family Trust	0	4	2.306	-8	0	-2	-6	0	0	-2	-0.99	-1.16	-1.45
296	van Heerden, HJV	0	4	2.301	2	0	-2	-4	0	0	-4	0.425	-0.17	1.089

Farm ID	Owner	Soil Cons.	Vegn. Cons.	Fauna Cons.	Popn Density	Land Tenure	Agric. Pot.	PLU	Tourism Pot.	Educn.	Locn.	"Project"	"No Weightings"	"Limited Factors"
297	Duiker Mining Ltd	0	4	2.296	4	0	-1.99	-8	-8	0	-4	-0.12	-1.16	1.6
298	Transnet Ltd	0	0	2.335	4	0	-2.03	-8	0	0	-4	-0.19	-0.77	0.545
301	Duiker Mining Ltd	0	0	2.315	-8	0	-2.01	-8	-8	0	-4	-2.2	-2.77	-2.5
302	Uys, GJvD	2	6	1.488	-4	0	3.953	4	0	0	-4	1.479	0.944	1.471
303	Moolman, JZ	2	6	1.379	2	0	3.515	4	0	0	-4	2.186	1.489	2.897
305	Hannes Viljoen Trust	4	2	2.81	2	0	3.834	4	0	0	-2	2.203	1.664	1.925
306	Jefkev Inv Pty Ltd	0	6	2.012	2	0	3.056	1	0	2	-2	1.837	1.407	2.79
307	Frances Development Corp Pty Ltd	0	0	3.557	4	0	4	2	2	0	-4	1.661	1.156	1.95
309	Dannheimer, WHH	0	0	0.915	2	0	1.66	4	0	0	-4	0.836	0.457	0.896
310	Hannes Viljoen Trust	0	0	0.343	2	0	-0.63	1	2	0	-4	0.347	0.071	0.362
311	Hinze, HH	0	0	0.239	2	0	-2.27	1	0	2	-4	0.141	-0.1	-0.02
312	SA Mutual Life Insurance Co	0	0	1.059	4	0	-3.41	-2	0	0	-4	0	-0.43	0.224
313	Neser, A	0	0	0	4	0	-2	-2	0	0	-4	0.023	-0.4	0.552
314	Klingenberg, WA	0	0	0.062	2	0	-1.75	1	0	0	-4	0.062	-0.26	0.101
315	Wida Investments Pty Ltd	0	0	0.234	4	0	-1.06	4	0	0	-4	0.683	0.317	0.771
317	Greyling Welgevonden Trust	0	4	2.298	2	0	-1.99	-2	0	2	-4	0.715	0.231	1.091
318	Thring, NE	0	0	2.296	2	0	-1.99	-6	0	0	-4	-0.27	-0.76	0.046
319	Foley, A	0	0	2.289	2	0	-1.99	-6	0	0	-4	-0.27	-0.77	0.046
320	Lombard, JH	0	0	1.327	2	0	-2.01	-6	0	0	-4	-0.4	-0.86	0.041
321	Myburgh, HJ	0	0	0	2	0	-2	-4	0	0	-4	-0.4	-0.8	0.043
323	Retief, HL	0	0	0.008	2	0	-1.96	1	0	2	-4	0.147	-0.09	0.053
324	Adila Investments Ltd	0	0	1.021	2	0	-1.8	1	0	0	-4	0.183	-0.17	0.09

