CHAPTER 14

BIOLOGICAL INVENTORY AND ITS APPLICATION IN FOREST NATURE CONSERVATION

CHAPTER OUTLINE

14.1 INTRODUCTION

The forest estate of any country, Uganda included, is not homogeneous. Different forests support different forest types and species; some are larger than others; some are surrounded by dense rural populations; some are near main roads or towns. If we decide that we would like to have a rational system of management that ensures that all that is of conservation value is protected, then how do we decide which parts of the forest estate to protect? It is generally unrealistic to try to protect everything, because conservation (like most forms of management) costs time and money and resources. So we have to be selective. In essence, we need to have a scientific or rational method of finding out which are the most important areas for conservation.

There are many criteria on which to base our assessment of which areas are most important for conservation. Box 14.1 lists some of the more commonly-used ones. These criteria beg another question, which is, how do we find out the information about each forest that we will need to make rational judgements about their value for conservation? Part of the answer is that we need some kind of **biological inventory**.

14.2 BIOLOGICAL INVENTORY

14.2.1 What is a biological inventory?

Most foresters are familiar with timber inventories. The primary aim of a timber inventory is to assess the distribution and value of timber trees, so that they can be exploited rationally. A thorough timber inventory will also assess the distribution of regeneration, in which case this information can be used to guide exploitation and silviculture many years ahead, usually through a working plan or management plan.

A biological inventory is in some ways similar to a timber inventory. It too is concerned with assessing the value and distribution of a resource so that its use and protection can be rationalised through the use of management plans. The main difference is in its scope: rather than limiting itself to timber species, the biological inventory seeks to assess the status of the whole biological resource of the forest.

14.2.2 The use of indicator groups

Obviously it is not feasible to inventory every species of plant and animal that lives in a forest: we have seen from Chapter 2 that there are just too many species, and we do not know anything about most of them. We need to choose certain groups of plants or animals, a sub-set of the total species pool, that can serve as **indicators** of the general ecological conditions of the forest. Box 14.1 lists some characteristics that have to be borne in mind when choosing indicator groups.

Box 14.1
Some of the more commonly-used criteria for assessing sites for their nature conservation value. Adapted from Margules and Usher (1991)

- **Species diversity**. A site with many species is likely to be more valuable than one with few species.
- **Ecosystem diversity**. A site with several ecosystems is likely to be more valuable than one with only one.
- **Naturalness**. A natural site is likely to be more valuable than a semi-natural or man-made site. By natural we mean unaffected by human activities. Note that few sites are truly natural these days.
- **Species rarity**. A site supporting rare species is likely to be more valuable than a site supporting only common species, because most common species can look after themselves and do not need special conservation measures, whereas rare species often cannot.
- **Ecosystem rarity**. A rare ecosystem is likely to be more valuable than a common one. This is partly because rare ecosystems will be more likely to support rare species, and partly because a rare ecosystem supports an unusual combination of species.
- **Area**. Island biogeography tells us that large sites are likely to be more valuable than small sites.
- **Threat of human disturbance**. Sites representing ecosystems or containing species that are widely threatened by human activities are likely to be more valuable than sites not so threatened, because unless such a site is protected then those ecosystems or species may disappear.
- **Amenity value**. Some sites have more appeal for humans than others, and these are likely to be more valuable than sites without such appeal, because conservation depends on the goodwill of people and can also benefit from revenue generated by visitors.
- **Educational value**. Sites than can be used for educational purposes, by nature of their accessibility or some other attribute, may in some circumstances be more valuable than sites that cannot be used in this way.
- **Representativeness and typicalness**. If we want to protect the full range of characteristic species and ecosystems of a given region, then we should look for representative sites that support a characteristic assemblage of species and ecosystems. The best of these, i.e. those that support the most characteristic species/ecosystems including rare ones, will be the best representatives of their type. Others may be typical but not exceptional. Both criteria are useful in determining conservation value of sites.
- **Scientific value**. This embraces both the intrinsic scientific value of a site, determined by the species and ecosystems present, as well as the opportunities the site offers for scientific study. Well-studied sites can tell us much about ecology and conservation.
- **Uniqueness**. A site may be unique in that it is the only one that supports a certain species, range of species or ecosystems. This uniqueness has conservation value, especially if the species or ecosystems it supports are themselves of particular conservation value.
- **Replaceability**. Fragile ecosystems are easily damaged and cannot easily recover from damage. Their conservation is therefore more important than that of more robust ecosystems. By the same token, climax communities are more valuable than communities at earlier stages of a succession.
- **Management considerations**. This criterion can be used to identify one site from a list of sites which are otherwise equally valuable. A site which is more easily policed or protected is worth conserving more than one where protection is likely to fail.

