ECOSYSTEM BIODIVERSITY IN LOWLAND TROPICAL RAIN FORESTS OF CENTRAL AMERICA: CHARACTERISATION AND APPLICATIONS TO LAND MANAGEMENT

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Resumen
El nivel de ecosistemas es importante en la medición de biodiversidad y en la planificación tanto para la conservación, como para el manejo forestal. No obstante, estudios sistemáticos de la biodiversidad de ecosistemas en centroamérica y su potencial para la planificación, raras veces avanzan más allá de las formaciones naturales determinadas por la variación macroclimática. Dichas formaciones pueden ser subdivididas a diferentes niveles jerárquicos, en relación a la distribución de impactos de huracanes, regímenes extremos de humedad del sustrato, y variaciones locales de las condiciones del mismo. Un análisis preliminar indica lagunas en la cobertura de la biodiversidad regional en las áreas protegidas. La diferenciación de tipos de bosque dentro de unidades de manejo forestal en la región puede ser marcada, siendo posiblemente más evidente en el sotobosque. Entre los métodos prácticos que pueden emplear los administradores de bosque para la identificación de tipos de bosque figura el análisis de datos de inventario en relación a tipos de suelo o unidades fisiográficas.

Introduction

General

Although biodiversity is a multifaceted concept, most discussion of it continues to focus on species (Heywood et al., 1995). Sustainable land management requires action at the ecosystem and landscape levels, however, and the diversity of ecosystems is the appropriate measure of biodiversity at these levels (see review by Finegan et al., in press). Furthermore, the identification and mapping of different ecosystems is a fundamentally important tool in both natural forest management - for planning purposes - and in conservation through the so-called "coarse filter" approach, now considered to be one of the most effective strategies for the conservation of species (Hunter, 1991). Finegan et al. (in press) argue for the application of a coarse filter approach to the assessement of biodiversity conservation in forest management units using Criteria and Indicators (C & I).

Ecosystems are most usefully described and delimited on the basis of their species composition and structure. Ecosystem biodiversity may be measured, and management of forests for production and conservation planned, on the basis of parameters such as the number, variety and spatial arrangement of different forest types within the immediately superior hierarchical level (Finegan et al., in press). The present paper outlines a preliminary synthesis concerning regional-level ecosystem biodiversity in Central American lowland rain forests, and presents a detailed case study at the forest management unit (f.m.u.) level. The potential application of this information to land management planning in the region is discussed.

Ecosystem biodiversity of Central America lowland rain forests

Ecosystem biodiversity is universal in tropical forests, though scientific discussion as to its nature and underlying causes continues (Condit, 1996). The ecoregion (Dinerstein et al. 1995) is currently seeing some use as a land unit for planning in tropical America, but is too broad for many purposes related to biodiversity assessment, conservation planning and forest management for production. We concentrate on the Central American Atlantic Moist Forest, the most extensive lowland rain forest (LRF) ecoregion in Central America (Dinerstein et al., 1995).

This ecoregion stretches from western Panama to Belize and Guatemala and was apparently delimited simply on the basis of existing maps of Holdridge's climatically-defined tropical moist, wet and rain forest Life Zones. Although no formal synthesis of information appears to have been attempted, ecosystem biodiversity within this ecoregion may be identified in relation to biogeographical factors, disturbance regimes and substrate variation. Frequent hurricane impacts in forests of the north-western half of the ecoregion probably contribute markedly to the diversity of forest types within it. LRF of southern Nicaragua, Costa Rica and western Panama is quite well-documented regarding forest types, though no formal attempts at synthesis appear to have been made.

As in all tropical regions, this LRF may usefully be divided into that of well-drained soils on undulating or hilly terrain, and that of seasonally or permanently flooded areas ("wetlands") (Whitmore, 1984). Both these broad categories show marked internal heterogeneity at different scales. Forest of well-drained soils is usually dominated by *Pentaclethra macroloba*, for example, though the characteristic canopy species associated with *Pentaclethra* on old alluvial terrace are different from those of residual soils on hills (personal observations of the authors). Wetland forests have their own characteristic dominants, such as *Carapa guianensis* and *Pterocarpus officinalis*, with dominance by palms such as *Raphia taedigera* in the wettest areas (personal observations of the authors; Myers, 1981). At more local scales, forest composition may vary markedly in relation to topographic position (Sections 2-4) or, in wetland forest, factors such as microrelief, local drainage and water flow (Myers, 1981).