Farm ID	Owner	Soil Cons.	Vegn. Cons.	Fauna Cons.	Popn Density	Land Tenure	Agric. Pot.	PLU	Tourism Pot.	Educn.	Locn.	"Project"	"No Weightings"	"Limited Factors"
325	Gertges, HHM	2	2	1.436	2	0	3.089	4	0	0	-4	1.615	1.053	1.752
326	Kolbe, FP	0	0	0	2	0	-2	-2	0	0	-4	-0.23	-0.6	0.043
327	Libiena Wentzel Trust	6	6	2.011	2	0	4.001	1	-2	2	2	2.748	2.301	3.01
328	Nebbe, F	0	2	3.945	2	0	4.001	4	2	0	-2	1.934	1.595	1.964
329	Schurwepoort Boerdery	0	0	1.885	2	0	3.696	4	2	0	-4	1.32	0.958	1.37
330	de Neckar, JAR	0	2	1.522	4	0	3.999	4	0	0	-4	1.713	1.152	2.473
332	Swart, AH	0	6	0.471	2	-4	-0.14	1	4	0	0	0.907	0.933	1.041
333	van Niekerk, JI	6	0	3.32	2	0	4.002	-2	-2	0	4	1.794	1.532	1.442
334	Amcoal Colliery and Industrial Operations Ltd	0	6	0.87	4	0	-1.57	-1	-8	0	-4	0.603	-0.37	2.221
335	Vryheid Natal Railway Coal and Iron Company Ltd	0	8	1.175	-8	-4	-1.49	3	-1	4	-4	-0.15	-0.23	-1.29
98	van Jaarsveldt, ES	0	6	2.314	2	0	-2	0	0	0	0	1.12	0.831	1.612
331	Steenkamp, JH	2	6	1.498	2	0	3.996	4	0	0	2	2.383	2.149	3.009

Appendix 7: Table Used to Determine Present Land Use Score

Present Land Use (PLU) score depended on the total area of the farm and the area currently supporting different intesities of land use. Estimates were made from aerial and orthophotographs of the percentage of each farm supporting different land uses. These estimates provided values for the columns labeled PLU 1, PLU 2, PLU 3, PLU 4, and PLU 5. The area of each land use class was calculated by multiplying the farm area by the proportion of the farm in that land use class. The seventh to twelfth columns of this table show the area of each land use class on each farm. The "Sum (%)" column contains the sum percentage of intensive PLU classes (2 - 5), and the "Sum (ha)" contains the area of each farm under intensive land uses (PLU classes 2 -5). The PLU score for each farm was worked out with a logical macro that followed the flow chart steps from figure 3.4 and related to the various columns in this table.

ID	AREA (ha)	PLU 1 (%)	PLU 2 (%)	PLU 3 (%)	PLU 4 (%)	PLU 5 (%)	PLU 1 (ha)	PLU 2 (ha)	PLU 3 (ha)	PLU 4 (ha)	PLU 5 (ha)	Sum (%)	Sum (ha)	Score
1	3145	70	0	30	0	0	2201.5	0.0	943.5	0.0	0.0	30	943.5	4
4	306	65	35	0	0	0	198.9	107.1	0.0	0.0	0.0	35	107.1	-4
8	2	100	0	0	0	0	2.0	0.0	0.0	0.0	0.0	0	0	-2
12	245	60	25	15	0	0	147.0	61.3	36.8	0.0	0.0	40	98	-2
13	250	30	0	70	0	0	75.0	0.0	175.0	0.0	0.0	70	175	-4
19	42	100	0	0	0	0	42.0	0.0	0.0	0.0	0.0	0	0	-2
22	674	100	0	0	0	0	674.0	0.0	0.0	0.0	0.0	0	0	2
33	600	90	0	10	0	0	540.0	0.0	60.0	0.0	0.0	10	60	1
39	945	80	0	20	0	0	756.0	0.0	189.0	0.0	0.0	20	189	1
41	477	80	0	20	0	0	381.6	0.0	95.4	0.0	0.0	20	95.4	-2
43	452	50	0	50	0	0	226.0	0.0	226.0	0.0	0.0	50	226	-4
50	466	60	0	40	0	0	279.6	0.0	186.4	0.0	0.0	40	186.4	-4
51	498	60	0	40	0	0	298.8	0.0	199.2	0.0	0.0	40	199.2	-4
52	627	90	0	10	0	0	564.3	0.0	62.7	0.0	0.0	10	62.7	1
54	456	90	0	10	0	0	410.4	0.0	45.6	0.0	0.0	10	45.6	-2

