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A simple system for monitoring biodiversity in protected areas of a developing country

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Abstract. The achievements of initiatives to strengthen biodiversity conservation in developing countries may be difficult to assess, since most countries have no system for monitoring biodiversity. This paper describes a simple and cost-effective, field-based biodiversity monitoring system developed specifically for areas where 'specialist staff' is lacking. We discuss the preliminary lessons learned from protected areas in the Philippines. Whilst the monitoring system aims to identify trends in biodiversity and its uses so as to guide management action, it also promotes the participation of local people in the management, stimulates discussions about conservation amongst stakeholders and builds the capacity of park staff and communities in management skills. In addition, it seeks to provide people with direction regarding the aims of protected areas, and reinforces the consolidation of existing livelihoods through strengthening community-based resource management systems. The field methods are: (1) standardised recording of routine observations, (2) fixed point photographing, (3) line transect survey, and (4) focus group discussion. Both bio-physical and socio-economic data are used and given equal importance. The system can be sustained using locally available resources. The approach is useful in countries embarking on shared management of park resources with local communities, where rural people depend on use of natural ecosystems, and where the economic resources for park management are limited. We hope this paper will encourage other countries to develop their own biodiversity monitoring system, letting its development become a means for capacity building whilst at the same time supporting the creation of ownership.

Key words: biodiversity, developing country, monitoring, participation, protected area

Introduction

Attempts to curb degradation of natural ecosystems world-wide have increasingly focused on the establishment of protected areas (e.g. Groombridge 1992), and these now cover 6.4% of the world's land area (WRI et al. 1998). The achievements of protected area management may be difficult to assess, since in most developing countries there is at present no established system for monitoring trends in biodiversity.

Countries contracting to the Convention on Biological Diversity are obliged to monitor biodiversity (Article 7.b), and donor countries increasingly demand account-

ability and quantifiable achievements in return for their assistance. The development of biodiversity monitoring systems now attracts a significant proportion of the international funding for biodiversity conservation. The Global Environment Facility, for example presently the single largest funding source for biodiversity conservation in developing countries (Wells 1998) – requires the majority of the conservation projects it finances to include biodiversity monitoring, although what this means in practice remains to be seen.

The Protected Area and Wildlife Bureau (PAWB) of the Department of Environment and Natural Resources (DENR) in the Philippines takes part in such international efforts (DENR and UNEP 1997; PAWB-DENR 1998) and, in addition, has legal requirements for monitoring stipulated in the NIPAS Act (DENR 1992).

Basic assumptions for quantitative recording of biodiversity have been described in the literature (e.g., Bibby et al. 1992; Wilson et al. 1996; Dallmeier and Comiskey 1998; Margules et al. 1998; Thompson et al. 1998). The broader concepts of biodiversity monitoring have also been outlined (e.g., Noss 1990; Brown and Wyckoff-Baird 1992; World Bank 1992; Harmon 1994; Kremen et al. 1994; Wangwacharakul et al. 1996). However, few suggestions have been made as to how these may be meaningfully translated into a developing country context (e.g., Fuller 1998; Kremen et al. 1998; Margoluis and Salafsky 1998; World Bank 1998; Hellier et al. 1999), given the inherent tensions between standardisation of data, facility of collection and ease of analysis (IBAMA 1998). Initial efforts have tended to follow the standards used in developed countries, probably because Western assistance has been involved. Compared with the West, developing countries have very limited human capacity and financial resources available. Furthermore, most protected areas in developing countries serve to meet the daily subsistence requirements of millions of rural poor (see e.g. Saberwal and Kothari 1996). It is therefore unlikely that Western-monitoring systems are suited to developing countries.

Most monitoring systems in tropical forests include the establishment of permanent vegetation plots where all plants above a certain size are identified to species and measured, for instance every 5 years. Such monitoring can generate data for rigorous hypothesis testing and provide important scientific evidence. However, since the frequency of data collection is low and limited data is collected on the use of resources, such exercise rarely provides any input to management. For conservation purposes protected areas in developing countries need monitoring that is realistic and at the same time useful for guidance rather than what is ideally required for in depth studies of how community structure and species richness are affected by different environmental changes.

In this paper we describe and discuss a simple and cost-effective biodiversity monitoring system for protected areas, which:

1. requires a minimum of training and education on the part of park staff,
2. requires little equipment and financial resources,
3. seeks to encourage participation of local communities in park management, and

4. strengthens existing local systems for monitoring and managing natural resources.

The ability of this monitoring system to detect trends in abundance of species and resource uses (i.e. to distinguish a situation different from the null hypothesis) could be strengthened by using more standardised methods e.g. territory mapping of birds (Bibby et al. 1992), arthropod protocols (Coddington et al. 1991) and permanent forest inventory plots (Alder and Synnott 1992). However, while more standardised methods can be valuable tools, their usefulness will in practice be constrained by:

1. the shortage of trained field scientists, support staff, and facilities,
2. the small proportion of taxa described and sufficiently known to make them useful in applied programs, and
3. the lack of identification manuals for most tropical species groups.

The aim of this monitoring system is to ensure better management and the involvement of local people rather than data-based falsification of scientific hypotheses concerning variation in biodiversity values. By allowing park staff to carry out the field assessments, this monitoring encourages them into the field and improves their capacity for park management.

The monitoring system was developed for use in protected areas of the Philippines. It was designed and tested in three protected areas and the Government is now embarking on large-scale implementation of the system in all the country's protected areas (G. Caleda *in litt*. 1998). We hope this paper will help and encourage others to proceed with similar efforts elsewhere.

We define 'monitoring' as data sampling which is repeated at certain intervals of time for management purposes. We distinguish this from surveys by emphasising repeated and replicable measurements over an extended time frame and by focusing on rates and magnitudes of change (modified from the World Bank 1992).

In developing countries in particular, most protected area management decisions are taken at a local level (e.g. Groombridge and Jenkins 1996), and the system thus focuses on monitoring at the level of the single protected area (or management unit).

Methods

Development of this monitoring system was carried out over a 3-year period, from 1996 to 1998, alongside building capacity among protected area staff and local decision-makers in protected area management, undertaking inventories of the biodiversity and its use, providing management information input, and raising awareness about conservation amongst local communities and decision-makers in three protected areas. Our team comprised Filipino professionals with expertise in ecology, field biology, socio-economy and training, a Danish ecologist and a Danish rural sociologist. The Filipino staff input, in terms of person-months, was 5–6 times as

high as the external staff input. The team was trained in protected area management and integrating conservation with local development.

We searched the literature for monitoring techniques based on conventional methods and then studied current natural resource and protected area management practices at field level in the three protected areas. Protected area staff and non-governmental organisations working with community development in the areas participated in the surveys. Survey findings were subject to interdisciplinary discussions within the survey team in the field or immediately after the surveys; this was time-consuming but generated awareness about methodological problems that had to be solved. It also meant that the conclusions were acceptable to a broader range of people and it encouraged ownership of the monitoring system. Survey findings were brought back to the communities and protected area field staff in order to validate results and involve local stakeholders in the process. The survey helped us identify priority species, resource uses and management interventions, and to adapt the monitoring system to the real situation in the field.

Based on the literature and the field survey, a theoretical framework for monitoring biodiversity was drafted and discussed at a national workshop (University of the Philippines, Los Baños, April 1997; Pollisco et al. 1997). This was attended by managers and scientists from the Philippines and abroad. We tested possible field methods, discussed them with field staff, developed a training package and identification guides for priority species and carried out one-week training courses for protected area staff in the forest and in the protected area villages where the staff would be working. Field methods and data interpretation were discussed in a workshop with senior staff of the Protected Areas and Wildlife Bureau of DENR (May 1998), and a manual was prepared (Nordeco and DENR 1998a). Regular visits were subsequently made to the sites to assist and supervise park staff in field implementation.

Study areas

The monitoring system was developed on the basis of fieldwork in three Natural Parks: Northern Sierra Madre, Bataan, and Mt. Kitanglad Range (Figure 1). These are covered by the Conservation of Priority Protected Areas Project (CPPAP), which supports the construction of park infrastructure, development of management plans, mapping, boundary delineation and demarcation, advocacy, community consultation and training, and non-degrading livelihood projects in buffer and multiple use zones.

Northern Sierra Madre Natural Park is in Isabela Province, north-eastern Luzon. With 359,486 ha, it is the largest protected area in the country. It has 36 park staff. The Park comprises the largest area of lowland forest remaining in the Philippines and is one of the few areas with a natural transition between coastal and terrestrial ecosystems. The Sierra Madre mountain range is the main water catchment area in eastern Luzon, which is one of the country's most important rice-producing areas.

During the El Niño of 1997, the Sierra Madre was the only part of the country that did not suffer from water supply deficit. A total of 70 wildlife species regarded as globally threatened or near-threatened by IUCN (1996) are known within the Park,

