PN-AAQ-713
ISN. 36036

6-3-3

Biological Conservation 27 (1983) 45–58

A Method for Siting Parks and Reserves with Special Reference to Colombia and Ecuador

John Terborgh & Blair Winter

Department of Biology, Princeton University,
Princeton, New Jersey 08544, USA

YALE FORESTRY LIBRARY

ABSTRACT

Many tropical countries contain large numbers of species with small geographical ranges, here, for convenience, termed endemics. South America, for example, harbours 440 endemic land birds having ranges of less than 50 000 km². These comprise about a quarter of the terrestrial avifauna of the continent. Such species are exceptionally vulnerable to deforestation and their preservation will require siting future parks or reserves in just the right places. Using Colombia and Ecuador as an illustration, we describe a simple procedure for locating areas of concentrated endemism that would be optimal for future protection. Unfortunately, there is little correspondence between the points of maximal endemism and the locations of existing and projected reserves in the two countries. The advantages and limitations of using satellite photos for habitat evaluation in centres of endemism are also discussed.

INTRODUCTION

Until very recently most national and regional parks were created to preserve outstanding scenic or recreational values. With the major exception of the great African game parks, the preservation of natural biotic diversity was usually only a secondary or incidental consideration. It is now abundantly clear that new parks must be designed specifically to protect species from habitat destruction. If not, we face the startling

Biol. Conserv. 0006-3207/83/$03·00 © Applied Science Publishers Ltd, England, 1983.
Printed in Great Britain

prospect of losing a sizeable fraction of the world's plants and animals within the next few decades (Myers, 1979). Most of these will succumb to the effects of uncontrolled deforestation, a process that threatens to destroy nearly all the remaining primary vegetation in most tropical countries by the end of this century (National Research Council, 1980).

Species with small ranges are unusually vulnerable to habitat destruction. Any such species that happens to inhabit a densely populated area or a zone of high soil fertility can potentially be eliminated before the

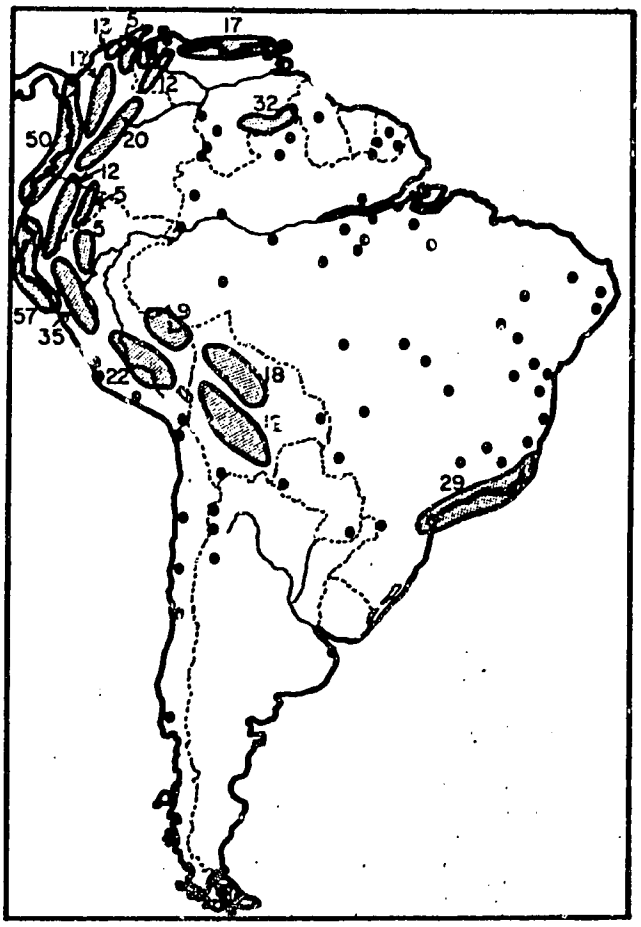

Fig. 1. Map of avian endemism in continental South America. Endemics are arbitrarily defined as species with ranges of less than 50 000 km^2. Stippled areas are regions of concentrated endemism deserving special attention from conservationists. Figures beside each area indicate the respective number of endemics; others are located by the scattered points.

