Biodiversity Indicators for Integrated Environmental Assessments at the Regional and Global Level:

Feasibility study on data availability of six biodiversity indicators

Final Report

WORLD CONSERVATION
MONITORING CENTRE

The **World Conservation Monitoring Centre**, provides information services on the conservation and sustainable use of species and ecosystems and supports others in the development of their own information systems.

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Prepared by

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The **World Conservation Monitoring Centre,** based in Cambridge, UK. is a joint-venture between the three partners in the *World Conservation Strategy* and its successor *Caring For The Earth*: IUCN - The World Conservation Union, UNEP - United Nations Environment Programme, and WWF - World Wide Fund for Nature. The Centre provides information services on the conservation and sustainable use of species and ecosystems and supports others in the development of their own information systems.

Prepared for: National Institute of Public Health and Environmental Protection (RIVM)

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This project was conceived by Mark Collins (WCMC) and Ben ten Brink (RIVM). The study has been undertaken by Martin Jenkins and Brian Groombridge, with later input from Tony Turner. The report has benefitted from discussion with Mark Aldrich, Clare Billington, Tim Johnson, Val Kapos and Sara Oldfield (all of WCMC) as well as John Fanshawe, Alison Stattersfield, and Graham Tucker (all of BirdLife International).

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INTRODUCTION

This document has been produced by the World Conservation Monitoring Centre (WCMC) in response to the terms of reference of an agreement with the National Institute of Public Health and Environmental Protection (RIVM), Bilthoven, The Netherlands. The original terms of reference and subsequent amendment are appended as Annex A.

Under a programme called the Global Environmental Outlook (GE0), The United Nations Environment Programme (UNEP) is developing integrated environmental assessments. It proposes to do this through:

- identifying interlinkages between socio-economic and environmental issues;
- identifying major social and economic driving forces;
- supporting the international policy process to come to action on driving forces.

As a "Collaborating Centre for Integrated Environmental Reporting, Assessments and Forecasting" of UNEP, RIVM is developing methodologies for integrated environmental assessments at the regional and global level. To describe and assess the impacts on biodiversity and the use of biological resources, RIVM has identified a preliminary core set of six biodiversity and use indicators. WCMC has been asked to assess the availability of data that might support these indicators. Interim results of this feasibility study were adapted and elaborated upon in a discussion paper "Biodiversity indicators for integrated environmental assessments at the regional and global level" of July 1995. The comments of several experts in various parts of the world will be used to further improve the core set of indicators. The intention is to publish the discussion paper in a technical report series of UNEP and to test and improve the indicators by means of pilot studies to take place in 1996 and 1997.

ASSESSMENT OF PROPOSED BIODIVERSITY INDICATORS

INDICATOR 1. ECOSYSTEM AREA

The proposal

As a measure of ecosystem area it has been proposed to use the 'habitat index' (Hannah *et al.* 1993, 1994). This system uses Udvardy (1975) to divide the world into 193 biogeographical provinces. Each province is assumed to have originally comprised one major ecosystem type (eg. East Malagasy rainforest). Hannah used the best available data sets from such sources as agricultural atlases, remote sensing analyses, world environmental maps, IUCN tropical forest maps, population sheets from world atlases, miscellaneous journal articles in addition to detailed local and regional maps. The area of undisturbed natural ecosystem in each province has been measured, as has the area of partially disturbed ecosystem.

An index is derived from these figures to give a measure of how much original ecosystem remains (current extent + 0.25 disturbed extent/original extent). According to RIVM this index appears to meet the 10 criteria for selecting indicators (see Annex A). Given the base assumption that habitat conversion is the greatest single cause of biodiversity loss, RIVM propose that this index can be used to provide an indication of biodiversity loss at the ecosystem level.

Assumptions and problems

1. The Udvardy classification system as a means of dividing terrestrial parts of the world into units.

   This has been the subject of some criticism. Udvardy himself never intended it to be definitive, but thought of it merely as a work in progress. This is not necessarily a fundamental problem: any global classification system will be to some extent arbitrary but this need not matter if the intention is to track changes over time (ie. as long as the boundaries between units are kept consistent it is not too important exactly where they are placed).

2. The assumption that each province essentially consists of one ecosystem (ie., has one form of potential vegetation cover).

   This is problematic. Each province in fact contains a wide range of natural ecosystems. Some of the smaller ones are disproportionately important for biodiversity. This system ignores, for example, almost all freshwater ecosystems (rivers, wetlands, and most lakes). At the very minimum any revised system must take these more fully into account.

3. The assumption that percentage of original ecosystem remaining is a useful measure for current monitoring.

   Assumptions about original (i.e., potential) vegetation cover are often contentious. The index is sensitive to changes in estimates for these, so that a change in knowledge or opinion about past conditions will apparently affect present conditions. On a more general level, it is far from clear what original vegetation really means. At what point in time does one take a base line?

4. The assumption that the data used can serve as a standardised, consistent baseline across the world.

   The baseline data differ widely in date and quality. This is probably inevitable, but makes it very difficult to use this as the baseline for an ongoing monitoring system: changes found after re-assessment are as likely to be a product of different means of data collection or interpretation of degree of disturbance, as a reflection of actual change in land cover.

5. The assumption that ecosystem quantity and quality are separate measures.

   The habitat index (ie, degrees of disturbance) is measured in terms of area or quantity of various ecosystem types. Disturbance can also be used as a measure of quality of an ecosystem. For example, indicators of highly fragmented landscapes can be used infer as much about the quality of the remaining habitat as the quantity.

Availability of Data

If it is possible to produce a meaningful estimate of original or potential vegetation cover, a measure of how much has already been converted (which is essentially what this index is) does not necessarily provide a sound guide to how threatened it currently is or might be in the future. For this purpose, absolute area and current and projected rates of conversion are much more useful and important.

Consistently available standard information on disturbances is best found from remote sensing imagery. Work is in progress at the EROS Data Centre to compile a global land use/land cover map from NOAA satellite imagery in support of the International Geosphere Biosphere Project (IGBP). The procedure would need to be repeated using comparable techniques to be able to calculate meaningful changes.

A second source of threats to ecosystems could be the Digital Chart of the World (DCW) compiled from 1:1,000,000 scale topographic maps. The DCW contains the distribution of infrastructure such as road, rail, communication networks as well as cities and population centres. Again this one time snapshot would serve to establish current conditions but would require repeating to obtain change information.

INDICATOR 2. ECOSYSTEM QUALITY

The proposal

It is proposed to use data on "a representative cross-section of both ecological and economic key species", selected and presented graphically in the AMOEBA approach (ten Brink *et al.*, 1991), to give an impression of biodiversity loss at the species and genetic level.

The AMOEBA approach is a diagrammatic means of representing the status of a particular region or ecosystem in terms of population levels of a representative number of species (or sometimes groups of species or other quality variables such as 'remaining area of salt marshes'). It postulates a reference population level for each of these species, generally based on assumptions of population levels in the undisturbed or little disturbed state. The AMOEBA graphic shows how far actual populations of each of the species deviate from the reference population level.

According to RIVM, population numbers and distribution of a representative cross section of species as indicators fits well with the terms of reference for quantitative integrated environmental assessments. Tracking species populations is intended to provide a rough picture of the current state of ecosystem quality and a basis for measuring future changes to that state. Linking the state of populations of specific causes or a surrogate measure of causal factors is not the intention of this indicator.

The plan is to use five species from each of six major groups of organisms (mammals, birds, reptiles, amphibians, fishes, vascular plants) for each of 160 Udvardy biogeographic provinces. This gives a target number of 4,800 species for which data on population numbers, past (reference) and present, are required.

Assumptions and problems

1. A major assumption is that the state or 'health' of a large ecosystem can be characterised by a relatively small number of species.

   The notion that individual species, particularly vertebrates and vascular plants, can be taken as indicators of habitats or, further, of ecosystem integrity is a long-standing one in ecology. Despite this, there is little hard information demonstrating this to be the case, and good theoretical reasons for questioning it.

   There may be some justification for adopting this approach in regions which can be viewed as relatively homogenous and simplified biological systems. Thus the inshore North Sea probably can be reasonably well characterised in terms of 30 species or groups of species. This is less conceivable in areas with high species diversity and/or high habitat heterogeneity, ie. most tropical areas. Then many species or other variables are needed.

2. Obtaining good population data is difficult. Monitoring populations of any wild species is a difficult and expensive business, particularly if this monitoring is to be carried out over wide areas (as will be necessary if the species is to be representative

of ecosystems of significant size).

Good population data are available for remarkably few species worldwide (see below). This applies particularly for historical data, which are virtually non-existent other than for a very small number of very well studied species; often those which are or have at some stage been extremely rare, such as Whooping Cranes *Grus americana* and Bison *Bison bison* and which are of limited use in tracking ecosystem quality over whole provinces. Populations may be monitored closely enough to track genuine changes of status only in small areas (sample plots and study sites).

It should be realised that separate ecosystem quality indicators will need to be developed for each of the different ecosystem types in each biogeographical province. This will greatly multiply the number of species it is necessary to monitor.

3. Correctly interpreting population data to reflect changes in ecosystem quality presents a challenge. If good data sets of changes in population of species over time can be acquired, interpreting them is very difficult indeed. A key factor that will require resolution is separating population fluctuations resulting from intra species characteristics and interactions with other species with those that are the result of genuine changes in the quality of the ecosystem.

Determining the causes of population changes is imperative if these changes are also to be used as indicators of changing ecosystem quality. This remains one of the most intractable problems in ecology. It requires intensive, long-term study of the species in question, and may need experimental modification of the species' environment to assess the impact of different management regimes or environmental conditions. The status of species is generally determined by more factors.

Where fairly direct causal connections can be made (eg. old trees and woodpeckers) it is generally easier and cheaper to monitor the changes in the habitat directly rather than through the intermediary of species (it is far simpler to count the frequency of standing dead trees than to monitor population changes of woodpeckers). The question of ecosystem level measures of quality is discussed further in a separate section.

Availability of population data for wild species

Good time-series data for global populations of individual species are very rare. This is a reflection of the difficulty in monitoring populations of most wild animals and also of the lack of investment in wildlife monitoring activities.

In general, the wider the area over which population data are sought, the greater the effort needed to obtain accurate figures and, therefore, the less likely such figures are to exist. Also, the wider the area in question, the more likely the figures are to based on samples rather than whole counts. Results will thus be in the form of a range of probabilities rather than constituting one firm figure. Discerning trends over relatively short time periods (up to a few decades) from such figures is often difficult. Moreover, the figures themselves are often the subject of dispute as different sampling methods will produce different results. Figures are also generally more readily available, all other things being equal, for species

which are: large, diurnal, conspicuous, predictable in their habits, gregarious, and occur in open habitats. Globally, such species are few in number.

In 1990 WCMC undertook a relatively exhaustive search on behalf of UNEP for good time-series population data for threatened species, for the years 1940 to 1989 (UNEP, 1989). Even stretching the limit of the definition of "good", figures could be found for a scant 29 taxa worldwide, of which eight were subspecies. Best data were available for a small number of extremely threatened bird species with very small total populations and usually under intensive conservation management. This exercise concerned globally threatened species only, however, these are the very species for which better and more complete data might be expected.

Reasonable or good population estimates, but not time-series, are available for a larger number of species, again mostly birds, and some non-threatened. Even where total estimates are available these are often not very useful as base-line figures for the establishment of trends because counting methodologies have often not been clearly documented. This means that different figures obtained on re-survey are at least as likely to reflect differences in survey techniques and/or efficiency as they are real changes in status.

Rather more figures are available for species in small portions of their range, but again it is surprising how few data are available, and in particular how little long-term monitoring of populations even in quite small areas has been carried out.

Groups for which there may be expected to be reasonable data are those which are of widespread interest, either for economic reasons (game animals, fishes, cetacea) or from a natural history viewpoint (birds and possibly butterflies).

Globally, the best data relate to pinnipeds (seals, sea-lions, walrus) and birds, and these appear to offer the best possibility for continued monitoring. These groups illustrate two different approaches to the extensive monitoring of wildlife populations. In the first, small numbers of specialists can census wide areas using aerial reconnaissance. In the second, a large number of recorders can be coordinated to produce information over a wide area: because of their number, a high proportion are invariably non-specialists. Each approach has its own advantages and disadvantages.

A third group, the cervids (Family Cervidae: deer), is also examined. These are of great economic importance and highly valued in much of their range as game animals. As such they have been the object of intense study and management. It has been asserted that the North American White-tailed Deer *Odocoileus virginianus* is the most highly studied wild animal in the world (Chapman and Feldhamer, 1982). They therefore undoubtedly represent the group of terrestrial mammals for which best data may be expected to be available.

Pinnipeds

The IUCN/SSC Pinniped status survey and action plan (Reijnders *et al.*, 1993), summarised the best available information on all the world's pinniped species. The pinnipeds are one of the best studied of all wild mammal groups. Because of their habit of hauling out in groups along coastlines when breeding and moulting, population censuses are probably easier for these than for any other group of mammals, and possibly any other animal group.

Of the 42 taxa reviewed (35 species of which 3 were divided into subspecies), reasonable species-wide population data were available for 14, or one third of the total. "Reasonable" here means either more than one reliable census over a period of 20 years, or a recent census with figures for rates of population change (generally based on recruitment levels). This probably represents a high proportion of the **total** number of animal species for which good global population figures are available (except for some extremely localised species). As is usual in wildlife censusing, population figures in almost all cases are based on samples rather than complete counts (eg. with Hawaiian Monk Seal *Monachus schauinslandi* where the entire population hauled out at one time is counted, the population figure has to be extrapolated from this to take into account individuals in the water at the time of census). The estimates thus lie within a range of probabilities rather than constituting one firm figure. This fact makes the discernment of trends over relatively short time periods (up to a few decades) more difficult.

Obviously, further figures are available for particular populations of a number of the other species. Even here, it is surprising how imprecise estimates often are. For example, the U.K. population of the Eastern Atlantic Harbour Seal *Phoca vitulina* is undoubtedly one of the better studied seal populations globally, yet the population figure for 1987 was given as at least 25,000 animals, but possibly as high as 46,000-47,000, based on telemetric studies. Clearly, figures such as these cannot be used as baseline figures until more precision can be obtained.

Similarly, the Northwest Atlantic population of the Harp Seal *Phoca groenlandica* has been the subject of intense scrutiny over the past several years, owing to controversy concerning the seal harvest in Canada. Population data may thus be expected to be particularly good, however Reijnders *et al.* note that "Consistently, Cooke *et al.* (1986) [who carried out a detailed review on behalf of the Canadian government] were unable to determine whether the population had been increasing or decreasing slightly or had been relatively constant during the preceding fifteen years." The question of what is happening to this population remains unresolved.

Cervids

In the late 1980s, UNEP initiated a project to try to collate available information on cervid populations and harvests in Europe and North America with the aim of establishing a framework for monitoring future trends. Although the final report (Gill, 1990) excludes the former USSR and several other European countries, it is still the most comprehensive compilation to date of information on this group of species (Gill, 1990).

Methods used in North America to estimate cervid populations over a wide area include: aerial surveys; pellet surveys; change-in-ratio techniques; computer models and estimates derived from harvest returns. The first two of these are often used with the intention of detecting population trends only, rather than providing full estimates.

Gill noted that many states in the USA and Canada, particularly those where White-tailed Deer predominated, managed populations adequately without making any estimates of abundance at all. Aerial surveys were frequently used for far northern species although air survey data which benefitted from stratified random sampling and/or some careful correction for sightability were very rarely available.

In Europe the majority of field methods involve direct counts from the ground, although aerial surveys were occasionally used. There was generally a lack of descriptive information on the methods used. In east and central Europe, prior to political changes in 1990, there was a legal requirement for an annual estimate of deer populations from all hunting grounds. Elsewhere survey methods were less consistently applied. All evidence assembled clearly indicated that estimation of deer numbers in woodland habitats was difficult and led to under-estimates.

By using population reconstruction from harvest records and estimates of fertility and mortality, it is possible to check the accuracy of many of the estimates of population size. Generally, ground surveys under-estimated numbers calculated from these models by a factor of 1.3-1.6, sometimes considerably more.

Data used to determine trends in populations were generally far from precise. It was normally only possible to classify populations as increasing, decreasing, stable or trend unknown. Nevertheless, it was possible to build up an extensive, if imprecise, picture of changes in cervid populations over the present century. As with changes in waterfowl populations discussed above, it was difficult to relate these changes to specific causal factors.

Birds

Birds form the only major terrestrial taxonomic group that has been the subject of extensive survey programmes. Even for these, useful population data are surprisingly scanty. Bibby (1994) analysed data from *The Threatened Birds of the Americas* (Collar *et al.*, 1992), a recent comprehensive analysis of the status of bird species in the Americas. He noted that despite the recent huge upsurge of ornithological interest in Latin America, only 37 (12%) out of 317 species identified as threatened had total population estimates. Green and Hirons (1993) analysed the data set from the first edition of *Birds to Watch* (Collar and Andrew, 1988), which listed all bird species worldwide then recognised by ICBP (now BirdLife International) and IUCN as threatened. Of 1,029 species, only 202 had any reasonable population estimate (including estimates for the breeding population only or for any more than 50% of the entire range). Furthermore, only 7% of the total had more than one comparable population estimate. They noted that even the crudest assessments of rate of population change were therefore impossible for the vast majority of threatened bird species. It should be stressed that these results apply to the taxonomic group (birds) which is by far the best known globally, and results for other groups will be much poorer.

For non-threatened species, useful country-wide time-series data only exist for two parts of the world: Europe and North America. Even within Europe, there are few countries with long-established and reliable monitoring schemes (Tucker and Heath, 1994). In both parts of the world, extensive annual censuses of birds (often breeding birds, based on singing males, and overwintering birds) are carried out by networks of largely amateur ornithologists. Although there are quite serious problems with the data (owing generally to non-standardised methodologies of collection), these represent undoubtedly the most useful body of data currently available on the abundance of wild species.

There are currently attempts to extend censuses of this type to other parts of the world (for example for waterfowl, coordinated by IWRB), but these are generally in a preliminary stage at present (Rose and Taylor, 1993).

Birds in North America

The most comprehensive surveys in the United States are sponsored by the National Audubon Society (NAS), the US Fish and Wildlife Service (USFWS) and Cornell University (US EPA, 1992).

NAS: Christmas Bird Counts. These have been carried out since 1900 by volunteers nation-wide without scientific protocol, therefore many biases are possible. Recently more stringent counting rules have been instigated, which should greatly increase the value of the surveys.

Breeding Bird Census based on counts of territorial males. Again, the protocol has not been scientific (dates from 1937).

Winter Bird Population Study. Winter analogue of Breeding Bird Census (from 1947/48).

USFWS Breeding Bird Survey, established in 1966, consists of an annual roadside survey of US and Canadian birds. Surveys are conducted each June along ca 2000 roadside routes. Experienced volunteers sample bird populations at 50 stops at 0.8 km intervals along secondary roads. Survey relies on singing males and therefore only detects changes in overall populations if these are reflected in changes in singing males. USFWS also carry out a census of breeding waterfowl in May each year.

Cornell University Laboratory of Ornithology manages several computerised databases on North American birds including the North American Nest Record Program, Colonial Bird Register and two new programmes: Project Birdwatch and Project Feederwatch. It also maintains the computerised databases for the National Audubon Society's three survey programmes.

Breeding wildfowl numbers in the USA and southern Canada have been estimated since at least 1955. This survey is conducted jointly by the US Fish and Wildlife Service and the Canadian Wildlife Service and is probably the most extensive regular professional wildlife survey in the world. It uses a standard technique to monitor wildfowl populations in which some 70,000 km of transects are flown by 8 teams of two in single engine aircraft at low altitudes across wetlands with findings confirmed by ground-based biologists at selected sites.

Breeding wildfowl numbers show considerable year on year fluctuations, both in overall totals and those for individual species, such that it is very difficult to discern definite trends in the short term. However, analysis of the data over a longer period can show definite trends. A comparison of 1991 population levels with the average for the previous 35 years showed a statistically significant 19% decline in total dabbler and diving duck populations. For several individual species, statistically significant declines were even higher (eg. Northern Pintail, 62% decline, $P<0.001$; Redhead, 26% decline, $P<0.001$; Mallard, 27% decline, $P<0.001$) (US EPA, 1992). These are some of the best data available showing widespread and significant changes in population levels of wild species.

Birds in Europe

A survey is currently being carried out by the British Trust for Ornithology (BTO) on behalf

of the Royal Society for the Protection of Birds (RSPB)/BirdLife International and the European Bird Census Council to determine the level and accuracy of surveillance of wild bird populations in each country in Europe. At present the majority of European countries do not have regular, systematic surveys of their bird populations (G. Tucker, BirdLife International, pers. comm). Nevertheless, in Europe data for birds are clearly better than data for any other group. Of 514 species considered in an analysis of the conservation status of birds in Europe (Tucker and Heath, 1994), 183 (36%) were considered particularly poorly monitored: over half of their European populations were thought to have poor data on size or population trend, implying that data for the remaining 64% were at least adequate. Other than in very few cases, trend data tend to be in generalised form ("large decline, small decline, stable, small increase, large increase").

Reliable bird data in other countries

In Australia, the most comprehensive study to date is the Atlas of Australian Birds undertaken by the Royal Australian Ornithologists' Union (Blakers *et al.*, 1984). This has dealt with breeding bird distributions, but notes that for virtually all species there are few if any data on abundance. In New Zealand although most of the fourteen or so highly threatened bird species are closely monitored, data on abundance of the rest of the avifauna are not systematically collected. In South Africa, a bird population unit has recently been established, but its work is at a preliminary stage at present and is concentrating on distribution (atlas work) rather than population abundance and trends.

Using expert judgement where population data are not available

As has been demonstrated above, reliable historical data for distribution and/or abundance of wild species are available in remarkably few cases. The possibility remains of using expert judgement to establish realistic reference points instead. These reference points must then be useable for measuring or estimating **quantitative** changes so that indices can be developed. Major points to consider with reference to changes in population level are:

1. As with indicator 1, such a process becomes very sensitive to initial conditions. These conditions will, by definition, be to some extent arbitrary and potentially unverifiable. They will need to be underpinned with facts and expert opinion.

2. Virtually all species which have been studied in detail in the wild show marked fluctuations in populations owing to natural causes. These fluctuations occur at all time-scales and appear to be particularly marked in seasonal environments, such as those at high latitude. It has been argued, principally on the basis of classic lynx - snowshoe hare studies in North America, that there is a regular ten-year periodicity in these natural fluctuations. This remains controversial, but the data do unequivocally demonstrate that fluctuations occur on the timescale on which monitoring is envisaged. Under these circumstances it becomes ecologically meaningless to talk of an expected or reference population level. It also means that, as discussed with reference to the duck data above, decades of data will be needed to determine if there are any genuine underlying population trends. These natural fluctuations will need to be an integral part of the indicator.

3. Unfortunately, those species which may be expected to have best prospects for

monitoring over a wide geographical area, ie. large gregarious animals in open environments, are precisely those which show widely fluctuating population levels under natural conditions. Conversely, those species which may be expected to have reasonably constant populations under natural conditions are, in classic terms, K-selected species. In general these occupy stable environments, which are usually forested if terrestrial, and occur at relatively low population density. These are precisely the species which are most difficult to monitor.

4. Monitoring changes in distribution, particularly of larger species, offers greater prospects of success. However, as with changes in population levels, unless species have been subject to intensive study, analysis will have to be at a coarse scale. This will often allow a rough estimate of what percentage of a given species' original range it now occupies but is unlikely to be precise enough to allow quantitative analysis of changes over a five or, in many cases, even a ten year time-scale. The case here is very similar that discussed under index 1, particularly as most experts will base their estimates of the original range of a species on suppositions of the original extent of suitable habitat.

Prospects for establishing new monitoring systems

If insufficient real data are currently available, and expert judgement is not a complete substitute, a third possibility is to set up new monitoring systems specifically designed to generate the information required for an indicator system. The text below provides a brief analysis of three Realms in order to illustrate the kinds of opportunities available for species monitoring, bearing in mind the caveats discussed above. Udvardy recognised eight biogeographic Realms. Four of these and selected ecosystems they contain, are examined below to illustrate the possibilities of this approach.

Nearctic Realm

Udvardy recognised 22 provinces. Along with the western Palaearctic, the Nearctic realm undoubtedly has the highest concentration of wildlife biologists and ecologists in the world, in academic institutions, government departments and non-governmental organisations (NGOs). Prospects for accurate, extensive monitoring should therefore be stronger here than in most other parts of the world. The Nearctic realm comprises largely temperate and boreal forest ecosystems. There are also extensive open ecosystems, including tundra, prairie and desert, and major freshwater ecosystems, both riverine and lacustrine.

High Arctic/Tundra ecosystems

Because of the open nature of these ecosystems, large species are theoretically relatively easy to monitor here. However, these ecosystems are very large in extent and significant areas are very inaccessible. Aerial surveys of large herbivores and social carnivores and counts of specific study sites of other species offer the best prospects. Analysis of harvest records of some game-species may also be valuable. Potential species for aerial survey include Caribou *Rangifer tarandus*, Musk Ox *Ovibos moschatus*, and Wolves *Canis lupus*. Potential species for sample monitoring Polar Bear *Urus maritimus*; Grizzly Bear *Ursus maritimus*; Arctic Fox *Alopex lagopus*; Arctic Hare *Lepus timidus*; possibly Wolverine *Gulo*; breeding waterfowl. For marine ecosystems: seals and the Walrus *Odobenus rosmarus* are suitable for aerial surveys when hauled out. Some cetaceans, notably Beluga *Delphinapterus leucas* and

Bowhead *Balaena mysticetus* offer good prospects for regular sampling. Monitoring of fisheries landings would provide an insight into changes in marine ecosystems.

Taiga/Northern Boreal ecosystems

As with other forest ecosystems, it is very difficult to monitor animal population levels in boreal forests. However, the forests are of generally low diversity and therefore there is some possibility of characterising them in terms of a relatively small number of species. Analysis of harvest records of game species along with studies of particular sample sites offer the best prospects. Suitable species: harvested fur-bearers (Beaver *Castor fiber* (aquatic), martens *Martes* spp., Wolverine *Gulo*, Muskrats *Ondantra zibethicus* and *Neofiber alleni* (aquatic - homes can be censused from the air); bears *Ursus arctos, U. americanus* (population changes in limited areas); Moose *Alces* (wetlands, aerial census).

Other species or species groups which may be suitable for different parts of the USA: Mountain Sheep *Ovis* spp. and Mountain Goat *Oreamnos americanus* (montane ecosystems in western N. America) - reasonable data exist for both these; Pronghorns *Antilocapra americana* - open grassland and shrubland ecosystems in American mid-west; deer (see discussion above); Caribbean Manatee *Trichechus manatus* - Florida wetlands; Sea Otter *Enhydra lutris* - inshore marine ecosystems in northern Pacific and California; River Otter *Lutra canadensis* - widespread in freshwater ecosystems but absent from central part of continent. Birds are discussed above. Trends in harvest of native fishes and spread of introduced species have been used to illustrate changing conditions in the Great Lakes.

Palaearctic Realm

Udvardy recognises 44 provinces. From a monitoring point of view, the realm can be divided unequally into western and eastern parts. Like the Nearctic Realm, the western Palaearctic has a high density of wildlife biologists and ecologists. Most of it has also been greatly affected by mankind: other than at the geographical margins, there are very few even relatively undisturbed ecosystems. The eastern Palaearctic has much larger areas of relatively undisturbed ecosystems, particularly in its northern parts and has, with the possible exception of Japan, a far lower density of wildlife biologists and ecologists.

Western Palaearctic

For some parts of the region, there are good data for a reasonably wide range of animal groups. Data availability for birds, deer and seals is discussed above.

Certain other species may offer opportunities for monitoring. River Otter *Lutra*: distribution in much of Europe has been reasonably accurately mapped. This species appears to be quite a good indicator of the general health of coastal and freshwater ecosystems. Changes in distribution may be detectable over 5 or 10 year intervals. European Mink *Mustela lutreola*: a threatened species; as otter, though generally less well studied and monitored. More limited distribution (eastern part of Western Palaearctic and very limited part of west). Wolf *Canis lupus*, and Brown Bear *Ursus arctos*: patchy distribution. Both species now confined to largely montane wilderness areas. Changes in distribution may be monitorable. Bats (Chiroptera): sensitive environmental indicators but very difficult to monitor. European Hare *Lepus capensis*: changes in population density may be a good indicator for agricultural ecosystems. A game species, so there may be reasonable data. Ground squirrels

Spermophilus: distribution reflects that of species-rich grasslands. Changes in distribution may be monitorable. European Beaver *Castor fiber*: as for north American beaver. Arctic Fox *Alopex lagopus*: as for Nearctic. Wolverine *Gulo*: as for Nearctic. Badger *Meles*: a possible indicator of biodiversity in agricultural land. Deer: discussed above.

Eastern Palaearctic

The eastern Palaearctic contains vast areas of largely natural ecosystems, although little of it is completely untouched. Much of the region is difficult of access and there are, relatively speaking, few wildlife biologists. In the short to medium term, monitoring by aerial survey and census of limited sample areas are likely to be the only feasible options. Southern parts of the region have large expanses of desert and steppe. Aerial survey is a realistic proposition here. Further north the region largely comprises northern boreal forests. Aerial survey of animal populations is far more problematic here.

Saiga *S. tatarica*, Chiru *Pantholops hodgsoni*, Goitred Gazelle *Gazella subgutturosa* and the three *Procapra* species are all largely gregarious open country species which have more or less extensive ranges in southern parts of the eastern Palearctic. The Saiga in particular has been subject to considerable management and monitoring over the past several decades, although their biology is such that population levels can change dramatically over very short time periods. Pinnipeds: Caspian and Lake Baikal seals, may be feasible subjects for monitoring. Fishes: eg. sturgeons, most are subject to intensive fisheries; catch statistics would provide valuable data, although populations are heavily managed, so their value as indicators of anything other than themselves is limited.

