ACHIEVING GLOBAL AND REGIONAL PERSPECTIVES ON FOREST BIODIVERSITY AND CONSERVATION

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Abstract

Forests are arguably the single most important repository of global biodiversity, attracting the attention of conservation planners as well as foresters. Diversity is an essential factor in maintaining forest function, so its conservation and management are important issues in forest planning.

Because species and ecosystems are no respecters of national boundaries, and international collaboration is required to ensure their preservation, conservation issues are increasingly being viewed on global and regional, as well as national scales. However, building reliable pictures of biodiversity resources at these scales is a complex task. Direct measures of species diversity over broad areas are neither possible nor meaningful. Instead, the issue may be addressed through indicators of species diversity such as ecosystem diversity, indicators of forest condition, and the identification of major centres of speciation and endemism. Even for these surrogates, problems arise in the process of scaling up from more local data sets because of the different definitions, classifications and data sources used by different agencies and groups of researchers. The broad scale data sets that are available for global and regional scale forest conservation planning include global forest cover, ecoregion distribution, protected areas coverages, endemic and important bird areas, distributions of endangered and threatened species, and information on deforestation and trade in endangered species.

Information as yet unavailable which would contribute substantially to broad scale perspectives on conservation of forest systems includes (a) potential forest cover at global and regional scales, (b) more complete information on plant and invertebrate species diversity and distribution, and (c) measures of the relationships between people and the forest, e.g. use of forest products, and their impacts on forest ecosystems and biodiversity. Improvements in the understanding of issues and processes in global forest biodiversity and its conservation will be derived from global assessment exercises like the Forest Resources Assessment of the FAO, increasing global compatibility of criteria and indicators for sustainable forest management, forest certification processes, and national reporting exercises, e.g. for the Convention on Biological Diversity.

1. Biodiversity and its Relation to Forests

The conservation of biodiversity has become a priority of the international community since the Convention on Biological Diversity (CBD) was drafted in Rio in 1992. Forests are the repository of much of the world's biodiversity, and therefore foresters must assume a degree of responsibility for its management and conservation. In fact, much of the forest managed for nature conservation in the tropics is held by the forestry sector (WCMC 1993).

2. The Need for a Global Perspective

For both practical and political reasons, there is an increasing need to develop global and regional perspectives on forests and their biodiversity. Ecosystems and species are no respecters of national boundaries; their protection and sound management require international collaboration and a view of the resource as an integrated whole. Global, regional and national conservation priority setting all depend on an understanding of the distribution of species and ecosystems, their protection status, and the threats to them. These parameters are all affected by being viewed in the broader context: national centres of diversity may or may not be of regional importance; sovereignty over such centres or other key ecosystems may be shared by several nations; and pressures and threats may be due to regional causes or conditions in neighbouring countries. With appropriate regional level information, a nation can evaluate the importance of its forests for their many productive and protective functions, including as refuges for rare and endangered species (particularly those unique to that country, for which the nation bears ultimate responsibility), and decide its own priorities in this context. An overview of the global state of forest systems, their composition and function, is essential for prioritizing conservation efforts at the international scale.

International initiatives (such as UNCED, the CBD, the CSD, Agenda 21 and the Helsinki and Montreal Processes) are demanding a concerted effort on the part of national governments and international bodies to control the decrease in global forest cover and quality. Signatories to these initiatives are bound by law to aid and contribute to the initiatives to the best of their respective capacities. The process is experiencing some growing pains, however, in that the requirements defined by the initiatives (eg the Helsinki and Montreal processes on criteria and indicators of sustainable forest management) may exceed the capacities of national forest departments. This issue is being addressed by UN agencies, which are currently involved in capacity-building programmes. The improved national level information generated by these assessment and reporting exercises will facilitate the construction of regional and global biodiversity data sets.

However, assembling valid regional and global views of forest biodiversity is a problematic task. Distribution of forest types (ecosystem diversity) may be well understood for any given country, but joining national data sets is fraught with problems caused by differences in definitions, classification systems and data sources between countries. Assembling species diversity information on the global scale is problematic for all but the highest groups of vertebrates, and even these may not be fully known in some regions (witness the recent history of new primate species in Brazil). So little is known about the distribution of genetic diversity in forests, that there is little point in addressing the question of a global overview of this aspect of biodiversity. The remainder of this paper is devoted to discussing what is currently available to assemble global perspectives on forest ecosystem and species diversity.