conservation community even has time to react. The seriousness of this problem can be put into perspective by comparing the bird faunas of a predominantly tropical continent—South America, and a temperate continent—North America. If a 'small range' is arbitrarily defined as any distribution encompassing less than 50 000 km^2 (roughly the combined area of Vermont and New Hampshire), then a survey of the best available distributional accounts shows that South America has approximately 440 species that meet the criterion, while North America has only eight (Fig. 1: Meyer de Schauensee, 1966; Robbins *et al.*, 1966). In the case of South America, the 440 species represent roughly a quarter of the resident land birds of the continent, while in North America, species with small ranges, hereafter referred to as endemics for convenience, comprise less than two percent of the terrestrial avifauna. Consequently, a conservation programme for North America could afford to overlook or ignore endemics with only relatively minor repercussions; to do so in South America would put at risk a major fraction of the fauna. Saving endemics from extinction will require siting reserves, not necessarily large ones, in just the right places. How to go about selecting the most appropriate locations is the subject of this article.

COLOMBIA AND ECUADOR: AN EXAMPLE

For concreteness we shall proceed by way of an example. For several reasons, Colombia and Ecuador are particularly appropriate for a detailed analysis of endemism; both countries contain large numbers of highly localised species; both are experiencing rapid deforestation, particularly in areas where endemics are found; and both have conservation programmes that are at an early stage of development. By knowing the pattern of spatial overlap of endemics, it would potentially be possible to locate future reserves optimally in the areas of most concentrated endemism.

The first step was to compile a list of Colombian and Ecuadorean endemic birds from a comprehensive summary of distributional information (Meyer de Schauensee, 1966). The list included 156 species whose described ranges appeared to cover less than 50 000 km^2, the same criterion that was mentioned above. It is a notably heterogeneous collection of species. Among them are representatives of many avian families: pigeons, parrots, hummingbirds, barbets, ovenbirds, antbirds, tanagers, finches, etc. To obtain more precise locality information, as well

3

as details about elevational ranges, habitat preferences and relative abundance, we examined, either personally or by proxy, the labels of all the specimens of all 156 species in nine major collections: Museum of Comparative Zoology (Cambridge, Mass.), American Museum of Natural History (New York, NY), Peabody Museum (New Haven, Conn.), Field Museum of Natural History (Chicago, Ill.), Academy of Natural Sciences (Philadelphia, Pa.), US National Museum of Natural History (Washington, DC), Museum of Zoology at Louisiana State University (Baton Rouge, La.), Moore Laboratory of Zoology, at Occidental College (Los Angeles, Cal.), and Museo de la Universidad del Valle (Cali, Colombia). This, obviously, was a major undertaking. In retrospect, there proved to be less information on the labels than we had initially hoped, and so the museum searches did not pay off from a cost/benefit standpoint. However, extension of the analysis to other taxa (e.g. mammals, reptiles, plants, etc.) would unavoidably require surveying museum collections, as comprehensive compilations of species distributions do not exist for these groups. The widespread lack of such compilations poses a serious impediment to conservation planning in many parts of the world.

Following the acquisition of distributional data, the next step was to prepare accurate range maps for the 156 species. The ranges were based primarily on locality data taken from examined specimens, supplemented with additional records reported in the literature and supplied by several knowledgeable individuals who examined early versions of the maps. In spotting the collecting localities on blank topographic maps we were greatly aided by the existence of a gazetteer of ornithological collecting localities in Colombia (Paynter & Traylor, 1981). Ecuador, for which a gazetteer was not then available, proved to be far more difficult. Outlined ranges, as represented on the final maps, encompass all known localities and stay within recorded elevations. Wherever there were major breaks in the continuity of known localities, we took the conservative course and excluded the unoccupied regions from the outlined ranges. This policy had the effect of somewhat overestimating disjunctions and underrepresenting probable ranges, errors we deemed preferable to those produced by the alternative policy of liberally incorporating into the ranges areas where perhaps the species do not occur. The conservative policy minimised the latter type of error which we felt was inimicable to a conservation objective. Many of the individual range maps are presented in another publication (Terborgh & Winter, 1982).