Africotropical Realm

Udvardy recognises 29 provinces in this realm. The major terrestrial ecosystems are forest and savannah/woodland; there are also important freshwater ecosystems (the African Great Lakes, major rivers, inland wetlands). Although some parts of the realm have been the subject of considerable ecological study over the past few decades (notably savanna ecosystems in eastern and southern Africa), in general there is a great shortage of wildlife biologists. Research institutions and government departments charged with wildlife are in generally extremely under-resourced.

Forest ecosystems

Prospects for any consistent monitoring of distribution or population levels of animal species in Africa's forested regions are very poor. These regions are highly biodiverse, often very inaccessible and with at present very few scientists working in them. Moreover, on first analysis there appear to be very few species which can be monitored from a distance (*cf* the Indomalayan Realm). Another approach is to monitor ecosystem composition or structure as proposed in a later section.

Open land ecosystems

Deserts/semi-deserts: low densities of large animal species and the nomadic nature of most large animal populations make quantitative assessment and particularly tracking of population changes very difficult. Open ecosystems: savannahs, floodplains etc. Survey methods are reasonably well developed and some regions have been reasonably well monitored (most notably the Serengeti/Mara complex); the major grazing herbivores certainly present good opportunities for monitoring. However, as with other ecosystems of this type, populations

undergo considerable fluctuation owing to natural causes. Within these ecosystems, large ungulates offer the best possibilities for monitoring. Available information until the late 1980s has been summarised in the IUCN/SSC Antelope Action Plans (East, 1988, 1989, 1990). The introduction notes that all population estimates must be interpreted with great caution. Many woodland species are very difficult to count accurately either from the air or from the ground. Estimates derived from low-intensity aerial surveys (currently the only realistic prospect for covering large areas) have large statistical sampling errors and wide confidence intervals. Because of these limitations, population estimates generally allow the reliable detection of only large-scale changes in numbers between sampling occasions. These problems will only be overcome with a increased intensity aerial survey and/or new and efficient monitoring technology along with small scale area sampling techniques focusing on change in population numbers, distribution or density instead of full population estimates.

Indomalayan Realm

Udvardy recognises 27 provinces. Until recently there has been a considerable shortage of wildlife field biologists active in this part of the world. This is changing rapidly, particularly in the more developed countries. The predominant natural terrestrial ecosystems are forests, either evergreen moist or seasonal (monsoon). These ecosystems are highly diverse. There is still a shortage of expertise in many regions, such as Indochina, Myanmar and Bhutan.

As with other forest ecosystems, it is very difficult to monitor the status of animal species within them. Best prospects are for species whose presence can be determined, and some indication of population density gained, without direct observation. Gibbons and Siamang (family Hylobatidae): surveys can be carried out relatively easily on the basis of calls. The family is widespread in south-east Asia (ie. occurs in much of the Indo-Malayan realm). Orang-Utan *Pongo pygmaeus*: estimates of relative population density can in principle be obtained by counting nests. Argus Pheasant *Argusianus argus*: surveys can be carried out on the basis of calls. Changes in distibution of large bovids (Gaur *Bos gaurus*, Banteng *Bos banteng*, Yak *Bos muticus*) and the Asian Elephant *Elephas maximus* should be detectable over sampling intervals of a few years. Estimating population densities for these species is extremely difficult.

Availability of ecosystem level data

In some cases, species population levels may not be the most representative measures of ecosystem quality, particularly in complex ecosystems. In these cases, ecosystem level measures may be more useful indicators. For example, in large a aquatic ecosystems such as the Great Lakes, numerous physical and chemical properties of the ecosystem are monitored to determine changes in the overall quality of the ecosystem. Some of these measures directly affect the ability of the lakes to sustain a diversity of species.

Besides environmental factors, socio-economic variables may also influence ecosystem quality. For example, human population density, transportation infrastructure and intensive agricultural land use may be appropriate indicators of the quality of a ecosystem. As these have a spatial component as well, they may also be used as indicators of ecosystem quantity.

Indicators of ecosystem quality are related to ideas of ecosystem health, which are in turn related to notions of ecosystem organisation, vigour and resilience. Central to this is the idea

that it is more important to maintain ecosystem processes than the individual elements (populations, species and their physical environment) which make up ecosystems. In one study, up to 21 ecological functions performed by biodiversity have been identified (Mosquin, 1994). Changes to any one or combination of these functions would result in a change in some aspect of ecosystem quality.

A major problem with this approach is that ecosystem processes are extremely complex and remain little understood, particularly over large spatial and temporal scales. It is known, however, that ecological processes operate over decades and even longer timescales. Long-term time series of data are therefore required before it is possible to understand them. One striking case is the effect of the periodic El Niño event on marine ecosystems, causing dramatic fluctuations, apparently on a decadal timescale, in for example populations of shoaling pelagic finfishes in upwelling areas such as those off the west coast of South America.

In terrestrial ecosystems attempts are being made to determine criteria for defining ecosystem health and quality, but it is widely acknowledged that much more work needs to be done, both theoretically and experimentally before these concepts can be made operational. And as with population indicators, ecosystem quality indicators will vary from ecosystem to ecosystem.

For forests, the following are examples indicators of quality are being developed.

- Tree health, based on defoliation, needle-loss and some crown characteristics. Data regarded tree health are widely available for much of Europe, the U.S.A. and Canada and are the subject of on-going surveys in most countries. There is still a need to standardise measures, particularly in Europe where a wide range of government institutions and non-governmental organisations is responsible for collecting data in different areas. In addition, interpretation of these data is still contentious so that it is unclear what exactly they mean. Outside Europe and North America data on tree health are very sparse.

- Fragmentation measures. Because of edge-effects and species-area relationships it is widely acknowledged that degree of fragmentation of forest cover is an important indicator of forest quality, in that the more fragmented forest cover is, in general the less valuable it is for biodiversity. FAO has developed a fragmentation index which can be applied to digitised maps of forest cover. The latter may be derived from remote sensing, or from conventional maps compiled from ground surveys or aerial photography. WCMC has an extensive data set of forest-cover maps with now virtually complete global coverage. However, the quality of the data, their resolution and their date of origin are highly variable. Considerable work therefore needs to be done to standardise these data. Obtaining reliable and repeatable measures of forest fragmentation will require an improved monitoring capability such as might be available through the use of remote sensing technology. This offers one of the best prospects for developing a globally applicable indicator.

- Age profiles and spatial variation in distribution of trees including primary and secondary forest or canopy structure. These factors give a good indication of the

naturalness of forest areas. Of particular importance are the distribution and standing biomass of "overmature" (in forester's terms), dying and dead trees. Other important factors are mean DBH (trunk diameter at breast height) and mean distance between trees. Overmature and dead trees provide very important habitats for a wide range of plants, animals and fungi (notably saproxylic fauna and flora) which contribute significantly to the biodiversity of forest ecosystems. Data are good in some well-studied areas, such as the North-west Pacific Coast forests in the U.S.A. and are patchily good for Europe, where preliminary inventories of remaining natural and semi-natural forest have been compiled. As yet, remote sensing systems are not sufficiently refined to enable measurements of these variables to made remotely. Data collection thus requires on-the-ground surveys, although this will generally be quicker and easier than surveying the specialist fauna and flora dependent on mature or natural forests.

In general for forested ecosystems, quality can also be measured at several levels, depending on the which aspect of ecosystem function one is interested in maintaining. Annex B describes specific indicators of quality proposed for temperate and boreal forests as they relate to three different objectives: maintenance of productive capacity, maintenance of forest ecosystem health, and maintenance of soil and water resources. One or all of these indicator areas could be used as measures of quality. All relate to maintaining some aspect of biodiversity.

Marine ecosystems

Oceanic ecosystems, which cover 71% of the earth's surface, are in general much less well understood than terrestrial ecosystems. Primarily this is because they are much more difficult to study directly, quite simply because man is a terrestrial animal. Biogeographic classifications of oceanic ecosystems are also made problematic because they are much more fluid and dynamic than terrestrial ecosystems, with far fewer natural boundaries. However, some sort of classification system will be necessary if any effective monitoring and management of the marine biosphere is to be developed. The most promising system developed to date appears to be that of the Large Marine Ecosystem (LME) as elaborated by Sherman and Busch (1995).

Large Marine Ecosystems (LMEs) are "regions of ocean space encompassing near-coastal areas from river basins and estuaries out to the seaward boundary of continental shelves and the seaward margins of coastal current systems. They are relatively large regions of the order of 200,000km^2 or larger, characterized by distinct bathymetry, hydrography, productivity, and trophically dependent populations. Nearly 95% of the usable annual global biomass yield of fishes and other living marine resources is produced within 49 identified LMEs which lie within and immediately adjacent to the boundaries of Exclusive Economic Zones of coastal nations (Sherman and Busch, 1995).

The current LME system is regarded as at least to some extent preliminary and may be expected to be modified as more research is carried out. Nevertheless, it provides an extremely useful framework in which to start developing indicators of the state of marine biodiversity.

Core monitoring activities which would be central to the development of such indicators

include the use of Continuous Plankton Recorders (CPRs) for plankton and water quality assessment, bottom trawling for measuring changes in the fish community and environmental pollution assessments. Sampling and monitoring efforts undertaken by the Office of Oceanography and Marine Assessment of the US National Oceanic and Atmospheric Administration (NOAA) exemplify the range of information which should be gathered:

- systematic collection and analysis of catch-statistics;
- fisheries-independent bottom and midwater trawl surveys for adults and juveniles;
- ichthyoplankton surveys for larvae and eggs;
- measurements of zooplankton standing stock, primary productivity, nutrient concentrations;
- measurements of important physical parameters such as water temperature, salinity, density, current velocity and direction, air temperature, cloud cover, light conditions; and
- in some habitats, measurement of contaminants and their effects.

INDICATOR 3. THREATENED/EXTINCT SPECIES

The proposal

The suggestion is to use the IUCN Red List as a source of data to indicate the species and locations, in terms of Udvardy provinces, for which urgent action is needed.

Assumptions and problems

The principal assumption is that changes in the list of species regarded as threatened, or in the status category to which listed species are assigned, reflect real changes in the overall status of wild species.

In order to yield a global perspective, globally or regionally consistent data sets are desirable. Birds are the only major taxonomic group to have been fully and consistently analysed on a worldwide basis. Other groups (of lower taxonomic rank) which may be useful are: primates, antelopes, deer, felids, canids, crocodilians, swallowtails, and some groups of plants.

Although there are a large number of national and regional Red Lists and Red Data Books, categorisation systems and criteria are not consistent. It would be extremely difficult therefore to use these as the basis for global indicators.

As part of a dynamic index threatened species listings will be of limited use: changes unconnected to species status - mainly taxonomic changes, improved information and changing classification criteria - generally swamp genuine changes in status. For example, 295 species categorised by BirdLife International as 'low risk' in *Birds to Watch* (Collar and

Andrew, 1988) were upgraded to 'threatened' in *Birds to Watch 2* (Collar *et al.*, 1994), but in only 10 cases (1% of the total of threatened birds) was this because of observed deterioration in status.

Even for groups as comprehensively analysed as the birds, the development of an index based on numbers of threatened species which can be used to track changes will depend on the establishment of baseline data for **all** species and the stabilisation of nomenclature, something which shows little sign of taking place.

Keddy (1991) notes that in Canada changes in the number of officially recognised threatened species reflect the number of listing reports completed each year (which is a function of the financial status of the listing agency) rather than the number of newly-threatened species. Even without invertebrates, for which there was little likelihood of comprehensive coverage in the foreseeable future, an investment of several hundred thousand dollars would be required to complete the back-log of listings. Only then (and assuming investment in species monitoring were maintained) would changes in number of species on the list start to reflect actual changes in status. This applies to a country which is, relatively speaking, biotically impoverished and financially wealthy, with a strong commitment to conservation. The problems will be magnified enormously in most other parts of the world, particularly those where biodiversity is richest.

Perhaps a more effective and efficient means of assessing status of, threats to and action taken to maintain biodiversity in any given area would centre around the identification of sites or areas with large numbers of localised and/or endemic species. These sites by definition make a disproportionately high contribution to the biodiversity of the larger area. In addition, localised species are generally inherently at greater risk than more widespread ones. Assumptions can therefore be made that these are likely to be threatened without the need to assess the actual population status and trends of each one. Although still often inadequate, this type of information, based on knowledge of the distribution of species, is much more readily available than that concerned with population status. One approach may be to choose endemic areas as sample sites for continued monitoring. The state of endemic areas may also contribute to the ecosystem quality indicator.

Monitoring of the sites and areas which contain large numbers of species will then give a good overall indication of progress made towards maintaining biodiversity. Assessment can be made of rates of destruction or conversion of these sites and areas (pressure indicators) and progress towards protecting them (response indicators). Sites and areas can be weighted for importance on the basis of numbers of endemic or localised species found within them.

As an example, in the United Kingdom, areas may be classified as Sites of Special Scientific Interest (SSSIs). One of the criteria for this is species diversity, and particularly richness of rare and localised species (on a national level). Sites can be ranked or classified in terms of their importance by this criterion. It is then possible to monitor the number of such sites destroyed or degraded in any given time period. This will serve as a powerful surrogate indicator of overall deleterious changes in biodiversity. Conversely, monitoring the number of such sites afforded formal protection (and further, those with active management plans developed and implemented) provides a good measure of the steps taken to maintain biodiversity.

Measuring these changes on a systematic basis is much easier than measuring changes in population status of all species identified as threatened or of conservation concern in a given area.

A system of this sort is applicable at many different geographical scales. Globally there are at least two important relevant data sets. These are the Endemic Bird Areas identified by BirdLife International (Bibby *et al.*, 1992) and the Centres of Plant Diversity (WWF and IUCN, 1994).

INDICATOR 4. BIODIVERSITY USE

Changes in human use of biological diversity is a result of complex interactions between changes in human behaviour and changes in the status of the resources being exploited.

Use values can be considered in three main categories:

- Option/existence values
- Direct resource use
- Indirect use

Option values and indirect use values have to date not been adequately quantified. It will be difficult to quantify them to the extent that they could be used to monitor changes. They are more likely to be extrapolated directly from changes in biodiversity.

There is perhaps some possibility of using option values to highlight differences in the importance of different regions (ie. option value of a given area of tropical moist forest could be said to be higher than that of a given area of boreal forest, therefore loss of the former would reflect more loss than the latter). However, such extrapolations are contentious and seem an unnecessary complication, as such differences could be indicated simply by using measures of biological diversity per unit area.

It is possible to assess direct use values in terms of absolute value of particular sectors (fisheries, timber from natural/semi-natural sources) or relatively, in terms of the proportion of a given sector (animal production; all timber production) or proportion of Gross Domestic Product provided by these sources.

Figures for direct use are generally at present only obtainable for major industries, namely fisheries and forestry.

Forestry

The major issue at stake is the extent to which timber from natural or semi-natural areas is being harvested unsustainably, that is the extent to which annual offtake exceeds annual incremental growth. Ideally, analysis should be at the level of individual species in particular forest areas. In the majority of cases this is clearly not practical.

The term "use", as the term "quality", can be interpreted in a variety of ways. For temperate forest, international committees have suggested several "use" indicators namely production

and consumption, recreation and tourism, investment, cultural, social and spiritual values, and employment and community needs (see Annex B).

Two additional approaches at the national level which offer prospects for the generation of indicators are:

1. Determining the proportion of annual timber production which originates from accredited sustainable sources.

2. Determining the proportion of the national forest estate which is managed on a sustainable basis.

Because analyses of this type are generally still at a preliminary stage, for many years to come changes in these two indicators are as likely to reflect changes in available information as they are changes in management regimes (*cf* listing of threatened species).

Fisheries

With fisheries the major problem is determining to what extent current harvest levels may be sustainable, often in the face of inadequate knowledge of the population dynamics of the species harvested. At present, indirect approaches are probably the best. Two which have possibilities are:

1. Measures of catch per unit effort. These give a good insight into changing population levels of harvested species. As with most indicators of this sort, quite long time-series are usually needed to determine underlying trends.

2. Measures of change in catch composition, in particular relative proportions of large *vs* small fishes in catches. These measures can be used both within species (numbers of adults *vs* numbers of juveniles caught) and between species (in mixed catches, numbers of individuals of large species *vs* numbers of individuals of small species harvested). More sophisticated analyses could track changes in the types of fishes harvested (predators *vs* herbivores and detritivores).

Proportion of harvest derived from aquaculture will also provide an indication of long-term changes in fisheries.

INDICATOR 5. NUMBER OF WILD SPECIES IN CULTIVATED AREAS

There are major questions of scale and definition. At a fine scale, this indicator area could be interpreted as an attempt to determine how much biodiversity can survive in areas wholly given over to various forms of production (eg. strictly arable land, softwood plantations). However, at a landscape or large ecosystem scale a cultivated landscape actually consist of highly complex mosaics of natural, semi-natural cultivated and other anthropogenic habitats with various uses.

For example, under the definitions of the 'Habitat index', the whole of the UK and the Netherlands would be classified as disturbed ecosystems, but actually contain areas which are

at least semi-natural some of which are wholly or partially devoted to conservation ends. Asking how many wild species survive in these landscapes is a different question from asking how many survive in improved rather than unimproved pasture. (ie, are we asking about status of species in particular areas or in particular, man-made habitats?)

Data are generally inadequate on this subject, even in highly studied areas such as Europe. It is one which will become increasingly important as more and more of the world is converted for direct human benefit and as such should be identified as a research priority.

One approach seems to be to use what research findings there are on impacts of physical changes on biodiversity (fertilizer input, clearance of hedgerows, clearance of riparian habitats) and then to track these changes. However, this may be seen as begging the question as there is in general still no unequivocal direct causal link between these changes and biodiversity.

As a complementary approach, in the few well-studied areas (parts of Europe, North America, Australia and possibly New Zealand), status changes of a number of species could be tracked.

Another approach might be to develop indicators of invasive exotic species within cultivated landscapes. To extent to which these affect crops are more well documented whereas the extent to which they affect the native landscape is less well documented. However, if the relationship between invasives and native species is established, a useful indicator may emerge.

INDICATOR 6. NUMBER OF DOMESTICATES IN CULTIVATED AREAS

The number, and if possible, the identity, of breeds and crops/varieties in a given area, and their change over time, would give a sound indication of levels of domestic biodiversity. It does not appear possible, unless all taxa are mapped and their ranges analysed in a GIS, to resolve these data accurately in terms of Udvardy's biogeographic provinces.

The most feasible approach is likely to be to monitor the changes in dominance of the major varieties of a given crop over time. This information is likely to be much easier to obtain than information on the numbers and production of local varieties and land-races (although this is potentially more interesting and useful), and could probably be gathered quite readily in many developed countries. Some data on plant genetic resources may be commercially sensitive and difficult to access. Some of this information might be collected at the level of sub-national administrative units. The FAO is developing a world database on domestic livestock; this currently has much information at the national level, and will eventually collate more data on numbers and status. It is not at present clear how rapidly these parameters change over time, nor how quickly such change will be reflected in existing reporting procedures.

DISCUSSION AND SUGGESTIONS ON BIODIVERSITY INDICATORS

INDICATOR 1. ECOSYSTEM AREA

Although there are serious reservations about the Udvardy biogeographic classification as a basis for analysis, and about the varied quality and age of the source data on land cover, the Habitat index is a useful overview of gross changes in global land cover. However, it is essentially a one-time snapshot of conditions, and any attempted future re-assessment will almost certainly be unable to distinguish actual on-the-ground changes in cover from the effects of changes in the way data on land cover are gathered and recorded. This factor, combined with reservations noted above, means that this methodology cannot provide a valid repeatable assessment of ecosystem area to track changes in time.

Including additional threats, developed for each biome or biogeographical province, as appropriate, might supplement the disturbance index. The indicators must be carefully selected to for their representativeness of changes in the landscape and their capability for repeat measures. GIS models of that project loss of ecosystem area may be possible to develop.

The underlying data that support Hannah's work could form a baseline for a current assessment of space available to enable ecological processes to occur without the direct influence of human activities. These would need to be carefully selected so that they capture the range of disturbance and yet can also be updated. One approach might be to combined Hannah's baseline with additional information on major threats to ecosystems. Threats or pressures on an ecosystem range from harvesting activities, introductions of invasive species, fragmentation resulting from economic infrastructure to contamination or pollution amounts in ecosystems. It should be ensured that a consistent time series of information is available. Also it should be noted that the influence of these threats on biodiversity will vary depending on the characteristics of the ecosystem in question. For example, fragmentation may be an appropriate measure of stress in forested ecosystems, but may be totally inappropriate for the Arctic or grassland ecosystems. A list of common threat categories applied to Udvardy biomes is found in Annex C.

Another potential solution might be to make the indicator simpler and less ambiguous so that the method has a higher potential to provide valid repeatable assessment of ecosystem area to track changes over time.

INDICATOR 2. ECOSYSTEM QUALITY

The major question arising here is whether or not the state of a large ecosystem (especially complex ecosystems such as species-rich tropical system or mountain complexes) be characterised by information on the small number of species whose status might be capable of being monitored.

We have found no sound theoretical basis for answering this question positively or negatively. However, lack of data appears to limit the extent to which ecosystem quality can be gauged by the changing status of species. To date the data currently available are too

sparse and too patchy geographically and taxonomically. From a global perspective and for the foreseeable future, it seems that (with few exceptions) monitoring of populations of individual species is difficult to derive indices of ecosystem condition.

The best opportunities to assess the population size of some species or populations in non-complex or open ecosystems. This suggests that a globally comprehensive system that is designed to use exclusively species population data to indicate ecosystem quality will have to rely heavily on inference and extrapolation.

There appear to be only restricted opportunities for using expert judgement instead of real population data, where such data are not available, to define initial population or area conditions. This will be less feasible in species-rich tropical areas, especially with dense vegetation cover, because the ecology of species present is too poorly known.

Setting up new global species monitoring systems designed to generate the required population data is likely to be prohibitively expensive. The expertise needed is concentrated in a small number of more developed, and sometimes biodiversity-poor, countries. The technical difficulty of monitoring most kinds of species and the problem of interpreting trends in the face of natural large-scale fluctuation in population levels will remain.

In the short term populations may be applicable in certain ecosystems. For most world areas, indicator species will need to be developed and monitored from scratch.

Populations of a limited set of species are only useful as measures of the state of biodiversity if i) supplementary monitoring systems are established worldwide, ii) they are standardised, iii) verifiable expert judgement is used to temporarily at least fill in information gaps, iv) species are chosen which are easy and unambiguous to monitor and are also sensitive to human pressures, v) natural population fluctuations are well understood and can be explained and ideally measured, and vi) population data is supplemented by ecosystem level indicators.

Ecosystem level measures of quality might be possible to develop but the specific aspect of quality should be clearly defined. Generally speaking, measures of quality differ among the world's major ecosystems. Annex C provides a list of suggested ecosystem and species indicator themes to pursue for various Udvardy biomes.

Opportunities for standardising procedures

A wide range of techniques has been developed for censusing wildlife. These tend to be tailored to the particular species involved and the habitat they occur in. They are constrained by considerations of cost and availability of manpower and technology.

In general, indirect census techniques - i.e. those that detect relative changes in abundance over space or time - are easier and cheaper than direct censuses which attempt to determine overall population sizes. They can be just as useful for determining trends and deriving indices of change.

Extensive census methods may be broadly divided into those where a small number of people cover large areas, either by sampling or by aerial survey, and those where a large number

of people each cover a more limited area. In the first instance, those carrying out the census are usually professional biologists and, in the second, a significant proportion of them are amateurs.

There is an extensive literature on wildlife census and survey methods. Standardised techniques can thus be fairly easily delimited. However, it is evident that different techniques will be appropriate for different species, environmental conditions and geographical locations. Rather than standardising techniques globally, it is more important that, first, techniques are sound (that is meet some minimum standard of reliability) and second, that they are standardised over time for the same species or areas, so that usable time-series can be built up. That is, it does not matter if, for example, kangaroos in Australia and caribou in Alaska are each censused in different ways as long as the techniques used for each species are consistent through time.

Techniques developed in one part of the world (often the U.S.A. and Canada) can undoubtedly be applied elsewhere. Again the constraint is generally manpower and funding. For example, the techniques adopted by the annual joint waterfowl survey conducted by the US Fish and Wildlife Service and the Canadian Wildlife Survey described on page 9 could theoretically be applied to wildfowl censuses in wetlands throughout the world. However, this would require a long-term commitment to running such a survey, including major investment in equipment, manpower and training, which is generally lacking in other parts of the world.

An alternative approach to the use of a small number of highly trained observers is the use of networks of amateurs to gather information on wild species. The most basic form of this is information on presence/absence of particular species in particular areas or sites. Harding (1991) sets out the following requirements for a successful extensive recording scheme of this sort:

- A volunteer national scheme organiser and/or a network of volunteer regional organisers;
- Volunteer specialists to record for the scheme;
- Readily accessible identification guides; and
- A practical selection of species to be covered (neither too many nor too few, and avoiding mixes of species which require vastly different survey techniques).

Ideally, data should be recorded in a standard format so that it can be coded and subsequently manipulated. Survey techniques of this sort only require that recorders are trained in species identification (although this is no small requirement). However, data produced from these surveys are to some extent limited in value, as they do not generally provide reliable information on abundance.

Using amateur networks to record abundance data, as for example in the UK annual common bird census, organised by the British Trust for Ornithology, is more problematic. Standardised methodologies can be developed for these, but observer bias (i.e. differences

in recording accuracy of different observers) is difficult to account for. Again, as long as the same observers continue to survey the same areas then to some extent this need not matter, but this is by no means always the case, and in longer time series there will inevitably be turnover of observers.

A greater problem than the standardisation of methodologies is the availability of recorders. In general there is an adequate number of observers only in highly populated areas with a strong natural history tradition (namely parts of Europe, particularly the U.K., Germany and the Netherlands, to some extent Japan, and the more populated parts of Canada, the U.S.A., Australia and New Zealand). Elsewhere it is likely to take many years, if not decades, to build up similar observer networks.

One possible response to this is to incorporate censuses into the education system, using networks of students to carry out surveys. This has the advantage of simultaneously training students in wildlife survey and management techniques as well as helping to ensure some form of quality control as groups of students should be under the control of trained professors and teachers. However, level of expertise will generally be lower than that of keen amateurs, and considerably lower than professional wildlife biologists, so that the categories of information to be considered should be carefully chosen to minimise the risk of inaccurate or misleading data being collected. If students are used, there is still a need for a centralised system (amateur or professional) for gathering, storing and analyzing the data, and to coordinate the data collection network.

Use of students is a particularly promising approach in regions such as South-east Asia, where there is a rapidly growing interest in biology and conservation and environmental issues amongst the young, but a marked shortage of both professionally trained mature wildlife biologists and expert amateurs.

Whatever the method chosen, local ecosystem quality measures will require monitoring at a number of sites, which can be rolled up into measures of regional indicators relevant at the Udvardy province level.

INDICATOR 3. THREATENED/EXTINCT SPECIES

Threatened species may be suitable as indicators for policy makers to demonstrate where urgent action is required.

It would be possible to use data from Red Lists and Red Data Books to determine where species identified as globally threatened are concentrated. This analysis is summarised at a national level. Though some effort would be required, it is quite possible to relate these species locations to Udvardy's biogeographic provinces. Methods can be developed to deal with migratory species that occupy several biogeographic provinces.

However, Red Lists in general not only reflect those species considered most threatened, but also very strongly reflect the *process* of assessment (which involves biology, bureaucracy and politics). Documenting threatened species are generally limited to higher taxa. Only birds have been comprehensively assessed. Continuing taxonomic changes have a strong influence

on the species listed and their categories and requires sorting out from real changes in threat status.

The use of other indicator groups such as introduced and/or pest species, or narrowly endemic species might be investigated further as a supplement to threaten species data.

INDICATOR 4. BIODIVERSITY USE

This potential indicator (or suite of indicators) has not yet been fully defined, and so is difficult to evaluate. Of the proposals, only *direct use value*, assessed in monetary terms, appears to have the potential for global application and to a wide range of commodities. The use of species trade data available through CITES reports might be investigated as a source of information on use of biodiversity.

INDICATOR 5. NUMBER OF WILD SPECIES

This indicator has not been fully defined. In principle, the number of wild species could be a useful guide to biodiversity levels in highly disturbed areas. It will be necessary to determine whether the aim is to monitor the persistence of species in patches of little-disturbed habitat within agricultural landscapes, or in the latter themselves (eg. arable fields and margins). It is unlikely that sufficient data are available for global level analysis, but progress in this research area will be increasingly pressing in the future.

A disturbed area is one which has been perceptibly affected by the activities of mankind. It thus covers a very wide spectrum, from concrete-covered parking lots to many areas which at first glance appear pristine (e.g. old-growth selectively logged forest). It can be argued that because of the wide dispersion of pollutants and the build up of greenhouse gases (attributable at least in part to man's activities) there are virtually no truly undisturbed areas remaining.

An operational distinction can be made between areas which have been completely converted to other use (e.g. forests cleared for agriculture or building) and those which have been only partially modified (e.g. forests selectively logged). In reality, of course, disturbance of habitat forms a continuum from pristine to completely altered. The demarcation between conversion and alteration will therefore always be to some extent arbitrary.

Where habitats have been only partially modified, the most obvious biodiversity indicator would be a comparison of existing diversity with that of the original habitat at that site. This presupposes that enough unaltered habitat exists in the region to enable its diversity to be measured. Measures of diversity used could vary from the simplest, that is counts of species richness (usually in a limited sample of easy to measure taxonomic groups), to more complex ecological diversity measures.