3. Ecosystem Diversity

The greatest difficulty encountered in assembling a global view of forest ecosystem diversity is the problem of how to harmonize or make compatible data which derive from different sources and are based on different definitions and classification systems. Even the international bodies theoretically compiling global data on forest cover have had difficulty in agreeing a good, basic and globally consistent definition of what a forest is (Box 1). The use of different degrees of closure in defining forest can make an appreciable difference to the estimated total area of forest cover derived for any given country or location (Box 2), and the problems involved in harmonizing different classification systems to examine the distribution of forest types and evaluate patterns of ecosystem diversity are even greater.

Box 2 Sample effects of different forest definitions:

Senegal	is 40% forested using FAO's 10% tree cover definition, which includes dry woodland, but is only 2% covered by closed forest
Australia	is 5% forested according to FAO's 20% tree cover threshold, but is only 0.4% covered by dense forest (with >70% canopy cover)

Box 1 Definition of Forest Cover

UNESCO (UNESCO, 1973):	*Closed Forest* - trees >=5m with crowns interlocking *Woodland* - trees >=5m tall with crowns not usually touching but with canopy cover >=40%
US classification standards (FGDC, 1995):	*Closed Tree Canopy* - trees with crowns interlocking, with crowns forming 60-100% cover *Open Tree Canopy* - trees with crowns not usually touching forming 10- or 25-60% cover
FAO (FAO, 1995, 1993):	*Forest (Developing Countries)* - 10% crown cover of trees and/or bamboos *Forest (Developed Countries)* - tree crown cover (stand density) of more than 20% of the area *Closed forest (tropical countries)* - tree crown cover greater than 40%

WCMC has recently compiled a global map of closed forest based on 70 different sources of forest cover data, which mostly date from between the early

1980s and the early 1990s (WCMC 1996b). The crudeness of its five-class classification (temperate needleleaf, temperate broadleaf and mixed, tropical moist, tropical dry and mangrove forests) reflects the difficulty of combining the many much more detailed classification systems used throughout the world.

Global satellite-derived forest cover data is not yet available, despite many regionally-focused programmes such as TREES and Pathfinder, which can contribute to it. A global satellite-based landcover map should be produced by the EROS Data Center (EDC) by the end of 1997. This will help to provide a consistent global view of where forests are, and some information about distribution of structurally different forests in terms of different categories of canopy closure. However, information about the distribution of forest vegetation classes is crucial to understanding the different roles of forests in carbon sequestration, hydrological cycles and other ecosystem processes, in supplying wood and non-wood forest products, and in supporting biodiversity. A global vegetation classification system is needed to ensure consistency, and it is likely that such a system will emerge from the combined efforts of FAO (ecofloristic zones), EDC and the inter-agency project on developing a General Global Nomenclature for Land Cover and Land Use involving UNEP, FAO, WCMC, ITE, ITC and WAU. Once the global classification system is resolved, it will be possible to achieve a global perspective on ecosystem diversity of remaining forests (rather than just their extent).

4. Species Diversity

Knowledge of the world's species diversity and its distribution is very incomplete. Some groups of organisms (e.g. conifers or birds; Table 1) and some parts of the world are far better known than others. The information presented in Table 1 refers only to total species diversity and does not address the question of whether individual species occur in, and/or depend on, forests. A global view of forest species diversity depends on such distinctions being made for at least some groups and is thus some way off.

Table 1. Data availability for the major taxonomic groups.

	No. of forest occurring species	**No. of endemic and/or restricted range forest species**	**No. of threatened forest species.**
Birds	Data available for all countries. Require compilation and classifying into forest/non-forest.	Data available for all countries. Require classifying into forest/non-forest.	Data available for all countries. Require classifying into forest/non-forest.
Mammals	Data available for all	Data available for all	Data available for all

	countries. Require compilation and classifying into forest/non-forest.	countries. Require classifying into forest/non-forest.	countries. Require classifying into forest/non-forest.
Reptiles	Data incomplete.	Data available for most countries. Require classifying into forest/non-forest.	Data incomplete.
Amphibians	Data incomplete.	Data available for all countries. Require classifying into forest/non-forest.	Data incomplete.
Invertebrates	Data very incomplete.	Data available for a small number of groups (dragonflies, swallowtail butterflies). Require classifying into forest/non-forest.	Data very incomplete.
Trees	Data to be completed by end of 1997.	Data to be completed by end of 1997.	Data to be completed by end of 1997.
Other plants	Data very incomplete.	Data very incomplete.	Data very incomplete.