4

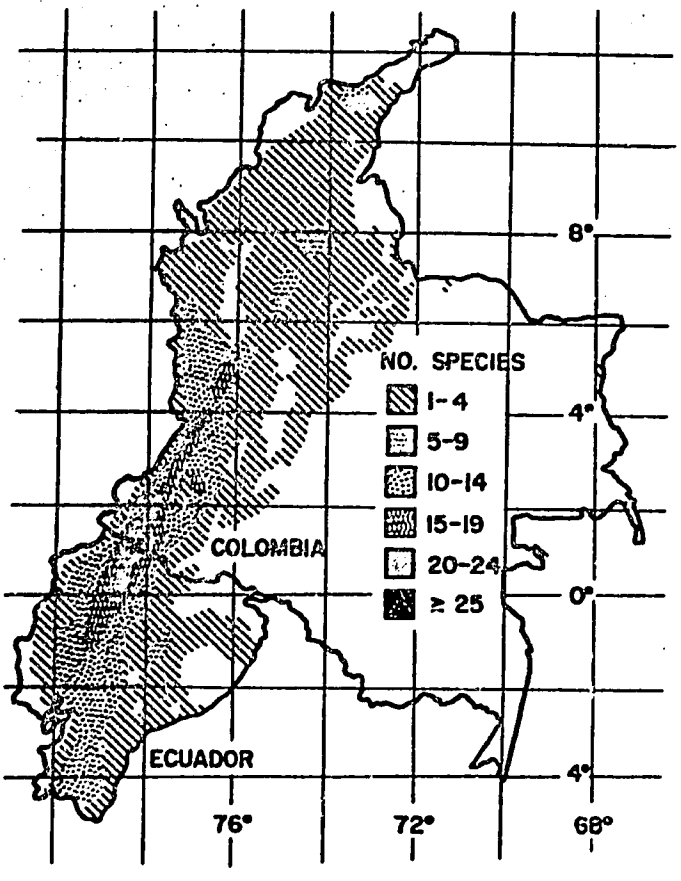

Fig. 2. Concentration map of 156 endemic land birds in Colombia and Ecuador.

YALE FORESTRY LIBRARY

The final step in the procedure was to produce a concentration map of endemics by superimposing the 156 separate range maps (Fig. 2).

SITING OF PARKS AND RESERVES

The zones of maximum overlap in the ranges of endemics, directly displayed in the concentration map, are obviously strategic sites meriting protection in a rational conservation plan. High concentrations of endemics occur in several distinct portions of Colombia and Ecuador (listed in descending order of importance): the base of the Western Andes on the border between the two nations, at the base of the Western Andes

5

in Valle, in the Western Andes themselves in Cauca and Caldas, at mid-elevations in the Santa Marta range, in the Serrania de Baudo, at the northern end of the Central Andes and in the adjacent humid lowlands of Antioquia, and in the Napo region of eastern Ecuador. Another concentration not readily discerned on the map is in the dry forest zone of southwestern Ecuador. (It is not distinguished by surrounding contours because the total number of endemics remains nearly constant over the whole distance between the wet and dry portions of western Ecuador. There is, however, a complete species turnover among the endemics between the wet and dry ends of the gradient.)

One region that has been conspicuously slighted by the procedure is the Amazonian lowlands. Although the avifauna of western Amazonia is the richest in the world, it contains few species that meet the 50 000 km^2 criterion for endemism. This is simply because there are very few barriers to dispersal in the almost featureless terrain. In fact there are many species of restricted occurrence in Amazonia, but most of them have comfortable distributions encompassing hundreds of thousands or millions of km^2. Concentration maps similar to ours showing the location of endemic birds in Amazonia have been published by Haffer (1974, 1978).