- **The ease with which the species in the group can be collected**. For example, choosing canopy-dwelling beetles would not be very fruitful because one would not be able to sample them effectively from ground-level.
- **The ease with which the species in the group can be identified**. For example, choosing forest mosses would not be very fruitful because there are no easy ways to identify them: no guide-books, and few experts qualified in their identification.
- **The ease with which the species in the group can be stored for later identification or reference**. For example, choosing forest slugs would necessitate carrying numerous fragile collecting-tubes of expensive preserving fluid to the field, and frequent curation of the collection back in the office or laboratory.
- **The degree to which the ecology of the species in the group is already understood**. For example, choosing forest earthworms would not be very fruitful because, even if the

species could be identified and stored, there are few if any experts who could say what the presence or absence of a particular species of earthworm meant in ecological terms.

- **The degree to which the distribution of the species in the group is already understood.** For example, choosing forest leaf-beetles would not be very fruitful because, even if the species could be identified, there are few if any experts around who could say whether a given species was widespread or endemic to a particular area, and whether it was common or internationally rare.

This is why the Uganda Forest Department chose five relatively well-known groups as indicators. These are woody plants, birds, small mammals, butterflies and two families of moths (Saturniidae and Sphingidae). Together they represent quite a wide range of taxonomic groups, and, it is hoped, ecological diversity.

14.2.3 Inventory procedures for the different indicator groups: a case study from Uganda

The biological inventory programme that has been carried out by the Uganda Forest Department has involved surveys of all 54 forest reserves exceeding 5000 ha in extent, plus 8 smaller reserves selected to represent vegetation types that do not occur in the larger reserves. Thus the programme has covered 62 forests, which together account for 75% of the total area of the forest estate (Howard and Viskanic, 1994). Other, smaller, forests were not covered, partly because of the costs of doing so and partly because smaller forests are less likely to be so valuable for nature conservation compared to other values (see Section 12.3).

In carrying out the field programme, the aim has been to list as many as possible of the species present in each forest. As far as possible, a standard amount of sampling effort is made in each forest, corresponding to roughly six weeks per forest, by a team of five trained Forest Department inventorists. Four such teams covered all the targeted reserves between 1993 and 1995.

14.2.31 Woody plant inventory

Field sampling at each site was aimed at providing coverage equivalent to at least one day per 20 km^2, so as to list the majority of woody plant species present in each forest. The field team comprised two experienced botanists, who used existing access routes (roads, paths) to visit as many parts of each forest as possible, recording and collecting as they went. In principle, they tried to visit the highest and lowest point of each forest; all distinct vegetation types (distinguished on 1:50,000 topographic maps and/or aerial photographs); all geologically distinct areas; and sites covering all aspects. The route taken each day is recorded, and the relative abundance of each species encountered during the day is recorded on a checklist. Two voucher specimens and a full description of each species is taken from each forest for verification by herbarium staff. The field records thus provide a list of woody plants from each reserve, and enable "species accumulation rates" to be monitored throughout the sampling period, to give an indication of the completeness of the data.

