Technical Guidance on Selecting Species for Landscape Scale Conservation

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Preface

This document provides technical guidance for selecting and using *surrogate species*[1] as measurable biological objectives in *landscape*[2] conservation planning and management. Using surrogate species as a conservation management tool reduces the burden of addressing the requirements of many species individually. This guide also describes how to identify and choose among different surrogate species approaches, discusses advantages, limitations, and conservation applications of those approaches, and offers assistance in developing an adaptive approach. The guide does not prescribe a single surrogate approach, but guides practitioners in choosing or developing methods based on state-of-the art information that is well documented, transparent, and linkable across multi-partner, multi-program conservation efforts.

Introduction

The U.S. Fish and Wildlife Service (FWS) and State, Federal, and Tribal governments are entrusted by law with conserving, protecting, and enhancing fish and wildlife and their habitats for the American people. Together, they work with nongovernment conservation organizations, business and industry, and private individuals to ensure healthy and sustainable populations of fish and wildlife at levels the American public expects. The challenges they face in accomplishing their collective missions and conservation goals are immense and growing. Chief among these are an increasing human population with growing demands for land, water, energy and other resources; current and anticipated impacts of climate change on habitats and

[1] The first time a term with a glossary definition is used in this document, it will be italicized and hyperlinked to the glossary. Please see the glossary for the term's definition per this guidance document (Appendix A).
[2] The term landscape, as used in this guidance document, also encompasses waterscapes/seascapes.

species; habitat loss due to changes in land use and fragmentation; invasive species; and difficult economic realities.

Large scale issues such as global warming and increasing human population pressure on natural resources are better addressed through *ecosystem* oriented solutions at the landscape scale (Millard et al. 2012). Fortunately, many conservation organizations are working with partners and stakeholders across ecologically meaningful landscapes to ensure more effective conservation of fish, wildlife, plants, and their habitats (Bottrill et al. 2006). For example, in 2005, State fish and wildlife agencies worked with partners to create *State Wildlife Action Plans* that identified Species of Greatest Conservation Need and established priority habitats and landscapes within each state (see http://teaming.com/state-wildlife-action-plans-swaps).

FWS has been pursuing a systematic, science-driven, partnership approach to conservation by implementing *Strategic Habitat Conservation* (U.S. Fish and Wildlife Service and U.S. Geological Survey. 2006; http://www.fws.gov/landscape-conservation/pdf/SHCReport.pdf). Strategic Habitat Conservation (Figure 1) relies on an *adaptive management* framework to identify the information, *management actions*, and monitoring needed to achieve conservation goals effectively and efficiently. With full implementation of Strategic Habitat Conservation across all its programs, FWS envisions:

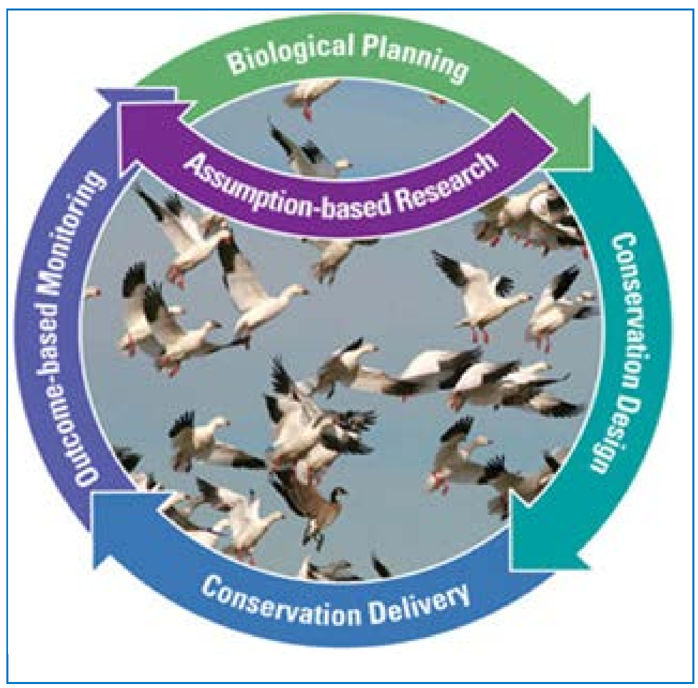


Figure 1. Strategic Habitat Conservation

- Explicitly linking the work of individual programs and field stations to sustaining species, populations, and natural communities as parts of whole systems and their ecological functions and processes;
- Using scientific information and predictive models to link work at project scales to conservation achievements on broader scales, such as landscapes, watersheds, major ecoregions, and entire species ranges;
- Focusing on measurable biological objectives (sustainable fish and wildlife populations and/or the habitat conditions that support them);
- Increased emphasis on organizational accountability and collaboration across FWS regions and programs, as well as with State fish and wildlife agencies and other conservation practitioners, to achieve common goals; and
- Increased emphasis on transparency, public participation, and engagement.

The Strategic Habitat Conservation Handbook (U.S. Fish and Wildlife Service. 2008) provides details on the concepts and application of the technical elements of Strategic Habitat Conservation. This document is intended to supplement the *Biological Planning* portion of that guidance with a more thorough process for considering and selecting species to be used for *landscape-scale conservation* planning. The handbook endorses the selection of focal species "to represent the needs of larger guilds of species that use habitats and respond to management similarly." Focal species are one type of surrogate species; this guide examines current scientific thinking on the use of a broader suite of surrogate species approaches and makes recommendations for when and how they can be used in Strategic Habitat Conservation.

This guide was developed under the direction of the FWS Strategic Habitat Conservation Executive Oversight Team with participation by State fish and wildlife agency partners and will be updated as needed. An agreement describing a framework for the U.S. Fish and Wildlife Service (FWS) and State fish and wildlife agencies (States) to work together in the selection of surrogate species has been developed (Appendix E). The agreement establishes a peer-to-peer relationship between FWS and States, respects the different authorities and responsibilities of the organizations, and clarifies and distinguishes the decision-making roles of States and FWS.

Introduction to Surrogate Species

In the last few decades, ecologists and conservationists increasingly worked at larger geographic scales to improve their ability to characterize and combat complex *threats* such as habitat fragmentation and human population growth (Groves et al. 2002; Bottrill et al. 2006). When conservation is planned for and carried out at larger scales, it is often easier to detect ecological patterns and population dynamics than when it is conducted within smaller geographic units. Working at larger scales improves the ability of conservationists to address *limiting factors* and achieve long-term benefits to species of plants and animals.

While a landscape approach to conservation offers significant benefits, it also presents limitations. For example, it is impractical to plan and implement conservation for all species and their habitat requirements at larger landscape scales. Given that agencies and organizations have limited resources, choosing a subset of priority *conservation targets* on which to focus, such as surrogate species, is often a necessary and prudent approach to conservation (Simberloff 1998; Caro and O'Doherty 1999; Groves et al. 2002; Bottrill et al. 2008; Wiens et al. 2008; Caro

2010). Chosen wisely, surrogate species can help inform conservation practitioners about where to direct efforts and what potential strategies to use (Groves et al. 2002; Caro 2010). A surrogate species approach assumes that by carrying out *management strategies* that produce *ecological conditions* favored by a smaller set of species, the needs of a larger number of species will also be met.

The usefulness of the surrogate approach depends on the size of the geographic area under consideration, as well as the relative species richness of the area. When the geographic scale is small, with relatively fewer species, it may be feasible to consider each species and their ecologicalrequirements individually. As the geographic scale and number of species increase, it becomes more difficult to consider all species, necessitating a method to simplify conservation of the overall landscape. At a landscape, or ecoregional scale, the surrogate approach may be a practical way to model the complexity of the system and ensure many species and other key ecological features benefit from conservation activities. This is known as the *surrogate zone* (Figure 2). At much larger geographic scales such as regional or continental levels, it becomes difficult to ensure all species can be represented using the surrogate approach (Wiens et al. 2008).

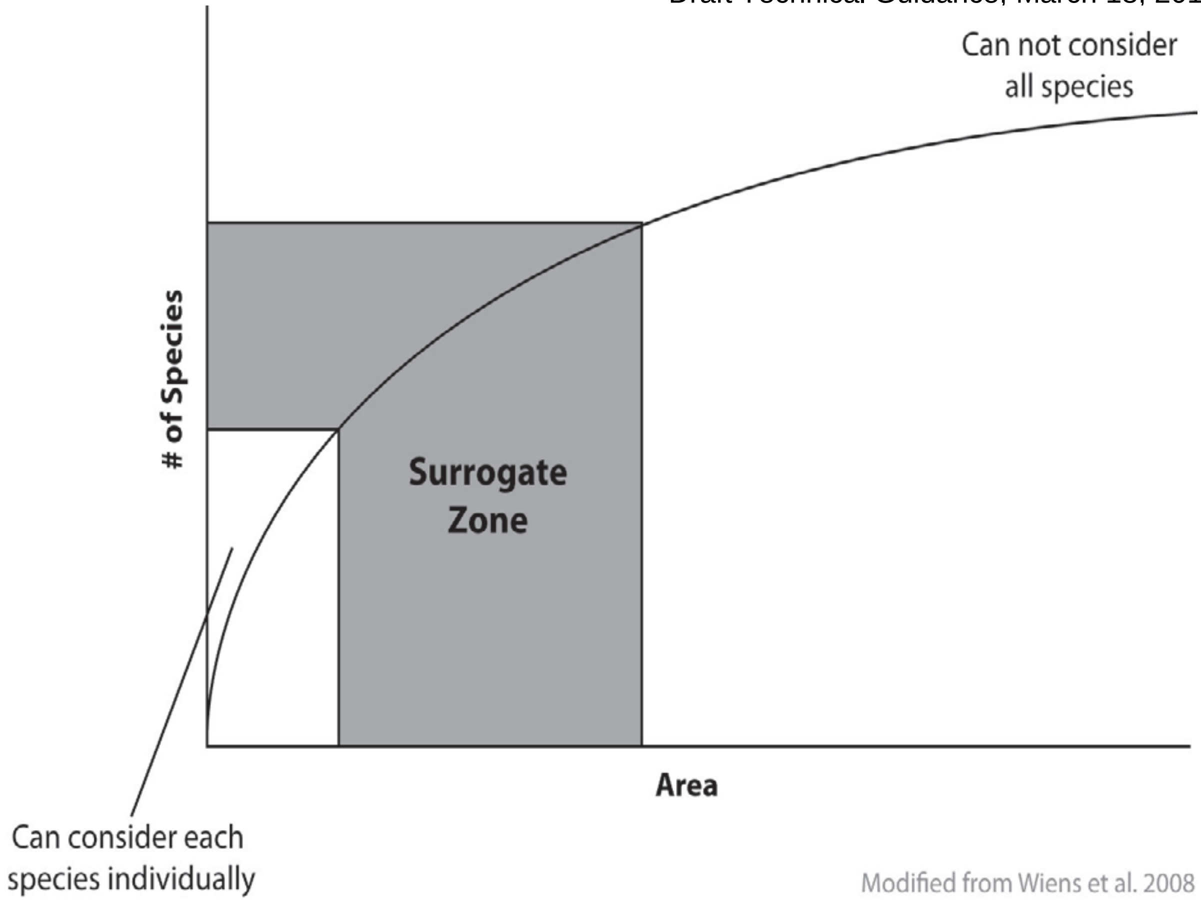


Figure 2. Graph of the surrogate zone concept, adapted from Wiens et al. 2008.

The scientific literature regarding the definition and use of surrogate species in conservation planning is exhaustive (Brock and Atkinson 2013; Martino et al. 2005). The book, Conservation By Proxy (Caro 2010), currently the most comprehensive literature review available on the subject, details both the benefits and limitations of using surrogate species approaches. Some of the author's principal findings relevant to this guide are listed below:

- "Surrogate species approaches are often necessary shortcuts to pursuing conservation goals/objectives;"
- Surrogate species approaches need empirical evidence to demonstrate successful practical application;

- Effective use of surrogate species requires precise and consistent use of concepts;
- The suitability of any particular surrogate species approach (e.g., umbrella, indicator, flagship) depends on the specific conservation goals/objectives of the application; and
- Implementation of surrogate species approaches should involve stakeholders and land-use planners and include socioeconomic considerations.

No surrogate species approach will fully represent the conservation needs of all species in the landscape; all have limitations (Appendix B). Additional planning and management likely will be required to conserve other species and non-species targets. For example, surrogate species approaches may not adequately address a disease or management concern unique to a few species or a critically endangered species having unique habitat requirements. Likewise, surrogate species approaches cannot meet the needs of every conservation organization's mission and mandate, and should be used in combination with other conservation methods and tools as appropriate.

It is critical to understand the concepts, goals, terminology, methodologies and appropriate applications of different surrogate species approaches in order to implement the approach that will best meet intended conservation objectives for a landscape and allow evaluation of the effectiveness of conservation and management actions. Conservation goals should dictate the surrogate species approach chosen, the criteria used to select surrogate species, and the monitoring required to determine if the chosen approach achieves intended outcomes. Caro and O'Doherty (1999) caution that "both the goals and selection criteria of different surrogate classes differ substantially,

> "Caro and O'Doherty (1999) reviewed surrogate species approaches and argued their efficacy has been impeded by the haphazard use of terminology and methods (see also Caro 2010). They recommended that surrogate species approaches be used with greater care and that species should be chosen according to explicitly stated criteria designed to meet previously defined conservation goals." (Brock and Atkinson 2013).

indicating that they should not be conflated" and that "surrogate species need to be used with greater care if they are to remain useful in conservation biology."