Although nearly all of the 156 species considered here occur near or in mountainous terrain, no simple statement can characterise their geographical circumstances. Some occupy isolated mountain peaks (Santa Marta) or ridges (Serrania de Baudo), others occur in disjunct pockets of xeric habitat (coastal zone of SW Ecuador, upper Cauca Valley), but the great majority inhabit montane forests along the principal Andean ranges. The distributions of many of the latter species abut on those of parapatric congeners that occupy similar elevational zones elsewhere in the Andean chain, either to the north and/or to the south. In these cases, the barriers to dispersal appear to be biological rather than physical. For a more comprehensive analysis of the distributions of these species, the reader is referred to Terborgh & Winter (1982).

High concentrations of endemism may or may not occur in areas of exceptionally high diversity. In the case of isolated pockets of habitat such as mountain peaks or dry intermontane valleys, it seems probable that the overall diversity is low. On the other hand, endemics located within regions of presumed Pleistocene forest refugia contribute to the very high diversity of these areas (Haffer, 1978). Elsewhere, such as in the montane

6

forests of the main Andean chain, it is not known whether the points of greatest endemism coincide with areas of higher than average faunal diversity. In any case, the question is largely irrelevant, for it is the distinctive character of the faunas of centres of endemism that is of interest, not diversity *per se*.

Identification of centres of endemism is important because of the potentially favourable cost/effectiveness of reserves in these areas. Within just a few well-located reserves it may be possible to protect a majority of a country's endemic species. By assigning top priority to the richest area, and then proceeding to the next richest, etc., one would be following a plan that was both rational and expedient. The more idealistic goal of protecting all the endemics in an avifauna as rich as that of Colombia (> 1650 species) is clearly unrealistic, as it would require a programme so ambitious as to be wholly impractical. Simply to ignore endemics, however, would be to deny that they have any special value. To the contrary, from the standpoint of winning popular support for conservation, endemics undoubtedly have an exceptionally high value, for it can be made a point of national pride that they are a unique part of the country's patrimony. A system of reserves designed to protect endemics would, of course, carry the subsidiary benefit of protecting a great many additional species as well.

The pattern of endemism in Colombia and Ecuador (Fig. 2) suggests cause for both optimism and pessimism: optimism because a large majority of the endemics can potentially be protected in a few well-situated reserves, pessimism because virtually none of the crucial areas are contained within the existing or projected park systems of either country (compare Fig. 3: Meganck, 1975; Gentry, 1977; Wetterberg *et al.*, 1978). It is particularly ironic, for example, that there should be a park in the Santa Marta range which preserves the habitat above 4000 m elevation, while all 12 of the endemic birds of that range frequent unprotected montane forests at lower elevations (Meganck, 1975).

It is a relatively easy matter to identify a location on a map and decide that is where there should be a reserve, but because of conflicting cultural, political or economic considerations, it is certain to be far more difficult to translate the recommendation into concrete action. For this reason we would like to amend our academic approach with a few practical comments and suggestions.

One important consideration is the size of reserves that would be needed to protect endemics. On this crucial point it is essential to specify

YALE FORESTRY LIBRARY

Fig. 3. Map of existing and projected national parks and equivalent reserves in Colombia and Ecuador (from Wetterberg *et al.*, 1978).

the main purpose in advance of land acquisition. If the purpose is to preserve an entire ecosystem that may include bears, harpy eagles, jaguars, nomadic white-lipped peccaries, or other species with large spatial requirements, then sizeable areas on the order of thousands of square kilometres will be required (Terborgh, 1976). Large reserves must, of necessity, be located in remaining tracts of wilderness. In view of the fact that large areas of wilderness are becoming increasingly scarce, there is unlikely to be much choice of location anyway. For this reason it can be presumed that large reserves will generally not be located in areas of high endemism.

For the preservation of endemics, the location of reserves will usually be far more critical than their size. Endemics are typically small-bodied

creatures with modest spatial requirements and moderate to high population densities where they occur. Relatively secure populations of 1000 individuals or more might commonly be retained within areas of 10 to 100 km^2. Of course, more is better, especially when several endemics with slightly differing habitat requirements are to be contained within the same area.

