❖Standard 6: Develop assessments/ visions within ecologically meaningful areas adopted or adapted from existing ecoregional classifications. [plan]

Rationale
Conservationists around the world use ecoregions as assessment units to conduct conservation planning because they are ecologically based and consistently globally mapped and are the appropriate scales for the types of questions being addressed by these assessments/visions.

Recommended Products
- Digital map of assessment units.
- Digital map of ecoregion stratification units.
- Documentation and justification of any newly created ecoregions and/or any aggregation, separation, or boundary modification of planning units based on environmental patterns within the assessment area.

GUIDANCE

Humans have organized the world along geopolitical boundaries. Such boundaries rarely coincide with environmental patterns that determine the distribution of biodiversity. Conservation planners and natural resource managers have utilized ecosystem geography to characterize and map biological and environmental patterns to identify spatial units for conservation and natural resource assessment and management. In his 1998 book entitled *Ecoregions: the Ecosystem Geography of the Oceans and Continents,* Robert Bailey defined ecoregions in a hierarchical fashion. For the broadest unit, Bailey defined major ecosystems resulting from large-scale predictable patterns of solar radiation and moisture. These patterns coupled with local topography are used to define the nested local ecosystems with characteristic animals and plants found within. Eric Dinerstein and others (1995) defined ecoregions as "relatively large areas of land and water that contain geographically distinct assemblages of natural communities". These communities (1) share a large majority of their species, dynamics, and environmental conditions, and (2) function together effectively as a conservation unit at global and continental scales." No ecoregion is homogeneous. However, ecoregions have biological and environmental patterns within them that are more similar to each other than patterns in other ecoregions.

In order to use ecoregions as units to develop assessments/visions for biodiversity conservation, we need to understand:

- the definitions of ecoregions,
- applications of ecoregions for conservation,
- freshwater ecoregions,
- marine ecoregions, and

- protocols for making modifications to ecoregional boundaries.

Defining ecoregions

The term "ecoregion" has been used to refer to many sets of geographic biophysical units. All things termed “ecoregions” are not the same. There are a variety of ecoregional frameworks that exist. Each framework uses different sets of criteria to address different purposes. Scientists don’t always agree on the specific ecoregional scheme that should be used or on all of the boundaries of the ecoregions within accepted schemes. Still, ecoregions are more effective units at capturing the ecological and genetic variability of biodiversity than political units (see Ricketts et al. 1999 for overview of U.S. ecoregions). Olson et al. (2001) identify three caveats for conservation planners:

- no single ecoregion classification will be optimal for all taxonomic groups or biological features,
- boundaries between ecoregions are usually transitions from one major ecosystem type to another and are rarely distinct edges, and
- most ecoregions will contain habitats that are more distinctive of adjacent ecoregions.

Regardless of these qualifications, ecoregions are better suited for biodiversity assessments than political boundaries. Information for specific countries, provinces, states or counties can be "clipped" from one or multiple ecoregions, providing an ecological basis for politically organized planning.

Many conservation organizations and governments use different ecoregional frameworks, yet their maps and descriptions often overlap significantly, since they use many of the same criteria, and the result is more similarity than disparity (Ricketts et al. 1999, McMahon et al. 2001). Anxiety over incongruities should be tempered by two points (Groves 2003): 1) any well-thought-out ecoregional classification will be an improvement over using geopolitical boundaries as planning units; and 2) for organizations that are conducting conservation planning and actions across contiguous regions, the assessment work that occurs *within* ecoregional boundaries is of far greater importance than energy spent debating the exact location of those boundaries.

