❖Standard 7: Select terrestrial, freshwater and marine conservation targets/biodiversity elements/features across multiple biological and spatial scales. [plan]

Rationale

It is necessary to define a subset of targets that best represent the biodiversity of an ecoregion to focus the assessment. Conservation targets should cover the suite of biological scales (species to communities, ecological systems and other targets), taxa, and ecological characteristics to adequately inform comprehensive biodiversity conservation. Targets should include coarse and fine filter targets. This includes using rare and endangered, wide ranging, migratory and keystone species, rare communities, and all ecological systems and/or ecosystem types, as well as additional targets that are useful in capturing the variety of biodiversity characteristics, scales and ecological processes.

Recommended Products

- List and attributes of fine-filter targets such as distribution (local, widespread), conservation status (threatened and endangered), endemic, wide-ranging, rare communities and coarse-filter targets (ecological systems and ecosystems) as well as other types of targets as appropriate. See the Ecoregional Assessment Data Standards 1.0 for required fields.
- Maps of occurrences of targets throughout the ecoregion.
- Description of data gaps for specific target groups and geographic areas.

GUIDANCE

A systematic approach to conservation planning demands that we be explicit about what features of biodiversity we are trying to conserve (Groves 2003). With the goal of conserving the biodiversity of an ecoregion, we need to define a subset of features to work with that will adequately capture that representation and variety. We refer to these features as conservation targets (Redford et al. 2003). Conservation targets are the species, communities, ecological systems[1] and surrogates that we focus our assessments on in order to capture the broad range of biodiversity as best we can. Targets are a subset of the biodiversity of an ecoregion, since it would be impossible to assess each component of biodiversity individually even if we knew what all of it was and where it resided.

Given all of the potential species, communities and ecological systems occurring in an ecoregion, which ones should be targets and why? One of the basic tenets used in regional conservation planning is the application of coarse and fine filters. Coarse filters aim to capture many species, communities and ecological processes as well as represent a given

---

[1] The distinction between ecological systems and ecosystems is described in this unit. Both are used as targets. However, the term ecological system is generally used throughout the Toolbox, but the concepts addressed apply to both types of targets.

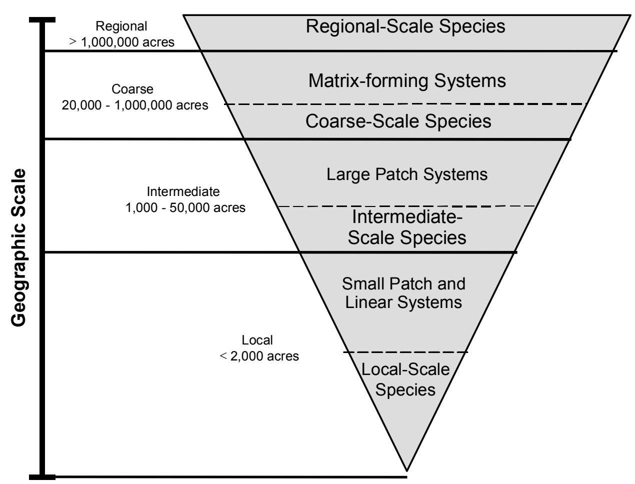
level and scale of biological organization. Fine filters capture those communities and species that fall through the coarse filter. We must select these targets with care; they will serve as the building blocks for defining areas of biodiversity significance, evaluating threats, informing strategies, defining priorities and measuring the impacts of conservation actions.

Comprehensive target selection will:

- Consider biological and spatial scales
- Identify coarse filter targets
- Identify fine filter targets
- Identify other target categories

Consider biological and spatial scales

Terrestrial, freshwater and marine biodiversity occurs at a variety of organizational levels. Some assessments focus on only one of these groups for practical reasons, or as a component of a broader assessment. Still, if a region is to be assessed comprehensively, all of these groups must be addressed. While there may be disagreements about the perfect representation of scales of biodiversity or the taxonomy of units at each level, we seek to conserve, at a minimum, spatial scales and levels of organization from species to ecosystems (e.g. Noss 1996, Margules and Pressey 2003, Groves 2003). In addition to looking at levels of biological organization, another way to view biodiversity is by spatial extent. Poiani et al. (2000) created a framework to organize biodiversity into spatial scales;



local, intermediate, coarse and regional (Figure 1). It is important to apply these scales across levels of biological organization when selecting targets to broaden representation of biodiversity in an assessment region.