With cooperative planning at the landscape scale, there is often more than one goal and a number of priorities that need to be addressed. Therefore, it may be appropriate to use a variety of different surrogate approaches to meet different goals. Factors to be considered should include cost-effectiveness, risk, uncertainty, spatial and temporal scale, and urgency. A surrogate species approach should be used only when, due to budget limitations or other constraints, it is more likely to conserve a large number of species than alternative approaches that attempt to address each species individually.

Even with these limitations, the use of surrogates may be a practical step in an adaptive approach that will be refined as conservation organizations develop collaborative capacity, use and develop new techniques, and improve the understanding of how landscape features and *ecological processes* affect conservation goals. Greater experience in practical application of surrogate species approaches can advance their assessment and potential improvement (Favreau et al., 2006).

Adaptive management allows structured and science-informed decisions to be made, even in the face of uncertainty, and gives practitioners the flexibility to adjust their choices along the way (Allen et al. 2011). To adaptively use a surrogate species approach, all assumptions, decisions, reasoning, and uncertainties made and encountered throughout the process must be documented. Equally important is a commitment to monitor results, test assumptions, evaluate outcomes, reduce uncertainties, and refine the approach.

Table 1. One surrogate approach, examples of surrogates selected, and sources.

Conservation Goal	Surrogate Approach	Examples	Source	Other Sources
Our goal is to define areas of conservation significance (i.e. composition, configuration, and function for reserve design, to inform conservation/management actions, etc.)	Umbrella/ Land-scape	• Florida's Closing the Gaps Program (multiple species)	• http://research.myfwc.com/publications/publication_info.asp?id=48583	• Caro 2010 • Brock and Atkinson 2013 • Roberge and Angelstam 2004 • Sanderson 2002 • Lambeck 1997 • Coppolillo et al 2004
		• Northern spotted owl (*Strix occidentalis caurina*) endangered bird species	• Meffe and Carroll 1997	
		• Tapir, sun bear, tiger, and sambar deer (Reza et al. 2013).	• Syrbe et al. 2013	
		• Sand martin (*Riparia riparia*)	• Heneberg 2012	

Biological Planning

The biological planning element of Strategic Habitat Conservation is used to identify clear goals and objectives and compile the information necessary to achieve them. Goals and objectives provide the motives for investing in a particular action, habitat or location. For the purposes of biological planning, a goal is a descriptive, open-ended, and often broad statement of desired future conditions that conveys purpose, but does not define measurable units. An objective elaborates on a goal. It provides a concise, measurable statement of what is to be achieved. The goal of the surrogate species method, as described in this document, is the conservation of *functional landscapes* capable of supporting *self-sustaining populations* of fish, wildlife, and plants for the continuing benefit of society. Biological objectives in support of that goal will include population and habitat objectives for surrogate species, as well as other conservation targets identified through biological planning.

This section provides guidance on selecting a surrogate approach and surrogate species for a given landscape. The first part details important overarching considerations required during the process of information gathering and surrogate species selection; the second provides guidance on how to set the stage for surrogate species selection by acquiring information critical to the selection process; and the third provides specific guidance on a step-by-step process for selecting and implementing a surrogate species approach. Also provided is guidance on establishing measurable, *outcome-based biological objectives* for selected surrogate species.

Overarching Considerations

Throughout the Strategic Habitat Conservation process, and in particular during the biological planning phase, the following considerations should be at the forefront of every decision:

The dynamic nature of landscapes. Consider any potential changes that may take place across the object landscape during the proposed management period. Also, take into account both the natural dynamics of a landscape's ecological and physical processes and any potential changes predicted to occur as a result of *stressors* such as climate change or urbanization (see Box 1). It is critical to use the best available science regarding such ecosystem level drivers and stressors when setting goals and priorities, and selecting surrogates. When possible, these potential changes should be analyzed up-front, and probable landscape scenarios should be considered.

Science excellence. All information used should be evaluated to ensure it is reliable, credible, and represents the best scientific understanding available. Primary and original sources of information should be relied upon as the basis for making recommendations or decisions whenever possible. Peer review by subject matter experts should be conducted to ensure the most current and accurate information is utilized.

Transparency. Both social and ecological sciences need to be considered when making any natural resource decisions. The role of human values in decision making and ultimately in achieving natural resource objectives must be taken into account (Williams and Johnson 2013). People' values, traditions and culture influence their perceptions of the value of natural resource conservation, land uses and other factors relevant to functional landscapes. Articulation of the underlying reasoning for decisions, including the role of values, makes the decision making process more understandable and transparent and helps clarify disagreements that may arise over the expected outcomes (Lee 1993).

Logic and consistency. Ensure that logic and consistency are used throughout the process. For example, after a set of candidate surrogate species has been identified, it is important to assess how well those surrogates likely will perform as representatives of the other species and/or aspects of the environment relative to conservation goals. Document any priority species that will not be adequately represented and will require individual attention. Testing for logic and consistency may be achieved by re-evaluating the literature, comparing a series of alternative conservation scenarios, testing *ecological models* (conceptual or other) for the landscape, and/or consulting with experts on the subject.

Coordination, consistency, and continuity across jurisdictional boundaries. By definition, the benefits of biological planning at a landscape scale diminish if conservation efforts among landscapes are disjunct, particularly when addressing needs of wide-ranging species and *landscape attributes* that may cross multiple jurisdictions. Consistent terminology and metrics, corresponding geographic and temporal scales, and close coordination among landscape planning efforts should be employed, with exceptions limited to a minority of circumstances (e.g., geographically isolated and unique areas such as remote island ecosystems).

Box 1. Climate Change Considerations for Landscape Conservation Planning

Climate change must be considered when making conservation decisions affecting the future of our landscapes. The National Fish, Wildlife and Plants Climate Adaptation Strategy (National Fish, Wildlife and Plants Climate Adaptation Partnership. 2012) provides recommendations for making consideration of climate change a part of landscape conservation planning (www.wildlifeadaptationstrategy.gov).

Things to consider include:

- *When climate changes, species move, and communities change.*

In past periods of climate change, species distributions have shifted independently of each other (Hunter et al. 1988, Graham et al. 1996, Jackson and Overpeck 2000, but see Lyons 2003)). Natural communities have not shifted in space, but rather have changed species composition through time (Hunter et al 1988, Graham et al. 1996, Jackson 2006, 2012). The natural communities recognized today are assemblages of species in which each species is responding to its own particular needs. As species respond to climate change in different degrees, rates, and directions, long recognized communities may break up and new communities will emerge (Hellmann 2012). The species or natural community a surrogate represents today may not be the same set of species or community tomorrow.

- *Climate zones aren't just going to move, some will disappear and novel zones will emerge.*

As the climate continues to change into the future, existing well known climate zones won't just shift around in space, some will disappear altogether, and entirely new (novel or no-analog) climate zones will emerge (Williams and Jackson 2007, Fox 2007). Species that may be well suited as surrogates for a particular suite of species in current climate zones may no longer be able to exist with the same suite of species under a novel climate.

- *Both stationarity and perpetuity are dead.*

In the past, humans have tended to view the natural world as variable, but within a more or less fixed band of variability. For example, meteorologists could describe a storm as being a "hundred-year storm" or a "five-hundred year storm." Climate change challenges these assumptions. Many conservation investments have been made for a species or natural community in "perpetuity." But with continued, unabated emissions of greenhouse gases, there really is no end or plateau in sight for further climate change. Thus, the conservation value of an action or even an area will not be constant through time; they will be time dependent.

As the climate changes, so too will the relationship of species to each other and the new communities they form, and we can expect continuing changes in such things as species' abundances and relationships and community composition. Thus, any level of surrogacy will be time-dependent as well.

This document describes an iterative process for selecting surrogate species adapted from numerous sources within the literature. An important consideration, climate change should be discussed at each decision point in the process of selecting species. Call-out boxes will be used within the document to call attention to the climate change considerations that should occur at particular places in the decision process.

Setting the Stage

Before selecting a surrogate approach and a subset of surrogates for biological planning and conservation design, the following key attributes should be identified for the given landscape. This information helps define the *conservation challenges* for the *species of conservation interest*[3]:

- Geographic scale -- the geographic boundaries of the landscape
- Critical participants -- subject matter experts, partners, stakeholders, and others to engage in the planning, design, and implementation process for the selected landscape
- Temporal scale associated with biological planning for the landscape
- Species of conservation interest – including information on abundance, distribution, life history, limiting factors, etc. within the landscape
- Landscape characterization – key landscape attributes, including threats, for the selected geography based on current and future conditions.

Geographic Scale: First determine the boundaries of the landscape to be considered during biological planning. Although much information exists concerning the concept of landscapes, landscape-scale conservation, and landscape ecology (Turner 1989, Forman 1995, Turner 2005), there is no widely accepted definition of a landscape. However, in general, landscapes are areas, typically larger than a few

Climate-driven shifts in species and community distributions may change appropriate scales for selecting species, or what is considered to be "ecologically meaningful subunits" over time. It will be important to regularly revaluate whether the selected scale is still appropriate or if expansion or contraction is needed. Connectivity between subunits should be considered, as populations declining in one area (such as the southern end of their range) may be increasing elsewhere.

Box 2. Geographic Scale Climate Change Consideration

[3] Species of conservation interest are species that the FWS, States, and/or partners have identified as being in need of conservation within the landscape. Conservation of many of these species may ultimately be addressed through efforts devoted to providing the conditions within the landscape needed to support the smaller subset of surrogate species.

square kilometers, with similar unifying characteristics (i.e. biomes, ecoregions, watersheds, etc.), but are heterogeneous in composition, especially in terms of vegetation communities, ecosystems, and physical and environmental factors (Adapted from Bottrill et al. 2006). There is no standard by which to gauge if the selected landscape is too small or large.

In setting the geographic boundaries, the following factors may be considered:

- Ecological distinctiveness from adjacent landscapes
- Ecological connectivity within the landscape, both for aquatic and terrestrial systems
- Heterogeneity of vegetation communities and ecosystems within the landscape
- Ability to maximize efficiency and effectiveness of using a surrogate species approach (See Figure Two)
- Ability to align with boundaries of adjacent landscapes to form a seamless regional and/or national framework
- Ability to integrate with existing conservation planning units among the partners involved in biological planning (e.g., State Wildlife Action Plans, Landscape Conservation Cooperative geographic framework, migratory bird Joint Venture boundaries).
- Feasibility to work within a particular geography with respect to scale and resolution of input data (e.g. climate models, species-habitat models) and the ranges of the associated species of conservation interest.
- Availability of resources to support simultaneous biological planning within multiple landscapes (e.g., a large number of smaller landscapes may create more workload than a smaller number of large landscapes.)

- Jurisdictional boundaries of the responsible organizations and funding sources.

Absent other suitable geographic schemes, first consider using the Omernik Ecoregion classification system (Omernik 1987) to promote connectivity among selected landscapes. Geographic boundaries may need to be adjusted to maximize effectiveness based on insights gained as the process unfolds (e.g., during the selection of surrogate species).

Critical Participants: It is important to engage potential partners, not only to define the geographic units for landscape planning, but also to carry out subsequent steps. Once a selected landscape is identified, it is critical to involve all relevant partners, stakeholders, and subject matter experts in evaluating the landscape, determining the associated temporal scale and selecting the surrogate approach and surrogate species. Key skill sets should be identified, based on the attributes of the selected landscape, and should guide recruitment of participants.

Temporal Scale: Define the timeframe or planning horizon. Partners should determine not only how far in the future to plan for the landscape, but also how far back to look when considering historical data. Furthermore, since this is part of an adaptive management process, the planning horizon should reflect the timeframe for completing and monitoring *conservation actions* and how often the planning process will be updated. Both ecological and socio-economic conditions should be considered when setting the planning horizon, and should be made with consideration of climate change and other system changes and variations likely to occur. The planning horizon should be established explicitly and transparently to enable biological compatibility and continuity across multiple landscapes and to promote collaboration and coordination at larger geographic scales. Varying the planning horizon end point can significantly affect the outcome of ecological assessments (Bertesmeier et. al., 2013). Applying several different time frames, and testing the logic and consistency of each, may be appropriate and advantageous.

Species of Conservation Interest: Species of conservation interest may include (but are not limited to):

- Species for which there is a legal conservation mandate on the landscape (e.g., listed under the Endangered Species Act, State protection);
- State Wildlife Action Plan species of greatest conservation need (SeeAppendix E) for State-Service agreement on selecting species that fall under the state jurisdiction);
- Species listed on the International Union for Conservation of Nature (IUCN) red list (IUCN 2013);
- Priority species identified by Partners in Flight, Landscape Conservation Cooperatives, Partners for Amphibian and Reptile Conservation, Joint Ventures, National Fish Habitat Partnership, and other cooperative efforts;
- Game species.

> *It may be valuable to include species that are likely to be particularly vulnerable to climatic shifts, even if they are not currently of concern, to ensure they are represented by the surrogate species selected. Other "non-priority" species such as potentially invasive or non-native species likely to move into a region as climate conditions shift should also be considered.*

Box 3. Species of Conservation Interest Climate Change Consideration

Conservation of many of these species may ultimately be addressed through efforts devoted to surrogate species chosen later in the process. However, it is important to clearly define all species of conservation interest first, since the conservation challenges and desired outcomes identified for the landscape are related to this larger group of species, not just the surrogates.

