THE IMPORTANCE OF ECOLOGICAL MONITORING FOR HABITAT MANAGEMENT - A CASE STUDY IN THE SABANGAU FOREST, CENTRAL KALIMANTAN, INDONESIA

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SUMMARY

Monitoring programmes to measure biodiversity and its threat status are globally recognised as crucial elements of any protected area management programme. In order to identify problems properly, target resources and achieve sustainable conservation outcomes, a well-structured, science-based monitoring and feedback system is essential. In the northern Sabangau Forest, Central Kalimantan, we are collecting data on forest structure, biodiversity and ape density and behaviour. Here we show how these can be used to monitor the condition of the forest and provide feedback to conservation managers on the effectiveness of habitat management/conservation activities in Sabangau.

KEYWORDS: peat swamp forest, biodiversity, monitoring, management

ECOLOGICAL MONITORING AS A CONSERVATION TOOL

The primary goal of conservation of a particular habitat is to maintain (or improve) the structure and integrity of that habitat, its plant and animal populations and the ecological processes and functions contained within. The effectiveness of conservation management actions – and the long-term success of these – must be evaluated against these objectives, which necessitates regular and rigorous scientific monitoring (Parrish *et al.,* 2003).

Monitoring programmes that include measurements of biodiversity and threat status are globally recognised as crucial elements of any protected area management program. An analysis of the effectiveness of 200 protected areas in 34 countries world-wide showed that a good monitoring and evaluation system was closely correlated to those protected areas where biodiversity was best being conserved (indeed, this had the best correlation of all variables investigated; Dudley *et al*., 2004). Without objective measurement, conservationists cannot claim success, learn from failures, or work effectively and efficiently toward the conservation of the remaining biological diversity of the planet (Parrish *et al.*, 2003).

Many conservation programmes fail to incorporate a rigorous monitoring and evaluation component, often owing to lack of funding or inadequate expertise (e.g., Hockings *et al.,* 2000). In order to identify problems properly, target resources and achieve sustainable conservation outcomes, a well-structured, thorough and science-based monitoring and feedback system is essential, particularly for long-term projects. The benefits of such a system come in many forms, including:

- Monitoring the effectiveness of management actions so that managers and government departments can identify problems and focus resources and efforts on addressing those problems.

- Identifying and understanding the threats facing the area (without effective monitoring only the most visible threats are apparent), the impact of those threats and the effectiveness of management strategies in preventing and mitigating the threats.
- Enabling the targeting of resources to conservation priority areas and/or problem regions.
- The ability to assess the effectiveness of conservation management programs and trial projects against a long-term dataset.
- Ensuring management plans are designed in accordance with all relevant scientific knowledge, and allowing them to be continuously assessed and altered as necessary.
- Justifying the success of specific conservation projects to grant-giving bodies and in requests for further funding.
- Obtaining essential information for inclusion in education and awareness programs.
- Judging the overall success of conservation actions in achieving its key objectives, which has implications for conservation projects elsewhere.

Monitoring biodiversity is best achieved by selecting a range of elements, processes and properties of the ecosystem, or 'indicators', that can be used to assess the condition of the environment or to monitor trends in condition over time (Dale & Beyeler, 2001). They can provide an early-warning system of changes in the environment, and can be used to diagnose the cause of an environmental problem or changes that cannot be measured in a more direct way (often for logistical, financial or technological reasons.) It is important to choose a representative sample of indicators and measures that characterize the ecosystem, yet are simple enough to be effectively and efficiently monitored and modelled (Dale & Beyeler, 2001). Suitable indicators include *keystone species* (those that have strong interactions with other species), *umbrella* species (those that require large areas of habitat and a wide range of ecological conditions that encompass other species), *flagship species* (those that can easily attract public support for conservation and are often the focus of conservation projects) and *resource-limited species* (those that require specific resources that may be in critically short-supply). Indicators are also found at other ecological levels, i.e. spatial distribution of communities over a landscape, species richness and evenness within a habitat, or parasite loads within organisms. A comprehensive conservation plan should thus include measures of indicators at several scales, to ensure that habitat integrity is preserved at every level (Carignan & Villard, 2002). These issues are discussed in detail by Dale & Beyeler (2001).