Figure 1: The full range of scales of biological organization should be considered during the target selection process. (Adapted from Poiani et al. 2000.)

Identify coarse filter targets

Conserving examples of all types of coarse filters should result in the conservation of a significant proportion of species, communities and ecological processes that occur in an ecoregion. Initially, the concept of the coarse filter was based on conserving representative communities to conserve the majority of species (Noss 1987, Hunter et al. 1988). This approach has evolved to include transitions between communities, combinations of communities, environmental gradients and ecological systems and ecosystems (Noss 1987, 1996, Groves 2003, Cowling and Pressey 2000, Higgins et al. 2005).

Coarse filter targets can include ecosystems, ecological systems, communities, environmental surrogates and certain types of species. For the sake of clarity, Groves (2003) suggests using Whittaker's 1975 definitions of communities and ecosystems. Communities are assemblages of populations of plants, animals, bacteria and fungi that live in an environment and interact with each other. An ecosystem is the sum of the community and its environment treated together.

It is necessary to define system and community level units for conservation planning. There has been a long history of ecologists that have attempted to define natural community types at a variety of scales. Community classifications have been primarily applied to terrestrial vegetation, and have been mostly based on vegetation structure and species composition. Examples include those for the United States (e.g. Grossman et al 1999) and Canada (http://www.glfc.forestry.ca/CFEC/icec/icec_e.html). However, many conservation assessments are shifting from using communities to ecological systems as coarse filter targets. There are a number of reasons for this shift in emphasis:

- Most countries lack comprehensive information about on-the-ground occurrences of plant associations and obtaining such information is financially impractical;
- Plant associations are not generally mapped over broad regions;
- Ecological systems are more comparable in scale to information available from remote sensing;
- Using ecological systems reduces the number of targets to a more practical number for conservation planning purposes, and;
- The complexity and cost of cross-walking plant association-level data across different community classifications cannot be borne by most ecoregional planning efforts.

Comer et al. (2003) and Josse et al. (2003) define ecological systems as biological communities that occur in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding. Groves (2003) summarizes different types of ecosystem classifications that exist, illustrating the great variety in approaches and products.

Choosing an appropriate classification system is an important step in the conservation assessment process. Because of the wealth of options that exist, Anderson et al. (1999) suggests five criteria to consider when selecting a classification system:

- what criteria are used to define the classification system,
- can the classification system be arranged hierarchically for use at multiple scales,

- can the units of classification be readily mapped, and to what extent is that mapping complete for the planning region,
- what is the geographic area for which the classification is most useful, and
- have successional types of vegetation units, usually resulting from natural disturbances to ecosystems, been incorporated into the classification system?

Even though these questions are specific to selecting a terrestrial classification system, they are useful for examining any classification product.

Coarse filter units have been defined using environmental information, such as elevation, geology and landform. Ecological Land Units have been used to describe landscape diversity as it influences ecological patterns and processes (see example in tool box). Land systems and environmental classes have been developed based on patterns of landform, soils, vegetation and hydrologic regimes as surrogates for ecosystems (e.g. Pressey and Nicholls 1989, Smart et al. 2000, Iacobelli et al. 1993). Environmental classes developed using geology, elevation and climate have been used as targets (e.g. Faith and Walker 1996, Moss et al. 1999, 2001, Fairbanks et al. 2001). Using a combination of both biotic and environmental targets has been suggested as a way to best represent biodiversity (e.g. Ferrier and Watson 1997, Pressey et al 2000, Kintsch and Urban 2000, Cowling and Heijnis 2001), and is recommended to best plan in light of climate change (Halpin 1997, Noss 2001, West & Salm 2003).