14.2.32 Bird inventory

Field sampling for birds involved two main methods for each area of forest. The first was to walk through the forest, listening for the distinctive calls made by different species of birds, and looking for birds with the use of binoculars. Skilled observers can identify most species this way. The second method, involving the use of **mist-nets**, was useful for confirming identifications based on the first method, and also revealed the presence of further, more secretive species. Mist-nets consist of fine nylon mesh formed into nets 12 m long and about 3 m high. When erected in the forest, between poles set along cleared lines through the undergrowth, they appear almost invisible to birds. Most birds that fly into them become entangled in the net, and can be examined at close quarters before being released. If there is any doubt about the specimen's identification, it can be killed by wringing its neck, and the skin retained for examination by other experts. Sampling intensity is expressed in terms of "metre-net-hours", based on the total length of net set and the number of hours left open.

14.2.33 Small mammal inventory

Field sampling for small mammals involved the use of various **traps**, set in different forest types, mostly at ground-level but also amongst branches. They are particularly effective when set in the evening and left overnight; they also work best along natural barriers such as stream-banks, where small mammals often congregate. Artificial barriers, such as wire or netting, can also be used to funnel small mammals towards the traps. The main traps used were **break-back traps**, **pitfall traps** and **Sherman traps**. The former are the familiar model used domestically to catch and kill rats and mice in the house.

Pitfall traps consist of small containers (such as old margarine tins) dug into the soil so that their open top is level with the soil surface; inquisitive small mammals often simply fall into them, sometimes even if the trap has no bait. Sherman traps consist of collapsible aluminium boxes open at one end, and baited with strong-smelling food such as ground-nut sauce or fish. When a small mammal enters the box, its weight on the foot-plate releases a flap that closes the entrance, entrapping it live within. With both sorts of live trap, the small mammals can either be identified live and then released, or killed and preserved in preserving fluid or as skins for later identification by other experts.

14.2.34 Butterfly inventory

Field sampling for butterflies involves two methods. The first is with the use of a hand-held **net**, which enables particular butterflies to be collected as the collector walks along a path or through the forest undergrowth. These can either be identified live or killed by squeezing the thorax between thumb and forefinger, put into individually labelled envelopes, and stored for later identification by experts. The second method involves **baited traps**, suspended from branches along forest paths and in clearings and gaps. These are cylindrical structures made of fine netting, with a base of stronger material on which is laid the bait of rotten fruit or fish. Gaps in the netting just above the base enable butterflies to enter, but when they fly upwards at the end of their meal they end up congregating at the closed top of the trap with no exit. The collector can remove them one by one, and either release them live or kill them for later identification.

14.2.35 Moth inventory

Field sampling was carried out with a **light trap** operated each night near to the inventory team's camp. A light trap is basically an aluminium box housing a powerful mercury-vapour lamp powered by a generator. The top of the box comprises clear Perspex grating pointing downwards towards the light. Moths (and other nocturnal insects) are attracted to the light within from a distance of many hundreds of metres; they find their way through the grating and take refuge amongst pieces of cardboard box laid out on the floor of the box. By the morning, a light trap may contain hundreds of insects, including many moths of the two families chosen as indicators. All specimens of these two families were collected, killed by gently squeezing the thorax between thumb and forefinger, and retained for later examination and identification by specialists. In the field, they were stored in individually labelled envelopes.

14.3 RANKING SITES ACCORDING TO THEIR NATURE CONSERVATION VALUE

14.3.1 The ranking process

If a biological inventory is to be put to maximum use, it must be carefully planned to fit in with overall objectives. In the case of the Uganda Forest Department, the objective has been to ensure that the forest biodiversity is adequately protected while at the same time avoiding conflict with other legitimate land-uses as much as possible. We therefore need to know which forests are most important for nature conservation, so that we can devote more resources to important forests.