CASE STUDY IN THE SABANGAU FOREST, CENTRAL KALIMANTAN

The Sabangau Forest is a 568,000 ha area of tropical peat-swamp forest located between the Sabangau and Katingan Rivers in Central Kalimantan, Indonesia, which has recently been protected to conserve one of the largest and most important areas of lowland rainforest remaining in Borneo. The Sabangau Forest supports the world's largest population of Bornean orang-utan, - 6,900 individuals in an area of 578,000 hectares of peat-swamp forest (Singleton *et al.,* 2004), and one of the largest populations of the Bornean agile gibbon, *Hylobates albibarbis* (Cheyne *et al.,* 2007). Both species are at risk throughout their range from logging, conversion of forest for agriculture, fire and hunting. Thus, the Sabangau forest is crucial for the continued survival of these species.

Although the area has recently been given protected-area status, the forest is not immune from these problems, and there are many challenges ahead. The habitat has undergone many years of disturbance, including uncontrolled illegal logging, which has resulted in drainage of the area owing to the digging of timber-extraction canals. This, in turn, has led to lowering of the water table and increased frequency and severity of forest fires (see review in Harrison *et al.,* 2007a). Exploitation of the forest and its wildlife remains a concern; particularly as many of the surrounding populace formerly relied on logging as their major source of income (Smith, 2002). Whilst protection of this region represents a major commitment on the part of the Indonesian government to protect these species and their habitat, it is only a first step towards ensuring the longer-term conservation of the Sabangau, as the long-term effects of past habitat degradation are not yet clear, but are likely to be detrimental to the long-term integrity of the ecosystem unless mitigating activities are undertaken now. Although illegal loggers have now been ejected from many areas, abandoned illegal-logging canals are still draining the ecosystem, threatening peat collapse and more fires. Blocking these canals is therefore considered to be the single most important management action to save this important ecosystem. The *Centre for International Co-operation in the Management of Tropical Peatland* (CIMTROP) manage and protect the Natural Laboratory of Peat Swamp Forest (NLPSF, 50,000 ha) in the north of the Sabangau forest. Their Patrol Team was formed in 2003 with the objectives of stopping illegal exploitation of timber and other forest resources, damming illegal logging canals and extinguishing forest fires. The next phase is for management and research bodies to collaborate closely, for implementing a successful long-term management plan for the Sabangau forest.

Habitat and biodiversity research has been carried out in the Sabangau peat swamp forest since 1993 as part of CIMTROP's international research programme. Elements of this research have been chosen to make up a suite of indicators that are being used to monitor trends over time, including aspects of forest structure and dynamics, including regeneration processes, orang-utan and gibbon population densities, ape health by monitoring urine ketone levels (Knott, 1998; Harrison *et al.,* 2007b), and relative abundances of certain bird and butterfly species that show marked responses to disturbance. A number of monitoring locations have been established in the northern section of the Sabangau Forest, an area that covers a wide spectrum of accessibility and habitat quality, is subject to varying degrees of human pressure, and is the target of conservation management activities by CIMTROP. This research is being developed into an ecological monitoring system that will provide feedback to management agencies and provides a scientific foundation for conservation management of the Sabangau Forest and its priority ape populations. To illustrate this, three methods for monitoring the area are described.

Changes in forest biomass

A simple way of monitoring forest growth is to measure the basal area of trees in permanent plots. This provides an indicator of changes in biomass, whether positive or negative. Since 2003, measurements of the basal circumference of all trees ≥ 7 cm diameter at breast height in six forest plots (total area 0.9 ha) in the mixed swamp-forest sub-type have been made once every two years. Ten years of concession and illegal logging reduced the total basal area by ca. 20% in comparison to 1993 data (Shepherd *et al.,* 1997), but, since the cessation of logging in 2004, the forest has shown signs of recovery, with an overall increase in basal area/ha over this time (Table 1). Thus, the effectiveness of the CIMTROP Forest Patrol Unit has been demonstrated in preventing illegal logging in the northern Sabangau Forest since 2003.