For areas which have already been converted to other habitat types, particularly those converted some time ago, other approaches are necessary. This applies, for example, in the large parts of Europe, which have been converted to agricultural or pastoral lands for centuries and sometimes for millenia. Reconstructing original habitats (and biodiversity measures) for such areas is in many cases a contentious scientific exercise and one which

explains little about the current value of that area.

A case in point is that of pasture or meadow land in Europe. Most European grasslands were undoubtedly originally forested (in most of lowland central and northern Europe with mixed beech-oak forest). They now have a very different flora and fauna from those forests. Unimproved grasslands (essentially those with low fertiliser input, subject to regular though not excessive grazing intensity) often have high species diversity (especially florsitic diversity). At some scales this diversity may be higher than that expected in the original forest cover. Intensification of agriculture (increased nutrient input, drainage, increased grazing or cutting pressure) leads to a marked decline in diversity. For habitats of this sort, it is better to regard them as entities separate from the original habitat type and to assess them independently. In these cases diversity can be measured relative to the most diverse known examples of these habitats. Again, simple measures of diversity (species richness) or more complex ones can be used.

Whatever measures are used, and whichever system is used, the end result will be indicators of diversity at a series of sites. These will have to be combined in some way to generate overall indicators of diversity for particular areas. One sensible approach to this may be to classify sites based on measured or estimated diversity at that site (e.g. into four groups with 0-25%, 25-50%, 50-75%, 75-100% original or maximum diversity) and to develop an index for a given area based on the proportion of sample sites falling in each category within that area. Repeat standardised sampling over time, of the same sites or of randomly chosen sites, should enable changes to be tracked in a straightforward manner.

A major advantage of a system such as this is that it would only require estimates of diversity at individual sites to be made, not detailed species identifications or population studies.

Other factors may also be used to derive indications of changes in biodiversity in disturbed areas. In agricultural lands these may include:

- loss of hedgerows;
- loss of small habitat patches (e.g. copses, farm ponds, unploughed field margins);
- stocking rates of livestock;
- fertiliser input (e.g. weight equivalent of N P K per hectare); and
- rate of application of herbicides and pesticides.

In some cases relationships between these and changes in biodiversity have been experimentally established (for example there is good correlation between application rates of nitrogenous fertiliser and loss of plant diversity in European grasslands), in others relationships have been inferred or have been established qualitatively, not quantitatively. More experimental work is clearly needed in these areas.

INDICATOR 6. NUMBER OF DOMESTICATES

This indicator has not been fully developed. In principle, the number of breeds and varieties in some defined area, and changes in the number and identity of these, would give a sound indication of levels of domesticated biodiversity. Analysis would probably have to be at national level (or lower administrative unit) rather than in terms of Udvardy provinces. It appears less difficult to monitor data on the use of major crops than on the use of varieties and local landraces. There is a significant amount of data on livestock breeds collected at national level; much of this information is collated in the global FAO database on breeds.

SUITABLE COORDINATING INSTITUTES AND PARTNERS

In order to establish a comprehensive biodiversity monitoring program in support of global integrated environmental assessments, it is necessary to develop partnerships. In the discussion paper, Udvardy's biogeographical provinces are proposed to be used. Unfortunately, aside from globally oriented institutes, most agencies operate on a national, or at best a regional basis. It is therefore helpful to understand which countries and agencies may be able to contribute to collection of information for particular biogeographical provinces.

Annexes D and E define the extent to which countries and Udvardy's biogeographical provinces overlap. A network of agencies that might be approached to coordinate data gathering for each biogeographical realm is presented in Annex F (derived from UNEP/WCMC, 1995). Included are the biogeographical realms over which the interest of these agencies appears to extend. Annex G then lists examples of key agencies which might either hold data or provide the expertise needed to select and develop indicators of ecosystem quality.

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Annex A

Terms of reference for feasibility study

1. Background

As a collaborating centre for UNEP one of RIVM's tasks is to develop methodologies for integrated environmental assessments, reporting and forecasting. The results of the RIVM's work will be taken up in UNEP's global environmental reports. Especially important is the framework that puts the different biodiversity indicators into perspective, and which make it possible to include biodiversity considerations in integrated environmental and sustainability assessments. For this, the project "Biodiversity indicators for integrated environmental assessments" has been initiated. This project aims at identifying and working out indicators which describe and assess the state and use of biodiversity, and which identify causes and societal consequences.

At the first stage of the project a core set of six biodiversity indicators which meet most basic requirements (see Plan of Approach, draft 23/11/94, section 1) is identified. A distinction has been made between natural and cultivated areas and the mode of assessment (fig 1). The indicators are:

2. Core set of indicators

Biodiversity indicators for natural areas (fig 2)
[Assessment principle: the closer to the natural state, the better]

1. Ecosystem area
The area of "undisturbed" and "partially disturbed" ecosystems (fig 3, 3a). This indicator provides an impression of the biodiversity loss at the ecosystem level as a result of habitat destruction by e.g. agriculture, road building and urbanisation. For this the "habitat index" as defined by Lee Hannah (Conservation International, 1994) can be used. This indicator does not give a clear impression of ecosystem quality.

2. Ecosystem quality
The population numbers (species abundancy) of a representative cross-section of both ecological and economic key species (fig 4, 4a). In addition to the ecosystem size, this indicator provides an impression of the biodiversity loss at the species and genetic level as a result of e.g. over-exploitation, pollution and fragmentation. For this the AMOEBA approach (Ten Brink et. al., 1991) is applicable. This indicator has an early warning function but does not give specific information on threatened species where action is urgent.
For reasons of data availability, mainly mammals, birds, reptiles, amphibians, fishes and vascular plants will be suitable as indicator species (Reid et al, 1993). If e.g. on average five species are chosen for each class, each biogeographical province is expressed in terms of population numbers of approximately 30 species for past, present and future. For 160 provinces this is approximately 5000 species. The number of species can be increased or decreased, according to the availability of data. The choice of the core set of indicators requires specialists per biogeographical province. This choice must be in the light of the 10 considerations in Section 8 of the Plan of Approach (see also appendix 1). It is proposed that the choice of these indicators is made by, still to be established, "realm or biogeographical province teams".

3. Threatened/extinct species
This indicator gives an impression of the species and locations for which urgent action is needed. For this the IUCN Red Lists can be used.

4. Biodiversity use (not yet elaborated)
Possible indicators for direct societal use are: yield, profit, number of inhabitants, employment (fig 5) .
Possible indicators for indirect use are: life-support functions like water regulation, local climate, erosion control.

Biodiversity indicators for cultivated areas (fig 1)
[Assessment principle: the higher the number of species resp. subspecies, the better]

5. Absolute numbers of wild species

6. Absolute numbers of livestock breeds and crop varieties.

3. Aim: feasibility study on data-availability

This core set of biodiversity indicators meet most basic requirements as defined in the Plan of Approach. However, there are still uncertainties about the availability of data, especially for indicator 2. Before this core set of biodiversity indicators is brought into discussion with UNEP/GEMS and potential collaborating institutes, a short feasibility study is needed on this subject.

Furthermore, a list of institutes (and their expertise) that might participate in the project is needed for each realm and biogeographical province. The World Conservation Monitoring Centre has been assigned to this study, as it has unique experience in identifying availability, managing and applying biodiversity data.

4. Scope of study

Subjects to be considered will include:

1. Which data are available in order to establish the proposed indicators?

Indicator 1:
Is the "habitat index" as defined by Lee Hannah (1994) suitable for this purpose?
- are the criteria as defined and applied in the "habitat index" sufficiently unambiguous?
- are data based on these criteria available to quantify "undisturbed" and "partially disturbed" areas for each biogeographical province?
- in which provinces are data not available?

(< 2 days)

Indicator 2:

Is the AMOEBA approach applicable for this purpose?

- of which species of the mammals, birds, reptiles, amphibians, fishes, vascular plants (and possibly others) are sufficient data available to make quantitative calculations for each biogeographical province and the oceans? This must be done for both past (approximately the natural state or a historical date e.g. 1900) and present population numbers or distribution area (within the undisturbed and partially disturbed area)
- for which biogeographical provinces are data entirely lacking?
- might expert judgements be an alternative approach to provide a quantitative indication of the changes which have occurred in these cases?
- for which historical date are sufficient data available for each biogeographical province?

(22 days)

Indicator 3:

Are the IUCN Red Lists suitable for this purpose?

- Are there Red Lists for each biogeographical province?
- Are the current Red Lists based on the same criteria?

(< 1 day)

Indicator 4:

This indicator has not been sufficiently elaborated yet.

- can WCMC give an indication of the data availability on these subjects?
- are there promising alternatives? (< 2 day)

Indicator 5 and 6:

Can WCMC give an indication as to whether quantitative data are available on vertebrates and vascular plants for each biogeographical province?
(3 days)

2. Which are suitable partner institutes at global, realm or biogeographical province level (e.g. as defined by Udvardy) ?

- Which institutes are important to discuss and elaborate the core set of biodiversity indicators? At least one institute for each realm. Which expertise? Which person?

- Which institute(s) for each realm has the expertise and skills to coordinate choosing the definitive set of species and to coordinate the production of the core set of indicators for each biogeographical province per realm? Which expertise? Which person?

- Which institute(s) for each biogeographical province has the expertise and skills to choose the definitive set of species and to produce the core set of indicators for each biogeographical province (past, present and future)? And if necessary, to make expert judgements/calculations? Which expertise? Which person?

- To what extent the organizational framework of the National Biodiversity Units (NBU), or other frameworks, are useful in this respect?
  (5 days)

5. Work plan

The study will result in an elaborated annotated outline within 2 weeks, a first draft report within 4 weeks, that will then be developed and finalised. All intermediate results and further steps will be discussed by the RIVM and WCMC staff. The time investment per indicator is indicated above.

The choice for a suitable biogeographical classification will be made in advance in joined consultation.

The study will include a review of published literature, unpublished reports from the several initiatives currently being undertaken, and the results of liaison with groups actively discussing these issues.

The study will extend over 8 weeks and commence 18 April 1995. The final report will be finalised 8 weeks later.

6. Product

The result will be a report on the availability of data for the six indicators mentioned above, and a list of suitable partner institutes (including persons, expertise, address) at global, realm and provincial level.
This report will also incorporate discussion of the purpose, design and use of biodiversity indicators and indices, specifically referring to the use of imperfect data sets and to issues of spatial and temporal scale.

Based on this *"Report on the availability of data for a core set of biodiversity indicators for global integrated environmental assessments and their potential sources"* (WCMC/RIVM) and the *"discussion paper on a core set of biodiversity indicators for integrated environmental assessments"* (RIVM/UNEP) discussions will be initiated with UNEP/GEMS staff and potential participating institutes on the indicator choice, possibilities to establish them and the organizational framework. Publication of the results by WCMC/RIVM needs approval of both institutes and depends on the conclusions of these discussions.

7. Budget

Staff time: 8 weeks
Budget: £4,500/month = £9,000
The RIVM contribution will be £4,500. WCMC will provide matching funds.

Extension of the study

The budget and staff time is extended in October and November 1995 (3 weeks) with a focuss on solutions for the appearing general shortage of data at the global level and supplementary indicators (see APPENDIX 2).

APPENDIX 1

Criteria for choosing indicators on biological diversity (version 8/2/95)

As a consequence of the basic requirements and choices mentioned in the Plan of Approach (draft 32/11/94) the following considerations are applied choosing indicators of biological diversity:

Each indicator must:

1. have available quantitative data;
   which abundance and distribution in the past (natural condition) and present? dose-effect relations?;
2. be policy and ecosystem relevant;
   e.g. red list species, extinct or threatened species, endemic species, ecosystems/species of economic or cultural interest, keystone species (see annex 1 UN-convention on biological diversity;
3. be susceptible to human influence
   steerable and predictable, linked to socio-economic and environmental models output;
4. be accessible to accurate and affordable measurement;
5. have indicative value
   provide more information than only its own value; show indirect information about other aspects of biological diversity;
6. be stable;
   not fluctuate too much with natural conditions;
7. be useful for at least a 10-20 year period;
   indicate a problem that is not solved within a few years;

The set of indicators as a whole must:

8. provide a representative picture of the loss of biological diversity at the global and the national level;
   the indicators must be a cross-section of the entire ecosystem to provide a representative picture of the state and the societal use of the biological diversity:
   - species from different sub-systems;
   - species form different taxonomic classes;
   - species from high and low parts of the food web;
   - present day and former species
   - sessile, migratory and non-migratory species
   - keystone species, threatened species, endemic species, species of socio-economic importance (food species, medicinal species, timber, recreation, ..);
9. reflect the effects of the main pressures and conservation programmes (see Section 9);
10. have a number as small as possible;
    the less indicators, the better the communication to the policy makers and the public; aggregation to 10-20 indicators must be possible

Box:a preliminary core set of biodiversity indicators and its uses for integrated environmental assessments at the regional and global level

Biodiversity indicators for natural areas

[Assessment principle: the closer to the natural state, the better]

1. Ecosystem area

The area of "undisturbed" and "partially disturbed" ecosystems. This indicator provides an impression of the biodiversity loss at the ecosystem level as a result of habitat destruction by e.g. agriculture, road building and urbanisation. For this the "habitat index" as defined by Lee Hannah (Conservation International, 1994) can be used. This indicator does not give a clear impression of ecosystem quality.

2. Ecosystem quality

The population numbers of a representative cross-section of both ecological and economic key species. In addition to the ecosystem size, this indicator provides an impression of the biodiversity loss at the species and genetic level as a result of e.g. over-exploitation, pollution and fragmentation. For this the AMOEBA approach (Ten Brink et. al., 1991) is applicable. This indicator has an early warning function but does not give specific information on threatened species where action is urgent.
For reasons of data availability, mainly mammals, birds, reptiles, amphibians, fishes and vascular plants will be suitable as indicator species (Reid et al, 1993).

3. Threatened/extinct species

This indicator gives an impression of the species and locations for which urgent action is needed. For this the IUCN Red Lists can be used.

4. Biodiversity use (not yet elaborated)

Possible indicators for direct societal use are: yield, profit, number of inhabitants, employment.
Possible indicators for indirect use are: life-support functions like water regulation, local climate, erosion control.

Biodiversity indicators for cultivated areas

[Assessment principle: the higher the number of species resp. subspecies, the better]

5. Absolute numbers of wild species

6. Absolute numbers of livestock breeds and crop varieties.

APPENDIX 2

Feasibility Study
on Biodiversity Indicators
for Integrated Environmental Assessments

- amendment to RIVM-WCMC Project 336 -

The terms of reference for this project are proposed to be amended in order to include additional research and redrafting required as a result of issues raised by RIVM to WCMC in a letter dated July 21, 1995 and following discussionsconcerning the second draft of the feasibility study (FS2).

Additional Redrafting

1. Assess how threatened ecosystems can be measured for degree of disturbance with the view to providing repetitive measurements and projections into the future. (FS2/p2/pt3)

2. Explain why the number of localised and endemic species may be as important as threatened species in the context of the assessment framework. (FS2/p14/para7)

3. Elaborate on the capability of using number of wild species in disturbed areas as an indicator. (FS2/p19)

4. Restate conclusions of Feasibility Study on data availability for six biodiversity indicators, to include possible solutions to obtaining a quantitative assessment of biodiversity. (FS2/p18)

5. Provide a list of suitable partner institutes which could be used to supply biodiversity data for GEO, including the biogeographical provinces which their holdings may represent.

Additional Research

6. Assess the feasibility of using (still to be determined) ecosystem level indicators for measuring ecosystem quality for complex ecosystems (e.g., forests) and species indicators for simple ecosystems, from the point of view of data availability. (FS2/p4/para5)

7. Determine the possibility of standardizing procedures for only restricted, well known, easy to measure species such as vertebrates. (FS2/p19)

8. Estimate the number and type of ecosystem and species variables that will be appropriate to measure ecosystem quality across the variety of the world's major biomes. (FS2/p4/para6, FS2/10).

Annex B

Criteria and indicators for the conservation and sustainable management of temperate and boreal forests

Criteria and indicators for the conservation and sustainable management of temperate and boreal forests

Criteria 1 to 6, proposed by the international Working Group on Criteria and indicators for the conservation and sustainable management of temperate and boreal forests ("Montreal Process")

The following six criteria and associated indicators characterize the conservation and sustainable management of temperate and boreal forests. They relate specifically to forest condition, attributes or functions, and to the values or benefits associated with the environmental and socio-economic goods and services that forests provide. The intent or meaning of each criterion is made clear by its respective indicators. No priority or order is implied in the alphanumeric listing of the criteria and indicators.

Criterion 1: Conservation of biological diversity

Biological diversity includes the elements of the diversity of ecosystems, the diversity between species, and genetic diversity in species.

Indicators:

Ecosystems diversity

a. Extent of area by forest type relative to total forest area-(a);[1]
b. Extent of area by forest type and by age class or successional stage-(b);
c. Extent of area by forest type in protected area categories as defined by IUCN[2] or other classification systems-(a);
d. Extent of areas by forest type in protected areas defined by age class or successional stage-(b);
e. Fragmentation of forest types-(b).

Species diversity

a. The number of forest dependent species-(b);
b. The status (threatened, rare, vulnerable, endangered, or extinct) of forest dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment-(a).

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[1] Indicators followed by an "a" are those for which most data are available. Indicators followed by a "b" are those which may require the gathering of new or additional data and/or a new program of systematic sampling or basic research.

[2] IUCN categories include: I. Strict protection, II. Ecosystem conservation and tourism, III. Conservation of natural features, IV. Conservation through active management, V. Landscape/seascape conservation and recreation, VI. Sustainable use of natural ecosystems.

Genetic diversity

a. Number of forest dependent species that occupy a small portion of their former range-(b);
b. Population levels of representative species from diverse habitats monitored across their range-(b).

Criterion 2: Maintenance of productive capacity of forest ecosystems

Indicators:

a. Area of forest land and net area of forest land available for timber production -(a);
b. Total growing stock of both merchantable and non-merchantable tree species on forest land available for timber production-(a);
c. The area and growing stock of plantations of native and exotic species -(a);
d. Annual removal of wood products compared to the volume determined to be sustainable-(a);
e. Annual removal of non-timber forest products (eg fur bearers, berries, mushrooms, game), compared to the level determined to be sustainable-(b).

Criterion 3: Maintenance of forest ecosystem health and vitality

Indicators:

a. Area and percent of forest affected by processes or agents beyond the range of historic variation, eg. by insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinisation, and domestic animals-(b);
b. Area and percent of forest land subjected to levels of specific air pollutants (eg. sulphates, nitrate, ozone) or ultraviolet B that may cause negative impacts on the forest ecosystem-(b);
c. Area and percent of forest land with diminished biological components indicative of changes in fundamental ecological processes (eg. soil nutrient cycling, seed dispersion, pollination) and/or ecological continuity (monitoring of functionally important species such as fungi, arboreal epiphytes, nematodes, beetles, wasps, etc.)-(b).

Criterion 4: Conservation and maintenance of soil and water resources

This criterion encompasses the conservation of soil and water resources and the protective and productive functions of forests.

Indicators:

a. Area and percent of forest land with significant soil erosion-(b);
b. Area and percent of forest land managed primarily for protective functions, eg. watersheds, flood protection, avalanche protection, riparian zones-(b);

c. Percent of stream kilometres in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation-(b);
d. Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties-(b);
e. Area and percent of forest land with significant compaction or change in soil physical properties resulting from human activities-(b);
f. Percent of water bodies in forest areas (eg. stream kilometres, lake hectares) with significant variance of biological diversity from the historic range of variability-(b);
g. Percent of water bodies in forest areas (eg. stream kilometres, lake hectares) with significant variation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electricity conductivity), sedimentation or temperature change-(b);
h. Area and percent of forest land experiencing an accumulation of persistent toxic substances-(b).

Criterion 5: Maintenance of forest contribution to global carbon cycles

Indicators:

a. Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age class, and successional stages-(b);
b. Contribution of forest ecosystems to the total global carbon budget, including absorption and release of carbon (standing biomass, coarse woody debris, peat and soil carbon)-(a or b);
c. Contribution of forest products to the global carbon budget-(b).

Criterion 6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies

Indicators:

Production and consumption

a. Value and volume of wood and wood products production, including value added through downstream processing-(a);
b. Value and quantities of production of non-wood forest products-(b);
c. Supply and consumption of wood and wood products, including consumption per capita-(a);
d. Value of wood and non-wood products production as percentage of GDP-(a or b);
e. Degree of recycling of forest products-(a or b);
f. Supply and consumption/use of non-wood products-(a or b).

Recreation and tourism

a. Area and percent of forest land managed for general recreation and tourism, in relation to the total area of forest land-(a or b);

b. Number and type of facilities available for general recreation and tourism, in relation to population and forest area-(a or b);
c. Number of visitor days attributed to recreation and tourism, in relation to population and forest area-(b).

Investment in the forest sector

a. Value of investment, including investment in forest growing, forest health and management, planted forests, wood processing, recreation and tourism-(a);
b. Level of expenditure on research and development, and education-(b);
c. Extension and use of new and improved technologies-(b);
d. Rates of return on investment-(b).

Cultural, social and spiritual needs and values

a. Area and percent of forest land managed in relation to the total area of forest land to protect the range of cultural, social and spiritual needs and values-(a or b);
b. Non-consumptive use forest values-(b).

Employment and community needs

a. Direct and indirect employment in the forest sector and forest sector employment as a proportion of total employment-(a or b);
b. Average wage rates and injury rates in major employment categories within the forest sector-(a);
c. Viability and adaptability to changing economic conditions, of forest dependent communities, including indigenous communities-(b);
d. Area and percent of forest land used for subsistence purposes-(b).

Annex C

Examples of species and ecosystem level indicators of ecosystem area and quality

EXAMPLES OF SPECIES AND ECOSYSTEM LEVEL INDICATORS OF ECOSYSTEM AREA AND QUALITY				
No.	**BIOME**	**MAJOR THREATS TO ECOSYSTEM AREA (A) AND QUALITY (Q)**	**SPECIES MEASURES**	**ECOSYSTEM MEASURES**
1.	Tropical Humid Forests	hunting (Q)	changes in population status of major game species;analysis of hunting records through time (composition of catches, age of harvested animals, catch per unit effort)	
		selective logging (A/Q)	changes in composition and age structure of tree populations; changes in population of species dependent on primary forest	changes in forest structure as determined by photography and remote sensing
		shifting cultivation (A/Q)	population density of shifting cultivators	extent of area cleared annually for shifting cultivation
		fragmentation (A/Q)		fragmentation indices; land use changes; rate of turnover of trees
2.	Subtropical/ Temperate Rainforest/ Woodlands	[same as 1.]	[same as 1, above]	[same as 1, above], plus age class profiles

EXAMPLES OF SPECIES AND ECOSYSTEM LEVEL INDICATORS OF ECOSYSTEM AREA AND QUALITY				
No.	**BIOME**	**MAJOR THREATS TO ECOSYSTEM AREA (A) AND QUALITY (Q)**	**SPECIES MEASURES**	**ECOSYSTEM MEASURES**
3.	Temperate Needle-leaf Forests/Woodlands	hunting (Q) [same as 1, above]	[same as 1, above]	[same as 1, above]
		logging (A/Q)	[same as 1, above], plus area broadleaf as % of ecosystem	[same as 1, above]
		atmospheric pollution (Q)	measurement of tree die-off; population changes of environmentally sensitive species (e.g. lichens)	

EXAMPLES OF SPECIES AND ECOSYSTEM LEVEL INDICATORS OF ECOSYSTEM AREA AND QUALITY				
No.	**BIOME**	**MAJOR THREATS TO ECOSYSTEM AREA (A) AND QUALITY (Q)**	**SPECIES MEASURES**	**ECOSYSTEM MEASURES**
4.	Tropical Dry Forests/ Woodlands	hunting (Q) [same as 1, above]	[same as 1, above]	[same as 1, above]
		livestock grazing (A/Q)	changes to understorey; changes in age-distribution of tree species (i.e. reduced regeneration); estimates of density of livestock	
		burning (A/Q)	changes in tree species composition and age-distribution of trees	measurements of area burnt, intensity and frequency of burning
		selective logging (A/Q)	[same as 1, above]	[same as 1, above]
		fuelwood collection/ charcoal production (A/Q)	volume and species composition of woody material converted	estimates of population density and per capita consumption of fuelwood and charcoal
		fragmentation (A/Q)	[same as 1, above]	[same as 1, above]
5.	Temperate Broad-leaf Forests	hunting (Q)	[same as 1, above]	[same as 1, above]
		logging (A/Q)	[same as 1, above]	[same as 1, above]
		atmospheric pollution (Q)	[same as 1, above]	[same as 1, above]
		livestock grazing (A/Q)	[same as 1, above]	[same as 1, above]

EXAMPLES OF SPECIES AND ECOSYSTEM LEVEL INDICATORS OF ECOSYSTEM AREA AND QUALITY				
No.	**BIOME**	**MAJOR THREATS TO ECOSYSTEM AREA (A) AND QUALITY (Q)**	**SPECIES MEASURES**	**ECOSYSTEM MEASURES**
6.	Evergreen Sclerophyllous Forests	hunting (Q)	[same as 1, above]	[same as 1, above]
		logging (A/Q)	[same as 1, above]	[same as 1, above]
		atmospheric pollution (Q)	[same as 1, above]	[same as 1, above]
		livestock grazing (A/Q)	[same as 1, above]	[same as 1, above]
7.	Warm Deserts/Semi-deserts	hunting (Q)		" "
		livestock grazing (A/Q)	stocking rates of livestock; wild ungulate populations	
		fuelwood collection/ charcoal production (A/Q)		
8.	Tropical Grasslands/ Savannas	hunting (Q)	[same as 1, above]	[same as 1, above]
		livestock grazing (A/Q)	% primary productivity used by livestock; sward characteristics	livestock stocking rates
		burning (A/Q)		
		agriculture		disturbed grassland as % of native grassland; area affected by salinization and water logging

EXAMPLES OF SPECIES AND ECOSYSTEM LEVEL INDICATORS OF ECOSYSTEM AREA AND QUALITY				
No.	**BIOME**	**MAJOR THREATS TO ECOSYSTEM AREA (A) AND QUALITY (Q)**	**SPECIES MEASURES**	**ECOSYSTEM MEASURES**
9.	Temperate Grasslands	ioss of soil nutrients (Q) pesticides/herbicides (Q) livestock grazing (A/Q) drainage (A/Q) introduced species (A/Q)	application rates of fertilisers application rates of pesticides/herbicides stocking rates	improved cropland as % of native grassland; % change in wetland area
10.	Mixed Island Systems	introduced/invasive species (A/Q)		% area occupied by representative invasive specie
11.	Tundra Communities	hunting (A/Q) climate change (A/Q)	contaminants levels in marine mammals	
12.	Mixed Mountain Systems	tourist infrastructure (A/Q) logging		% area mountain resort infrastructure; % valley bottoms developed

EXAMPLES OF SPECIES AND ECOSYSTEM LEVEL INDICATORS OF ECOSYSTEM AREA AND QUALITY				
No.	**BIOME**	**MAJOR THREATS TO ECOSYSTEM AREA (A) AND QUALITY (Q)**	**SPECIES MEASURES**	**ECOSYSTEM MEASURES**
13.	Cold-winter Deserts	hunting (Q) livestock grazing (A/Q)	populations of nomadic ungulates	
14.	Lake Systems	eutrophication (Q) sedimentation (Q) other pollutants (Q) overfishing (Q) introduced species (Q) changes to water levels (Q)	 changes in population status of major target species abundance measures of introduced species; changes in catch composition changes in catch composition	concentrations of nitrogen & phosphorus changes in trophic structure turbidity measures conventrations of pesticides; concentrations of fecal coloiform, tissue analysis

EXAMPLES OF SPECIES AND ECOSYSTEM LEVEL INDICATORS OF ECOSYSTEM AREA AND QUALITY				
No.	**BIOME**	**MAJOR THREATS TO ECOSYSTEM AREA (A) AND QUALITY (Q)**	**SPECIES MEASURES**	**ECOSYSTEM MEASURES**
15.	Ocean Systems	overfishing (Q) destruction of coastal habitat (A/Q)	changes in catch composition	area of mangrove; destruction coral reefs (A/Q); changes in tourist traffic; changes in coastal human population.

