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Biodiversity planning and monitoring in Namibia

by

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This series of Research Discussion Papers is intended to present preliminary, new or topical information and ideas for discussion and debate. The contents are not necessarily the final views or firm positions of the Ministry of Environment and Tourism. Comments and feedback will be welcomed.

Prepared for the Directorate of Environmental Affairs, Namibian National Biodiversity Programme

by

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1. An overall program structure

This document describes a proposal for an integrated biodiversity planning and monitoring program for Namibia. The program would operate at three scales, national, regional (e.g. conservancy wide) and local. The activities at each of these scales would be different, but complementary. The structure of the program means that these activities are nested geographically and ecologically within each other from the national to local scales. The activities do not have to be carried out sequentially so that monitoring at the local scale, for example, could proceed while planning at the national scale is taking place. The program as envisaged requires the establishment of a national Biological Monitoring and Survey Unit within the Ministry of Environment and Tourism (MET) to carry out national scale planning and data management and coordinate regional surveys and local monitoring programs. The second section below describes a biodiversity monitoring program that could be implemented in two community conservancies as pilot studies to test methods and to forge links with national programs. This first section provides context for a series of monitoring programs and some suggestions for overall biodiversity conservation planning in Namibia.

1.1 Biodiversity Planning at the National Scale.

A first step is to establish a biodiversity monitoring and survey unit (BMSU) within the MET. This unit would have two main roles. One would be to provide a meta-database facility, retrieving and manipulating biodiversity data for national planning and policy-making. The other would be to coordinate and oversee biological survey activities at regional scales and monitoring programs at local scales, and to analyze data and report results. To do this thoroughly is both ambitious and costly. However, it can be started modestly and built up over time. It is important, though, that the proper design and management structure is put in place at the start and that the unit has a well-defined goal, which is conservation planning and monitoring trends in biodiversity.

The Directorate of Environmental Affairs (DEA) seems an appropriate location for this unit for two reasons. First, the DEA already houses the National Biodiversity Program. Second, the new Namibian Atlas of Natural Resources, which will be compiled within the DEA, will provide the ideal base on which to develop such a unit. Compilers of the atlas will draw together most, if not all, of the existing relevant data and in the process develop expertise in the manipulation of those data. The data can then be used to begin national conservation planning and to identify gaps in the coverage of existing biological and environmental data. In addition, as Phoebe Barnard (DEA) has indicated, the DEA has numerous environmental monitoring needs, including an effective early warning system for environmental degradation and the determination of policy/project success or failure.

All possible use can and should be made of existing data, including the field records held in museums and herbariums. These data should continue to be stored in the institutions, which have primary responsibility for them, but be made available to the BMSU as needs be.

Namibia is in the fortunate position, relative to most developing countries, of having a substantial biological data base on which to build. The Biological Diversity Country Study (Barnard, 1998) and the special issue of the journal Biodiversity and Conservation, which was devoted to the biological diversity of Namibia, are clear statements of the work that has gone on in the past and the knowledge of Namibian biodiversity that has been accumulated to date. Now is an appropriate and opportune time to determine future directions for biodiversity management in Namibia.

1.1.1 Biodiversity planning

At the national scale, planning for biodiversity conservation should proceed in the following way.

Step 1. Determine the major environmental variables controlling the distribution patterns of species at the national scale. Experience in arid and semi-arid Australia suggests that rainfall, temperature, solar radiation, rock type and land form are suitable at this broad scale, but appropriate variables for Namibia should be chosen by Namibian ecologists. Map these variables across Namibia. Methods already in use in Namibia, and likely to be used in the compilation of the forthcoming atlas, appear to be adequate for mapping, but the spatial modeling tools in the BioRap toolbox are also available if needed.

Step 2. Overlay these variables on a polygon base (e.g. a regular grid) and use the data matrix formed by this overlay to generate environmental domains, either by simple overlay, or using multivariate cluster analysis (e.g. BioRap toolbox). This could form one map in the new atlas, called perhaps 'Environments of Namibia'. Because such a classification is hierarchical, the choice of the number of domains is arbitrary, and can be different for different purposes, which is an advantage. For display in an Atlas, 100 or so might be appropriate. For use as one kind of biodiversity surrogate in national conservation planning, 2,000 or so might be appropriate.

Step 3. Collate existing biological data. This includes field records held in museums and herbariums as well as any maps of, for example, vegetation types. Evaluate these data and choose a set of biodiversity surrogates to begin conservation planning. Examples from a recent project in Papua New Guinea (PNG) are environmental domains, vegetation types, rare and threatened taxa and areas of endemism. Biological field records of many taxa are more comprehensive and reliable in Namibia than in PNG so more taxa might be included initially, e.g. vascular plants and terrestrial vertebrates, with less emphasis placed on environmental classes.

Step 4. Begin conservation planning using this set of biodiversity surrogates by measuring the complementarity value of areas and finding biodiversity priority areas, using the area selection tools in the BioRap toolbox (Faith & Nicholls, 1996). This step requires a biodiversity goal to be set (see Box 1) and should incorporate opportunity cost trade-offs and other constraints such as population density and land use intensity. Again, the PNG project provides an example, but different constraints and opportunity costs will pertain in Namibia.

<u>Biodiversity conservation goals.</u>

In recent years, there has been considerable debate in the international community and within nations on the quantification of conservation goals. This debate has focused on the nomination of arbitrary targets, principally the proportion of ecosystems, which should be represented in protected areas. For example, WWF and IUCN are campaigning for a minimum of 10 per cent of all forest types to be represented in forest protected area networks. Many countries are committed to this goal and some, for example Australia, are committed to exceeding it (Commonwealth of Australia, 1997). The Namibian goal is at least 10% of "... all ecological regions and their major variations" (Brown, 1992).

Setting targets has both advantages and disadvantages. On the one hand, a target is a clear goal against which achievement can be assessed. Targets are probably necessary if Namibians are to agree on biodiversity objectives and make progress towards them. On the other hand, it should also be remembered that any specific target for an area or proportion of an ecosystem to be protected is an essentially arbitrary choice, guided loosely, rather than defined, by science and usually reflecting political expediency. It may also be sensible to adopt different targets for different ecosystems (or vegetation types). For example, it might be necessary to protect a very high proportion (80-100%) of a localised or rare habitat such as an inselberg, in order to ensure its persistence. On the other hand, it may only be necessary to formally protect 10% of widespread ecosystems that are not heavily used, such as Kalahari woodland.

In addition, a focus on protected area targets may diminish the necessary focus on other complementary means of achieving conservation goals. Once arbitrary targets have been met the incentive to address values not adequately protected may be diminished.

Setting targets for conservation planning should therefore be seen in the same light as target setting in other areas of human endeavour. It is a means to an end rather than the end in itself. As knowledge of biological diversity accumulates and as social, economic and environmental conditions change, conservation planning goals should be revisited to ensure they remain appropriate.

Step 5. Repeat steps 3 and 4 periodically as new data become available from regional surveys and data analyses of the kind described in section 1.1.2 below, and as social and economic conditions change.