ID	AREA (ha)	PLU 1 (%)	PLU 2 (%)	PLU 3 (%)	PLU 4 (%)	PLU 5 (%)	PLU 1 (ha)	PLU 2 (ha)	PLU 3 (ha)	PLU 4 (ha)	PLU 5 (ha)	Sum (%)	Sum (ha)	Score
55	1215	60	10	30	0	0	729.0	121.5	364.5	0.0	0.0	40	486	4
56	1188	85	15	0	0	0	1009.8	178.2	0.0	0.0	0.0	15	178.2	4
57	994	95	0	5	0	0	944.3	0.0	49.7	0.0	0.0	5	49.7	1
61	2787	98	0	2	0	0	2731.3	0.0	55.7	0.0	0.0	2	55.74	4
62	627	85	0	15	0	0	533.0	0.0	94.1	0.0	0.0	15	94.05	1
63	496	70	0	30	0	0	347.2	0.0	148.8	0.0	0.0	30	148.8	-4
65	2181	90	0	10	0	0	1962.9	0.0	218.1	0.0	0.0	10	218.1	4
70	181	100	0	0	0	0	181.0	0.0	0.0	0.0	0.0	0	0	-2
71	642	90	0	10	0	0	577.8	0.0	64.2	0.0	0.0	10	64.2	1
77	179	30	0	70	0	0	53.7	0.0	125.3	0.0	0.0	70	125.3	-4
78	728	85	10	5	0	0	618.8	72.8	36.4	0.0	0.0	15	109.2	1
79	439	70	0	30	0	0	307.3	0.0	131.7	0.0	0.0	30	131.7	-4
81	751	100	0	0	0	0	751.0	0.0	0.0	0.0	0.0	0	0	2
83	492	90	0	10	0	0	442.8	0.0	49.2	0.0	0.0	10	49.2	-2
84	21	0	0	0	100	0	0.0	0.0	0.0	21.0	0.0	100	21	-8
85	202	0	30	70	0	0	0.0	60.6	141.4	0.0	0.0	100	202	-4
87	21	0	0	0	100	0	0.0	0.0	0.0	21.0	0.0	100	21	-8
89	21	0	0	0	100	0	0.0	0.0	0.0	21.0	0.0	100	21	-8
90	21	0	0	0	100	0	0.0	0.0	0.0	21.0	0.0	100	21	-8
91	22	0	0	0	100	0	0.0	0.0	0.0	22.0	0.0	100	22	-8
92	22	0	0	0	100	0	0.0	0.0	0.0	22.0	0.0	100	22	-8
93	22	0	0	0	100	0	0.0	0.0	0.0	22.0	0.0	100	22	-8
94	20	0	0	0	100	0	0.0	0.0	0.0	20.0	0.0	100	20	-8
96	22	0	0	0	100	0	0.0	0.0	0.0	22.0	0.0	100	22	-8
98	21	0	0	0	100	0	0.0	0.0	0.0	21.0	0.0	100	21	-8
99	22	0	0	0	100	0	0.0	0.0	0.0	22.0	0.0	100	22	-8