Higgins et al. (2005) developed a framework to classify and map freshwater ecosystems using geology, elevation and hydrography data within a biogeographic context. Freshwater systems are classified into hierarchical units: Aquatic Zoogeographic Units, Ecological Drainage Units, Aquatic Ecological Systems (AES) and Macrohabitats. As mentioned in the narrative for Standard 6, the two largest scale units serve as assessment unit boundary and stratification units respectively. In this framework, the lower two units (AESs and Macrohabitats) often serve as coarse filter targets. Similar approaches are being developed in the Aquatic GAP program (e.g. Sowa et al. 2005), and in South Africa (Roux et al. 2002)

For marine environments, shoreline characterizations are often employed to define abiotic habitats. Physical variations in substrate, wave exposure, salinity, and light availability are strongly correlated to variations is species composition. Coastal geomorphology can be used as a guide for representing the array of potential habitats within a coastal ecosystem. In fully submerged habitats, benthic habitat characterizations have been developed to track variations in underwater topography (NOAA Biogeog, Halpin 1997, Ardron 2002). Biotic components such as coral reefs, oyster reefs, saltwater marshes, seagrass meadows, mangroves, shellfish beds, and estuaries are often tracked as important ecological systems. These ecological systems not only have predictable suites of species composition, but also form a functional unit at a broader scale of environmental variability, such as serving protecting coastal areas from erosion or serving as nursery areas for juvenile fish.

Identify fine filter targets

The fine filter is composed of species and communities that are not well captured by coarse filter targets, and require individual attention. For instance, Kirkpatrick and Gilfedder (1995) showed that there was little overlap between remnants of vegetation in good condition and the presence of rare and endangered species. Many characteristics of species have been offered as criteria for defining fine filter targets:

- *Threatened, endangered and imperiled species* defined by the World Conservation Union's (IUCN) Red List of Threatened Species, NatureServe/Natural Heritage Programs globally imperiled or critically imperiled, and federally defined species, such as those Threatened and Endangered Species under the Endangered Species Act.

- *At Risk Species* which are not included in the above category. Many species are listed as species of special concern, sensitive, species of community interest, or extinction prone. Many countries have published analyses of conservation priorities for various taxonomic groups.

- *Endemic Species* are those with distributions restricted to the ecoregion or smaller areas within an ecoregion.

- *Declining species* exhibit significant, long-term declines in habitat/and or numbers, are subject to a high degree of threat, or may have unique habitat or behavioral requirements that expose them to great risk.

- *Vulnerable species* are usually abundant, may or may not be declining, but some aspect of their life history makes them especially vulnerable to future threats (e.g., migratory concentration or rare/endemic habitat).

- *Disjunct species* have populations that are geographically isolated from that of other populations.

- *Species life-stage* habitats required for particular life-cycle stage requirements, such as breading habitats, nursery habitats, and migratory corridors. Certain species or groups of species will have habitat requirements for different stages of development and in cases where these habitats are geographically distinct we establish representation objective for the full range of habitat requirement of targeted species.

Identify other target categories

Certain species can serve functionally as coarse filters, but also may be a component of a fine filter, depending on the perspective. *Focal species* have spatial, compositional, and functional requirements that may encompass those of other species in the region and may help address the functionality of ecological systems. Focal species may not always be captured in the portfolio through the coarse filter. Several types of focal species (Lambeck 1997 and Carroll et al. 2000) can be considered.

- *Keystone species* provide significant impacts on community and ecosystem structure and function. The impact of keystone species on a community or ecological system is disproportionately large for their abundance (Simberloff 1996). They contribute to ecosystem function in a unique and significant manner through their activities. Their removal initiates changes in ecosystem structure and often a loss of diversity (e.g., beaver, bison, prairie dog, salmon).

- *Umbrella/wide ranging species* such as a migratory fish, bird, or grizzly bear, depend on vast areas, and may be useful as coarse filters. There is some doubt about their effectiveness (e.g. Andelman and Fagan 2000). Caution must be used, and hypotheses tested about their efficacy as a coarse filter target. As an individual fine filter target, these species may not be well captured by coarse-filters because they tend to cover multiple numbers of coarse-filter target types, such as multiple ecosystems or land types.