Annex D

List of countries
and the proportions of
Udvardy's biogeographical provinces they contain

Country (Biogeographical province)	Area (sq km)	%Country
Afghanistan		
Anatolian-Iranian Desert	210067	33
Himalayan Highlands	22589.9	4
Hindu Kush Highlands	192834	30
Indus-Ganges Monsoon Forest	28662.8	4
Iranian Desert	158018	25
Pamir-Tian-Shan Highlands	12630.8	2
Thar Desert	11288.0	2
Tibetan	6064.5	1
Total area:	642155	
Albania		
Balkan Highlands	6564.0	23
Mediterranean Sclerophyll	22143.7	77
Total area:	28707.7	
Algeria		
Atlas Steppe	190331	8
Mediterranean Sclerophyll	206274	9
Sahara	1822057	80
Western Sahel	54247.7	2
Total area:	2272910	
Andorra		
Atlantic	469.6	100
Total area:	469.6	
Angola		
Congo Rain Forest	27962.3	2
Congo Woodland/Savanna	526906	42
Miombo Woodland/Savanna	526106	42
Namib	55988.8	4
South African Woodland/Savanna	115642	9
Total area:	1252604	
Anguilla		
Lesser Antillean	38.6	100
Total area:	38.6	
Antigua and Barbuda		
Lesser Antillean	445.9	100
Total area:	445.9	
Argentina		
Argentinian Pampas	512047	18
Brazilian Rain Forest	26235.7	1
Chilean Nothofagus	10148.6	< 1
Gran Chaco	389920	14
Insulantarctica	493.1	< 1
Monte	1183785	43
Patagonian	403307	14
Southern Andean	124573	4
Uruguayan Pampas	131536	5
Total area:	2782046	

Country (Biogeographical province)	Area (sq km)	%Country
Armenia		
Caucaso-Iranian Highlands	1365.4	100
Total area:	1365.4	
Australia		
Brigalow	228280	3
Central Desert	1766998	23
Eastern Grasslands and Savannas	558269	7
Eastern Sclerophyll	632668	8
Neozealandia	145.3	< 1
New Caledonian	73.4	< 1
Northern Coastal	349970	5
Northern Grasslands	962826	12
Northern Savanna	584642	8
Queensland Coastal	313555	4
Southern Mulga/Saltbush	829217	11
Southern Sclerophyll	232956	3
Tasmanian	67970.1	1
Western Mulga	780873	10
Western Sclerophyll	396657	5
Total area:	7705101	
Austria		
Balkan Highlands	502.6	1
Central European Highlands	46805.7	56
Middle European Forest	36249.7	43
Pannonian	397.8	< 1
Total area:	83955.8	
Azerbaijan		
Caucaso-Iranian Highlands	114074	100
Total area:	114074	
Bahamas		
Bahamas-Bermudean	12396.0	100
Total area:	12396.0	
Bahrain		
Anatolian-Iranian Desert	507.6	100
Total area:	507.6	
Bangladesh		
Bengalian Rainforest	79706.0	58
Burma Monsoon Forest	28633.6	21
Burman Rainforest	29392.9	21
Total area:	137733	

Country (Biogeographical province)	Area (sq km)	%Country
Barbados		
Lesser Antillean	440.3	100
Total area:	440.3	
Belarus		
Boreonemoral	186820	90
Middle European Forest	19938.3	10
Total area:	206759	
Belgium		
Atlantic	30598.6	100
Total area:	30598.6	
Belize		
Campechean	21925.2	100
Total area:	21925.2	
Benin		
Guinean Rain Forest	22800.1	20
West African Woodland/Savanna	93599.8	80
Total area:	116400	
Bhutan		
Bengalian Rainforest	179.4	< 1
Burma Monsoon Forest	1006.1	3
Himalayan Highlands	38750.7	97
Total area:	39936.2	
Bolivia		
Amazonian	45584.7	4
Campos Cerrados	105844	10
Gran Chaco	344039	32
Lake Titicaca	3070.1	< 1
Madeiran	110827	10
Monte	26798.3	2
Puna	202752	19
Southern Andean	74773.1	7
Yungas	176133	16
Total area:	1089821	
Botswana		
Kalahari	194911	34
Miombo Woodland/Savanna	19816.4	3
South African Woodland/Savanna	364709	63
Total area:	579436	

Country (Biogeographical province)	Area (sq km)	%Country
Brazil		
Amazonian	1483711	18
Babacu	292852	3
Brazilian Planalto	219143	3
Brazilian Rain Forest	1381841	16
Caatinga	899777	11
Campos Cerrados	1672461	20
Campos Limpos	116868	1
Gran Chaco	715.2	< 1
Guyanan	409131	5
Madeiran	1557999	18
Serro Do Mar	243553	3
South Trinidade Island	10.5	< 1
Uruguayan Pampas	192015	2
Yungas	2908.0	< 1
Total area:	8472985	
British Virgin Islands		
Lesser Antillean	90.3	100
Total area:	90.3	
Brunei		
Borneo	5772.6	100
Total area:	5772.6	
Bulgaria		
Balkan Highlands	57843.9	52
Mediterranean Sclerophyll	32280.1	29
Middle European Forest	14749.9	13
Pontian Steppe	6001.5	5
Total area:	110875	
Burma		
Burma Monsoon Forest	126838	19
Burman Rainforest	215814	32
Indochinese Rainforest	52172.5	8
Szechwan Highlands	80629.9	12
Thailandian Monsoon Forest	190558	29
Total area:	666012	
Burundi		
East African Woodland/Savanna	7783.2	28
Lake Tanganyika	1950.0	7
Miombo Woodland/Savanna	17620.1	64
Total area:	27353.3	

Country (Biogeographical province)	Area (sq km)	%Country
Cambodia (Formerly Kampuchea)		
Indochinese Rainforest	61459.2	34
Thailandian Monsoon Forest	120878	66
Total area:	182337	
Cameroon		
Congo Rain Forest	200889	43
Guinean Highlands	27656.8	6
West African Woodland/Savanna	224250	48
Western Sahel	13301.9	3
Total area:	466098	
Canada		
Alaskan Tundra	237417	2
Arctic Archipelago	687603	7
Arctic Desert and Icecap	486130	5
Canadian Taiga	4962930	50
Canadian Tundra	1732011	18
Eastern Forest	81803.6	1
Grasslands	281154	3
Great Lakes	93725.8	1
Oregonian	11902.7	< 1
Rocky Mountains	620830	6
Sierra-Cascade	31422.2	< 1
Sitkan	174832	2
Yukon Taiga	451878	5
Total area:	9853639	
Cape Verde		
Macaronesian Islands	2396.9	100
Total area:	2396.9	
Cayman Islands		
Cuban	218.7	100
Total area:	218.7	
Central African Republic		
Congo Rain Forest	2037.4	< 1
East African Woodland/Savanna	218593	35
Eastern Sahel	261.3	< 1
West African Woodland/Savanna	400437	64
Total area:	621329	
Chad		
East African Woodland/Savanna	4059.2	< 1
Eastern Sahel	13990.8	1
Sahara	568144	44
West African Woodland/Savanna	205666	16
Western Sahel	486227	38
Total area:	1278087	

Country (Biogeographical province)	Area (sq km)	%Country
Chile		
Chilean Araucaria Forest	32848.2	4
Chilean Nothofagus	110745	15
Chilean Sclerophyll	57098.4	8
Insulantarctica	3677.2	1
Monte	24158.8	3
Pacific Desert	118367	16
Patagonian	9693.6	1
Southern Andean	266283	36
Valdivian Forest	111302	15
Total area:	734174	
China		
Altai Highlands	44383.0	< 1
Chinese Subtropical Forest	847393	9
East Siberian Taiga	631.0	< 1
Himalayan Highlands	157535	2
Manchu-Japanese Mixed Forest	705494	8
Mongolian-Manchurian Steppe	1013679	11
Oriental Deciduous Forest	2583457	28
Pamir-Tian-Shan Highlands	116601	1
Pontian Steppe	14126.5	< 1
South Chinese Rainforest	163618	2
Szechwan Highlands	434922	5
Takla-Makan-Gobi Desert	2125982	23
Thailandian Monsoon Forest	10159.8	< 1
Tibetan	1117027	12
Total area:	9335009	
Colombia		
Amazonian	405195	36
Colombian Coastal	146997	13
Colombian Montane	96525.4	8
Llanos	207245	18
Northern Andean	174609	15
Panamanian	2.8	< 1
Venezuelan Dry Forest	107994	9
Total area:	1138569	
Congo		
Congo Rain Forest	303942	88
Congo Woodland/Savanna	16053.8	5
West African Woodland/Savanna	24415.9	7
Total area:	344412	

Country (Biogeographical province)	Area (sq km)	%Country
Costa Rica		
Central American	51701.3	100
Total area:	51701.3	
Cuba		
Cuban	109313	100
Total area:	109313	
Cyprus		
Mediterranean Sclerophyll	9213.7	100
Total area:	9213.7	
Czech republic		
Central European Highlands	51333.8	65
Middle European Forest	28118.7	35
Total area:	79452.5	
Denmark		
Atlantic	12079.9	30
Middle European Forest	28456.5	70
Total area:	40536.4	
Djibouti		
Somalian	21557.6	100
Total area:	21557.6	
Dominica		
Lesser Antillean	702.8	100
Total area:	702.8	
Dominican Republic		
Greater Antillean	48590.3	100
Total area:	48590.3	
Ecuador		
Amazonian	11271.2	5
Colombian Coastal	60968.5	25
Colombian Montane	7882.2	3
Equadorian Dry Forest	34821.3	14
Northern Andean	80920.3	33
Southern Andean	9112.8	4
Yungas	43256.1	17
Total area:	248232	
Egypt		
Arabian Desert	56310.4	6
Mediterranean Sclerophyll	7949.5	1
Sahara	919969	93
Total area:	984229	

Country (Biogeographical province)	Area (sq km)	%Country
El Salvador		
Central American	18807.1	91
Madrean-Cordilleran	1850.9	9
Total area:	20658.0	
Equatorial Guinea		
Congo Rain Forest	24931.8	100
Total area:	24931.8	
Eritrea		
Eastern Sahel	8529.0	7
Ethiopian Highlands	45057.8	38
Somalian	66393.4	55
Total area:	119980	
Estonia		
Boreonemoral	39850.2	100
Total area:	39850.2	
Ethiopia		
Eastern Sahel	16649.0	1
Ethiopian Highlands	349452	31
Lake Rudolf	30.3	< 1
Somalian	766918	68
Total area:	1133050	
Faeroe Islands		
Scottish Highlands	1191.0	100
Total area:	1191.0	
Falkland Islands (Islas Malvinas)		
Insulantarctica	14491.0	100
Total area:	14491.0	
Federated States of Micronesia		
Micronesian	1450.3	100
Total area:	1450.3	
Fiji		
East Melanesian	17515.1	100
Total area:	17515.1	
Finland		
Boreonemoral	37696.2	11
Subarctic Birchwoods	11909.7	4
West Eurasian Taiga	281233	85
Total area:	330839	

Country (Biogeographical province)	Area (sq km)	%Country
France		
Atlantic	446655	83
Central European Highlands	31709.7	6
Iberian Highlands	1.3	< 1
Mediterranean Sclerophyll	56953.2	11
Total area:	535319	
French Guiana		
Guyanan	83691.7	100
Total area:	83691.7	
Gabon		
Congo Rain Forest	258867	100
Total area:	258867	
Gambia		
West African Woodland/Savanna	10336.6	100
Total area:	10336.6	
Gaza Strip		
Arabian Desert	389.8	100
Mediterranean Sclerophyll	0.0	< 1
Total area:	389.8	
Georgia		
Caucaso-Iranian Highlands	50658.6	72
Mediterranean Sclerophyll	19494.5	28
Total area:	70153.1	
Germany		
Atlantic	148505	42
Central European Highlands	86171.3	24
Middle European Forest	120624	34
Total area:	355300	
Ghana		
Guinean Rain Forest	103825	44
West African Woodland/Savanna	133311	56
Total area:	237136	
Greece		
Balkan Highlands	6774.0	5
Mediterranean Sclerophyll	116680	95
Total area:	123454	
Greenland		
Arctic Desert and Icecap	1628758	77
Greenland Tundra	496395	23
Total area:	2125153	

Country (Biogeographical province)	Area (sq km)	%Country
Grenada		
Lesser Antillean	290.9	100
Total area:	290.9	
Guadeloupe		
Lesser Antillean	1770.1	100
Total area:	1770.1	
Guatemala		
Campechean	33121.1	30
Central American	25494.3	23
Madrean-Cordilleran	50803.6	46
Total area:	109419	
Guernsey		
Atlantic	54.6	100
Total area:	54.6	
Guinea		
Guinean Rain Forest	11941.3	5
West African Woodland/Savanna	233755	95
Total area:	245697	
Guinea-Bissau		
West African Woodland/Savanna	30887.1	100
Total area:	30887.1	
Guyana		
Campos Limpos	18765.6	9
Guyanan	192164	91
Total area:	210930	
Haiti		
Greater Antillean	27192.0	100
Total area:	27192.0	
Honduras		
Central American	61966.0	55
Madrean-Cordilleran	50251.6	45
Total area:	112218	
Hong Kong		
South Chinese Rainforest	2922.4	100
Total area:	2922.4	
Hungary		
Middle European Forest	29053.0	31
Pannonian	63572.3	69
Total area:	92625.3	

Country (Biogeographical province)	Area (sq km)	%Country
Iceland		
Icelandian	101242	100
Total area:	101242	
India		
Andaman and Nicobar Islands	6181.5	< 1
Bengalian Rainforest	94308.9	3
Burma Monsoon Forest	140712	4
Burman Rainforest	12270.8	< 1
Coromandel	88383.1	3
Deccan Thorn Forest	338403	11
Himalayan Highlands	354943	11
Indus-Ganges Monsoon Forest	1294258	41
Mahanadian	219348	7
Malabar Rainforest	223488	7
Szechwan Highlands	52930.7	2
Thar Desert	273836	9
Tibetan	59059.6	2
Total area:	3158122	
Indonesia		
Borneo	527741	28
Java	137255	7
Lesser Sunda Islands	86034.1	5
Papuan	469385	25
Philippines	1505.9	< 1
Sulawesi (Celebes)	196480	10
Sumatra	464572	25
Total area:	1882974	
Iran		
Anatolian-Iranian Desert	826450	51
Caucaso-Iranian Highlands	590419	36
Iranian Desert	205824	13
Turanian	70.3	< 1
Total area:	1622763	
Iraq		
Anatolian-Iranian Desert	281229	65
Arabian Desert	145833	34
Caucaso-Iranian Highlands	4545.1	1
Total area:	431607	
Iraq-Saudi Arabia Neutral Zone		
Arabian Desert	6876.2	100
Total area:	6876.2	

Country (Biogeographical province)	Area (sq km)	%Country
Ireland		
British Islands	69061.3	100
Total area:	69061.3	
Isle of Man		
British Islands	568.1	100
Total area:	568.1	
Israel		
Arabian Desert	14740.2	71
Mediterranean Sclerophyll	6106.3	29
Total area:	20846.5	
Italy		
Balkan Highlands	860.8	< 1
Central European Highlands	113725	38
Mediterranean Sclerophyll	186203	62
Total area:	300789	
Ivory Coast		
Guinean Rain Forest	134766	42
West African Woodland/Savanna	186251	58
Total area:	321017	
Jamaica		
Greater Antillean	10887.7	100
Total area:	10887.7	
Japan		
Japanese Evergreen Forest	207550	56
Manchu-Japanese Mixed Forest	65817.7	18
Micronesian	55.6	< 1
Oriental Deciduous Forest	91836.9	25
Ryukyu Islands	2444.5	1
Taiwan	637.3	< 1
Total area:	368342	
Jersey		
Atlantic	128.9	100
Total area:	128.9	
Jordan		
Arabian Desert	89546.1	100
Mediterranean Sclerophyll	404.4	< 1
Total area:	89950.5	

Country (Biogeographical province)	Area (sq km)	%Country
Kazakhstan		
Altai Highlands	50107.1	2
Aral Sea	423.2	< 1
Caucaso-Iranian Highlands	29.8	< 1
Middle European Forest	13021.3	< 1
Mongolian-Manchurian Steppe	14528.3	1
Pamir-Tian-Shan Highlands	127930	4
Pontian Steppe	993984	34
Turanian	1515655	52
West Eurasian Taiga	189510	7
Total area:	2905189	
Kenya		
East African Highlands	65300.6	11
East African Woodland/Savanna	129546	22
Lake Rudolf	7300.7	1
Lake Ukerewe (Victoria)	4221.6	1
Somalian	377354	65
Total area:	583723	
Kiribati		
Chihuahuan	14.3	20
Micronesian	38.6	53
Tamaulipan	19.8	27
Total area:	72.7	
Korea		
Japanese Evergreen Forest	58908.1	27
Manchu-Japanese Mixed Forest	84051.2	38
Oriental Deciduous Forest	75690.9	35
Total area:	218650	
Kuwait		
Anatolian-Iranian Desert	14521.2	89
Arabian Desert	1780.5	11
Total area:	16301.7	
Kyrgyzstan		
Pamir-Tian-Shan Highlands	196991	99
Takla-Makan-Gobi Desert	1140.7	1
Turanian	626.4	< 1
Total area:	198758	
Laos		
Indochinese Rainforest	18339.6	8
Szechwan Highlands	4243.8	2
Thailandian Monsoon Forest	207599	90
Total area:	230183	

Country (Biogeographical province)	Area (sq km)	%Country
Latvia		
Boreonemoral	64563.1	100
Total area:	64563.1	
Lebanon		
Mediterranean Sclerophyll	10295.3	100
Total area:	10295.3	
Lesotho		
South African Highlands	11836.6	39
South African Woodland/Savanna	18636.3	61
Total area:	30472.9	
Liberia		
Guinean Rain Forest	93193.3	97
West African Woodland/Savanna	3201.7	3
Total area:	96395.0	
Libya		
Atlas Steppe	45584.7	3
Mediterranean Sclerophyll	3502.7	< 1
Sahara	1571402	97
Total area:	1620489	
Liechtenstein		
Central European Highlands	171.4	100
Total area:	171.4	
Lithuania		
Boreonemoral	64617.9	100
Total area:	64617.9	
Luxembourg		
Atlantic	2635.7	100
Total area:	2635.7	
Macau		
South Chinese Rainforest	59.6	100
Total area:	59.6	
Madagascar		
Malagasy Rain Forest	194642	33
Malagasy Thorn Forest	70144.7	12
Malagasy Woodland/Savanna	322342	55
Total area:	587128	
Malawi		
Central African Highlands	48982.2	41
Lake Malawi (Nyasa)	21397.7	18
Miombo Woodland/Savanna	48595.7	41
Total area:	118976	

Country (Biogeographical province)	Area (sq km)	%Country
Malaysia		
Borneo	197560	60
Malayan Rainforest	131570	40
Total area:	329129	
Maldives		
Maldives and Chagos Islands	36.2	100
Total area:	36.2	
Mali		
Sahara	311196	25
West African Woodland/Savanna	405461	32
Western Sahel	534692	43
Total area:	1251348	
Martinique		
Lesser Antillean	1058.7	100
Total area:	1058.7	
Mauritania		
Sahara	277172	27
West African Woodland/Savanna	47024.3	5
Western Sahel	717057	69
Total area:	1041253	
Mauritius		
Mascarene Islands	1494.8	100
Total area:	1494.8	
Mexico		
Californian	8709.6	< 1
Campechean	204054	10
Central American	16320.3	1
Chihuahuan	321826	16
Grasslands	36.8	< 1
Guerreran	158380	8
Madrean-Cordilleran	601172	31
Revilla Gigedo Island	194.0	< 1
Sinaloan	191937	10
Sonoran	210672	11
Tamaulipan	210403	11
Yucatecan	39942.0	2
Total area:	1963647	
Moldova		
Middle European Forest	4367.5	13
Pontian Steppe	29443.9	87
Total area:	33811.4	

Country (Biogeographical province)	Area (sq km)	%Country
Mongolia		
Altai Highlands	224704	14
East Siberian Taiga	37.5	< 1
Mongolian-Manchurian Steppe	1276542	82
Takla-Makan-Gobi Desert	57426.2	4
Total area:	1558709	
Montserrat		
Lesser Antillean	77.3	100
Total area:	77.3	
Morocco		
Atlas Steppe	131758	20
Mediterranean Sclerophyll	151249	22
Sahara	293334	44
Western Sahel	96363.7	14
Total area:	672704	
Mozambique		
Central African Highlands	5.4	< 1
Lake Malawi (Nyasa)	7240.9	1
Miombo Woodland/Savanna	505929	64
South African Woodland/Savanna	274110	35
Total area:	787286	
Namibia		
Kalahari	244719	30
Karroo	33804.9	4
Miombo Woodland/Savanna	23059.4	3
Namib	300794	36
South African Woodland/Savanna	223785	27
Total area:	826162	
Naura		
Micronesian	15.6	100
Total area:	15.6	
Nepal		
Bengalian Rainforest	5679.1	4
Himalayan Highlands	141580	96
Indus-Ganges Monsoon Forest	93.0	< 1
Total area:	147352	
Netherlands		
Atlantic	36900.9	100
Total area:	36900.9	

Country (Biogeographical province)	Area (sq km)	%Country
Netherlands Antilles		
Lesser Antillean	16.5	2
Venezuelan Dry Forest	848.5	98
Total area:	865.0	
New Caledonia		
New Caledonian	19001.1	100
Total area:	19001.1	
New Zealand		
Neozealandia	266003	100
Total area:	266003	
Nicaragua		
Central American	102166	79
Madrean-Cordilleran	26892.6	21
Total area:	129059	
Niger		
Sahara	377418	32
West African Woodland/Savanna	58549.5	5
Western Sahel	750484	63
Total area:	1186451	
Nigeria		
Guinean Highlands	52234.3	6
Guinean Rain Forest	166387	18
West African Woodland/Savanna	568207	62
Western Sahel	123894	14
Total area:	910722	
Northern Mariana Islands		
Micronesian	145.3	100
Total area:	145.3	
Norway		
Atlantic	18992.2	6
Boreonemoral	61946.3	20
Subarctic Birchwoods	49378.8	16
West Eurasian Taiga	180771	58
Total area:	311088	
Oman		
Anatolian-Iranian Desert	41786.8	13
Arabian Desert	269202	87
Total area:	310988	

Country (Biogeographical province)	Area (sq km)	%Country
Pakistan		
Anatolian-Iranian Desert	163485	19
Himalayan Highlands	140137	16
Indus-Ganges Monsoon Forest	89112.5	10
Iranian Desert	39663.2	5
Thar Desert	426513	49
Tibetan	18922.7	2
Total area:	877833	
Panama		
Central American	33421.5	45
Colombian Coastal	1.1	< 1
Panamanian	40053.7	55
Total area:	73476.3	
Papua New Guinea		
Papuan	463474	100
Total area:	463474	
Paraguay		
Brazilian Rain Forest	125747	31
Gran Chaco	253810	63
Uruguayan Pampas	20391.2	5
Total area:	399948	
Peru		
Amazonian	394617	30
Colombian Montane	54.5	< 1
Equadorian Dry Forest	15354.3	1
Lake Titicaca	4174.9	< 1
Pacific Desert	171868	13
Puna	262108	20
Southern Andean	188465	15
Yungas	260838	20
Total area:	1297480	
Philippines		
Borneo	802.8	< 1
Philippines	290112	100
Total area:	290915	
Poland		
Boreonemoral	109453	35
Central European Highlands	5513.3	2
Middle European Forest	195753	63
Total area:	310719	

Country (Biogeographical province)	Area (sq km)	%Country
Portugal		
Iberian Highlands	62259.3	68
Macaronesian Islands	3106.7	3
Mediterranean Sclerophyll	26664.4	29
Total area:	92030.4	
Puerto Rico		
Greater Antillean	8972.9	100
Total area:	8972.9	
Qatar		
Anatolian-Iranian Desert	10872.5	100
Total area:	10872.5	
Republic of Palau		
Micronesian	454.5	100
Total area:	454.5	
Reunion		
Mascarene Islands	2308.8	100
Total area:	2308.8	
Romania		
Balkan Highlands	5.1	< 1
Middle European Forest	186118	79
Pannonian	948.8	< 1
Pontian Steppe	49555.9	21
Total area:	236628	
Russia		
Alaskan Tundra	2561.3	< 1
Altai Highlands	729062	4
Aral Sea	184.8	< 1
Arctic Desert	132334	1
Boreonemoral	592811	3
Caucaso-Iranian Highlands	110590	1
East Siberian Taiga	5555044	33
Higharctic Tundra	949771	6
Kamchatkan	280931	2
Lake Baikal	32253.9	< 1
Lake Ladoga	17606.6	< 1
Lowarctic Tundra	2137005	13
Manchu-Japanese Mixed Forest	396462	2
Mediterranean Sclerophyll	10301.3	< 1
Middle European Forest	367205	2
Mongolian-Manchurian Steppe	300428	2
Pontian Steppe	586029	3
Subarctic Birchwoods	62290.0	< 1
Turanian	270556	2
West Eurasian Taiga	4419663	26
Total area:	.16E+8	

Country (Biogeographical province)	Area (sq km)	%Country
Rwanda		
East African Woodland/Savanna	25432.8	100
Total area:	25432.8	
Saudi Arabia		
Anatolian-Iranian Desert	34522.9	2
Arabian Desert	1895946	98
Total area:	1930469	
Senegal		
West African Woodland/Savanna	196247	100
Western Sahel	238.0	< 1
Total area:	196485	
Seychelles		
Seychelles and Amirantes Islands	75.1	100
Total area:	75.1	
Sierra Leone		
Guinean Rain Forest	49838.9	69
West African Woodland/Savanna	22194.3	31
Total area:	72033.2	
Singapore		
Malayan Rainforest	484.0	100
Total area:	484.0	
Slovakia		
Middle European Forest	41159.9	87
Pannonian	6412.5	13
Total area:	47572.4	
Soloman Island		
Papuan	26456.5	100
Total area:	26456.5	
Somalia		
Somalian	638068	100
Total area:	638068	
South Africa		
Cape Sclerophyll	125913	10
Kalahari	65208.1	5
Karroo	343086	28
Namib	4943.9	< 1
South African Highlands	187127	15
South African Woodland/Savanna	495659	41
Total area:	1221935	

Country (Biogeographical province)	Area (sq km)	%Country
Spain		
Atlantic	13041.1	3
Iberian Highlands	240773	48
Macaronesian Islands	7328.0	1
Mediterranean Sclerophyll	243947	48
Total area:	505089	
Sri Lanka		
Ceylonese Monsoon Forest	34907.6	53
Ceylonese Rainforest	31093.6	47
Total area:	66001.2	
St. Christopher and Nevis		
Lesser Antillean	240.1	100
Total area:	240.1	
St. Helena		
Ascension and St Helena Islands	111.3	100
Total area:	111.3	
St. Lucia		
Lesser Antillean	564.7	100
Total area:	564.7	
St. Pierre and Miquelon		
Canadian Taiga	218.5	100
Total area:	218.5	
St. Vincent and the Grenadines		
Lesser Antillean	325.9	100
Total area:	325.9	
Sudan		
East African Woodland/Savanna	498310	20
Eastern Sahel	1128279	45
Ethiopian Highlands	110973	4
Sahara	724952	29
Somalian	26565.4	1
Western Sahel	21833.7	1
Total area:	2510914	
Surinam		
Campos Limpos	126.6	< 1
Guyanan	145097	100
Total area:	145224	

Country (Biogeographical province)	Area (sq km)	%Country
Svalbard		
Arctic Desert	60638.1	100
Total area:	60638.1	
Swaziland		
South African Woodland/Savanna	17249.0	100
Total area:	17249.0	
Sweden		
Boreonemoral	123336	28
Middle European Forest	32618.4	7
Subarctic Birchwoods	8626.1	2
West Eurasian Taiga	273337	62
Total area:	437918	
Switzerland		
Atlantic	7102.4	17
Central European Highlands	34115.2	83
Total area:	41217.6	
Syria		
Anatolian-Iranian Desert	96178.6	51
Arabian Desert	53650.1	29
Mediterranean Sclerophyll	38129.0	20
Total area:	187958	
Taiwan		
Taiwan	35895.5	100
Total area:	35895.5	
Tajikistan		
Himalayan Highlands	4522.7	3
Hindu Kush Highlands	2391.4	2
Pamir-Tian-Shan Highlands	98103.6	69
Takla-Makan-Gobi Desert	0.0	< 1
Tibetan	36984.3	26
Total area:	142002	
Tanzania		
East African Woodland/Savanna	157844	17
Lake Malawi (Nyasa)	312.5	< 1
Lake Tanganyika	14140.4	2
Lake Ukerewe (Victoria)	35912.8	4
Miombo Woodland/Savanna	478837	51
Somalian	254480	27
Total area:	941526	

Country (Biogeographical province)	Area (sq km)	%Country
Thailand		
Indochinese Rainforest	155962	30
Malayan Rainforest	47038.5	9
Thailandian Monsoon Forest	309938	60
Total area:	512938	
Togo		
Guinean Rain Forest	19911.2	35
West African Woodland/Savanna	37408.6	65
Total area:	57319.8	
Trinidad and Tobago		
Guyanan	4768.4	94
Lesser Antillean	280.3	6
Total area:	5048.7	
Tunisia		
Atlas Steppe	53622.6	35
Mediterranean Sclerophyll	56385.9	36
Sahara	44737.8	29
Total area:	154746	
Turkey		
Anatolian-Iranian Desert	415440	53
Caucaso-Iranian Highlands	64248.3	8
Mediterranean Sclerophyll	262163	34
West Anatolian	37617.6	5
Total area:	779469	
Turkmenistan		
Anatolian-Iranian Desert	50789.4	11
Caucaso-Iranian Highlands	0.2	< 1
Hindu Kush Highlands	21184.8	4
Pamir-Tian-Shan Highlands	6464.5	1
Turanian	392425	83
Total area:	470863	
Turks and Caicos Islands		
Bahamas-Bermudean	312.7	100
Total area:	312.7	
Uganda		
East African Woodland/Savanna	213341	88
Lake Ukerewe (Victoria)	29284.4	12
Total area:	242625	

Country (Biogeographical province)	Area (sq km)	%Country
Ukraine		
Boreonemoral	3694.7	1
Mediterranean Sclerophyll	6110.7	1
Middle European Forest	322441	54
Pontian Steppe	266440	45
Total area:	598686	
United Arab Emirates		
Anatolian-Iranian Desert	53334.1	49
Arabian Desert	55286.2	51
Total area:	108620	
United Kingdom		
British Islands	194352	81
Scottish Highlands	45115.2	19
Total area:	239467	
United States		
Alaskan Tundra	621152	7
Aleutian Islands	123611	1
Austroriparian	596544	6
Californian	191766	2
Canadian Taiga	162627	2
Chihuahuan	255265	3
Cuban	30.0	< 1
Eastern Forest	2140866	23
Everglades	6824.5	< 1
Grasslands	2160990	23
Great Basin	660717	7
Great Lakes	160771	2
Hawaiian	16673.6	< 1
Kamchatkan	1910.6	< 1
Madrean-Cordilleran	32222.4	< 1
Oregonian	112579	1
Rocky Mountains	957557	10
Sierra-Cascade	196902	2
Sitkan	174244	2
Sonoran	297310	3
Tamaulipan	9.7	< 1
Yukon Taiga	568566	6
Total area:	9439138	
Upper Volta (Burkina Faso)		
West African Woodland/Savanna	265513	98
Western Sahel	6232.5	2
Total area:	271745	