"Phase One" of the nature reserve planning programme within the Uganda Forest Department has involved a process through which each forest is scored for its importance for biological conservation (and other factors) and decisions taken on how much of each forest should be designated as nature reserve. Box 14.2 outlines the procedure once the inventory is complete.

14.3.2 Ranking forests on the basis of how many species are recorded

Table 14.1 is a **provisional** ranking of the 42 forests that make up the minimum critical set of sites needed to protect all of the 739 species of woody plants recorded during the inventory. Note that it is not the final version. Nevertheless, it is clear that some forests are far more important than others for the conservation of woody plants. The "best" forests, such as Budongo, support many unique species, and therefore their conservation is a priority because if they were allowed to disappear then those unique species would effectively become extinct in Uganda's forest estate. However, this ranking does not take account of sampling *intensity*: Budongo Forest is undoubtedly species-rich, but maybe the inventory teams spent more time there or were able to collect more samples because of the ease of access. Until such factors are taken into account (which they can be using information on species accumulation rates), we should not conclude too much from this table.

Box 14.2
Phase One of the nature reserve planning programme within the Uganda Forest Department (Howard and Viskanic, 1994)

1. **Derive biodiversity importance scores**. For each forest, and each indicator group, an **importance score** for species conservation has been calculated, which takes into account both the number of species recorded, and the level of endemism/rarity. The highest scoring forests are those with most species and the greatest representation of species not found elsewhere.

2. **Adjust scores according to sampling intensity**. Since no species list is likely to be complete, and the sampling intensity has varied between forests, the biodiversity importance scores have to be adjusted so that they reflect an estimate of the total list for any given forest or indicator group. These adjustments are based on observed species accumulation rates over the period of sampling.

3. **Combine adjusted scores for all indicator groups to derive overall biodiversity importance score for each forest**. This overall score can then be used to guide decisions on the amount of each forest to be designated as nature reserve.

4. **Examine complementarity between sites**. To protect as many species as possible in the most efficient way, nature reserves need to be established in forests which are as biologically different from one another as possible. This complementarity between forests has been examined by firstly ranking them according to the number of species each can contribute to the protected total, and then sorting them into groups of similar forests through computer analysis (TWINSPAN), to examine their relatedness.

5. **Define a minimum critical set of sites**. In order to protect as many species as possible, it has been necessary to define a minimum critical set of sites that would be necessary to ensure that every species is represented at least once. This minimum set includes all forests which support unique species, together with other sites selected to include any other species not already represented in the network.

6. **Decide on the area of each forest to be designated as nature reserve**. This has been done by combining a variety of scores assigned to each forest, quantifying attributes contributing to its suitability for nature conservation. These attributes include biodiversity importance scores, as well as hydrological functions, timber values, local community needs, management requirements and so on. By combining scores for these various attributes into composite "suitability scores for nature reserve establishment", quantitative values for each forest are derived, which can be used in apportioning the areas of each forest to be designated as nature reserves.

Furthermore, the table refers only to woody plants, and does not take account of the other indicator groups that were also inventoried. It is likely that the "best" forests for woody plants will also be the best for other indicator groups, but it is not a foregone conclusion, and a composite ranking based on all indicator groups would give us a better picture.

14.3.3 Examining complementarity between forests

If we have limited resources then we want to make sure we protect a **representative** range of forest types. Just protecting the most species-rich forests may miss some interesting but species-poor types. Figure 14.1 is the result of a TWINSPAN computer analysis of the provisional inventory data for saturniid moths. It allows us to compare forests on the basis of overall similarities or differences in species composition. It is clear that the saturniid moth fauna of Bwindi is very similar to that of Echuya, and fairly similar to Mafuga. If we only have limited resources for conservation, we might want to pick the "best" from this group to ensure that most species representative of this type of forest are protected. On the other hand, these three forests are all very different, in terms of their saturniid moth faunas, from Kazooba, Nsowe and Zoka, so we should also seek to protect at least one of this latter group as well since they form a distinct forest type, even if it transpires that they are relatively species-poor. Note that this discussion refers only to saturniid moths: we may get a slightly different picture if we used data on all the inventoried groups.