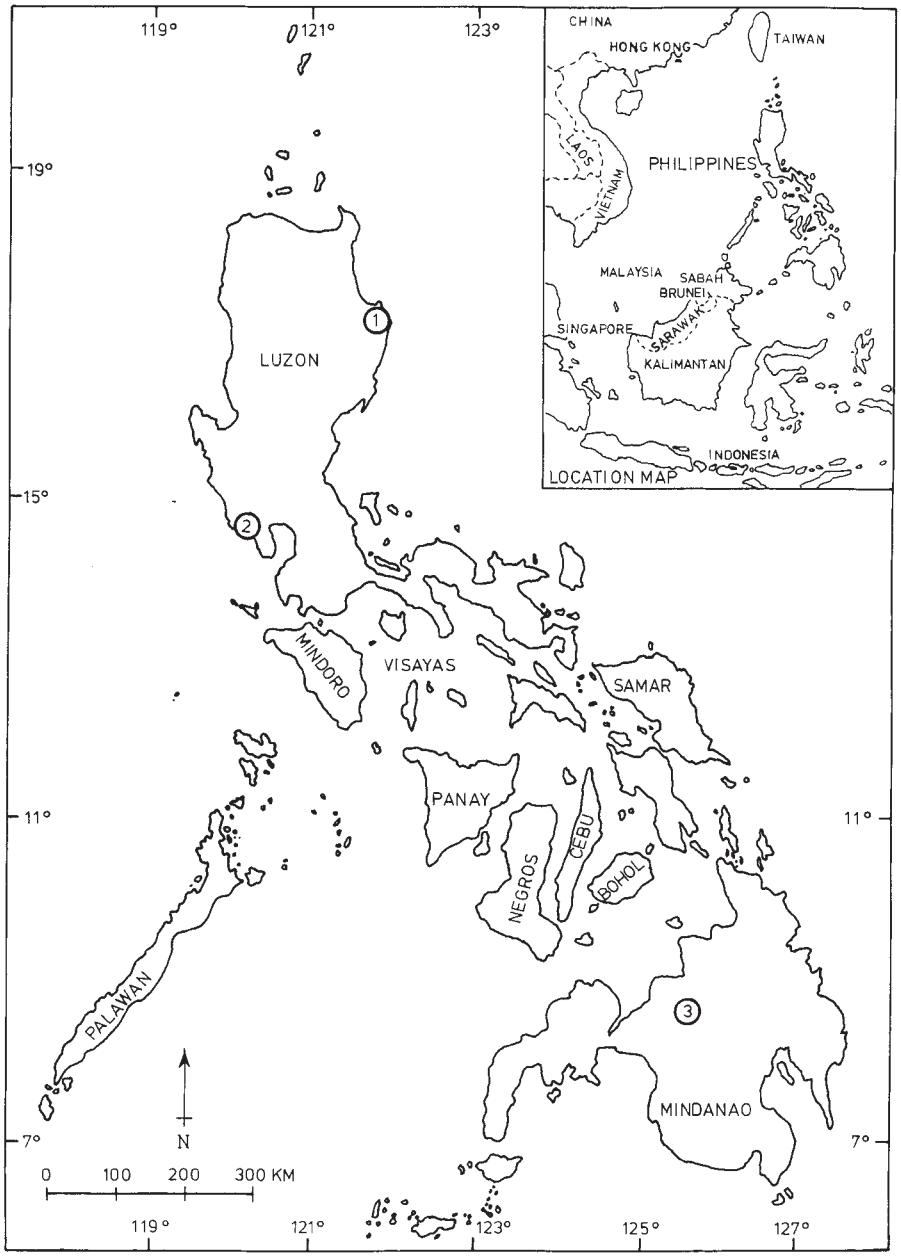

Figure 1. Location of Northern Sierra Madre Natural Park (1), Bataan Natural Park (2), and Mt. Kitanglad Range Natural Park (3) in the Philippines.

including the Golden-crowned Flying Fox *Acerodon jubatus*, Dugong *Dugong dugon*, Philippine Eagle *Pithecophaga jefferyi* and Estuarine Crocodile *Crocodylus porosus*. A total of 1000 indigenous Agtas and 31,500 migrants residing adjacent to or within the Park heavily depend on the forest and coastal resources. The human activities with most negative impact on the conservation values of the Park are logging (both large and small-scale), swiddening, agricultural development, and forest clearing for land speculation (Nordeco and DENR 1998b).

Bataan Natural Park is located in Bataan Province in western Luzon. It covers 23,668 ha and has 30 park staff. A total of 25 wildlife species regarded as globally threatened or near-threatened by IUCN (1996) are known within the park. A total of 300 indigenous people and 3000 migrants reside in the Park. The indigenous people depend on the forest as a source of food and medicine, whilst other residents largely use the forest for cultivation, extraction of bamboo and timber, and fishing. Human activities severely impacting on the Park are: construction of roads, buildings and factories, and large-scale plantations of coffee, mangoes and other tree crops (Nordeco and DENR 1998c).

Mt. Kitanglad Range Natural Park is located in Bukidnon Province in northern Mindanao. It covers 40,176 ha and has 24 park staff. The Park protects the major part of the remaining forest in the Province and comprises one of the largest areas of montane forest in the country. It is one of the main water catchment areas in northern Mindanao. A total of 45 wildlife species regarded as globally threatened or near-threatened by IUCN (1996) have been recorded in the Park, including the Philippine Eagle *Pithecophaga jefferyi* and a mammal only known in this area, the Mindanao Pygmy Fruit Bat *Alionycteris paucidentata*. A total of 34,000 indigenous people and 9000 migrants reside in or adjacent to the Park. The indigenous people and households close to the forest heavily depend on the forest as a source of food and medicine. They use more than 500 species of flora and fauna. The human activities with the most severe impact on the Park are the establishment of commercial crop plantations and large farms, swiddening and small-scale logging (Nordeco and DENR 1998d).

Theoretical framework for monitoring biodiversity in Philippine protected areas

Questions the monitoring is intended to answer

The ultimate objective of the Philippine protected areas is “to secure for the Filipino people [..] the perpetual existence of all native plants and animals” (NIPAS Act; DENR 1992). Guided by this long-term objective, monitoring is intended to answer the following questions in each protected area:

- Are habitats and ecosystems being degraded?
- Are the populations of threatened species of plants and animals declining?

- What are the causes?
- Has management intervention had the intended impact on the ecosystem?
- Are there increased benefits to local people from sustainable natural resource use?

In other words, monitoring should answer the question: are the management interventions in the area effective in addressing biodiversity conservation?

Existing monitoring activities

Many protected area communities in the Philippines, especially indigenous people, still implement some form of traditional system for controlling access to resources. These people have lived in a particular area for generations and have intimate knowledge of the habitats and behaviour of wildlife species. Observing events in nature influences their survival strategies and resource use. Traditional systems for controlling access to resources are used in all three Natural Parks concerned. Community leaders and people regularly discuss the availability and quality of natural resources. One such example is the Talaandigs and Higaonon in Mt. Kitanglad Range Natural Park who perform rituals for hunting and forbid resource extraction in some places which are called *lalaw* (Nordeco and DENR 1998d). In this way, they control and monitor access to certain areas and the use of resources. Merely by living in the areas, using the resources and observing their environment, they monitor changes in the resources. The biodiversity monitoring system was designed to build upon and strengthen existing community-based monitoring.

The central Department of Environment and Natural Resources (DENR) regularly monitors forest cover, trade in endangered species, etc., but most of this data compilation is undertaken on a country-wide or regional basis, and is therefore of limited use for local protected area management. Further monitoring activity is undertaken by local DENR staff who regularly visit the field where, for example, they assess the size of extracted timber.

Available human capacity and financial resources

The availability of human capacity and financial resources has an important bearing on a monitoring system. In each protected area covered by the Conservation of Priority Protected Areas Project (CPPAP), the following people typically work with protected area management: staff of the Protected Area Superintendent (PASu) 8–10 people, staff of the Host NGO (HNGO) 8–15 people and local forest guards up to ca. 25 people. The forest guards can be '*Datu*'s or other members of the indigenous communities, and they may be selected by the local people. There is a high turnover among PASu staff (personal observation). In some protected areas, each PASu employee is responsible for one particular geographical area, for instance two to four valleys.

On the CPPAP sites, the PASu staff have B.Sc.'s in forestry or an associated field, and they receive training in different aspects of protected area management. Since in the past, protected area management activities have mainly focused on enforcing regulations, there is limited capacity for creating a dialogue with local communities. Local people perceive PASu staff as law enforcers and they are sometimes unwilling to share information.

One HNGO employee is assigned to the same area such that in any one part of the protected area one PASu and one HNGO are responsible for Government and NGO activities respectively. The HNGO staff generally have a background in community organising or forestry. While most of the local forest guards have no formal education, some have attended primary or even secondary school. They have not received any systematic training in protected area management. Given the size of most protected areas and the high number of people living there, the workload for the protected area staff is enormous. They have very limited time available for monitoring work, and this is not likely to change.

The financial resources available for monitoring are limited. For CPPAP sites, there are some funds set aside for this purpose but beyond that project the only funding sources are the endowment fund for each protected area (the Integrated Protected Area Fund, IPAF), and the Government of the Philippines. The local IPAF is expected to provide funds for alternative livelihood activities in the buffer zone, whilst it is hoped that the Government will continue to fund basic protected area staffing and transport costs etc. Biodiversity monitoring has to 'compete' for funds with other highly needed activities.

For a monitoring system to be sustained it needs to be based on locally available personnel and resources. Satellite imagery, aerial surveillance and in-depth sociological and biological inventories can generate very useful data for protected area management. These methods, however, rely on personnel and equipment, such as computer technology, which is not available at the level of the local protected area. Given the limited availability of funding for biodiversity, it was thus important to choose simple monitoring procedures. The monitoring nevertheless had to be able to provide tangible results that could be used – even in the short-term – for improving protected area management. Otherwise protected area staff would not be likely to continue the data compilation.

Management levels in protected areas

Given the constraints in the human capacity and financial resources available for protected area management, we envisaged that the management level in most protected areas would remain rather limited: only the most important management interventions would be undertaken. The biodiversity monitoring system was designed to focus on addressing priority issues and providing input to protected area manage-

ment that would be of a sufficiently general nature to lead to actions which could be implemented.

Indicators

An 'indicator for biodiversity' can be defined as a parameter which describes the state of biodiversity in an area. Indicators serve three main functions: (1) they measure complex phenomena, but (2) in a simplified way, by reducing the numbers of measurements normally required to make an exact presentation of a situation, (3) thereby promoting communication about complex relationships (Hammond et al. 1995).

Biodiversity indicators for protected areas should ideally highlight, as unambiguously as possible, emerging problems in biodiversity conservation and draw attention to the effectiveness of management policies and actions (Hammond et al. 1995; a review of indicators for ecosystem health is provided by Vora 1997). Relevant criteria regarding the usefulness and practicality of indicators for biodiversity in Philippine protected areas are (modified from Noss 1990; Weber 1990; Wangwacharakul et al. 1996) those which:

- are easy and cost-effective to collect, analyse and report;
- are meaningful to local people;
- point as directly as possible to changes in biodiversity and resource use;
- are suited for providing a continuous assessment over a wide range of stress;
- are able to differentiate between natural cycles or trends (weather, climate, etc.) and those induced by anthropogenic stress;
- are relatively independent of sample size;
- are sufficiently sensitive to provide an early warning of change;
- are applicable over the range of ecosystems in the Philippines.