Country (Biogeographical province)	Area (sq km)	%Country
Uruguay		
Argentinian Pampas	45.2	< 1
Uruguayan Pampas	178183	100
Total area:	178228	
Uzbekistan		
Aral Sea	66935.3	14
Hindu Kush Highlands	692.2	< 1
Pamir-Tian-Shan Highlands	84351.1	17
Turanian	332870	69
Total area:	484849	
Vanuatu		
East Melanesian	12152.8	100
Total area:	12152.8	
Venezuela		
Amazonian	147521	16
Campos Limpos	71488.8	8
Colombian Coastal	28839.6	3
Colombian Montane	50642.9	6
Guyanan	164403	18
Llanos	230672	25
Northern Andean	481.1	< 1
Sonoran	0.1	< 1
Venezuelan Deciduous Forest	58924.8	6
Venezuelan Dry Forest	161441	18
Total area:	914414	
Vietnam		
Chinese Subtropical Forest	15519.9	5
Indochinese Rainforest	164397	50
South Chinese Rainforest	19857.6	6
Szechwan Highlands	5822.8	2
Thailandian Monsoon Forest	120580	37
Total area:	326178	
Virgin Islands		
Lesser Antillean	232.4	100
Total area:	232.4	
West Bank		
Arabian Desert	3795.9	66
Mediterranean Sclerophyll	1955.6	34
Total area:	5751.5	

Country (Biogeographical province)	Area (sq km)	%Country
Yemen		
Arabian Desert	399448	99
Somalian	3267.7	1
Total area:	402716	
Yugoslavia		
Balkan Highlands	148711	59
Central European Highlands	350.8	< 1
Mediterranean Sclerophyll	43995.8	17
Middle European Forest	27266.2	11
Pannonian	31196.4	12
Total area:	251521	
Zaire		
Central African Highlands	153423	7
Congo Rain Forest	1075910	46
Congo Woodland/Savanna	718828	31
East African Woodland/Savanna	241774	10
Lake Tanganyika	14451.6	1
Miombo Woodland/Savanna	18024.3	1
West African Woodland/Savanna	92146.4	4
Total area:	2314557	
Zambia		
Central African Highlands	67001.3	9
Congo Woodland/Savanna	94415.7	13
East African Woodland/Savanna	13293.8	2
Lake Tanganyika	2208.8	< 1
Miombo Woodland/Savanna	577962	77
Total area:	754882	
Zimbabwe		
Miombo Woodland/Savanna	212161	54
South African Woodland/Savanna	178311	46
Total area:	390472	

Annex E

List of Udvardy's biogeographical provinces
and the proportions of
countries they contain

Biogeographical province (country)	Area (sq km)	% Province
Alaskan Tundra		
Canada	237417	28
Russia	2561.3	< 1
United States	621152	72
Total area:	861130	
Aleutian Islands		
United States	123611	100
Total area:	123611	
Altai Highlands		
China	44383.0	4
Kazakhstan	50107.1	5
Mongolia	224704	21
Russia	729062	70
Total area:	1048256	
Amazonian		
Bolivia	45584.7	2
Brazil	1483711	60
Colombia	405195	16
Ecuador	11271.2	< 1
Peru	394617	16
Venezuela	147521	6
Total area:	2487901	
Anatolian-Iranian Desert		
Afghanistan	210067	10
Bahrain	507.6	< 1
Iran	826450	38
Iraq	281229	13
Kuwait	14521.2	1
Oman	41786.8	2
Pakistan	163485	7
Qatar	10872.5	< 1
Saudi Arabia	34522.9	2
Syria	96178.6	4
Turkey	415440	19
Turkmenistan	50789.4	2
United Arab Emirates	53334.1	2
Total area:	2199183	
Andaman and Nicobar Islands		
India	6181.5	100
Total area:	6181.5	

Biogeographical province (country)	Area (sq km)	% Province
Arabian Desert		
Egypt	56310.4	2
Gaza Strip	389.8	< 1
Iraq	145833	5
Iraq-Saudi Arabia Neutral Zone	6876.2	< 1
Israel	14740.2	< 1
Jordan	89546.1	3
Kuwait	1780.5	< 1
Oman	269202	9
Saudi Arabia	1895946	63
Syria	53650.1	2
United Arab Emirates	55286.2	2
West Bank	3795.9	< 1
Yemen	399448	13
Total area:	2992803	
Aral Sea		
Kazakhstan	423.2	1
Russia	184.8	< 1
Uzbekistan	66935.3	99
Total area:	67543.3	
Arctic Archipelago		
Canada	687603	100
Total area:	687603	
Arctic Desert		
Russia	132334	69
Svalbard	60638.1	31
Total area:	192972	
Arctic Desert and Icecap		
Canada	486130	23
Greenland	1628758	77
Total area:	2114888	
Argentinian Pampas		
Argentina	512047	100
Uruguay	45.2	< 1
Total area:	512092	
Ascension and St Helena Islands		
St. Helena	111.3	100
Total area:	111.3	

Biogeographical province (country)	Area (sq km)	% Province
Atlantic		
Andorra	469.6	< 1
Belgium	30598.6	4
Denmark	12079.9	2
France	446655	62
Germany	148505	21
Guernsey	54.6	< 1
Jersey	128.9	< 1
Luxembourg	2635.7	< 1
Netherlands	36900.9	5
Norway	18992.2	3
Spain	13041.1	2
Switzerland	7102.4	1
Total area:	717164	
Atlas Steppe		
Algeria	190331	45
Libya	45584.7	11
Morocco	131758	31
Tunisia	53622.6	13
Total area:	421296	
Austroriparian		
United States	596544	100
Total area:	596544	
Babacu		
Brazil	292852	100
Total area:	292852	
Bahamas-Bermudean		
Bahamas	12396.0	98
Turks and Caicos Islands	312.7	2
Total area:	12708.7	
Balkan Highlands		
Albania	6564.0	3
Austria	502.6	< 1
Bulgaria	57843.9	26
Greece	6774.0	3
Italy	860.8	< 1
Romania	5.1	< 1
Yugoslavia	148711	67
Total area:	221262	

Biogeographical province (country)	Area (sq km)	% Province
Bengalian Rainforest		
Bangladesh	79706.0	44
Bhutan	179.4	< 1
India	94308.9	52
Nepal	5679.1	3
Total area:	179873	
Boreonemoral		
Belarus	186820	15
Estonia	39850.2	3
Finland	37696.2	3
Latvia	64563.1	5
Lithuania	64617.9	5
Norway	61946.3	5
Poland	109453	9
Russia	592811	46
Sweden	123336	10
Ukraine	3694.7	< 1
Total area:	1284789	
Borneo		
Brunei	5772.6	1
Indonesia	527741	72
Malaysia	197560	27
Philippines	802.8	< 1
Total area:	731876	
Brazilian Planalto		
Brazil	219143	100
Total area:	219143	
Brazilian Rain Forest		
Argentina	26235.7	2
Brazil	1381841	90
Paraguay	125747	8
Total area:	1533824	
Brigalow		
Australia	228280	100
Total area:	228280	
British Islands		
Ireland	69061.3	26
Isle of Man	568.1	< 1
United Kingdom	194352	74
Total area:	263982	

Biogeographical province (country)		Area (sq km)	% Province
Burma Monsoon Forest			
Bangladesh		28633.6	10
Bhutan		1006.1	< 1
Burma		126838	43
India		140712	47
	Total area:	297190	
Burman Rainforest			
Bangladesh		29392.9	11
Burma		215814	84
India		12270.8	5
	Total area:	257478	
Caatinga			
Brazil		899777	100
	Total area:	899777	
Californian			
Mexico		8709.6	4
United States		191766	96
	Total area:	200476	
Campechean			
Belize		21925.2	8
Guatemala		33121.1	13
Mexico		204054	79
	Total area:	259100	
Campos Cerrados			
Bolivia		105844	6
Brazil		1672461	94
	Total area:	1778305	
Campos Limpos			
Brazil		116868	56
Guyana		18765.6	9
Surinam		126.6	< 1
Venezuela		71488.8	34
	Total area:	207249	
Canadian Taiga			
Canada		4962930	97
St. Pierre and Miquelon		218.5	< 1
United States		162627	3
	Total area:	5125776	

Biogeographical province (country)		Area (sq km)	% Province
Canadian Tundra			
Canada		1732011	100
	Total area:	1732011	
Cape Sclerophyll			
South Africa		125913	100
	Total area:	125913	
Caucaso-Iranian Highlands			
Armenia		1365.4	< 1
Azerbaijan		114074	12
Georgia		50658.6	5
Iran		590419	63
Iraq		4545.1	< 1
Kazakhstan		29.8	< 1
Russia		110590	12
Turkey		64248.3	7
Turkmenistan		0.2	< 1
	Total area:	935929	
Central African Highlands			
Malawi		48982.2	18
Mozambique		5.4	< 1
Zaire		153423	57
Zambia		67001.3	25
	Total area:	269412	
Central American			
Costa Rica		51701.3	17
El Salvador		18807.1	6
Guatemala		25494.3	8
Honduras		61966.0	20
Mexico		16320.3	5
Nicaragua		102166	33
Panama		33421.5	11
	Total area:	309877	
Central Desert			
Australia		1766998	100
	Total area:	1766998	
Central European Highlands			
Austria		46805.7	13
Czech republic		51333.8	14
France		31709.7	9
Germany		86171.3	23
Italy		113725	31
Liechtenstein		171.4	< 1
Poland		5513.3	1
Switzerland		34115.2	9
Yugoslavia		350.8	< 1
	Total area:	369896	

Biogeographical province (country)	Area (sq km)	% Province
Ceylonese Monsoon Forest		
Sri Lanka	34907.6	100
Total area:	34907.6	
Ceylonese Rainforest		
Sri Lanka	31093.6	100
Total area:	31093.6	
Chihuahuan		
Kiribati	14.3	< 1
Mexico	321826	56
United States	255265	44
Total area:	577105	
Chilean Araucaria Forest		
Chile	32848.2	100
Total area:	32848.2	
Chilean Nothofagus		
Argentina	10148.6	8
Chile	110745	92
Total area:	120894	
Chilean Sclerophyll		
Chile	57098.4	100
Total area:	57098.4	
Chinese Subtropical Forest		
China	847393	98
Vietnam	15519.9	2
Total area:	862913	
Colombian Coastal		
Colombia	146997	62
Ecuador	60968.5	26
Panama	1.1	< 1
Venezuela	28839.6	12
Total area:	236807	
Colombian Montane		
Colombia	96525.4	62
Ecuador	7882.2	5
Peru	54.5	< 1
Venezuela	50642.9	33
Total area:	155105	

Biogeographical province (country)	Area (sq km)	% Province
Congo Rain Forest		
Angola	27962.3	1
Cameroon	200889	11
Central African Republic	2037.4	< 1
Congo	303942	16
Equatorial Guinea	24931.8	1
Gabon	258867	14
Zaire	1075910	57
Total area:	1894540	
Congo Woodland/Savanna		
Angola	526906	39
Congo	16053.8	1
Zaire	718828	53
Zambia	94415.7	7
Total area:	1356203	
Coromandel		
India	88383.1	100
Total area:	88383.1	
Cuban		
Cayman Islands	218.7	< 1
Cuba	109313	100
United States	30.0	< 1
Total area:	109562	
Deccan Thorn Forest		
India	338403	100
Total area:	338403	
East African Highlands		
Kenya	65300.6	100
Total area:	65300.6	
East African Woodland/Savanna		
Burundi	7783.2	1
Central African Republic	218593	14
Chad	4059.2	< 1
Kenya	129546	9
Rwanda	25432.8	2
Sudan	498310	33
Tanzania	157844	10
Uganda	213341	14
Zaire	241774	16
Zambia	13293.8	1
Total area:	1509977	

Biogeographical province (country)	Area (sq km)	% Province
East Melanesian		
Fiji	17515.1	59
Vanuatu	12152.8	41
Total area:	29667.9	
East Siberian Taiga		
China	631.0	< 1
Mongolia	37.5	< 1
Russia	5555044	100
Total area:	5555712	
Eastern Forest		
Canada	81803.6	4
United States	2140866	96
Total area:	2222670	
Eastern Grasslands and Savannas		
Australia	558269	100
Total area:	558269	
Eastern Sahel		
Central African Republic	261.3	< 1
Chad	13990.8	1
Eritrea	8529.0	1
Ethiopia	16649.0	1
Sudan	1128279	97
Total area:	1167709	
Eastern Sclerophyll		
Australia	632668	100
Total area:	632668	
Equadorian Dry Forest		
Ecuador	34821.3	69
Peru	15354.3	31
Total area:	50175.6	
Ethiopian Highlands		
Eritrea	45057.8	9
Ethiopia	349452	69
Sudan	110973	22
Total area:	505483	
Everglades		
United States	6824.5	100
Total area:	6824.5	

Biogeographical province (country)	Area (sq km)	% Province
Gran Chaco		
Argentina	389920	39
Bolivia	344039	35
Brazil	715.2	< 1
Paraguay	253810	26
Total area:	988484	
Grasslands		
Canada	281154	12
Mexico	36.8	< 1
United States	2160990	88
Total area:	2442182	
Great Basin		
United States	660717	100
Total area:	660717	
Great Lakes		
Canada	93725.8	37
United States	160771	63
Total area:	254497	
Greater Antillean		
Dominican Republic	48590.3	51
Haiti	27192.0	28
Jamaica	10887.7	11
Puerto Rico	8972.9	9
Total area:	95642.9	
Greenland Tundra		
Greenland	496395	100
Total area:	496395	
Guerreran		
Mexico	158380	100
Total area:	158380	
Guinean Highlands		
Cameroon	27656.8	35
Nigeria	52234.3	65
Total area:	79891.1	
Guinean Rain Forest		
Benin	22800.1	4
Ghana	103825	17
Guinea	11941.3	2
Ivory Coast	134766	22
Liberia	93193.3	15
Nigeria	166387	28
Sierra Leone	49838.9	8
Togo	19911.2	3
Total area:	602662	

Biogeographical province (country)	Area (sq km)	% Province
Guyanan		
Brazil	409131	41
French Guiana	83691.7	8
Guyana	192164	19
Surinam	145097	15
Trinidad and Tobago	4768.4	< 1
Venezuela	164403	16
Total area:	999256	
Hawaiian		
United States	16673.6	100
Total area:	16673.6	
Higharctic Tundra		
Russia	949771	100
Total area:	949771	
Himalayan Highlands		
Afghanistan	22589.9	3
Bhutan	38750.7	5
China	157535	18
India	354943	41
Nepal	141580	16
Pakistan	140137	16
Tajikistan	4522.7	1
Total area:	860057	
Hindu Kush Highlands		
Afghanistan	192834	89
Tajikistan	2391.4	1
Turkmenistan	21184.8	10
Uzbekistan	692.2	< 1
Total area:	217103	
Iberian Highlands		
France	1.3	< 1
Portugal	62259.3	21
Spain	240773	79
Total area:	303034	
Icelandian		
Iceland	101242	100
Total area:	101242	
Indochinese Rainforest		
Burma	52172.5	12
Cambodia (Formerly Kampuchea)	61459.2	14
Laos	18339.6	4
Thailand	155962	34
Vietnam	164397	36
Total area:	452330	

Biogeographical province (country)	Area (sq km)	% Province
Indus-Ganges Monsoon Forest		
Afghanistan	28662.8	2
India	1294258	92
Nepal	93.0	< 1
Pakistan	89112.5	6
Total area:	1412126	
Insulantarctica		
Argentina	493.1	3
Chile	3677.2	20
Falkland Islands (Islas Malvinas)	14491.0	78
Total area:	18661.3	
Iranian Desert		
Afghanistan	158018	39
Iran	205824	51
Pakistan	39663.2	10
Total area:	403506	
Japanese Evergreen Forest		
Japan	207550	78
Korea	58908.1	22
Total area:	266458	
Java		
Indonesia	137255	100
Total area:	137255	
Kalahari		
Botswana	194911	39
Namibia	244719	48
South Africa	65208.1	13
Total area:	504837	
Kamchatkan		
Russia	280931	99
United States	1910.6	1
Total area:	282841	
Karroo		
Namibia	33804.9	9
South Africa	343086	91
Total area:	376891	
Lake Baikal		
Russia	32253.9	100
Total area:	32253.9	

Biogeographical province (country)	Area (sq km)	% Province
Lake Ladoga		
Russia	17606.6	100
Total area:	17606.6	
Lake Malawi (Nyasa)		
Malawi	21397.7	74
Mozambique	7240.9	25
Tanzania	312.5	1
Total area:	28951.1	
Lake Rudolf		
Ethiopia	30.3	< 1
Kenya	7300.7	100
Total area:	7331.0	
Lake Tanganyika		
Burundi	1950.0	6
Tanzania	14140.4	43
Zaire	14451.6	44
Zambia	2208.8	7
Total area:	32750.8	
Lake Titicaca		
Bolivia	3070.1	42
Peru	4174.9	58
Total area:	7245.0	
Lake Ukerewe (Victoria)		
Kenya	4221.6	6
Tanzania	35912.8	52
Uganda	29284.4	42
Total area:	69418.8	
Lesser Antillean		
Anguilla	38.6	1
Antigua and Barbuda	445.9	7
Barbados	440.3	7
British Virgin Islands	90.3	1
Dominica	702.8	11
Grenada	290.9	4
Guadeloupe	1770.1	27
Martinique	1058.7	16
Montserrat	77.3	1
Netherlands Antilles	16.5	< 1
St. Christopher and Nevis	240.1	4
St. Lucia	564.7	9
St. Vincent and the Grenadines	325.9	5
Trinidad and Tobago	280.3	4
Virgin Islands	232.4	4
Total area:	6574.8	

Biogeographical province (country)	Area (sq km)	% Province
Lesser Sunda Islands		
Indonesia	86034.1	100
Total area:	86034.1	
Llanos		
Colombia	207245	47
Venezuela	230672	53
Total area:	437917	
Lowarctic Tundra		
Russia	2137005	100
Total area:	2137005	
Macaronesian Islands		
Cape Verde	2396.9	19
Portugal	3106.7	24
Spain	7328.0	57
Total area:	12831.6	
Madeiran		
Bolivia	110827	7
Brazil	1557999	93
Total area:	1668826	
Madrean-Cordilleran		
El Salvador	1850.9	< 1
Guatemala	50803.6	7
Honduras	50251.6	7
Mexico	601172	79
Nicaragua	26892.6	4
United States	32222.4	4
Total area:	763193	
Mahanadian		
India	219348	100
Total area:	219348	
Malabar Rainforest		
India	223488	100
Total area:	223488	
Malagasy Rain Forest		
Madagascar	194642	100
Total area:	194642	
Malagasy Thorn Forest		
Madagascar	70144.7	100
Total area:	70144.7	

Biogeographical province (country)	Area (sq km)	% Province
Malagasy Woodland/Savanna		
Madagascar	322342	100
Total area:	322342	
Malayan Rainforest		
Malaysia	131570	73
Singapore	484.0	< 1
Thailand	47038.5	26
Total area:	179092	
Maldives and Chagos Islands		
Maldives	36.2	100
Total area:	36.2	
Manchu-Japanese Mixed Forest		
China	705494	56
Japan	65817.7	5
Korea	84051.2	7
Russia	396462	32
Total area:	1251825	
Mascarene Islands		
Mauritius	1494.8	39
Reunion	2308.8	61
Total area:	3803.6	
Mediterranean Sclerophyll		
Albania	22143.7	1
Algeria	206274	14
Bulgaria	32280.1	2
Cyprus	9213.7	1
Egypt	7949.5	1
France	56953.2	4
Gaza Strip	0.0	< 1
Georgia	19494.5	1
Greece	116680	8
Israel	6106.3	< 1
Italy	186203	12
Jordan	404.4	< 1
Lebanon	10295.3	1
Libya	3502.7	< 1
Morocco	151249	10
Portugal	26664.4	2
Russia	10301.3	1
Spain	243947	16
Syria	38129.0	3
Tunisia	56385.9	4
Turkey	262163	17
Ukraine	6110.7	< 1
West Bank	1955.6	< 1
Yugoslavia	43995.8	3
Total area:	1518401	

Biogeographical province (country)	Area (sq km)	% Province
Micronesian		
Federated States of Micronesia	1450.3	67
Japan	55.6	3
Kiribati	38.6	2
Naura	15.6	1
Northern Mariana Islands	145.3	7
Republic of Palau	454.5	21
Total area:	2159.9	
Middle European Forest		
Austria	36249.7	2
Belarus	19938.3	1
Bulgaria	14749.9	1
Czech republic	28118.7	2
Denmark	28456.5	2
Germany	120624	8
Hungary	29053.0	2
Kazakhstan	13021.3	1
Moldova	4367.5	< 1
Poland	195753	13
Romania	186118	13
Russia	367205	25
Slovakia	41159.9	3
Sweden	32618.4	2
Ukraine	322441	22
Yugoslavia	27266.2	2
Total area:	1467140	
Miombo Woodland/Savanna		
Angola	526106	22
Botswana	19816.4	1
Burundi	17620.1	1
Malawi	48595.7	2
Mozambique	505929	21
Namibia	23059.4	1
Tanzania	478837	20
Zaire	18024.3	1
Zambia	577962	24
Zimbabwe	212161	9
Total area:	2428111	
Mongolian-Manchurian Steppe		
China	1013679	39
Kazakhstan	14528.3	1
Mongolia	1276542	49
Russia	300428	12
Total area:	2605177	

Biogeographical province (country)	Area (sq km)	% Province
Monte		
Argentina	1183785	96
Bolivia	26798.3	2
Chile	24158.8	2
Total area:	1234742	
Namib		
Angola	55988.8	15
Namibia	300794	83
South Africa	4943.9	1
Total area:	361727	
Neozealandia		
Australia	145.3	< 1
New Zealand	266003	100
Total area:	266148	
New Caledonian		
Australia	73.4	< 1
New Caledonia	19001.1	100
Total area:	19074.5	
Northern Andean		
Colombia	174609	68
Ecuador	80920.3	32
Venezuela	481.1	< 1
Total area:	256011	
Northern Coastal		
Australia	349970	100
Total area:	349970	
Northern Grasslands		
Australia	962826	100
Total area:	962826	
Northern Savanna		
Australia	584642	100
Total area:	584642	
Oregonian		
Canada	11902.7	10
United States	112579	90
Total area:	124481	
Oriental Deciduous Forest		
China	2583457	94
Japan	91836.9	3
Korea	75690.9	3
Total area:	2750985	

Biogeographical province (country)	Area (sq km)	% Province
Pacific Desert		
Chile	118367	41
Peru	171868	59
Total area:	290235	
Pamir-Tian-Shan Highlands		
Afghanistan	12630.8	2
China	116601	18
Kazakhstan	127930	20
Kyrgyzstan	196991	31
Tajikistan	98103.6	15
Turkmenistan	6464.5	1
Uzbekistan	84351.1	13
Total area:	643071	
Panamanian		
Colombia	2.8	< 1
Panama	40053.7	100
Total area:	40056.5	
Pannonian		
Austria	397.8	< 1
Hungary	63572.3	62
Romania	948.8	1
Slovakia	6412.5	6
Yugoslavia	31196.4	30
Total area:	102528	
Papuan		
Indonesia	469385	49
Papua New Guinea	463474	48
Soloman Island	26456.5	3
Total area:	959316	
Patagonian		
Argentina	403307	98
Chile	9693.6	2
Total area:	413001	
Philippines		
Indonesia	1505.9	1
Philippines	290112	99
Total area:	291618	
Pontian Steppe		
Bulgaria	6001.5	< 1
China	14126.5	1
Kazakhstan	993984	51
Moldova	29443.9	2
Romania	49555.9	3
Russia	586029	30
Ukraine	266440	14
Total area:	1945581	

Biogeographical province (country)		Area (sq km)	% Province
Puna			
Bolivia		202752	44
Peru		262108	56
	Total area:	464861	
Queensland Coastal			
Australia		313555	100
	Total area:	313555	
Revilla Gigedo Island			
Mexico		194.0	100
	Total area:	194.0	
Rocky Mountains			
Canada		620830	39
United States		957557	61
	Total area:	1578387	
Ryukyu Islands			
Japan		2444.5	100
	Total area:	2444.5	
Sahara			
Algeria		1822057	26
Chad		568144	8
Egypt		919969	13
Libya		1571402	23
Mali		311196	5
Mauritania		277172	4
Morocco		293334	4
Niger		377418	5
Sudan		724952	10
Tunisia		44737.8	1
	Total area:	6910380	
Scottish Highlands			
Faeroe Islands		1191.0	3
United Kingdom		45115.2	97
	Total area:	46306.2	
Serro Do Mar			
Brazil		243553	100
	Total area:	243553	
Seychelles and Amirantes Islands			
Seychelles		75.1	100
	Total area:	75.1	

Biogeographical province (country)		Area (sq km)	% Province
Sierra-Cascade			
Canada		31422.2	14
United States		196902	86
	Total area:	228324	
Sinaloan			
Mexico		191937	100
	Total area:	191937	
Sitkan			
Canada		174832	50
United States		174244	50
	Total area:	349076	
Somalian			
Djibouti		21557.6	1
Eritrea		66393.4	3
Ethiopia		766918	36
Kenya		377354	18
Somalia		638068	30
Sudan		26565.4	1
Tanzania		254480	12
Yemen		3267.7	< 1
	Total area:	2154604	
Sonoran			
Mexico		210672	41
United States		297310	59
Venezuela		0.1	< 1
	Total area:	507982	
South African Highlands			
Lesotho		11836.6	6
South Africa		187127	94
	Total area:	198963	
South African Woodland/Savanna			
Angola		115642	7
Botswana		364709	22
Lesotho		18636.3	1
Mozambique		274110	16
Namibia		223785	13
South Africa		495659	29
Swaziland		17249.0	1
Zimbabwe		178311	11
	Total area:	1688101	

Biogeographical province (country)	Area (sq km)	% Province
South Chinese Rainforest		
China	163618	88
Hong Kong	2922.4	2
Macau	59.6	< 1
Vietnam	19857.6	11
Total area:	186457	
South Trinidade Island		
Brazil	10.5	100
Total area:	10.5	
Southern Andean		
Argentina	124573	19
Bolivia	74773.1	11
Chile	266283	40
Ecuador	9112.8	1
Peru	188465	28
Total area:	663207	
Southern Mulga/Saltbush		
Australia	829217	100
Total area:	829217	
Southern Sclerophyll		
Australia	232956	100
Total area:	232956	
Subarctic Birchwoods		
Finland	11909.7	9
Norway	49378.8	37
Russia	62290.0	47
Sweden	8626.1	7
Total area:	132205	
Sulawesi (Celebes)		
Indonesia	196480	100
Total area:	196480	
Sumatra		
Indonesia	464572	100
Total area:	464572	
Szechwan Highlands		
Burma	80629.9	14
China	434922	75
India	52930.7	9
Laos	4243.8	1
Vietnam	5822.8	1
Total area:	578549	

Biogeographical province (country)	Area (sq km)	% Province
Taiwan		
Japan	637.3	2
Taiwan	35895.5	98
Total area:	36532.8	
Takla-Makan-Gobi Desert		
China	2125982	97
Kyrgyzstan	1140.7	< 1
Mongolia	57426.2	3
Tajikistan	0.0	< 1
Total area:	2184549	
Tamaulipan		
Kiribati	19.8	< 1
Mexico	210403	100
United States	9.7	< 1
Total area:	210433	
Tasmanian		
Australia	67970.1	100
Total area:	67970.1	
Thailandian Monsoon Forest		
Burma	190558	20
Cambodia (Formerly Kampuchea)	120878	13
China	10159.8	1
Laos	207599	22
Thailand	309938	32
Vietnam	120580	13
Total area:	959712	
Thar Desert		
Afghanistan	11288.0	2
India	273836	38
Pakistan	426513	60
Total area:	711637	
Tibetan		
Afghanistan	6064.5	< 1
China	1117027	90
India	59059.6	5
Pakistan	18922.7	2
Tajikistan	36984.3	3
Total area:	1238058	

Biogeographical province (country)	Area (sq km)	% Province
Turanian		
Iran	70.3	< 1
Kazakhstan	1515655	60
Kyrgyzstan	626.4	< 1
Russia	270556	11
Turkmenistan	392425	16
Uzbekistan	332870	13
Total area:	2512202	
Uruguayan Pampas		
Argentina	131536	25
Brazil	192015	37
Paraguay	20391.2	4
Uruguay	178183	34
Total area:	522125	
Valdivian Forest		
Chile	111302	100
Total area:	111302	
Venezuelan Deciduous Forest		
Venezuela	58924.8	100
Total area:	58924.8	
Venezuelan Dry Forest		
Colombia	107994	40
Netherlands Antilles	848.5	< 1
Venezuela	161441	60
Total area:	270284	
West African Woodland/Savanna		
Benin	93599.8	3
Cameroon	224250	7
Central African Republic	400437	12
Chad	205666	6
Congo	24415.9	1
Gambia	10336.6	< 1
Ghana	133311	4
Guinea	233755	7
Guinea-Bissau	30887.1	1
Ivory Coast	186251	6
Liberia	3201.7	< 1
Mali	405461	13
Mauritania	47024.3	1
Niger	58549.5	2
Nigeria	568207	18
Senegal	196247	6
Sierra Leone	22194.3	1
Togo	37408.6	1
Upper Volta (Burkina Faso)	265513	8
Zaire	92146.4	3
Total area:	3238860	