The surrogates, rather, are a tool to be used to help attain the landscape conditions needed to support the species of conservation interest at the desired levels. Once species of conservation interest have been identified, key aspects about each species should be summarized. This information should include, but is not limited to:

- Life history traits
- Habitat requirements for each life history stage
- Limiting factors
- Current range, and any existing projections associated with the selected planning horizon
- Spatial requirements for a viable population (e.g., area, connectivity, configuration)
- Population objectives, if established
- Existing conservation and/or monitoring programs

Characterization of the Landscape: The following key landscape attributes should be defined for the selected geography based on the current and predicted state (if available) of the landscape:

- Composition and configuration of existing habitat types (e.g., early successional forest) and other landscape features
- Connectivity of aquatic and terrestrial ecosystems, and existing corridors for migratory species Current land uses, including protection/management/ownership status
- Physical disturbance regimes, both natural and anthropogenic
- Succession types and rates

Any attempt to project the conditions within a landscape and assess how well surrogate species meet the needs of species of conservation interest requires the consideration of climate change projections and models for future conditions. This is complicated by the need to consider the potential for novel climates and species assemblages.

Box 4. Landscape Characterization Climate Change Consideration

- Projections of future landscape conditions (e.g., temperature and precipitation due to climate change, land use due to urban growth, etc.) based on the temporal scale selected

- Known existing and future threats to landscape function related to species of conservation interest and associated limiting factors
- Any other components that help portray the *ecological integrity* of the landscape

Selecting the Surrogate Approach and Surrogate Species

This section provides guidance for first selecting a surrogate species approach, then surrogate species associated with the selected approach for a given landscape. It also provides advice on setting measurable population objectives for the surrogate species selected.

To identify the best-fitting surrogate approach(es) and corresponding surrogate species, it is vital to clearly define how they will be used to help achieve conditions on the landscape needed to support the species of conservation interest. Each surrogate approach and set of surrogate species selected will be unique to the conservation goals and challenges for a given landscape. The following actions may be taken when selecting a surrogate approach and the surrogate species associated with that approach:

- Define the Conservation Goal and Challenges
- Select the Surrogate Approach(es)
- Establish Surrogate Species Selection Criteria
- Employ Available Decision Support Tools for Selecting Species
- Select Surrogate Species
- Develop Biological Objectives

1. Define the Conservation Goal and Challenges: It is vital to first identify the conservation goal(s) for using surrogate species. Under the Strategic Habitat Conservation framework, the goal is conservation of populations of fish and wildlife and the ecological functions that sustain them (U.S. Fish and Wildlife Service and U.S. Geological Survey. 2006). In this guide, that goal has been re-stated as "functional landscapes supporting self-sustaining populations of fish, and wildlife and plants for the continuing benefit of society." For the purposes of selecting a surrogate approach, this can be simplified as "sustainable populations of species of conservation interest." With that goal in mind, the next step is to identify the conservation challenges facing the species of conservation interest in the identified landscape. These conservation challenges help define the components of the landscape needed to support those species, and help in the selection of the surrogate approach and the surrogate species. Although not measurable, these challenges help clarify expected achievements.

2. Select the Surrogate Approach: Most conservation researchers (Caro 2010; Brock and Atkinson 2013) identify 3 major categories of surrogate species approaches:

1. Selecting species to define areas of conservation interest;
2. Selecting species to document effects of environmental or management conditions; and/or
3. Selecting species to engender public support.

These and other approaches are described more fully in Appendix B. Using the identified conservation goal(s) and information gathered in the setting the stage section, you can choose the most appropriate surrogate approach for the identified landscape. In most cases the surrogate approaches selected for Strategic Habitat Conservation will help define landscape conditions such as habitats, features, and processes needed to support species of conservation interest. Given the diverse challenges and stakeholders within many landscapes, multiple surrogate approaches may be needed to achieve a set of desired conservation outcomes and objectives for a landscape. The approaches must be clearly defined, and the conservation goals and desired outcomes clearly articulated, to ensure selection of the most appropriate and effective surrogate species.

3. Establish Surrogate Species Selection Criteria: The next step is to establish surrogate species selection criteria that are specific to the surrogate approach selected and to the way surrogates species will be used to help address the conservation challenges on the landscape. Criteria defined in the literature for particular surrogate approaches can be used as a starting point (see Appendix B), but should not confine the final list of criteria used to select surrogate species. This guide focuses on the selection of species as surrogates; however, there may be instances, especially when working with a diverse partnership, when the best surrogate might be an ecosystem process or other environmental attribute. Criteria for selecting surrogate species may include:

Species likely to have a high adaptive capacity to cope with or ameliorate the effects of climate change may not be good surrogates; their lack of response could mask significant impacts to other species with a lower ability to adapt. Species likely to have a lower adaptive capacity or those particularly sensitive to climatic changes may be better surrogates in terms of providing a clear signal of how climate conditions are shifting on the landscape. It may be necessary to select species with a range of adaptive capacities to try to represent the diversity of species' reactions to climate change.

Box 5. Climate Change considerations when selecting criteria

- Measurable population objectives exist or can be developed for the species. If not, that species cannot be used as a surrogate.
- The species' life history traits can be linked to threats/stressors or limiting factors;
- The species' expected response can be linked to conservation strategies;
- The species' life cycle demands are equal or greater than those of other species';
- Data are available for the species;
- The species is valued by the public and/or stakeholders in the process;

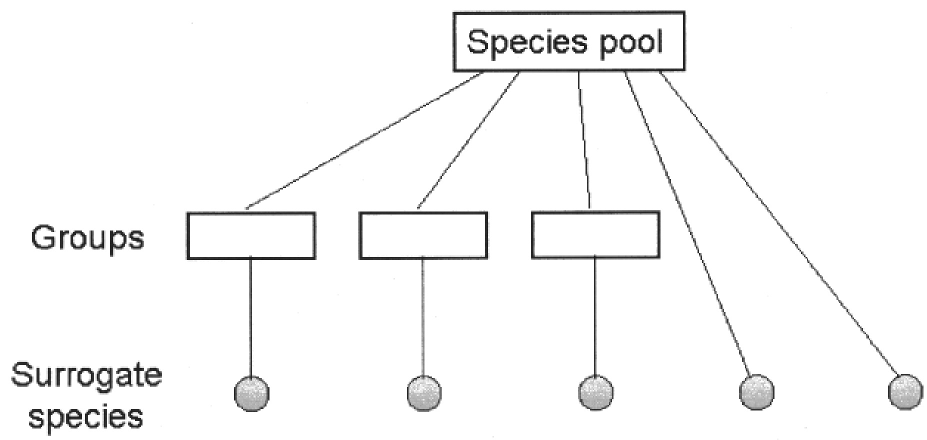
- The species is feasible to monitor (e.g. location, cost, existing program, available capacity).

4. Employ Available Decision Support Tools for Selecting Species: A number of decision support tools are available to help with the selection of species. Decision support tools help users take a complex array of information and systematically test alternatives. The result is a clearly documented set of potential outcomes for the various alternatives, which helps the user prioritize and select from among the alternatives based on desired outcomes and potential benefits. Some potential decision support tools include:

- Conceptual or quantitative models generating ranks or "best fits" by combining criteria with data inputs from landscape assessment and species of conservation interest;
- Multivariate statistical methods to decipher and quantify the differences and similarities among species (Wiens et al. 2008).

5. Select Surrogate Species: Prior to selecting surrogate species, it may be useful to organize a pool of species of conservation interest (i.e. potential surrogates) into smaller groups based on similar characteristics such as habitat associations, taxonomy, life history traits, and stressors/limiting factors affecting the species (Figure 3). For example, if a number of the species of conservation interest within a particular landscape are migratory birds, then one pool of potential surrogates would be all migratory birds occurring within that landscape. Migratory birds might be grouped by habitat associations, landscape attributes, and limiting factors. The selection criteria developed for the surrogate approach could be used to further refine the list. Several migratory bird species might be eliminated as potential surrogates either because there are limited data available for them or because they are too costly to monitor effectively. This grouping process may be complicated or simple, but always should be based on available documented information.

Figure 3. Conceptual diagram (from Wiens et al. 2008) of the grouping of species of conservation interest, based on similar characteristics, to prepare for selecting surrogate species from the potential "pool" of species within the landscape.



After placing species into groups, select surrogate species for each group by using the established selection criteria and results available from any decision support tools used. When selecting surrogate species, consider the following:

- If multiple surrogate approaches have been identified to address conservation challenges within a landscape, a collection of various surrogate species can be selected using criteria specific to the approach. For example, a group of species can be used to define the composition, configuration, and condition of the landscape; another group of species can be used to monitor the condition of the landscape or ecosystem changes within that landscape; or a different group of species may be selected because they are significant to the public.

- A single species may serve in more than one surrogate approach (Brock and Atkinson 2013), as long as the criteria used and the reasons for selection of the surrogate are clearly defined and applied independently for each approach.
- Using a combination of surrogate approaches, and multiple species within approaches, increases the power of a surrogate approach to achieve landscape conservation (Brock and Atkinson 2013), as long as the criteria used and the reasons for selection of the surrogate are clearly articulated.

Box 6. Climate Change Considerations When Selecting Surrogate Species

1. *Conservation planning surrogates can be species or other features of the environment, like geophysical settings. In fact, as we enter a period of climate change, the more enduring features of the landscape may prove to be better surrogates for future diversity than current species or communities.*
2. *Consider expanding the concept of surrogates to include refugia as surrogates for today's communities. Identifying those areas least likely to change climatically might be the best way of identifying where conservation investment could extend the lifetime of existing community types and the species they support.*
3. *Consider surrogates for the range of species' sensitivities to climate change. If we select only highly adaptable or climatically insensitive species as surrogates, we will likely "under provide" for the less adaptable or more climatically sensitive and vice versa. We need surrogates that represent the spectrum of climate sensitivities.*
4. *Consider surrogates for a range of species' connectivity needs. The ability to move is highly variable among species. Birds and other highly mobile species have a much greater chance of navigating a fragmented landscape than do more sedentary species and thus low mobility species may need special attention. Be realistic about the longevity of this first iteration of surrogates. Climate induced changes are already happening, they are happening faster than many thought they wouldWe need to monitor and adjust our work going forward. By the time we select our surrogates, develop plans, implement strategies, and begin measuring results, a decade or two may have past. By then, if not sooner, the collection of surrogates will need to be revisited and adjusted in light of experience and emerging conditions at the time.*

- In most situations, for one surrogate approach, suites of surrogates species (Sanderson et al. 2002) based on multiple criteria (Lambeck 1997; Fleishman et al. 2000; Sanderson et al. 2002; Seddon and Leech 2008) provide a more robust biological foundation for conservation planning.

6. Develop Outcome-based Biological Objectives: Development of clear, measureable objectives is an integral component of the practice of conservation, especially when set in an adaptive management framework such as Strategic Habitat Conservation (U.S. Fish and Wildlife Service 2008). Without them, there is no way to determine whether or not conservation efforts have been successful. Development of population objectives, one type of biological objective, is the focus of this section. If surrogates other than species are selected; other kinds of objectives will need to be developed.

Population objectives can be expressed as abundance, trend, vital rates and/or other measurable indices of a species' population status (Andres et al. 2012). These objectives generally represent value-based goals from an estimate of what constitutes a healthy and sustainable population and/or of how many individuals of a species society wants and will support through conservation (Sandler 2012). For example, most waterfowl species are represented by the North American Waterfowl Management Plan population objectives (North American Waterfowl Management Plan, Plan Steering Committee. 2012). These objectives are based on duck population levels measured in the 1970s, a time when these populations were considered to be at desirable levels (i.e., provide adequate harvest). Partners in Flight (Rich et al. 2005) generally set objectives for landbirds based on population numbers measured at the beginning of the Breeding Bird Survey in the mid-1960s.

Population objectives should always be stated as a range of values (e.g., mean +/- s.e.) rather than a single value. This method of expressing objectives helps communicate appropriate confidence in the precision of the data used to develop the objective. Framing objectives as ranges also acknowledges natural variability. It is more realistic to expect management actions to achieve responses within a desired range than to reach a static, exact number. Population objectives need to be comparable across the entire range of the species. Therefore, it is essential that practitioners coordinate across boundaries and landscapes, especially where similar conservation targets such as surrogate species have been identified. This ensures that compatible population objectives for shared surrogate species on different landscapes can be “rolled-up” to meaningful measures at the national or continental scales, a step necessary to enhance the ability for assessing progress toward range-wide objectives and stated conservation goals.

Methods for setting population objectives

Unfortunately, there is no single best method for setting population objectives that are quantitative, measurable, and account for uncontrolled environmental variation. An overview of the most common methods of setting population objectives for any given species follows:

Re-scaled from broad scale conservation plans

If the selected species have population objectives set at either a larger ecoregional or continental scale, then it is possible to re-scale or “step down” these objectives to the region of interest. This approach is used by many migratory bird joint ventures where ecoregional-scale (Bird Conservation Region) objectives have been stepped down from national or continental-scale objectives as stated in bird initiative plans for waterfowl, landbirds, shorebirds, waterbirds, and some resident game birds (Fitzgerald et al. 2009). The stepping-down process has the advantage of linking regional and local conservation actions to continental or national strategies. For some species, particularly landbirds, some waterfowl, some resident game birds, and some threatened and endangered species, range-wide and ecoregional population objectives have already been developed.