Table 1 Changes in basal area/hectare in the Sabangau mixed-swamp forest between 1993 (pre-illegal logging) and 2007 (three years after the cessation of illegal logging).

Year	Basal Area (m^2 ha^{-1})
1993	50.0
2003	38.1
2005	39.9
2007	40.1

Changes in orang-utan density

Based on our research in Sabangau, we have earlier recommended that monitoring of orang-utan and gibbon populations should be an integral part of research into the effectiveness of conservation measures in areas where these animals are found (Husson & Morrogh-Bernard, 2003; Harrison *et al.,* 2007b). This recommendation was based partly on the suitability of these species as indicators of habitat change and partly owing to their "flagship" status. Monitoring densities is important as, although there is a time lag between disturbance and changes in density, these data are easily collected, easily understood by non-experts, and ultimately indicate the overall success of the conservation project in achieving its aim (i.e., to conserve large, viable populations) (Harrison *et al.,* 2007b). Our discussion here is limited to orang-utans, as this population has been monitored since 1995.

Orang-utan density is estimated by counting nests along straight-line transects (van Schaik *et al*., 1995). Orang-utans make a new nest each night for sleeping and sometimes another nest during the day for feeding or resting. The perpendicular distance from the transect to the nest is measured and orang-utan nest density estimated using the computer programme DISTANCE. Nest density can be converted to animal density using locally-obtained nest-building parameters (Morrogh-Bernard *et al.*, 2003). This is a quick, cost-effective method that uses indicators of presence, as opposed to actual counts of animals (which are very hard to see). Thus, orang-utan nest density is a suitable indicator of abundance that can be compared between sites and to monitor trends over time. Although orang-utans are long-lived animals with a long life history, and thus relatively slow to respond to disturbance, they are one of the main foci for conservation in the region and thus important to monitor.

We found dramatic changes in annual estimates of orang-utan density from 1995-2007 in the Sabangau mixed-swamp forest. Density declined dramatically between 1996 and 1999, owing to heavy illegal logging that reduced the availability of their preferred fruiting trees and displaced some individuals out of the diverse, food-rich mixed-swamp habitat into the depauperate low-pole habitat . These factors ultimately caused many orang-utans to die of starvation. Since 2004 and the cessation of logging and hunting activities, the orang-utan population in this habitat has started to increase, probably in response to the recovery of the forest and decreased human disturbance, as orang-utans will return to old disturbed areas when human disturbance has ended (Morrogh-Bernard *et al.,* 2003).

