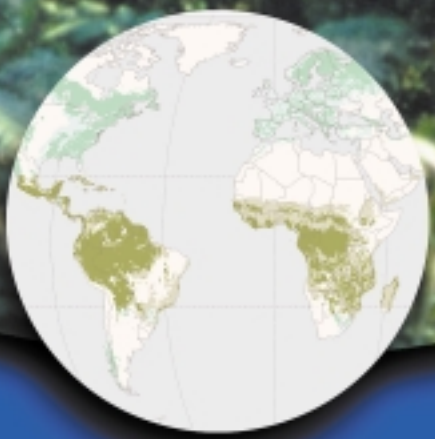
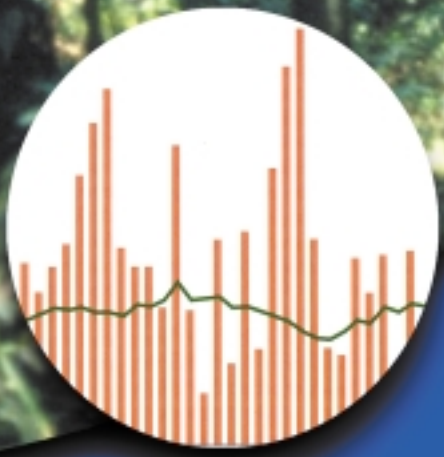
FOREST BIODIVERSITY INDICATORS





TOOLS FOR POLICY-MAKING AND MANAGEMENT

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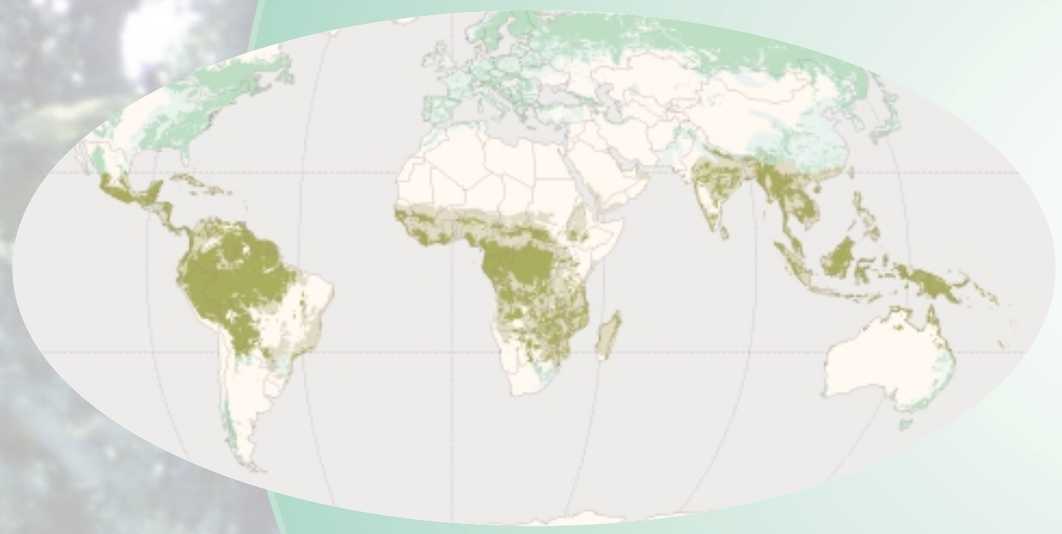
Forests are important for biodiversity

Globally, forests are vitally important for biodiversity. Tropical moist forests are the most diverse ecosystems on earth. Although they only cover around 6% of the land surface, they hold well over half, and perhaps as many as 90%, of all the world's species. Other forest types, though less diverse, harbour unique elements of biodiversity of vital importance both to people and to the biosphere in general.

Forest policy and management need to take account of biodiversity

Ideally, a national forest programme incorporates holistic planning for the use of a nation's entire forest estate. This includes zoning existing natural forest into areas for conversion, for extractive uses and for non-extractive uses, including protection. Biodiversity conservation and sustainable use are among many conflicting demands on forests that must be accounted for in national forest policy, planning and management decisions. Information is needed that clearly illustrates the impacts of these and other decisions on forest biodiversity. Indicators can play a very important role in providing this information.