Since no single indicator possessed all of these desirable properties, a (small) set of complementary indicators was required.

We found it most relevant to concentrate on indicators at ecosystem/habitat/community level, at species/population level, and at what we called 'use of ecosystem/species' level. Based on workshop discussions, we selected four indicators:

1. Changes in number of sightings of designated species and local resource uses;
2. Changes in size of vegetation type blocks and in land-use of priority areas;
3. Changes in frequency of detection of specified signs of presence of designated fauna species and local resource uses along established transects;
4. Changes in perceived harvest volume per effort and in number of people engaged in specific biodiversity impacting activities within a given time period.

For each of these indicators, we assessed possible use for management decisions, habitat coverage, proposed field method, type of data set, proposed compilers, equipment needs, frequency of data collection, data storage, and general pros and cons (Table 1). The indicators were intended to focus on trends (or changes in status) in biodiversity and resources rather than changes in absolute figures.

Approach and methods

The objective of the Philippine biodiversity monitoring system is to improve the information available for decision-makers in protected areas through the regular collecting of data on natural biological resources and their utilization. The focus is on identifying trends in important biodiversity assets of an area and the use of the area's biodiversity in order to guide action in park management. In addition, the system is intended to improve the participation of protected area communities in park management.

Who undertakes biodiversity monitoring?

The monitoring system is for use by protected area staff, local forest guards, local environmental groups and others from the local communities. It is designed so that anyone interested in gathering information on changes in the environment can use it. Since people living in or adjacent to protected areas represent important sources of information it is an advantage when the protected area staff responsible for biodiversity monitoring are different to those involved in enforcement in order to encourage open discussion with local people.

How are the data used?

The information gathered is analysed by the Head of the Protected Area Office. The results are used by the Protected Area Management Board to take better decisions on the management of the land and people in the protected areas. Sometimes the information alerts the Head of the Protected Area Office to situations which should be examined further. The information is also used by the people living in or adjacent to the protected area to improve local resource management.

Which species and resource uses are monitored?

During the development of the monitoring system it was on several occasions suggested that all plant and animal species living within the protected areas should be monitored or that some indicator groups would be used which would represent the total biodiversity well. Biodiversity in a Philippine protected area encompasses thousands of life-forms, many of them not even named and described. It would be impossible to monitor all of these and there is no *a priori* way of assessing how specific well-known groups such as birds or larger mammals will reflect the total biodiversity. We do not even know what a species richness estimate will tell us as forest disturbance often leads to an increase in species richness even though forest specialists decline. The biodiversity of a Philippine park will probably remain virtually the same provided no large-scale habitat changes take place. If habitat changes do take place

Table 1. Four indicators for monitoring biodiversity and resource use in Philippine protected areas.

	Indicator 1	Indicator 2	Indicator 3	Indicator 4
Indicator	Changes in number of sightings (or 2nd hand records provided by local people) of designated species and local resource uses (species and use of ecosystem/ species level).	Changes in size of vegetation type blocks and in land-use of priority areas (ecosystem/habitat/ community and use of ecosystem/species level).	Changes in frequency of detection of specified signs of presence of designated fauna species and local resource uses along established transects for the same search effort (species/population and use of ecosystem/species level).	Changes in perceived harvest volume per effort and in number of people engaged in specific biodiversity impacting activities within a given time period (use of eco-system/species level).
Possible use	Indicates possible changes in relative abundance of species and resource use.	Indicates effectiveness of habitat protection and conservation. It can tell if the size of important habitats are declining and why.	Indicates possible changes in wildlife population size/human intensity of resource use and/or shift in range of wildlife/human resource extraction.	Provides an early warning of overharvesting situations and indicates changes in resource use, and effectiveness of park in providing benefits to local communities.
Habitat coverage	Useful in both land and water habitats.	Useful in land habitats, particularly in undulating terrain and along curved coastlines.	Useful in land habitats.	Useful in both land and water habitats.
Field method	Field Diary method. Standardised recording of routine observations on resource use and wildlife in a simple pocketbook or on a data sheet during regular patrols.	Photo Documentation method. On-the-ground fixed point photographing of selected hillsides in priority forest blocks at regular intervals.	Transect Walk method. Line-transect survey of wildlife and resource use along permanent routes.	Focus Group Discussion method. Park staff cooperate with community leaders and establish a volunteer Community Monitoring Group of 5–8 persons, who are encouraged to collect information on a regular basis between quarterly discussions with park staff. The results are analysed by the park staff and presented annually for the entire village in order to enable the communities' inputs and responses to be obtained, leading to agreed mitigating actions.

Table 1. Continued.

	Indicator 1	Indicator 2	Indicator 3	Indicator 4
Data set	Field data sheet with date, name of observer, location, species, number/amount and remarks.	Colour photo 10 × 15 cm with date, location and name of photographer.	Transect Walk data sheet with date, name of observer, location, species, number/amount and remarks.	Amount of resource harvested (per unit effort) in a defined area as recorded by a community or sub-group; Number of people engaged (total or extrapolated from a sample).
Compilers	All protected area staff. Skills needed in communicating with local people and in identifying species.	Protected area staff with a working knowledge of the basic operations of a camera.	Protected area staff with skills in identifying species. Each transect route should be surveyed by the same person.	Protected area staff who are not involved in enforcement activities. One person facilitates discussions and another records the minutes. Skills in PRA methods are an advantage.
Equipment	Notebook, pen, field guide and binoculars.	Camera with battery, compass, films, forms and, if possible, a tripod. During establishment of this method other needed equipment is a topographic map and, if possible, an altimeter, a GPS, and paint or other materials for marking the site permanently.	Binoculars, field guide, watch, Transect Walk data sheet, water container with water, and food. During establishment of this method other equipment needed is a topographic map, compass, a long string (50 or 100 m), permanent marker (paint), and, if possible, a GPS and an altimeter.	Field guide, large sheets of paper, markers, food.
Frequency	Protected area staff keep a field diary whenever they are in the field.	Protected area staff take quarterly photos. This may later be reduced to annually at view-points where no changes in land-use and habitats have occurred. Typically one protected area staff can be responsible for 3–5 photo documentation sites.	Each Transect Walk route is walked once every quarter within a defined two-week period. Typically one protected area staff can be responsible for 3–5 routes.	A discussion meeting of two hours is undertaken quarterly with the Community Monitoring Group. Once a year a meeting is held with the village. Monitoring Groups can be be set up in all settlements within the protected area. Two park staff can be responsible for 4–6 Monitoring Groups.

Data storage	If a notebook is used, it is stored carefully. If seperate sheets of paper are used, they are filed in a ring-binder and never taken to the field again.	Each photo is marked with date, location and name of photographer, and numbered according to the sequence of frames on the negative film. Negatives and prints are kept in a photo-album or ring-binder in a safe dry place	After each Transect Walk, the observations written in the Transect Walk data sheet are tallied. The filled out form is filed in a ring-binder at the Protected Area Office. A copy is submitted to the Regional DENR for safe storage.	Minutes of the meetings are stored in a ring-binder in the Protected Area Office.
Pros	This method is easy to undertake in the field.	Minimal staff training needed. Data-set is objective, independent of observer (and identification skills) and of permanent value. Photos are useful when presenting results of monitoring as most people will be convinced by photographic documentation. In addition, ground-based photos are useful for ground-truthing of remote sensing images.	Minimal staff training needed. Corrected for effort. Relatively easy interpretation.	Minimal training needs. Relatively easy interpretation. Encourages a dialogue between park staff and local communities. When the park communities are directly involved in biodiversity monitoring they will become more aware of the need for conservation and they are more likely to agree on, and participate in, law enforcement and regulation of resource use.
Cons	Limited correction of effort possible thus easily biased, for instance, by changes in patrol routines. Only very large changes in relative abundance of species or resource use can be detected.	Staff need camera operation skills. Expensive.	Staff need identification skills. Staff transfer should be minimal. Biased by seasonal changes in detectability of wildlife.	It is often unclear whether resources are harvested inside or outside of a protected area. There may be no clear entry/exit point. People may be reluctant to provide harvest information. Data is qualitative. Information is not objective.

Table 1. Continued.

	Indicator 1	Indicator 2	Indicator 3	Indicator 4
Remarks	Some effort correction possible, if data is confined to specified locations and a constant number of informants.	Careful selection of sites is critical. Sites should overlook forest in seriously threatened areas where logging, swiddening or other disturbance may occur or recently occurred. A few sites should be in areas without human use. Sites should be easily accessible (such as view-points along the patrol routes), from where one can see the surrounding landscape (not just the nearest few trees).	Careful selection of transect routes is critical. Patrolling routes which pass through primary forest can be useful. Some should pass through areas with human use, others through areas with no or minimal human use. Routes should be easily accessible. Areas which are not safe to travel in alone should be avoided.	The information is based on local communities' own perceptions of trends. However, data gathered continuously from a number of representative communities can provide a valid picture of general trends.

these will probably be the result of human activity. We therefore found it reasonable to focus biodiversity monitoring mainly on key habitats and uses in the parks.

We identified species and signs of resource uses which we thought would provide useful proxy information about the unique biodiversity of Northern Sierra Madre Natural Park, Bataan Natural Park and Mt. Kitanglad Range Natural Park (Table 2).

Some species may be more sensitive or more threatened than those we selected. None of these, however, are easily identified. Results based on surveys of species which are difficult to identify are likely to reflect the identification skills of the observer rather than a change in species abundance. Species which are recorded only

Table 2. Species and signs of resource uses which are monitored in the natural parks, Northern Sierra Madre, Bataan and Mt. Kitanglad Range.