Completion of the first four steps and reiteration in step 5 will result in
1. the identification of biodiversity priority areas, in particular, gaps in the coverage of the existing protected area network.
2. estimated costs (in foregone opportunities for production) of filling those gaps, and
3. an explicit measure of the contribution to the overall biodiversity goal that each part of Namibia makes, including community conservancies and existing protected areas. Given the data currently available, this contribution will, at least initially, be expressed as areas of vegetation type, or environmental domain, or lists of plant and vertebrate species, or some combination of these. Different management options for unprotected biodiversity priority areas can then be canvassed. Full protection is not necessarily the only way to ensure the persistence of the biodiversity features being contributed by a particular area.

1.1.2 Data analysis

Data analyses at this national scale have to be completed initially as part of the evaluation of existing data for conservation planning above. But beyond that there is an ongoing need for analyses to continue. New field data will become available and spatial modeling methods are continually being improved. The necessary tasks in data analysis at this scale are described below.

Task 1. Plot the field records from existing collections in the environmental space formed by the chosen variables in Step 1 under section 1.1.1 above. Begin with the better-known taxa, e.g. birds, vascular plants, termites, etc. As time goes by, and new knowledge accumulates, add other taxa.

Task 2. Identify gaps in the coverage of environmental space by the chosen taxonomic groups. Map the geographic space occupied by that environmental space.

Task 3. Identify and prioritize those taxa for which better spatial information is required.

Task 4. Design field surveys to fill the gaps; both geographic gaps in existing collections and gaps in the coverage of taxonomic groups (design criteria are discussed in section 2.2 below).

Task 5. Conduct these surveys opportunistically with the help of overseas museums and universities when such help is offered (e.g. Humboldt & Köln) or pro-actively where major gaps are identified, by approaching donors such as Gesellschaft für Technische Zusammen Arbeit, USAID, Global Environment Facility, etc.

Task 6. In the meantime, in order to make the most of what data are already available, estimate wider distribution patterns from the point samples that field records represent using the statistical or empirical modeling tools of the kind available in the BioRap toolbox. (Hutchinson et al., 1996; Margules et al., 1995; see Austin & Meyers, 1996; Margules & Austin, 1994 for current conceptual frameworks; and Rich, 1997 for a practical discussion). Refine these models, as new data become available from task 5.

1.2 Regional biological surveys.

Environmental stratification also underpins efficient and cost-effective biological surveys. All field collections are samples of the geographic space and of the biota, not inventories, which are impossibly expensive and time consuming to conduct. A sample should be a statistically accurate representation of the whole, with minimal bias. Briefly, and in order to minimize bias, the area to be surveyed should be stratified and all combinations of all strata that occur in the area should be sampled the same number of times. The more samples the better, but this number should be determined by trading off the resources available for the survey against the number of species recorded at each sample site. More detail can be found in Gillison & Brewer (1985), Austin & Heyligers (1989), Margules & Austin (1991), Margules & Austin (1994) and Margules et al. (1995). Wessels et al. (1998; 1999) provide recent South African examples.

Aerial photographs and/or satellite imagery could be used to help map environmental strata. Much of northern Namibia has recent (1996) aerial photography coverage at a scale of 1:80,000 and Caprivi has recent (1996-97) coverage at a scale of 1:20,000.

Priorities for regional surveys should, ideally, be determined following the collation and analysis of existing data to identify major gaps, as outlined above. However, the widespread interest in, and government and NGO commitment to, community conservancies, suggests they are appropriate starting points while national gaps are being discovered.

Methods for designing and carrying out such surveys are described below using examples from the Caprivi and Kunene Regions.

1.3 Local monitoring.

Biological surveys are snapshots in time. They record only the species that were found in a place when the survey was conducted. Species distribution patterns change in response to both natural variation (e.g. drought) and human interference (e.g. livestock grazing, fire). Effective biodiversity planning at both the national and local scales will require information on trends in biodiversity associated with both natural fluctuations in the environment and management practices.

1.3.1 Taxa

Monitoring should take place at sites representative of wider ecological conditions so that the results can be extrapolated beyond the local scale. This is a difficult requirement as ecological variation in space, as well as time, is the norm. However, a national classification of environments, and/or vegetation types, as envisaged in section 1.1.1 above, would provide a degree of homogeneity within classes so that cautious and qualified extrapolations might be made. Thus, an argument might be that, as with priorities for regional surveys, locations of monitoring sites should await the national scale analyses proposed above. However, the location of monitoring sites in conservancies would be better determined based on the ecological attributes of each conservancy, their management plans and their management objectives, and should be decided in consultation with conservancy managers. In this way conservancy managers will have a direct stake in the program as opposed to providing a collection site to meet the needs of a national biodiversity monitoring program.

The national scale stratification and analyses will locate the conservancies in an environmental and biological context, including estimating the contribution they make to a national biodiversity goal. Data derived from local monitoring programs will still contribute to the national program by monitoring the extent to which conservancies continue to make that contribution to the national goal. In addition, because monitoring sites will be mapped onto this national classification, the data collected can also be used, albeit with caution, to predict biodiversity trends over the wider area of the class that a monitoring site is located within.

Methods for integrating rural development with the conservation of biological diversity are in demand in many parts of the world today. Because of strong government support for Community Based Natural Resource Management (CBNRM) and the ample commitment from NGOs, Namibia is in a position to lead world best practice in the development of these methods. The CBNRM program has already proven to be successful in promoting rural development for the benefit of local communities, but it is not yet clear to what extent the other primary goal, biodiversity conservation, is being met.

Biodiversity monitoring programs should test the predictions that community conservancies will

1. continue to make their identified contribution to the national biodiversity goal identified in national analyses of the kind described in section 1.1.1 above, and
2. make greater contributions as time goes by, while meeting the other primary goal of providing a sustainable level of well being for their occupants.

1.3.2 Landscape function

Landscape function analysis (LFA) is a method for predicting whether or not a current land use can be sustained. It measures the way in which a landscape conserves, regulates, uses, recycles and redistributes ecosystem resources such as water, soil, nutrients and propagules. It is based on three assumptions: 1) the sustainability of a landscape depends on its capacity to control its resources;

2) most nutrients are moved by water (though wind plays a role); and 3) water flows downhill. Thus, in general, resources flow from the top of a watershed, through a landscape, and out the bottom. Landscape function analysis measures the rate and extent of that flow. Obstacles to the flow such as trees, shrubs, clumps of grass, local physical features such as small depressions, even fallen branches, accumulate water, soil, nutrients and propagules forming, over time, resource 'sinks' more fertile and productive than the surrounding ground. In this way, landscapes develop patches, which accumulate resources and bare ground, or 'fetches', which lose resources. Conservative or sustainable landscapes retain and recycle many resources, while leaky or unsustainable landscapes lose many resources (Tongway & Ludwig, 1990; Ludwig et al., 1997). Degrading landscapes also lose biodiversity and conservative landscapes are more likely to retain biodiversity over time.