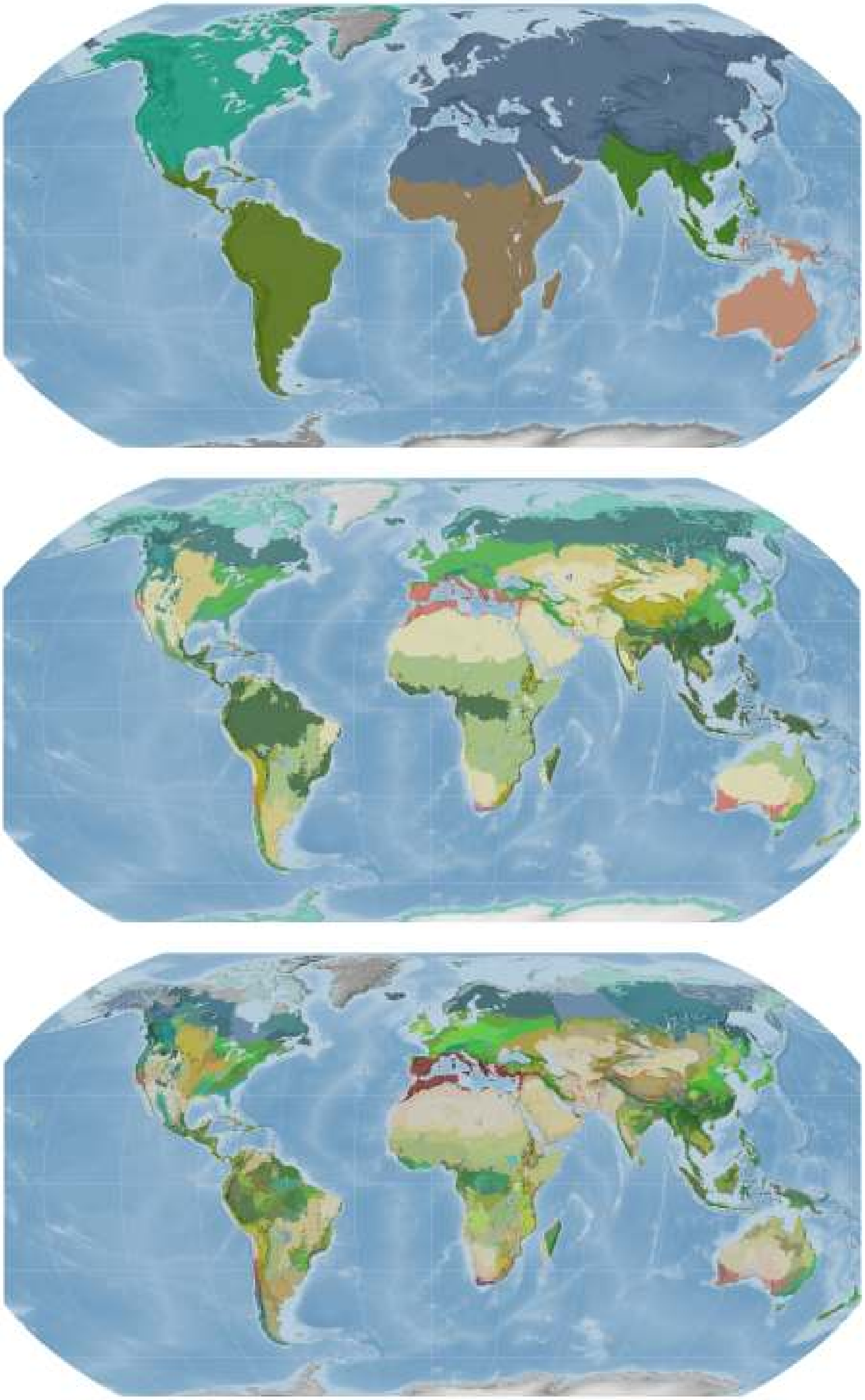
Applications of ecoregions for conservation

In the United States, The Nature Conservancy has used the U.S. Forest Service ECOMAP (1993) and Bailey (1995) ecoregions with some modifications, as its base map for conservation planning. Differences between the U.S. ecoregional map and similar maps across the border with Canada (Ecological Stratification Working Group, 1996) and Mexico have been reconciled. This framework was chosen almost a decade ago by The Nature Conservancy for several reasons: 1) TNC focused on the U.S. and consistency with global efforts was not a major concern; 2) the framework was published; 3) several government agency partners used the framework; and 4) it corresponded well to terrestrial biodiversity and small and moderate-sized freshwater system patterns.

