❖Standard 9: Screen all target/biodiversity element occurrences for viability or ecological integrity. [plan]

Rationale

The screening of target occurrences enables the development of a conservation portfolio/vision that builds on the best available examples of biodiversity in an ecoregion. A thorough understanding of target viability further enables investment in areas where populations and ecosystems can function in light of current and imminent threats and allows practitioners to determine the need for conservation or restoration efforts. Understanding the patterns of viability are central to measuring status and progress of effective conservation, informing conservation strategies, and as indicators of the impact of conservation actions.

Recommended Products

- Documentation of size, condition, and landscape context criteria and indicators used for viability/integrity assessment.
- Description of screening methodology for each target or target group.
- Viability/integrity rating (preferably in both spatial and tabular data formats) for all target occurrences (including list of screened occurrences, list of occurrences that met minimum thresholds, and list of occurrences with insufficient information).

GUIDANCE

The concept of persistence is embedded in the conservation goal of ecoregional assessments and biodiversity visions. The intention is to conserve native species, communities and ecological systems that will persist over time. The potential for persistence can be evaluated through assessing the viability of populations, and the ecological or biological integrity of communities and ecological systems. Viable populations maintain their rigor and potential for evolutionary adaptation (Soule 1987). Biological systems with integrity have the capacity to support and maintain the full natural range of biological elements and ecological processes (Karr and Chu 1995). Viable populations and communities and ecological systems with integrity can withstand and recover from natural and human-caused perturbations.

Assessing the viability or integrity of biodiversity targets and features is important for several reasons. Ecoregional portfolios and biodiversity visions identify areas of biodiversity significance that if conserved, will maintain the biodiversity of an ecoregion. It is critical that these areas are composed of populations, communities and ecological systems that are the best candidates for persistence, and they have an inherent capacity to maintain viability and integrity. Conserving areas with inherently persistent biodiversity is less costly and less risky that investing in restoration. Secondly, conservation goals suggesting the abundance and distribution of species, community and ecological systems needed to maintain them across an ecoregion, are dependent on having persistent examples in order to achieve those goals. Knowing the gap in achieving a conservation goal informs the need to inventory and identify more persistent examples of biodiversity, and to restore examples that are not currently viable or exhibiting integrity. Last but not least, measuring progress in conservation is dependent on knowing the distribution and abundance of examples of biodiversity targets that are viable or exhibit integrity, and the degree of progress towards meeting goals.

Populations, especially small ones, are subject to great influence by chance events. Demographic uncertainty – random events in the survival and reproduction of individuals, and genetic drift can have significant impacts on the viability of populations. The persistence of populations, communities and ecological systems are all influenced by environmental uncertainty - unpredictable events related to weather, predators and competitors, as well as natural catastrophes and disturbance events, such as hurricanes, fires and floods. Characteristics that help them to persist in the face of these events include their size, condition, and their landscape context.

No area should be included in an ecoregional portfolio or biodiversity vision unless its targets (at a minimum, the coarse-filter targets) have been screened for viability or ecological/biological integrity. While many of the methods presented below provide several categories that describe ranges of viability, at a minimum, a viable/non-viable classification should be completed. Below we describe approaches that are applicable for:

- both viability and integrity assessments
- assessing integrity, and
- assessing viability.

Approaches to viability and integrity assessments

There are a number of approaches to assess the viability and integrity of populations, communities and ecological systems. Our principal recommendation is for ecoregional planners to work with experts and apply the criteria of size, condition, and landscape context (described below) to as many occurrences of conservation targets as is possible and practical. As a first priority, we strongly encourage planning teams to develop viability specifications for ecological systems. Next in importance is for teams to assess the viability of finer-scale community and species targets.

A fairly rapid approach to defining population viability, and community and ecological system integrity is to use single or combined criteria (depending on available data) of size, condition and landscape context (Stein and Davis 2000):

- *Size* is the abundance/density of a population, or the area of a population or ecological system.
- *Condition* is the quality of biotic and abiotic factors, structures and processes within a population or ecological system occurrence, such as age structure, species composition, ecological processes and physical/chemical factors.

- *Landscape context* is the quality of structures, processes and biotic/abiotic factors of the landscape surrounding a population or ecological system, including degrees of connectivity and isolation to adjacent habitats, populations and ecological systems.

