The Challenge of Measuring Global Change in Wild Nature: Are Things Getting Better or Worse?

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Introduction

The Ministerial Declaration made at the World Summit on Sustainable Development in Johannesburg agreed to protection and restoration of the integrity of our planet's ecological systems and identified as a major priority a significant reduction in the rate of current biodiversity loss at national and global levels. This goal is essentially a reformulation of that of the Convention on Biological Diversity agreed to in Rio de Janeiro 10 years ago. For us to have any idea of where we are in relation to this goal, we need information on current global trends in the status of natural systems. By 2005 it is envisaged that the Millennium Ecosystem Assessment (MA) will have provided a comprehensive account of global biodiversity from a compilation of existing data, but that is a long time to wait. What can we say now about trends in the state of wild nature since the United Nations' 1992 Conference on Environment and Development in Rio de Janeiro? Here, we briefly review recent global trends in habitat area in as many broadly defined natural habitats as possible and in indices of animal populations characteristic of those habitats. The information available indicates continuing declines in habitat area and species, but that data are extremely sparse.

Trend Estimates

We searched the published literature and available databases for global estimates of recent trends in the areal extent of largely unmodified habitats in all the biome categories of Costanza et al. (1997) except rock, ice, and open ocean, which are usually not converted by humans to other habitats, and except urban and cropland, which are already modified fundamentally. We included any estimate of global trend that was based on a series of studies beginning in 1970 or later and that included at least 5 years of data collection after 1992. Because we found estimates fulfilling these criteria for only four habitats, we supplemented these with biome-specific indices based on time-series data on populations of wild vertebrates derived from the World Wildlife Fund (WWF) 2000 Living Planet Index (LPI) (Loh et al. 2000). We calculated annual percent change in area or index (a) value by taking the values a_1, a_2 in the first year (t_1) and the last year (t_2) of the series under consideration and calculating $100*(1-(a_2/a_1)^{(1/(t_2-t_1))})$.

Tropical Forests

The Forest Resource Assessment 2000 (Food and Agriculture Organization [FAO] 2000) estimates a global net change of −7% in the area of natural moist and dry tropical forest for the period 1990-2000, yielding an annual decline of 0.8%. We recognize the technical difficulties and potential inaccuracies that arise from this assessment's use of a mixture of reports on forest inventory data from national forest services and remote sensing. These and other problems have led some authorities to suggest that the 1990-2000 assessment underestimates the rate of decline (e.g., Stokstad 2001). A more recent study, however, based entirely on remote-sensing measurement of changes in tropical moist forest cover in a stratified random sample of areas comprising 6.5% of the humid tropics (Achard et al. 2002), yielded a somewhat lower estimate of 0.4% for annual net deforestation for this forest type during the period 1990-1997 and annual conversion of forest to "visibly degraded" areas of 0.2%. The LPI for vertebrates in tropical forests showed a decrease of 26% between 1970 and 1999, yielding an average annual decline of 1.1%. This is somewhat higher than the FAO figure (FAO 2000) for change in area and notably higher than the estimates of Achard et al. (2002).

Temperate and Boreal Forests

The FAO estimates that temperate and tropical forests have increased in extent by 1% during the period 1990-2000, yielding an annual increase of 0.1%. The LPI for temperate forests showed a change of +4% between 1970 and 1999, yielding a similar, small annual increase of 0.1%.

Mangroves

Valiela et al. (2001) estimates on the basis of a comprehensive assessment of mangrove resources that at least 35% of the global area of mangrove forests has been lost in the past two decades. This yields an annual decline of at least 2.5%.

Coral Reefs

Although Bryant et al. (1998) report that around one-quarter of the world's reefs are believed to be at high risk of degradation, there are no reliable global estimates for the rate at which coral reefs are actually being lost.

Sea Grass and Algal Beds

There are no global estimates for the extent of or rates of change in algal beds. No comprehensive survey of sea grass beds has been carried out, although it has been estimated that there may be between 500,000 and 1,000,000 km^2 (M. Spalding, personal communication). Short and Wyllie-Echeverria (1996) have stated that perhaps 900 km^2 of sea grass beds were lost globally between 1985 and 1995, although the basis for this estimate is not clear. Extrapolation would give an annual decline of 0.01-0.02%, although clearly little confidence can be attached to this figure.

Estuaries

We found no global assessment of rates of loss of estuarine habitats.

Coastal Shelf and Open Ocean

The only measure of coastal-shelf habitat modification for which we found global estimates was for disturbance of the seafloor by bottom trawling. It is not clear, however, what proportion of bottom trawling caused long-term habitat degradation, so we did not use this estimate.

The marine component of the WWF LPI does not distinguish between different marine biomes. Overall it indicates a 35% decline in abundance of marine fishes, mammals, birds, and reptiles over the period of 1970-1999, yielding an average annual decline of 1.5%. Further evidence for decline is provided by fitting a curve to FAO (2001) data on changes since 1974 in the proportion of all the world's marine fish stocks that are exploitable (i.e., stocks with status categories of overexploited, depleted, and recovering). Most fish stocks reduced to unexploitable levels show little evidence of recovery within 15 years of their decline (Hutchings 2000) and so can be regarded as effectively lost to exploitation for the foreseeable future. The fitted curve suggests that exploitable fish stocks have declined in number at a rate of 1.0% per year.

Swamps, Floodplains, Lakes, and Rivers

There are no global estimates for rates of change in the extent of these habitats. The WWF LPI for inland waters shows a decline of 51% between 1970 and 1999, yielding an average annual decline of 2.4%.