English name	Species	Indicator for
Mammals		
Long-tailed Macaque	*Macaca fascicularis*	f, H
Philippine Warty Pig	*Sus philippensis*	f, H
Philippine Brown Deer	*Cervus mariannus*	f, H
Large flying foxes	*Acerodon jubatus/Pteropus vampyrus*	f, H
Dugong	*Dugong dugon*	s, H
Birds		
Philippine Eagle	*Pithecophaga jefferyi*	f, H
Philippine Duck	*Anas luzonica*	w, H
Philippine Scrubfowl	*Megapodius cumingii*	cfo, E
Rufous Hornbill	*Buceros hydrocorax*	f
Tarictic Hornbill	*Penelopides panini*	f
Red Junglefowl	*Gallus gallus*	f, H
Pigeons and doves[a]	Columbidae	f, H
Bleeding-heart Pigeon	*Gallicolumba luzonica/criniger*	f, H
Philippine Eagle-Owl	*Bubo philippensis*	f
Reptiles		
Crocodile	*Crocodylus mindorensis/porosus*	w, H
Marine turtles	*Chelonia mydas*	s, c, H
	Erethmochelys imbricata	s, c, H
Shellfish		
Giant Triton	*Charonia tritonis*	c, S
Scaly Giant Clam	*Tridacna squamosa*	c, S
Signs of resource uses		
Stump		L
Piece of timber		L
Bundle of rattan		R
Person (and activity)		U
Sound of chainsaw		L

[a] Experienced observers can distinguish between different pigeons and doves.
Habitats: f – forest habitat; cfo – coastal forest habitat; w – wetland habitat (fresh/brackish water); s – seagrass bed habitat; c – coral reef habitat.
Human uses: H – hunting; E – egg collecting; S – shellfish gathering; L – logging; R – rattan gathering; U – resource use.

rarely will not generate enough data. Species where the reason for possible change in status can be relatively easily established (habitat versus hunting) are preferred.

Other parks may have different priority species and resource uses for monitoring. We have recommended that protected area staff in other parks should assess whether there are other species or signs of resource uses which are equally useful and practical to monitor in their park and change the list accordingly.

Equipment

Only basic equipment is needed. These are: notebook and pencils, binoculars, watch, compass, camera with batteries and film, markers, large sheets of paper, ring binders for data storage, Photo Documentation forms, Transect Walk field data sheet, and food. Whilst setting up the monitoring system it is also useful to have an altimeter and a GPS (Global Positioning System receiver). Apart from the initial costs of purchasing equipment, the most expensive items in the establishment and implementation of the system are staff time and travel (budget in Nordeco and DENR 1998a).

Field methods

Establishing and implementing the monitoring system comprises ten steps in each protected area (Table 3). For each indicator there is a corresponding field method.

The Field Diary method (Table 1) encourages protected area staff to be observant of changes in the use of park resources and the abundance of species. Data gathered by this method is difficult to correct for effort and can be easily biased – by a change in patrol routines, for instance.

The Photo Documentation method provides data that is independent of observer and identification skills (Table 1). It documents habitat changes and provides an insight into the cause. If negatives and prints are stored in a safe, dry place, they can last for many years. The photos can also be used for demonstration and education purposes.

The Transect Walk method (Table 1). Parts of existing patrol routes are used as survey routes whenever possible (instead of establishing new trails) and only observations, signs and spoor marks of a few preselected wildlife species and resource uses are recorded. As the capacity of the protected area staff improves, this method can be further elaborated (by estimating the perpendicular distance from the trail to each record) as it is a simplified version of the variable-distance line-transect method (Burnham and Anderson 1984; Buckland et al. 1993; Laake et al. 1993). The data might subsequently be used to reveal national trends in the population of priority species.

The Focus Group Discussion method draws upon Participatory Rural Appraisal (PRA) techniques developed by social scientists over the last decades. The strength of the Focus Group Discussion method is that it encourages a dialogue between

Table 3. Ten steps in establishing and implementing the biodiversity monitoring system in Philippine protected areas.

Step 1. Compile basic information on the protected area
Before you can establish and use the monitoring system you should have at least a rough idea of what the major threats are to the park and where they are most serious. In addition, you should know which parts of the area are particularly important to conservation and local use by park communities. These can for instance be areas known to support species of conservation interest, or where local people fish, hunt and collect non-timber forest and wetland products.

Step 2. Identify priorities for biodiversity monitoring
Identify those sites and those species and resource uses, which should be monitored. Discuss these with the Head of the Protected Area Office and other knowledgeable people, and decide which of those sites and species are the most important to monitor.

Step 3. Training
Ask the Protected Area Wildlife Division of the regional office of the Department of Environment and Natural Resources (DENR) for training in monitoring biodiversity and resource use. They may be able to provide a trainer, or they can get staff from other protected areas to assist you.

Step 4. Establish the biodiversity monitoring system
The monitoring system entails four field methods: the Field Diary method, the Photo Documentation method, the Transect Walk method and the Focus Group Discussion method. Look at the list of the most important sites and species you wish to monitor. Read the methods and identify which sites and species can usefully be monitored by each method. Your choice will depend on available time, number of park staff, funds and transport facilities. Establish monitoring sites in the field (Photo Documentation, Transect Walk, Focus Group Discussion). If necessary, prepare a simple guide for the field identification of your priority species, using available existing literature (see Nordeco and DENR 1998a).

Step 5. Compile data using the field methods
Use the field methods to compile data on biodiversity and resource use. Write a Field Diary whenever you travel in the park. Every quarter use the methods on Photo Documentation, Transect Walk and Focus Group Discussion.

Store the data sheets and photos carefully in ring-binders and photo albums at the Protected Area Office. Prepare copies of the Transect Walk data sheet and submit them to the Regional Protected Area Wildlife Division of the DENR for safe storage.

Step 6. Analyse data and identify trends
Once a year you should look at your data and try to highlight any changes over time. If there seem to be changes, you should assess whether the data is likely to reflect the true situation in the park, or if the data could be biased, e.g. by a change in monitoring routines or the weather.

If there seems to be a real change you should try to identify the reason for the change, the importance of the change, and then assess if any management intervention is appropriate. The reason for a change is often related to the human use of the area. The common impacts of human activities and typical causes of destructive activities in Philippine parks are described in Tables 4–6.

Step 7. Validate results with the protected area communities
Present findings to local people and ask for their advice. Use pictures and figures but very few words, and try to be as site-specific as possible. Do the local people consider the findings relevant? Also discuss possible actions to be taken by the people themselves, the Protected Area Management Board or the Local Government Units on the basis of your findings. Maintaining a dialogue with the park communities is an important part of the monitoring process.

Step 8. Present findings and recommended actions to the Protected Area Management Board
Present the most significant findings to the decision-makers in the Protected Area Management Board. Present corresponding options for action. How you display your findings is very important. Use graphs, figures and few words.

Table 3. Continued.

Step 9. Make decisions to improve protected area management Remember that the reason for spending time and money on monitoring biodiversity is to guide action in park management. You should encourage the Protected Area Management Board to take decisions on the basis of your findings. A list of possible management interventions is provided in Table 7.
Step 10. Revise and strengthen the monitoring system Assess whether the methods provided useful data or not, find out why, and then adjust the monitoring system. Perhaps a method generated too few data, or it did not cover the habitats you wanted it to cover. Perhaps some park staff were not fully committed to the work, and the task of monitoring biodiversity needs to be given to somebody else.

protected area staff and park communities regarding the status of park resources and management. Consequently, park communities are more likely to agree on, and participate in, law enforcement, regulation of resource use and reaction to encroachment by outsiders. In fact, this method seems to enhance local ownership of the monitoring system as well as of the protected area. For the Focus Group Discussion method, even the initial monitoring activities can provide useful results, as past changes in availability of resources may be memorized. The success of using this method, however, depends on the ability of protected area staff to communicate with local communities. Appendix 1 describes how protected area staff introduce the biodiversity monitoring system to the park communities. An example of a Focus Group Discussion in a community (Appendix 2) is provided. The method contributes to building capacity in environmental management as possible solutions to problems of environmental management will inevitably be aired when discussing changes in biodiversity.

Monitoring sites are chosen on the basis of the location of the most serious threats to unique biodiversity in the protected area, priority areas for conservation and resource use by local people, and accessibility. The Photo Documentation and Transect Walk methods are carried out both in areas with and without human use, so that the latter can serve as reference areas.

From field data to results

The Head of the Protected Area is responsible for ensuring that at the first meeting of the Protected Area Management Board each year, the results of the previous year's biodiversity monitoring are on the agenda.

All the methods assume that data is compared with *previous* monitoring data. Data organization, analysis and interpretation differ from method to method (guidelines in Nordeco and DENR 1998a). Some of the questions which have to be answered follow here:

Field Diary method. Have there been any changes in land-use or area and quality of habitats noted? Are there apparent changes in the distribution or frequency of

species or signs of resource uses? Have there been major changes in the numbers or distribution of records of target species or resource uses (the selected species and uses which should always be noted)?

Photo Documentation method. Do the photographs show any change in land-use or vegetation when compared with older photographs of the same area?

Transect Walk method. Does the data indicate any change in species abundance or resource use?

Focus Group Discussion method. Do the local communities experience any changes in the environmental benefits, the amount of a resource harvested, the time it takes to harvest a desired quantity of some resource, the equipment used, or the number of people involved in harvesting a resource?

It is important to assess whether the data is sufficiently extensive in order to ensure that an apparent change is not merely caused by chance. What appear to be large changes will often happen by chance when data sets are very small. For the Transect Walk method, simple statistical tests can be used to obtain an indication of the likelihood of changes in frequency of records reflecting real changes. Results from all methods may be biased by changes in weather, seasons or other natural background conditions. Other potential bias includes: changes in patrol routines or intensity of patrolling (Field Diary method); timing of the transect walks, the ability of the observers to detect wildlife species and resource uses (Transect Walk method) and changes in the composition of the Community Monitoring Group (Focus Group Discussion method). Interpretation should consider improvements of accuracy or efficiency from the first study period. Interpretation may also be complicated by spatial and temporal variations in biodiversity, which may be unrelated to the management of the area. In the Philippines there is currently very limited knowledge of these natural variations.

From results to management responses

The most challenging part of the biodiversity monitoring system is to move from results to identifying appropriate management responses. It is relatively easy to detect a change but much more difficult to find a cause (e.g. Wilson 1994). Since significant change in the biodiversity of a park is often related to the human use of the area, one needs to know what the likely impacts of different human activities are in order to identify the reason for the change. This will often be a matter of understanding whether change is caused by direct use of the species in question or by habitat modification which may affect whole communities.