LFA is comprised of two main parts: a conceptual framework which generically describes how landscapes work (Ludwig et al., 1997) and a field procedure (Tongway 1994; Tongway & Hindley, 1995), which enables variables that can later be converted into indicators to be collected quickly and inexpensively (say an hour per site). These field data are reduced in the laboratory to a series of indices reflecting: 1) landscape integrity, 2) erosion potential, 3) infiltration and water store and 4) nutrient cycling. An interpretational framework (Tongway and Hindley, 1999) is provided to enable index values predicting critical sustainability thresholds to be determined and appropriate management action taken.

LFA asks the principal question: "How does this landscape mediate the availability of vital resources in space and time?" Because it directly addresses the vigour and effectiveness of biophysical **processes**, it has a generic application. In Australia, it has been used in rainfall regimes from 150 mm to 1250 mm annual average. The issue of scale at which processes are important is an integral part of the methodology: no particular scale is assumed. The scale at which processes are important may vary from a few centimetres to hundreds of metres.

LFA may be used to prescribe the mode of rehabilitation, based on restoring the **types of processes** that have been diminished or eliminated by degradation. (Ludwig & Tongway, 1996; Tongway & Ludwig, 1996)

Landscape function analysis was developed in Australian rangelands. It should be evaluated for use in Namibia to test the prediction that community conservancy management for game and livestock is sustainable. It may also be suitable for developing a Namibian standard against which the health of landscapes in different ecological settings can be measured. Chris Weaver has suggested that the approaches to measuring range condition being developed by veld scientists in Ministry of Agriculture, Water & Rural Development (MAWRD) should be evaluated and compared to landscape function analysis. It might be possible to build on some current Namibian research activities.

Methods for designing and carrying out monitoring programs, and the criteria for choosing monitoring locations, are described below using examples from the Salambala Conservancy in the Caprivi Region and from the Kunene Region.

2. Biodiversity monitoring programs in community conservancies in the Kunene and Caprivi Regions

This is the report on 'Biodiversity monitoring and evaluation of CBNRM and non-CBNRM areas in Kunene and Caprivi Regions, Namibia.' Phase I: Project Planning Consultancy.

2.1 Introduction

Two local monitoring programs are proposed as pilot studies to test methodologies and to develop appropriate links with the proposed national biodiversity monitoring and planning program in section 1 above.

Monitoring programs have to be seen for what they really are – field experiments – and designed accordingly. This is one ingredient of successful monitoring programs. A second is the adequate commitment of resources: people, time and money. A third is appropriate ongoing administrative arrangements, including dedicated office space, computing facilities and administrative staff. The fourth is one (perhaps two, but no more) permanent member(s) of the managing agency with the interest, drive and personal commitment to oversee the program. If any one of these ingredients is missing, monitoring programs will fail. This report deals primarily with the first, the science, but they are all equally important.

In order to test the assumption formally that more biodiversity is sustained where CBNRM operates than where other forms of management, or a lack of management operate, paired plots in CBNRM areas and non-CBNRM areas would have to be established. These pairs would have to be ecologically as similar as possible and they would have to be geographically adjacent. They would have to have had the same land use history prior to the advent of CBNRM. In addition, current land use in the non-CBNRM areas would have to be maintained over the term of the monitoring program and security of tenure would have to be guaranteed. All of this would have to be replicated at least twice and preferably more often, in each area being monitored. If any one of these requirements could not be met then trying to test this assumption would be a waste of money. Brief field examinations of Salambala and Torra Conservancies and adjacent areas, and discussions with Integrated Rural Development and Nature Conservation (IRDNC) staff (Richard Diggle in Katima Mulilo and Garth Owen-Smith at Wêreldsend) suggest strongly that all of the above conditions are unlikely to be able to be met.

Two alternative goals were canvassed. One would be to test the prediction that the advent of CBNRM increases the level of biodiversity protection and the sustainability of game and livestock production, relative to what it was before. This could be tested in a conservancy in the Kunene region. The other, which could be pursued in the Salambala Conservancy, would be to test the assumption that management for game alone protects more of biodiversity than management for livestock and game. Designs for both of these are given below.

The results of biodiversity monitoring programs will feed into the local management of the conservancies concerned, but they will have two other important related benefits. One will be to inform World Wildlife Fund (WWF) and other conservancy sponsors of the effectiveness of conservancy management in protecting non-target species. The other will be to help determine whether or not the goal of providing for people through game and livestock management is compatible with the goal of biodiversity protection. Put another, perhaps more accurate way, what level of biodiversity protection can be sustained while meeting livestock and game production targets. This knowledge will, in turn, help determine management options in other conservancies, and even outside conservancies, and feed back to the overall national conservation planning process.

2.2 Selecting study areas for monitoring

Design and implement a biological survey of each conservancy. These surveys will describe and map the habitat types or ecological assemblages present and list the species each one contains. The resulting maps should be used to make a final decision on the location of the actual monitoring sites. Different treatments (e.g. game vs. livestock and game) must be monitored in the same habitat type or variation due to environmental differences will confound the results.

To establish this necessary ecological knowledge base requires

1. a conceptual framework based on ecological theory,
2. field survey design principles based explicitly on the conceptual framework,
3. a rationale for determining which species should be recorded and what other variables should be measured at the chosen field sample sites, and
4. Appropriate methods for analyzing survey data to predict wider distribution and abundance patterns from the point records that field samples represent (Margules & Austin, 1994).

2.2.1 Conceptual framework

Plant ecologists use the concept of individualistic continuum (Gleason, 1926) to explain observed patterns of variation in vegetation. Each species has a unique distribution determined by its genetic make-up and physiological requirements, which is constrained by ecological interactions with other species (Austin, 1985). This is closely related to the niche concept used by animal ecologists and similar continuum patterns have been observed for animals (Rotenberry & Wiens, 1980).

This is a useful conceptual framework for ecological survey design because it links species distribution patterns with variation in the environment. The best estimates of the patterns in range and abundance that species exhibit come from data collected in surveys which first stratify the area to be surveyed using major resource gradients or environmental variables such as temperature, moisture and substrate. The subsequent survey is then designed to ensure that all existing combinations of these variables is sampled.

2.2.2 Survey design

Survey design is a neglected topic (Austin & Heyligers, 1989). There now exists a sophisticated and still rapidly developing technology for displaying and manipulating data in computers, but the methodology for acquiring those data in the first place remains primitive. This is unfortunate because the design of a survey has such a profound influence on how the data can be used subsequently. Rigorous design rules should be formulated, explicated and applied (Margules & Austin, 1994).

Based on the conceptual framework outlined above, Gillison & Brewer (1985) proposed the use of gradient directed transects, or gradsects, as a practical tool for designing surveys efficiently. Gradsects are transects aligned along gradients of steepest environmental change. Austin & Heyligers (1989) proposed refinements of this idea, including replication within transects and explicit rules for locating field sample sites. There have been many successful applications in Australia (e.g. Margules & Austin, 1991), although many are published in reports that may be difficult to access in Namibia (e.g. New South Wales National Parks and Wildlife Service, 1994a & b). Wessels et al. (1998; 1999) have tested the idea in Mopane woodlands and found it to work well there.