Although this “step-down” approach is intuitive and appealing, it is based on the assumption that local or regional populations are additive in nature and can be aggregated to larger spatial scales. In fact, the functional form of the relationship among populations at different scales is not well understood. For example, the relationship of continental breeding population objectives to wintering populations of migratory species, also called “cross-seasonal effect, is uncertain. For most species, information is not available on the seasonal survival rates during migration and wintering periods, which are needed to develop reasonable estimates of wintering population size based on breeding ground objectives. Thus, when using the step-down approach it is critical to document all assumptions made during the translation of broader scale population objectives to population objectives at finer spatial scales. These assumptions become the subject of future research to ensure that the agreed upon objective is based on the best available science. Additional research is required to address the uncertainties associated with the development of biologically reasonable population objectives at multiple spatial scales.

<u>Habitat-based estimates</u>

Another approach to determine population objectives is to assess the present capability of the landscape to support populations by measuring available habitat and translating this estimate to a population target through a metric such as density or a species-habitat model that accounts for limiting factors and population demographics. Population objectives can then be set by estimating the expected net change in the capability of habitats in the landscape to support populations based on changes (loss or gain) in quantity and quality. This “bottom-up” approach provides a useful comparison to the “top-down” translation of continental population objectives to regional ones. Numerous modeling approaches can be used to assess the capability of any landscape to support populations of a species or set of species. Approaches include Habitat Suitability Index (HSI) models (Larson et al. 2003, Tirpak et al. 2009), population viability models (Bonnot et al. 2013), energetic models (Loesch et al. 2000), and statistical modes (Fitzgerald 2009). Thus, each partnership will need to select the most appropriate method based on how much information is available for any given surrogate species.

The benefits of these model-based methods are that the process of setting population objectives is codified and transparent and assumptions are explicitly stated, a critical step in the adaptive management paradigm adopted in Strategic Habitat Conservation. These assumptions should be the focus of future research to gain refined additional information about the system. Lastly, model-based methods make it easy to incorporate environmental variability by incorporating stochastic processes in the parameterization of any factor included in the model.

Expert advice

For species without existing population objectives or where there is limited information from which to build a reasonable habitat-based model, species experts may be consulted to develop an acceptable, reasonable population objective. Although this may be the least desirable method of setting population objectives, several simple steps can be taken to ensure this process is transparent and leads to objectives that are easily refined as additional information is gained. First, a structured process must be identified and agreed upon by partners and stakeholders. It is important to ensure that the full range of partners, with relevant biological expertise, be invited to participate in this objective-setting activity. Inclusiveness ensures “buy-in” and a sense of ownership in achieving the stated objectives.

Species Requiring Individual Attention

Some species of conservation interest demand resource commitments due to legal status, management needs, vulnerability, geographic areas of interest, political sensitivity, or other factors. These species should be flagged when developing a list of species of conservation interest to determine if they can serve as surrogates. Some may have established monitoring, research, and management programs, population objectives, and other biological information to help inform how to address their limiting factors. However, these species may not be selected as surrogates or have conservation needs not addressed by the surrogates selected. These species may require individual attention due to:

Especially vulnerable species including those likely to be particularly sensitive to climatic changes, those that may be highly exposed to new habitat conditions, and species with low adaptive capacity should be considered among those requiring special attention. These species may not be well represented by less vulnerable surrogates.

Box 7. Species Requiring Individual Attention Climate Change Consideration

1. Unique threats or vulnerability. Limiting factors or threats for a species may not be addressed by landscape level conservation based on a surrogate species approach. The endangered Indiana bat is an example of a species with a unique limiting factor. While this species also has habitat-related threats, the most significant threat currently is White Nose Syndrome, a disease affecting cave hibernating bats from the northeastern to the central United States. Focused efforts to conduct monitoring, research, and development of protocols and strategies to help minimize spread of the disease will need to continue to sustain this species.

2. Limited range. The needs of species with limited ranges and highly specific habitat requirements (Wiens et al., 2008, Favreau et al., 2006) may not be addressed by surrogate species approaches. Examples of species that may fit in this category include federally and state listed endangered and threatened species, some State identified Species of Greatest Conservation Need, and endemic species.

3. Legal mandates. FWS is legally mandated to conserve threatened and endangered species, Bald and Golden Eagles, migratory birds, and certain marine mammals. State agencies are legally responsible for federal and state listed endangered and threatened species, game species, and all other fish and wildlife found within their borders, including on Federal lands within a state. Listing, de-listing, and recovery of species protected by Federal and State laws occurs for species separately. Species covered by such regulatory programs may have to be considered individually due to the monitoring, research, reporting, and management needs required under the regulatory process.

Species requiring individual attention may need to be prioritized, depending upon how many there are on the landscape. Conservation work for these species will be conducted in addition to work focused on surrogate species. The value and contribution of species requiring individual attention to the functioning landscape should be defined, documented and integrated into landscape conservation planning efforts.

It will be important to document how decisions are made to continue work on these species. Consideration should be given to factors such as the legal status of the species, degree or severity of threat(s) to the species, existing partnerships and capacity to manage the species over time, and effectiveness and cost of management strategies. Work on these individual species should incorporate the principles of Strategic Habitat Conservation.

Conclusion

In the 21st Century, the conservation community is faced with unprecedented environmental, socio-economic, and fiscal resource challenges. It is imperative to address the many complex underlying drivers and stressors that operate at broad geographic scales and threaten the survival of the fish, wildlife, and plant species. It is necessary to work at ecologically meaningful scales, across boundaries and borders, and throughout the ranges of these species, while actively collaborating with other individuals and organizations that have a stake in the conservation of wildlife and their habitats. The uncertainty inherent in conservation work requires a commitment to plan and evaluate our actions with greater intention and effort. A strong biological foundation allows us to move forward with confidence that our conservation activities are grounded in scientific planning, that decisions, theories, and thought processes are well-documented and transparent, and that we can learn from the results of our actions and be held accountable for them.

This document also acknowledges that the science of surrogate species is evolving. Therefore, following the adaptive management framework upon which it is based, this guide can be improved with use, including clear documentation of methods and assumptions, monitoring of results, and evaluation. By working in close coordination, Federal, State and Tribal fish and wildlife agencies and other partners can develop and use the surrogate species methodology presented in this guidance to build a strong biological foundation for our collective work in meeting the complex conservation needs and challenges of our Nation’s fish, wildlife, and plants.

Literature Cited

Allen, C., J. Fontaine, K. Pope, A. Garmestani. 2011. *Adaptive management for a turbulent future.* Journal of Environmental Management 92:1339-1345.

Andres, B. A., B. L. Altman, A. M. Bartuszevige, C. J. Beardmore, R. Dettmers, D. T. Jones-Farrand, E. J. Laurent, R. S. Mordecai, J. M. Tirpak, W. Vermillion, and J. A. Wheeler. 2012. *Considerations for establishing bird population and habitat objectives to further conservation within habitat Joint Ventures*. Partners in Flight Technical Series No. 6. Partners in Flight website: http://www. Partnersinflight.org/pubs/ts/06-PopObjectivesGuidance.pdf

Bertelsmeier, C., Luque, G. M., & Courchamp, F. (2013). *The impact of climate change changes over time.* Biological Conservation, 167(0), 107-115. doi:http://dx.doi.org/10.1016/j.biocon.2013.07.038

Bonnot, Thomas W.; Thompson, Frank R.; Millspaugh, Joshua J.; Jones-Farland, D. Todd. 2013. *Landscape-based population viability models demonstrate importance of strategic conservation planning for birds*. Biological Conservation. 165: 104-114.

Bottrill M., K. Didier, J. Baumgartner, C. Boyd, C. Loucks, J. Oglethorpe, D. Wilkie, and D. Williams. 2006. *Selecting Conservation Targets for Landscape-Scale Priority Setting: A comparative assessment of selection processes used by five conservation NGOs for a landscape in Samburu, Kenya.* World Wildlife Fund, Washington, DC, USA.

Bottrill, M., L. Joseph, J. Carwardine, M. Bode, C. Cook, E. Game, H. Grantham, S. Kark, S. Linke, E. McDonald-Madden, R. Pressey, S. Walker, K. Wilson and H. Possingham. 2008. *Is conservation triage just smart decision making?* Trends in Ecology and Evolution:23(12):649-654.

Brock, B. and Atkinson, E. 2013. *Selecting species as targets for conservation planning*. In Conservation Planning: shaping the future, edited by F. Lance Craighead and Charles L. Convis, Jr. Redlands, California: Esri Press, 2013. 1st ed

Caro, T. and G. O'Doherty. 1999. *On the use of surrogate species in conservation biology*. Conservation Biology 13(4):805-814.

Caro T. 2010. *Conservation by Proxy: indicator, umbrella, keystone, flagship, and other surrogate species*. Island Press, Washington, DC

Coppolillo, P., Gomez, H., Maisels, F., & Wallace, R. (2004). *Selection criteria for suites of landscape species as a basis for site-based conservation*. Biological Conservation, 115(3), 419-430. doi:http://dx.doi.org/10.1016/S0006-3207(03)00159-9

Favreau, J., C. Drew, G. Hess, M. Rubino, F. Koch, and K. Eschelbach. 2006. *Recommendation for assessing the effectiveness of surrogate species approaches*. Biodiversity and Conservation 15:3949-3969.

Fitzgerald, J.A., W.E. Thogmartin, R. Dettmers, T. Jones, C. Rustay, J.M. Ruth, F.R. Thompson and T. Will. 2009. *Application of models to conservation planning for terrestrial birds in North America.* Pages 593-624. In: Millspaugh, J.M. and Thompson, F.R. 2009. Models for planning wildlife conservation in large landscapes. Academic Press. Burlington, MA.

Fleishman, Erica, Dennis D. Murphy, and Peter F. Brussard 2000. *A new method for seletion of umbrella species for conservation planning.* Ecological Applications 10:569–579. http://dx.doi.org/10.1890/1051-0761(2000)010[0569:ANMFSO]2.0.CO;2

Forman, R. T. T. 1995. *Land Mosaics: The Ecology of Landscapes and Regions.* Cambridge University Press, Cambridge/New York. 632 pp.

Fox, D. (2007). *Ecology - back to the no-analog future?* Science, 316(5826), 823-+. doi:10.1126/science.316.5826.823

Graham, RW, EL Lundelius Jr., MA Graham, EK Schroeder, RS Toomey III, E Anderson, AD Barnosky, JA Burns, CSDK Grayson, RD Guthrie, CR Harington, GT Jefferson, LD Martin, G McDonald, RE Morlan, HA Semken Jr., SD Webb, L Werdelin, MC Wilson. (1996). *Spatial response of mammals to late quartenary environmental fluctuations*. Science 272:1601-1606, 272, 1601.

Groves, C., D. Jensen, L. Valutis, K. Redford, M. Shaffer, J. Scott, J. Baumgartner, J. Higgins, M. Beck, and M. Anderson. 2002. *Planning for biodiversity conservation: putting conservation science into practice.* BioScience 52(6):499-512.

Hellman, J. J., K. M. Prior, S. L. Pelini. 2012. The influence of species interactions on geographic range change under climate change. *Ann. N.Y. Acad. Sci.* 1249:18-28.

Heneberg, P. 2012. *Flagship bird species habitat management supports the presence of ground-nesting aculeate hymenopterans*. Journal of Insect Conservation 16:899-908.

Hunter, M. L., Jacobson, G. L., & Webb, T. (1988). *Paleoecology and the coarse-filter approach to maintaining biological diversity*. Conservation Biology, 2(4), 375-385. doi:10.1111/j.1523-1739.1988.tb00202.x

IUCN 2013. *The IUCN Red List of Threatened Species*. Version 2013.2. <http://www.iucnredlist.org>. Downloaded on 3 March 2014.

Jackson, S. T. (2006). *Vegetation, environment, and time: The origination and termination of ecosystems.* Journal of Vegetation Science, 17, 549.

Jackson, S. T. (2012). *Conservation and resource management in a changing world: Extending historical range of variation beyond the baseline*. In J. A. Wiens, G. D. Hayward, H. D. Safford & C. M. Giffen (Eds.), Historical environmental variation and natural resource management. (pp. Chapter 7, pp 92-109) John Wiley and Sons, Ltd.

Lambeck, R.J. 1997. *Focal species: a multi-species umbrella for nature conservation.* Conservation Biology 11:849-856.

Larson, Michael A.; Dijak, William D.; Thompson, Frank R. III; Millspaugh, Joshua J. 2003. *Landscape-level habitat suitability models for twelve species in southern Missouri*. Gen.

Tech. Rep. NC-233. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 51 p.

Lee, K. N. 1999. *Appraising adaptive management*. Conservation Ecology **3**(2): 3. [online] URL: http://www.consecol.org/vol3/iss2/art3/

Loesch, C.R., D.J. Twedt, K. Tripp, W.C. hunter and M.S. Woodrey. 2000. Development of Management Objectives for waterfowl and shorebirds in the Mississippi alluvial valley. Pages 8-11 In: Bonney, Rick; Pashley, David N.; Cooper, Robert J.; Niles, Larry, eds. 2000. *Strategies for bird conservation: The Partners in Flight planning process; Proceedings of the 3rd Partners in Flight Workshop*; 1995 October 1-5; Cape May, NJ. Proceedings RMRS-P-16. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Martino, D., C.S. Lam and T. Longcore. 2005. *Green Visions Plan for 21st Century Southern California: Terrestrial target species for habitat conservation planning*. University of Southern California GIS Research Laboratory and Center for Sustainable Cities, Los Angeles, California.