Table 14.1.
Provisional ranking of forests which make up the minimum critical set of sites needed to protect all 739 species of woody plants recorded by the Uganda Forest Department inventory teams, 1992-1994 (Howard and Viskanic, 1994)

Rank	Forest	No. spp. collected	No. spp. unique	No. spp. added	Cumulative no. spp.
1	Budongo	277	7	277	277
2	Mount Moroto	182	7	112	389
3	Kasyoha-Kitomi	220	4	83	472
4	Otze	188	6	49	521
5	Mount Rwenzori	116	9	29	550
6	Sango Bay	188	3	25	575
7	Labwor Hills	200	4	23	598
8	Mount Kei	179	5	16	614
9	Mount Elgon	186	6	15	629
10	Mpigi	206	0	12	641
11	Nyangea-Napore	201	6	9	650
12	Kalinzu-Maramagambo	236	2	8	658
13	Mikanebolola	66	1	7	665
14	Morogole	115	5	6	671
15	Semliki	181	3	6	677
16	Bwindi	152	5	5	682
17	Kasagala	103	2	5	687
18	Timu	117	3	4	691
19	Echuya	66	2	4	695
20	Kibale	220	3	3	698
20	Jubya	122	3	3	701
20	Era	144	3	3	704
21	South Busoga	135	2	3	707
21	Kasana Kasambya	103	2	3	710
21	Mafuga	73	2	3	713
22	Bugoma	227	2	3	716
22	Maruzi	74	2	3	719
23	Mount Kadam	198	2	2	721
23	Rom	127	2	2	723
23	Itwara	223	2	2	725
24	Kagambe	196	1	2	727
24	Aswa	43	1	2	729
25	Agoro-Agu	172	1	1	730
25	Napak	149	1	1	731
25	Namwasa	108	1	1	732
25	Kibeka	44	1	1	733
25	Rwoho	92	1	1	734
25	Matiri	99	1	1	735
25	Ogili	117	1	1	736
25	Opit	62	1	1	737
25	Mpanga	173	1	1	738
26	Kazooba	78	0	1	739