In the Philippines, human activities which involve serious destruction of natural habitats include: logging using bulldozers and trucks, carabao (buffalo) logging,

swiddening, agricultural development, industrial development, mining and road construction. Human activities which normally involve only minimal destruction of the natural habitats but which may affect single species are: hunting, fishing and shellfish gathering and gathering of non-timber forest and wetland products. Whilst the latter four activities usually have limited impact on the natural ecosystems, there are exceptions in cases such as fishing using dynamite, poison or electricity. A summary of the common impacts of human activities in, or adjacent to, Philippine parks is provided in Tables 4 and 5. A special case is camping and hiking, which can sometimes cause severe disturbance (when it is targeted towards sensitive species or ecosystems such as coral reefs), but which usually has only very limited impact (although it may occasionally lead to the desecration of the sacred places of indigenous communities).

Identifying the appropriateness of any management response involves examining the typical causes of destructive human activities in Philippine protected areas (Table 6) and possible management responses (Table 7). For instance, indications of over-harvesting will require discussions with the villagers at a community meeting. Observations indicating rapid and serious decline in biodiversity (such as big tree stumps indicating large-scale logging) may need the immediate attention of the Head of the Protected Area. It is important to avoid hasty conclusions but also to be aware that the interest in participating in monitoring can easily be jeopardised if no management decisions are forthcoming on the basis of the monitoring system.

Table 4. A summary of the common impacts of logging, swiddening (kaingin), agricultural development, industrial development, mining and road development in, or adjacent to, Philippine protected areas.

1. *Increased access and in-migration*. Increased access to the interior of the park by new roads and trails, and increased in-migration and pressure on land for farming.
2. *Fragmentation of habitat*. Further degradation, fragmentation and destruction of the remaining small areas of natural habitat, which may eventually lead to the total disappearance of these habitats.
3. *Extinction of plant and wildlife*. Decline in the diversity and population of plants and animals of importance to conservation and local use. For instance, many threatened species are found in lowland forest, and some occur only in this habitat; those species would become extinct in the park if the remaining lowland forest disappears.
4. *Deterioration of watershed functions*. Through destruction of the vegetation cover, further deterioration of watershed functions and increased occurrence of floods, landslides, soil erosion, siltation, poor quality of potable water, incidence of fires, and a dryer and hotter micro-climate.
5. *Decline in fish stocks*. Sedimentation of rivers and coastal waters leads to a decline in stocks and diversity of riverine and marine fish and degradation of coral reefs and sea grass beds, which are spawning and nursery areas for fish and crustaceans.
6. *Marginalisation of local communities*. Local communities, directly dependent on a diversity of forest and wetland resources, become increasingly marginalised and forced to adopt intensive extractive activities.
7. *Damage of crops*. Destruction of natural habitats may dislocate animals and drive them to infest or feed on crops.
8. *Water pollution*. Mining and agricultural development such as high value crop plantation may contaminate water sources.

Table 5. A summary of the common impacts of hunting, fishing and gathering of non-timber forest and wetland products when used beyond sustainable levels.

1. *Decline in availability of resources*. Decline in availability of plant and animal resources which are important for local food and income.
2. *Decline in populations of threatened species*. Decline in local populations of species of plants and animals, which are important to conservation.
3. *Increased competition for resources*. With the decline in resources, people need to travel further into the park to find the resources, and harvesting methods become increasingly destructive. Competition over the use of resources intensifies. Most affected are the indigenous people and poorer households, who are further marginalised.

Role of biodiversity in performance monitoring of conservation project

The Conservation of Priority Protected Areas Project (CPPAP) seeks to conserve biodiversity in ten priority protected areas in the Philippines. The biodiversity monitoring system has been integrated into this project's performance monitoring plan which serves the purpose of indicating whether or not the project achieves its objectives (Pollisco-Botengan 1997). The four indicators of the biodiversity monitoring system (Table 1) are used as indicators for the Development Objective of CPPAP ('to conserve biodiversity'), while the associated methods are the Means of Verification. The success of the project is assessed by summing up the local experiences. For evaluation exercises involving local people the results are expressed in trends and not in numerical indices or absolute figures. Since the biodiversity monitoring system was only recently incorporated into the monitoring of CPPAP, its usefulness for performance monitoring still remains to be seen.

Evaluation of how the biodiversity monitoring system is implemented

The success or otherwise of this biodiversity monitoring system will be evaluated on the basis of an assessment of the implementation of the system and its impact. We will use the following criteria for assessing implementation:

- Is the system in operation in those parks where it was established;
- Are the field methods used in accordance with prescriptions;
- Is the generated data stored in a systematic and safe manner;
- Is data regularly being analysed and presented to decision-makers;
- Are wildlife species properly identified, and are sufficient notes made to document observations of rare species;
- Number of park staff who record routine observations of wildlife and resource use in writing;
- Number of established and surveyed Photo Documentation sites and Transect Walk routes, and number of Community Monitoring Groups and Focus Group Discussions and village meetings undertaken;

Table 6. Typical causes of destructive human activities in Philippine protected areas.

Destructive human activities in, and adjacent to, parks are often caused by:

1. *Inadequate co-ordination between government agencies*. The National Integrated Protected Areas System (NIPAS) Act is sometimes implemented in isolation from other development programmes in and around the park because of inadequate co-ordination between different government agencies and an unclear division of authority. Sometimes the Head of the Protected Area Office and the Protected Area Management Board are not, in practice, in control of the provision of land use permits, rights or titles to land in the park; these may be controlled by Local Government Units and other government agencies, which do not prioritise the NIPAS Act.
2. *Unclear demarcation of management zones*. Insufficient on the ground demarcation of Alienable and Disposable zones, park boundaries and zoning to guide people on what activities to undertake where.
3. *Lack of security of tenure over land*. Lack of security of tenure over land on the part of park communities encourages land speculation and creates opportunities for people to claim new land by opening up swiddens. It is a disincentive to investing in sustainable land use (i.e. conservation measures, soil fertility improvement) and it leaves park communities powerless in trying to prevent people from expanding destructive human activities in the forest areas.
4. *Limited environmental information available*. Destructive practices may not be recognised if there is a lack of knowledge among park communities and park staff regarding local environmental issues, for instance, the status of threatened species and the relationship between forest degradation and the productivity of coastal and other ecosystems.
5. *Insufficient and inappropriate monitoring and enforcement*. Park rangers may lack appropriate training and operational funds to implement the law. In addition, there may be a poor relationship between enforcement rangers and park communities and no participation of local people in monitoring and enforcement. Rangers may be seen by locals as concentrating their enforcement efforts on local people's use of timber and non-timber forest products for household consumption rather than apprehending those involved in the commercial cutting of timber and other more destructive human activities.
6. *Minimal follow-up on legal actions against major offenders*. In some areas, a large proportion of people may depend on big companies for employment and social services and the commercial sector is, to a large degree, in control of the economy. Consequently, if these companies seriously violate the NIPAS Act, they may not be brought to court, or there may be no follow-up to legal actions. Sometimes, local government agencies may be involved in, or protecting, seriously destructive human activities in the park, which makes enforcement even more difficult.
7. *Other reasons*. Other important causes – particularly for swiddening (kaingin) – are poverty, a decline in land area available for swiddening, and few cash-generating livelihood options for the park communities. Traditionally swiddening was a fairly sustainable practice, but today it has become unsustainable in many areas due to a decline in the land area available for farm plot rotation and a decrease in the use of traditional soil conservation measures. Swiddening is rooted in poverty, a lack of alternative farming practices and limited income generating possibilities. In many areas, communities are forced to open swiddens in foothills and uplands because of a shortage of permanent fields in the valleys, increased incidence of flooding and periods of drought and depleted soils. Added to these problems are a lack of skills in alternative agricultural practices and a preference among many people for a livelihood derived from a combination of small-scale logging and cultivation, rather than permanent farming.

- Number of occasions where photos from the Photo Documentation method are used for demonstration or education purposes.

For assessing the impact of the system we envisage using the following criteria:

- Do protected area staff and Protected Area Management Board continue to use the biodiversity monitoring system;

Table 7. A list of possible management interventions in Philippine protected areas.

Typical management responses could be to:

1. Disseminate information to relevant authorities on the conservation needs and problems faced by the park due to encroaching development projects and discuss and agree on solutions. The Protected Area Management Board (PAMB) may find it necessary to make recommendations for the Secretary of the Department of Environment and Natural Resources (DENR) to take action.
2. Strengthen co-ordination amongst the government agencies involved in resource use and conservation in, and adjacent to, the park.
3. Delineate park management zones and boundaries by mapping, ground truthing and monumenting. Establish areas in the vicinity of communities which will be for the sole use of people from these communities. These areas should accommodate their needs for fishing, hunting and forest product gathering and, within a smaller part of this area, farming and household supply of timber. Establish agreements on land use and quotas and state criteria for adherence to the agreed land and resource use in a contract.
4. Support a fast and efficient processing of 'tenured migrant instruments' and 'ancestral domains' so as to provide an incentive for the sustainable use of the land, minimise land speculation, and encourage park communities to keep people from expanding destructive activities in forest areas.
5. Raise awareness among local communities of specific conservation needs, the role of local people in park management and observed destructive practices in resource and land use.
6. Strengthen staff capacity. Further train, support and deputise local forest guards. Strengthen capacity of enforcement rangers in community approaches such as style of communication and establishing dialogue with community members. PAMB may find it necessary to recommend to DENR that they obtain more operational funds.
7. Discuss and agree with park communities and Local Government Units on the establishment of a system of closed season, quotas or zones for hunting and gathering of selected species. In addition, discuss and agree with park communities and Local Government Units on the prohibition of capture, trade and possession of products from the most endangered species.
8. Encourage municipalities to issue by-laws supporting park regulations and PAMB resolutions.

- Number of women, indigenous and other local people who participate in village meetings to discuss monitoring results;
- Opinion on the biodiversity monitoring system by different groups of end-users;
- Number of occasions where monitoring results are being used by local communities, park staff or the PAMB;
- Number of examples of reaction to encroachment by outsiders on the part of the protected area communities;
- Number of management interventions implemented, based on results of the biodiversity monitoring system.