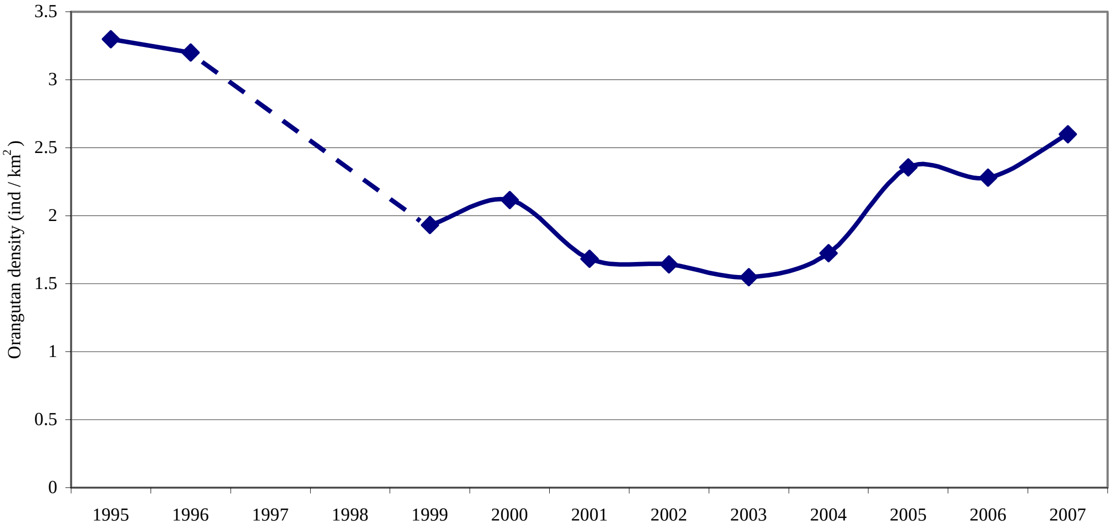

Figure 1 Changes in orang-utan density in the Sabangau mixed-swamp forest between 1995 and 2007. No surveys were carried out in 1997 or 1998.

Bird indicator species

The Sabangau has 201 species of bird recorded. Birds are a good group to use as indicators of forest growth and recovery as (i) several species show consistent responses to disturbance and forest recovery; (ii) many species have short life-histories and small ranges, and thus show early and measurable responses to changes in forest structure; (iii) most species are easy to detect by identifying their songs and calls; and (iv) different species show different responses to disturbance and forest recovery. Since 2005, we have surveyed relative bird abundance along transects in areas of different disturbance levels. Fourteen common species show significant preference for either disturbed forest ('positive indicators' – Figure 2) or undisturbed forest ('negative indicators' – Figure 3).

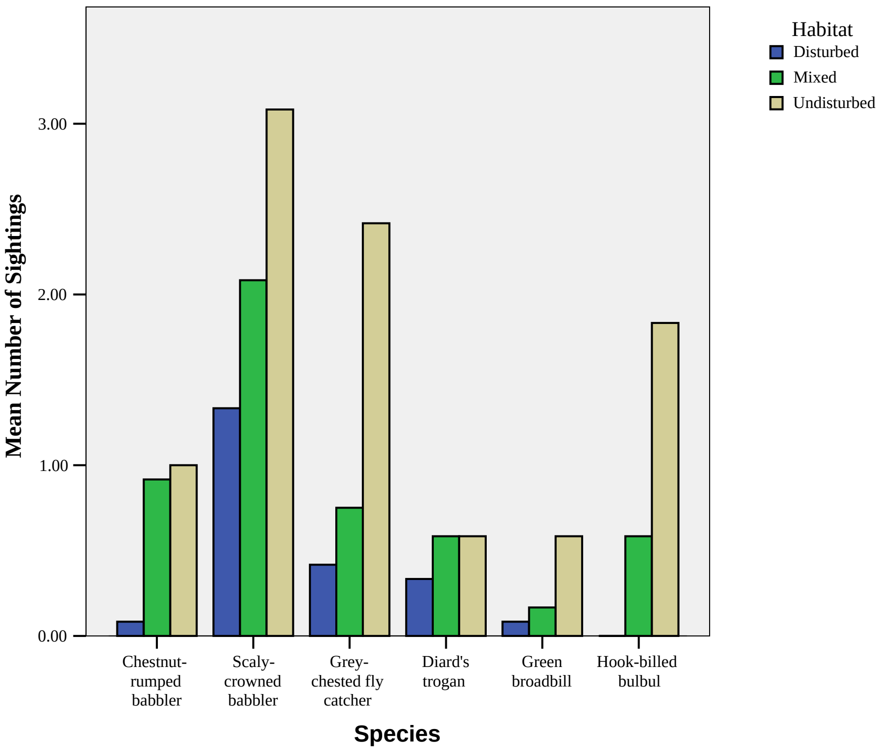

Figure 2 Bird species that show significant preference for undisturbed forest and thus act as positive indicators of forest quality