Biogeographical province (country)	Area (sq km)	% Province
West Anatolian		
Turkey	37617.6	100
Total area:	37617.6	
West Eurasian Taiga		
Finland	281233	5
Kazakhstan	189510	4
Norway	180771	3
Russia	4419663	83
Sweden	273337	5
Total area:	5344514	
Western Mulga		
Australia	780873	100
Total area:	780873	
Western Sahel		
Algeria	54247.7	2
Cameroon	13301.9	< 1
Chad	486227	17
Mali	534692	19
Mauritania	717057	26
Morocco	96363.7	3
Niger	750484	27
Nigeria	123894	4
Senegal	238.0	< 1
Sudan	21833.7	1
Upper Volta (Burkina Faso)	6232.5	< 1
Total area:	2804570	
Western Sclerophyll		
Australia	396657	100
Total area:	396657	
Yucatecan		
Mexico	39942.0	100
Total area:	39942.0	
Yukon Taiga		
Canada	451878	44
United States	568566	56
Total area:	1020444	
Yungas		
Bolivia	176133	36
Brazil	2908.0	1
Ecuador	43256.1	9
Peru	260838	54
Total area:	483135	

Annex F

Examples of potential co-ordinating institutes for biodiversity indicators

Potential Co-ordinating Institutes for Biodiversity Indicators
- Summary -

REALM: All

Botanic Gardens Conservation International (BGCI)
CAB International (CABI)
CARE International
Centre for International Forestry Research (CIFOR)
Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT)
Conservation International (CI)
Consortium for International Earth Science Information Network (CIESIN)
Consultive Group on the International Agricultural Research (CGIAR)
Durrell Institute of Conservation and Ecology (DICE)
Friends of the Earth International (FoEI)
International Academy of the Environment
International Center for Agricultural Research in the Dry Areas (ICARDA)
International Center for Living Aquatic Resources Management (ICLARM)
International Council of Scientific Unions (ICSU)
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
International Institute for Applied Systems Analysis (IIASA)
International Institute for Environment and Development (IIED)
International Mycological Institute (IMI)

International Organisation for Standardisation (ISO)
International Plant Genetic Resources Institute (IPGRI)
International Service for National Agricultural Research (ISNAR)
International Union of Forestry Research Organisations (IUFRO)
IUCN - The World Conservation Union
IUCN Commission on Natural Parks and Protected Areas (CNPPA)
IUCN Environmental Law Centre (ELC)
IUCN Species Survival Commission (SSC)
Missouri Botanical Gardens (MOBOT)
New York Botanical Gardens (NYBG)
New York Zoological Society (NYZS) - The Wildlife Conservation Society
Oxford Forestry Institute (OFI)
Royal Botanical Gardens, Edinburgh (RGBE)
Royal Botanic Gardens, Kew (RBGK)
Smithsonian Institution (SI)
STOAS - Foundation for the Development of Agricultural Education & Training
Stockholm Environment Institute (SEI)
Tropical Agricultural Center for Research and Education (CATIE)
UNEP Global Environment Monitoring System (GEMS)
UNEP Global Resource Information Database (GRID)
UNEP International Environmental Information System (INFOTERRA)
United Nations Educational, Scientific and Cultural Organisation (UNESCO)
United Nations Statistical Division (UNSTAT)
World Conservation Monitoring Centre (WCMC)
World Resources Institute (WRI)

World Tourism Organisation (WTO)
World Wide Fund for Nature (WWF) International

REALM: All except Antarctica
Birdlife International (BLI)

REALM: Nearctic, Neotropical
International Institute of Tropical Forestry (IITF)
The Nature Conservancy (TNC)

REALM: Neotropical, Africotropical
Centro Internacional de Agricultura Tropical (CIAT) [International Centre of Tropical Agriculture]

REALM: Palaearctic, Indomalayan
Rijksherbarium/ Hortus Botanicus (RHHB)

REALM: Africotropical
International Institute of Tropical Agriculture (IITA)
World Bank Programme on Environmental Information Systems (EIS)

REALM: Neotropical
Caribbean Natural Resources Institute (CANARI)
Caribbean Conservation Association (CCA)
Centro Internacional de la Papa (CIP) (International Potato Centre)

REALM: Oceanian
Pacific Science Association (PSA)

REALM: Palaearctic
European Centre for Nature Conservation (ECNC)
European Environment Agency (EEA)

Potential Coordinating Institutes

Botanic Gardens Conservation International (BGCI)

Descano House, 199 Kew Road, Richmond, Surrey TW9 3BW, UK.

Tel: +44 181 352 5953 Fax: +44 181 332 5955

REALM: All

INDICATORS: 2, 7

EXPERTISE

BGCI, a registered charity, based at Kew, UK, was founded in 1987 as a result of the 1985 conference in Las Palmas, Gran Canaria, on the theme 'Botanic Gardens and the World Conservation Strategy'. BGCI was founded to link together Botanic Gardens in a cooperating global network for effective plant conservation. It now includes over 400 member institutions in 90 countries, all working together to implement a world-wide Botanic Garden Conservation Strategy and Action Plan for Plant Conservation.

The mission of BGCI is to *conserve plant diversity world-wide* by:

A. working with botanic gardens to ensure the global loss of plant variety can be halted

B. coordinate a world-wide collection of plant resources in botanic gardens by means of an international database

C. develop public awareness of the environment and more particularly the consequences of loss of biodiversity

D. strengthen their capacity for conservation action

BGCI's activities thus far have included: providing technical guidance data and support for botanic gardens in almost one hundred countries world-wide; helping to create and strengthen national and regional networks of gardens in many parts of the world, to focus their efforts on plant conservation in new cooperative partnerships; and, helping to develop a computer database on rare plants in over 300 institutions to bring world-wide coordination to the individual efforts of each garden. BGCI also provides publications and aids environmental awareness education in many countries.

Potential Coordinating Institutes

CAB International (CABI)

Wallingford, Oxon, OX10 8DE, UK.

Tel: +44 1491 832111 Fax: +44 1491 833508

REALM: All

INDICATORS: 2, 7

EXPERTISE

CAB International is an international intergovernmental organisation which provides research information, scientific and development services for agriculture, forestry and related disciplines throughout the world. It is owned by its 34 member governments.

It has the worlds largest bibliographic database (CAB Abstracts) of relevant research and development publications. CABI's resources and activities include:

A. customised database derivatives in the form of printed and electronic publications diagnostic identification services for harmful and beneficial organisms

B. authoritative and up-to-date information on harmful and beneficial organisms

C. field surveys of pests and natural enemies and advice on the assessment of economic and environmental impacts

D. biological control programmes.

CABI has four constituent institutions, namely the International Institute of Entomology; International Mycology Institute, International Institute of Biological Control, and the International Institute of Parasitology.

Potential Coordinating Institutes

CARE International

Secretariat, Boulevard du Régent 58/10, B-1000 Brussels, Belgium.

Tel: +32 2 502 43 33 Fax: +32 2 502 82 02

REALM: All

INDICATORS: 6

EXPERTISE

CARE was established fifty years ago to bring emergency relief supplies to the people of Europe and Asia who had to rebuild their lives amidst the rubble of the Second World War. Today, CARE International is the largest private aid organisation in the world, bringing help to those most in need. It is concerned with the human dignity and self-sufficiency of the poorest of the poor, and is fast to respond to humanitarian emergencies around the globe.

CARE international is a confederation of eleven national agencies, working together to implement more than 350 development programmes in more than 60 countries. Each year, over 30 million people benefit from US$600 million in emergency and sustainable development programmes. Since 1945, CARE has provided more than US$8 billion in goods and services through its development projects and relief operations.

The priority of CARE International is longer-term development, designed to improve economic and social well-being. It also gives high priority to emergencies and the needs of refugee and displaced populations, concentrating on logistics, management, health sanitation and the provision of food, water and shelter.

CARE International utilises more than 90% of its funds for development and relief programmes and less than 10% on management and fund-raising. It has won a high reputation among governments and international agencies, many of whom channel assistance through CARE programmes. CARE maximises its efficiency by combining the expertise of its international staff with the active participation of local people and the host government.

CARE developed activities are coordinated through a multi-year planning system, and are subject to systematic reviews and evaluations. The know-how, processes and community dynamics that a project leaves behind are as important as the material benefits the project creates.

CARE's eleven offices around the world have different objectives: emergency aid; health care, water and population; small business support; education and training; and, agriculture and natural resources. The latter has been active in developing countries since the 1950s. As a non-governmental organisation, CARE works directly alongside the local community. All CARE projects are carefully targeted and managed in such a way that their positive impacts become sustainable in the long term. While all projects have to meet immediate objectives, CARE's commitment to the people involved, and its determination to foster positive change, may require its presence over 15-20 years.

Potential Coordinating Institutes

Centre for International Forestry Research (CIFOR)

PO Box 6596, JKPWB-Jakarta 10065, Indonesia.

Tel: +62 251 31 9423 Fax: +62 251 31 6433

REALM: All

INDICATORS: 1, 2, 7, 8

EXPERTISE

CIFOR was established in 1993 as an autonomous international research organisation under the umbrella of the Consultative Group on International Agricultural Research (CGIAR). It defines the issues and designs strategic research to solve forest problems and it aims to provide a global research partnership to enhance and sustain the contribution of forests to human well-being. In consultation with partner institutions, CIFOR has set out its objectives in a formal Strategic Plan.

After the first year of operations, collaboration with research partners was reported to be well developed. CIFOR sees its constituency as governments, universities, industry, NGOs, multilateral agencies including FAO, UNDP, World Bank and regional development banks, UNEP, UNESCO and IUFRO. The key specialisms are: wet tropical forests, monsoon forests, mangrove forests and drier woodlands. CIFOR anticipates its main geographical areas of operation will be: South and South-east Asia, the Pacific, South and Central America, the Caribbean and Sub-Saharan Africa.

The priority programme areas are:

A. policy development

B. management and conservation of natural forests

C. afforestation of degraded lands

D. products and markets

E. research support and information services.

These programmes are staffed by research scientists at the Headquarters and in partner institutions world-wide. Published work has reflected the main programme activities, eg international research agencies and forest research in Africa and sustainable forest management. The organisation has held a number of seminars on these subjects over the two-year period of its existence.

Potential Coordinating Institutes

Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT)
(International Maize and Wheat Improvement Center)

Apartado 6-641, Lisboa 27, Mexico City CP 00660, DF Mexico.

Tel: +52 5 761 3311 Fax: +52 5 761 41069

REALM: All

INDICATORS: 4, 6, 7, 8

EXPERTISE

Established in 1966 in Mexico, the International Maize and Wheat Improvement Center is supported by CGIAR, the Mexican Ministry of Agriculture, plus various international organisations, governments, and private foundations. The Center aims to improve maize, wheat and triticale research and production in the developing countries of the South by operating breeding programmes and providing specialist training for scientists and technicians. The Center operates in seven experimental stations within Mexico, and has staff stationed in various countries throughout the world to provide full time assistance.

The Regional Maize Program (Programa Regional de Maiz, or PRM) is a network of researchers from nine countries and CIMMYT, with funding and guidance from the Swiss Development Corporation. PRM's objective is to help reach farmers with useful technology, and has developed improved maize varieties that are sown on more than 500,000 hectares in Central America and the Caribbean, and PRM is evaluating and spreading a range of economically viable, soil-conserving practises. These practises increase productivity while conserving or improving the resource base.

CIMMYT scientists are developing a whole series of bread wheat families possessing an exceptionally rich source of genetic diversity and with multiple beneficial traits such as resistance to major wheat diseases and tolerance to serious environmental stress.

CIMMYT's Economics Program closely monitors changes and interactions within countries among public, private, and non-governmental seed organisations to provide clues about future seed industry requirements and performance.

Potential Coordinating Institutes

Conservation International (CI)

1015 18th Street NW, Suite 1000, Washington DC 20036, USA.

Tel: +1 202 429 5660 Fax: +1 202 887 5188

REALM: All

INDICATORS: 1, 2, 7, 8

EXPERTISE

Conservation International was founded in 1987. It acts as 'a catalyst for conservation action' in Latin America, 'working with people and sovereign nations as partners within the context of local socio-political and economic realities'. CI's main focus is on developing national conservation data centres, fellowships for conservation leaders, and creating and managing ecosystem reserves. CI is best known for carrying out 'debt-for-nature' trades in Bolivia and Costa Rica, in which CI purchased part of the countries' foreign debt at a discounted rate. In exchange for CI's agreement to cancel the debt, the governments agreed to establish legal protection for conservation areas.

Conservation International is dedicated to the protection of natural ecosystems and species that rely on these habitats for their survival, and runs ecosystem conservation programmes in over 16 Bioregions around the world resulting in the range of CI's projects and partnerships being as varied as the ecosystems they protect. By developing conservation programmes according to Bioregion, CI is able to focus its energies on the worlds 'hotspots' and wilderness areas - ecosystems of the greatest strategic significance for protecting biodiversity. CI programmes are scientifically based, economically sound, and culturally sensitive.

Conservation International's priorities for on the ground conservation include 'building local capacity'. An example of one such project is in Minas Gerais, Brazil, where CI is coordinating education with community organising. CI works with landowners to turn their forest remnants into protected areas. The ultimate goal is a 'forest archipelago' - a chain of forests connecting several large national parks together. Other CI priority action areas include:

A. integrated strategies

B. forging economic solutions

C. leveraging experiences (seed ventures)

D. setting conservation priorities

E. innovative partnerships.

Conservation International publishes *TROPICUS Newsletter* and monographs including *The Debt for Nature Exchange*.

Potential Coordinating Institutes

Consortium for International Earth Science Information Network (CIESIN)

2250 Pierce Road, University Center Saginaw MI 48710, USA.

Tel: +1 517 797 2700 Fax: +1 517 797 2622

REALM: All

EXPERTISE

CIESIN is a private, non-profit organisation established in 1989. Its mission is to provide access to and enhance the use of information world-wide, advancing understanding of human interactions in the environment and serving the needs of science and public and private decision making.

CIESIN is developing simple data query software which integrates many different data systems in the United States and other countries, making them accessible to a wide range of users through a single access point.

To carry out its mission, CIESIN is building an organisational and technical infrastructure that will serve global environmental change research scientists and the broader community of policy analysts, resource managers, educators, and the general public. At its hub is the Information Cooperative: a distributed archive that allows user communities to catalogue and share data and information electronically among major international data archives and resource centres.

Participation in CIESIN's Information Cooperative provides organisations with a mechanism for disseminating their data and information to a broad audience while retaining ownership and responsibility. Each participating organisation also acquires access to data, information, technologies, and expertise from CIESIN and from other organisations.

The CIESIN Catalog Service allows search and retrieval of metadata concerning the environment. Data available through the system will consist primarily of CIESIN's holdings and the holdings of CIESIN's Information Cooperative partners and those that are referenced by the US Global Change Master Directory. The Catalog Service is accessible via the Internet as well as modem dial-in access and is based on a distributed network of *servers*.

Metadata information stored in the databases of servers is currently in Directory Interchange Format (DIF) or full-text format. Thus far, DIF has been a focus of the CIESIN Catalog Service due to its wide acceptance as a metadata standard in the environmental community.

Institutions or countries wishing the make their environmental metadata accessible to the CIESIN community should contact the CIESIN Customer Service.

Potential Coordinating Institutes

Consultative Group on the International Agricultural Research (CGIAR)

1818 H Street NW, Washington DC 20433, USA.

Tel: +1 202 473 8951 Fax: +1 202 334 8750

REALM: All

INDICATORS: 4, 8

EXPERTISE

The International Agricultural Research Centres (IARC's), supported by the Consultative Group on International Agricultural Research (CGIAR), have been active in the international coordination of activities concerned with plant resources, particularly gene banks.

CGIAR was founded in 1971, and consists of a consortium of donor countries, foundations and development banks, jointly sponsored by the World Bank, the Food and Agriculture Organisation (FAO) and the United Nations Development Programme (UNDP). The establishment of this international network was motivated by international concern over the problems of genetic erosion in cultivated species and the loss of related wild species of flora.

At present there are 13 IARC's supported by the CGIAR. Most of these centres have specific responsibilities in crop variety development and germplasm conservation. A few of these centres also serve as an international base for specific crops and actively collect data on a world-wide basis. The collection efforts of the CGIAR network were initially focused on crop plants and were based on the economic importance of the crop, the quality of existing collections and the degree of threat to the crop. The most important of these IARC's is the International Board of Plant Genetic Resources (IBPGR) in Rome, Italy.

Potential Coordinating Institutes

Durrell Institute of Conservation and Ecology (DICE)

University of Kent, Canterbury, CT2 7PD, UK.

Tel: +44 1227 475480 Fax: +44 1227 475481

REALM: All

EXPERTISE

The Durrell Institute is an international, non-governmental and non-profit research and postgraduate training school dedicated to conserving biodiversity and the ecological processes which support ecosystems and people. Its objective is to integrate conservation and development sustainably through combining natural and international partnerships. By disseminating knowledge through postgraduate training and undertaking research they aim to integrate the biological and social sciences with practical experience of conservation. The following are undertaken:

A. Research and development; wildlife conservation, environmental management, and sustainable solutions for development

B. Training and professional programmes

C. Conservation implementation in partnership with national governments from around the world, universities, and private institutions and foundations.

Potential Coordinating Institutes

Friends of the Earth International (FoEI)

PO Box 19199, 1000 GD Amsterdam, The Netherlands.

Tel: +31 20 622 1369 Fax: +31 20 639 2181

REALM: All

EXPERTISE

Friends of the Earth International (FoEI) was founded in 1971 by four organisations from France, Sweden, England and USA. FoEI is a world-wide federation of national environmental organisations which aims to:

A. Protect the Earth against further deterioration and restore damage inflicted upon the environment by human activities and negligence

B. Preserve the Earth's ecological, cultural and ethnic diversity

C. Increase public participation and democratic decision making

D. Achieve social, economic and political justice and equal access to resource and opportunities for men and women on the local, national and international level

E. Promote environmentally sustainable development on local, national, regional and global levels.

FoEI has a highly decentralised democratic structure with autonomous national groups complying with the guidelines established by the federation. Friends of the Earth member groups are united by a common conviction that these aims require both grassroots activism and effective national and international campaigning and coordination. FoEI is seen as an unique and diverse forum pursuing international initiatives, taking advantage of the variety of backgrounds and perspectives of its members.

By sharing information, knowledge, skills and resources on both a bilateral and multilateral level, the FoE group aims to support each other's development and strengthen their international campaigns.

Potential Coordinating Institutes

International Academy of the Environment

Chemin de Conches 4, CH-1231, Geneva, Switzerland

Tel: +41 22 789 1311 Fax: +41 22 789 2538

REALM: All

INDICATORS: 2, 6, 8

EXPERTISE

The Academy is an independent foundation based in Geneva. It was founded in 1991, through cooperation with the University of Geneva, UNEP and the Swiss government, and received official recognition and financial support from the Swiss Confederation in July 1992.

The mandate of the Academy is:

A. to provide high-level decision-makers with the basic knowledge and management principles that will enable them to take decisions consistent with sustainable development

B. to develop new insights on policies and implementation strategies from the dialogue between experts and decision makers.

The Academy counts the following among its achievements: ministers of environment from several countries have attended its seminars; a major training contribution was given to the Mediterranean Environmental Technical Assistance Programme; important research results have been obtained in the field of biodiversity conservation; an innovative basic education programme on sustainable development management was implemented; and IAE policy dialogues have made significant contributions to the successful negotiation of the Convention to Combat Desertification, and to the 1994 International Conference on Population and Development.

The Academy has developed collaborative links with major organisations in the world in the field of sustainable development. Examples include the Commission for Sustainable Development, UNEP, the World Bank, UNFPA, UNDP, UNESCO and many others.

The activities of the Academy are organised in programmes. They are based on three types of activities: policy dialogues, research, and executive seminars.

The Programmes of the Academy are chosen so as to be closely connected to the vocation of Geneva as a centre for international negotiations in environment and sustainable development. Current programmes are indicated below:

A. governance for sustainable development

B. biodiversity and biotechnology

C. consumption and lifestyles.

Potential Coordinating Institutes

International Center for Agricultural Research in the Dry Areas (ICARDA)

PO Box 5466, Aleppo, Syria.

Tel: +963 21 213433/213477 Fax: +963 21 213490/225105

REALM: All

INDICATORS: 4, 5, 8

EXPERTISE

ICARDA was founded in 1977 in Syria, and has since been designated a world international centre for barley, and chickpeas. ICARDA's main focus is increasing productivity of farming systems involving wheat, barley, chickpeas, lentils, pasture legumes, faba beans, and small ruminants in North Africa and West Asia. ICARDA is supported by CGIAR and sponsored by sixteen countries and international organisations.

ICARDA became involved in a Syrian fodder-shrub plantation project - providing food for grazing by sheep and goats in 1989. Their role was to work alongside the Syrian Government to develop technical know-how on saltbush plantation management. The latest phase of the ICARDA project is aimed at showing the benefits of shrubs over natural pasture for livestock feeding and will thus make more effort to "sell" the idea to farmers. This work is all part of ICARDA's regional effort to restore and rehabilitate natural resources in the rangelands and steppe of West Asia and North Africa. ICARDA is also looking into direct seeding of saltbushes on rangeland combined with a micro-water-catchment technique; this should enable vast tracts of steppe to be rehabilitated with shrubs with minimal disturbance of the native flora. Survey and collection of indigenous plants (especially legumes), with subsequent assessment of their characteristics, has led to the identification of species suitable for further restoration of the steppe.

ICARDA has 600 staff and produces three bi-annual papers: *RACHIS; FABIS;* and *LENS,* and an *Annual Report.*

Potential Coordinating Institutes

International Center for Living Aquatic Resources Management (ICLARM)

PO Box 2631, Manilla 0718, Phillipines.

Tel: +63 2 817 5163 Fax: +63 2 816 3183

REALM: All

INDICATORS: 2, 8

EXPERTISE

The International Centre for Living Aquatic Resources Management was founded in 1977, and entered the CGIAR in 1992. ICLARM conducts and fosters research and training in aquaculture, fisheries management, and coastal area management. The Centre works to resolve critical technical and socio-ecological constraints to increased production, improved resource management, and equitable distribution of benefits.

Due to ICLARM's small size, research is essentially organised into two research programmes: the Coastal and Coral Reef Resource Systems Program (CCRRSP), and the Inland and Aquatic Resource Systems Program (IARSP). ICLARM's programmes have a new emphasis on social science research to compliment biophysical science research, and a greater integration of the respective disciplines.

ICLARM is a major research force in developing fisheries assessment methods for the tropical marine fisheries and new technologies for aquaculture. ICLARM's new challenge is to continue to develop as a research and service provider to assist sustainable food production, poverty alleviation, environmental quality and social equity.

ICLARM staff undertake many activities in addition to research, in support of national institutions and researchers. These are categorised as education and training, advisory services, and workshops.

ICLARM publishes *Naga*, *The ICLARM Quarterly*; bibliographies; educational materials; technical reports; and conference proceedings.

Potential Coordinating Institutes

International Council of Scientific Unions (ICSU)

51 Boulevard de Montmorency, Paris F-75016, France.

Tel: +33 1 4525 0329 Fax: +33 1 4288 9431

REALM: All

INDICATORS: All (data organisation/management)

EXPERTISE

The International Council of Scientific Unions (ICSU) supports a scientific committee, known as CODATA, to address at an international level the issues of data quality and utilisation. The general objectives of CODATA are:

A. to improve data quality and accessibility, as well as the collection, management and analysis methodology

B. to facilitate international cooperation among those collecting, managing and using data

C. to promote an increased awareness in the scientific and technical community of the importance of these activities.

In order to address and achieve these objectives, CODATA initiated several projects, including:

A. coordinating multinational programmes

B. establishing format standards to promote compatibility of databases

C. developing guidelines for the presentation of data in the primary literature

D. training and education programmes

E. organising conferences and workshops.

Only recently has CODATA begun formally addressing environmental data in a comprehensive fashion. To date, it has been concerned with all types of quantitative data collected from a wide variety of monitoring sources and disciplines. The following is a list and brief description of current CODATA projects:

A. Chemical Thermodynamic Tables: a standardised, computer based mechanism for the collaboration of thermodynamic data centres in five countries

B. Fundamental Physical Constants: a task group of physics and metrology experts is responsible for maintaining this database of fundamental constant which are generally accepted

Potential Coordinating Institutes

C. Biological Macromolecules: a project addressing the improved coordination of protein and DNA sequence data compiling institutions

D. Working Group on Access to Data: a group charged by ICSU with examining and reporting on problems in freedom of access to scientific and technical data by the international scientific community.

Potential Coordinating Institutes

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Patancheru P.O, Andhra Pradesh 502324, India.

Tel: +91 842 224016 Fax: +91 842 241239

REALM: All

INDICATORS: 2, 4, 8

EXPERTISE

ICRISAT was founded in 1972 as an international non-governmental institution with regional geographical scope in the semi-arid tropics. Its main activities are education and research in crops, ecosystems, and sustainable agricultural development. The institute was set up as a world centre for genetic improvement of Sorghum, millets, pigeonpea, chickpea and groundnut, and for research on the management of resources in the worlds semi-arid tropics; research covers all physical and socio-economic aspects of improving the entire system of agriculture on non-irrigated land.

ICRISAT works on genotypes of its mandate crops and their environment. The objective is to develop sustainable agricultural technology for the semi-arid tropics. ICRISAT project areas include:

A. socio-economic monitoring through village level surveys and detailed studies at four selected locations

B. agro-climatic and crop production studies at selected bench-mark sites and experimental stations

C. working in collaboration with other institutions on crop production technologies across different ecological zones.

Environmental measurement activities include an early warning system for soil erosion in different land use systems (and related environmental pollution), observation of climatic and agro-climatic changes, and preparation and construction of crop models.

Potential Coordinating Institutes

International Institute for Applied Systems Analysis (IIASA)

A-2361 Laxenburg, Austria.

Tel: +43 2236 807 Fax: +43 2236 71313

REALM: All

INDICATORS: 2, 7

EXPERTISE

IIASA was founded jointly in 1972 by the USA and USSR, with the participation of the governments of 14 other Eastern and Western nations. Its research efforts are primarily related to the development and use of scenarios and computer models. These activities include: environment; systems and decision sciences; technology, economy and society; and population.

Each programme in turn, is responsible for a number of projects. The Environment Programme is currently involved in a number of projects including:

A. Biosphere Dynamics (BIO)

B. Trans-boundary Air Pollution (TAP)

C. Water Resources (WAT)

D. Environmental Monitoring (MON)

E. Climate Change (CLI).

Data and information management are an integral part of model and scenario development. Within the Environment Programme, TAP is in the process of developing a Database Information System. This database will serve the practical needs of establishing cause-and-effect relationships in mapping critical loads for sulphur and nitrogen under EC Convention on Long Range Trans-boundary Air Pollution.

IIASA is a member of such organisations as ICSU, SCOPE and IFIAS. It collaborates extensively with such programmes as IFIAS's Human Dimensions of Global Change and ICSU's International Geosphere-Biosphere Programme (IGBP). The Environment Programme actively contributes to and/or works with institutions such as UNEP/WMO Intergovernmental Panel on Climate Change (IPCC), WMO's World Climate Programme (WCP) as well as many others.

Potential Coordinating Institutes

International Institute for Environment and Development (IIED)

3 Endsleigh Street, London WC1H 0DD, UK.

Tel: +44 171 388 2117 Fax: +44 171 388 2826

REALM: All

INDICATORS: 2, 6

EXPERTISE

IIED was founded in 1971 to promote the sound management and sustainable use of natural resources. It is a non-membership organisation, and is governed by an international board. IIED conducts policy research both independently and on behalf of donors, governments, and international aid agencies with particular emphasis on working at the local level with community groups in developing countries.

Research is carried out by six programmes in the Institute:

A. Drylands (focus on soil and water conservation and assessment studies in Africa)

B. Forestry and Land Use (concentrating on the tropics)

C. Human settlements (covering housing and health, basic services, population and urban change, and human rights)

D. Southern Networks (focus is on Africa, working building South-South links between NGOs at the sub-regional level)

E. Economics (defining and applying concepts of sustainable development)

F. Sustainable Agriculture (training, advice, and research in developing countries).

In 1988, an IIED office opened in Latin America. IIED cosponsors include the London Environmental Economics Centre at University College, University of London.

Potential Coordinating Institutes

International Mycological Institute (IMI)

Bakeham Lane, Egham, Surrey TW20 9TY, UK.

Tel: +44 1784 470111, Fax: +44 1784 470909

REALM: All

INDICATORS: 7

EXPERTISE

The IMI was established to provide a world service in mycology. It was founded in 1920 and is part of CABI, an organisation supported by 32 Member Governments established by treaty and with international legal status.

The IMI culture collection comprises over 16,500 strains of filamentous fungi, yeasts and bacteria of interest in plant pathology, industry, biodeterioration studies, standards testing and specifications, systematic and biochemical research and education. The IMI runs an identification service for microfungi, and has a genetic resource collection of 17,000 living fungi. Uses of fungi include biosynthesis of organic compounds, physiological asssay, soil analysis, and enzyme production.

The institute provides contract, consultancy, training, development of preservation protocols, safe deposit and patent deposit services. Research is carried out in the areas of microbial pesticides, identification techniques for pathogenic strains of *Fusarium oxysporum*, biocontrol of locusts and grasshoppers, lichen-forming fungi as potential sources of new pharmaceuticals, and coconut Phytophthora diseases.