Grasslands, Rangelands, Deserts, and Tundra

There are no global estimates of rates of change in the extent of these habitats or of overall changes in their condition. The available data for vertebrate populations are currently inadequate for developing a reliable LPI for any of these biomes.

Discussion and Conclusions

Our review indicates that the conversion and modification of three of the four relatively unmodified natural habitats for which we found data on change in habitat area, usually for use by humans, has continued into the period since the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. Declines in area have occurred for tropical forests, mangroves, and sea grass beds, whereas the area of temperate and boreal forests has increased. Unfortunately, there were many habitats large in extent and important for biodiversity and ecosystem services for which we found no estimates of change in area. The list includes estuaries, coral reefs, algal beds, grasslands, savannahs, and freshwater wetlands. Without global data on these important habitats, it is not possible to be certain that this pattern of decline applies to wild nature as a whole. However, our estimates based on aggregated trends in the abundance of free-living vertebrates from the LPI showed average rates of change broadly similar to those based on area. By including the LPI and FAO fisheries data and averaging for habitats with more than one estimate, we obtained area trends for six habitats. Five of these habitats have declined (tropical forest, freshwater wetlands, mangroves, sea grass beds, and marine habitat) and one has increased (temperate and boreal forest). The mean of the six rates of change is a decline of 1.1% per year (SE = 0.47%).

Comparison of estimates of change in area and LPI changes is instructive. In the case of temperate forests, the one habitat for which area increased rather than declined, both approaches showed a similar increase. For tropical forests, the rate of loss based on indices of vertebrate populations was considerably higher than either of the estimates of net area loss. This is perhaps not surprising, given the high levels of exploitation of wild vertebrates for food in tropical forests (Robinson & Bennett 2000; Fa et al. 2002).

The trend estimates for the marine environment based on data for populations of all classes of free-living vertebrates from the LPI and from the trend in exploitable stocks of fish were broadly similar. We conclude from this that indices based on animal populations, although currently rather crude and based on a nonrandom set of vertebrates, have considerable potential for assessment of the status of habitats. Further attention should be given to the sampling and selection of the taxa to include in the calculation of an index and the statistical methods used to estimate a single trend from combined data on many taxa.

Ideally, an index of global trend for a given habitat would be based on information for a random sample of species selected from within specified taxonomic and geographical strata. To date, however, such analyses have necessarily tended to use whatever population time-series information can be obtained from the scientific literature. Inevitably, the taxa covered are not representative of the specified subset of the biota of the selected habitat, and geographical coverage tends to be strongly biased. Furthermore, series vary widely in duration and in starting and ending points. These problems make the analytical methods used especially important, although that may seem at first to be a minor technical issue. Differences in approach can lead to a wide divergence in interpretation of the same data series. For example, Houlahan et al. (2000) and Alford et al. (2001) analyzed the same data set on trends in 936 amphibian populations in different ways and reached markedly different conclusions about both global trends and regional variations (see also Houlahan et al. 2001).

Although there is a clear need to collect new data on populations from a more widely representative set of taxa and regions, it would be a counsel of despair to conclude that good use cannot be made of existing information. What is needed is further development, testing, and application of robust analytical techniques for combining time-series for multiple populations of different species in ways that reduce their sensitivity to bias from the usual lack of representative sampling.

We recognize that our primary objective of finding estimates of the change in area of broadly defined habitats is itself insufficient. First, the apparent trend in a broadly defined habitat may be particularly sensitive to the details of the definition used. Producing separate data for subdivisions of a habitat and then evaluating the sensitivity of the trend in the aggregated area of them to changes in the components grouped in different ways allows this possibility to be explored.

Second, information is also needed on the degradation of habitats as well as changes in their area. For example, coral reefs affected by sediment deposition, or tropical forests depleted of large vertebrates by overexploitation of bushmeat, may still be the same habitats by definition, but their stock of biodiversity, function, and service delivery may be very different. The LPI figure for tropical forests indicates that vertebrate populations are being depleted in these forests far faster than the forest itself is disappearing. The study by Achard et al. (2002) is the first we are aware of that attempts a global assessment of degradation in a major biome, although even here it is unclear how the category of "visibly degraded" relates to ecosystem function and value for biodiversity. It is evident that a combination of both approaches is likely to be required to build up any kind of comprehensive picture.

Our most striking finding is the dearth of information on trends at a global scale. A major source of information at a global level remains the FAO, which manages reasonably comprehensive global data sets on forestry and fisheries. As its full name implies, however, its primary focus is on food security and the provision of natural resources for direct human use. Although the value of natural habitats to humans is high, it is frequently not recognized in economic decisions about conversion, degradation, and exploitation because of a lack of information, market failures, and intervention (Balmford et al. 2002).

Thirty years after the establishment of the U.N. Environment Programme (UNEP) and 8 years after the entry into force of the Convention on Biological Diversity, there is no program focused directly on documenting changes in biodiversity and natural habitats. The Millennium Ecosystem Assessment will provide an account of existing data on biodiversity, but there is a clear need to extend its mission to ongoing monitoring of global change in biodiversity based on systematic and repeatable methods. There are, admittedly, many conceptual and technical problems to be overcome, but these are far from insurmountable. We found a range of excellent regional and local studies of changes in biodiversity that, given adequate investment and political will, could be used as models for a major global monitoring effort. What seems clearly lacking at present is the political will to implement such a program. Without it, the declaration of the World Summit on Sustainable Development is likely to continue to ring hollow and the target of reducing biodiversity loss will remain elusive.

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