Biodiversity

The Convention on Biological Diversity (CBD) defines biodiversity as the "variability among living organisms from all sources, . ." including ". . . diversity within species, between species and of ecosystems". The concept can be applied at a single locality or over broad geographic areas including, ultimately, the Earth as a whole. Biodiversity is used to refer not only to the numbers of genes, species and ecosystems existing in the area in question, but also the types present.

Uses of Indicators:

Forest biodiversity indicators are needed for many purposes, including:

- State of environment reporting
- National reporting under Multilateral Environmental Agreements such as the CBD
- Identifying priority areas and components of forest biodiversity
- Evaluating impacts of particular policies and decisions

These uses imply two distinct types of activities needed to generate relevant biodiversity information: **monitoring and assessment**. Indicators vary in their suitability to respond to these needs.

Biodiversity Assessment is the process of determining the biodiversity complement and value of particular areas or resources. It is generally aimed at comparisons among sites and prioritisation of sites for management with an emphasis on biodiversity.

Monitoring explicitly addresses temporal changes in biodiversity and its status. It therefore depends on measurements that can be repeated and are comparable over time.

Users of these indicators include:

- National environment ministries
- Forest departments
- Planning and natural resource authorities
- Nongovernmental organisations
- Reserve managers
- Local communities

In developing and using biodiversity indicators it is important to:

- Identify and address the correct questions;
- Identify the data needed to address these questions;
- Initiate and sustain measurement programmes to obtain those data;
- Work adaptively and within the constraints of available data.

The way indicators are developed and presented is critical to their utility and success in supporting decision-making. They must be presented in easily interpretable forms that are also appropriate to the data they depend on.

This document presents some examples of approaches that can be used for developing forest biodiversity indicators and suggestions for future work in this area.

What are indicators?

Indicators are measurements or expressions that convey information about more than just themselves. They quantify and simplify information on complex issues that is often derived from technical investigations. Indicators are purpose-dependent and open to interpretation, and rarely, if ever, tell the whole story. Indicators should be:

- scientifically valid;
- based on easily available data;
- responsive to change;
- easily understandable;
- relevant to focal issues and users' needs;
- subject to target or threshold setting.

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Indicators for forest biodiversity assessment based on species

Biodiversity assessment is the process of determining the biodiversity complement and value of a particular area. It plays a vital role in planning for the management of biodiversity, by allowing the identification of both priority areas and important components of biodiversity.

Several different indicators based on species can be used in biodiversity assessment. The most important are:

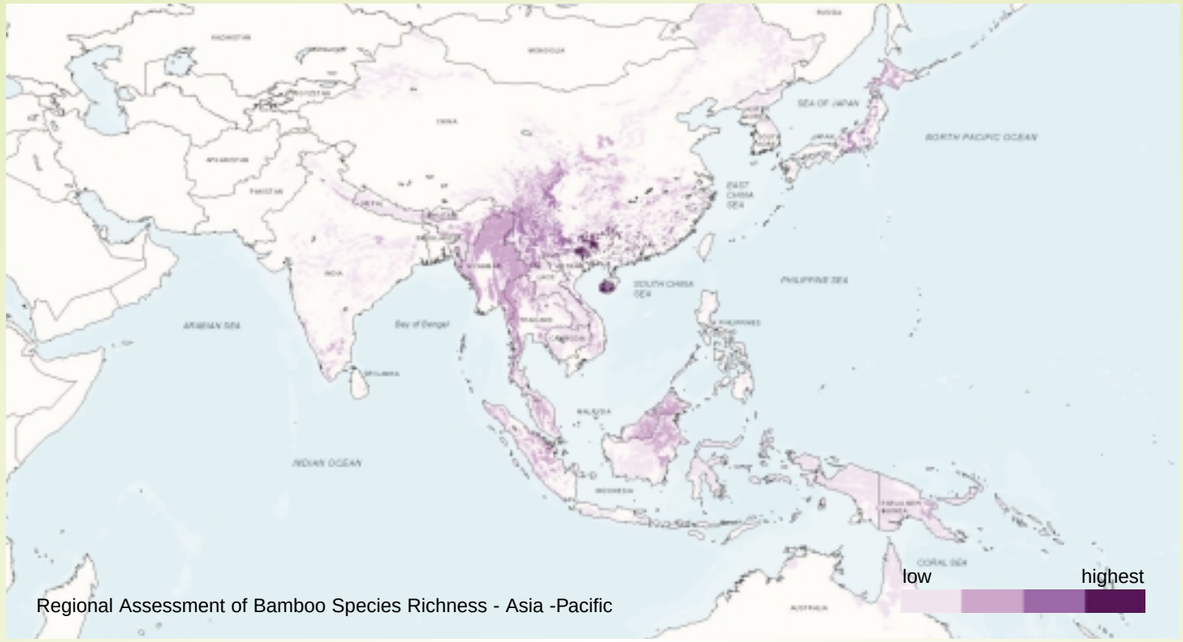
Presence of particular important species:

- Globally threatened species
- Nationally or locally threatened species
- Economically or socially important species
- Scientifically important species
- Species listed by agreements such as CITES

Overall species richness - the total numbers of species present

Species endemism - the numbers of species that are largely or wholly confined to that area

Forests, especially tropical moist forests, typically have so many species that exhaustive inventories are rarely possible. Estimates of species richness and endemism therefore almost always use better-known groups as indicators. While there is often good agreement at coarse resolution between areas of importance for different groups of species, this relationship may break down at finer resolution. Therefore using a single indicator group to identify priority areas for forest biodiversity as a whole requires caution.



Regional Assessment of Bamboo Species Richness - Asia -Pacific

Many groups have been proposed as indicators, including termites, several groups of beetles and non-vascular epiphytes. In general, however, the most useful groups are those for which most data are available because they are easier to observe and identify, namely birds, butterflies, trees and mammals.

Data on forest species composition can come from a number of different sources. Tree species data most frequently come from forest inventory, but approaches such as timber cruising and reconnaissance survey that focus on timber trees may ignore many other species. Wildlife and parks departments, academic ecological studies and amateur surveys provide data on other groups. These are often checklists that document the presence and (by inference) absence of particular species. Quantification of the area surveyed and the effort expended increases the usefulness of such data. Particularly for more cryptic animal species, quantifying survey effort is fundamental to estimating total richness.

It is important in biodiversity assessment that the data used are at an appropriate scale of resolution. Species distribution data on, for example 50x50 km grids, may provide little guidance on the presence or absence of species in any given square kilometre of forest. However, such data may be useful for estimating patterns of species richness in particular groups by superimposing distribution data for each individual species. Such potential richness maps, though coarse, can be combined with data on forest cover to indicate forest areas that are likely to have high species richness and to direct further inventory work.

Results can be presented in the form of maps highlighting areas of importance under particular criteria, as rankings or as graphs.

Prioritisation based on biodiversity assessment can also be used in combination with assessments of threats or likely impacts to prioritise investment in monitoring and reporting of other indicators.

Identifying Globally Threatened Species

The IUCN Red List categories of threat are designed to provide an impartial assessment of the likelihood of extinction of a taxon under current circumstances. The following categories are the most relevant for evaluating biodiversity priorities in natural forests:

Critically Endangered taxa are facing an extremely high risk of extinction in the wild in the immediate future

Endangered taxa are not Critically Endangered but face a very high risk of extinction in the wild in the near future

Vulnerable taxa are not Critically Endangered or Endangered but face a high risk of extinction in the wild in the medium-term future

The status of a taxon is decided according to criteria and associated thresholds based on recent or projected trends in:

- the degree of population reduction;
- the extent of population occurrence, including the degree of fragmentation and fluctuations in occurrence of the total number of mature individuals,
- the probability of extinction, estimated by population viability analysis (PVA).

Meeting any one of these criteria is sufficient to qualify a taxon for listing in a particular threat category. Where estimates vary widely, the precautionary principle is applied and the estimate assigning the category of highest risk is used.

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Indicators of forest condition based on species

Changes in the biodiversity of a forest can be expressed as changes in the distribution and abundance of all the species occurring there. However the complexity and species richness of forest ecosystems, especially tropical moist forests, make measuring and monitoring all species impossible. Much effort has therefore been expended in trying to identify indicator species or groups of species, i.e. those whose status can be tracked in order to provide information on general or underlying trends in biodiversity in a particular area.