Potential Coordinating Institutes

International Organization for Standardization (ISO)

Case Postale 56, CH-1211 Genève 20, Switzerland.

Tel: +41 22 749 0111 Fax: +41 2 733 3430

REALM: All

INDICATORS: 7

EXPERTISE

ISO is a world-wide federation of national standards bodies from 90 countries. The scope of ISO covers standards in all fields except for electrical and electronic engineering which are the responsibility of the International Electrotechnical Commission (IEC). The results of ISO technical work are published as International Standards; mid-1990 more than 7,500 standards had been published, and are listed in the ISO Catalogue.

ISO's technical work is carried out through Technical Committees (TCs). Currently, it has TCs working in the following fields: air quality; water quality and soil quality.

Many standards have been written for air pollution, including work-place air, ambient air and stationary source emissions. In addition, technical reports have been compiled on the monitoring of ambient air quality. To promote and develop Certified Reference Materials ISO initiated the Committee on Reference Materials (REMCO).

ISO is active in many fields related to the environment. It has developed International Standards for such environmentally related topics as: acoustics; air quality; building construction; chemistry; fertilisers; fire protection; mining, nuclear energy; pesticides; petroleum products; natural gas; soil and water quality.

Potential Coordinating Institutes

International Plant Genetic Resources Institute (IPGRI)

Via delle Sette Chiese 142, Rome 00145, Italy.

Tel: +39 6 518921 Fax: +39 6 5750309

REALM: All

INDICATORS: 4, 7

EXPERTISE

The International Plant Genetic Resources Institute (IPGRI) is an autonomous international scientific organisation operating under the aegis of the CGIAR. IPGRI's mandate is to advance the conservation and use of plant genetic resources for the benefit of present and future generations. IPGRI works in partnership with other organisations, undertaking research, training, and the provision of scientific and technical advice and information. IPGRI retains the strong programme link of its predecessor, the International Board for Plant Genetic Resources, with the Food and Agriculture Organization of the United Nations. IPGRI, the legal successor to IBPGR, became operational when its Headquarters Agreement with the Italian Republic was ratified by the Italian Parliament in December 1993. IPGRI comprises eight programme groups: Five regional (Sub-Saharan Africa, West Africa and North Africa, the America's, Europe, and Asia, the Pacific and Oceania), and three thematic (Genetic diversity, Germplasm maintenance and use, and Documentation, Information and training) based at the Headquarters in Rome.

IPGRI has a single Integrated Programme built on a set of projects, each designed to contribute to one or more of the institute's major strategic objectives, which are:

A. Strengthening national programmes

B. Contributing to international collaboration

C. Improving strategies and technologies for conservation

D. Providing an international information service.

IPGRI intends to expand its information service to better meet the needs of the plant genetic resources community. Existing services and databases held by other institutions already cater to many of these needs. Wherever appropriate, IPGRI will refer users to such sources.

IPGRI maintains a database on the known Directories of Germplasm Collections. These directories list the germplasm holdings of specific crops and food plants in institutions around the world. The information aids scientists in making contact with other workers involved in the same crop.

Potential Coordinating Institutes

International Service for National Agricultural Research (ISNAR)

PO Box 93375, NL-2509 AJ, The Hague, The Netherlands.

Tel: +31 70 496100 Fax: +31 70 3819677

REALM: All

INDICATORS: 4, 8

EXPERTISE

ISNAR is a non profit autonomous institute, it was established in 1979 by the CGIAR on the basis of recommendations from an international task force. It is funded by an informal group of c.40 donor countries, banks, and foundations. ISNAR began operating at its headquarters in The Hague, the Netherlands, on September 1, 1980.

The International Service for National Agricultural Research (ISNAR) assists developing countries in making lasting improvements in the performance of their national agricultural research systems and organisations. ISNAR promotes appropriate agricultural research policies, sustainable research institutions, and improved research management. ISNAR's services to national research are ultimately intended to benefit producers and consumers in developing countries and to safeguard the natural environment for future generations.

Potential Coordinating Institutes

International Union of Forestry Research Organisations (IUFRO)

Secretariat, Seckendorff-Gudent-Weg 8, Vienna A-1131, Austria.

Tel: +43 1 87 70151 Fax +43 1 87 79355

REALM: All

INDICATORS: 1, 2, 7

EXPERTISE

IUFRO is a non-governmental, international organisation, based in Vienna. The scope of IUFRO's work is global, the activities include research and data information management, in many sectors including; Air pollution, climatic change, soil conservation, tropical forest and woodland ecosystems, deforestation, forest fires, wildlife habitats, forest management, forest products, biomass energy, forest legislation, agroforestry. IUFRO have regular international meetings, issuing guidelines for measurement techniques and publishing treatises are undertaken, both in project groups and in task forces. There are two programmes related to environmental information management: 'Special programme for developing countries', and task force 'Forest climate change and air pollution'.

Potential Coordinating Institutes

IUCN - The World Conservation Union

Rue Mauverney 28, Gland CH1196, Switzerland.

Tel: +41 22 999 0001 Fax: +41 22 999 0002

REALM: All

INDICATORS: All

EXPERTISE

The World Conservation Union was founded in 1948 at an international conference at Fontainebleau, France, under the sponsorship of the Government of France, the Swiss League for the Protection of Nature, and the United Nations Educational, Scientific and Cultural Organisation (UNESCO).

IUCN's mission is to provide knowledge and leadership for the sustainable use of the planets natural resources. It provides leadership that can guide governments, aid agencies, non-governmental organisations and local communities. It helps governments to develop international Conventions and national laws on conservation. The IUCN's initiatives have helped to create many well-known international measures like the Convention Concerning the Protection of The World Cultural and Natural Heritage, Convention on International Trade in Endangered Species, and the Convention on Wetlands of International Importance.

There are 636 members representing 120 countries. The IUCN has two global information centres: the World Conservation Monitoring Centre and the Environmental Law Centre. See profiles on WCMC and ELC.

The IUCN monitors the global environment and collects scientifically-based data about species and ecosystems. It investigates the causes of environmental change and degradation in different places, assesses the problems and determines options for solutions. Drawing on information and analysis, specialists consider how to reverse destructive trends and make development sustainable. The Union designs actions, provides advice and helps to carry both through to conclusion working with governments, aid agencies, NGOs and local groups and communities.

The IUCN publishes authoritative reviews on conservation policy and the Red Data Books on the status and urgent conservation needs of flora and fauna. It also publishes directories, handbooks, guides, reports, and guideline documents on biodiversity conservation.

Potential Coordinating Institutes

IUCN Commission on National Parks and Protected Areas (CNPPA)

Rue Mauverney 28, Gland CH-1196, Switzerland.

Tel: +41 22 999 0001 Fax: +41 22 999 0002

REALM: All

INDICATORS: 2, 7

EXPERTISE

The IUCN Commission on National Parks and Protected Areas (CNPPA) is the leading international scientific and technical body concerned with the selection, establishment and management of national parks and other protected areas. Its membership includes more than 500 protected areas professionals from about 120 countries. CNPPA is served by IUCN's Protected Areas Programme in order to promote the establishment of a world-wide network of effectively managed terrestrial and marine protected areas.

Potential Coordinating Institutes

IUCN Environmental Law Centre (ELC)

Adenauerallee 214, Bonn D-5300 1, Germany.

Tel: +49 228 269 2232 Fax: +49 228 269 2250

REALM: All

INDICATORS: 2, 6

EXPERTISE

ELC is the legal arm of the IUCN Secretariat. It monitors and maintains databases on legal trends and developments in the environmental field, including international agreements, binding instruments of international organisations, national legislation, and legal literature. It also develops specific databases (eg on species protection); contributes to the work of other organisations working in the field; supports activities of other IUCN components (eg organising an international symposium on legal aspects of wetlands protection); and develops and carries out specifically legal activities (eg drafting international treaties).

Potential Coordinating Institutes

IUCN Species Survival Commission (SSC)

Rue Mauverney 28, Gland CH-1196, Switzerland.

Tel: +41 22 999 0057 Fax: +41 22 999 0015

REALM: All

INDICATORS: 1, 3, 5, 7

EXPERTISE

The Species Survival Commission (SSC) is one of the six volunteer Commissions of IUCN - The World Conservation Union. It was founded in 1949 to provide global leadership for plant and animal conservation efforts. Within IUCN, the mission of SSC is to conserve biological diversity by developing and executing programmes to study, save, restore and manage wisely species and their habitats. SSC volunteers (5000 in 169 countries) assess the status of biodiversity at the species level, determine the conservation status of individual species, identify the detrimental factors that may be operating, and devise strategies to mitigate these negative factors.

Potential Coordinating Institutes

Missouri Botanical Gardens (MOBOT)

PO Box 299, St. Louis MS 63166-0299, USA.

Tel: +1 314 577 5100 Fax: +1 314 577 9521

REALM: All

INDICATORS: 2, 7, 8

EXPERTISE

The Missouri Botanical Gardens (MOBOT) operates an active research programme in tropical botany. Scientific research at the Garden focuses on the exploration of the tropics, which encompasses the Earth's least known, most diverse, and most rapidly vanishing ecosystems. Because of the speed with which irreversible changes are occurring in tropical regions, the Garden has made a long-term commitment to the study and conservation of these threatened habitats.

MOBOT was founded in 1857 when Henry Shaw purchased a comprehensive herbarium collection of 62,000 specimens which became the basis for the present collection of 4.3 million specimen collection. There are 56 research botanists who work in the tropics world-wide. MOBOT is under contract with the National Cancer Institute to collect plants to screen for anti-cancer and anti-AIDS agents.

The Garden also coordinates the Flora of North America, the Flora of China and the Flora of Mesoamericana projects. In conjunction with the Missouri Department of Conservation, the Garden sponsors the Flora of Missouri project. Images and data are now available for the Conspectus of the Vascular Plants of Madagascar project.

Potential Coordinating Institutes

New York Botanical Gardens (NYBG)

200 St. & Southern Boulevard, The Bronx NY 10458, USA.

Tel: +1 212 220 8700 Fax: +1 212 220 6504

REALM: All

INDICATORS: 2, 7, 8

EXPERTISE

Founded 1981 by botanist Nathaniel Lord Britton, it is one of the oldest botanic gardens in the world, and is owned in a public and private partnership within New York. Today NYBG is recognised for its horticultural excellence, educational programmes and research. The site includes 27 outdoor gardens and a 40 acre pre-settlement forest, and receives over 500,000 visitors a year.

NYBG is an international leader in botanic research and is at the forefront of the battle to preserve the worlds plant life. NYBG operates an active programme in systematic and economic botany, concentrating on tropical regions where plant diversity is rapidly vanishing.

The institution is also active in training next generation botanists through graduate programmes here and in field research abroad. NYBG is committed to educating the public about the beauty, science, and importance of plants.

Potential Coordinating Institutes

New York Zoological Society (NYZS) - The Wildlife Conservation Society

Wildlife Conservation Park, The Bronx, New York 10460, USA.

Tel: +1 718 220 5100

REALM: All

INDICATORS: 3, 5, 7

EXPERTISE

The NYZS was founded nearly one century ago, and since that time it has been engaged in wildlife conservation around the globe, recently it merged with the Bronx Zoo operation and became the NYZS/The Wildlife Conservation Society.

The NYZS/The Wildlife Conservation Society has the following action areas: Wildlife management; Breeding programmes; National and international initiatives; Collaborative efforts; Wildlife health; and, exhibition and graphic arts.

The Headquarters is at the Bronx Wildlife Conservation Park, where interests lie in Mammals (shy ungulates, connubial gorilla's, and Naked mole rats for example) - their captive breeding and conservation, birds - their reformation, and transformation, and in amphibians and reptiles. There is a Wildlife Conservation Center in Georgia which essentially deals with disaster relief (eg post-hurricane). As well as these, nationally, there are four other activity centers, they are:

A. Aquarium for Wildlife Conservation - simulation of varied coastal environments

B. Central Park Wildlife Center - houses over 660 animals of 96 species

C. Queens Wildlife Center - exhibition of 12 major North American habitats and associated species (including Bison)

D. Prospect Park Wildlife Center - a 12 acre Zoo containing hamadryas baboons and rare birds.

Internationally the Society conducted 183 conservation projects in 46 countries, from Argentina to Zimbabwe, with particular emphasis on saving wildlife and habitat in tropical forests, coastal ecosystems, and highland and lowland plains. Some examples of their work include the following:

A. African Savannahs - human pressures and environmental conflicts

B. African forests - promoting better conservation through team work

C. Mesoamerica and the Caribbean - creating a biotic corridor

D. Tropical south Africa - community interests

E. Temperate south America - Patagonian action plan

F. Temperate Asia - conservation of snow leopards and bengal tigers.

Potential Coordinating Institutes

The NYZS/The Wildlife Conservation Society is also responsible for producing the award winning magazine *Wildlife Conservation*.

Potential Coordinating Institutes

Oxford Forestry Institute (OFI)

University of Oxford, Department of Plant Sciences, South Parks Road, Oxford OX1 3RB, UK.

Tel: +44 1865 275000 Fax: +44 1865 275074

REALM: All

INDICATORS: 1, 2, 7

EXPERTISE

The Oxford Forestry Institute is the base for Oxford University's activities in forestry, education, training, research, information and advisory services. The Institute functions within the University's Department of Plant Sciences, and has as its principal internal mission 'the pursuit of excellence in education and academic research.' Its external mission is 'to maintain and enhance its role and reputation in training, strategic research, information and advice.' In support of these roles and through association with CAB International, the Institute's library has developed as the world's leading centre for forestry literature accession and dissemination.

In their educational role, institute staff:

A. conduct a one-year taught MSc course: 'Forestry and its Relation to Land Use'

B. contribute to teaching of an undergraduate degree in biology

C. supervise research students at master's and doctoral levels.

The research activities of the OFI focus on three principal subject areas:

A. exploration, conservation, and utilisation of forest genetic resource

B. forest ecology, silviculture, and management

C. natural resource policy and use.

Subsidiary activities include agroforestry, forest inventory, soils, in addition to aspects of wood science. Most research projects are based on cooperation with other agencies and institutions in the UK and abroad.

The Institute's information service, provided in conjunction with CAB International, offers access to a wide range of abstracts such as *Agroforestry Abstracts* and *Forest Products Abstracts*, and to a wealth of other forestry literature.

In addition to these University-related roles, staff of the OFI provide consultancy and advisory services to both the public and private sectors. The OFI acts as managing agent for ODA's strategic forestry research programme, and several ODA projects linking British and overseas institutions; it also functions as ODA's Resource Centre for Forestry.

Potential Coordinating Institutes

Royal Botanic Gardens, Edinburgh (RGBE)

20a Inverleith Row, Edinburgh EH3 5LR, UK.

Tel: +44 131 552 7171 Fax: +44 131 552 0382

REALM: All

INDICATORS: 8

EXPERTISE

Located centrally in Edinburgh, Scotland and three other specialist sites in Scotland, the Botanic Gardens are the National Botanic Gardens of Scotland. Established in 1670, the gardens contain a herbarium of c. 2,000,000 specimens, and carry out taxonomic and plant science research. The gardens offer a course in botany leading to a diploma, and produce a journal - Edinburgh Journal of Botany.

Potential Coordinating Institutes

Royal Botanic Gardens, Kew (RBGK)

Kew Road, Kew, Richmond, TW9 3AB, UK.

Tel: +44 181 940 1171 Fax: +44 181 332 5197

REALM: All

INDICATORS: 2, 7, 8

EXPERTISE

The Royal Botanic Gardens at Kew were established in as a royal garden in 1721 and opened as a public body in 1850. The mission of the Royal Botanic Gardens is to ensure better management of the Earth's environment by increasing knowledge and understanding of the plant kingdom. The Kew Herbarium is one of the world's largest, and houses an encyclopaedic collection of over six million specimens of vascular plants and fungi from every country in the world. The Jodrell Laboratory carries out fundamental research in plant biochemistry, physiology, anatomy, cytology, and molecular systematics. The library with its collection of over 750,000 books and journals is a resource for all Kew's research work. the living collections are the world's largest with 79,600 accessions representing 35,900 species; one in ten of all vascular plants. In addition, Kew has the largest seed bank of wild plants containing over 4,000 species.

Kew is involved in major biodiversity research programmes in many parts of the world including tropical and West Asia, Africa, South America, and the Pacific and Indian Oceanic Islands. Kew staff carry out systematic programmes in many major plant families, such as the grasses, legumes, palms, daisies, orchids and fungi. Kew also through its Herbarium services, makes about 10,000 identifications a year and provides specialist advice on taxonomy and nomenclature in difficult cases.

Potential Coordinating Institutes

Smithsonian Institution (SI)

1000 Jefferson Drive SW, Washington DC 10560, USA.

Tel: +1 202 357 1300/2700 Fax: +1 202 786 2515

REALM: All

INDICATORS: 4, 6, 8

EXPERTISE

The SI was established in 1846 by an act of congress with funds bequeathed to the US by James Smithsonian, an English scientist. The SI is a trust instrumentality of the US Government holding some 140 million artefacts and specimens in its trust for *"the increase and diffusion of knowledge"*. The SI has an operating budget of over US$360 million and 5000 employees, the SI is the nation's centre for the study and display of art history and science. With 16 museums and galleries on the national Mall, the national zoo and numerous research stations worldwide, the SI covers disciplines from art history to astrophysics. The SI receives financial support through federal appropriations and private funds derived from investments, grants, contracts, gifts, sales and other revenue.

Seven research bureau's of the SI conduct most of the environmentally oriented research: the National Air and Space Museum, the National Museum of American History, the National Museum of Natural History (NMNH), the National Zoological Park, the Smithsonian Astrophysical Observatory, the Smithsonian Environmental Research Center and the Smithsonian Tropical Research Institute (STRI).

The interests of the NMNH include all aspects of the natural sciences. The scientific program of the museum involves field observation, and refined laboratory techniques. In addition to describing natural history artefacts, objects and phenomena, most of the investigations are also concerned with the present and historical relationships of cultures and organisms, both phylogenetic and environmental. With its extensive history of studying the natural world, the SI is a leader in basic ecological research.

The activities of the STRI are centred on, but not confined to, marine and terrestrial ecosystems in and around the Isthmus of Panama. The physical facilities include a mature lowland tropical forest, and surrounding mainland peninsulas supporting forests and recent clearings. There are library, office and laboratory facilities at the Trivoli and Ancon sites and marine laboratories. STRI also has cooperative arrangements for comparative studies in the Old World Tropics (Kenya, India, Malaysia, Papua New Guinea).

Potential Coordinating Institutes

STOAS - Foundation for the Development of Agricultural Education & Training

PO Box 78, 6700 Wageningen, The Netherlands.

Tel: +31 8370 72711 Fax: +31 8370 24770

REALM: All

INDICATORS: 4, 6, 8

EXPERTISE

STOAS is a Dutch organisation serving the agricultural sector in the Netherlands and the rest of the world. The main activities are agricultural education, training and extension. STOAS has a staff of 220, organises 30,000 trainee days a year and has an annual turnover of US$25 million.

Areas of expertise include: transfer of agricultural technology; organisation development and management; training materials and information technology; training of agricultural teachers and extension workers; and labour market research.

STOAS has strong ties with organisations in the Dutch agricultural sector including the Wageningen Agricultural University, Agricultural Colleges of Higher Education, National Reference Centre and the Agricultural Extension Service. In the European Community STOAS participates in networks such as REIFEA, Euroqualification and Eurotecnet. To date STOAS has undertaken projects in some 15 countries world-wide. Some of these are multi-disciplinary projects managed and administered by STOAS, and others are components of larger projects managed by other organisations.

Potential Coordinating Institutes

Stockholm Environment Institute (SEI)

Jaerntorget 84, Stockholm S-103 14, Sweden.

Tel: +46 8 723 0260 Fax: +46 8 723 0348

REALM: All

EXPERTISE

The SEI was established in 1989 by the Swedish parliament as an independent foundation for the purpose of carrying out global environmental research. To achieve its objective, the Institute receives an annual core grant from the Swedish Government. Additional funding, usually linked to specific projects, is received from both national and international as well as Swedish agencies and institutions.

SEI's work is built on the insights developed by both the 1972 UN Stockholm Environment Conference and the work of the World Commission for Environment and Development (Brundtland Commission).

A major aim of SEI's work is to bring together scientific research and policy development. The Institute applies scientific and technical analysis in environmental and development issues of regional and global importance, the results of research are made available through publications, the organisation of and participation in conferences, seminars and university courses, and also through the development of software packages for use in the exploration of scientific problems.

SEI has three main centres: the headquarters in Stockholm (Sweden), and the centres in Boston (USA) and York (UK). An International network of senior scientists, project advisors and field staff work in various locations around the world, engaged in carrying out specific projects. SEI is based around a global network approach.

Potential Coordinating Institutes

Tropical Agricultural Center for Research and Education (CATIE)

7170 Turrialba, Costa Rica.

Tel: +506 56 6081/6431 Fax: +506 56 6166

REALM: All

INDICATORS: 2, 4, 6, 7, 8

EXPERTISE

CATIE is an inter-governmental organisation with regional scope in the tropics of South America its main activity is research in the following areas; Tropical ecosystems, wetland ecosystems, resources management, forest management, sustainable development, agricultural methods, and animal husbandry.

CATIE was created by IICA, OAS and the Government of Costa Rica. It is principally concerned with developing and promoting technologies for sustainable development in the tropics. It is active in the fields of natural resource management and conservation, and sustainable production systems in agriculture, forestry and animal husbandry.

CATIE runs approximately five programmes related to environmental information management at the present time: Geographic Information Systems and Remote Sensing; Management Information System for Tropical Forestry Research; Central American Information Network on Natural Resources; Natural Forests Information Databank on Key Research Sites; and, a graduate programme (MSc) Natural Resources Management.

Potential Coordinating Institutes

UNEP Global Environment Monitoring System (GEMS)

PO Box 30552, Nairobi, Kenya.

Tel: +254 2 621234 Fax: +254 2 226491

REALM: All

INDICATORS: 2, 7

EXPERTISE

GEMS was established as part of UNEP's Earthwatch programme in 1975. Its major objectives are to make comprehensive assessments of major environmental issues and thus provide the scientific data needed for the rational management of natural resources and the environment as well as to provide early warning of environmental changes by analysing monitoring data. To address these objectives, GEMS has developed several methods including:

A. developing techniques for establishing monitoring activities and networks

B. improving the quality and comparability of data collected

C. improving existing networks and establish new ones.

GEMS concentrates primarily on five areas: climate, trans-boundary pollution, terrestrial renewable resources, oceans, and the health consequences of pollution. The Programme Activity Centre (PAC) in Nairobi, Kenya was established to act as an umbrella to coordinate and expand global monitoring activities within its area of concentration. Through PAC GEMS aims to place more emphasis on such issues developing multi-media and integrated monitoring and assessment as well as improving the harmonisation of data and measurement techniques.

GEMS cooperates extensively with other international organisations as well as national institutions in implementing and maintaining its activities. This is particularly the case with the projects, which are usually sponsored by several different organisations.

Potential Coordinating Institutes

UNEP Global Resource Information Database (GRID)

PO Box 30552, Nairobi, Kenya.

Tel: +254 2 624202 Fax: +254 2 226491

REALM: All

EXPERTISE

GRID was established as part of the Global Environment Monitoring System (GEMS) network after the 1972 UN Stockholm Conference on the Human Environment. GRID aims to collect and disseminate the most advanced information available on the state of natural resources world-wide. In order to better collect, manage and disseminate datasets and other information, GRID has established a series of *nodes*. At the moment there are four nodes: Nairobi, Geneva, Bangkok, and Arendal, Norway. GRID Arendal was the first national node in 1989. The Arendal centre is responsible for a number of different tasks including collecting and collating data; assisting in the establishment of national GIS in developing countries, and exploring the possibilities of expanding into a regional node for the Nordic Countries and polar regions. Additional GRID nodes are to be established in such regions as West Africa, Latin America and the South Pacific.

The information GRID holds consists of processes geo-referenced data sets drawn from various sources, including the GEMS network.

Potential Coordinating Institutes

UNEP International Environmental Information System (INFOTERRA)

Programme Activity Centre, PO Box 30552, Nairobi, Kenya.

Tel: +254 2 333930 Fax: +254 2 520711

REALM: All

INDICATORS: Broad data

EXPERTISE

INFOTERRA was established by UNEP in 1974 in order to identify and aid in the exchange sources of environmental information and expertise. It was established as a decentralised world-wide network of information storage and dissemination facilities. These are primarily independent National Focal Centres (NFCs) whose activities are coordinated by the INFOTERRA Programme Activity Centre. Currently, approximately 135 countries have designated NFCs within their borders. In addition, INFOTERRA has contracted 20 institutions, including the IUCN Environmental Law Centre (ELC), to act as special sectoral sources. These would respond to queries related to their areas of expertise. In order to facilitate regular demands for information Regional Service Centres have been established in Australia, India, Morocco and Chile.

The type of data being managed by INFOTERRA is extremely broad, including scientific as well as literary data. Consequently, management procedures and quality considerations will vary from data set to set, and from storage centre to centre. Information, however, is made readily available through a variety of means. These include regular publications such as *International Directory of Sources* and the *World Directory of Environmental Expertise*.

INFOTERRA cooperates extensively with other institutions in the area of information exchange. This is seen in its extensive network of NFC's and Regional Service Centres. It also cooperates with the UN Advisory Committee for the Coordination of Information Systems (ACCIS) (UNEP HEM, 1994).

Potential Coordinating Institutes

United Nations Educational, Scientific and Cultural Organization (UNESCO)

7 Place de Fontenoy, Paris F-75700, France.

Tel: +33 1 4568 1000 Fax: +33 1 4567 1690

REALM: All

EXPERTISE

UNESCO was established in 1946 'for the purpose of advancing, through the educational, scientific and cultural relations of the peoples of the world, the objectives of international peace and the common welfare of mankind'. UNESCO's activities are funded through a regular budget provided by member states and also through other sources, particularly the UNDP. UNESCO is involved in International Intellectual Cooperation; Operational Assistance; and the Promotion of Peace.

UNESCO's Executive Board consists of 51 members. In accordance with its constitution, national commissions have been set up in most member states. UNESCO's activities can be divided into three levels: international; regional and sub-regional; and national. At the international level UNESCO has over the years set up various forms of inter-governmental cooperation concerned with the environmental sciences and research on natural resources.

Key programmes in biodiversity include:

A. Man and the Biosphere Programme (MAB). This was launched in 1971 to provide the knowledge, skills, and human values to support harmonious relationships between people and their environment throughout the world. Biosphere reserves act as a keystone of MAB by providing a global network of sites for cooperative research toward this goal. The programme is overseen by the MAB Secretariat, based at UNESCO.

B. World Heritage Programme (WH). In order to apply the principles of the 1972 *Convention Concerning the Protection of the World Cultural and Natural Heritage*, UNESCO set up a committee of 21 state parties to the Convention. This is the World Heritage Committee, which, acting on proposals from all the state parties, is responsible for establishing the list of natural and cultural sites of exceptional and universal value. The Committee meets once a year to decide on nominations, financial and technical help to state parties for the preservation of sites.

Potential Coordinating Institutes

United Nations Statistical Division (UNSTAT)

DC 2-1652, 2 United Nations Plaza, New York NY 10017, USA.

Tel: +1 212 963 4581 Fax: +1 212 963 4116

REALM: All

EXPERTISE

The United Nations Statistical Division UNSTAT (formerly the United Nations Statistical Office) concentrates on developing economic methodologies. Two current projects involve the development of indicators for sustainable development and environmental accounting.

UNSTAT has developed *The Framework for the Development of Environment Statistics (FDES)* as a basis for developing and organising environmental statistics. The United Nations Economic and Social Commission for Western Asia, Statistical Division (UN ESCWA) and the State Ministry for Environment in Indonesia are testing and using the UNSTAT Framework.

The United Nations also has developed the United Nations Statistical Information System (UNSIS). A major feature of the system is the specialised output facility for photo and xerographic typesetting via user definitions written in a unique publication definition language. Supporting on-line facilities include a register of all codes with their interpretation in English, French and Spanish; individual libraries of user definitions and an extensive collection of variable conversion factors.

UNSTAT contributes to the United Nations Statistical Yearbook.

Potential Coordinating Institutes

World Conservation Monitoring Centre (WCMC)

219 Huntingdon Road, Cambridge CB3 0DL, UK.

Tel: +44 1223 277314, Fax: +44 1223 277136

REALM: All

INDICATORS: 1, 2, 3, 5, 8

EXPERTISE

WCMC is recognised as a centre of excellence in the handling and management of information on the conservation of biodiversity. The Centre has more than 12 years' experience in this field, providing advice and information services not only to its three founder organisations, IUCN - The World Conservation Union, the World Wide Fund for Nature (WWF) and the United Nations Environment Programme (UNEP), but also to development aid agencies, UN agencies, international convention secretariats, government and non-governmental organisations, the media, commerce and industry.

WCMC is a non-profit organisation, independent of government funding and public membership. Occupying a new, purpose-built, building in Cambridge, WCMC is a highly professional organisation with full project development and management capabilities. WCMC employs some 60 professional staff, with a wide range of international experience.

Annually WCMC delivers upwards of 30 projects, as well as providing regular information services for a wide range of clients. WCMC's project portfolio of over 100 projects, in execution or development, builds on the Centre's resources and staff experience and is centred upon the main aims of the Centre, which are to provide:

- Information Services - based on programmes of analyses, compilation and assessment
- Technical Assistance - based on experience in information management.