ID	AREA (ha)	PLU 1 (%)	PLU 2 (%)	PLU 3 (%)	PLU 4 (%)	PLU 5 (%)	PLU 1 (ha)	PLU 2 (ha)	PLU 3 (ha)	PLU 4 (ha)	PLU 5 (ha)	Sum (%)	Sum (ha)	Score
100	20	0	0	0	100	0	0.0	0.0	0.0	20.0	0.0	100	20	-8
106	22	0	0	0	100	0	0.0	0.0	0.0	22.0	0.0	100	22	-8
107	274	0	0	100	0	0	0.0	0.0	274.0	0.0	0.0	100	274	-6
109	721	40	0	60	0	0	288.4	0.0	432.6	0.0	0.0	60	432.6	-1
110	1	100	0	0	0	0	1.0	0.0	0.0	0.0	0.0	0	0	-2
116	343	100	0	0	0	0	343.0	0.0	0.0	0.0	0.0	0	0	-2
119	138	100	0	0	0	0	138.0	0.0	0.0	0.0	0.0	0	0	-2
120	26	100	0	0	0	0	26.0	0.0	0.0	0.0	0.0	0	0	-2
126	215	100	0	0	0	0	215.0	0.0	0.0	0.0	0.0	0	0	-2
131	96	100	0	0	0	0	96.0	0.0	0.0	0.0	0.0	0	0	-2
132	331	95	5	0	0	0	314.5	16.6	0.0	0.0	0.0	5	16.55	-2
135	243	40	0	60	0	0	97.2	0.0	145.8	0.0	0.0	60	145.8	-4
136	303	100	0	0	0	0	303.0	0.0	0.0	0.0	0.0	0	0	-2
139	47	0	0	0	0	100	0.0	0.0	0.0	0.0	47.0	100	47	-2
144	46	0	0	0	0	100	0.0	0.0	0.0	0.0	46.0	100	46	-2
146	38	0	0	50	0	50	0.0	0.0	19.0	0.0	19.0	100	38	-2
147	4	0	0	0	0	100	0.0	0.0	0.0	0.0	4.0	100	4	-2
153	300	40	0	60	0	0	120.0	0.0	180.0	0.0	0.0	60	180	-4
162	374	0	0	0	0	100	0.0	0.0	0.0	0.0	374.0	100	374	-4
163	6	0	0	0	0	100	0.0	0.0	0.0	0.0	6.0	100	6	-2
177	5	100	0	0	0	0	5.0	0.0	0.0	0.0	0.0	0	0	-2
181	232	40	30	30	0	0	92.8	69.6	69.6	0.0	0.0	60	139.2	-4
188	29	40	60	0	0	0	11.6	17.4	0.0	0.0	0.0	60	17.4	-2
189	173	100	0	0	0	0	173.0	0.0	0.0	0.0	0.0	0	0	-2
190	14	0	45	55	0	0	0.0	6.3	7.7	0.0	0.0	100	14	-2
192	231	100	0	0	0	0	231.0	0.0	0.0	0.0	0.0	0	0	-2

ID	AREA (ha)	PLU 1 (%)	PLU 2 (%)	PLU 3 (%)	PLU 4 (%)	PLU 5 (%)	PLU 1 (ha)	PLU 2 (ha)	PLU 3 (ha)	PLU 4 (ha)	PLU 5 (ha)	Sum (%)	Sum (ha)	Score
193	185	65	0	35	0	0	120.3	0.0	64.8	0.0	0.0	35	64.75	-2
196	163	85	0	15	0	0	138.6	0.0	24.5	0.0	0.0	15	24.45	-2
197	46	80	0	20	0	0	36.8	0.0	9.2	0.0	0.0	20	9.2	-2
200	108	95	0	5	0	0	102.6	0.0	5.4	0.0	0.0	5	5.4	-2
201	212	90	0	10	0	0	190.8	0.0	21.2	0.0	0.0	10	21.2	-2
202	12	80	0	20	0	0	9.6	0.0	2.4	0.0	0.0	20	2.4	-2
207	217	80	20	0	0	0	173.6	43.4	0.0	0.0	0.0	20	43.4	-2
210	14	70	30	0	0	0	9.8	4.2	0.0	0.0	0.0	30	4.2	-2
211	34	0	0	0	100	0	0.0	0.0	0.0	34.0	0.0	100	34	-8
212	137	30	0	70	0	0	41.1	0.0	95.9	0.0	0.0	70	95.9	-2
213	20	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0	0	-2
214	2	0	0	0	0	100	0.0	0.0	0.0	0.0	2.0	100	2	-2
215	23	0	0	0	100	0	0.0	0.0	0.0	23.0	0.0	100	23	-8
216	22	0	0	0	100	0	0.0	0.0	0.0	22.0	0.0	100	22	-8
217	21	0	0	0	100	0	0.0	0.0	0.0	21.0	0.0	100	21	-8
218	20	0	0	0	100	0	0.0	0.0	0.0	20.0	0.0	100	20	-8
219	20	0	0	0	100	0	0.0	0.0	0.0	20.0	0.0	100	20	-8
220	22	0	0	0	100	0	0.0	0.0	0.0	22.0	0.0	100	22	-8
221	3	0	0	0	0	100	0.0	0.0	0.0	0.0	3.0	100	3	-2
222	2	0	0	0	0	100	0.0	0.0	0.0	0.0	2.0	100	2	-2
223	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	100	0	-2
224	20	100	0	0	0	0	20.0	0.0	0.0	0.0	0.0	0	0	-2
225	10	0	100	0	0	0	0.0	10.0	0.0	0.0	0.0	100	10	-2
226	28	100	0	0	0	0	28.0	0.0	0.0	0.0	0.0	0	0	-2
228	195	100	0	0	0	0	195.0	0.0	0.0	0.0	0.0	0	0	-2
229	23	0	80	0	0	20	0.0	18.4	0.0	0.0	4.6	100	23	-2