A comprehensive conservation plan for any country would ideally include a mix of large reserves for preserving representative ecosystems, and small special-purpose reserves for protecting endemics as well as other highly localised biotic phenomena such as rookeries, migration funnels or sea turtle nesting beaches (Terborgh, 1974).

Another practical issue is that of multiple use of areas designated as reserves for endemics. Certain types of use are obviously compatible, such as watershed protection for reservoirs or hydroelectric projects. Hunting may be permissible if the species being conserved are too small to be of interest as game. Limited exploitation of the habitat for shifting cultivation or selective timber harvest might not be detrimental in some instances, but the intensity of exploitation would have to be strictly regulated. A flexible policy is clearly most likely to be politically acceptable, but in all cases the habitat requirements of the species to be protected should be taken into account before decisions are made.

An important implicit assumption in the procedure described here is that the pattern of endemism brought out by studying one taxonomic group, birds in this case, will be paralleled in other groups. Regrettably, there are few data available to test this assumption for Colombia and Ecuador. Some reinforcement of the pattern shown by birds is to be found in the reports of Gentry (1977, 1979) that the Pacific lowlands west of the Andes contain large numbers of endemic plant species. In the Amazonian region there is widespread concordance in the patterns of endemism in several disparate taxa (birds, *Heliconius* butterflies, frogs, lizards, certain plant families, etc.: references in Prance, 1982). The coincident foci of endemism are interpreted as indicating the approximate locations of forested habitat during intermittent dry periods in the Pleistocene when it is presumed that much of Amazonia was covered by non-forest vegetation. There is, however, no such mechanism yet known or hypothesized to operate on the Andean slopes that would result in concordant patterns of endemism in the montane biota. Although the issue merits serious investigation, any attempt to resolve patterns would be severely hampered by the fact that the distributions of Andean species

YALE FORESTRY LIBRARY

in most major taxa are inadequately known. Even in birds, which are unquestionably the best known group, major range extensions, often of hundreds of kilometres, are being documented for South America every year. In many other groups the available information is very spotty indeed, and scores of species are known only from the type specimen or type locality. So, until urgently needed faunal and floral surveys of tropical countries are completed, one is unavoidably confined to working with birds, and for the sake of planning reserves, it must be hoped that other groups will parallel birds in their patterns of endemism.

HABITAT EVALUATION

Once presumptive evidence for the existence of centres of endemism has been obtained from museum and literature surveys, it would be desirable to confirm the actual presence of the species in question in whatever tracts of natural vegetation may remain within the implicated area. Field surveys, however, are both expensive and time-consuming, and may not always be practical. Remnant tracts of forest are often located on steep ridges that are inaccessible to any conveyance. Reaching them may require hours of arduous hiking, or hiring pack animals for expeditions of several days. In extreme situations it may be necessary to presume the presence of endemics on the basis of distributional evidence, and to recommend for protection areas that have not yet been studied biologically. The necessary information for making such decisions can potentially be obtained from air or satellite photos.

For this reason, we attempted to procure high-resolution satellite images of all of Colombia and Ecuador to complement the present study. Our efforts were met with certain frustrations, and were only partially successful, so it might be helpful to describe some of the factors that limit the utility of satellite images for habitat evaluation.

Perhaps the most severe of these was our failure to obtain any images whatsoever of the western slope of the Andes or the Pacific coastal lowlands. This is a region of intense year round rainfall, with annual accumulations of more than 10 m at some stations. The whole region must be under clouds much of the time, for none of the images available met the specified criterion of less than 30 % cloud cover. (Higher values of cloud cover render the pictures almost useless for interpretation.) The

10

second major frustration came in interpreting the pictures we did obtain, especially ones of mountainous terrain. Whether the landscape was forested or not could easily be discerned in the lowlands, where the boundaries of clear cuts are sharp and conspicuous, but on steep slopes the vertical angle of view results in a foreshortening of the terrain with a consequent reduction in resolvable detail. Nevertheless, densely settled districts and agricultural land are readily distinguished, even in mountainous topography. Another problem affected shots taken at low sun angles. Long shadows cast by ridges often obscured much of the scene. In view of these rather serious limitations of satellite imagery, we recommend that air photos be the medium of choice wherever available.