Meffe, G. K., and C. R. Carroll 1997. *Principles of Conservation Biology*. Sinauer Associates, Inc., Sunderland, Massachusetts.

Millard, MJ, Czarnecki, CA, Morton JM, Brandt, LA, Briggs, JS, Shipley, FS, Sayre, R, Sponholz, PJ, Perkins, D, Simpkins, DG, Taylor, J. 2012. *A national geographic framework for guiding conservation on a landscape scale*. Journal of Fish and Wildlife Management. 3(1):175-183.

North American Waterfowl Management Plan, Plan Committee. 2012: *North American Waterfowl Management Plan 2012: People Conserving Waterfowl and Wetlands*. Canadian Wildlife Service, U. S. Fish and Wildlife Service, and Secretaria de Medio Ambiente y Recursos Naturales, U. S. Fish and Wildlife Service, Arlington, Virginia.

Omernik, J. M. (1987), *Ecoregions of the Conterminous United States*. Annals of the Association of American Geographers, 77: 118–125. doi: 10.1111/j.1467-8306.1987.tb00149.x;

Reza, M. I. H., S. A. Abdullah, S. B. M. Nor, and M. H. Ismail. *Integrating GIS and expert judgment in a multi-criteria analysis to map and develop a habitat suitability index: a case study of large mammals on the Malayan Peninsula*. Ecological Indicators 2013: 149-158.

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. 2005. *Partners in Flight North American Landbird Conservation Plan*. Review by: John Faaborg, The Auk, Vol. 122, No. 1, pp. 373-375. Article Stable URL: http://www.jstor.org/stable/4090387

Roberge, Jean-Michel, Angelstram, Per,. 2004. *Usefulness of the umbrella species concept as a conservation tool.* COBI Conservation Biology, 18(1), 76-85. Retrieved from /z-wcorg/ database.

Sanderson, E. W., Redford, K. H., Vedder, A., Coppolillo, P. B., & Ward, S. E. (2002). *A conceptual model for conservation planning based on landscape species requirements.* Landscape and Urban Planning, 58(1), 41-56. doi:10.1016/S0169-2046(01)00231-6

Sandler, R. 2012. *Intrinsic Value, Ecology, and Conservation*. Nature Education Knowledge 3(10):4

Seddon, P. J., & Leech, T. 2008. *Conservation short cut, or long and winding road? A critique of umbrella species criteria*. Oryx, 42(2), 240-245. doi:10.1017/S003060530806119X

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

Syrbe, R., E. Michel, and U. Walz. 2013. *Structural indicators for the assessment of biodiversity and their connection to richness of avifauna*. Ecological Indicators 31:89-98

Tirpak, John M.; Jones-Farrand, D. Todd; Thompson, Frank R., III; Twedt, Daniel J.; Uihlein, William B., III. 2009. *Multiscale habitat suitability index models for priority landbirds in the Central Hardwoods and West Gulf Coastal Plain/Ouachitas Bird Conservation Regions.* Gen. Tech. Rep. NRS-49. Newtown Square, PA: U.S. Department of Agriculture, Forest Service Northern Research Station. 195 p.

Turner, M. G. 1989. *Landscape Ecology: The Effect of Pattern on Process.* Annual Review of Ecology and Systematics, Vol. 20: 171 -197.

Turner, M. G. (2005). *Landscape ecology: What is the state of the science?* Annual Review of Ecology Evolution and Systematics, 36, 319-344. doi:10.1146/annurev.ecolsys.36.102003.152614

U. S. Fish and Wildlife Service. 2008. *Strategic Habitat Conservation Handbook.* U. S. Fish and Wildlife Service, Arlington, Virginia

US Fish and Wildlife Service, U.S. Geological Survey. 2006. *Strategic habitat conservation: A report from the national ecological assessment teamUS Fish and Wildlife Service.* Retrieved from http://www.fws.gov/nc-es/habreg/NEAT_FinalRpt.pdf

Wiens, J., G. Hayward, R. Holthausen, and M. Wisdom. 2008. *Using surrogate species and groups for conservation planning and management.* BioScience 58(3):241-252.

Williams, J. W., & Jackson, S. T. (2007). *Novel climates, no-analog communities, and ecological surprises.* Frontiers in Ecology and the Environment, 5(9), 475-482. doi:10.1890/070037

Williams, Byron K. and Fred A Johnson. *Confronting dynamics and uncertainty in optimal decision making for conservation*. 2013 Environ. Res. Lett. 8 025004: doi:10.1088/1748-9326/8/2/025004

Appendix A - Glossary of Terms Used in the Guidance Document

The glossary defines terms used in this document. While many may have several different definitions in the literature, those offered here are specific to how the terms are used in this particular material.

Adaptive Management

Adaptive management is a framework that promotes flexible decision making in the face of uncertainty by allowing future decisions and actions to be adjusted as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. The process is not "trial and error," but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure lies in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders. (DOI AM Technical Guide, Williams et al. 2009).

Biological Planning

Biological Planning is the initial phase or step of the Strategic Habitat Conservation adaptive management cycle. The process of gathering stakeholders and partners, identifying priorities, clear goals and objectives, compiling information (e.g. limiting factors, species life history, current ecological conditions, potential decision making methods and decision support tools, etc.), and selecting conservation targets (e.g., surrogate species, species in need of individual attention, and other non-species targets such as water quality/quantity) necessary to begin conservation design.

Conservation/Management Action

A specific action or set of tasks undertaken by project staff and/or partners to reach one or more objectives. Sometimes called a task, activity, intervention, response or action. Required to implement an Annual Work Plan, Monitoring Plan, or other components of a landscape-scale conservation effort. (*Source: Adapted from CMP Open Standards for the Practice of Conservation*)

Conservation Challenge

Conservation challenges help define the components of the landscape needed to support species of conservation interest and help in the selection of the surrogate approach and the surrogate species. Although not measurable, these challenges help clarify expected achievements.

Conservation Design

Conservation Design builds on the planning accomplished in the Biological Planning portion of the Strategic Habitat Conservation framework. Conservation Design provides an on-the-ground conservation blueprint and strategy for achieving goals and objectives established for a particular landscape using a process that combines geospatial data and models with information derived from biological planning. During Conservation Design management/conservation actions to help achieve the common vision are identified. Conservation Design involves spatially integrating conservation goals and biological objectives into a model or models that define (and forecast) landscape patterns and ecological processes necessary to support self-sustaining levels and distribution of plants, fish, and wildlife populations. Results of these models are used to establish conservation and adaptation strategies that define specific management objectives and actions to help target conservation delivery for the landscape.

Conservation Target

A Conservation Target is the measurable biological, chemical, or physical attribute of a particular landscape that is valued or important to stakeholders identified during the biological planning phase of SHC. Conservation targets can include metrics related to species, ecological communities, landscape features, habitat types, ecological processes, or other significant natural resources (e.g., groundwater supplies, productive farmland). Identification of threats affecting conservation target(s) helps to inform the conservation strategies carried out in a landscape.

Ecological Conditions

Ecological condition refers to the state of the physical, chemical, and biological characteristics of the environment, and the processes and interactions connecting them. These characteristics describe landscape composition (e.g., land cover, soil types, riparian cover) and landscape structure (e.g., elevation, forest block size, aquatic substrate).

Ecological Integrity

Ecological Integrity describes the capacity of an area or system of natural areas to continue to support and maintain a diversity of native organisms, ecosystem structure, and ecosystem processes when perturbed by stressors, through resiliency and adaptation.

Ecological Models

An intellectual tool, a model is any representation or abstraction of a system or process. Models help: (1) define problems, (2) organize thoughts, (3) understand data, (4) communicate and test that understanding, and (5) make predictions. (Starfield and Bleloch 1986)

Ecological Processes

These are the physical, chemical and biological actions or events linking organisms and their environment. *(Source: http://www.greenfacts.org/glossary/def/ecosystem-processes.htm)*

Ecosystem

A community of living organisms (plants, animals and microbes), abiotic components (air, water, minerals, soil, sunlight) and their interrelationships, linked together through nutrient cycles and the flow of energy through the system, within a defined unit of space.

Federal Trust Resources, Responsibilities and Species

Federal legislation identifies certain resources to be protected and conserved for the benefit of all Americans. Federal agencies act as trustees for the American public by managing these resources. Trust species for the U.S. Fish and Wildlife Service include migratory birds, species listed as threatened or endangered species under the Endangered Species Act, inter-jurisdictional fishes, and certain marine mammals. Other Trust resources for the Service include wetlands as well as all lands and waters included in the National Wildlife Refuge System.

Flagship species

Also called iconic species, this surrogate approach selects charismatic species in order to increase public awareness of conservation issues and/or rally support for other conservation targets in the landscape (e.g., Great Blue Heron). *See Surrogate Approaches Appendix B for more information.*

Functional Landscapes

These are lands and waters with the ecological conditions required to support self-sustaining populations of plants, fish and wildlife while also providing human societal needs. *Note: this is a subjective term that will need to be further defined by the involved partners/stakeholders depending on the characteristics of and goals and objectives for a particular landscape.*

Indicator Species

This is a surrogate approach that uses species to indicate a trend within a landscape, or to assess the effects of a condition or action on the landscape and/or species within it. There are a variety of indicator species types (e.g., environmental indicators, management indicators*); see Surrogate Approaches Appendix B for more information.*

Keystone Species

A keystone species is a species whose ecological impact is greater than would be expected from its relative abundance or total biomass. Essential to maintaining ecosystem structure and function, their abundance may be directly related to the abundance and viability of other species in that system.

Landscape

A landscape is a subjective spatial area of interest considered a single unit for conservation planning, design, and delivery. An implicit characteristic of a landscape is that it is large enough to encompass ecological processes such as watersheds; thus landscapes are connected mosaics of lands and waters with similar characteristics that form the geographic basis for biological planning and conservation design. The term landscape, as used in this document, encompasses waterscapes/seascapes. See definition for functional landscape given above.

Landscape Attributes

Landscape attributes are features or characteristics that describe or contribute to the overall composition, structure, and/or function of a landscape including: spatial aspects of landscape pattern; aspects of landscape texture such as dispersion and interspersion of patch types ; type, number and range of land units; number and proportion of land use types; number and variety of ecotones; number and types of corridors; characterization of habitats or communities; some measures of beta (between sites of a similar type) and gamma (overall landscape) diversity; range and modalities of organisms regularly crossing ecotones; cycling indices of flows and exchanges of water, nutrients and energy within and among ecosystems; pattern and tempo of water and nutrient movements; ecological disturbance regimes; level of anthropogenic transformation of a landscape; and number and importance of biological invasions.

Landscape-Scale Conservation

Landscape-Scale Conservation occurs over large geographic scales (e.g. ecoregion, entire watershed, etc.) allowing easier detection of patterns and mosaics and the ability to account for natural ecological boundaries and address stressors and drivers operating at these scales.

Landscape Species

Landscape species are characterized by a surrogate approach using species that use large ecologically diverse areas and often have significant impacts on the structure and function of natural ecosystems (Sanderson et al. 2002). The requirements of landscape species in time and space make them particularly vulnerable to human alteration and use of natural landscapes.

Limiting factor

A limiting factor restricts the ability of a species or process to function normally, such as a factor that limits species population size, or distribution or prevents/alters the occurrence of an essential ecological process. The availability of food, alteration of hydrologic regime, predation pressure, or availability of shelter are examples of factors that could be limiting for a species. It is also a primary factor constraining the achievement of defined biological objectives.

Management Action (see Conservation Action)

Management Strategy

A broad course of management (and conservation) actions with a common focus designed (alone or together with other strategies) to achieve specified outcomes and related intermediate results.

Strategies focus on "means" – the "how" for achieving particular results (from TNC Conservation Business Planning Guidance, Version 1.3, July 2013; https://connect.tnc.org/sites/ConservationPlanning)

Outcome-based Biological Objectives

These are clear, realistic, specific, measurable statements describing a desired set of conditions necessary to achieve one or more conservation goals. Objectives derive from goals and provide the basis for determining management actions or conservation strategies, monitoring and research accomplishments, and evaluating the success of strategies. Objectives are outcome-based when they are **SMART** (specific, measurable, achievable, results-oriented, and time-relevant). Several different types of objectives are discussed within the document:

- ***Biological Objective***

  A concise, measurable (SMART) statement describing the desired state of the conservation target (e.g. species of conservation interest, surrogates, species requiring individual attention), including the temporal and spatial scale (what and how much we want to achieve and when and where we want to achieve it). Note: A population objective is a type of biological objective that describes the desired state of the population of a species. They may be expressed as demographics, abundance, trend, vital rates or other measurable indices of population status.

- ***Habitat/Landscape Objective***

This is a concise, measurable (SMART) statement that describes the set of landscape attributes or habitat conditions necessary to achieve one or more conservation goal(s) and biological objective(s).

- ***Management Objective***

  A concise, measurable (SMART) statement, a management objective describes the conservation/management actions necessary to achieve one or more conservation goal(s) and biological or habitat/landscape objective(s). Sometimes these are called Means Objectives in the literature.

Representative Species

Species that can represent the habitat conservation requirements of larger suites of fish and wildlife species because of their habitat use, ecosystem function or management response and can represent desired biological outcomes in the landscapes in which they occur.

Species of Conservation Interest

Species that the FWS, States, and/or partners have identified as being in need of conservation (e.g., Species of Greatest Conservation Need listed in State Wildlife Action Plans, Federally listed species, etc.).