Methodology

The study was carried out at CATIE's La Tirimbina Key Site for long-term research and had the objective of determining the relationships of species abundance and stand composition to a topographical gradient. A full description of this site and its silvicultural experiment is given by Finegan and Camacho (in press). The site is located in northeastern Costa Rica in Holdridge's tropical wet forest life zone at 160-220 m.a.s.l. Topography is of low hills and soils are Ultisols, deep, well-drained but of very low fertility. Experimental units are nine 3.24 ha square plots in three contiguous blocks of three. In the centre of each is a square 1,0 ha permanent sample plot (PSP). Each complete PSP was divided into 20 m x 20 m subplots and all trees and palms $\geq$ 10 cm dbh (the "overstory") enumerated, but not lianas. All individuals $\geq$ 2.5 cm – 9.9 cm dbh, including lianas (the "understorey") were sampled in eighty square subplots of 5 m x 5 m, distributed randomly within each of six of the nine 1.0 ha PSPs. For both sizes of subplot, for both size-classes, topographical position of each subplot was identified as one of three categories: hilltop, valley bottom, and slopes.

For both size-classes of vegetation, mean values per subplot of the abundances of all individual species represented by ≥ 20 individuals were calculated for each topographical position for each PSP and used in statistical analyses.

Results

Of 54 individual sp:cies tested for the overstory, 25 showed significant differences of abundances between topographical positions, among them being most of the characteristic dominant species of the forest (all comparisons for both size-classes ANOVA, $P < 0.05$). *Pentaclethra macroloba* was the most abundant species in all three topographical categories, although it was significantly more abundant on hilltops and slopes than in valley bottoms (Tukey test, $\alpha < 0.05$).

The characteristic overstorey species associated with *Pentaclethra* on hilltops were quite different from those of valley bottoms, and the Czekanowski similarity coefficients confirm this impression of marked compositional variation, showing intermediate similarities between slopes and the other two habitat types, but low similarity between hilltops and valley bottoms (Table 1). The distributions of several species, such as *Lonchocarpus oliganthus*, a species of wet valley bottoms, were clearly related to the topographical gradient, although statistical testing was not carried out because of small sample sizes.

For the understorey, 18 species of 47 tested showed significant variation of abundances between topographical positions. These included many of the most abundant species and the compositional contrasts between hilltops and valley bottoms were particularly marked, the very distinctive understoreys of both being characterised by palms: *Geonoma congesta* on hilltops, and *Prestoea decurrens* in valley bottoms. Values of the Czekanowski coefficient were lower than for the overstorey, with the lowest value found in this study being that between the understories of hilltops and valley bottoms (Table 1).

Table 1. Degree of compositional similarity (Czekanowski's similarity coefficient: values of this coefficient vary between 0.0 for no similarity, and 1.0 for identical composition) between the vegetation of different topographical position, in two size-classes of vegetation; tropical wet forest managed for timber production, La Tirimbina, northeastern Costa Rica.

Topographic position	**Slope**		**Valley bottom**	
	Over[1]	Under[1]	Over	Under
Hilltop	0.71	0.56	0.48	0.27
Slope		-	0.61	0.42

[1] Terms refer to overstorey (vegetation ≥ 10 cm dbh) and understorey (vegetation ≥2.5 – 9.9 cm dbh)

Discussion and conclusions

Ecosystem biodiversity as a concept, and ecosystem maps as a planning tool, have been criticised because the limits of ecosystems are not distinct in space or time, while sophisticated techniques are supposedly necessary for their identification (Boyle and Sayer, 1995). Nevertheless, these factors have not impeded the development and application to management of maps of forest types in many regions of the world, and should not be allowed to do so in Central America; the methodological objection is simply incorrect (Finegan et al., in press).

It is evident that further research could provide a much more comprehensive information base on ecosystem biodiversity of Central America. Even a tentative subdivision of the Central American Atlantic Moist Forest ecoregion (Section 1.2), however, indicates probable gaps in the coverage of forest types by national systems of protected areas. Some types of wetland forest of Costa Rica and Panamá, for example, have been extensively cleared for permanent agriculture and forest management projects may turn out, in the long run, to make a significant contribution to their conservation.

The spatial distributions of different forest types in f.m.u.s, as illustrated in this paper, may be revealed in a practical way by analysis of forest inventory data, by the use of easily-identified indicator species such as palms, or by simple land classifications based on physiography and soils (Finegan et al. in press). Overall, we believe that the conservation of biodiversity at regional and landscape levels, and the management of f.m.u.s for both production and conservation, will be improved by planning based on better knowledge of Central American ecosystem biodiversity.

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