- *Focal Species* have been defined by the WWF as a specific target category. Focal species have many of the attributes listed above. They suggest that focal species have at least one of the following criteria:
  - High demand for space, wide-ranging
  - Seasonal/daily population concentration
  - Limited dispersal ability
  - Low reproductivity or fecundity
  - Large body or largest member of feeding guild
  - Specialized dietary, habitat requirements
  - Reproductive specialization
  - Dependence on rare, widely dispersed habitat
  - Climatic sensitivity
  - Population status
  - Small or declining population
  - Metapopulations with unique genetic compositions
  - Human-effect factors
  - Population threatened by direct exploitation, harassment, or ecological interactions
  - Habitat threatened by loss, conversion, degradation, or fragmentation

Species aggregations, groups and hot spots of richness may also serve as targets. These are unique, irreplaceable examples of a certain species or suite of species.

- *Globally significant examples of species aggregations* (i.e., critical migratory stopover sites that contain significant numbers of migratory individuals of many species). For example, significant migratory stopovers for shorebirds have been formally designated through the Western Hemisphere Shorebird Reserve Network. A common example from freshwater planning is mussel beds composed of many species. A marine example is Spawning Aggregation Sites (Heyman et al. 2002), a place used by many species at different times throughout the year.

- *Major groups of species share common ecological processes and patterns, and/or have similar conservation requirements and threats* (e.g., freshwater mussels, forest-interior birds). It is often more practical in ecoregional plans to target such groups as opposed to each individual species of concern.

- *Biodiversity hotspots* contain large numbers of endemic species and usually face significant threat (Mittermeier *et al.* 1998). This particular target category is largely applicable only to Conservancy and partner work in tropical forests in Latin America/Caribbean and Asia-Pacific Regions.

Another category of target which is used by many conservation planners is important *ecological processes*. These include seasonal migratory routes, important predator/prey relationships, hydrologic processes, disturbance regimes and refugia, pollination and seed dispersal, among others. See the Case Studies for examples.

Practical Tips for Selecting Conservation Targets

- Consult with adjacent ecoregional planning projects to ensure that conservation target lists are as consistent as possible.
- Use expert workshops to refine and finalize the target list as early as possible.
- Establish taxonomic teams at the beginning of the project and assign each team the task of developing target lists for that group.
- Make sure targets encompass multiple levels of biological organization and multiple spatial scales.
- In ecoregions with large numbers of targets, consider grouping finer-scale targets into coarse-scale ones to make the planning process simpler. Variability criteria for coarse-scale targets may explicitly account for habitat requirements of finer-scale targets.

OPPORTUNITIES FOR INNOVATION

While the approach of using the coarse-fine filter and selecting certain sets of targets to represent the biodiversity of an ecoregion has been widely used, there has been little explicit testing of the efficacy of these approaches. Verification of the effectiveness of our approaches using different types and scales of targets is critical to providing the scientific backing to define the strength of our work, and to develop more efficient targets for the future.

CASE STUDIES

- Ecological Systems in the Northern Great Plains Steppe. In order to circumvent the paucity of system level data, plant associations and natural community associations were identified for use as terrestrial targets. Natural communities were grouped into ecological complexes and size class was assigned to each ecological complex to represent the spatial pattern and scale of these complexes.

- Ecological Land Units in the Central Appalachians Ecoregion (CAP). Ecological Land Units were generated using geology, topography and elevation data under the premise that natural distributions of species and communities are driven by environmental gradients and unique combinations of these three attributes can be used to approximate the location and distribution of communities and species. This case study highlights how ELUs were utilized to identify matrix community targets.

- Selecting Bird Targets in the East Gulf Coastal Plain Ecoregion. Partner in Flight bird occurrence lists were used as a basis for selecting bird targets. The list was further refined using Geography of Hope criteria and PiF Global Score, Abundance and Trend rankings.

- Hierarchical Aquatic Classification System for Target Selection in the Upper Mississippi River Basin. A hierarchical aquatic classification system was used to define freshwater ecological system targets. The freshwater landscape was classified at four spatial scales; Aquatic Zoogeographic Unit, Ecological Drainage Unit, Aquatic Ecological System and Macrohabitat. These informed the selection of coarse filter targets. Additional analyses were conducted to select fine filer targets.

- Terrestrial, Freshwater and Nearshore Marine Target Selection in the Willamette Valley-Puget Trough- Georgia Basin Ecoregion. Five teams of experts were assembled to create the target list for the WPG. Three teams focused on terrestrial targets (plants, animals and ecological systems). One team complied nearshore marine targets and another, freshwater targets. Habitat or coarse filter classification systems were developed for both aquatic target identification processes.