Criteria 1 - Size: At the population level, size is a measure of the area of occupancy by a species and/or its population abundance and density. All else being equal, larger populations are assumed to be more viable than smaller populations. Communities and ecological systems, are commonly impacted from large-scale natural disturbances, resulting in a diverse shifting mosaic of successional stages and physical settings. The necessary area needed to ensure survival or re-colonization from such disturbances (e.g., disease, fire, insect outbreaks, hurricanes) has been called the minimum dynamic area. For communities and ecosystems to persist over time it must be able to sustain, buffer, and absorb these disturbances and maintain these minimum dynamic areas. Size can be determined in two ways for ecological communities and systems. First, the home range of a species (usually a vertebrate) that is a typical occupant of that system and is at the higher end of the food chain can be used to estimate the size of the community or system (e.g., Flammulated Owl in ponderosa pine forests). Alternatively, there is a rule of thumb from the field of patch dynamics and disturbance ecology that suggests the size of a community or system needs to be the size of the largest natural disturbance to that community or system over a 500–1000 year time frame.

For aquatic communities and systems, large-scale natural disturbances like floods and droughts create a mosaic of habitat suitability. Aquatic organisms will often move to refugia during disturbance events and recolonize after habitat conditions become favorable again. A minimum dynamic area for aquatic systems must be large enough to ensure the linear connectivity of habitats at scales appropriate to the targets. As with populations, larger occurrences for communities and systems are generally preferable to smaller ones, especially for matrix types.

Criteria 2 - Condition: Condition is an integrated measure of the quality of biotic and abiotic factors, structures, and processes that characterize targets. Criteria for measuring condition include success and regularity of reproduction, presence/absence of competitors/predators, degree of anthropogenic impacts and presence of biological legacies.

- Anthropogenic impacts – fragmentation, presence of exotic species, alteration of natural disturbance regimes, pollution, and so on. Occurrences that contain relatively continuous cover of natural vegetation (i.e., less fragmentation) are more likely to have intact ecological processes and be free of invasive exotic species.
- Biological legacies – critical features of communities and systems that take generations or sometimes hundreds to thousands of years to develop. For example, in old-growth forests the presence of fallen logs and rotting wood, a well-developed herbaceous under-story, and structural complexity in the canopy are examples of biological legacies. As a general rule, the presence of a well-

developed structure and species composition that include characteristic, but also uncommon species, implies good habitat quality and some historical continuity. Those communities and systems that are depauperate in species composition for any of a variety of reasons make poor "coarse filters" In regions with high species diversity, but are important in regions that are naturally low in species diversity.

Criteria 3 - Landscape Context: For populations, landscape context is an integrated measure of two criteria: connectivity to other populations and intactness of surrounding ecological processes and environmental regimes. Although landscape context is important for all communities and systems, those patch and matrix types and aquatic communities and systems that depend on easily disrupted ecological processes occurring at a scale larger than the individual community are most at risk by what happens in the surrounding landscape (e.g., altered fire regime, altered flow regime, ground water pumping). A few patch communities such as those on raised bogs, perched wetlands, isolated lakes, and cliffs and rocky summits are more dependent upon atmospheric input of nutrients and water than the surrounding landscape. In general, communities and systems that are connected to or in proximity to other natural habitats are usually preferable to isolated examples.

In the United States and parts of Latin America, Natural Heritage Programs, Conservation Data Centers and NatureServe have developed and applied element occurrence ranks based on these criteria for many species and communities, and are developing them for ecological systems. Ranks of A (excellent estimated viability), B (good), C (fair), and D (poor) are available in their databases. Where these are available, they should be applied. Occurrences with a rating of Poor (D) should not be considered viable, and any Fair (C) ratings should be accepted with some caution. Such data will largely be available only for communities (i.e., plant associations, not ecological systems) and usually only for highly ranked (G1-G2) communities. If resources allow, expert opinion or site visits should be used to assess viability of community occurrences for which no information is available. Alternatively, GIS analytical approaches may be used to readily assess size and landscape context.

Integrity specific approaches

Approaches to evaluate ecological integrity include assessing the potential for communities and ecosystems to be composed largely of their native species, and have ecological processes and natural disturbances such as fires and floods operating within their natural range of variation (Groves 2003). Some principle criteria used to assess community and ecosystem viability is minimum dynamic area (Pickett and Thompson 1978) and natural flow regimes (e.g. Poff et al. 1997). In the United States, the Index of Biotic Integrity is a widely applied measure of freshwater ecosystems that can be obtained from state and federal Environmental Protection Agencies.