Self-Sustaining Populations

Self-sustaining populations are likely to persist with minimal human intervention and whose annual growth rate, on average, is not negative over some specified time period. They may require some management action (e.g., periodic habitat manipulation) but not direct handling of the species (e.g., captive propagation, translocation).

State Trust Species

Federal and State legislation identifies certain resources to be protected and conserved for the benefit of all Americans. State agencies act as trustees for the American public by managing these resources. State trust species include all species of fish and wildlife within a State's boundary, unless management authority has been otherwise designated by Congress (e.g. Federally- listed species, migratory birds, marine mammals, some anadromous fish, specific exemptions on Federal land, etc.).

State Wildlife Action Plans

State Wildlife Action Plans (SWAPs) are developed by each state fish and wildlife agency and outline the steps needed to conserve wildlife and habitat before they become more rare and costly to protect. Each plan assesses the health of each state's wildlife and habitats, delineates priorities, identifies threats and limiting factors, and outlines the actions needed to conserve these species and habitats over the long term. *(Source: http://teaming.com/state-wildlife-action-plans-swaps)*

Strategic Habitat Conservation

Strategic Habitat Conservation (SHC) is the conservation approach adopted by the FWS that establishes self-sustaining populations of fish and wildlife, in the context of landscape and system sustainability, as the overarching target of conservation. The SHC model relies on an adaptive management framework consisting of biological planning, conservation design, conservation delivery, monitoring and research, and revision as necessary to inform decisions about where and how to deliver conservation efficiently with partners to achieve predicted biological objectives necessary to sustain fish and wildlife populations. The SHC framework requires objectives be set, that strategic decisions about any actions are made, and that approaches to achieve objectives are constantly reassessed and improved.

Stressors

The proximate activities or processes that directly have caused, are causing or may cause stresses and thus the destruction, degradation and/or impairment of focal conservation targets (species of conservation interest) (e.g., logging). *(Source: TNC Conservation Action Planning Handbook)*

Structured Decision Making

This is an organized, inclusive, and transparent approach to understanding complex problems and generating, evaluating, and employing creative alternatives to address a problem. The primary purpose of a Structured Decision Making process is to aid and inform decision makers, rather than to prescribe a preferred solution (*adapted from Gregory et al. 2012*).

Surrogate Species

Caro (2010) defines surrogate species as, "species that are used to represent other species or aspects of the environmnent to attain a conservation goal/objective. There are a variety of surrogate species approaches (e.g., umbrella, indicator, and flagship species, etc.). See Surrogate Species Approaches Appendix B for more information.

Threats (see Stressors)

Umbrella Species

This is a surrogate species approach that uses a species or suite(s) of species to encompass or represent the biological needs of other species on the landscape. Often umbrella species have large home ranges, and conservation of their habitat needs will typically conserve the habitat needs of the other species they represent (e.g., a wide-ranging predator that reflects habitat connectivity needs in a landscape). A landscape species approach is a variation of the umbrella species approach, which takes into account the key threats (e.g., urbanization, energy extraction) associated with a landscape. See Surrogate Species Approaches Appendix B for more information.

Literature Cited

Caro T. 2010. *Conservation by Proxy: indicator, umbrella, keystone, flagship, and other surrogate species*. Island Press, Washington, DC

Structured Decision Making: A Practical Guide to Environmental Management Choices, First Edition. R. Gregory, R., L. Failing, M. Harstone, G. Long, T. McDaniels, and D Ohlson. 2012. Wiley-Blackwell Publishing Ltd.

Sanderson, E. W., Redford, K. H., Vedder, A., Coppolillo, P. B., & Ward, S. E. (2002*). A conceptual model for conservation planning based on landscape species requirements. Landscape and Urban Planning,* 58(1), 41-56. doi:10.1016/S0169-2046(01)00231-6

Starfield, A. M., & Bleloch, A. L. (1986). *Building models for conservation and wildlife management*. New York: Macmillan.

The Conservation Measures Partnership. 2013. *Open Standards for the Practice of Conservation.* Version 3.0; http://www.conservationmeasures.org/wp-content/uploads/2013/05/CMP-OS-V3-0-Final.pdf

The Nature Conservancy. 2013. Conservation Business Planning Guidance. Version 1.3; https://connect.tnc.org/sites/ConservationPlanning

Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2009. *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Appendix B – Comparison of Surrogate Species Concepts

Surrogate Species Approaches

One of the main issues with using surrogate species approaches in biological conservation is confusion over the applications and goals of these types of conservation approaches, caused, in large part, by confusion over the terminology, concepts, and appropriate applications of different surrogate species approaches (Brock and Atkinson 2013, Caro 2010, Martino et al. 2005, Zacharias and Roff 2001). It is critical to keep the concepts, goals, methodologies and appropriate applications of different surrogate species approaches clear, so that their implementation and intended objectives are clear and can be measured to evaluate effectiveness.

> "Caro and O'Doherty (1999) reviewed surrogate species approaches and argued their efficacy has been impeded by the haphazard use of terminology and methods (see also Caro 2010). They recommended that surrogate species should be used with greater care and that species should be chosen according to explicitly stated criteria designed to meet previously defined conservation goals." (Brock and Atkinson 2013).

The surrogate species approach you use, the criteria used to select surrogate species, and the monitoring required to test the efficacy of the approach in achieving intended outcomes all depend on your conservation goals. Caro and O'Doherty (1999) caution that "both the goals and selection criteria of different surrogate classes differ substantially, indicating that they should not be conflated" and that "surrogate species need to be used with greater care if they are to remain useful in conservation biology." When planning at the landscape scale, there is often more than one goal and a suite of priorities that need to be accounted for. Given this, it may be appropriate to use a variety of different surrogate approaches to meet these different goals. Keep in mind that there are conservation goals pursues which may not lend themselves to a surrogate species approach (e.g., stopping illegal trade of wildlife, permitting take of species, recovery of individual endangered species, rearing fish)… and need to be dealt with using other appropriate methods/approaches. Cost-effectiveness, risk, uncertainty, spatial and temporal scale, urgency, and the nature of the system and issues identified all need to be considered. A surrogate species approach should only be used when it is the most effective conservation technique and when due to budget limitations or other constraints, is more likely to conserve a set of species than approaches that attempt to address each species individually.

Most conservation researchers Caro (2010), Brock and Atkinson (2013) list 3 major categories of surrogate species approaches (many also list 2 other categories: keystone species, which are described below and special needs species, which are described in the Guidance). These categories have distinct objectives:

A. Species to help define areas of conservation significance

The surrogate species approach that is suitable for defining and conserving the necessary elements of functional landscapes (by establishing the necessary habitat configuration, size and connectivity) is called umbrella (Roberge and Angelstam 2004) or landscape species (Sanderson 2002). Lambeck (1997) expanded upon the umbrella species concept, suggesting selecting multiple species that are the most demanding in the ecosystem, which he termed "focal species: a multi-species umbrella for nature conservation." Caro (2010) claims "Lambeck's insight" has led to the current consensus to use several "umbrella species" simultaneously. The idea is, that selecting the species in a landscape that have the most demanding resource needs (resource limited), and managing for those, in theory, will provide for the needs of the less demanding species in the landscape (Figure 1). Sanderson et al. (2002) expanded this approach to what they call Landscape Species, which adds to this concept, ways to incorporate human and other threats to the system (Coppolillo et al 2004).

1. Conservation Goals

Strategically growing the network of protected lands within a specific landscape to ensure persistence of identified landscape priorities (e.g., Strategic Growth of the Refuge System as called for in the 1997 Refuge Improvement Act) is an example of one goal that might be effectively met using a landscape or umbrella species approach. Defining the components of a landscape that are needed for it to function properly to sustain native species populations, may require conserving vital pieces of property that provide connectivity or minimum habitat features required for species in that system. And providing these components to support the most demanding species should also provide for less demanding species. With this approach you can also determine the habitat types to manage for, as well as their size, condition, and configuration. This approach tells you what, where and how much to conserve.

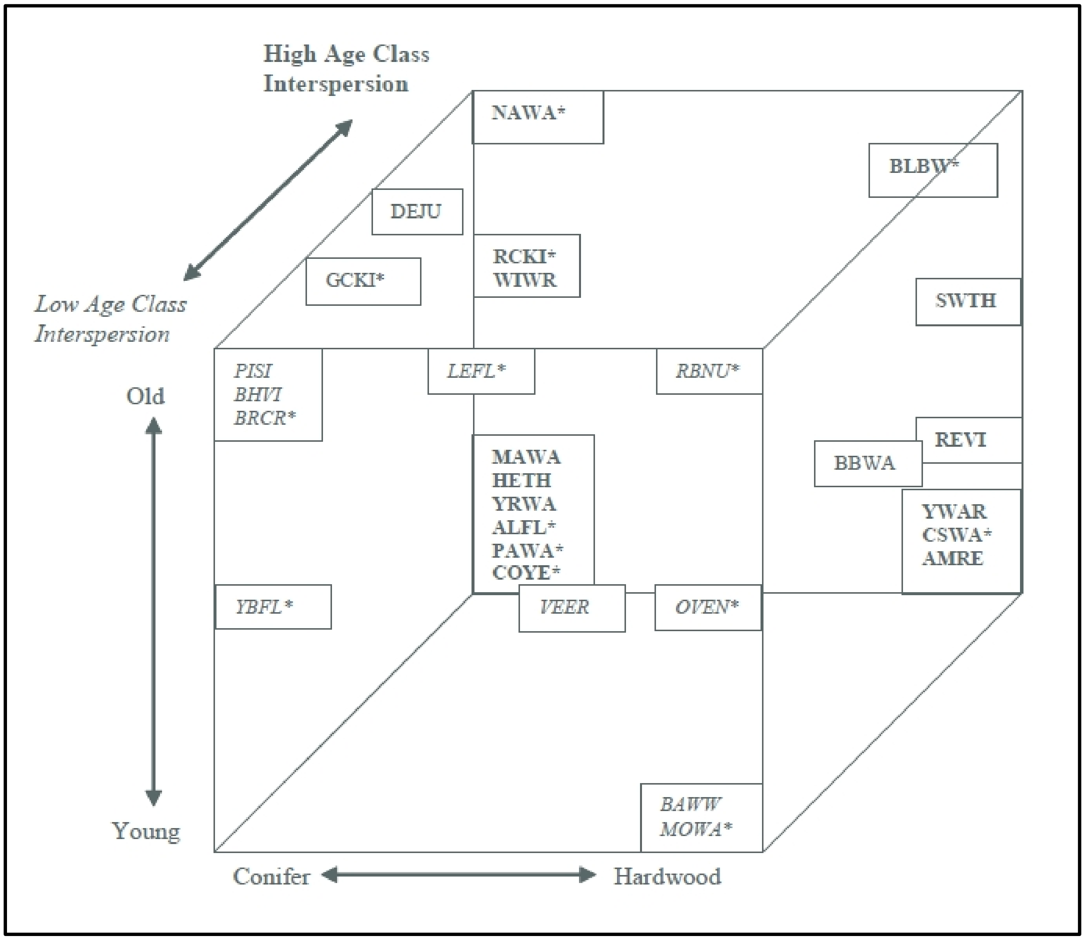


Figure 1. Habitat niche space model with focal bird species selected (*) to represent specific habitat conditions within a boreal forest matrix (Rempel and Donnelly 2010). The idea is that by selecting species on the edges and corners of the box (those likely to be most demanding of aspects of the habitat, space, etc.) as surrogates and designing conservation plans for them, you can account for all the species in the interior of the box that are less demanding.

2. Assumptions

A main assumption for this approach is that by selecting species that are most demanding of (or limited by) some aspect of the landscape, you will be meeting the needs of species that are less demanding. This needs to be tested through monitoring and evaluation of selected biological objectives. Another assumption is that by selecting a suite of species intended to cover the variety of species and other key landscape features within a landscape, that you are in fact doing so. Ideally you should only select the minimum number of species necessary to cover all identified priorities. However, the surrogacy coverage will need to be tested and likely adjusted after monitoring the effects of your landscape design.

3. Intended Outcome

The intended outcome for this approach is viable populations of all desired species associated with the landscape.

4. Criteria for Selecting Species

1. Most demanding of resources/area
   a. area limited
   b. dispersal limited
   c. resource limited
   d. process limited
   e. most vulnerable to existing and future ecological threats to this landscape
2. Cover all the variety of habitat niches within the landscape

3. Of those with equal resource demands, select those that are easiest to monitor

5. Monitoring

You will need to monitor population viability of the surrogate species and, maybe to a lesser extent, all of the species that the surrogate is intended to protect, at least initially, to test efficacy of the approach.

6. Examples

This approach has been used to help design landscapes capable of supporting self-sustaining species populations in the Adirondacks (Didier et al. 2009), California (Chase and Geupel 2005), Montana (Brock et al. 2006, Brock and Atkinson 2013), North Carolina (Hess and King 2002, Rubino and Hess 2003), Canada (Rempel 2007, Rempel and Donnelly 2010), Argentina (Didier et al. 2009), South American rainforests (Castellón and Sieving 2012), Australia (Brooker 2002, Freudenberger and Brooker 2004, Huggett 2007), and South Africa (Solomon 2000).