The choice of environmental variables depends on local ecological knowledge and the scale of the survey. Topographic position inevitably will be one variable, so it can serve as an example. Ridges and the crests of rises and dunes, upper slopes, mid-slopes, lower slopes and drainage lines or dune swales should be distinguished from one another (see Fig. 1, for example). Sample quadrats should be aligned along the contour except in drainage lines, where they should follow the line of drainage. Care should be taken to ensure that a quadrat samples one and only one topographic position or the data will be confounded and subsequent analyses made very difficult, or impossible.

2.2.3 Survey taxa and other variables

The taxa surveyed should be of two kinds; those likely to characterize habitat types such as conspicuous woody plants and those that might be sensitive to grazing and other disturbances such as fire and might therefore be suitable for longer term monitoring. A discussion of these factors and likely appropriate taxa appears in section 2.3 below.

A final decision on which taxa to survey should probably not be made until there has been an opportunity to consult more widely with Namibian taxonomists. The number of different taxa recorded will inevitably end up being determined by a trade-off between the need for detailed ecological knowledge and the resources available for the surveys, as discussed under *2.3.2 sampling efficiency* below. At this stage, the indications from the literature and the Namibian Biodiversity Country Study are that perennial vascular plants, birds, ground dwelling beetles, termites, ants, spiders and scorpions should be surveyed.

Other variables recorded should be kept to a minimum and should only be those which will be used in subsequent analyses. I suggest that latitude, longitude, altitude (or a grid reference from a topographic map), topographic position, soil type and soil depth will be sufficient.

2.2.4 Analytical methods

The data should be used to generate ecological types, that is assemblages of co-occurring species. These then form the basic management units. Obvious examples include pans, low sandy rises and ancient river terraces in Salambala, and water courses, outwash plains and plateau surfaces in Torra, but there are likely to be more subtle variations revealed by a proper survey. The methods used to derive these assemblages are multi-variate cluster analyses. They can then be mapped using spatial modeling methods, which correlate recorded distributions with environmental variables for prediction to unsampled areas. At the conservancy scale, spatial modeling need not be technically elaborate and can probably be done intuitively once assemblages are derived. However, this mental model will still be one that relates species to environmental variation.

2.3 Identifying appropriate indicators

The discussion of species sensitivity and sampling efficiency below is relevant to choosing survey taxa as well as species for long-term monitoring.

Taxonomic indicators for the long-term monitoring program should not be finally determined until the surveys in 2.2 above are complete. It will probably not be necessary to monitor all of the species surveyed. Experience gained during the survey phase will be a valuable guide to choosing which species to monitor. A much better understanding of sampling efficiency and a better indication of grazing and other disturbance sensitivities will be available once the surveys are complete. In general, long-term monitoring species should be a sub-set of the taxa surveyed. However, it may be that in conducting a survey, other more appropriate species come to notice. It is important that the monitoring and survey program remains flexible enough to incorporate sensible changes as it proceeds.

In testing the sustainability of both game and livestock production in the Kunene Region, landscape function should also be monitored (see section 1.3.2 above). Coupling landscape function with trends in species composition in this monitoring study will provide a more powerful and informative management tool than taxonomic indicators alone.

2.3.1 Sensitivity of species to disturbance

Plant species likely to be sensitive to grazing are palatable, obligate seed producers and produce low numbers of large seeds that are poorly dispersed with a limited capacity for survival in the dormant state (O'Connor, 1991; Lavorel et al., 1997; Landsberg et al., in press). Less is known about the responses of different animal species to different grazing regimes. Morton et al. (1996) reviewed the literature. They found evidence for changes in the small mammal, bird and reptile assemblages, mainly due to changes in vegetation structure accompanying grazing. They also found evidence for changes in the grasshopper (Orthoptera) and herbivorous bug (Hemiptera) assemblages, with explosions in abundance of a few favoured species, and changes in the composition of ant species assemblages but little decline in overall abundance. They found no significant evidence for the effects of grazing on tenebrionid beetles (Coleoptera: Tenebrionoidae). The evidence for termites suggested a variable response depending on environment (Landsberg et al., in press).

2.3.2 Sampling efficiency

Landsberg et al. (1997) define sampling efficiency as the trade-off between the success and the cost of sampling and identification. Their experience in arid and semi-arid Australian rangelands suggest that plants, birds and ants may be appropriate indicators. Of the higher order taxa, plants and birds were sensitive to grazing, relatively abundant, and relatively efficient to sample. Mammals and reptiles were less speciose and less abundant and they had to be sampled by the expensive pit-trap method. Among the invertebrate groups tested, ants showed a significant and consistent response to grazing. Responses were more difficult to detect in other taxa because of very low numbers of species (Collembola), very low numbers of individuals per species (Coleoptera) or difficulties with identification (Orthoptera; Coleoptera).

2.3.3 Other factors

Dung beetles (Coleoptera: Scarabinae) and birds have been found to be accurately predicted by landform patterns in Mopane woodlands in Northern Province, South Africa (Wessels et al., 1999). Termites are known to be important ecosystem engineers (Muller et. al., 1997) and for that reason should also be considered as indicator candidates. The three arachnid groups, spiders, solifuges and scorpions, are abundant, speciose and relatively easy to collect in Namibia. Many are endemic to restricted areas, they have relatively small ranges and they are predators high in the food chain and therefore particularly sensitive to pollution and habitat destruction (Griffen, 1998).

Dung beetles, ants, termites and most arachnids are ground dwellers. The advantage of ground dwellers is that samples taken at different times can be more easily compared with one another, than samples of, for example, more mobile species such as flies or phytophagous insects, which can be strongly influenced by prevailing weather conditions.

Local ecologists should be consulted before a final decision is made, but the indications from the literature are that at least vascular plants, birds, ground dwelling beetles, termites, ants, spiders, solifuges and scorpions should be surveyed and that a sub-set of these should be chosen for long-term monitoring.

2.4 Existing data types, community game guards and resource monitors

Community Game Guards (CGG) and Resource Monitors collect data on significant community resources such as game and thatching grass and veld foods (water lilies, mangetti nuts, etc.) and therefore play a very important role in community conservancies. However, these species have not been chosen for their sensitivity to disturbance or their sampling efficiency and there is no reason to expect that they will indicate trends in other components of biodiversity.

It may be that some landscape level indicators such as connectivity, habitat complexity and landscape heterogeneity could be developed and that some of the data items collected by CGG and Resource Monitors could be used to monitor these indicators. That is the subject of a separate project that might be undertaken with Namibia Nature Foundation (NNF) sometime in the future. However, even if such indicators can be developed they will be based on best current practice and current ecological concepts and theory, which still require formal testing in longer term monitoring programs of the kind being proposed here. That is, landscape level indicators would have to be tested and adjusted with the results of formal monitoring programs if they were to be successful over the long term.

The long-term monitoring program should, if possible, utilize the Community Game Guards and Resource Monitors for data collection. This would be cost-effective, promote local ownership of the program and contribute to teaching interested local people about biodiversity.