On a regional scale, progress in mapping total species richness in many groups has been greater (e.g. the Mapping African Biodiversity Patterns project of the Danish Centre for Tropical Biodiversity), but as yet these efforts do not incorporate separate analysis of forest species.

However, other approaches can be used to evaluate species diversity and/or identify global priorities for its conservation. Endemic Bird Areas (EBAs; Bibby et al. 1992) and Centres of Plant Diversity (CPDs; WWF & IUCN 1994) of the world can be overlaid with forest cover data to determine forest biodiversity "hot spots".

EBAs are areas which contain at least two restricted-range bird species (those whose distribution covers less than 50,000 square kilometres). These have been reasonably accurately mapped and classified according to their major habitat type. They have also been ranked according to conservation importance. In the absence of similar data for other taxonomic groups, EBAs provide a useful measure of the importance for biodiversity of particular geographic areas.

A joint WWF/IUCN project has identified, mapped and described in detail over 200 Centres of Plant Diversity (CPD) worldwide (WWF & IUCN 1994). Far more areas than these meet the selection criteria (Box 3), but have not yet been analyzed and described in detail. Unfortunately, the criteria have not been applied uniformly across the world. Moreover no size criteria have been imposed, so that

CPDs vary in size from a few tens of square kilometres to over one million square kilometres. These factors seriously limit their usefulness for analysis and comparison.

Box 3 Criteria for defining Centres of Plant Diversity

- area is evidently species-rich, even though the number of species present may not be accurately known;
- area is known to contain a large number of species endemic to it.

Other characteristics also considered include:

- site contains an important genepool of plants of value or potential use to humans;
- site contains a diverse range of habitat types;
- site contains a significant proportion of species adapted to special edaphic conditions;
- site is threatened or under imminent threat of large-scale devastation.

In addition to showing the locations of forest biodiversity "hot spots", overlaying current forest cover with EBA and CPD distributions would allow determination of the numbers and areas of forest units which occur in EBAs and CPDs. This may be used as a tool for planning future protected areas or for managing those that already exist. However, because an area important for bird or plant conservation will not automatically be a priority for other groups organisms, the limitations of this approach must be considered in its application.

The occurrence of threatened and endangered forest species could also be mapped to identify areas where they are concentrated. This depends on the categorization of species as to their forest-occurrence and ideally would require relatively detailed data on their distributions. Nonetheless, some advances could be gained simply from addressing presence/absence data at national or provincial scales.

A further approach to examining global patterns of forest biodiversity is the development of some sort of broad scale biodiversity index, combining information on the diversity found in different groups of organisms. Preliminary work at WCMC has generated a national biodiversity index based on species richness and endemism for vertebrates and plants, normalized and averaged across groups so that it can make use of incomplete data sets (WCMC 1994). Further development of this approach is needed so that it can address biodiversity for particular ecosystem types such as forests.

A country's forests may have high species diversity either due to a wide range of different forest types, each with its own distinct biota (e.g. the U.S.A.), or because individual forest types are highly diverse (e.g. lowland tropical moist forest). The former is generally related to the size of the country, the latter not necessarily so. Countries with very high forest diversity usually combine these two. Measures of diversity that take into account the size of the country can be derived to give an indication of the richness or importance of a country's forests per unit area.

Other approaches to identifying priority areas in terms of species diversity conservation at broad scales (Box 4) depend to a high degree on harnessing expert knowledge, but do not necessarily require detailed field survey data (WCMC 1996b).

Box 4 Other Biodiversity Inventory Techniques for use at Broad Scales

Conservation Biodiversity Workshops (Tangley 1992)

Workshop discussions among regional field experts on species and ecosystems based on mapped info on vegetation, land use, topography, and distribution of key species generate agreed biological priorities for conservation presented in mapped form.

Conservation Needs Assessments (Alcorn 1993)

Similar to above with incorporation of socioeconomic and political perspective resulting in identified priorities that take account of social and political realities

Biodiversity Information Management System (e.g. MacKinnon 1991)

Existing habitat maps and species habitat requirements are used to model species distributions through a relational database and to monitor conservation status of species and ecosystems.

5. Habitat Condition and Management

Other information useful in establishing a global view of biodiversity is that which assesses the current condition and management of habitats. There are relatively few parameters that can serve as effective indicators of forest condition at the global scale.