The most rapid method to assess community and ecological system integrity is to develop suitability indices using spatial information and other available data. These indices provide a way to evaluate the relative conditions and landscape contexts of spatial units such as ecological systems, watersheds, or comprehensive regular mapping polygons such as hexagons. The indices are built from combining information from several data layers. Data layers commonly used for terrestrial and freshwater indices include: number of sensitive species, percent natural land cover, road density, human population density, degree of fragmentation, and community/ecological system size (e.g. Moyle and Randall, 1998, Davis et al. 1999. See Groves 2003 for other examples). A readily available global data layer to assess anthropogenic impacts is the Human Footprint (see resources) which was developed using data indicating the extent of human population pressure, land use, infrastructure and access (Sanderson et al. 2002). Developing a suitability index in itself does not define thresholds for viability. Often, spatial patterns are categorized by quartiles or quintiles, and suitability indices identify clearly those targets that are affected the most by many factors, and are probably not viable, and those that are affected the least, and have the highest relative integrity. However, this does not ensure integrity. It merely provides an initial screening to identify those examples that are the best candidates for inclusion in an ecoregional portfolio or biodiversity vision because they have the best size, and are in the best condition and landscape context. Working with regional experts to define thresholds for integrity is strongly urged.

Viability specific approaches

Population viability analysis (PVA) is the quantitative assessment and modeling of the probability of a population to go extinct. What is most helpful to conservation planners is the minimum population size necessary to maintain viability. In addition to population size, understanding meta-population dynamics and the landscape context of single, large populations vs. many small, populations with immigration and emigration among them is helpful. Unfortunately, few species have had PVAs conducted on them, and most of them that have are in relatively data-rich areas. Groves (2003) suggests that PVAs are most helpful for site-based management planning, and generally not very helpful for regional assessments. However, if a planning team is interested in using PVA or other population viability assessments, they should consult available sources. In the United States, many PVAs have been applied to species listed under the Endangered Species Act, and there are recovery plans for listed species (see resources). Practitioners working internationally may find it useful to consult IUCN Action Plans (see resources) for endangered, critically endangered, and vulnerable species in order to assess the viability of target species' populations. These plans typically include a Population and Habitat Viability Analysis (PHVAs). This tool, developed by the IUCN Conservation Breeding Specialist Group, focuses on specific factors affecting the status of the population and recommends conservation action.

In the absence of rigorous population viability analysis, conservation planners have used rules of thumb: defining how many individuals are needed to maintain a population in the face of demographic, genetic and environmental uncertainties, as well as natural and human caused catastrophes. Recent analyses suggest a census population of 5000 individuals for many species (Allendorf and Ryman 2002). This is often unachievable. However, there are other approaches to maintaining species with lower population sizes including improving landscape context through increasing connectivity among geographically isolated populations (Groves 2003).

Empirical habitat suitability models have been developed for a variety of species, such as wide ranging carnivores (e.g. Carroll et al. 2001), birds and mammals (e.g. Block et al. 1994), and freshwater fishes (e.g. Filipe et al. 2004). These approaches can indirectly provide an indication of the potential for viable populations in a given habitat.

Key Steps

- Identify and use existing information on population viability analyses and management recovery plans for species, and viability/integrity rankings for communities and ecological systems. Develop criteria for acceptable levels of viability (e.g. A and B ranks from Natural Heritage Programs, C ranks with justifications), and for acceptable age of data (e.g. do not apply any ranks that are older than 20 years in a landscape that is undergoing measurable change).
- Identify available survey and spatial data, and methods to fill in gaps in viability/integrity assessments.
- Apply a method using GIS data and technology to evaluate size, condition and landscape context. Develop empirical models of spatial patterns and on-the-ground ranks to inform ranking criteria and thresholds (if possible).
- Work with regional experts to define criteria and ranks for viability/integrity using available information and spatial data in the framework of size, condition and landscape context. At a minimum, define viable/non-viable categories.
- Document data sources, procedures and decisions used to define viability/integrity.
- Document data gaps and next steps to fill gaps and to strengthen future assessments
- Document the number and distribution of target occurrences (examples) that are viable or have integrity, and measure the progress towards goals for these targets. Summarize using guidance in the Measures standard.
- NOTE: If a suite of targets do not have any occurrences that meet minimum viability/integrity criteria, the best examples can be included in a portfolio, but they cannot be included in progress towards achieving goals. They will be initial restoration priorities.

OPPORTUNITIES FOR INNOVATION

Assessing viability and integrity is a new component of regional conservation planning, and should be treated as developing testable hypotheses. The most outstanding questions are:

1) Are the thresholds that are being defined for viability and integrity accurate and meaningful?
2) How well do spatial data and suitability indices inform the viability of conservation targets?
3) What are the relationships between environmental variables and viability/integrity of targets? Are they linear, exponential or geometric?
4) When developing a suitability index, is it most appropriate to weight all variables the same, or should some be weighted more than others?
5) How do different environmental variables interact, and how should these interactions be taken into account when using them to assess viability and integrity?