As a first step, they should be engaged as technical support for the conservancy surveys. Plant, vertebrate and invertebrate experts will have to conduct these initial surveys, but they will need technical support and if conservancy members can be involved right from the start, the chances are enhanced that they will be able and willing to conduct the ongoing monitoring program.

Caution should be exercised though, because data collection has to be reliable and consistently accurate and the data collectors will have to be well trained. In this regard, Chris Weaver (WWF) suggests three steps that could be undertaken.

1. As would be found with any group of people, some Game Guards and Resource Monitors have a much greater aptitude for and interest in data collection than others so these are the individuals who should be tasked with long-term monitoring.
2. Data collection must be done under close supervision after extensive training.
3. A clear link has to be demonstrated to conservancy managers between the data being collected and conservancy management needs or there will be little commitment towards a long-term monitoring program.

2.5 The sampling regimes

Monitoring plots should always be established within distinct ecological assemblages identified in the surveys and not span more than one assemblage.

Two separate sampling designs are described below to answer the two questions identified above. These questions were 1) does the advent of conservancy management increase the level of biodiversity protection and sustainability of game and livestock production and 2) does management for game alone protect more of biodiversity than management for game and livestock?

2.5.1 Changes post-conservancy

1. Select a conservancy in the Kunene region currently being finalized but not yet gazetted.

2. Select two local watersheds currently grazed by cattle and currently degraded. If resources permit, select more. Use cattle grazing because cattle are the most destructive introduced grazers in the Kunene Region (Garth Owen-Smith, pers. comm.).

3. Conduct landscape function analysis (LFA) along transects down these watersheds. The analysis should be conducted at the beginning of the experiment and then again after two years. Following a comparison of these first two analyses, a decision can be made on the frequency of future analyses. This will depend on the speed at which changes are occurring, but would probably have to be in the order of every 3 to 4 years.

4. Monitor taxa in plots located to sample the topo-sequence along the same transects. Care should be taken to ensure that each monitoring plot is confined to one topographic unit (e.g. ridge, upper slope, mid-slope, lower slope, outwash fan, drainage line) and, where the watershed spans more than one ecological assemblage, that each is confined within a distinct assemblage, not spanning more than one.

Figure 1 illustrates the proposed sampling design with an idealised cross-section from a Damaraland landscape. The quadrats shown are for plant sampling. Invertebrates should be sampled with pitfall traps within these quadrats and birds should be recorded using the accepted sampling strategy for these landscapes, but centred on the quadrats.

5. Monitor invertebrates and birds twice each year timed to coincide with major seasonal changes. The unpredictability in both space and time of rainfall events, which drive biological processes in this region, means that the timing of sampling will have to vary from year to year. The dry season sample could probably be taken on, or very close to, the same date each year, and that would facilitate management and planning of the program. The wetter season sample should be taken at least 10 days after rain, and this should probably be after the first rain because it may be the only rain. In some years it may not be possible to obtain a wetter season sample. If it doesn't rain on the study plots there is no point in sampling them.

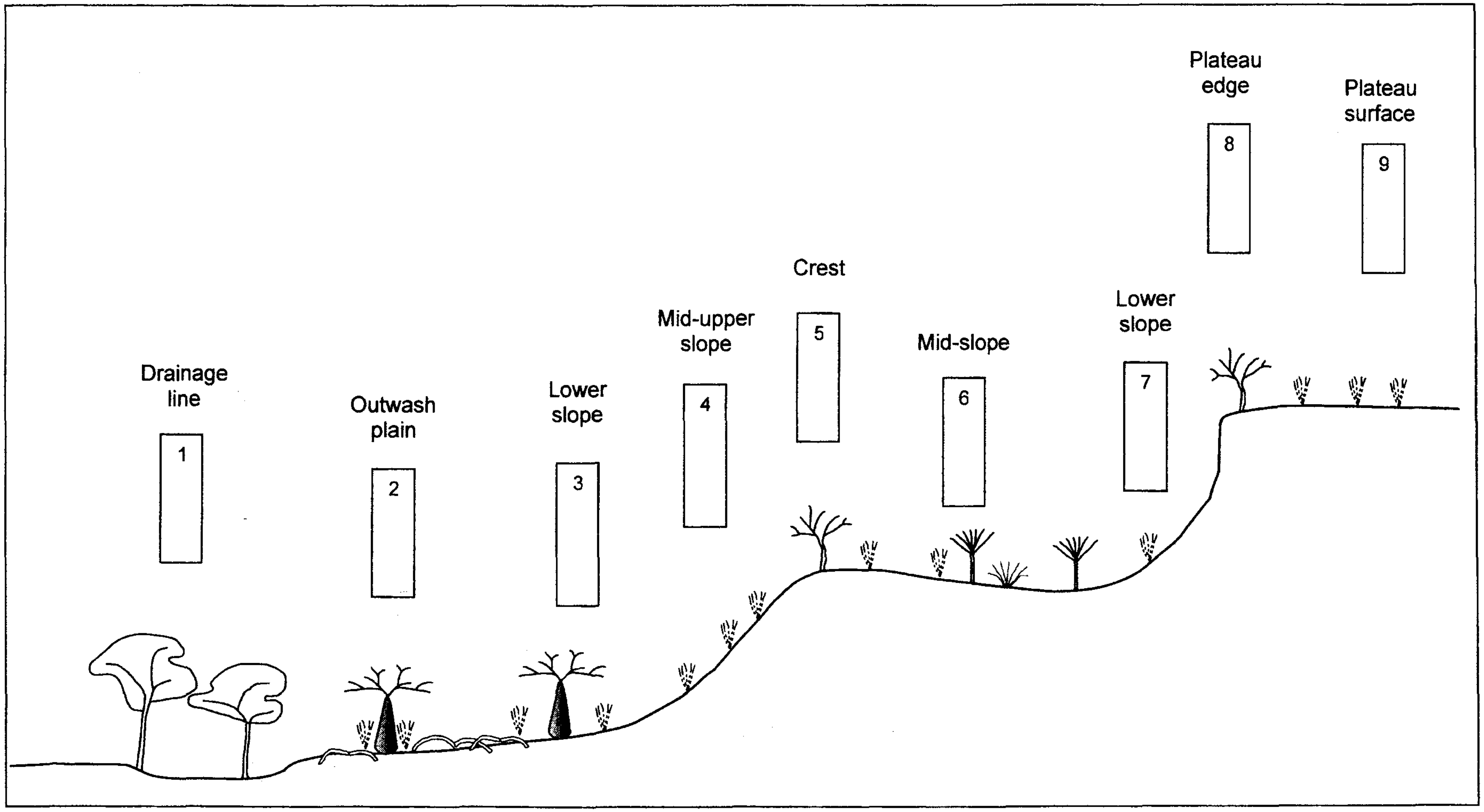


Figure 1. A diagrammatic representation of a Damaraland landscape illustrating the proposed sampling design. Quadrats must be aligned along contours, except in drainage lines where they should follow the line of drainage.