This framework was developed to inform ecosystem management. The framework is hierarchical, with a consistent set of criteria and nested spatial units for every level in the hierarchy. These criteria are the driving biophysical factors that influence ecosystem type and function at the different scale. The criteria were chosen based on the concept that different factors operate at different spatial and temporal scales. The nested units range from global scale (Domain), sub-continental (Division), regional (Province, what we refer to as "ecoregion"), sub-regional (Section), and a set of finer nested units called Sub-Sections Land types, and Land Type Associations. The finer-nested units are important because stratification of an ecoregion is critical for developing distributional conservation goals in order to capture biodiversity across the environmental gradients important for ecological and evolutionary diversity within an ecoregion(Groves 2003). See Case Studies for examples of how to subdivide terrestrial ecoregions.

At the same time, for Latin America and Asia, the Nature Conservancy chose to use WWF terrestrial ecoregions which were later published comprehensively for the world (Olson et al. 2001), and they chose to use World Bank ecoregions for Oceania. There are 867 terrestrial ecoregions stratified by 14 biomes and 8 biogeographical realms for regional and global context. The 14 biomes have since been renamed Major Habitat Types. MHT's are groupings of ecoregions with similar dominant characteristics (e.g. temperate broadleaf and mixed forest, tundra, montane grasslands and shrublands). While WWF terrestrial ecoregions do not have a formal set of smaller nested units within them, stratification of the ecoregions is recommended for setting goals.

Subsequently, The Nature Conservancy has broadened its perspective to a global scale, and has adopted the WWF terrestrial and freshwater ecoregions, Major Habitat Type and biogeographic realm global stratification. The WWF terrestrial and freshwater ecoregions, and the draft marine ecoregions being developed, are all nested within Major Habitat Types (Figure 1b), and are stratified by biogeographic realms (Figure 1a). This global context allows ecoregions (Figure 1c) to be grouped according to their similarity in structure and biological composition. Major Habitat Types have similar dynamics and structure, and ecoregions within the same MHT and biogeographic realm have closely related biological composition as well. This context has been used by the WWF and The Nature Conservancy to identify priorities for ecoregional assessments and actions to most immediately conserve the biodiversity representative of the Earth. Given the magnitude of the biodiversity crisis, ecoregional assessments/biodiversity visions cannot be conducted in every ecoregion on the planet. Priorities need to be defined to focus resources in specific ecoregions.



a

b

c

Figure 1: WWF Global Terrestrial Biogeographic Realms (a), Major Habitat Types (b) and Ecoregions (c) (Olsen et al 2001).

The WWF defined the Global 200, a set of the most biologically distinctive terrestrial, freshwater and marine ecoregions (or best available units from regionalization schemes), stratified by Major Habitat Types and biogeographic realms in order to provide representation of the Earth's biodiversity (Eco)regions were selected based on: species richness, endemism, higher taxonomic uniqueness (e.g., unique genera or families, relict species or communities, primitive lineages), extraordinary ecological or evolutionary phenomena (e.g., extraordinary adaptive radiations, intact large vertebrate assemblages, presence of migrations of large vertebrates), and global rarity of the major habitat type (see: http://www.panda.org/about_wwf/where_we_work/ecoregions/global200/pages/method.htm and Olson and Dinerstein, 1998).

The Nature Conservancy is in the process of defining global priorities for a conservation goal for the year 2015. This goal is centered around conserving at least 10% of every major habitat on Earth. A process is underway to identify priority ecoregions using a suite of criteria that include biological significance, and the urgency and feasibility of actions. These criteria are not final, and will include other criteria such as representation.

Freshwater ecoregions

The Nature Conservancy initially planned for terrestrial, freshwater and marine biodiversity using the same framework in the U.S. and elsewhere. It was clear to many conservation planners that these boundaries did not adequately delineate all of the important patterns for marine and freshwater biodiversity and ecosystem processes (see Abell et al. 2000, chapters by Higgins, Beck in Groves 2003). The process to create global freshwater and marine classification systems for conservation planning is still underway.

