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# BIODIVERSITY ASSESSMENT FOR CONSERVATION PLANNING IN UGANDA'S FORESTS

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## ABSTRACT

The Uganda Forest Department recently completed a major national inventory of forest biodiversity, aimed at providing the information necessary to design a representative protected area system for the country. The inventory covered five national parks and a further 60 forest reserves, and involved the collection of data on five indicator taxa of plants and animals. The project involved approximately 100 man-years of work, during which 17,600 plant site records were made, 100,000 trap-nights of small mammal work undertaken, 57,000 large moths, 21,000 butterflies and 14,000 birds trapped.

The analysis of data generated by the inventory has involved the development of a scoring system, by which the biodiversity and socio-economic values of different sites were compared, and nature conservation priorities established.

More than 95% of species belonging to the five indicator taxa are represented in the present 10 national parks combined with 11 selected forest reserves, and a more complete network of 43 sites would encompass more than 98% of species. The proposed network of forest Nature Reserves is presently being put in place.

## INTRODUCTION

The Uganda Forest Department manages approximately 1.2 million hectares of land (7% of Uganda) as a permanent forest estate, distributed across the country in more than 700 forest reserves. These reserves encompass a wide range of vegetation types: more than two thirds of the associations recognised by Langdale-Brown *et al.* (1964) are represented in the major reserves, including forest, woodland, and more open communities. The reserves are managed to satisfy a variety of purposes, including the protection of fragile environments (mountain catchments), environmental services and biodiversity; the sustained production of timber and other forest products; and meeting the subsistence needs of local communities. Operationally, multiple-use management objectives are satisfied by designating particular reserves to specified uses, or defining different management zones within each reserve.

In the late 1980s, a decision was taken to manage 50% of the natural forest land primarily for environmental protection, with 20% maintained as Nature Reserves and 30% as low-impact use 'Buffer Zones'. The remaining 50% of the estate is to be managed primarily for the sustained supply of quality tropical hardwoods and other forest products. The Forest Department seeks to achieve these broad allocations by applying the principles embodied in the Man and Biosphere concept of reserve design in which management zones are defined

around a totally protected core (Nature Reserve), with zones of increasingly intensive use towards the periphery of each reserve (Batisse, 1985).

This paper describes how decisions have been made over the selection of sites for Nature Reserve establishment. There is a rapidly expanding literature on the subject of biological reserve selection, and the related problem of priority-setting in conservation programme planning and resource allocation. Known examples at a global scale include WORLDMAP (Vane-Wright *et al.*, 1991), and the ICBP priority-setting programme based on endemic bird areas (ICBP, 1992); while at the national and sub-national level examples include work in Australia (*e.g.* Margules *et al.*, 1988; Pressey *et al.*, 1994), South Africa (Rebelo, 1994) and India (Daniels *et al.*, 1991) amongst many others. Useful recent reviews have been provided by Pressey *et al.* (1993), Johnson (1995) and McNeely (1996). The procedures developed for Nature Reserve selection in Uganda's forests build on this experience, adapting it to local conditions.

When the decision to establish new forest Nature Reserves was taken there was very little information available on the suitability of different areas for particular uses, and information on biodiversity values was limited to very few sites (Howard, 1991). A major programme of biological inventory work was therefore undertaken between 1990 and 1995, focusing on five 'indicator groups' of plants and animals sampled from all reserves exceeding 50 $km^2$, and some smaller ones (where these included vegetation types not otherwise represented). The inventory programme involved about 100 man-years of work, during which 17,600 plant site records were made; 100,000 trap-nights of small mammal work undertaken; 57,000 large moths, 21,000 butterflies and 14,000 birds trapped. The results of this work now provide a very strong basis from which to identify 'biodiversity hotspots', and ensure that the selection of areas for designation as Nature Reserves is technically sound.

This paper aims to describe how this new biodiversity information is being used to ensure that decisions over the allocation of forest land to nature conservation are made as objectively as possible. A scoring system is developed as a means of evaluating each site in terms of its potential for various alternative uses, and ensuring that decisions over land allocations are made accordingly. The aim is to adjust the 50-30-20 percent (national average) management zone allocations according to the specific characteristics of each site.

In respect of land to be designated as Nature Reserves, the selection procedure incorporates the following principles:

A) Nature Reserves should be designated to protect:
   - 'biodiversity hotspots'—areas which support an unusually large number of species; and/or concentrations of rare species;
   - sites that encompass a large number of habitat/vegetation types; and/or unusual vegetation associations;
   - sites that are natural, undisturbed and likely to remain so.

B) Nature Reserves should contribute to an efficient national protected areas system, which protects the full range of biodiversity represented in Uganda without unnecessary (and costly) duplication.

C) Nature Reserves should be selected in the most cost-efficient way, avoiding areas that are well-suited to commercial forestry or community-use wherever this is possible. However where species and/or habitats occur only in such areas, they should be designated for protection.