For this study of changes with the advent of conservancy management, it will be important to note any recruitment of perennial plants, and whether or not they survive to maturity. It is not necessary to monitor perennial plants in the dry season sample, but they should be monitored annually in the wetter season sample, at least for the first three years at which time monitoring duration could be re-assessed.

2.5.2 Game versus game and livestock

In this case there is the equivalent of a treatment and a control. Game only, can be thought of as the control and game plus livestock, the treatment. Therefore, hold all other variables as constant as possible. The Salambala Conservancy in eastern Caprivi is suitable for this study because it contains a mostly fenced core area for game only and areas outside this core for livestock grazing as well.

1. Choose two distinct ecological assemblages. If resources permitted, it would be desirable to choose more. However, the current vegetation map suggests that probably only Mopane woodland and Burkea-Combretum woodland are extensive enough along the core area fence, for this purpose.

2. Within each assemblage, select five pairs of monitoring plots at geographically separate locations. Each plot of a pair should be adjacent to one another but separated by the fence dividing the core area from outside.

3. Ensure that these plots are in the same topographic position. Plot size and sample strategy can be determined when the study is implemented.

4. Subject all pairs of plots in this study to the same fire regime. If one is burnt all have to be burnt. Different fire regimes would amount to introducing a new treatment and the size of the program (number of monitoring plots) would have to be doubled, at least, for enough degrees of freedom to test the effect of fire, as distinct from different kinds of grazing, on biodiversity. Different responses to fire under different grazing regimes would be better treated as a separate study.

5. Monitor the selected vertebrate and invertebrate taxa at least twice each year. Time the monitoring to coincide with major seasonal changes. The wet season sample should be taken at least 10 days after the advent of the rains. Perennial plants can be monitored annually during the wet season.

3. Timeframe, budget, personnel and administration

The suggestions here are made by an outsider looking in. There may be some advantages in that position, but there are certainly many disadvantages. I see these suggestions as merely a basis for discussion and subject to extensive modification by the major players in biodiversity monitoring and survey in Namibia.

3.1 Timeframe

3.1.1 National planning

Planning at the national scale should commence as soon as the new atlas data become available. There seems little point in starting before then because it would only be necessary to re-run the analyses. However, using priority area selection methods in BioRap for particular groups for which already have good data, e.g. birds, action plans could be developed now. This would have the added benefit of developing skills in using the relevant analytical techniques in preparation for the arrival of the atlas data.

National scale planning should be ongoing so the timeframe is the duration of concern for biodiversity. The planning analyses themselves are not time-consuming, although the necessary data management and manipulation can be time-consuming. A biodiversity monitoring and survey unit (BMSU) should conduct these ongoing national scale analyses, as well as coordinating and managing data collection, data synthesis and monitoring activities.

3.1.2 Conservancy and other regional surveys

These are basically one-off snap-shots in time for the purposes of mapping species assemblages and listing species from different locations. Of course, re-survey should be undertaken periodically because species distribution patterns change. But for the purposes of this proposal, each one is a short-term activity, which could be carried out part-time or under contract.

Two criteria should be used to select areas for biological surveys. These are a lack of coverage by biological records identified by the proposed BMSU as described in section 1.1.2 above, and the need for long-term monitoring programs to measure the extent to which community conservancies are meeting their stated biodiversity goals.

It is difficult to estimate the time needed for, and the associated costs of, surveys because it depends on how many taxa are to be recorded and how extensive is the area to be surveyed. It is important to be aware of the inevitable trade-off that has to be made between the number of survey sites that can be visited and the number of features about each site that can be recorded. The more features (species and other site variables) that are recorded at each site the fewer sites can be visited. The time, funds and personnel available for a survey are always limiting. The primary use of the data collected in these surveys is to compare areas for biodiversity planning and management purposes. This means that the same information should be available for all areas so that valid comparisons can be made and that means that this trade-off should favour more sites over more features per site.

As a guide to costs, a survey, including data analysis and reporting of the floristics of an area of 30,000 ha in south-eastern Australia cost between A$40,000 and

A$50,000. This figure does not include overheads, just salary and operating costs. Because a Namibian dollar purchases more or less the same in Namibia as an Australian dollar does in Australia, a direct comparison is reasonable. The details of this particular survey, including a full list of items costed, are included in Appendix 1. Adding vertebrates and invertebrates to floristics would double the cost, at least.

3.1.3 Long-term monitoring programs

Long-term monitoring to test the predictions that the advent of CBNRM improves biodiversity protection as well as sustaining game and livestock production, and that management for game alone protects more of biodiversity than management for game and livestock, should continue for at least 30 years. The Wog Wog habitat fragmentation experiment, a long term monitoring program in an Australian *Eucalyptus* forest, to measure the responses of species to habitat fragmentation (Margules et al., 1994; Davies & Margules, 1998), only began to return useful results after 12 years, and there is every indication that results will continue to change as time goes by. One of the main reasons that a time series is required at this experimental site is the natural environmental variation experienced, especially in rainfall and temperature, from year to year. Because of this variation it is often difficult to separate experimental treatment effects from the effects of natural variation. In comparison with this south-eastern Australian site, the north-west of Namibia is much more variable, and eastern Caprivi is probably similar, suggesting that in both cases a long time series will be necessary.

3.2 Budget

Formulating a budget for this program is especially difficult because of the time frame required and the unforeseen changes that will inevitably take place. It would be better to formulate a definite budget in discussions with NNF, WWF and DEA. In the meantime, the following, determined in discussion with Phoebe Barnard, is offered as a starting point. It covers the whole proposed program from the national scale on down.

Vehicles	2 4wd trucks with trailers	US$ 50,000
Vehicle maintenance	incl. spares & tools	US$ 5,000 per annum
Staff (1 full-time, 6 part-time or contract (see below)		US$ 83,000 per annum