However, every species has its own specific set of ecological requirements and each will

therefore respond in its own way to any given change in its environment. Changes that might lead to population increases in one species are very likely to lead to population decreases in others. It is therefore not possible to find one single species or group of species that can act as an indicator for all other species.

Because of this, other approaches need to be used. Effort can be concentrated on monitoring species that are considered of importance for specific management goals, such as those that are used locally or commercially, or are threatened or endemic.

Alternatively, information can be combined from as wide a range of species as possible to produce a **multi-species index** giving an overall impression of change in biodiversity, as in the WWF/UNEP-WCMC Living Planet Index approach.

In either case, data on changes in **species abundance** are of primary importance. However, these are difficult to collect in a rigorous and consistent manner. Inevitably, monitoring must be confined to relatively few species, which should be carefully chosen. Some characteristics of species that can be used as criteria for selecting those to monitor include:

- *extent to which taxonomy is resolved and accepted* – taxonomic confusion can limit the comparability of data in time and space;
- *ease of observation* – cryptic and rare species require much greater investment of effort and resources to achieve reasonable sample sizes;
- *ease of identification* – surveys by non experts and less technically qualified teams can generate higher quality data for species that are easily identified in the field;
- *sensitivity or responsiveness to key pressures* – where it is clear which pressures are likely to have the greatest impact on forests, those species known to be sensitive to those pressures may be of highest priority for monitoring.

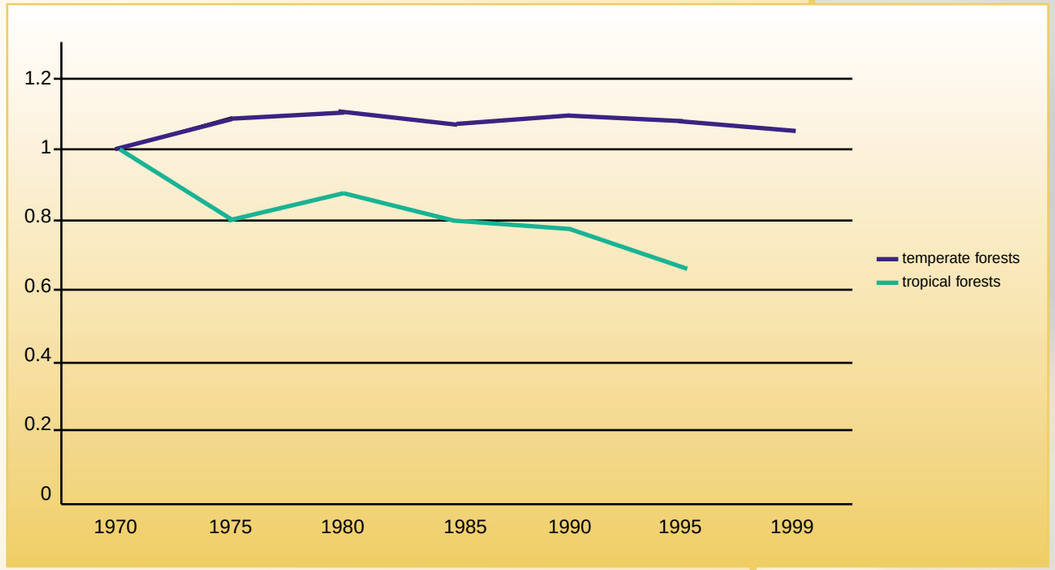
The sampling designs and monitoring methods employed should be selected with care, and attention must be paid to maintaining consistency in both field and analysis methods over time.

Checklist or presence/absence data are of limited use for monitoring. However, changes in these data, especially if based on controlled-effort surveys, can be important pointers to where more detailed investigation is needed.