## METHODS

The procedure followed in the selection of areas to be designated as Nature Reserves involved three phases, starting with field data collection, followed by analysis of national priorities and selection of a suitable network of sites, and finally the designation of management zones within individual forests. The last of these phases has only just commenced.

### Data collection

*Selection of sites for evaluation*

The forest estate as a whole covers 1.2 million hectares, comprising 713 separate forest reserves. From this total, biological inventory work was carried out in all the larger forests (54 reserves exceeding 5,000 ha), plus 10 smaller reserves selected to represent vegetation types that do not occur in the larger reserves. Altogether these 64 forest reserves account for 75% of the total area of the forest estate. A map of the sites that were surveyed is provided in figure 1.

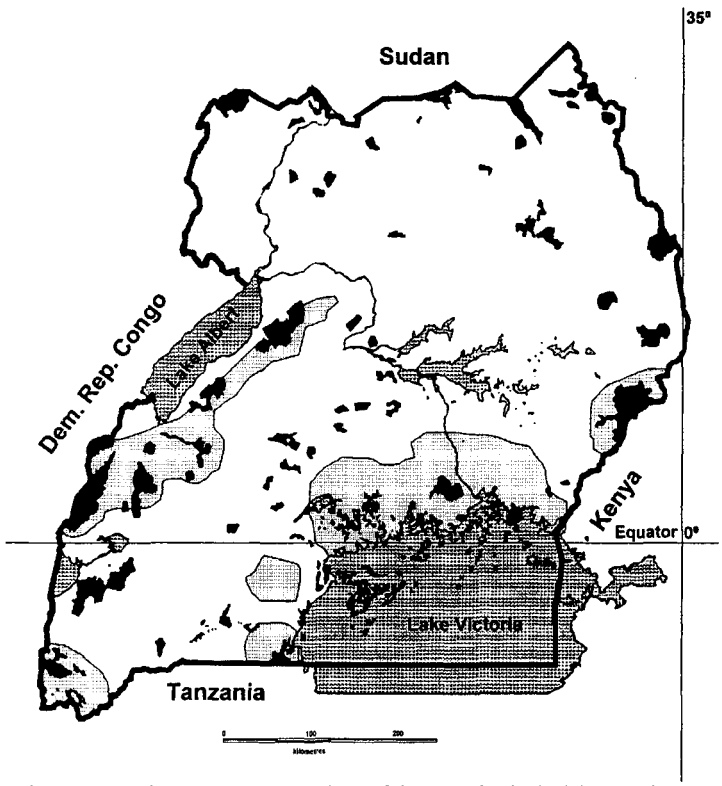


*Figure 1. Map of Uganda showing the location of forests included in the biodiversity inventory programme (black), and areas of country that naturally support closed canopy forest (light grey).*

*Selection of indicator taxa*

Ideally conservation planning should be based on a thorough and complete knowledge of all groups of flora and fauna, but this is obviously impossible, so indicator taxa have to be used. Recognising that priorities established for particular groups of organisms are often quite

different (*e.g.* Daniels *et al.*, 1991; Howard, 1991; Pomeroy, 1993; Prendergast *et al.*, 1993a) we selected five groups to represent the widest possible taxonomic and ecological diversity, consistent with the need for rapid assessment, and reliable identification. Woody plants, birds, small mammals, butterflies and large moths were used to define an overall 'importance score for biological conservation' for each forest.

*Fieldwork*

Having decided on the forests to be surveyed, and the indicator taxa to be sampled, the field programme was initiated by training 25 technical grade Forest Rangers for three months in biological inventory techniques. These men subsequently formed four field teams, each accompanied and supervised in the field by an expatriate biologist. The four field teams worked simultaneously in different forests, establishing base camps at strategic locations so as to provide maximum possible coverage of each reserve. In principle the field sampling regime was designed to cover the full range of altitude, vegetation types and aspect represented in each reserve (full details are provided in Howard & Davenport, 1996).

**Data analysis**

The analysis of data was carried out as an iterative process, aimed at selecting a network of sites for designation as forest Nature Reserves in which all species and habitats are represented in the most cost-effective way. The various steps in this process are summarised in figure 2 and described in more detail below:

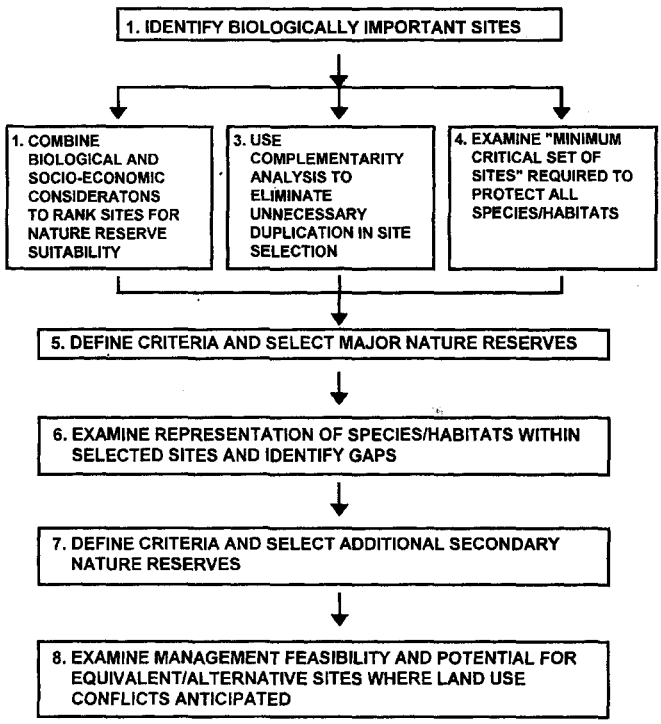


*Figure 2. Diagram indicating the methodology used to select the sites for the establishment of Nature Reserves (see text for further explanation).*

*Step 1. Rank sites according to their relative biological value*

An overall biological importance score was derived for each forest, by combining scores for each of the five indicator taxa. These scores take into account both species richness (standardised for differences in sampling intensity using rarefaction; Krebs, 1989; Prendergast *et al.*, 1993b), and the rarity of the 'average' species (considered at continental and national scales). Further details are provided in Howard (in prep.).

*Step 2. Combine biological and socio-economic considerations to rank sites according to their suitability for Nature Reserve designation*

Nature Reserve suitability scores were derived to help identify sites of high conservation value where Nature Reserves could be designated without conflicts over land use. Initially, the biological importance score (STEP 1) was combined with a score for compatible non-consumptive uses (namely tourism and recreation potential, watershed value and importance for education and research) to derive an overall conservation value for each site. This was then 'traded off' against the socio-economic pressures impinging on the forest, which reduce the feasibility of long-term site protection. These pressures are scored on the basis of an evaluation of commercial forestry prospects, and the needs of local communities around the periphery of each forest, to derive a score for alternative use potential (details of which are provided in Howard, in prep.). Thus a final Nature Reserve Suitability score is derived for each forest as:

Nature Reserve Suitability = Conservation Value - Alternative Use Potential

Figure 3 shows the relative values of the scores derived in this way for the 64 forests that were evaluated.

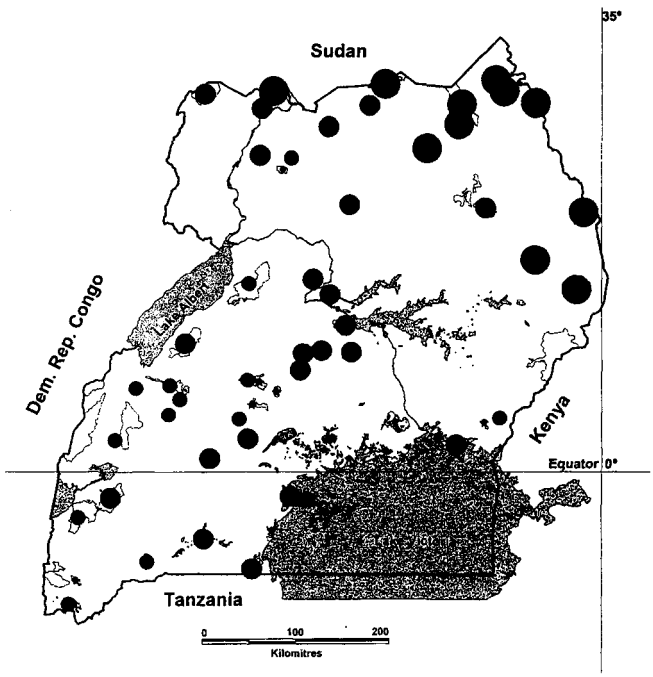


*Figure 3. Relative values for Nature Reserve Suitability of the forests surveyed. Symbol size is scaled according to the value of derived scores (see text for explanation). National parks are not considered for the calculation of the suitability scores as they already provide the highest degree of protection.*

*Step 3. Rank sites according to the complement of species contributed to a representative national network of protected areas.*
A complementarity table (Johnson, 1995) was derived for each of our five indicator taxa to rank forests according to the number of additional species they contribute to a network of sites, after taking into account species already represented in forests higher up the table. Such a table always starts with the most species-rich site, followed by the site that adds the greatest number of 'new' species, not known from the richest site. Initially the 64 forests were arranged in this way, based entirely on the representation of species at each site. Subsequent analyses, however, were designed to take into account the existence of national parks (already under protective management), and the socio-economic considerations incorporated into the Nature Reserve Suitability scores (STEP 2). Thus, an alternative complementarity table was derived by combining five subsets of sites, arranged sequentially and starting with the national parks subset at the top of the table. Next were added all steep mountain catchment forests (since these will inevitably be protected), followed by subsets of sites characterised by high, medium and low Nature Reserve Suitability scores.