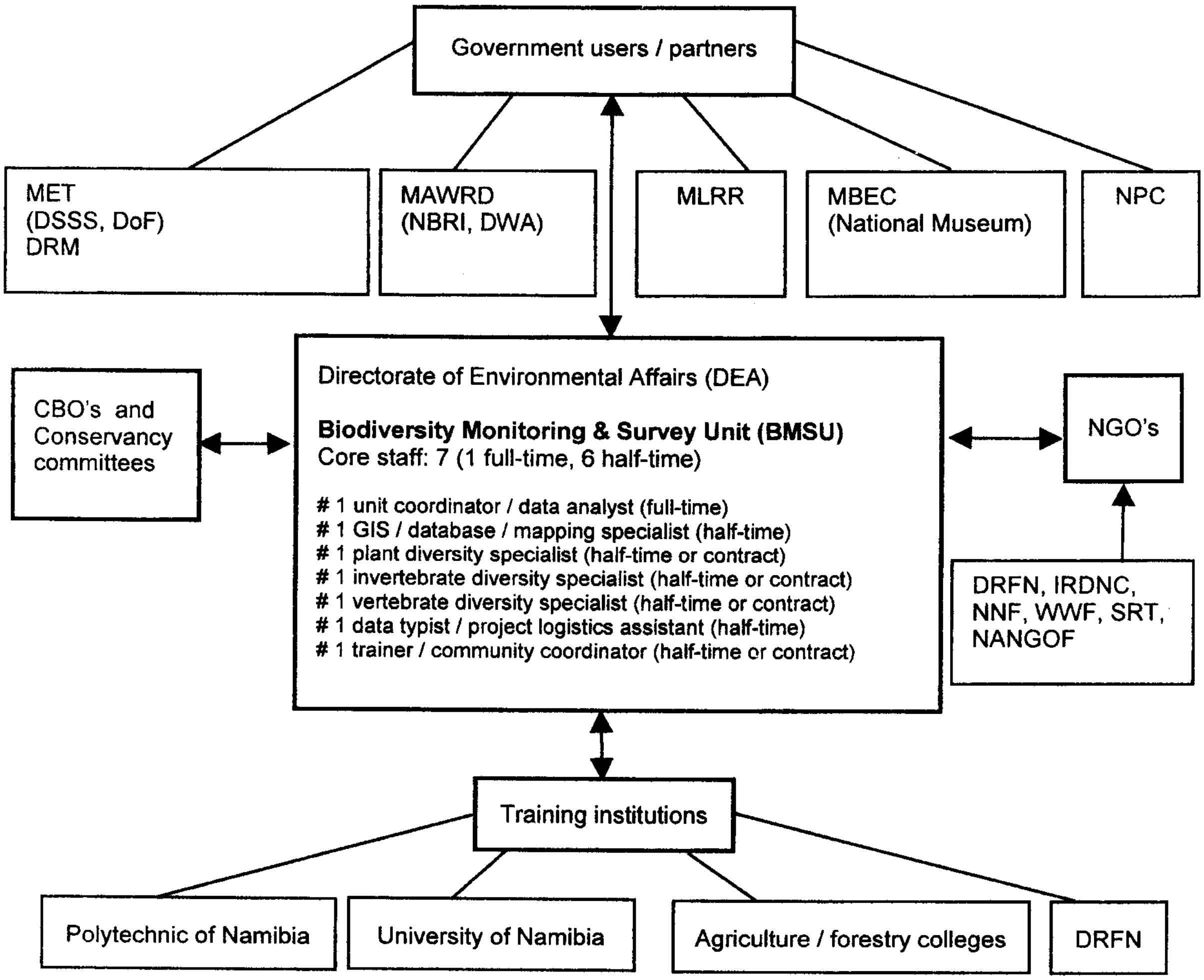
3.3 Personnel and administration

The overall management and coordination of this biodiversity monitoring and planning program should be conducted by the proposed new biodiversity monitoring and survey unit (BMSU) housed within the DEA of the MET (section 1 above). This unit would oversee all three proposed activities: national biodiversity planning, regional and conservancy wide biological surveys and long-term monitoring studies. It would develop national scale biodiversity plans and identify gaps in the knowledge of Namibian biodiversity and prioritize data gathering activities to fill those gaps. It would coordinate regional and conservancy wide surveys and long-term monitoring studies and analyze and synthesize the data to help meet the environmental monitoring needs of the DEA and communicate those results to community conservancies in a way that will enable the conservancies to adapt management programs accordingly.

3.3.1 National planning

A BMSU as proposed in section 1.1 above, would require three DEA staff consisting of a full-time coordinator and data analyst, a part-time GIS/data management specialist and a part-time data management assistant. Four more core staff would need to be contracted or employed part-time, or seconded part-time from within the MET or from other agencies. These are a trainer and coordinator of field activities, a plant diversity specialist, a vertebrate diversity specialist and an invertebrate diversity specialist. In principle, secondment would be best because it would be cheaper and it would explicitly involve other MET Directorates and outside agencies such as museums and herbariums. However, this may be difficult in practice because other directorates and agencies may be unable to afford the loss of staff time. Hence the budget above includes 4 half-time biologists.

Figure 2 shows the relationship of this proposed unit to other government agencies, non-government organizations and training institutions. Figure 3 illustrates the relationship between the proposed BMSU and field activities.



MET = Ministry of Environment & Tourism; MAWRD = Ministry of Agriculture, Water & Rural Development; MLRR = Ministry of Lands, resettlement & Rehabilitation; MBEC = Ministry of Basic Education &Culture; NPC = National Planning Commission; DSSS = Division of Specialist Support Services; DoF = Directorate of Forestry; DRM = Directorate of Resource Management; NBRI = National botanical Research institute; DWA = Department of Water Affairs; CBO's = Community based Organisations; NGO's = Non-government Organisations; DRFN = Desert Research Foundation of Namibia; IRDNC = Integrated Rural Development & Nature Conservation; NNF = Namibia Nature Foundation; WWF = World Wildlife Fund (US); SRT = Save the Rhino Trust; NANGOF = Namibian Non-governmental Forum.

Figure 2. Relationship of proposed biodiversity monitoring and survey unit (BMSU) with existing agencies in Namibia