- Pacific Northwest Coast (PNWC) Ecoregion Offshore Classification Methodology. The PNWC ecoregional assessment team has developed an innovative method for classifying and mapping offshore benthic habitats utilizing a topographic model and existing classifications that characterize depth and benthic substrate to model and generate offshore benthic conservation targets.

- Shoreline Habitat Classification for Northern California Current (NCC), Pacific Northwest Coast (PNWC), Northwest Atlantic Coastal and Marine (NAC-marine) Ecoregional Assessments Described is an approach for defining shoreline conservation targets based on NOAA's Environmental Sensitivity Index (ESI) data. This approach has been tested in several marine ecoregion assessments.

- Analysis of Representation in the Klamath-Siskiyou Forests. This case study provides an example of developing a surrogate for biodiversity (coarse filter target) in a data poor region.

- Conserving Ecological Processes in the Eastern Himalayas. This WWF ecoregion conservation team identified critical ecological processes with the Eastern Himalayas ecoregion that are critical elements of a biodiversity vision.

TOOLS

General/terrestrial

IUCN Redlist of threatened and endangered species at http://www.iucnredlist.org/

Threatened and endangered species data available at http://endangered.fws.gov

NatureServe biological data and species rankings can be downloaded at http://www.natureserve.org/getData/index.jsp

NatureServe's Ecosystem Mapping approach and data needs, with examples: http://www.natureserve.org/prodServices/ecomapping.jsp

EcoPath with EcoSim has three main components: Ecopath – a static, mass-balanced snapshot of the system; Ecosim – a time dynamic simulation module for policy exploration; and Ecospace – a spatial and temporal dynamic module primarily designed for exploring impact and placement of protected areas at http://www.ecopath.org/

Riparian Delineation Model is a largely automated method for mapping riparian areas consistently and quickly across large areas at a relatively coarse scale. The mapping employs the use of two AML scripts, a DEM and other widely-available GIS data. This method was developed for the Okanagan and North Cascades ecoregional assessments in order to map riparian ecological systems which are important but often poorly-represented terrestrial coarse-filter targets.

Landform Clustering is a method for classifying and mapping landforms via cluster analysis. The resulting landforms function as terrestrial coarse filter targets, and specifically as stratification units for matrix-forming ecological systems

BIOM 1.1 Nowicki et al. (2004) is a a computerized bio-climatic model for the extrapolation of species ranges and diversity patterns (see resources for citation)

WildFinder at www.worldwildlife.org/wildfinder is a map-driven, searchable database of more than 30,000 species containing information on birds, mammals, reptiles, and amphibians. Maps show location by ecoregion.

Freshwater

GIS Tools for Stream and Lake Classification and Watershed Analysis: a set of GIS tools used by TNC for regional-scale ecological classification of streams and lakes

Sowa et al. (2005). The Aquatic Component of Gap Analysis: The Missouri Prototype http://www.cerc.usgs.gov/morap/projects/aquatic_gap/sowa_etal_dod_legacy_final_report.pdf

Marine

Living Oceans Recipe for Benthic Complexity (Ardron 2002): Description of approach to developing representation of areas with high topographic relief. Areas having "rugosity" or high topographic relief often display great levels of ecological significance.

IKONOS, LandSat, satellite imagery: Recent development in processing and analysis methods for satellite imagery have led to increased capacity to remove the effects of both the atmosphere and the water column enabling grater utility for employing satellite collected information in marine ecosystems. Satellite information collection has become an effective means for mapping submerged aquatic vegetation, coral reefs, and other coarse filter marine targets.

NOAA Environmental Sensitivity Index was developed as a tool to identify coastal areas vulnerable to oil spills. Maps have been created for coastal areas throughout the U.S. Maps contain shorelines color-coded to indicate their sensitivity to oiling, sensitive biological resources, such as seabird colonies and marine mammal hauling grounds, and sensitive human-use resources, such as water intakes, marinas, and swimming beaches. Read the fact sheet for more information.

Defining Shoreline Conservation Targets using ESI data (Ferdana 2005). This method builds on a shoreline classification system developed by NOAA to create a regionally specific approach to target selection that can be rolled up across regions.