Sources of existing data on species abundance & trends include:

- Forestry inventories and monitoring plots
- Published academic literature
- Ongoing ecological studies of species
- Protected areas management records
- Game surveys
- Stock management data

Detecting change in populations of forest species is problematic, especially for animals, which are usually difficult to census, and especially in tropical moist forests where most species are, statistically speaking, rare. It is unlikely that significant changes can be detected with confidence in less than 4-5 years. Even when change can be detected, caution must be exercised when interpreting it, mainly because populations of species constantly change under natural conditions. Such changes are brought about by climatic fluctuations, disease, predator-prey cycles and other interactions between species, as well as random or stochastic variation. Distinguishing these changes from those brought about by human actions may be difficult.



The forest biodiversity component of the WWF Living Planet Index for 2000 is based on available estimates of changes in the size of populations of wild forest species, expressed relative to the estimated 1970 population sizes. The index shows the change in status over time of an "average" species. When the sample is divided into temperate and tropical species, temperate forest species show little net change over the period 1970 to 1999, mirroring trends in temperate forest cover (most deforestation here having taken place before the 20th century). The tropical sample shows a downward trend, consistent with the continuing deforestation in many tropical areas. This indicator approach is theoretically applicable at more local scales, provided data are available for a minimum of 45-50 species.

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Indicators of forest condition from spatial data on extent and fragmentation

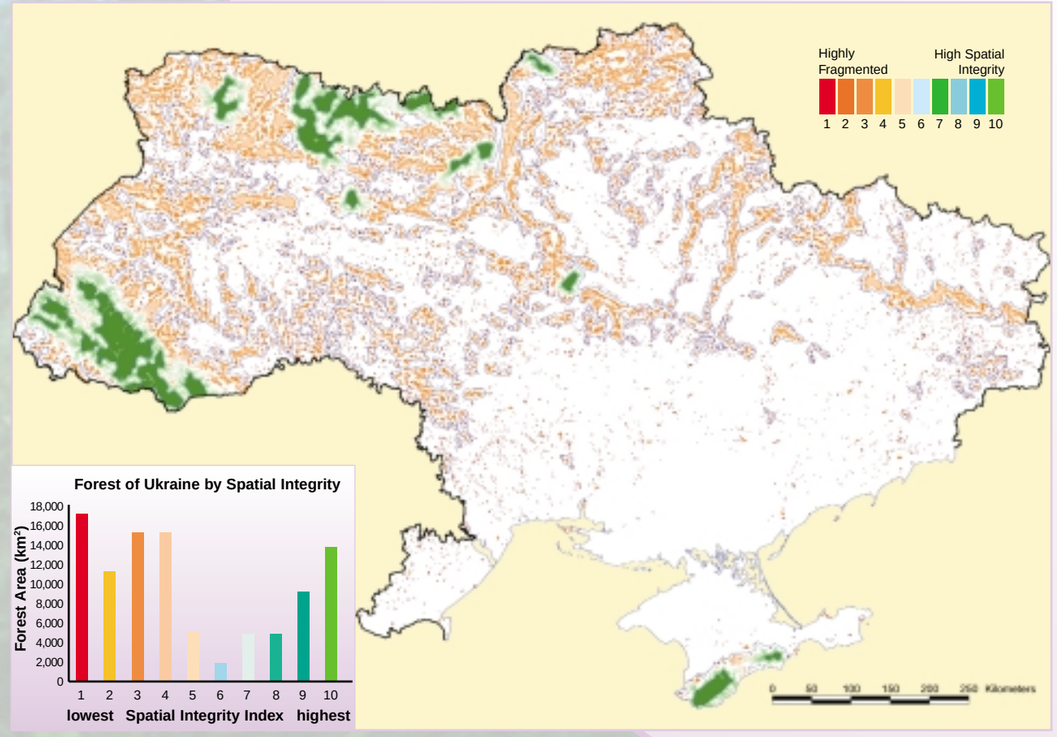
The **total area of each type of forest** present in a country has a major bearing on the biodiversity that can be supported. Spatial or mapped data on the extent and location of forests can thus be used to generate useful indicators for both assessing and monitoring forest biodiversity. This information can be derived from satellite remote sensing or aerial survey. Its usefulness depends on an ability to classify forest types in ways that are meaningful in biodiversity terms. This usually requires integration with other types of information, including forest structure, soils, topography and expert knowledge.