Power of the Transect Walk method to detect a trend

In order to judge the power of the Transect Walk method to monitor trends in the abundance of Philippine forest wildlife species, we used a series of five replicated transect walks carried out by the authors during a project of DENR and BirdLife International in Northern Sierra Madre in 1991–1992 in order to determine the precision of this method. On the basis of these replicates, the coefficient of variation of

a single census of, e.g., Red Junglefowl *Gallus gallus* was estimated to be 0.55. We used the program TRENDS developed by Gerrodette (1987, 1991) and assumed that population change is linear, that the coefficient of variation is inversely proportional to the square root of the abundance, and that the distribution was standard normal (z). We assumed that data will be analysed at the $\alpha = 0.05$ significance level (two-tailed). With four censuses made each year, the probability of detecting a 20% per year change in abundance after three years is 0.15, while after seven years the probability is 0.81. In other words one should not be overly optimistic: for the Transect Walk method to be able to detect a trend with a statistically acceptable degree of confidence a long period is needed.

Constraints

By 1999, the biodiversity monitoring system had been established, tested and revised in the three protected areas and was in almost full operation. The main constraint has been insufficient institutional support for implementing the system. Biodiversity monitoring is a new activity, which until 1999 did not figure in the annual work plans of DENR. It is not included in the job description of the park staff and only from 1999 will there be government funds available for transport and other costs. Another constraint has been the limited management skills of some park staff. Some staff have difficulty in organizing themselves before going to the field, e.g., ensuring enough food and water, and in arranging that field data are copied, filed and stored properly.

Discussion

Necessary further development of the Philippine monitoring system

The DENR of the Philippine Government would like to expand the biodiversity monitoring system to 184 protected areas (DENR 1998). We have suggested that it be first established and further tested and refined in a small number of sites so that revisions needed in the approach, methodology and in the list of species and resource uses for monitoring can be identified (see e.g. Simberloff 1998). We have proposed the following criteria for selection of further sites:

1. their combined coverage of Philippine flora and fauna,
2. the interest of protected area communities in cooperating with government staff on resource management,
3. legislative status and field personnel available (sites should have protected area status and staff),
4. coverage of the administrative regions of DENR, and
5. the law and order situation.

There is a need for a national policy on biodiversity monitoring and a directive to the regional and provincial offices of DENR. In each protected area, biodiversity monitoring should be incorporated into annual work and financial plans, equipment should be purchased if not already available, and biodiversity monitoring should become part of the job description and performance evaluation of park staff. We suggest that specific staff from the Protected Area and Wildlife Bureau of DENR be given responsibility for overseeing the implementation and supervision of the biodiversity monitoring system. Staff from each protected area and some members of the local NGOs and communities should be trained in the monitoring system, and the system should be installed on the sites. National and regional staff of PAWB-DENR should be trained in supervising its installation and implementation. Biodiversity monitoring training should be fully accredited by DENR and integrated into their existing training systems. In addition, field guides for the identification of priority species and resource uses in other parts of the Philippines need to be developed. Partnership between park staff and universities should be promoted. Park staff and local academics should be encouraged to present results of monitoring in national meetings, in conference proceedings, newsletters, scientific journals and local and national newspapers in order to stimulate discussions and increase awareness on biodiversity conservation and the importance of biodiversity monitoring. PAWB should regularly prepare a national synthesis report for decision-makers and the broader public on the results of the monitoring in order to provide an overview of the knowledge of trends in biodiversity and resource use.

It was unfortunately not possible for us to conduct methodological studies to document to what extent the parameters collected reflect changes recorded by more standardized methods. In the Natural Parks of Northern Sierra Madre and Mt. Kitanglad Range however universities are currently establishing permanent vegetation plots, which we hope on long term can be used for comparison.

Minimum starting point

For forest biodiversity monitoring programs to be able to provide unequivocal answers, Margules et al. (1998) identified a number of important elements:

1. controls in areas with no human activity,
2. replication in sampling to account for spatial heterogeneity and random variation,
3. knowledge of conditions before human activity began,
4. environmental stratification to capture the habitat preferences of specialized species and facilitate analyses of the responses of less abundant species,
5. a sufficient period of monitoring to establish human use effects and distinguish them from climatic fluctuations or other episodic events, and
6. replication at more than one location to avoid location-specific phenomena.

In the Philippine monitoring system, controls in unused or largely unused areas (1) are made for the Photo Documentation and Transect Walk method where undisturbed

forest areas are easily accessible. Replication of sampling (2) is undertaken in the Photo Documentation, Transect Walk and Focus Group Discussion methods, as these methods are applied on several sites in each protected area. The monitoring system does not establish knowledge of pre-human use conditions (3), since this would be logistically very difficult and human use of Philippine protected areas cannot be regulated as in an experiment. Environmental stratification (4) is made for the Transect Walk method where data is compiled on the location of vegetation types and records of species and resource uses along the transect. The monitoring system is expected to continue for a long period (5), and the monitoring system is replicated in several protected areas (6).

In the Philippine system, we have not included all those elements that are desirable for monitoring programs but we have shown what monitoring can be undertaken in practice by protected area staff and local communities. Many recent attempts to establish biodiversity monitoring systems in developing countries have run into serious trouble because the systems were too large and complicated. For instance, in the Tarangire National Park, Tanzania, the University of Milan assisted the government by monitoring wildlife migration routes using radio-telemetry and 'GIS'. Funds, however, ran out rendering the high technology useless. The project is now simplifying all monitoring routines so that they can be sustained with minimal funds and a small number of government staff (V. Galanti, pers. com.).

The Philippine biodiversity monitoring system was developed bearing the typical problems of developing countries in mind, including those relating to high numbers of species, incomplete taxonomic knowledge, few economic resources and large total size of protected areas. We consider this monitoring system as a feasible minimum starting point, which can evolve further over time as more resources and skilled people become available to manage and monitor biodiversity. As long as the procedures of the four methods are continued on the same sites (and by the same persons, especially for the Transect Walk method) development of the system does not significantly violate the assumption for monitoring that quality and reliability of data sampling remain unchanged. Further development of the system may include adding methods and storage and analysis of biodiversity data on computer. Studies of the habitat requirement and ecology for the target species will increase their value as indicators for biodiversity. The records from transect walks can be related to population density if estimates are made of the perpendicular distance from the trail to each record to correct for visibility bias. This need only be done until the relationship between frequency of records and population density is understood. Data compiled on a geographical basis (with latitude and longitude) can be entered into a computerised 'GIS'-database, if and when this is appropriate. We anticipate the current methods being backed up by remote sensing of land-use and vegetation on a regular basis, as well as by in-depth monitoring of selected habitats, species and sites.

Participation of local communities in biodiversity monitoring

Until the late 1980s it was a maxim of practical conservation in developing countries that biodiversity was best conserved by establishing strict protected areas. This resulted in many conflicts with local communities who depended on the natural resources of the areas. It was morally impermissible in many places, and it was costly and difficult (or impossible) to enforce regulations. The real threats to biodiversity often come from organised elites or other non-local residents, and long established local people frequently have strong interests in conserving their resource base.

By the beginning of the 1990s, many policy and decision-makers therefore abandoned this 'fines and fences' approach in protected area management and instead attempted to provide positive incentives through alternative income-generating strategies aimed at reducing dependence on natural resource use. However, in most developing countries, at least in Africa (Brown 1998) and South East Asia (e.g., Danielsen and Enghoff 1999), this approach has also generally proved ineffective. Instead, the way forward in protected areas with long established local communities probably lies in the consolidation of existing livelihoods in the protected areas through strengthening non-destructive natural resource management systems and supporting partial exclusion of non-traditional resource users and users of external origin. The biodiversity monitoring system plays a role in reinforcing this strategy in Philippine protected areas.

The communities expected to participate in the Philippine monitoring system are the indigenous people and migrants who live in and adjacent to the protected areas. These people take decisions on resource management every day in the field, often far away from park staff, municipal officials and others at higher levels. These decisions are imperative for the future of the protected areas and should inform higher level decision-making.

These people are expected to provide information on resource use and wildlife to the protected area staff (Field Diary method) and take part in discussions of photos of habitats and land-uses (Photo Documentation method). In addition, they are supposed to collect biodiversity relevant information, present and discuss this with other local people and park staff and agree on and take part in law enforcement and regulation of resource use (Focus Group Discussion method).

As of 1999, the role of local communities in monitoring has, however, been limited largely to collecting information and taking part in discussions with park staff. The ability of the Focus Group Discussion method to encourage shared management of the parks' resources with local communities has only partly begun to be utilized. There are several reasons, which we try to address in the revised training courses.

It is relative easy and straight forward to take photos or walk transects. One merely needs to follow the 'recipe' (and be able to identify species on the transect). Facilitating Focus Group Discussions for the purpose of monitoring biodiversity requires reflection and an independent way of thinking on the part of the park staff if they are

to be able to respond in a constructive manner to what the members of the Community Monitoring Groups say.

Training is also difficult. You can walk a transect twice to become better at it but you cannot repeat community meetings. A community meeting requires a lot of time for many people. During training it rarely was possible to conduct a community meeting because people had limited time in settlements within reach of the training venue. In addition, it was difficult to find Philippine socio-economists with the appropriate experience and ability to conduct such training.

Most park staff had minimal previous exposure to socio-cultural issues, to participatory methods and to entering into dialogue with local communities, in part because many had as the point of departure of their career the 'fines and fences' approach. Park staff used to see local people as potential offenders of the park regulations. Some might have been reluctant to hand over control of resources to local people. It has been difficult for park staff to understand and accept the basic strategy for this method of sharing insight and knowledge with 'normal' community members and of accepting the subjective statements of community members as being of value to monitoring. Staff are used to dealing with outspoken and influential people in the communities. They sometimes have difficulty in communicating effectively with the lower level stakeholders such as indigenous negritos (Agtas) and others who depend most directly on the use of minor forest and wetland products. It does not help that many park staff have witnessed earlier externally-funded projects, which formally emphasized the assignment of active key roles to local stakeholders but in reality limited the role of 'the beneficiaries' to the subjects of consultation and passive reception of training and inputs. In addition, Focus Group Discussions are very time-consuming in the short run. With the time constraints of the park administrations, low priority was sometimes given to this method.