ID	AREA (ha)	PLU 1 (%)	PLU 2 (%)	PLU 3 (%)	PLU 4 (%)	PLU 5 (%)	PLU 1 (ha)	PLU 2 (ha)	PLU 3 (ha)	PLU 4 (ha)	PLU 5 (ha)	Sum (%)	Sum (ha)	Score
230	21	100	0	0	0	0	21.0	0.0	0.0	0.0	0.0	0	0	-2
233	2	0	0	0	0	100	0.0	0.0	0.0	0.0	2.0	100	2	-2
236	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	100	0	-2
246	1	0	0	0	0	100	0.0	0.0	0.0	0.0	1.0	100	1	-2
247	1	0	0	0	0	100	0.0	0.0	0.0	0.0	1.0	100	1	-2
248	7	0	0	0	100	0	0.0	0.0	0.0	7.0	0.0	100	7	-8
249	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	100	0	-2
250	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	100	0	-2
251	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	100	0	-2
252	4	0	0	0	0	100	0.0	0.0	0.0	0.0	4.0	100	4	-2
253	17	100	0	0	0	0	17.0	0.0	0.0	0.0	0.0	0	0	-2
255	50	0	0	0	0	100	0.0	0.0	0.0	0.0	50.0	100	50	-2
263	64	100	0	0	0	0	64.0	0.0	0.0	0.0	0.0	0	0	-2
264	103	100	0	0	0	0	103.0	0.0	0.0	0.0	0.0	0	0	-2
265	7	100	0	0	0	0	7.0	0.0	0.0	0.0	0.0	0	0	-2
268	34	20	0	80	0	0	6.8	0.0	27.2	0.0	0.0	80	27.2	-2
269	1	0	0	0	0	100	0.0	0.0	0.0	0.0	1.0	100	1	-2
271	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	100	0	-2
273	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	100	0	-2
275	0	0	0	0	0	100	0.0	0.0	0.0	0.0	0.0	100	0	-2
276	4	0	0	0	0	100	0.0	0.0	0.0	0.0	4.0	100	4	-2
277	17	100	0	0	0	0	17.0	0.0	0.0	0.0	0.0	0	0	-2
278	1	0	0	0	0	100	0.0	0.0	0.0	0.0	1.0	100	1	-2
280	2	0	0	0	0	100	0.0	0.0	0.0	0.0	2.0	100	2	-2
281	10	100	0	0	0	0	10.0	0.0	0.0	0.0	0.0	0	0	-2
282	3	100	0	0	0	0	3.0	0.0	0.0	0.0	0.0	0	0	-2