In order to plan within units that were ecologically meaningful for freshwater biodiversity, freshwater conservation planners in TNC began to extend ecoregions out to include catchment boundaries. These catchment boundaries were classified as Aquatic Zoogeographic Units. These units collectively served as freshwater planning units. These units were subdivided by Ecological Drainage Units to stratify conservation target goal setting. These two geospatial units are part of a freshwater classification for conservation planning and target classification developed by Higgins et al. (2005). A comparable delineation of freshwater planning units needed to be developed for the entire globe.

The WWF has developed a first iteration of freshwater ecoregions and major habitat types for the world. The first set of freshwater ecoregions was developed for North America (Abell et al. 2000). The Nature Conservancy first began using these freshwater ecoregions as formal assessment units in the Southeastern United States in 2000 (see Smith et al. 2002). The successful use of these boundaries led TNC to adopt WWF’s freshwater ecoregions are as Aquatic Zoogeographical Units (AZUs). In order to subdivide these units, existing ecological drainage unit boundaries will be reconciled with these AZUs in the future. This will establish a consistent freshwater classification context for conservation planning.

Until a global framework is completed several existing or draft versions of freshwater units are available for certain geographies. Freshwater ecoregions of Africa and Madagascar have been published (Thieme et al. 2005). Congruent efforts are taking place for the freshwater ecoregions of the rest of the world. TNC has been working with WWF to develop freshwater ecoregions in South America, and to classify and map the freshwater Major Habitat Types of the world. Shape files of the draft freshwater ecoregions of the world are available through the WWF Freshwater program and TNC's Global Conservation Approach Team.

Another system of freshwater classification is worthy of mention due to its prominence. In the United States, Omernik (1987) developed a framework for surface water quality assessments. These ecoregions are in a nested hierarchy similar to Bailey's but are more focused on freshwater ecosystem patterns and biotic content, as well as adding current land use patterns to inform the classification. While these ecoregions are not being used as planning units for biodiversity, they are important sources of information on regional patterns of biota, ecosystem characteristics and threats. Omernik's freshwater framework is used by the U.S. Environmental Protection Agency and the U.S. Geological Survey as a national framework for water quality and biotic assessments, and is an important framework to consider for alternative data reporting when providing information to partners.

Marine ecoregions

No global marine ecoregional framework has been published, although one has been drafted by a global working group (TNC Marine Habitat Assessment Group). Biogeographic boundaries for the nearshore waters of the United States have been most clearly delineated by NOAA (http://nerrs.noaa.gov/). Most federal agencies involved in the marine environment (e.g., NOAA, EPA, USGS, and MMS) use this system.

In 1997, The Nature Conservancy's Florida and Caribbean Marine Conservation Science Center (FCMCSC) at the University of Miami led a project aimed at delineating and ranking coastal ecoregions in Latin America and the wider Caribbean (Sullivan, Sealey and Bustamante, 1999). This framework and the subsequent exercise of setting priorities were developed with the contribution of 26 experts on marine science and fisheries. Nine Coastal Biogeographic Provinces were delineated based on climate, ocean circulation, coastal geology, and geomorphology along the Pacific, and Atlantic coasts of the study area. A second level of biogeographic division, the Coastal Biogeographic Region (or Marine Ecoregion) was conducted within each Province. This division was based on smaller-scale physical attributes such as ocean gyres and eddies, upwelling occurrence, coastline features and shelf width, as well as the distribution of major biological populations (fish, coral, algae, mangrove, invertebrates). In some cases, the country boundaries were ultimately used for segregating marine ecoregions. For both the province and the ecoregion the 200-mile Exclusive Economic Zone was taken as the seaward limit recognizing that this is the extent of the country jurisdiction upon marine resources.

Protocols for making modifications to ecoregional boundaries

Some ecoregional teams have found it necessary to modify ecoregional boundaries. The ecoregions that are currently being used are first iterations, and some boundaries may be changed. Changing boundaries should be done in conjunction with regional experts, and implications to changes in surrounding ecoregions need to be documented. Documentation of changes should be captured in the ecoregion's metadata and/or using the proposed framework that should be submitted to the Conservation Approach Group Data Manager to update the existing data layer of Ecoregions. Also, changes need be communicated to adjacent ecoregional assessment teams.