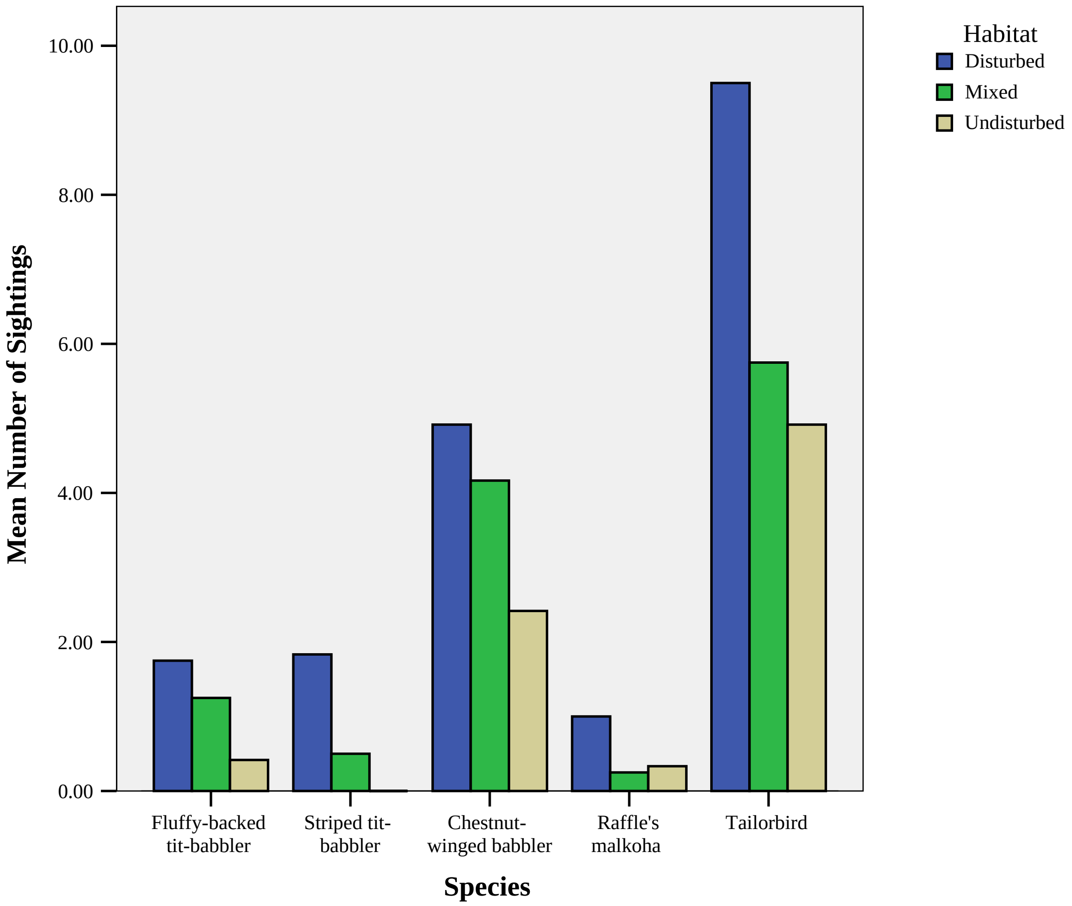

Figure 3 Bird species that show significant preference for disturbed forest and thus act as negative indicators of forest quality

CONCLUSIONS

Ecological monitoring is frequently neglected in protected-area management world-wide, but is crucially important to a project's success. Conservation projects need to have objective measurements with which to assess the success of the project and to adapt to changes, in order to properly manage the area and its species in the long term. Naturally, species and ecosystems manage themselves very successfully, but in this day and age, no tropical ecosystems are truly devoid of human interference and, consequently, conservation management is required. The Sabangau Forest is no exception. By monitoring changes in habitat quality and selected faunal indicator species, such as birds and primates, we will improve our ability to assess the effectiveness of conservation activities in the region and, hence, to justify further conservation efforts. To date, this research indicates that CIMTROP's conservation activities are aiding the forest's recovery, but restoring the area to its original, natural state will take continued investment of time and resources, particularly for damming canals, the top conservation priority for the area.

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