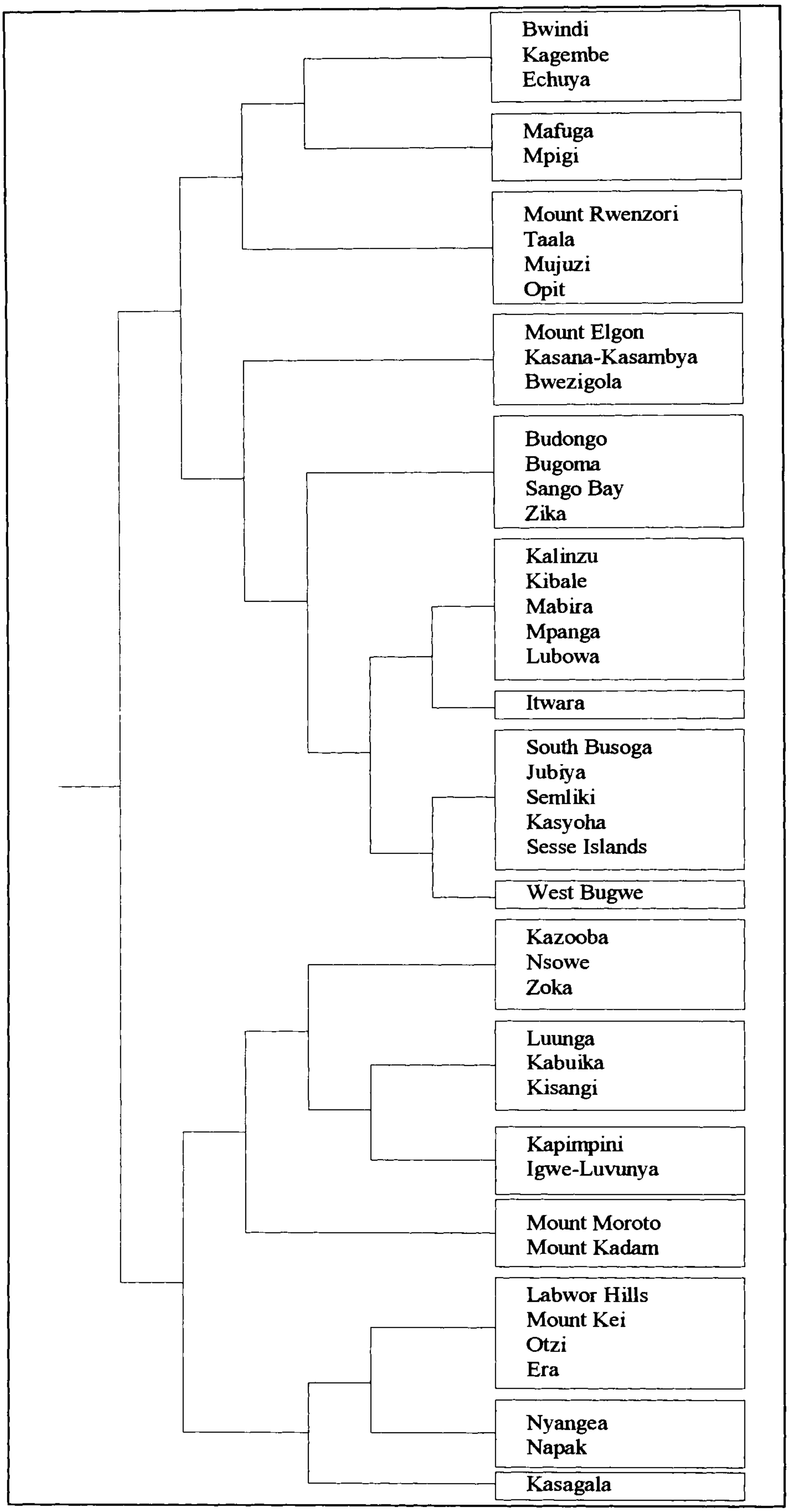

Figure 14.1. Results of a TWINSPAN computer analysis showing the relationship between Ugandan forests based on consideration of their known saturniid moth faunas. Redrawn from Howard and Viskanic (1994).

14.4 SUMMARY

The Uganda Forest Department's biological inventory and nature reserve planning process has been widely acclaimed internationally, and it is likely that other countries will seek to follow Uganda's example. Although the process takes a lot of time, money and resources, it is a very rational method that enables nature conservation objectives to be met with minimum conflict with other legitimate land-use objectives.

The inventory and subsequent planning process involves several stages, which can be summarised as follows:

- Defining indicator groups;
- Carrying out the inventory;
- Ranking the forests according to species-richness;
- Grouping the forests on the basis of similarity of species composition;
- Using the limited resources available to protect as many of the most species-rich forests as possible including as many species overall as possible while at the same time representing as wide a range of forest types as possible.

14.5 FURTHER READING

Howard, P.C. and Viskanic, P. 1994. *Biodiversity assessment for the planning of Forest Nature Reserves in Uganda.* Paper presented at IUFRO Forest Biodiversity Symposium on Measuring and Monitoring Biodiversity in Tropical and Temperate Forests, Chiang Mai, Thailand, 28th August - 2nd September 1994.

Pomeroy, D. 1989. *The making of inventories: an introductory survey of methods for trees and shrubs, mammals and birds.* 36 pp. Makerere University, Kampala.

Springall, H. (ed.). 1994. *Proceedings of workshop on nature conservation for senior forest officers, 19th-23rd September 1994.* Forest Department, Kampala.