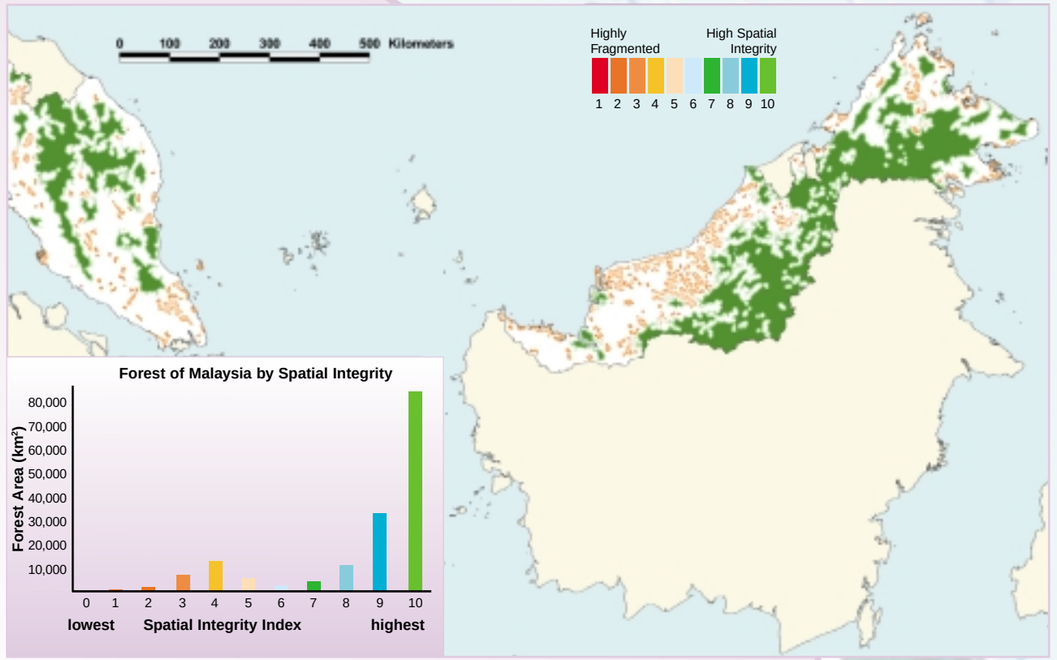
Maps and statistical summaries of the total area of each forest type can be used to identify and locate specific forest types that are relatively rare within a country and which may be of high priority. For assessment purposes, a single baseline evaluation is most important; updates on a five-year cycle would ensure that priorities can be modified in the light of any observed changes. An active monitoring programme for this indicator will highlight the rate of change and identify particular areas or forest types where such change is unduly high. In priority areas, annual monitoring may be desirable, but the effort involved means that this is rarely practical at national level.

This indicator provides important biodiversity-relevant information on overall change in the national forest estate. It allows comparison of authorised or expected change with observed change. Major discrepancies should prompt review of relevant policies and investigation of factors contributing to high forest loss in particular areas.

Presentation

Indicators relating to forest area and configuration should generally be expressed as absolute areas rather than as percentages or proportions, which can give a misleading impression. For example the destruction of small forest patches in a given area would increase the proportion of forest in large patches, apparently decreasing fragmentation. This might be taken as implying an apparent improvement in forest condition, when in reality forest habitat would have been lost.





The ability of forest areas to support biodiversity is also affected by their configuration. **Forest fragmentation** can affect biodiversity in three major ways:

Area effects - When large forest blocks are broken into smaller ones, not all species are included in all the remaining patches; rare species and those requiring large areas of habitat are especially vulnerable.

Edge effects - Forest fragmentation creates forest edges adjacent to other land cover types, generating environmental gradients that affect vegetation, animal populations, ecological processes and species composition along forest edges.

Isolation effects – Fragmentation creates gaps between forest blocks that reduce the movement of species, increase the chance of local extinctions and may reduce the genetic diversity within populations.

Indicators that address each of these effects can be derived from spatial data on forest cover using geographic information systems (GIS). Measures of patch size, shape and isolation can be combined to provide a single **index of spatial integrity** of forest cover. Such indicators can be presented in both mapped and statistical forms by identifying forest belonging to different classes and reporting the total area in each class. Their usefulness is dependent on the resolution and accuracy of the source data.