5.1 FOREST FRAGMENTATION

Measures of the spatial continuity of forests and the size and shape of remaining forest patches are one means of determining something about the probable condition of existing forests and the likely state of their biodiversity. Deforestation not only removes forest cover, it also disrupts the continuity of the remaining forest and affects ecological processes within it. Remaining forest fragments may be too small to be effective habitat units for many species. The viability of their component populations may be limited by isolation from other forest areas, which restricts gene flow through pollination and dispersal. Remaining forests (both fragments and large blocks) are also affected by proximity to the forest-nonforest interface. These "edge effects" may be ecological, including influences on microclimate (e.g., Kapos, 1989; Camargo and Kapos, 1995) and changes in species composition (e.g. Laurance 1991; Matlack 1994), or anthropic as they relate to pressures and the probability of further disruption of the forest by human activity. Forests near edges are far more likely to be heavily exploited and disturbed by people than those in distant core areas. The smaller a forest patch, the less chance each species population has of survival in the long term.

Thus, an indication of the fragility of the forest system and its overall health as a functioning ecosystem can be gained from an examination of the size class distribution of remaining forest patches. In the case of the AVHRR data that will be the basis for the next view of current global forest cover, the smallest discernible forest patch is likely to be 3-5 km^2. However, in some countries, particularly those with low forest cover, patches much smaller than 5 km^2, and even patches less than 1 km^2 can be very important as refuges for remnant populations of forest species. Higher resolution satellite imagery could be used on a sampling basis to estimate the importance of such patches in any given country or region.

Further information about the state of remaining forests and their biodiversity can be derived from analyses of their shapes using perimeter to area ratios. High ratios indicate that more of the forest is exposed to the influence of an edge and may have been affected by human activities both inside and outside the forest. Forest units with lower ratios will have some "core" or central area that is buffered from external disturbances and therefore more likely to have intact ecosystem functionality. Average perimeter:area ratios can be calculated at national or other scales. Similar information can be obtained by examining the total "core" area of forest more than an arbitrary buffer distance from the perimeter; total "core" forest area can be calculated at national or other spatial scales. Both of these approaches have been used by FAO for some tropical countries (FAO 1993).

Both size class and core-area analyses can only be used for broad scale comparisons if the data on forest cover originate from comparable sources at equivalent resolutions. Thus, the global land cover data set being generated by EDC will be an excellent basis for such analyses, which will be even more useful in setting conservation priorities if they can be applied to different forest types.

5.2 FOREST PROTECTION

The protection status of any given forest can be a predictor of its condition; forests that have been set aside for conservation purposes are often in a better state than those designated for exploitation, though this relation is far from infallible. From the standpoint of global forest biodiversity conservation priority setting, a useful analytic technique is that of Gap analysis (Scott et al. 1993) in which the extent of existing protected areas is overlaid with maps of species and ecosystem distribution to identify gaps in the protection network. At the global scale this has been done for the five broad forest categories included in the World Forest Map (WCMC 1996a). The results of this (Box 5) show clearly that Temperate Needleleaf and Tropical Dry forests are the most poorly protected, while

Box 5 Global Forest Protection

Forest Type	**Global Area (km^2)**	**Percentage Protected**
Tropical Moist	11.2 million	8 %
Tropical Dry	0.8 million	5 %
Temperate Broadleaf/ Mixed	7.2 million	6 %
Temperate needleleaf	13.9 million	5 %
Mangrove	0.2 million	9 %

Mangrove is the best protected. However, to be truly meaningful for biodiversity, such an analysis needs to focus on ecosystem classifications that reflect ecosystem diversity much more directly. One such analysis has been done for the tropics using FAO's Ecofloristic Zone designations (WCMC 1995). A more detailed analysis of the Indo-Malayan Realm has been carried out (Asian Bureau for

Conservation, 1996) and a feasibility study for a European analysis was carried out by WCMC in 1995. Results of a global gap analysis of extant forest data from a variety of sources using a harmonized global classification will be presented at the World Forestry Congress (Iremonger et al. 1997). Similar analysis using a consistent remotely sensed global forest cover data set and improved protected area information will be yet more useful as the basis for taking steps to build a truly effective global protected areas network.

5.3 FOREST MANAGEMENT

Other aspects of forest management are important for the global analysis of forest biodiversity status. Forest reserves managed for watershed and soil protection, for or by indigenous peoples, and for religious or spiritual functions are all likely to be relatively effective reservoirs of forest species diversity. Forests managed for the extraction of timber and non-timber forest products are important in biodiversity conservation, depending on the type and quality of their management. The drive towards assessing sustainability of forest management according to standardized schemes of criteria and indicators (ISCI 1996) will improve our ability to monitor forest management in relation to biodiversity on a global scale (though the indicators relating directly to biodiversity have yet to be developed in most cases). The certification programme backed by the Forest Stewardship Council (Dudley et al. 1996) also provides a basis for tracking sites that are managed sustainably, i.e. in ways not prejudicial to the native forest species, worldwide.