Potential for application in other countries

The potential for using the present approach to biodiversity monitoring in other countries depends on the government's strategy for park management, the importance of forest and wetland resources to the rural people and the availability of human capacity and financial resources for protected areas. The system is particularly useful when a government is embarking on a policy of shared management of park resources with local communities, when a large proportion of the rural population depends on forest and wetland products (and where they have a long history of settlement and attachment to the areas) and when there is limited available human capacity and funds for protected areas.

Most protected areas in developing countries fall within this category. In these cases, the approach of the Philippine monitoring system may be readily applicable, but the management objectives of the protected areas may differ. In addition, there will be different species and resource uses, different destructive human activities and

different appropriate management interventions. In countries where most natural habitats have been converted to other land-uses, few people depend on resources from these habitats. Communities would generally have little or no incentive to participate in this kind of biodiversity monitoring, and it would be difficult to encourage people to participate. Where protected area staff have very minimal education and government funding but the relationship between park staff and local communities is generally good (e.g. in Lao PDR), very useful results may be achieved by the Focus Group Discussion method, and biodiversity monitoring may be limited to this and the Field Diary method.

In any case, we recommend that other countries develop their own biodiversity monitoring system with park staff and representatives of park communities. We suggest that:

- The process of developing the biodiversity monitoring system should involve protected area staff and representatives of park communities;
- The monitoring should be focused at the field level, where the management decisions are taken (c.f. the principle of subsidiarity in capacity development in environment; Boesen and Lafontaine 1998);
- Equal priority should be given to bio-physical and socio-economic information;
- The monitoring system should encourage a dialogue between all stakeholders in protected area management, and it should build bridges between local resource management systems and the natural resource management agencies;
- It should be kept simple and practical, so that methods can be easily integrated into the other work activities of the field staff and the system can be continued with locally available resources.

The development of the system in the Philippines has taken 3 years. It could have been done faster, but only at the expense of the process itself being a means for development of capacity, and the creation of ownership of the monitoring system at the field and at national agency level being facilitated (c.f. OECD/DAC 1997). Strong ownership is a prerequisite for sustaining biodiversity monitoring in the long-term.

Protected areas cover 4.6 million square kilometres in Asia, Africa and Central and South America (WRI et al. 1998). A large proportion still exist largely on paper (see e.g. Schaik et al. 1997). If the process of developing and implementing simple biodiversity monitoring systems can contribute to strengthening the management of just a small proportion of these sites, this would be an important achievement.

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Appendix 1. How protected area staff introduce the biodiversity monitoring system to the park communities.

Park communities may be interested to participate in biodiversity monitoring if the park staff can generate trust and establish reliable two-way communication with them. Below we describe how park staff introduce themselves and the biodiversity monitoring system to the local communities.

1. Introduce yourself (name, job, where you come from).

2. Explain how the park has been established and what will happen in the future.
The Philippine government decided in (year) that the area you are living in and the area within (name of geographical features) shall be an area in which the use of the natural resources shall not destroy the resources in the long term, and where conservation is very important. This area is called (name). I, together with other park staff in the area, have been given the responsibility of working with you for the best conservation and use of the area. It is the policy of the government that collaboration between you and us, both expressed by park staff working directly with you and by the working of the Protected Area Management Board as representing your interests, is the best way to make sure that the park remains with good forest cover/water quality/wetland resources and with many different animals and plants when your children and their children grow up.

3. Describe the reason for establishment of the park.
The park was established because it is one of the few remaining areas in the country with good forest/wetlands which are important for providing a clean and stable supply of water, and because it is home to animals and plants that have been wiped out in most other places in the country and in the world (name a few). The area is also providing many benefits such as fish, animals and forest products to many people in the area. The government wants to ensure that this unique area is not disappearing and is for the benefit of both you and people in the country as a whole.

Appendix 1. Continued.

4. Explain how the park staff will work with villagers.
We will be able to work with you in order to assist you in seeking ways:
- of using the wild plants and animals in your area in such a manner that they are not disappearing,
- of better protecting the forest from destruction,
- of improving protection of those wild animals and plants that are getting very rare such as (name a few),
- of improving the methods for farming, use of forest/wetlands, hunting and fishing in such a way that they are not destroying the forest and wetlands,
- of securing your rights to use the land, water, forest products and wild animals in your area within certain limits and in a way that is approved by the Protected Area Management Board and Local Government Units.

We are able to do this by visiting your village frequently to discuss, maybe advise and hopefully assist you during the coming year and perhaps longer.

5. Explain the objectives and activities of the biodiversity monitoring system.
I have come to your village today because we would like to know if you will work with us to observe changes in the numbers of wild plants and animals and in the use of the forests and/or wetlands for the best conservation and use of the area. If you are interested, we would like to find 10–15 local people who are willing to collect data on wild plants, animals and resource use, and who will spend two hours with me every quarter so that I can listen to, and we can discuss, their observations. It is best if those people are involved with community work within natural resource management (forest guards, community forestry committee members, etc.) or villagers otherwise interested in the use of forest/wetland resources. We would like the most experienced indigenous healer and all-round hunter/forest product gatherer to be members of this group (explain possible issues you would like them to look for but say that they might have better suggestions). Every year or so we would also like to discuss the findings with the whole village so that we can tell them about your findings and get input and responses from all members of the village.

6. Describe how the park staff will work in other ways.
We will also work in other villages, and we will work, both here and in other places, on issues such as: trying to stop commercial hunting and gathering by outsiders, trying to prevent developments that will destroy the park, co-ordinating with other agencies, preventing large-scale logging, providing information to park communities and others, etc.

Appendix 2. Description of a Focus Group Discussion in a protected area community.

The discussion took place in a village located partly inside a park and inhabited by both migrants and indigenous people. People in the village practise both swiddening (kaingin) and permanent agriculture. Small-scale logging, fishing, hunting and gathering of non-timber forest products are important activities for part of the population.

The main problems of natural resource management in the village are: decreased access to non-timber forest products, decreased fishing and hunting, logging supported by outside business people, less availability of clean water, occasional flooding, constraints in availability of land for agriculture, unclear rights to land and resource use inside the park.

The discussion lasted about one hour. Five members of the Community Monitoring Group and two park staff participated.

A monitoring group has been established in the village and has, in consultation with park staff, decided to concentrate on monitoring:
- the number of people involved in rattan collection for sale at market and the change in time needed for people to collect a bundle of good quality rattan;
- the change in effort needed for collection of durian from the forest and for collection of orchids from the montane forest;

Appendix 2. Continued.

- the expansion of hectarage of land under swiddening in a specific upper watershed inside the park;
- the change in number of households in the village with land under agriculture inside the park;
- the number of new tree stumps above 30 cm in diameter in a specific area of good quality lowland forest inside the park;
- the number of days that water from two specific streams is considered to be undrinkable because it is not clean enough or because it has dried out;
- the number of days/hours needed by selected expert hunters to hunt one wild pig or one deer;
- the change in size of fish and shellfish caught in specific streams and wetlands;
- any sightings or reports of Philippine Eagle and all sighting of hornbills in the valley behind the village inside the park.

For the above monitoring, the monitoring group in the village depended on information from the other villagers and on their own collection of data. Two people in the monitoring group noted the data in a notebook.

The discussion started with the park staff reporting back to the group on how the issues they discussed three months ago have been developing and whether any management actions have been undertaken or decided by the park or the Protected Area Management Board. The main issue was the protection of the upper watershed of one of the mountains in the park from further clearing for coffee growing and the decision on a closed season for hunting deer in the park.

The park staff then reported to the group on how the data they discussed last time had been handled, whether any common aspects were found with other villages and whether any new trends had been discovered or any existing trends reinforced.

The main issues were that data on hunting was too unevenly collected to be reliable and that collection must be more continuous by talking to the same hunters at regular intervals. It now seems that improvements in the size of fish was quite consistent in the data for the last year. In general in the park this is quite unique and seems to be related to the villagers imposing regulations in the major fishing stream and wetland in their area. In other streams in the park the size is decreasing. The data on quality of water in one of the two streams in the village has now shown a decline as compared to the same time last year because more days with dirty water have been reported; this is consistent with other villages in the park.

It was then discussed as to whether the monitoring group, which now only consisted of six members, was still able to monitor as many different aspects as before. The park staff reported that in other areas the monitoring groups had decided to collect less data by concentrating on fewer aspects, but the group felt that they could still manage.

Following this, the chairman of the group presented the monitoring data from the last three months. Unlike last time, when they copied the data from their notebooks to the park staff, they had not had the time on this occasion so it was decided that one would sit with the park staff after the meeting in order to copy the data.

The monitoring data follows:

- the number of people collecting rattan remains unchanged. One of the collectors reported that during the last three months she had had to increase her time for collection; others reported no change over the last three months;
- no durians were collected (not the season);
- data on orchid collection was still not easy to obtain, but at least two outsiders have been seen with orchids and one new businessman has approached the villagers to buy one very special orchid only found in the montane forest;
- the hectarage of land under kaingin remains unchanged, but a number of households in the village are preparing for clearance of some good quality forest in the watershed, as they have too little land available. Discussions with the monitoring group are taking place;
- one new household is now farming inside the park. As a newly married son of one of the families, he has received part of the cultivated family land. One family from outside the village has been asking for permission to open up land in the area; status of application not known;
- ten new tree stumps were reported (size ranging from 30 to 85 cm in diameter, with 5 from 30–40 cm, 1 of 50 cm, 3 between 60–70 cm, and 1 of 85 cm);
- two days with water too dirty for drinking were reported in one of the streams. In the other stream no dirty water was reported. No floods or drying out of streams were reported;

Appendix 2. Continued.