The initial motive in acquiring satellite images was the hope of being able to pinpoint remaining tracts of natural vegetation within the areas of concentrated endemism. For the reasons described above, this part of the project did not succeed. Visual inspection of the images provided only a general indication of the intensity of use of the landscape (Fig. 4). Virtually the entire Andean plateau and the many intermontane valleys are densely settled and have been largely, if not completely, deforested. The foothill region at the eastern base of the mountains has been less systematically exploited, but is currently being colonised at a rapid rate. Large sections of the eastern slope itself, corresponding to the cloudforest belt between 1000 and 3000 m, are still intact, as is nearly all of the forested lowland plain of the Amazon basin. Farther north, the Colombian llanos are subjected to cattle grazing and periodic burning (visible in the satellite photos), while the whole area of the lower Cauca and Magdalena valleys in northern Colombia supports a dense human population and is under intensive use.

While much detail has been passed over in this rough sketch, it is nevertheless clear that the natural vegetation of major portions of the two countries has been wholly destroyed or substantially modified. Endemics occur, or once did, over most of the affected area. Without on-the-spot checks, or any knowledge of which species may be able to tolerate alterations in the natural habitat, it is difficult to make a precise statement as to how many endemics may be endangered, if not already extinct. About a third of the species investigated, approximately 50, occupy areas that have been almost totally deforested. One can presume that many of these are under imminent threat of extinction; a number of them may already have disappeared. It is probably still possible to save many of the threatened ones, but there is no time to lose if we are to succeed.