WCMC has significant experience in the development of information services required by the users of biodiversity data. For example, WCMC provides information services to:

- the Secretariat and several Contracting Parties (including the EU) of the *Convention on International Trade in Endangered Species*
- IUCN and UNESCO on *World Heritage*
- IUCN's expert networks on species and protected areas
- UNEP and the *Convention on Biological Diversity.*

In addition, WCMC has been developing an advanced map-based information management system - the *Biodiversity Map Library*. This system aims to facilitate access to computer maps and the databases linked to them, providing non-expert users much of the power of a computer GIS, without requiring them to be familiar with GIS software and technology. This database offers an advanced take-off point for further projects in this area.

Potential Coordinating Institutes

WCMC has been very active in supporting development of in-country information management, and is the hub of a network of organisations preparing guidelines and materials for capacity building. These activities build on an earlier collaboration between WCMC and UNEP on the development of *Guidelines for Country Studies on Biological Diversity*. They are to provide the support necessary for developing and implementing the national biodiversity strategies and action plans called for by the *Convention on Biological Diversity*. WCMC activity in this area is likely to increase significantly over the next few years.

WCMC has an active environmental indicators programme that develops indicators and disseminates indicator products to support all levels of decision-making.

WCMC works to a three-year programme, reviewed annually by its international management board. The programme identifies the wide range of activities being undertaken by the Centre, most of them in collaboration with a wide range of national and international organisations. The programme also charts the general direction in which the Centre is moving, while providing sufficient flexibility to encompass new services which fall within the Centre's mission. WCMC actively seeks new opportunities.

Potential Coordinating Institutes

World Resources Institute (WRI)

1709 New York Avenue NW, Washington DC 20006, USA.

Tel: +1 202 662 2583 Fax: +1 202 638 0036

REALM: All

INDICATORS: 1, 2, 6, 7

EXPERTISE

The World Resources Institute (WRI) was founded in 1982. It is a major policy research institute created to help governments, international organisations, and private businesses of all types enlarge their capacity to cope with environmental, resource, and development challenges of global significance. In 1989, the International Institute for Environment and Development-North America joined WRI as the Center for International Development and Environment to strengthen WRI's ability to work at the country level in the developing world.

WRI's work is carried out by a 105-member interdisciplinary staff, strong in the sciences and economics and augmented by a network of advisors, collaborators, international fellows, and cooperating institutions in more than 50 countries.

WRI is a private not-for-profit corporation that receives financial support from foundations, governmental and inter-governmental institutions, private corporations, and concerned individuals. WRI tries to grapple with a fundamental question: how can societies meet basic human needs and nurture economic growth without undermining the natural resources and environmental integrity on which life, economic vitality, and international security depend?'. To address this question, WRI conducts policy research, publicises options, encourages adoption of innovative approaches, and provides strong technical support to developing countries to help them implement policies that sustain healthy economic development. This three-pronged approach is reflected in WRI's structure.

WRI carries out policy research in five major areas:

A. Climate, Energy, and Pollution

B. Biological Resources and Institutions

C. Economics and Population

D. Technology and the Environment

E. Resource and Environmental Information.

The Resource and Environmental Information program seeks to improve the accuracy and usefulness of environmental and resource information and to make it available to a variety

of audiences from policy-makers to the general public. It does this through the compilation and maintenance of an extensive database of policy relevant information which is used to support comprehensive reporting such as the *World Resources Report* and the development of environmental indicators. In developing countries, WRI's Center for International Development and Environment provides policy advice, technical assistance, and other supporting services to governments, non-governmental organisations, and local groups charged with managing natural resources and economic development. In the field, the Center helps to translate general policy recommendations into options that work in a particular time and place. Within WRI, it helps policy researchers stay up-to-date on the institutional constraints and local conditions facing policy-makers in developing countries.

Potential Coordinating Institutes

World Tourism Organisation (WTO)

Capitan Haya 42, Madrid 28020, Spain.

Tel: +34 1 571 0628 Fax: +34 1 571 3733

REALM: All

EXPERTISE

WTO is an intergovernmental organisation based in Spain whose activity areas include: policy development, coordination, education, research, monitoring, assessment and data/information management. WTO's Environment Committee, a subsidiary organisation of the Executive Council, composed of Member States, conducts a general programme on tourism and the environment of which monitoring and research are components.

Potential Coordinating Institutes

World Wide Fund for Nature (WWF) International

Avenue de Mont-Blanc, Gland CH-1196, Switzerland.

Tel: + 41 22 364 9111 Fax: +41 22 364 5468

REALM: All

INDICATORS: 1, 2, 3, 5, 7, 8

EXPERTISE

The World Wide Fund for Nature (WWF) was founded in 1961. It was formerly known as the World Wildlife Fund, and is still known by that name in Australia, Canada and the USA. It is the largest private international nature conservation organisation in the world, with more than 4.7 million supporters and 28 national and associate organisations on all continents. WWF promotes public awareness of conservation problems and raises funds for the protection of threatened species and environments. WWF works through fieldwork, policy development and lobbying, education and training, public awareness campaigns and support for other organisations. Since its founding, WWF has channelled more than US$335 million into 10,500 projects in over 130 countries. Grants support work undertaken by educators, scientists, other NGOs and government bodies.

WWF's missions are protection of biodiversity; pollution control; and promoting sustainable use of natural resources. Priority is given to conservation of forests, woodland, wetlands and coasts. The following are some of WWF Internationals major activities: TRAFFIC, WWF's international network of wildlife trade monitoring centres in 15 countries, works to prevent illegal exports and imports of wildlife; and, with IUCN and UNEP, WWF sponsored *Caring for the Earth: A Strategy for sustainable Living*, the second World Conservation Strategy.

Potential Coordinating Institutes

BirdLife International (BLI)

Wellbrook Court, Girton Road, Cambridge, CB3 0NA, UK.

Tel: +44 1233 277318 Fax: +44 1223

REALM : All except Antarctica

INDICATORS. : 2, 3, 8

EXPERTISE

BirdLife International is an international charity founded in 1922. BirdLife International is a global partnership of more than 110 non-governmental organisations devoted to the conservation of biodiversity in Africa, Asia, the Americas, Europe, and the Pacific region, in all programmes local participation and the sustainable use of resources is emphasised.

In recent years BirdLife has increasingly used information systems to identify priority areas for conservation, and developed the approach of using birds as indicators to set priorities for the conservation of all biodiversity. This work has generated a number of databases, analyses and texts which are of relevance to the Biodiversity Convention and which deal with species, sites and habitats. These include:

- a series of comprehensive analyses of all the worlds birds published from 1966
- the internationally renowned Bird Red Data Books
- Species Action Plans
- comprehensive data on threatened status, and population size and trends.

BirdLife, amongst other programmes and activities, has a major programme to identify Important Bird Areas (IBAs), the top priority sites for bird conservation world-wide, which are identified using a set of globally accepted criteria. Inventories have already been published for Europe and the Middle East, and the BLI partnership is now working on inventories for Africa, the Americas and Asia. Information is compiled on the sites, their value for birds and other forms of biodiversity, and the conservation issues which affect them. Other priority areas include:

- BirdLife biodiversity project mapping distribution of all the world's restricted-range bird species in order to identify Endemic Bird Areas (EBAs)
- identification of the priority areas for bird conservation in the Neotropics.

BirdLife International also publishes the 'World Birdwatch' newsletter four times a year; various technical publications and monographs, an annual report and a publications list.

Potential Coordinating Institutes

International Institute of Tropical Forestry (IITF)

USDA Forest Service, Call Box 25000, Rio Piedras, Peurto Rico, PR 00928, USA

Tel: +1 809 766 5335 Fax: +1 809 766 6302

REALM: Nearctic, Neotropical

INDICATORS: 1, 2, 7

EXPERTISE

IITF was founded in 1939 with support from the US government, it is currently an integral part of the United States Department of Agriculture (USDA) Forest Service. IITF is located in the grounds of the University of Puerto Rico, and has formerly been known as the Tropical Forest Research Center (1965), and the Institute of Tropical Forestry (1993).

IITF's research activities include tropical silviculture and ecosystem management, with emphasis on species adaptability, timber plantation culture, forest genetics, regeneration techniques, thinning practices, management of natural tropical forests, watershed management, nutrient cycling of tropical forests, soil biology and fertility, ecological impacts of plantation establishment, and the global role of tropical forests. IITF also carries out studies on endangered forest wildlife, particularly the Puerto Rican parrot and other avian and invertebrate species. It cooperates with academic and government institutions interested in tropical forestry research.

IITF offers cooperative assistance to State and private landowners, and timber processors, it also undertakes research with universities, and US and foreign governmental agencies. The IITF provides training for foreign students in cooperation with USAID and the FAO.

IITF's special resources include a laboratory for soil and plant analysis, arboretum, and forest research sites. IITF produces journals, reports and other publications.

Potential Coordinating Institutes

The Nature Conservancy (TNC)

1815 N. Lynn Street, Arlington VA 22209, USA.

Tel: +1 703 841 5300 Fax: +1 703 525 8024

REALM: Nearctic, Neotropical

INDICATORS: 1, 2, 3, 5, 6, 7

EXPERTISE

The Nature Conservancy, originally the United States Nature Conservancy, was founded in 1951 and presently has 588,000 members. It is widely recognised as the leading private sector organisation working to preserve biological diversity in the United States by protecting lands and the life they harbour. TNC operates a system of over 1,000 nature sanctuaries, '*the largest private system of nature sanctuaries in the world*'.

TNC's mission is *"to preserve biological diversity - species, natural communities. and ecosystems - through habitat conservation"*. It is a private international organisation protecting more than 7.9 million acres in the United States and Canada, and has worked with partner conservation organisations to protect more than 20 million acres in Latin America. Its staff of more than 1,200 is skilled in biology, business, law, real estate, data management, government, and resource development.

The cornerstone of the Conservancy's work is objective scientific information - using scientific information to advance biodiversity conservation. Conservancy science programmes are primarily responsible for identifying plants, animals, and communities in need of protection, and developing strategies for their management and restoration. TNC's strategy focuses on preserving and restoring ecological processes and protecting entire landscapes and ecosystems.

The Latin American Programme works with national agencies and NGOs, as well as international organisations, to protect critical natural areas. This is done by strengthening like-minded organisations, assisting to found national conservation organisations, supporting development of national conservation data centres, and helping to design national parks. TNC has set up the *Natural Heritage Program* and the *Conservation Data Center Network*, the *Last Great Places* conservation initiative (aimed at protecting exemplary ecosystems), and numerous computerised inventories of information on plants, animals, and natural communities through their biological and conservation data system.

Publications include: *The Nature Conservancy Magazine*, bi-monthly, and *International News*.

Potential Coordinating Institutes

Centro Internacional de Agricultura Tropical (CIAT) (International Centre of Tropical Agriculture)

Apartado Aereo, Cali 6713, Colombia

Tel: +57 23 675 050 Fax: +57 22 647 243

REALM: Neotropical, Africotropical

INDICATORS: 4, 5, 8

EXPERTISE

CIAT, an international non-governmental crganisation, was established in 1967 by the Rockefeller and Ford Foundations, and currently is supported by the Government of Colombia. It undertakes activities in research and data/information management in the following sectors: food (especially of beans, cassava, rice and tropical fodder), ecosystem, environment and development, and environment and social conditions. CIAT is dedicated to the alleviation of hunger and poverty in developing countries of the tropics by applying science to agriculture in order to increase production whilst sustaining the natural resource base. CIAT works with national agricultural research institutions across the tropicos to ensure that food production keeps pace with growing demand - demand that is driven by population growth, and by greater buying power among the poor.

CIAT considers the Earth's natural resources the capital on which future growth depends. Sustainable agriculture means living off the interest from this capital, not off the capital itself.

The increased production from improved varieties of the CIAT cross-beans, cassava, pastures, and rice already brings Latin America about US$270 million worth of additional food yearly. Further research has the potential to produce another US$650 million a year.

CIAT is one of 18 international centres sponsored by the Consultative Group on International Agricultural Research (CGIAR). About 20 countries, international agencies and private foundations also support CIAT.

Potential Coordinating Institutes

Rijksherbarium/ Hortus Botanicus (RHHB)

PO Box 9514, 2300 RA Leiden, The Netherlands.

Tel: +31 71 273526 Fax: +31 71 273511

REALM: Palaearctic, Indomalayan

INDICATORS: 2, 7, 8

EXPERTISE

The Rijksherbarium/Hortus Botanicus combines two institutions with a long history. The Leiden Botanic Garden founded in 1590 as one of the earliest University Gardens in Europe, and the Rijkisherbarium founded in 1829 by Royal Decree of King William I. They were united in 1987 to form the first 'Research Institute' within the Faculty of Mathematics and Natural Sciences of the University of Leiden.

The institute has developed into an active research centre focusing both on European and Indo-Malaysian plant diversity, thereby facilitated by an ever growing collection of dried and liquid-preserved plant specimens of great international importance. With its current collection of over three million plant specimens and a staff of 18 scientists, 15 PhD students, and a varying number of graduate students and honorary and contract researchers, the Rijksherbarium/Hortus Botanicus is one of the largest and most productive institute's of systematic botany in the world.

Potential Coordinating Institutes

International Institute of Tropical Agriculture (IITA)

Oyo Road, PMB 5320, Ibadan, Nigeria.

Tel: +234 22 400300 Fax: +234 2 2412221, (or Inmarsat +874 1772276)

REALM: Africotropical

INDICATORS: 4, 7 ,8

EXPERTISE

Established in 1967 in Nigeria, the Institute has a mandate for research in tropical Africa. The main focus of the IITA is contributing to sustainable and increasing food production in the humid and sub-humid tropics in partnership with African national agricultural research systems particularly on maize, cassava, cowpea, plantain, soybean, and yam.

The IITA has its headquarters in Nigeria and research stations in Cameroon, and Côte d'Ivoire, and a biological control centre at Cotonou (Benin).

There are three main research divisions:

- Resource and crop management
- Commodity improvement
- Plant health management

The Institute also runs training programme in tropical agriculture for researchers, and collaborative programmes for delegates from many other African countries.

Potential Coordinating Institutes

World Bank Programme on Environmental Information Systems (EIS)

Program Secretariat - Room J3-169, Environmentally Sustainable Development Division, Technical Department, Africa Region, The World Bank, 1818 H Street NW, Washington, DC 20433, USA.

Tel: +1 202 473 4332 Fax: +1 202 473 7916

REALM: Africotropical

EXPERTISE

The Programme on Environmental Information systems in Sub-Saharan Africa provides a framework for planning and developing institutional environmental information in Africa. It helps facilitate the coordination of donor activities with regard to environmental information systems in Sub-Saharan Africa. It is a network and forum to help examine EIS activity trends in Africa. The programme was initiated in the early 1990 by the World Bank in association with other donors and international agencies. The EIS Secretariat undertakes many activities including the workshops, disseminating information, and networking; It consists of establishing and formalising collaboration and contact points in the EIS programme. A recent interest of the EIS has been the educational process in capacity building.

Potential Coordinating Institutes

Caribbean Natural Resources Institute (CANARI)

1104 Strand Street, Suite 208, Christianstad, St. Croix, US Virgin Islands 00820.

Tel: +1 809 73 9854 Fax: +1 809 773 5770

REALM: Neotropical

INDICATORS: 4, 6, 7

EXPERTISE

The Caribbean Natural Resources Institute (CANARI) is a regional non-governmental organisation concerned with issues of conservation, environment and development in the insular Caribbean. CANARI is registered as a not-for-profit charitable organisation with offices in St. Croix, US Virgin Islands and St. Lucia. CANARI formerly known as the Eastern Caribbean Natural Area Management Programme (ENCAMP), has over fifteen years experience in the implementation of programmes and field projects in the region, with special emphasis on community-based resource management.

CANARI's mission is to strengthen the capacity of Caribbean communities and their institutions to manage the natural resources critical to their development'. In order to achieve these goals, CANARI undertakes activities in four principal programme areas, namely:

Research

To test and demonstrate techniques and approaches that foster co-management, and to provide field cases for documentation and training. These activities are also designed to support the development of appropriate policies at the local, national and regional levels. CANARI's research programme is carried out within the framework of a number of long-term site-specific or resource specific field projects that are undertaken in collaboration with a wide range of local and national agencies.

Information

Through the establishment and cooperation of an information centre on co-management, protected areas, common property resources, and local institutional development, and through the preparation and production of case studies, articles and papers. The institute also produces and distributes newsletters and papers on topics of interest to professionals and institutions involved in issues of environment and development.

Training

To establish and expand a cadre of Caribbean persons, of diverse background and institutional affiliations, with the skills and expertise to support and promote co-management of natural resources. Activities range from a university-level module in community-based

resource management and local institutional development.

Technical collaboration

To support and foster the involvement of Caribbean groups and institutions in co-management arrangements, through networking, technical assistance, financing and support services.

Potential Coordinating Institutes

Caribbean Conservation Association (CCA)

Savannah Lodge, The Garrison, St. Michael, Barbados, WI.

Tel: +1 809 426 5373/9633/9635 Fax: +1 809 429 8483

REALM: Neotropical

INDICATORS: 1, 2

EXPERTISE

CCA is a regional umbrella NGO with offices in Barbados and established focal points in several Caribbean Countries. CCA has, for over 25 years, focused on the conservation, protection and wise use of the regions natural and cultural resources. CCA has taken a leadership role in these activities and its initiatives have acted as a catalyst for many of the major environmental programmes and initiatives launched in the Caribbean. The mission statement of the CCA is as follows: 'The CCA promotes and coordinates policies, programmes and practises which contribute to the conservation, protection and the judicious use of the regions natural and cultural resources in order to enhance the quality of life for present and future generations.'

At present, CCA membership comprises 19 of the regions governments, 78 Caribbean-based non-governmental organisations, several non-Caribbean institutions, as well as individual associates. Support is derived largely from Caribbean Governments, membership contributions, international donor agencies, private corporations and concerned individuals.

CCA's programmes are regional in scope, and include the following subject areas: Cultural heritage, environmental education, information management, and, natural resource management.

Potential Coordinating Institutes

Centro Internacional de la Papa (CIP) (International Potato Centre)

SSD-CIP, PO Box 5969, Lima, Peru.

Tel: +51 14 36 6920 Fax: +51 14 35 1570

REALM: Neotropical

INDICATORS: 6, 8

EXPERTISE

Founded in 1970, based in Peru, CIP is an intergovernmental organisation with regional scope particularly in the Andean eco-region. Its main focus is on potato and sweet potato improvement, and natural resource conservation in the Andean region. Activities are also undertaken in long term modelling and monitoring of alternative land use systems.

CIP has established the 'Consortium for Sustainable Management of Andean Natural Resources' (CONDESAN), through which research on sustainable agricultural production will be carried out. The CIP conducts research to develop the technology necessary to solve the priority problems that limit potato and sweet potato production in developing countries. The CIP has regional offices in Lima, Nairobi, Tunis, Bogor and New Delhi.

Potential Coordinating Institutes

Pacific Science Association (PSA)

POB 17801, Honolulu, HI 96817, USA

Tel: +1 808 847 3511 Fax: +1 808 841 8968

REALM: Oceanian

INDICATORS: 1, 7

EXPERTISE

PSA is a regional, non-governmental scientific organisation serving the entire family of nation-states in and around the Pacific Ocean. Since its inception some seventy five years ago the PSA has continued to function effectively as a clearing house for information, and as an information dissemination centre for matters of Pacific science.

PSA promotes scientific and technical cooperation in the Pacific region, with respect to its purpose, function and tradition. It has available applicable resources of scientific-technological expertise and experience.

The emphasis of relevant current workshops are on information management priorities, GIS and database management for the marine/coastal biodiversity of Pacific tropical islands.

PSA functions at national, regional and international levels. It connects groups regionally and internationally in order to facilitate scientific technical and technological cooperation in each and all areas. The result is that PSA serves a vital, unique regional role in science, in society and with respect to the environment.

Potential Coordinating Institutes

European Centre for Nature Conservation (ECNC)

Warandelaan 2, PO Box 1352, Tilburg 5004 BJ, Netherlands

Tel: +31 13 466 3240 Fax: +31 13 466 3250

REALM: Palaearctic

INDICATORS: 2, 6, 7

EXPERTISE

ECNC is a Europe-wide network of institutions working towards nature conservation. These institutions have formally committed themselves to cooperation in the development, exchange and application of information, expertise and research.

ECNC aims to further the cause of nature conservation and, in particular, to contribute to the reconstruction of the European ecological network. The Centre facilitates the exchange of expertise, provides information services, and initiates and coordinates international projects. ECNC's main sphere of interest is policy analysis and research into social context of nature conservation. The organisation is pan-European and thus, through the ECNC network, national expertise becomes available in an international context.

ECNC combines expertise on nature conservation with a thorough knowledge of legislation, policy, planning, economy and agriculture. Its field of operation is where ecology interacts with socio-economic science, and where research supports policy development. ECNC facilitates cross-disciplinary international projects in nature conservation.

ECNC is a clearing house for European conservation information; through the Centre national information becomes available in the European context. ECNC can locate and access data, expertise and experience throughout Europe.

ECNC is a non-profit foundation, governed by a board, whose members represent European countries and international conservation organisations. The Board appoints the ECNC director and deputy. The latter are responsible for the day-to-day running of ECNC. A Scientific Council judges and guards the scientific merit of ECNC activities and products. The head office is located in Tilburg in the Netherlands, and there is a regional office in Budapest.

ECNC takes on projects at the request of national and regional governments, international organisations or in reply to calls for tender. ECNC activities are based on a five year work programme. The work programme indicates four areas of action: policy support research and studies; information and expertise resources; capacity building (developing and enhancing institutional capacity on nature conservation in Europe; promoting exchange of expertise between institutions, and improving the quality of education and professional training); and dissemination of knowledge.

Potential Coordinating Institutes

European Environment Agency (EEA)

6 Kongens Nytorv, 1050 Copenhagen, Denmark.

Tel: +45 33 145075 Fax: +45 33 146599

REALM: Palearctic

INDICATORS: 2, 7

EXPERTISE

The establishment of the EEA was agreed upon at a March 1990 meeting of the European Ministers' Environment Council in Brussels. The EEA was conceived as a smaller coordinating unit of a large decentralised network. As well as EEA, the EU also established a European Environment Information and Observation Network (EEION) at the same time. Together, the Agency and the Network are to provide the European Union and its member states with objective and reliable information and assessments about the state of the environment in Europe. EEION is to be coordinated by the EEA and participants will come from three different backgrounds:

- national focal point in each member state
- various national information networks
- institutions given responsibilities for specific task and projects (termed Centres of Excellence).

In the first years of its operation emphasis will be placed on providing information which can be directly used in environmental policy implementation. Such areas include:

- air quality and atmospheric emissions
- water quality, pollutants and water resources
- the state of soil, flora, fauna and of biotopes
- land use and natural resources
- waste management
- noise emissions
- environmentally hazardous chemical substances
- coastal protection.

Upon its implementation, EEION will coordinate and provide Member States with objective, reliable and comparable information at the European level to enable them to take the necessary measures to protect the environment as well as assess the results of measurements

they have taken. EEA will be open to other non-EU Members. Already interest has been shown by EFTA (European Free Trade Association), Eastern and Central European nations as well as by the OECD (Organisation for Economic Cooperation and Development) and ESA (European Space Agency). The latter will be of particular importance as information provided by the ERS-1 satellite is crucial to assessing the state of the environment. Within the EU, JRC (Joint Research Centre) and EUROSTAT have also expressed an interest in cooperating close with EEA. JRC for example, will play an essential role in researching, developing and harmonising new environmental measurement methods and the standardisation of data.

Annex G

Examples of potential national institutes for indicator selection and development

REALM: PALAEARCTIC

Albania
Academy of Science
Institute of Biological Research
Albania

Austria
Bundesministerium fur Gesundheit und Umweltschutz
A-1010 Wien
Stubenring 1

Baltic Region
Swedish Threatened Species Unit
Uppsala.

Fauanasektionen
Sveriges lantbruksuniversitet
Box 7002
750 07 Uppsala

China
Institute of Botany
Academia Sinica
China

Czechoslovakia
Institute of Systematic & Ecological Biology of the CSAV
Kvetna 8
603 65 Brno
Czecholovakia

Denmark
Miljoministeriets Fredningsstyrelse
Amaliegade 13
DK-8410 Ronde

Egypt
Department of Botany
Faculty of Science
University of Cairo
Giza, Egypt

Ireland
Wildlife Service
Office of Public Works
51 St.Stephen's Green
Dublin 2, Ireland

Italy
WWF Italia
00199 Roma
Via Salania, 290

France
Ministere De L'Environment
Direction de la Protection de la Nature
Paris

Secretariat de la faune et de la flore
Museum National d'histoire naturelle
57, rue Cuvier
75231 Paris Cedex 05

Germany (Former Bundesrepublik) Plants & Animals
Bundesforschngsanstalt fur Naturschutz und Landschaftsokologie
Bonn-Bad
Godesberg

Institut fur Okologie der Technischen Universitat
Berlin

Bayerisches Landesmat fur Umweltschutz
Rosenkavalierplatz 3
8000 Munchen 81

Lithuania
Lithuainain Republic Environmental Protection Department
A.Juozapaviciaus 9
Vilinius 2326000
GAMTA SU

Maltese Islands
Department of Biology
University of Malta
Msida, Malta

Nepal
Department of National Parks and Wildlife Conservation
Kathmandu

Nordic Region
Nordisk Ministerrad
Store Strandstraede 18
DK-1255 Kobenhvn K

Poland

Polish Academy of Sciences
Nature Protection Research Centre
31-505 Krakow
ul.Arianska

Instytut Botaniki im. W.Szafera
Polska Akademia Nauk
ul.Lubicz 46
31-512 Krakow

Portugal

Ministerio Do Ambiente E Dos Recursos Naturais
Servico Nacional de Parques
Reservas E Conservacao Da Natureza
Rua da Lapa 73
1200 Lisboa Portugal

Slovenia

Zavod Republike Slovenije za varstvo naravne in kulturne dediscine
Plecnikov trg 2
SLO-61001
Ljubljana

Spain

Instituto Nacional Para La Conservacion De La Naturaleza
Gran Via De San Francisco 4
28005 MADRID

Switzerland

Bundesamt fur Umwelt, Wald und Landschaft (BUWAL)
3003 Bern

International Union for Conservation & Natural Resources
Morges
Switzerland

SBN - Schweizerischre Bund fur Naturschutz
Postfach 73
CH- 4020 Basel

Lique Suisse pour la protection de la Nature (LSPN)
Case postale 73
4020 Bale

Turkey

Ankara Universitesi Fen Fakulyesi
(Biyologi Bolumii)
06100 - Besevler
Ankara

UK

Mammal Society
Conservation Office
Zoology Department
Woodland Road
Bristol BS8 1UG

European Bureau for Conservation and Development (EBCD)
9 rue de la Science
B-1040 Brussels
Belgium

European Community (EC)
Rue de la Loi 200
B-1049
Brussels
Belgium

REALM: INDOMALAYAN

India

Zoological Survey of India
Prani Vigyan Bhawan
'M' Block, New Alipore
Calcutta 700 053

Botanical Survey of India
Department of the Environment
Botanic Garden
Howrah

Laos PDR

Wildlife in Lao PDR - A status Report
IUCN
Vientiane Lao PDR

Singapore

The Nature Society (Singapore)
c/o Department of Botany
National University of Singapore
Lower Kent Ridge Road
Singapore 0511

Thailand

Nagao Natural Environment Foundation
Yushima 2-29-3
Bunkyou-ku
Tokyo 133 Japan

Vietnam

NHA XUAT BAN KHOA HOC VA KY THUAT
70 TRAN HUNG DAO - HA NOI
(Science & Publishing House)
WWF office?

Multidisciplinary Action Research Centre (MARC)
House 12
Road 12
Dhanmandi R.A.
Dhaka 1209

REALM: NEOTROPICAL

Brazil

Fundacao Biodiversitas
Rua Maria Vaz de Melo
71-32160-110
Belo Horizonte
MG

Chile

Chilean Forest Service
Santiago
Chile

REALM: AUSTRALIAN

Australia

Ecofund Australia
10 Belgrave Street
Manly 2095

Queensland Department of Primary Industries
Fisheries Division
GPO Box 46
Brisbane QLD 4001

Royal Australasian Ornithologists Union
21 Gladstone Street
Moonee Ponds, Victoria 3039
Australian Museum
PO Box A285
Sydney South NSW 2000

REALM: NEARCTIC

USA

Environmental Institute
Oklahoma State University
Stillwater
Oklahoma

University of Alaska Museum
Fairbanks
Alaska

CANADA

International Development Research Centre
PO Box 8500
Ottawa
Ontario K1G 3H9

Canadian Wildlife Service
Environment Canada
Ottawa
K1A OH3

REALM:OCEANIC

Argentina

Albatross
Hipolito Yrigoyen 3920 (1208)
Capitol Federal
Buenos Aires - Argentina

New Zealand
Nature Conservation Council
PO Box 12-200
Wellington
New Zealand

Pacific Coast
ANAI Association
Apartado 170
2070 Sabanilla

REALM: AFRICOTROPICAL

South Africa (plants also)
Foundation for Research Development
Council for Scientific & Industrial Research
PO Box 395, Pretoria
0001 South Africa

Pan African Council for the Protection of Env. & Dev (CCPED)
B.P.994
Nouakchott
T:53-77

WORLD CONSERVATION
MONITORING CENTRE

World Conservation Monitoring Centre
219 Huntingdon Road
Cambridge CB3 0DL
United Kingdom

Telephone: +44 1223 277314
Fax: +44 1223 277136
e-mail: info@wcmc.org.uk

IUCN
The World Conservation Union

UNEP

WWF

The World Conservation Monitoring Centre is a joint-venture between the three partners who developed the *World Conservation Strategy* and its successor *Caring for the Earth:* IUCN-The World Conservation Union, UNEP-United Nations Environment Programme, and WWF-World Wide Fund for Nature.