Coastal/Marine Systems of North America: Framework for an Ecological Classification Standard developed by NatureServe and NOAA.

ShoreZone is a methodology for mapping the biological and physical characteristics of the marine shoreline. Its application is can be read about in more detail in the Terrestrial, Freshwater and Nearshore Marine Target Selection in the Willamette Valley- Puget Trough-Georgia Basin Ecoregion case study.

NOAA Biogeography Benthic Habitat Mapping program will be creating benthic habitat maps, a habitat classification manual and a georeferenced mosaic of the raw imagery at http://biogeo.nos.noaa.gov/projects/mapping/

Topographic Position Index, (TPI) v. 1.01a. (Jenness 2005). Topographic Position Index (tpi_jen.avx) extension for ArcView 3.x. Jenness Enterprises. Available at: http://www.jennessent.com/arcview/tpi.htm

Benthic Terrain Modeler-This tool develops a benthic habitat characterization based on topographic analysis and input of geospatial information. Developed as an extension to ESRI ArcGIS see an Example from American Samoa.

Reef Resilience Principles and Toolkit was produced through the Transforming Coral Reef Conservation (TCRC) program, can be downloaded from http://www.nature.org/initiatives/marine/strategies/art12286.html

RESOURCES

Websites

Gap Analysis at www.gap.uidaho.edu

NatureServe Terrestrial Ecological Systems data download for the United States and Latin America and the Caribbean. http://www.natureserve.org/getData/ecologyData.jsp

National Wetlands Inventory at www.nwi.fws.gov

FISHBASE is a comprehensive database providing information about status and requirements of freshwater and marine fishes at www.fishbase.org

Partners in Flight physiographic areas and The Nature Conservancy's ecoregions (map) and bird list at http://www.blm.gov/wildlife/pifplans.htm.

Partners in Flight website with North American Landbird Conservation Plan http://www.partnersinflight.org/cont_plan/

NOAA Biogeography Program at http://biogeo.nos.noaa.gov/

NatureServe had developed a classification for ecological systems. The classification and report can be downloaded at http://www.natureserve.org/publications/usEcologicalsystems.jsp

Publications

Abell, R. M., M. Thieme, et al. (2002). A sourcebook for conducting biological assessments and developing biodiversity visions for ecoregion conservation. Volume II: Freshwater ecoregions. Washington, DC, USA, World Wildlife Fund.

Andelman, S. J. and W. F. Fagan (2000). "Umbrellas and flagships: Efficient conservation surrogates or expensive mistakes?" Proceedings of the National Academy of Sciences of the United States of America 97(11): 5954-5959.

Planning Methods for Ecoregional Targets: Eastern U.S. Conservation Region

> Anderson, M. G., S. L. Bernstein, et al. (2003). Planning methods for ecoregional targets: Species. Boston, MA, Eastern Conservation Science, The Nature Conservancy.
>
> Anderson, M. G., S. L. Bernstein, et al. (2003). Planning methods for ecoregional targets: Terrestrial ecosystems and communities. Boston, MA, Eastern Conservation Science, The Nature Conservancy.

Anderson, M. G., S. L. Bernstein, et al. (2003). Planning methods for ecoregional targets: Matrix-forming ecosystems. Boston, MA, Eastern Conservation Science, The Nature Conservancy.

Olivero, A. P., M. G. Anderson, et al. (2003). Planning methods for ecoregional targets: Freshwater aquatic ecosystems and networks. Boston, MA, Eastern Conservation Science, The Nature Conservancy.

Anderson, M. G., P. Comer, et al. (1999). Guidelines for representing ecological communities in ecoregional conservation plans. Arlington, VA, The Nature Conservancy. Available on the Conservancy's internet http://conserveonline.org/coldocs/2000/11/ecguide.pdf

Ardron, J. (2002). A GIS Recipe for Determining Benthic Complexity: An Indicator of Species Richness (draft). Canada, Living Oceans Society: 7 available at http://www.livingoceans.org/files/complexity_draft8.pdf

Carroll, C., R. F. Noss, et al. (2001). "Carnivores as focal species for conservation planning in the Rocky Mountain region." Ecological Applications **11**(4): 961-980.