A national baseline assessment of forest spatial integrity can provide the basis for identifying the blocks of forest in the best condition. Monitoring should parallel that of forest area change – i.e. on a 2-5 year cycle at national level, except where particularly active change is occurring.

The index is more meaningful in biodiversity terms than simple forest area statistics. It can therefore highlight changes that may have adverse impacts on forest biodiversity and help identify areas where action is needed to improve forest spatial integrity. Such actions could include restrictions to limit land use change in areas of concern and forest restoration programmes. The spatial integrity index can also be used as a forecasting tool to examine the potential impacts of planned land use changes.

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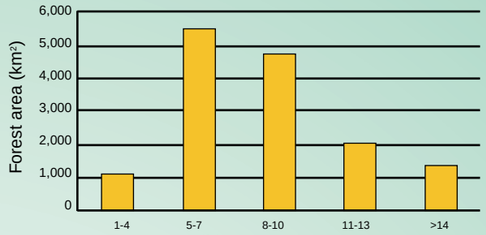
Indicators of forest condition from spatial data on human impacts

Natural global patterns in biodiversity have been altered almost everywhere by human action. In the contemporary world, human activities are almost certainly the most important influence on forests' capacity to maintain their original biodiversity. Such activities as commercial and artisanal logging, large scale land conversion, fuelwood and charcoal production, slash and burn agriculture, harvesting of non-timber forest products, hunting and mining all affect forest biodiversity.

Measures of the intensity of specific activities can be useful local indicators of likely trends in forest biodiversity, but it is important that the most relevant activities are addressed. When broader geographical scales are considered or when the relative importance of particular pressures are unknown, a generalised measure of potential human impact can be a useful indicator of forest biodiversity status.

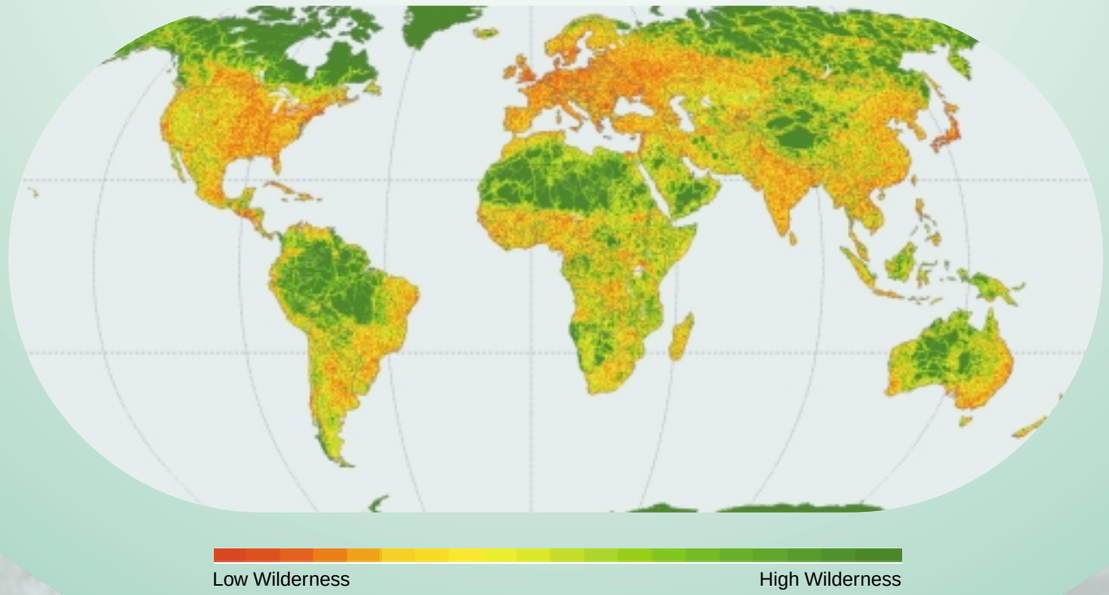
The potential for human impact can best be assessed by combining spatial information about settlements, infrastructure and land use with data on ecosystem distribution. A good example of this approach is the **"Wilderness Index"** developed by the Australian Heritage Commission[1], which evaluates remoteness from human influence in terms of distance and land-use intensity. This approach can be applied to forests by combining spatial data on forest cover, classified as meaningfully as possible, with mapped data on roads, settlements and other forms of infrastructure. For each forest unit a combined measure of relative remoteness from human access (settlements, roads, rail) or interference (permanent man-made features, biophysical naturalness) is expressed on a numerical scale, which can be summarised in both mapped and statistical forms. Wilderness index can be mapped independently of land cover (see global map) or forest cover can be coded according to its wilderness score.