6. Pressures on Forests and their Biodiversity

Another approach to assessing the status of forest biodiversity is to examine the pressures on forests at a broad scale. Many of the most important pressures on forests (e.g. large scale conversion, timber harvesting, pests and diseases, invasive alien species, agricultural encroachment, airborne pollutants/acid precipitation, fuelwood extraction, poaching/illegal collection, fire, natural catastrophes) operate at such local scales that achieving any kind of global overview is very problematic.

A certain amount can be achieved using a sampling approach and extrapolating from local studies, for example on the impact of non-timber forest product extraction. However conditions vary so much from one place to another that these kind of extrapolations can be quite dangerous. Two other approaches examine pressures on forest in a more generic way and may be more appropriate to global scale analysis.

One is assessing loss of original forest cover. The absence of forest where it once existed is *de facto* evidence of pressure on forests, though this may be either current or historic. WCMC has recently compiled a preliminary estimate of original forest cover at the global scale, which can be compared with the global map of current forest cover to estimate total loss of original forest cover. Besides the difficulties caused by its intrinsically hypothetical nature, original forest cover mapping suffers from the same classification problems as assessing current forest cover and requires a globally consistent classification system before it can contribute to the identification of the forest types most at risk and critically important remnants.

The second way of assessing generalized pressures on forests is the evaluation of likely human impact or wilderness assessment. The Australian Wilderness Index (Box 6), which estimates wilderness value along a continuum, is one means

Box 6 The Australian National Wilderness Index
(Lesslie & Maslen 1995)

The Australian Wilderness Index combines several different measures of the "naturalness" of a site:

- remoteness from access - the distance to the nearest access route in each of several grades
- remoteness from settlement - the distance to the nearest human population centre according to its grade
- aesthetic naturalness - the distance of the site from structures of modern society
- biophysical naturalness - an estimate of the intensity of disturbance of the natural vegetation often based on land use

These four measures are combined to give an overall Wilderness Index, but if adequate data are lacking (as is often the case for land use intensity) a particular component can be left out.

of making such an assessment that might be applicable at the global scale. A global "wilderness surface" could be generated, based on road and settlement data, which could then be overlaid with current forest cover information to identify areas of key forest types exposed to both high and low degrees of human influence. Some modification will be required to take into account regional variations in, for example, the relative importance of different types of access such as roads and rivers. Ultimately, other factors modulating pressure such as human population density could be incorporated.

7. Conclusions

Assembling a global perspective on biodiversity is a slow and complex task. Major advances have been made in compiling global data sets on current and original forest cover, but these need to be viewed in the context of a global vegetation classification, which is still lacking. Other advances at the global scale have come from the identification of areas important for species diversity in key groups, but congruence of diversity patterns between groups has been addressed only at the regional scale, and not yet thoroughly even then.

The increasing volumes of data involved in the analysis and management of global forest biodiversity require new approaches to data management. National capacities to gather and manage data to generate useful information both for national use and to contribute to our understanding of the global picture will need to be built. Recent experiences show that the greatest challenges are organisational, not technological (UNEP/WCMC 1996). By focusing on the processes involved in creating environmental information, as opposed to concentrating on data, international efforts such as the Biodiversity Data Management Project (UNEP/WCMC 1996) are making useful advances.

In addition to contributions from national sources, international research and other efforts can also make a useful contribution to the improvement of the global biodiversity information base. Likely sources of improvement in the broad-scale information available in the near future include:

- a globally consistent land cover data set from AVHRR imagery;
- progress towards a global vegetation classification;
- analysis of the resulting spatial data sets to examine patterns of forest fragmentation and wilderness evaluation;
- FAO Forest Resources Assessment 2000, including more biodiversity-related parameters & efforts to improve global consistency;
- research to: examine the congruence of diversity patterns among groups; extend knowledge of species distributions and habitat requirements; examine effects of different forest management practices on biodiversity;
- national reporting efforts for the Convention on Biological Diversity;
- initiatives on development of criteria and indicators of sustainable forest management;
- forest management certification efforts.

Combining these and other initiatives should enable a much more coherent global view of biodiversity in forests to emerge. However it must be remembered that the crucial step in maintaining biodiversity in forests is the translation of this knowledge into improved forest management and conservation practices throughout the world.

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