- hunting data was from one hunter who went on three hunting expeditions during the period, it took him two days to get one pig on the first, four days on the second and he did not get any on the third. He claims that hunting has become more difficult but that this has been so for many years and there has been no change during the last quarter;
- size of fish and shellfish caught remains unchanged according to people fishing in the village. On two trips to the river, three people from the monitoring group measured the size of the catch of people fishing with nets and hooks and the size of shellfish. The measuring data is in the notebook;
- number of hornbills sighted by members of the group in the valley seem to show that more hornbills are being found. On two trips to the valley that lasted one day each to collect rattan, one of the group members saw or heard 23 hornbills (15 one day and 8 the next). Other people also report more hornbills over the last quarter. One person in the village claims that he has seen a Philippine Eagle or at least a very big bird of prey.

The monitoring data was then discussed. The data on orchids collected needs to be improved. There must be more efforts made to ask other villagers what, and how much, they collect. Contact with more hunters should be established on a more regular basis. The data on hornbills should be compared to see if there is fruiting of specific trees found in the valley as this will attract hornbills and might explain the apparent increase in numbers. The sighting of a Philippine Eagle should be treated with care, as it can be fairly difficult to distinguish the Philippine Eagle from other large birds of prey. The most significant data is probably the number of big stumps (above 60 cm in diameter) found in the forest.

Problems of monitoring were then discussed and the group expressed a need for training in monitoring and for having an opportunity to share experiences with other monitoring groups in the park. Moreover, some material support such as pencils, paper, a pair a binoculars and a small per diem for the chairman of the monitoring group who spends a lot of time on the work, were discussed. The park staff member agreed to look at the issues with the park management.

Following this, some major management issues were discussed. Specifically, the issue of increased pressure to open up new agricultural land inside the park and the increased demand for orchids were discussed. Also, the possibility of extending the fishing regulations imposed by the villagers to the other stream near the village was discussed. Moreover, the reasons for increased logging of large logs were discussed and possible mitigating measures were looked at. The meeting ended, and a tentative new date for the next meeting was agreed upon. The park staff member ended by congratulating the group on the good work they had been doing.

References

Alder D and Synnott TJ (1992) Permanent sample plot techniques for mixed tropical forest. Tropical Forestry Papers 25: 1–124

Bibby CJ, Burgess ND and Hill DA (1992) Bird Census Techniques. Academic Press, London

Boesen J and Lafontaine A (1998) Indicators and monitoring of capacity development in environment initiatives. In: Danida and DANCED International Workshop on Danish Assistance to Capacity Development in Environment, Snekkersten, Denmark 12–14 May 1998, Workshop Proceedings, pp 96–130. Danida and DANCED, Copenhagen

Brown D (1998) Participatory biodiversity conservation rethinking the strategy in the low tourist potential areas of tropical Africa. ODI Natural Resource Perspectives 33: 1–5

Brown M and Wyckoff-Baird B (1992) Designing Integrated Conservation and Development Projects. Biodiversity Support Program. WWF, Washington, DC

Buckland ST, Anderson DR, Burnham KP and Laake JL (1993) Distance Sampling: Estimating Abundance of Biological Populations. Chapman and Hall, New York

Burnham KP and Anderson DR (1984) The need for distance data in transect counts. Journal of Wildlife Management 48: 1248–1254

Coddington JA, Griswold CE, Dávila DS, Peñaranda E and Larcher SF (1991) Designing and testing sampling protocols to estimate biodiversity in tropical ecosystems. In: Dudley EC (ed) The Unity of

Evolutionary Biology: Proceedings of the Fourth International Congress of Systematic and Evolutionary Biology, pp 44–60. Dioscorides Press, Portland
Dallmeier F and Comiskey JA (eds) (1998) Forest Biodiversity Research, Monitoring and Modeling: Conceptual Background and Old World Case Studies. Parthenon Publishing, Paris
Danielsen F and Enghoff M (1999) Fredet natur – mellem udnyttelse og beskyttelse. Den Ny Verden 32(4): 74–81
DENR (1992) National Integrated Protected Area System Act R.A. No. 7586 and Implementing Rules and Regulations DAO 25, Series of 1992. DENR, PAWB, Manila
DENR (1998) Medium Term Development Plan for the Protected Area and Wildlife Sector of DENR 1999–2004. DENR, Quezon City, Philippines
DENR and UNEP (1997) Philippine Biodiversity. An Assessment and Action Plan. Bookmark, Inc., Makati City, Philippines
Fuller J (1998) Participatory monitoring of forest resources: current methodologies being developed in Thailand. Rural Development Forestry Network 23e: 23–27
Gerrodette T (1987) A power analysis for detecting trends. Ecology 68: 1364–1372
Gerrodette T (1991) Models for power of detecting trends – a reply to Link and Hatfield. Ecology 72: 1889–1892
Groombridge B (ed) (1992) Global Biodiversity. Status of the Earth's Living Resources. World Conservation Monitoring Center. Chapman and Hall, London
Groombridge B and Jenkins MD (eds) (1996) Assessing Biodiversity Status and Sustainability. WCMC Biodiversity Series No. 5. World Conservation Press, Cambridge
Harmon D (1994) Coordinating Research and Management to Enhance Protected Areas. IUCN, Cambridge
Hammond A, Adriaanse A, Rodenburg E, Bryant D and Woodward R (1995) Environmental Indicators: A Systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development. World Resources Institute, Washington, DC
Hellier A, Newton AC and Gaona SO (1999) Use of indigenous knowledge for rapidly assessing trends in biodiversity: a case study from Chiapas, Mexico. Biodiversity and Conservation 8: 869–889
IBAMA (1998) International Workshop on Biodiversity Monitoring in Federal Protected Areas: Observations and General Remarks. www.erols.com/dsbaker/
IUCN (1996) 1996 IUCN Red List of Threatened Animals. IUCN, Gland
Kremen C, Merenlender AM and Murphy DD (1994) Ecological monitoring: a vital need for integrated conservation and development programs in the tropics. Conservation Biology 8: 388–397
Kremen C, Raymond I and Lance K (1998) An interdisciplinary tool for monitoring conservation impacts in Madagascar. Conservation Biology 12: 549–563
Laake JL, Buckland ST, Anderson DR and Burnham KP (1993) Distance User's Guide, v. 2.0. Colorado Cooperation of Fish and Wildlife Research Unit, Colorado State University, Fort Collins
Margules CR, Austin MP, Davies KF, Meyers JA and Nicholls AO (1998) The design of programs to monitor forest biodiversity: lessons from the Wog Wog habitat fragmentation experiment. In: Dallmeier F and Comiskey JA (eds) Forest Biodiversity Research, Monitoring and Modelling: Conceptual Background and Old World Case Studies, pp 183–196. Parthenon Publishing, Paris
Margoulis R and Salafsky N (1998) Measures of Success: A Systematic Approach to Designing, Managing and Monitoring Community-Oriented Conservation Projects. Adaptive Management Series, Biodiversity Support Program, Washington
Nordeco and DENR (1998a) Biodiversity Monitoring System Manual. DENR, Manila; Nordeco, Copenhagen
Nordeco and DENR (1998b) Integrating Conservation and Development in Protected Area Management in Northern Sierra Madre Natural Park, the Philippines. DENR, Manila; Nordeco, Copenhagen
Nordeco and DENR (1998c) Integrating Conservation and Development in Protected Area Management in Bataan Natural Park, the Philippines. DENR, Manila; Nordeco, Copenhagen
Nordeco and DENR (1998d) Integrating Conservation and Development in Protected Area Management in Mt. Kitanglad Range Natural Park, the Philippines. DENR, Manila; Nordeco, Copenhagen
Noss RF (1990) Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology 4: 355–364

OECD/DAC (1997) Capacity Development in Environment: Proceedings of a Workshop held in Rome, Italy, 4–6 December, 1996. OECD, Paris

PAWB-DENR (1998) The First Philippine National Report to the Convention on Biological Diversity. PAWB-DENR, Quezon City, Philippines

Pollisco-Botengan MA (1997) CPPAP Monitoring and Evaluation (M&E) Framework. DENR and NIPA, Inc., Manila

Pollisco W, Danielsen F, Nozawa C, Jensen A and Balete D (1997) Proceedings of Workshop on Monitoring Biodiversity in Protected Areas of the Philippines. SYLVATROP The Technical Journal of Philippine Ecosystems and Natural Resources 7: 101–104

Saberwal VK and Kothari A (1996) The human dimension in conservation biology curricula in developing countries. Conservation Biology 10: 1328–1331

Schaik CP van, Terborgh T and Dugelby B (1997) The silent crisis: the state of rain forest nature preserves. In: Kramer R, Schaik CP van and Johnson J (eds) Last Stand: Protected Areas & the Defense of Tropical Biodiversity. Oxford University Press, New York

Simberloff D (1998) Flagships, umbrellas, and keystones: is single-species management passé in the landscape era? Biological Conservation 83: 247–257

Thompson WL, White GC and Gowan C (1998) Monitoring Vertebrate Populations. Academic Press, San Diego

Vora RS (1997) Developing programs to monitor ecosystem health and effectiveness of management practices on Lakes States National Forests, USA. Biological Conservation 80: 289–302

Wangwacharakul V, Claridge G and Mather R (1996) Biodiversity Monitoring and Evaluation in the Lao PDR: Developing a Protected Area Approach. MIDAS Agronomics Co. Ltd., Bangkok

Weber FR (1990) Preliminary Indicators for Monitoring Changes in the Natural Resource Base. A.I.D. Program Design Evaluation Methodology No. 14. USAID, Washington, DC

Wells MP (1998) Institutions and incentives for biodiversity conservation. Biodiversity and Conservation 7: 815–835

Wilson JG (1994) The Role of Bio-indicators in Estuarine Management. Estuaries 17: 94–101

Wilson DE, Cole FR, Nichols JD, Rudran R and Foster MS (eds) (1996) Measuring and Monitoring Biological Diversity. Standard Methods for Mammals. Smithsonian Institution Press, Washington and London

World Bank (1992) Guidelines for Monitoring and Evaluation of GEF Biodiversity Projects. The World Bank, Washington

World Bank (1998) Guidelines for Monitoring and Evaluation for Biodiversity Projects. Environment Department Note No. 65. The World Bank, Washington

WRI, UNEP, UNDP and WB (1998) World Resources 1998–99, pp 320–321. Oxford University Press, New York, Oxford