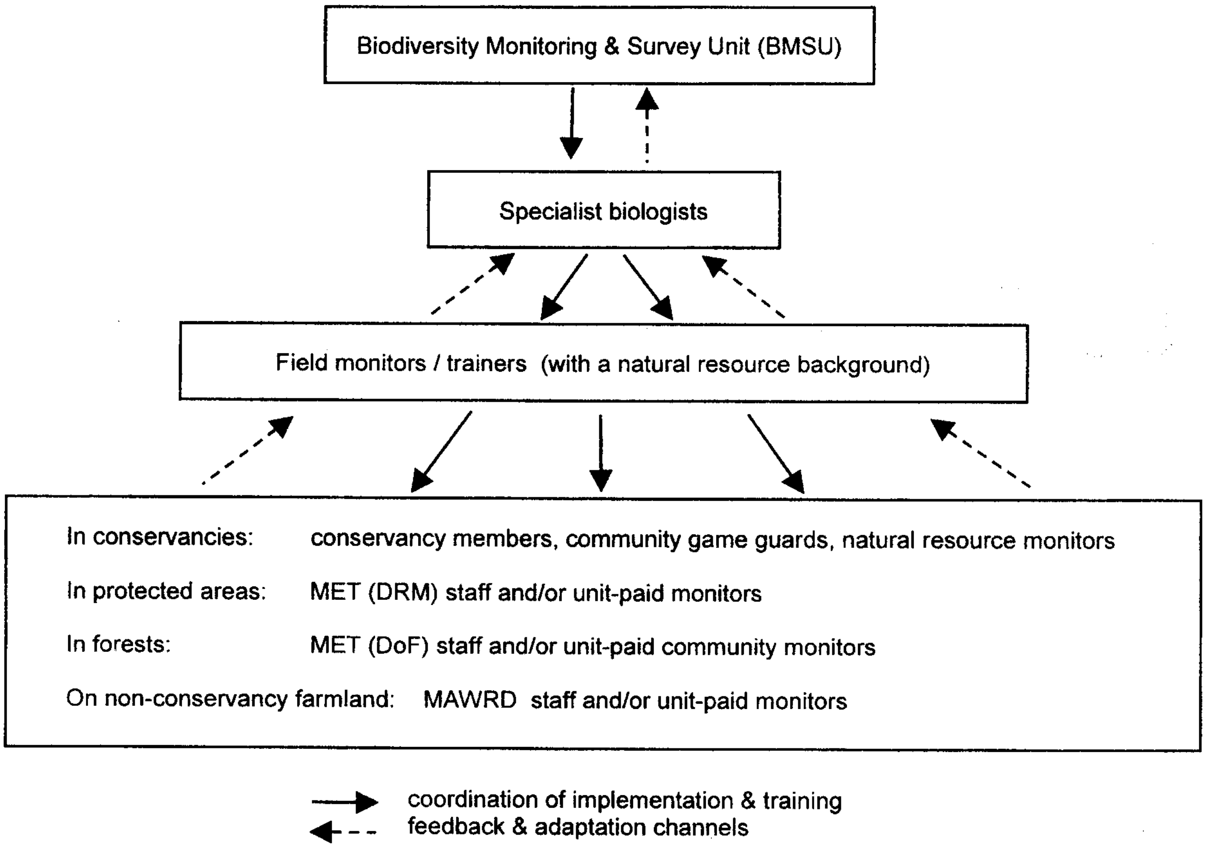


Figure 3. The relationship between existing and planned field monitoring activities and the proposed biodiversity monitoring and survey unit (BMSU). For legend see Figure 2.

3.3.2 Regional surveys

These regional and/or conservancy wide surveys should be managed and coordinated by the BMSU, as proposed in section 1.2 and 3.3.1 above. The personnel carrying out the surveys would be the part-time or contracted staff nominated above, except in cases where overseas institutions were conducting survey work opportunistically. Even then, the locations of their activities should be guided, if not determined, by the BMSU as proposed in section 1.1.2 above and the data should be retained by the BMSU for incorporation into ongoing planning analyses.

3.3.3 Long-term monitoring programs

Long-term monitoring studies would also be managed and coordinated, and the resulting data would be analysed and/or synthesised by the BMSU. While the new staff identified for the BMSU would manage and coordinate the monitoring programs, day to day management and field data collection would be carried out by Community Game Guards and/or Resource Monitors after extensive training and under close supervision (section 2.4 above). The BMSU staff would also be responsible for seeing that the results were made available in a form suitable for conservancy managers to use in adapting management programs. This would involve BMSU staff in active collaboration with conservancy managers.

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Appendix 1

Example of Costs Associated with a Full Floristic Vegetation Survey and Mapping Exercise

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Brindabella National Park and Surrounding Vacant Crown Lands, Southern Tablelands, NSW, Australia

Area:	30,000 hectares
Altitudinal Range:	400 – 1400 metres a.s.l.
Geology:	2 classes
Rainfall:	6 classes (<800 mm - >1200 mm)
Temperature:	5 classes (<10□ C - >13□ C)
Regional Floristic Diversity:	400-500 vascular plant species
Access:	Reasonable (by 4-wheel drive, minimal walking)

Cost: $40,000 - $50,000 covering:
2 days stratification and preparation (using pre-existing digital layers)
3 days reconnaissance
20 days fieldwork @ 6 sites/day = 120 sites minimum (x 2 people - botanist & helper i.e. 40 person days)
15 days plant identification and herbarium preparation
10 days data entry
1 day PATN analysis
10 days Air Photo Interpretation and pattern delineation
2 days digitising
15 days report write up
Herbarium materials
Petrol
Film

Methods:

The survey design used was that of stratified random sampling involving sampling within unique environmental cells that were environmentally representative, geographically randomised and replicated. Given that plant species respond to environmental gradients, an environmental stratification ensures that all potential variation can be sampled. The survey design also involved stratification using toposequences within these environmental cells. Thus, one sample in each environmental cell consisted of a number of sites, which reflected the topographic variation found within that cell. In this survey, three sites per environmental cell were sampled and were chosen from six potential topographic positions: crest, upper crest, mid-slope, lower slope, flat and open depression. The survey aim was to sample all cells at least once and to complete at least two samples in those environmental cells of larger extent.
Before sampling was commenced, the National Park was stratified by lithology, rainfall and temperature using GIS software to determine in which environmental cells

the sites should be located. The cells were then printed as a 1:10000 overlay, which could be used over the 1:10000 topographic map to select cells in the field. Cells to be sampled were located well within cell boundaries and site placement was random, but within a definite topographic unit. As the ultimate goal of the vegetation survey was the production of a vegetation map, this approach was used to try to avoid sampling ecotonal areas which arise from the relatively continuous variation of vegetation with environmental gradients. Distinct and biologically meaningful mappable vegetation types were the priority of the survey.

The vegetation survey collected full floristic information using a site pro-forma. This pro-forma was also used to collect structural and limited environmental information at each site. Soil information collected is only indicative and surficial and no detailed profiles were attempted. Similarly, where outcrops occurred on a site, the lithology was readily discernible but, in boundary areas, the parent material was less obvious.

Sites were 20m x 20m unless they occurred on a creek line in which case they were elongated to 40m in length but only 10m in width. This gives a plot size for all sites of 0.4 ha. Sites were placed such that the sides were parallel to the direction of maximum slope, except for creek lines. All sites were permanently marked with metal droppers driven into the centre of the site and all droppers have a metal tag attached to their top. Slope and aspect measurements were taken at the centre of each site and colour photographs were taken from the centre-rear of each site looking down slope toward the centre. The camera used was a standard 35 mm SLR camera fitted with a 35 mm lens.

All vascular plant species on the sites were recorded using a 6 point cover abundance scale. Fungi, liverworts and mosses were not sampled. Data was entered into an EXCEL spreadsheet. This site by species matrix was analysed in quantitative (cover values between 1 and 6) format using the PATN software package (Belbin, 1995). Compositional dissimilarity between sites was calculated using the Bray - Curtis coefficient and an unweighted pair group arithmetic averaging (UPGMA) clustering strategy was then used to produce a hierarchical classification. Site relationships were interpreted from the resulting dendrogram utilising the floristic relationships shown by the proximity of sites to one another combined with environmental and structural data from the field. The data were then transposed and a species by site analysis was undertaken. The Two-Step algorithm was used for this analysis and the same fusion strategy then used as for the Bray-Curtis analysis. A two way-table derived from this procedure shows the relationship between species composition and site groupings.

Colour aerial photographs at a scale of 1:25000 were then interpreted in light of the vegetation survey. The canopy-only analysis was used to define vegetation types mapped from air photo interpretation. Unique photo patterns were interpreted using the classification where sites fell within defined photo patterns. In some instances, sites appeared to be ecotonal, but these still assisted in assigning vegetation types to air photo patterns. Photo patterns were marked in acetate overlays over the aerial photographs and these boundaries were then digitised a GIS along with labels and all site locations.

Note: Targeted surveys for particular species such as rare plants usually results in the completion of only 1-2 full floristic sites per day.

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