Most viability and integrity thresholds are defined in an informed manner, but lack the empirical data to reflect accuracy. They tend to provide categories that reflect the relative but not actual viability or integrity among occurrences. Using such thresholds, it is easy to identify occurrences that have the highest or lowest potential for persistence. For instance, quartiles are often used in developing suitability indices. The top quartile does not necessarily define a meaningful cut off of viability. It merely defines the 25% of occurrences with the highest opportunity for persistence. There are, however, some good empirical studies evaluating biological data and spatial data to explore minimum dynamic area requirements (e.g. Anderson et al. 2004), and relationships between land use/cover and aquatic ecosystem integrity (e.g. Jones et al. 2001, Moyle and Randall 1999, Roth et al. 1996). More empirical studies on spatial patterns and biodiversity viability and integrity should be conducted by conservation planners and researchers in order to explicitly test the assumptions being made in their assessments. We know so little about the patterns and thresholds of viability and integrity and how they correlate to complex environmental patterns and processes. However, if we are explicit about our assumptions, ignorance and important next steps, we can move forward to strengthen our work.

CASE STUDIES

- Ecological Integrity of Grasslands in the Apache Highlands Ecoregion. The Apache Highlands Ecoregional Assessment team conducted a detailed assessment of the ecological integrity of grasslands throughout the ecoregion in order to identify the best remaining examples of native and restorable grasslands.

- Derivation of Suitability Index Yakima/Palouse EDU Washington. A suitability index was developed from five indicators of freshwater system integrity—land use, dam density, riparian buffer width, land ownership and irrigated land. This index was then used as a cost surface in a portfolio selection algorithm.

- Assessing the Quality and Threats to Aquatic Targets. This summary provides an overview of viability/integrity assessments of freshwater target occurrences and discusses size, condition and landscape context as it pertains to the freshwater biome.

- Assessing condition/integrity of ecosystems: using spatial data to develop suitability indices. This summary provides a series of brief examples highlighting the use of spatial data for viability/integrity assessments for terrestrial and aquatic systems.

- Focal species and minimum area requirements in Southwestern Amazon. In the absence of data identifying minimum area requirements to sustain viable populations of biodiversity targets, an umbrella species approach was used to estimate minimum block size.

TOOLS

Terrestrial/general

Guidelines for representing ecological communities in ecoregional conservation plans (Anderson et al 1999).

The Human Footprint is a downloadable dataset. Nine global data layers were used to create this global "human footprint" map. The layers covering the following themes: human population pressure, human land use and infrastructure and human access.

A practical handbook for population viability analysis (Morris et al.1999). An introduction to methods for assessing viability. This document also provides information on **software programs** available for PVA such as those for estimating viability from census counts over several years and for programs that use more detailed demographic data (RAMAS, ALEX, Vortex).

NatureServe summary of *Population Viability Analysis* in the context of ecological stewardship.

WWFs "Assess landscape integrity to estimate long-term persistence of biodiversity" document is a summary of an approach to determining landscape Integrity. This document contains a list of suggested readings on the topic. A table summarizing biodiversity elements conserved and lost and varying levels of landscape integrity is also available here. From WWF (2002).

Freshwater

Guide to information for assessing quality and threats to biodiversity of freshwater systems (DePhilip 1999).

The Indicators of Hydrologic Alteration (IHA): Software for Understanding Hydrologic Changes in Ecologically-Relevant Terms. Software and training information available at http://www.freshwaters.org/tools/

RESOURCES

Websites

Element Occurrence Ranks available in North America from Natural Heritage Programs and Conservation Data Centers (http://www.natureserve.org)

IUCN Species Survival Commission Action Plans are available on IUCN web site http://www.iucn.org/themes/ssc/index.htm

Recovery Plans for federally listed Endangered Species – see http://www.fws.gov/endangered/recovery/index.html for list of available recovery plans

NatureServe web site describing criteria they use to define population viability is available at: http://www.natureserve.org/explorer/popviability.htm

Sustainable Waters Program has information on freshwater viability and assessment tools at www.freshwaters.org

Publications

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Woodley, S.: 1993, 'Monitoring and Measuring Ecosystem Integrity in Canadian National Parks', in: S.Woodley, J. Kay and G. Francis (eds), Ecological Integrity and the Management of Ecosystems. St-Lucie Press, Florida. p. 155–176 --degree of human disturbance; rates of succession; species richness; average body size of mammals; population of an indicator species; efficiency of nutrient cycling; degree of fragmentation; population viability of threatened species.