Comer et al. (2003). Ecological Systems of the United States: A working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, Virginia. http://www.natureserve.org/library/usEcologicalsystems.pdf

Cowling, R. M. and C. E. Heijnis (2001). "The identification of Broad Habitat Units as biodiversity entities for systematic conservation planning in the Cape Floristic Region." South African Journal of Botany 67(1): 15-38.

Dinerstein, E., G. Powell, et al. (2000). A workbook for conducting biological assessments and developing biodiversity visions for ecoregion-based conservation. Washington, D.C., USA, Conservation Science Program, World Wildlife Fund.

Driver, A. et al. 2005. National Spatial Biodiversity Assessment 2004: priorities for biodiversity conservation in South Africa. *Strelitzia* 17. South African National Biodiversity Institute, Pretoria.

Fairbanks, D. H. K., B. Reyers, et al. (2001). "Species and environment representation: selection reserves for the retention of avian diversity in KwaZuluNatal, Sout Africa." Biological Conservation 98: 365-379.

Faith, D. P. and P. A. Walker (1996). "Environmental diversity: on the best possible use of surrogate data for assessing the relative biodiversity of sets of areas." Biodiversity and Conservation 5: 399-415.

Ferdana, Z., M. Gleason, et al. (2005). General Approach for Defining Shoreline Conservation Based on NOAA ESI Data (draft), The Nature Conservancy.

Ferrier, S. and G. Watson (1997). An Evaluation of the Effectiveness of Environmental Surrogates and Modelling Techniques in Predicting the Distribution of Biological Diversity. Canberra, AU, Environment Australia.

Grossman, D. H., P. Bourgeron, et al. (1999). Principles for ecological classification. Ecological Stewardship: A common reference for ecosystem management. R. C. Szaro, N. C. Johnson, W. T. Sextion and A. J. Malk. Oxford, UK, Elsevier Science. Volume 2: 353-393.

Groves, C. R. 2003. What to Conserve? Selecting Conservation Targets. In: Drafting a Conservation Blueprint: A practitioner's guide to planning for biodiversity. Island Press.

Heyman, Will, 2002. Reef Fish Spawning Aggregation Monitoring Protocol for the wider Caribbean. (Draft Document).

Higgins, J. V., M. T. Bryer, et al. (2005). "A freshwater classification approach for biodiversity conservation planning." Conservation Biology 19(2): 432-445.

Higgins, J.V., M. Lammert and M. Bryer. (1999). Designing a Geography of Hope Update #6: Including Aquatic Targets in Ecoregional Portfolios: Guidance for Ecoregional Planning Teams. The Nature Conservancy.

Halpin, P. N. (1997). "Global climate change and natural-area protection: Management responses and research directions." Ecological Applications 7(3): 828-843.

Hunter, M. L., G. L. Jacobson Jr., et al. (1988). "Paleoecology and the coarse filter approach to maintaining biological diversity." Conservation Biology 2: 375-385.

Iacobelli, T., K. Kavanaugh, et al. (1993). A protected areas gap analysis methodology: Planning for the conservation of biodiversity. Toronto, Ontario, World Wildlife Fund- Canada.

Josse, C. et al. 2003. Ecological Systems of Latin America and the Caribbean: A working Classification of Terrestrial Systems. NatureServe, Arlington, Virginia. http://www.natureserve.org/library/LACEcologicalSystems.pdf

Kingsford RT, Dunn H, Love D, Nevill J, Stein J, and Tait J (2005) Protecting Australia's rivers, wetlands and estuaries of high conservation value: a blueprint. Final consultant's report to Land and Water Australia, Canberra: Un-edited full report.

Kintsch, J. A. and D. L. Urban (2002). "Focal species, community representation, and physical proxies as conservation strategies: a case study in the Amphibolite Mountains, North Carolina, USA." Conservation Biology 16(4): 936-947.

Kirkpatrick, J. B. and L. Gilfedder (1995). “Maintaining integrity compared with maintaining rare and threatened taxa in remnant bushland in subhumid Tasmania.” Biological Conservation 74: 1-8.

Lambeck, R. J. (1997). “Focal species: A multi-species umbrella for nature conservation.” Conservation Biology **11**(4): 849-856.