Another situation that has arisen with the transition from using ecoregional provinces in the U.S. to WWF terrestrial ecoregions in other parts of the world is the generally vast difference in size and number of ecoregions. The Nature Conservancy uses 66 ecoregions in the conterminous 48 states.. There are 169 WWF terrestrial ecoregions in South America. Taking an ecoregion-by-ecoregion approach to planning in South America in the same way that was taken in the U.S. would be more costly and time consuming. Ecoregions may be assessed in groupings that make ecological sense, but that retain the capacity for appropriate scale and depth of analyses. Groupings of ecoregions make most sense when done on an ecological basis. For instance, assessing several ecoregions that are members of the same Major Habitat Type may reduce redundancy in defining targets, threats and strategies. However, it is critical to maintain the stratification *within* ecoregions as a fundamental component of setting conservation target goals, and to maintain a reasonable geographic scope so that sufficient depth and breadth of targets, and information on target viability, threats and strategies can be developed.

OPPORTUNITIES FOR INNOVATION

Most ecoregions are first or second iteration products. Many may need adjustments when more data are available. These adjustments need to be reviewed and well documented before making changes. Additionally, local partners and agencies are sometimes dissatisfied with the ecoregions, and prefer to use their existing spatial planning and management units as assessment units. Coordinating assessments into these units and cross-walking them to global frameworks is a challenge that needs to be addressed. These alternative frameworks may be necessary units to cross-walk existing global ecoregional assessment products into in order to make information more useful for partners. Freshwater and marine ecoregions are still in their first iteration and may need to be refined.

CASE STUDIES

- **Refining Ecoregional Boundary Delineations Through the Incorporation of New Data in the Selva Maya, Zoque and Olmeca Ecoregion.** The Selva Maya, Zoque and Olmeca assessment unit is an aggregated unit containing several ecoregions in portions of Southern Mexico, Guatemala and Belize. The original boundaries were derived from coarse-scale data which showed dramatic inconsistencies with currently available finer-scale spatial data. In order to revise the boundaries of and within the Selva Maya, Zoque and Olmeca ecoregions, several iterations of data integration, expert input/review, and boundary modification were conducted.

- Revising Bi-National Ecoregional Boundaries in the Superior Mixed Forest Region. The original SMF ecoregion delination stopped at the Canadian-U.S. border. A binational team used existing data to draw the boundary. A table organizing differences in terminology was developed to help the involved groups communicate about biogeographic land units. A detailed boundary change justification was included as appendix to the SMF ecoregional plan.

- Establishing Subecoregions Using Cluster Analysis in the SW Amazon. Cluster analysis using climate data was used to identify 14 subecoregions in Southwest Amazon.

TOOLS

General/terrestrial

Assessment unit boundary modification justification documentation guidance. L. Sotomayor (2005).

Terrestrial Ecoregions of the United States Bailey (1995). Also, a shapefile is available for download at http://www.fs.fed.us/institute/ecoregions/eco_download.html

Terrestrial Ecoregions of the World. Olson et al. (2001). Also, a shapefile is available for download at http://worldwildlife.org/science/data/terreco.cfm

Bioregions of Canada –Ecological Stratification Working Group (1996). Bioregions defined for both Marine and Terrestrial biomes.

Checklist of Online Vegetation and Plant Distribution Maps. Compiled by C. Englander and P. Hoehn (2005) University of California, Berkeley.

Freshwater

Freshwater Ecoregions of the World. WWF is currently developing this global dataset.

Global Lakes and Wetlands Database – Lehner, B. and P. Döll (2004). Downloadable ArcView layers of the World's lakes and wetlands.

Marine

Nearshore National Estuarine Research Reserve System Biogeographic Regions. NERRS/NOAA. Map and documentation.

Setting Geographic Priorities for Marine Conservation in Latin America and the Caribbean
Sullivan Sealey, K. and Bustamante, G. (1999). Includes a classification of Marine environment.

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