7. Drawbacks

Many criticisms of the umbrella species concept are actually criticisms of biodiversity indicators. The ranges of a single, or set of, "umbrella species" were judged on whether they coincided with areas of high biodiversity (species richness) or priority species ranges (Launer and Murphy 1994, Andelman and Fagan 2000, Fleishman et al. 2000, Betrus et al. 2005, Ozaki et al. 2006). The original concept was that managing the area or configuration of areas occupied by a population of an "umbrella species" would conserve viable populations of other explicitly listed "background species" (Caro 2010). There are several critiques of using a single umbrella species as a surrogate for conserving populations of other species (Simberloff 1998, Roberge and Angelstam 2004). Lindemayer et al. (2002) criticized the Lambeck (1997) approach, claiming it was untested, that the data to make species selection were difficult to come by, and that managers should use multiple approaches and not just one. Lambeck (2002) responded that all conservation approaches need to be tested, that data to make species selection for any conservation scheme is difficult to come by, and there was no assertion to use only one approach. Another drawback is that it will be expensive to initially monitor for viable populations of all species to test the efficacy of this approach, but it may be possible to monitor background species with less rigor.

8. Alternatives

There really are no alternatives to determining the vital components of functioning ecosystems other than via the perspective of the species that rely on them. This approach can be used to determine what type, where and how much habitat is required to sustain species populations, and surrogates are selected because you can't know and consider the requirements of every species.

B. Species to help document effects of environmental or management conditions

There are many types of surrogate species approaches in this category, all usually termed as some type of indicator species approach. Management indicators are used to assess the effects of management actions on the species potentially affected by the management. Under the management indicator species approach, a subset of species are selected to monitor and it is assumed that other species within the area where the management action or regime is being applied will respond in the same way as the subset of selected species. Environmental indicators are used to monitor the effects of environmental conditions (Lindenmayer and Likens 2011, Dale and Beyeler 2001). A few species are selected to monitor that are particularly sensitive to some environmental condition, and if the species population starts to change (e.g., decrease in numbers, shift in range, illness, etc.), it may be an indication that environmental change is effecting the other species they represent. (e.g., worsening water quality reduces a population of indicator fish species and therefore may be affecting other species in that same ecosystem). There are several other categories of indicator species, such as climate change indicators, biodiversity indicators, and predation indicators. Using a climate change indicator species approach involves selecting a subset of species for their potential sensitivity to climate change and monitoring their populations may tell you something about other species affected by that change (Kao et al. 2012). A biodiversity indicator approach involves selecting a subset of species to represent the biodiversity within a landscape. A unique application of indicator species is monitoring an indicator prey species to see what effects an introduced predator may be having on complementary prey species (Tulloch et al. In press).

B. Conservation Goals

Indicator species are used as a monitoring tool. You monitor the populations of a species to tell you something about effects of environmental change or management actions on the indicator and the species/landscape attributes it is meant to represent, or as an indication of condition of the landscape and species within it (biodiversity hotspots, invasives, predation, etc). Some examples of goals that might be relevant to the use of an indicator species approach are to research the potential effects of climate change on species of conservation concern, to eliminate contaminants A and B within landscape X, or to reduce incidence of disease M within landscape X.

C. Assumptions

The main assumption in using a species as a surrogate for measuring the response of other species to particular stressors, changes in landscape conditions, or management actions, is that the different species will respond similarly to the stressor, change in conditions, or management action. The assumption with using a species to represent particular conditions within the environment is that we are able to get a representative sample of these conditions by using only a subset of species. In order for this to be true, the species must share similar characteristics, such as life histories, limitations, ability to tolerate or adapt, niche space, or climate envelope.

D. Intended Outcome

The outcome you would want to see using these types of approaches is a change in the population trend of a surrogate species, correlated with changes in environmental or management conditions, as well as responses in other species populations that the surrogate is intended to represent.

1. Criteria for Selecting Species

A. Management Indictors

a) Sensitive to management actions

b) Easy to monitor

c) Able to detect changes in populations caused by stressor vs caused by something else
d) Representative of other species responses to the same stressors

B. Environmental Indicators
a) Sensitive to environmental changes
b) Easy to monitor
c) Able to detect changes in populations caused by stressor vs caused by something else
d) Representative of other species responses to the same stressors

C. Climate Change Indicators
a) Sensitive to climate change
b) Easy to monitor
c) Able to detect changes in populations caused by stressor vs caused by something else
d) Representative of other species responses to the same stressors

D. Biodiversity Indicators
a) Ranges overlap areas of high biodiversity (hotspots)
b) Easy to monitor
c) Representative of other species found in same areas

E. Predation Indicators

a) Sensitive to predation

b) Easy to monitor

c) Able to detect changes in populations caused by stressor vs caused by something else

d) Representative of other species responses to the same stressors

F. Monitoring

You will need to monitor population trends and demographies of the indicator over time in relationship to anticipated stressors. Also need to monitor the species or landscape attribute represented by the surrogate to test whether the indicator is in fact acting as a surrogate (if this relationship has already been verified in the literature, then monitoring to test this assumption might not need to be as intensive). And you should have some sort of control or comparison population to monitor to see if the change in indicator population is indeed being caused by the suspected stressor. You will also need to monitor the environmental or management condition itself, to see if there is a change in the condition that can then be isolated causally to the change in species populations.

G. Examples

Walleye, largemouth bass, lake trout and herring gull eggs in the Great Lakes Region were monitored for concentrations of mercury as indicators of mercury pollution in the environment and water, which are difficult to measure directly. These species were selected due to the assumption being that the mercury affecting them has similar effects on other species in this ecosystem (Evers et al. 2011). Lichens and mosses are monitored as indicators of climate change, air quality and wildlife (caribou) habitat in Alaska

(Wesser 2011). Biodiversity indicators are being used to monitor the functioning and resiliency or Arctic ecosystems (Gill and Zöckler 2008), NEON is planning long-term, continental-scale monitoring of species to ascertain the effects of climate change (Kao et al. 2012), the U.S. Forest Service's management indicator monitoring (Patton 1987). Zacharias and Roff (2001) argue that the cryptic and fluid nature of marine environments lends greater support for the use of indicator species (over umbrella or keystones). A unique application of an indicator species approach is to monitor an indicator prey species to gauge the effects of an invasive predator (Ayesha citation).

H. Drawbacks

The biggest drawback to using indicator species as a surrogate for measuring the response of other species to changes in landscape condition, is that each species may respond differently to the conditions. Species have unique environmental niches and may have different abilities to cope with or adapt to environmental changes (plasticity), so monitoring one species may not indicate the effects of the change on other species (Caro et al. 2005). Also the reasons for identifying a species or a group of species are indicator species are often not valid (Lindenmayer and Likens 2011). The criteria for selecting indicators have to be specific to their use. In addition, when monitoring population trends, you must to be able to distinguish between signals tied to the stressor of interest and unrelated variations (Carignan and Villard 2002). It will be expensive to monitor the species and environmental factors to be able to determine cause and effect of environmental changes on species. Landres et al. (1988) concluded that the U.S. Forest Service use of management indicator species failed on conceptual and empirical grounds. In considering whether to use indicator species, the ability to monitor the broader set of species and/or directly measure the underlying provocation to those species needs to be weighed against the risks of using the surrogates. Which one will involve the least scientific uncertainty and will that scientific uncertainty decrease over time based on the use of adaptive management?

1) Alternatives

You could directly measure expected environmental or management responses (Lindenmayer and Likens 2011). Or, you could do some minimal level of surveillance monitoring for all species, to see if there if there is some detectable level of response to changes in the environment and do more focused (targeted) monitoring on the species that show a response (e.g., BBS).

C. Species used to engender public support

Flagship or iconic species are species that are used to reflect or engender public support for conservation efforts carried out by an entity (Caro and O'Doherty 1999). A flagship species approach is often used in combination with other surrogate approaches and may help to inform the *conservation design* of your landscape. You may want to manage in such a way to increase the opportunity for the public to encounter flagship species (e.g. viewing blinds, feeders, ideal habitat surrounding a visitor center, etc). Enhancing public engagement with a particular species may result in defining a particular area of the landscape for conservation that is accessible – to help connect the public with that species in its natural habitat. All things being equal, it may be desireable to select species with greater public appeal or identification, in order to build and sustain public engagement with the broader goals of your conservation effort.

B. Conservation Goals

This approach uses flagship or iconic species to engender support from the public or stakeholders in landscape conservation efforts. Flagship species are selected based to a greater or lesser degree upon their marketing value and not their ecological significance (Verissimo et al. 2011)); ideally you could identify species that may serve dual functions as more than one type of surrogate (i.e. umbrella and flagship or indicator and flagship), in which case they may also be chosen for their ecological significance. An example of a goal that might be relevant to the use of a flagship approach is to increase public support for conservation of federally listed species within landscape X or to increase support for a network of protected lands within landscape X.

C. Assumptions

The assumption with this type of approach is that the selected species will increase public or stakeholder support, not only for the selected species, but for landscape conservation efforts in general. This involves understanding the target public and the cultural, political, economic and social contexts that shape their attitudes and interactions with a potential flagship species (Verissimo et al. 2011).

- **Intended Outcome**

The outcome of employing this approach would be measured by gauging public and stakeholder support of wildlife conservation in the selected landscape. Specifically, the measures would be the extent to which a flagship species approach builds attitudinal, behavioral, financial or political support in your target audience (Verissimo et al. 2011).

- **Criteria for Selecting Species**

    a. Significant to the target audience that you are trying to influence
    b. Incorporates understanding of the public's perceptions about and interactions with species
    c. Must be beloved or highly valued by the public

    Public support for this species should relate directly to support for conservation in general or conservation related to a species area/subset of

- **Monitoring**

    Monitoring the efficacy of using a flagship species approach will involve gauging the public support of management of background species, landscape features, or the landscape itself that the flagship is supposed to build support for. The monitoring will go beyond just ensuring viable populations of the selected flagship (which will need to be done with any conservation approach); the public's support for conservation actions related to other priorities or for conservation of the landscape in general will also need to be evaluated, with and without using the flagship, to gauge whether the approach is having the desired effect. The impacts of flagship species on public attitudes and the ability to deliver strategic conservation goals have not been well evaluated (Barua et al. 2011).

- **Examples**

An image of an Amur tiger cub on a U.S. postal stamp used to raise money for the USFWS Wildlife Without Borders Program, the giant panda image used by the World Wildlife Fund to garner support for conservation (Lorimer 2007), using the polar bear as symbol of the dangers of climate change (Stirling and Derocher 2007), using golden lion tamarin in marketing to protect Brazilian forests (Dietz et al. 1994), marketing using sea turtles to raise awareness and funding for turtle conservation in Australia (Tisdell and Wilson 2005), promoting axolotl to increase tourism in Mexico (Bride et al. 2008).

- **Drawbacks**

Species used as flagships are symbols and as such can invoke different reactions from different audiences (Barua et al. 2011, Verissimo et al. 2011). You need to understand the reactions a species may raise in different groups before selecting a flagship. For instance, if you selected a wolf, or a tiger, or an elephant (Barua et al. 2010) as a flagship species you may engender enthusiastic support for conservation from one group, while provoking equally vehement condemnation from another group. A flagship species may not actually increase support or funding for the conservation target (Tisdell and Wilson 2005) or protect other species in the ecosystem (Zacharias and Roff 2001). A return on investment analysis should be done on different marketing techniques to determine whether using a flagship species is the best way to reach the desired outcome (Verissimo et al. 2011).

- **Alternatives**

Use other means (e.g. classes, participation, talks, etc) to gain public support for conservation of functional landscapes and the wildlife that they support. Also, see the survey commissioned by The Nature Conservancy (2013).

Keystone species

Many authors mention keystone species when describing different surrogate species approaches (Caro 2010, Favreau et al. 2006, Martino et al. 2005, Zacharias and Roff 2001,Linnell et al. 2000, Simberloff 1998). However, the concept of keystone species is defined by the role a species has in an in ecosystem, and is not a surrogate species approach (Mills et al. 1993). A keystone species, as defined by Power et al. (1996), is a species “whose impact on its community is large, and disproportionately large relative to its abundance.” Keystone species are vital to functioning ecosystems and viable populations of the keystone species need to be maintained, but the approach to accomplish that may be a surrogate species approach, or it may just be by assuring adequate habitat for viable populations of keystone species. A keystone may make a good umbrella species, in that managing for the keystone (e.g.., prairie dogs in shortgrass prairies) may provide protection for many other species (e.g., black-footed ferrets, burrowing owls, ferruginous hawks, rattlesnakes, lizards, swift foxes, etc.). However, selecting bison as the umbrella species for a shortgrass prairie ecosystem and managing for a viable population of bison may provide protection for prairie dogs, the species associated with them, as well as other species not associated with prairie dogs (e.g., pronghorn). So, a keystone species will not necessarily serve as the best surrogate species, but does need to be included in the conservation of functioning ecosystems.

Literature Cited

Andelman, S.J. and W.F. Fagan. 2000. *Umbrellas and flagships: efficient conservation surrogates or expensive mistakes?* Proceedings of the National Academy of Sciences 97:5954-5959.

Barua, M., M. Root-Bernstein, R.J. Ladle and P. Jepson. 2011. *Defining flagship uses is critical for flagship selection: a critique of the IUCN climate change flagship fleet.* AMBIO 40:431-435.

Barua, M., J. Tamuly and R.A. Ahmed. 2010. *Mutiny or clear sailing? Examining the role of the Asian elephant as a flagship species.* Human Dimensions of Wildlife 15:145-160.