Madden, Christopher J., and Dennis H. Grossman. 2004. Coastal/Marine Systems of North America: Framework for an Ecological Classification Standard. NatureServe, Arlington, Virginia.

Mehlman, D. and L. Hanners. 1999. Designing a Geography of Hope Update: Reflections of Current Thinking and Conversations. Update # 7. Incorporating Birds into the Ecoregional Planning Process. The Nature Conservancy

Mittermeier, R. A., N. Myers, et al. (1998). “Biodiversity hotspots and major tropical wilderness areas: Approaches to setting conservation priorities.” Conservation Biology 12(3): 516-520.

Nel, J. et al. 2004. South African National Spatial Biodiversity Assessment. Technical Report. Volume II. River Component. CSIR-Environmentek. Department of water affairs and forestry, Botanical Society of South Africa. CSIR Report Number ENV-S-I-2004-063.

Noss, R. F. (1996). “Ecosystems as Conservation Targets.” Trends in Ecology and Evolution 11: 351.

Noss, R. F. (1987). “From Plant-Communities to Landscapes in Conservation Inventories - a Look at the Nature Conservancy (USA).” Biological Conservation **41**(1): 11-37.

Nowicki, C., A. Ley, R. Caballero, J.H. Sommer, W. Barthlott & P.L. Ibisch 2004. Extrapolating distribution ranges - BIOM 1.1., a computerized bio-climatic model for the extrapolation of species ranges and diversity patterns. In: Vásquez Ch., R. & P.L. Ibisch (eds.) Orchids of Bolivia. Diversity and conservation status. Vol. 2. Laeliinae, Polystachinae, Sobraliinae with update and complementation of the Pleurothallidinae. Editorial F.A.N., Santa Cruz de la Sierra, Bolivia. 39-68.

Oliver, I., et.al. 2004. Land Systems as Surrogates for Biodiversity in Conservation Planning Ecological Applications 14(2) 485-503

Poiani, K. A., B. D. Richter, et al. (2000). “Biodiversity conservation at multiple scales: Functional sites, landscapes, and networks.” Bioscience **50**(2): 133-146.

Pressey, R. L. and A. O. Nicholls (1989). “Application of a numerical algorithm to the selection of reserves in semi-arid New South Wales.” Biological Conservation 80: 207-219.

Redford, K. H., P. Coppolillo, et al. (2003). "Mapping the conservation landscape." Conservation Biology **17**(1): 116-131.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W., Bradstreet, G. S. Butcher, D.W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J.S. Wendt, T. C. Will. (2004) Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY. (VERSION: March 2005).

Roux, D, F. de Moor, J. Cambray, and H. Barber-James. 2002. The Resiliance Alliance. Use of Landscape-Level River Signatures in Conservation Planning: A South African Case Study. Conservation Ecology 6(2): 6.

Simberloff, D. (1998). "Flagships, umbrellas, and keystones: Is single-species management passe in the landscape era?" Biological Conservation **83**(3): 247-257.

Smart, J. M., A. T. Knight, et al. (2000). A conservation assessment for the Cobar Peneplain Biogeographi Region- Methods and opportunities. Hurtsville, AU, New South Wales National Parks and Wildlife Service.

Sommer, J. H., C. Nowicki, et al. (2003). "Extrapolating species ranges and biodiversity in data-poor countries: The computerized model BIOM." Revista de la Sociedad Boliviana de Botanica 4(1): 171-190.

Ward, T.J., M. A. Vanderklift, A. O. Nicholls, and R. A. Kenchington. 1999. Selecting Marine Reserves using Habitat and Species Assemblages as Surrogates for Biological Diversity. Ecological Applications 92. pp 691-698.

West, J. M. and R. V. Salm (2003). "Resistance and resilience to coral bleaching: Implications for coral reef conservation and management." Conservation Biology 17(4): 956-967.

Whittaker, R. H. (1975). Communities and Ecosystems. New York, NY, Macmillan Publishing Co.

WWF Canada and CLF (2003). A Draft MPA Planning Framework for the Greater Gulf of Maine and Scotian Shelf, World Wildlife Fund-Canada and the Conservation Law Foundation: 73.