Ecological Monitoring: Its Importance for the Conservation of Biological Diversity in the Eastern Arc Forests

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Introduction

The Eastern Arc forests of Tanzania have been classified as one of the 14 most threatened tropical forest hotspots worldwide because of their unusual concentrations of endemic species and the significant threats facing them (Myers 1990, 1991). The Eastern Arc Mountains are for their size the richest site biologically in Tanzania. Although the closed forests of the Eastern Arc Mountains cover less than .2% (1,800 sq km) of the land surface of mainland Tanzania, these forests contain approximately 18% of all plants, 43% of all butterflies, 22% of all amphibians and reptiles, 26% of all birds, and 24% of all mammals found in mainland Tanzania (Newmark in prep.). Possibly even more importantly, these forests contain one of the highest proportions of endemic species of any region in Africa. Approximately 25% of plant species, 82% of linyphiid spider species, 39% of butterflies species, 66% of herpetofauna species, 28% of montane bird species, and 7% of mammals species are endemic to the Eastern Arc mountains (Newmark in prep.). Furthermore, the Eastern Arc forests contain the majority of the globally endangered, vulnerable, and rare mammal and bird species and subspecies found in mainland Tanzania (Newmark in prep.).

As a result of their unusual diversity and endemism, there has been considerable interest both nationally and internationally in conserving the biological diversity of the Eastern Arc Mountains. A number of projects have been implemented (e.g., East Usambara Forest Catchment Project, East Usambara Agriculture and Conservation Projects, and proposed Ambangulu Conservation Project) and protected areas established (e.g., Udzungwa National Park and proposed Amani Nature Reserve) in the last 10 years to conserve biological diversity in the Eastern Arc forests. The long-term success of these projects and protected areas is dependent upon reducing human pressures upon the forests, increasing the effectiveness of forest management, and developing a more complete understanding of the ecological dynamics of these forests. Ecological monitoring is central to particularly these latter two requirements.

The purpose of this paper is to briefly highlight the useful role that ecological monitoring can play as part of a broader program of activities to conserve biological diversity and to discuss current and planned ecological monitoring activities in the East Usambaras.

Broad-scale Strategies for Conserving Biological Diversity

Biological diversity is the natural variation in genes, populations, species, communities, ecosystems, and landscapes (Wilson 1988). This variation changes both through space and time. In addition, this variation is a result of the interaction of organisms with their environment of which such ecological and evolutionary processes as predation, competition, nutrient cycling, energy flows, succession, pollination, disturbance, dispersal, and movement are particularly important. Thus the conservation of biological diversity requires not only conserving the spatial and temporal dimensions of biological diversity but also maintaining the ecological and evolutionary processes upon which this natural variation is dependent.

In principle, information and activities required to conserve biological diversity does not differ from that required to conserve most other resources. That is one must know: (1) the location of the resource; (2) the abundance of the resource; (3) changes in the abundance of the resource over time; and (4) factors responsible for changes in abundance in the resource over time.

The process of documenting the location and relative abundance of biological diversity may be thought of as inventory, while that of identifying the temporal variation in biological diversity and factors responsible for this variation can be considered as ecological monitoring.

Importance of Ecological Monitoring for Forest Management

Ecological monitoring is important for forest management for a variety of reasons. First, ecological monitoring can provide advanced warning of undesirable ecological change and thus permit managers to adopt an adaptive management approach to conserving biological diversity. Given the complexity of tropical forest ecosystems, following an adaptive management approach is essential. Secondly, ecological monitoring is a necessity in order to objectively evaluate whether project or protected area objectives of conserving biological diversity are being achieved. One of the major short-comings of most of the early integrated conservation and development projects has been the absence of a comprehensive ecological monitoring program (Kremen et. al 1994). Thirdly, ecological monitoring is a necessity in order to evaluate the long-term impacts of human activities and disturbance on biological diversity. This is particularly true because there is often a lag between a disturbance event and a subsequent response. Fourthly, ecological monitoring can provide important insights into the functioning of complex ecosystems. Understanding the ecological dynamics of a forest is a perquisite to developing sustainable forest practices.

Important Considerations in Designing an Ecological Monitoring Program

Prior to implementing any ecological monitoring program, there must be clear objectives and hypotheses. For the Eastern Arc forests, two obvious objectives of an ecological monitoring program are: (1) to enhance the understanding of the ecological dynamics of the forests; and (2) to evaluate the impact of human activities and disturbance on populations, species, communities, and landscapes. In relationship to the latter objective, a null hypothesis is that human activities do not adversely affect biological diversity while the alternative hypothesis is that human activities do adversely affect biological diversity.

Ecological Indicators

Identifying what to monitor can be simplified if indicators of various functional and organizational levels can be identified (Noss 1990, Hellawell 1991). Identifying species and suites of species which are representative of various functional groups (primary producers, primary consumers, secondary consumers, tertiary consumers) is a strategy which has been frequently advocated (Kremen et. al 1993, 1994). In many cases, the suitability of

species or suites of species as indicators of change may need to be pretested. In many tropical forests, epiphytes and orchids (Turner et. al 1994), butterflies (Hill et. al 1995), termites (Collins 1980), and dung beetles (Klein 1989), understory birds (Johns 1986, Newmark 1991, Thiollay 1992) and primates (Skorpua 1986, Weisenseel et. al 1993) have been found to be particularly sensitive to human disturbance and thus are useful indicators of ecological change.

Current and Proposed Ecological Monitoring in the Usambaras

Since 1987, I have been monitoring annually understory bird populations on an archipelago of nine forest fragments and an adjacent control site in the East Usambaras. In 1989, I initiated a parallel study on a second archipelago of four forest fragments and an adjacent control site in the West Usambaras. The broad objectives this research are to evaluate the impact of forest fragmentation on understory bird communities; and to gain a greater understanding of the population dynamics of tropical forest birds. Specific objectives of this research are to examine (1) the metapopulation dynamics of understory bird communities on two archipelagoes of forest fragments whose total size are nearly identical but whose fragments differ in average size and distance from a control site; (2) variation in understory bird survivorship, natality, and movement within the two archipelagoes and across individual forest fragments; (3) how temperature, humidity, luminescence, and vegetation structure varies from forest edge to the interior and its relationship to the distance that understory birds species are encountered from the forest edge; and (4) the impact of past selective logging upon understory bird communities.

Understory birds in the Usambara Mountains are quite sensitive to forest disturbance and thus appear to be good indicators of ecological change. However our understanding of the dynamics of forest ecosystems and the impact of human disturbance on biological diversity could be enhanced if additional suites of species which are representative of other functional groups are also simultaneously monitored. Efforts are currently under way through the support of the MacArthur Foundation to develop a more comprehensive ecological monitoring program in the East Usambaras which will include additional functional groups and organizational scales.

Acknowledgements

Support has been provided by the John D. and Catherine T. MacArthur Foundation (#95-33728A).

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