YALE FORESTRY LIBRARY

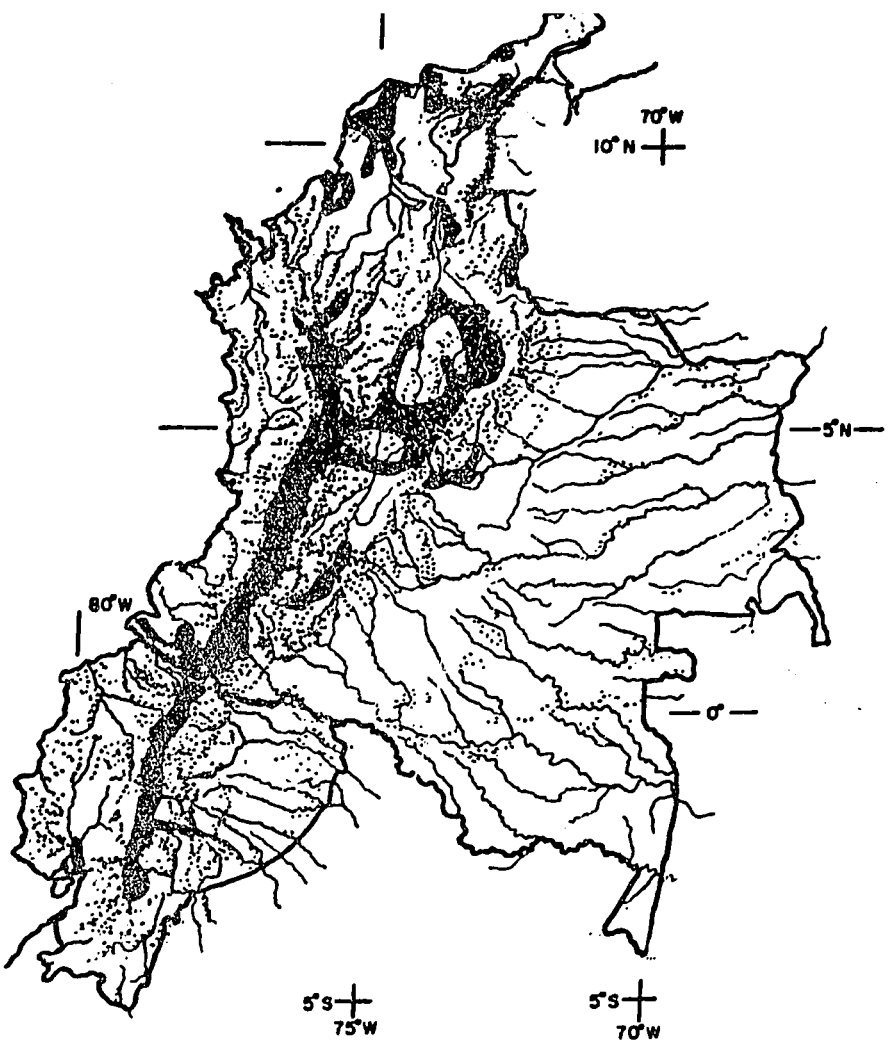

Fig. 4. State of the habitat in Colombia and Ecuador ca. 1977, based on visual inspection of satellite images. Heavy stippling indicates complete deforestation, high human population density and intensive agricultural development; light stippling indicates areas that are extensively deforested but subject to less intensive exploitation; blank areas in the Andes and eastward indicate portions of the terrain that are as yet lightly settled and covered with more or less natural vegetation; the region west of the Andes in Colombia was left blank for lack of data, images being unavailable due to chronically heavy cloud cover.

12

ACKNOWLEDGEMENTS

This research was supported by a grant from the World Wildlife Fund. Many individuals aided us in gathering information on the ranges of endemic species. We would like to thank especially L. F. Baptista, W. L. Brown, J. Haffer, J. Orejuela, F. Ortiz, J. P. O'Neill and R. Ridgley. We are grateful to C. Janson for writing a computer program and to G. Russell for preparing the illustrations.

REFERENCES

Gentry, A. H. (1977). Endangered plant species and habitats of Ecuador and Amazonian Peru. In *Extinction is forever*, ed. by G. Prance & T. Elias, 136–49. New York, New York Botanic Garden.

Gentry, A. (1979). Extinction and conservation of plant species in tropical America: a phytogeographical perspective. In *Systematic botany, plant utilisation, and biosphere conservation*, ed. by I. Hedberg, 100–26. Stockholm, Almquist and Wiksell.

Haffer, J. (1974). Pleistozäne Differenzierung der amazonischen Vogelfauna. *Bonn. Zool. Beitr.*, 25, 87–117.

Haffer, J. (1978). Distribution of Amazon forest birds. *Bonn. Zool. Beitr.*, **29**, 38–78.

Meganck, R. (1975). *Colombia's national parks: an analysis of management problems and perceived values*. PhD thesis, Oregon State University, Corvallis, Oregon.

Mayer de Schauensee, R. (1966). *The species of birds of South America and their distribution*. Narberth, Pa., Livingston.

Myers, N. (1979). *The sinking ark*. Oxford, Pergamon Press.

National Research Council (1980). *Conversion of tropical moist forests*. Washington, DC, National Academy of Sciences.

Paynter, R. A., Jr. & Traylor, M. A., Jr. (1981). *Ornithological gazetteer of Colombia*. Cambridge, Mass., Harvard University.

Prance, G. T. (Ed.) (1982). *Biological diversification in the tropics*. New York, Columbia University Press.

Robbins, C. S., Brunn, B. & Zim, H. S. (1966). *A guide to field identification of birds of North America*. New York, Golden Press.

Terborgh, J. (1974). Preservation of natural diversity: the problem of extinction prone species. *BioScience*, 24, 715–22.

Terborgh, J. (1976). Island biogeography and conservation: strategy and limitations. *Science, N.Y.*, **193**, 1028–9.

Terborgh, J. & Winter, B. (1982). Evolutionary circumstances of species with small ranges. In *Biological diversification in the tropics*, ed. by G. Prance, 587–600. New York, Columbia University Press.

THE FORESTRY LIBRARY

13

Wetterberg, G. B., Soares de Castro, C., Tresinari B. Quintão, A. & Rocha Porto, E. (1978). Estado atual dos parques nacionais e reservas equivalentes na america do sul-1978. *Brasil Florestal*, **36**, 11–36. Brasilia, Min. Agric. IBDF. (English translation publ. 1980 by National Park Service, US Dept of Interior, Washington, DC.)