ID	AREA (ha)	PLU 1 (%)	PLU 2 (%)	PLU 3 (%)	PLU 4 (%)	PLU 5 (%)	PLU 1 (ha)	PLU 2 (ha)	PLU 3 (ha)	PLU 4 (ha)	PLU 5 (ha)	Sum (%)	Sum (ha)	Score
283	1755	100	0	0	0	0	1755.0	0.0	0.0	0.0	0.0	0	0	4
285	436	0	25	75	0	0	0.0	109.0	327.0	0.0	0.0	100	436	-4
286	294	70	0	30	0	0	205.8	0.0	88.2	0.0	0.0	30	88.2	-2
287	555	70	0	30	0	0	388.5	0.0	166.5	0.0	0.0	30	166.5	1
288	1584	80	0	20	0	0	1267.2	0.0	316.8	0.0	0.0	20	316.8	4
289	1273	90	2	8	0	0	1145.7	25.5	101.8	0.0	0.0	10	127.3	4
290	2172	90	0	10	0	0	1954.8	0.0	217.2	0.0	0.0	10	217.2	4
291	1078	70	0	30	0	0	754.6	0.0	323.4	0.0	0.0	30	323.4	4
292	2152	65	5	0	0	30	1398.8	107.6	0.0	0.0	645.6	35	753.2	4
293	520	45	55	0	0	0	234.0	286.0	0.0	0.0	0.0	55	286	-1
294	2	0	0	0	0	100	0.0	0.0	0.0	0.0	2.0	100	2	-2
295	39	0	0	0	100	0	0.0	0.0	0.0	39.0	0.0	100	39	-8
296	413	20	40	40	0	0	82.6	165.2	165.2	0.0	0.0	80	330.4	-4
297	140	0	0	0	0	100	0.0	0.0	0.0	0.0	140.0	100	140	-4
298	33	0	0	0	0	100	0.0	0.0	0.0	0.0	33.0	100	33	-2
301	76	0	0	0	0	100	0.0	0.0	0.0	0.0	76.0	100	76	-2
302	1024	40	0	60	0	0	409.6	0.0	614.4	0.0	0.0	60	614.4	4
303	1010	40	0	60	0	0	404.0	0.0	606.0	0.0	0.0	60	606	4
305	1499	70	0	30	0	0	1049.3	0.0	449.7	0.0	0.0	30	449.7	4
306	948	60	0	40	0	0	568.8	0.0	379.2	0.0	0.0	40	379.2	1
307	763	100	0	0	0	0	763.0	0.0	0.0	0.0	0.0	0	0	2
309	1060	100	0	0	0	0	1060.0	0.0	0.0	0.0	0.0	0	0	4
310	830	70	10	20	0	0	581.0	83.0	166.0	0.0	0.0	30	249	1
311	664	90	5	5	0	0	597.6	33.2	33.2	0.0	0.0	10	66.4	1
312	88	0	100	0	0	0	0.0	88.0	0.0	0.0	0.0	100	88	-2
313	467	85	15	0	0	0	397.0	70.1	0.0	0.0	0.0	15	70.05	-2