*Step 4. Define the minimum critical set of sites necessary to protect all species*
In doing this, species represented in national parks were taken into consideration, so that only forests that make a unique contribution to the protected area system as a whole were included in the minimum critical set. Furthermore, species that are (or may be) of national, regional or global conservation concern were distinguished. Thus a minimum critical sites matrix was derived, listing each site and the number of species of each taxon that are unique to it (distinguished as 'conservation important' and 'less concern').

*Step 5. Define criteria and select key sites for the designation of major Nature Reserves*
Key sites were taken to be those which either:

- support a large proportion of unique species, found in no other Ugandan forest; more than 1% of species within any one taxon was used as the qualifying criterion; or
- contribute more than 1% of species of any taxon in the complementarity analysis after taking species represented in national parks and forests satisfying the 1% uniqueness criterion into account.

Within these key sites, the aim is to designate significantly more than the national average (as a proportion of area) as Nature Reserves.

*Step 6. Define criteria and select secondary sites for the designation of additional Nature Reserves*
Secondary sites were then added on the basis of three further criteria:

- adding at least 0.5% to the complement of species within any taxon;
- contributing at least one species considered to be of conservation concern on account of its limited range;
- contributing a vegetation type (based on Langdale-Brown *et al.*, 1964) not otherwise represented (or seriously under-represented) in the protected area system.

*Step 7. Examine potential for alternative/equivalent sites*
Cluster analysis (TWINSPAN) was used to compare forests on the basis of species lists for each taxon, and examine the potential for designating alternative Nature Reserves to those selected during STEP 5 and STEP 6. This was particularly valuable where a major Nature

Reserve was indicated that appeared incompatible with alternative demands on the land, or where the condition of the forest did not warrant Nature Reserve status. The results of cluster analysis were used to check that each major group of forests was represented in the proposed national system.

**Designation of nature reserves and other management zones within individual forests**

Now that the relative importance of different forests has been analysed and a suitable national network of sites selected for Nature Reserve establishment, appropriate management zones must be selected within each forest, mapped at 1:50,000, demarcated on the ground and managed appropriately. Where feasible a substantial undisturbed core area of each forest, covering the widest possible range of altitude, and variety of vegetation types is required as a Nature Reserve. An important consideration will be the location of natural features (such as streams, ridges) that can serve as clear internal boundaries between Nature Reserves and adjacent management zones. Where Nature Reserves are to be established for the benefit of particular species, the preferred habitat and breeding ranges of those species (where known) will be taken into account. Special consideration will be given to the needs of local people, and areas within 2 km of a forest boundary avoided, with a preference for areas at least 5 km from forest-adjacent communities.

## RESULTS

Nationally a network comprising 14 key sites and 20 secondary sites has been identified for designation of forest Nature Reserves to complement the existing national parks. Based on available information, at least 77% of species are represented in Uganda's national parks, and more than 95% are included with the addition of the 11 forests listed in table 1. The full network of protected areas (national parks and forest Nature Reserves) would protect more than 98% of species belonging to the five indicator taxa investigated under this programme.

*Table 1. Summary complementarity table listing forests which individually contribute at least 0.5% to the total No. of species represented in the national protected area network. Note that species represented in the country's national parks are considered to be protected and incorporated collectively in the top line of the table. Forests added below are not sorted for Nature Reserve Suitability (see text STEP 3 for explanation)*

| Reserve | % of species added | Cumulative % species represented |
|---|---|---|
| National parks (10) | 77.0 | 77.0 |
| Budongo | 6.1 | 83.1 |
| Otzi | 3.3 | 86.4 |
| Moroto | 2.6 | 89.0 |
| Mount Kei | 1.1 | 90.1 |
| Sesse Islands | 1.1 | 91.2 |
| Labwor Hills | 0.9 | 92.1 |
| Sango Bay | 0.7 | 92.3 |
| Kasyoha-Kitomi | 0.7 | 93.6 |
| Nyangea-Napore | 0.6 | 94.2 |
| Kalinzu-Maramagambo | 0.5 | 94.7 |
| Timu | 0.5 | 95.1 |

The Biodiversity Inventory Programme has produced a vast amount of information on Uganda's forests which has been presented as a series of 33 biodiversity reports (Howard & Davenport, 1996). Each report provides a summary of the data collected at one major forest, or a group of similar adjacent ones. The subsequent data analysis and national protected area systems planning exercise (outlined above) has only recently been completed, and the results are to be documented more fully in a Nature Conservation Masterplan, currently in preparation.

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