Forest cover of Belize displayed by "wilderness" score.



Forest area of Belize belonging to different categories of wilderness index or potential human impact

Assessment of forest wilderness index values can help identify areas where the original complement of forest biodiversity is most likely to be relatively intact. Because of the limited rate at which changes in infrastructure are incorporated into available data, measuring real change in potential human impacts on forests can be quite difficult. Changes in summary measures are likely to be due to change in forest cover. Therefore, the appropriate monitoring interval is dictated by these changes and is likely to be 2-5 years. Reduction in forest cover will tend to generate a reduction in the average wilderness of remaining forest, except where the forest loss is by elimination of low-wilderness fragments.



Data quality and consistency

These are important factors that can limit the utility of any indicator.
In many cases the available digital spatial data on roads and other infrastructure are poor and out-of-date, and sometimes better data sets are available in paper form. Harmonisation and upgrading of the available data sets is needed to create a good quality access and settlement layer. Attention needs to be paid to the grading of these features as major or minor, and in tropical forest countries the role of rivers and coastlines as access must also be considered. Decisions about the classes should be made empirically in the first instance, but should not be altered in future assessments without very strong justification. When such a decision is made the initial assessment should be repeated using the new categories.

The wilderness indexing procedure provides a useful visualisation of the accessibility or vulnerability of forest areas to human interference. If forest wilderness values decline appreciably, it is likely that forest biodiversity is at increasing risk and appropriate response measures are needed. The index can be scaled to local conditions so that it reflects relative wilderness within an appropriate range. It is also a potentially very useful tool for scenario testing and planning as new roads or population centres can be provisionally "constructed" within the infrastructure data set and the magnitude of their likely impacts evaluated.

1. Lesslie, R. and Maslen, M. (1995). *National Wilderness Inventory Handbook. 2nd edition, Australian Heritage Commission, Australian Government Publishing Service, Canberra.*

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Ways Forward for Forest Biodiversity Indicators

Indicators of forest biodiversity clearly have great potential value in supporting policy and decision-making that affect forests. The next step in realising this value is to make some indicators operational.

To do this:

Choose indicators by identifying the questions you want answered and the primary audience for the indicator

To generate indicators, in the first instance make use of the available data. Good sources include:

- Aerial photos and remote-sensing images
- Published and ongoing academic studies of sites and species
- Species and habitat checklists of protected areas and other sites
- Forest inventories
- Listings of threatened species

Remember, however, that indicators are products of and not substitutes for assessment and monitoring programmes. Therefore:

- Initiate and sustain systematic programmes for monitoring and assessing biodiversity
- Do not wait until you can implement the perfect programme - it is much more important to try to establish baselines as soon as you can with whatever resources are available
- To make best use of limited resources, focus on those aspects of biodiversity that are most important in local and national contexts.

Work adaptively, incorporating better data as they become available. The more systematically you collect your data and the more clearly you record your methods, the easier this will be.

Present your indicators in clear, understandable and policy-relevant forms: maps and simple graphs often have the greatest immediate impact.

Continually test and refine your indicators:

- Evaluate the scientific validity of the relationship between the indicator and the phenomenon it is supposed to represent
- Assess how well stakeholders understand the indicators and the degree to which they use them in making decisions that affect forest biodiversity

UNEP-WCMC is continuing to develop and apply biodiversity indicators. For further information or advice contact: Dr. Valerie Kapos, Forest Programme, UNEP-WCMC, 219 Huntingdon Road, Cambridge CB3 0DL, U.K. email: val.kapos@unep-wcmc.org

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