ID	AREA (ha)	PLU 1 (%)	PLU 2 (%)	PLU 3 (%)	PLU 4 (%)	PLU 5 (%)	PLU 1 (ha)	PLU 2 (ha)	PLU 3 (ha)	PLU 4 (ha)	PLU 5 (ha)	Sum (%)	Sum (ha)	Score
314	741	70	20	10	0	0	518.7	148.2	74.1	0.0	0.0	30	222.3	1
315	2004	70	5	25	0	0	1402.8	100.2	501.0	0.0	0.0	30	601.2	4
317	403	85	0	15	0	0	342.6	0.0	60.5	0.0	0.0	15	60.45	-2
318	62	0	0	0	100	0	0.0	0.0	0.0	62.0	0.0	100	62	-8
319	42	0	0	0	100	0	0.0	0.0	0.0	42.0	0.0	100	42	-8
320	42	0	0	0	100	0	0.0	0.0	0.0	42.0	0.0	100	42	-8
321	217	50	50	0	0	0	108.5	108.5	0.0	0.0	0.0	50	108.5	-4
323	857	65	25	10	0	0	557.1	214.3	85.7	0.0	0.0	35	299.95	1
324	786	80	15	5	0	0	628.8	117.9	39.3	0.0	0.0	20	157.2	1
325	10072	77	5	18	0	0	7755.4	503.6	1813.0	0.0	0.0	23	2316.56	4
326	236	90	10	0	0	0	212.4	23.6	0.0	0.0	0.0	10	23.6	-2
327	711	75	0	25	0	0	533.3	0.0	177.8	0.0	0.0	25	177.75	1
328	1591	80	0	20	0	0	1272.8	0.0	318.2	0.0	0.0	20	318.2	4
329	1374	95	0	5	0	0	1305.3	0.0	68.7	0.0	0.0	5	68.7	4
330	1325	95	0	5	0	0	1258.8	0.0	66.3	0.0	0.0	5	66.25	4
331	1022	18	2	80	0	0	184.0	20.4	817.6	0.0	0.0	82	838.04	4
332	948	60	10	30	0	0	568.8	94.8	284.4	0.0	0.0	40	379.2	1
333	359	85	0	15	0	0	305.2	0.0	53.9	0.0	0.0	15	53.85	-2
334	627	0	30	40	0	30	0.0	188.1	250.8	0.0	438.9	100	877.8	-1
335	5021	45	25	0	0	30	2259.5	1255.3	0.0	0.0	1506.3	55	2761.6	3

Appendix 7.1: Macro Used to Determine PLU Score

The macro used to determine Present Land Use score from the area and proportion of each farm under each land use class is presented in this appendix. The slash (\) preceding the letter in the left hand cell indicates that the right hand cell contains the first line of a macro that can be executed by depressing the "Control" button and the letter (in the right hand cell) button simultaneously. Macros \A to \H each assigns a suitability score to a farm, moves the cursor down one cell (equivalent to calling up the next farm to go through the process), and refers the next farm on to the main decision making macro.

The main decision making macro in this list is \Y. This macro controls the process and keeps count of how many times the process has run so that only the cells containing farm scores are analysed. This macro also queries values in the PLU score table according to the steps set out in the flow chart in Figure 3.4. Where the PLU score depends on just one factor; such as extremely unsuitable farms (score of -8) which are taken up entirely with mining, commercial, transport or residential infrastructure; the farm is passed straight on to the scoring macro (in this case: \H). Where a further condition needs to be met a further step in the process is needed. For example highly suitable farms require a total area of over 1000ha and less than 100ha of cultivated land. In these situations, the farm is passed on to a further decision making macro (\I and \J) before being assigned a score. This process is repeated for each farm, until the macro has run itself 161 times. The scores are listed in a column in the original worksheet and are presented in Appendix 7.1).

Macro	Action
\A	4~ {down} {Branch \Y}
\B	3~ {down} {Branch \Y}
\C	2~ {down} {Branch \Y}
\D	1~ {down} {Branch \Y}
\W	-1~ {down} {Branch \Y}
\E	-2~ {down} {Branch \Y}
\F	-4~ {down} {Branch \Y}
\G	-6~ {down} {Branch \Y}
\H	-8~ {down} {Branch \Y}
\Y	{If @cellpointer("row")>161}{quit} {IF []C(-7)R(0)=100}{Branch \H} {IF []C(-8)R(0)=100}{Branch \G} {IF []C(-12)R(0)>1000}{Branch \I} {IF []C(-12)R(0)>500}{Branch \J} {IF []C(2)R(0)<100}{Branch \E} {Branch \F}
\I	{IF []C(1)R(0)<100}{Branch \A} {Branch \B}
\J	{IF []C(-11)R(0)=100}{Branch \C} {IF []C(-11)R(0)>50}{Branch \D} {Branch \W}