Betrus, C.J., E. Fleishman and R.B. Blair. 2005. *Cross-taxonomic potential and spatial transferability of an umbrella species index.* Journal of Environmental Management 74:79-87.

Bride, I.G., R.A. Griffiths, A. Melendez-Herrada and J.E. McKay. 2008. *Flying an amphibian flagship: conservation of the axolotl Ambystoma mexicanum through nature tourism at Lake Axolotl Xochimilco, Mexico*. International Zoo Yearbook 42:116-124.

Brock, B.L. and E.C. Atkinson. 2013. *Selecting species as targets for conservation planning.* Pages 123-147 in F.L. Craighead and C.L. Convis Jr., editors. Conservation Planning: shaping the future. ESRI Press, Redlands, California.

Brock, B.L., E.C. Atkinson, C. Groves, A. Toivola, T. Olenicki and L. Craighead. 2006. *A wildlife conservation assessment of the Madison Valley, Montana*. Wildlife Conservation Society, Greater Yellowstone Program, Bozeman, Montana.

Brooker, L. 2002. *The application of focal species knowledge to landscape design in agricultural lands using ecological neighbourhood as a template*. Landscape and Urban Planning 60:185-210.

Carignan, V. and M. Villard. 2002. *Selecting indicator species to monitor ecological integrity: a review*. Environmental Monitoring and Assessment 78:45-61.

Caro, T.M. 2010. *Conservation by proxy: indicator, umbrella, keystone, flagship, and other surrogate species*. Island Press, Washington, DC.

Caro, T.M. 2003. *Umbrella species: critique and lessons from East Africa*. Animal Conservation 6:171-181.

Caro, T.M., J. Eadie and A. Sih. 2005. *Use of substitute species in conservation biology.* Conservation Biology 19:1821-1826.

Caro, T.M. and G. O’Doherty. 1999. *On the use of surrogate species in conservation biology.* Conservation Biology 13:805-814.

Castellón, T.D. and K.E. Sieving. 2012. *Can focal species planning for landscape connectivity meet the needs of South American temperate rainforest endemics?* Natural Areas Journal 32:316-324.

Chase , M.K. and G.R. Geupel. 2005. *The use of avian focal species for conservation planning in California.* USDA Forest Service Gen. Tech. Rep. PSW-GTR-191:130-142.

Coppolillo, P., H. Gomez, F. Maisels, R. Wallace. 2004. *Selection criteria for suites of landscape species as a basis for site-based conservation.* Biological Conservation 115:419-430.

Dale, V.H. and S.C. Beyeler. 2001. *Challenges in the development and use of ecological indicators*. Ecological Indicators 1:3-10.

Didier, K.A., M.J. Glennon, A. Novaro, E.W. Sanderson, S. Strindberg, S. Walker and S. Di Martino. 2009. *The landscape species approach: spatially-explicit conservation planning applied in the Adirondacks, USA and San Guillermo-Laguna Brava, Argentina landscapes.* Oryx 43:476-487.

Dietz, J.M., L.A. Dietz and E.Y. Nagagata. 1994. *The effective use of flagship species for conservation of biodiversity: the example of lion tamarins in Brazil*. Pages 32-49 in P.J.S. Olney, G.M. Mace and A.T.C. Feistner, editors. Creative Conservation: interactive management of wild and captive animals. Chapman & Hall, London.

Evers, D.C., J.G. Wiener, C.T. Driscoll, D.A. Gay, N. Basu, B.A. Monson, K.F. Lambert, H.A. Morrison, J.T. Morgan, K.A. Williams and A.G. Soehl. 2011. *Great Lakes mercury connections: the extent and effects of mercury pollution in the Great Lakes Region.* Biodiversity Research Institute. Gorham, Maine. Report BRI 2011-18.

Favreau, J.M., C.A. Drew, G.R. Hess, M.J. Rubino, F.H. Koch and K.A. Eschelbach. 2006. *Recommendations for assessing the effectiveness of surrogate species approaches.* Biodiversity and Conservation 15:3949-3969.

Fleishman, E., D.D. Murphy, and P.F. Brussard. 2000. *A new method for selection of umbrella species for conservation planning.* Ecological Applications 10:569-579.

Freudenberger, D. and L. Brooker. 2004. *Development of the focal species approach for biodiversity conservation in the temperate agricultural zones of Australia*. Biodiversity and Conservation 13:253-274.

Gill, M. and C. Zöckler. 2008. *A strategy for developing indices and indicators to track status and trends in arctic biodiversity.* Conservation of Arctic Flora and Fauna, Circumpolar Biodiversity Monitoring Program, Report No. 12. Akureyri, Iceland.

Hess, G. R. and T. J. King. 2002. *Planning open spaces for wildlife I: selecting focal species using a Delphi survey approach*. Landscape and Urban Planning 58:25-40.

Kao, R.H., C.M. Gibson, R.E. Gallery, C.L. Meier, D.T. Barnett, K.M. Docherty, K.K. Blevins, P.D. Travers, E. Azuaje, Y.P. Springer, K.M. Thibault, V.J. McKenzie, M. Keller, L.F. Alves, E.S. Hinckley, J. Parnell and D. Schimel. 2012. *NEON terrestrial field observations: designing continental-scale, standardized sampling*. Ecosphere 3:1-17.

Lambeck, R.J. 1997. *Focal species: a multi-species umbrella for nature conservation.* Conservation Biology 11:849-856.

Lambeck, R.J. 2002. *Focal species and restoration ecology: response to Lindenmayer et al.* Conservation Biology 16:549–551.

Landres, P.B., J. Verner and J.W. Thomas. 1988. *Ecological uses of vertebrate indicator species: a critique.* Conservation Biology 2:316–328.

Launer, A.E. and D.D. Murphy. 1994. *Umbrella species and the conservation of habitat fragments: a case of a threatened butterfly and a vanishing grassland ecosystem.* Biological Conservation 69:145-153.

Lindenmayer, D.B. and G.E. Likens. 2011. *Direct measurement versus surrogate indicator species for evaluating environmental change and biodiversity loss*. Ecosystems 14:47-59.

Lindenmayer, D.B., A.D. Manning, P.L. Smith, H.P Possingham, J. Fischer, I. Oliver and M.A. McCarthy. 2002. *The focal-species approach and landscape restoration: a critique*. Conservation Biology 16:338-345.

Linnell, J.D., J.E. Swenson and R. Andersen. 2000. *Conservation of biodiversity in Scandinavian boreal forests: large carnivores as flagships, umbrellas, indicators, or keystones?* Biodiversity and Conservation 9:857-868.

Lorimer, J. 2007. *Nonhuman charisma*. Environment and Planning D 25:911-932.

Martino. D., C.S. Lam and T. Longcore. 2005. Green Visions Plan for 21st Century Southern California*: Terrestrial target species for habitat conservation planning.* University of Southern California GIS Research Laboratory and Center for Sustainable Cities, Los Angeles, California.

Mills, L.S., M.E. Soulé and D.F. Doak. 1993. *The keystone-species concept in ecology and conservation.* BioScience 43:219-224.

Ozaki, K., M. Isono, T. Kawahara, S. Iida, T. Kudo and K. Fukuyama. 2006. *A mechanistic approach to evaluation of umbrella species as conservation surrogates*. Conservation Biology 20:1507-1515.

Patton, D.R. 1987. *Is the use of "management indicator species" feasible?* Western Journal of Applied Forestry 2:33-34.

Power, M.E., D. Tilman, J.A. Estes, B.A. Menge, W.J. Bond, L.S. Mills, G. Daily, J.C. Castilla, J. Lubchenco and R.T. Paine. 1996. *Challenges in the quest for keystones: identifying keystone species is difficult – but essential to understanding how loss of species will affect ecosystems*. BioScience 46:609-620.

Rempel, R. S. 2007. *Selecting focal songbird species for biodiversity conservation assessment: responses to forest cover amount and configuration*. Avian Conservation and Ecology 2(1):6. http://www.ace-eco.org/vol2/iss1/art6/

Rempel, R.S. and M. Donnelly. 2010. *A spatial landscape assessment modeling framework for management and biodiversity conservation.* Sustainable Forest Management Network, Edmonton, Alberta.

Roberge, J. and P. Angelstam. 2004. *Usefulness of the umbrella species concept as a conservation tool.* Conservation Biology 18:76-85

Rodrigues, A.S.L. and T.M. Brooks. 2007. *Shortcuts for biodiversity conservation planning: the effectiveness of surrogates.* Ecology, Evolution, and Systematics 38:713-737.

Rubino, M. J. and G. R. Hess. 2003. *Planning open spaces for wildlife II: modeling and verifying focal species habitat*. Landscape and Urban Planning 64:89-104.

Sanderson, E.W., K.H. Redford, A. Vedder, P.B. Coppolillo and S.E. Ward. 2002. *A conceptual model for conservation planning based on landscape species requirements*. Landscape and Urban Planning 58:41–56.

Simberloff, D. 1998. *Flagships, umbrellas, and keystones: is single-species management passé in the landscape era?* Biological Conservation 83:247-257.

Solomon, M. 2000. *The relative performance of surrogate measures for viable populations.* Master's Dissertation, University of Pretoria, South Africa.

Stirling, I. and A.E. Derocher. 2007. *Melting under pressure: the real scoop on climate warming and polar bears.* The Wildlife Professional 1:24-27.

The Nature Conservancy. 2013. *The language of conservation 2013: updated recommendations on how to communicate effectively to build support for conservation*.

Tisdell, C.A. and C. Wilson. 2005. *Does tourism contribute to sea turtle conservation? Is the flagship status of turtle advantageous?* MAST/Maritime Studies 3/4:145-167.

Tulloch, A., I. Chades and H. Possingham. In press. *Accounting for complementarity maximizes monitoring power for species management.* Conservation Biology.

Verissimo, D., D.C. MacMillan and R.J. Smith. 2011. *Toward a systematic approach for identifying conservation flagships.* Conservation Letters 4:1-8.

Watts, K., A.E. Eycott, P. Handley, D. Ray, J.W. Humphrey and C.P. Quine. 2010. *Targeting and evaluating biodiversity conservation action within fragmented landscapes: an approach based on generic focal species and least-cost networks.* Landscape Ecology 25:1305-1318.

Wesser, S. 2011. *Lichens and mosses.* Resource Brief. National Park Service, Inventory and Monitoring Program, Alaska Region, Anchorage.

Zacharias, M.A. and J.C. Roff. 2001. *Use of focal species in marine conservation and management: a review and critique.* Aquatic Conservation: Marine and Freshwater Ecosystems 11:59-76.

Appendix C – Hypothetical Example #1 of Biological Planning to Select Surrogate Species

Region A of the USFWS and States B and C agree to use a surrogate species approach to develop a conservation design for Landscape X, so that it will function to support self-sustaining populations of plants, fish and wildlife, for the continuing benefit of society. Landscape X is contained within States B and C. It contains a large river valley, bounded at one end by the ocean and elsewhere by mountains. It contains a wide variety of habitats, from coastal wetlands to alpine forests and headwater streams. Over 500 species call it home, most occurring in adjacent landscapes. There is one ESA-listed rodent and several listed seabirds that spend at least some part of their life history in Landscape X. Dozens of nonnative plants and animals are established. There is a patchwork of urban, suburban, rural agricultural and protected land uses, and 20 percent of the landscape is protected as part of a larger national park.

The USFWS convenes a partnership of conservation organizations to initiate conservation planning for Landscape X using a surrogate species approach. Based on an affiliated climate change forecasting effort for the region that projects conditions for the year 2050, the partnership agrees to use the same temporal scale for their planning effort. They also agree to use a 1980 comprehensive statewide fish and wildlife conservation assessment as their primary baseline.

A steering committee compiles information on species of conservation interest (SCI) that occur in Landscape X, drawing from the 1980 assessment, the states' Wildlife Action Plans, candidate and listed species under the Endangered Species Act, priority species in an associated National Fish Habitat Partnership, priority species identified by the associated Joint Venture, and information provided by two overlapping LCCs. This list consists of 70 invertebrates, 200 vertebrates and 30 plants.

For each of the 300 SCI, one or more species experts (based on taxonomic groups) complete a spreadsheet with summary information on:

- Unique life history traits
- Habitat requirements for each discrete life history stage
- Current range, and projected range in 2050
- Spatial requirements for a viable population (area, connectivity, configuration)

An expert panel also compiles a geo-referenced database and associated GIS layers describing:

- Current composition and extent of habitat types
- Current patterns of land use, including urban, rural, and protected natural areas, as well as new wind, solar, and wave energy project sites.
- Existing corridors for migratory species on the landscape, including fish passage
- Projections of future landscape conditions based on 2100 climate forecasting and additional modeling of urban development

Narrative information also is compiled on existing disturbance regimes and how those may be different in 2100; habitat succession rates; and major existing and projected landscape threats.

Using the information gathered, expert opinions, and niche analysis models (Figure 1), an expert panel determines which species are most demanding of aspects of Landscape X (e.g., resources, area, configuration). They create a list of these species and under each listed species list the species that are less demanding of the resource and would be accommodated by managing for the “surrogate species”. For example, if a certain species of trout requires the coldest water of any other species in a stream system, they would select that more demanding trout species as the surrogate and list the other species under it that also require cold water, but to a lesser degree. By designing and managing the landscape to meet the cold water needs for the surrogate trout species, the other associated aquatic species with related but lesser demands (e.g., other native fish, aquatic invertebrates, amphibians, river otters, etc.) would be conserved too.

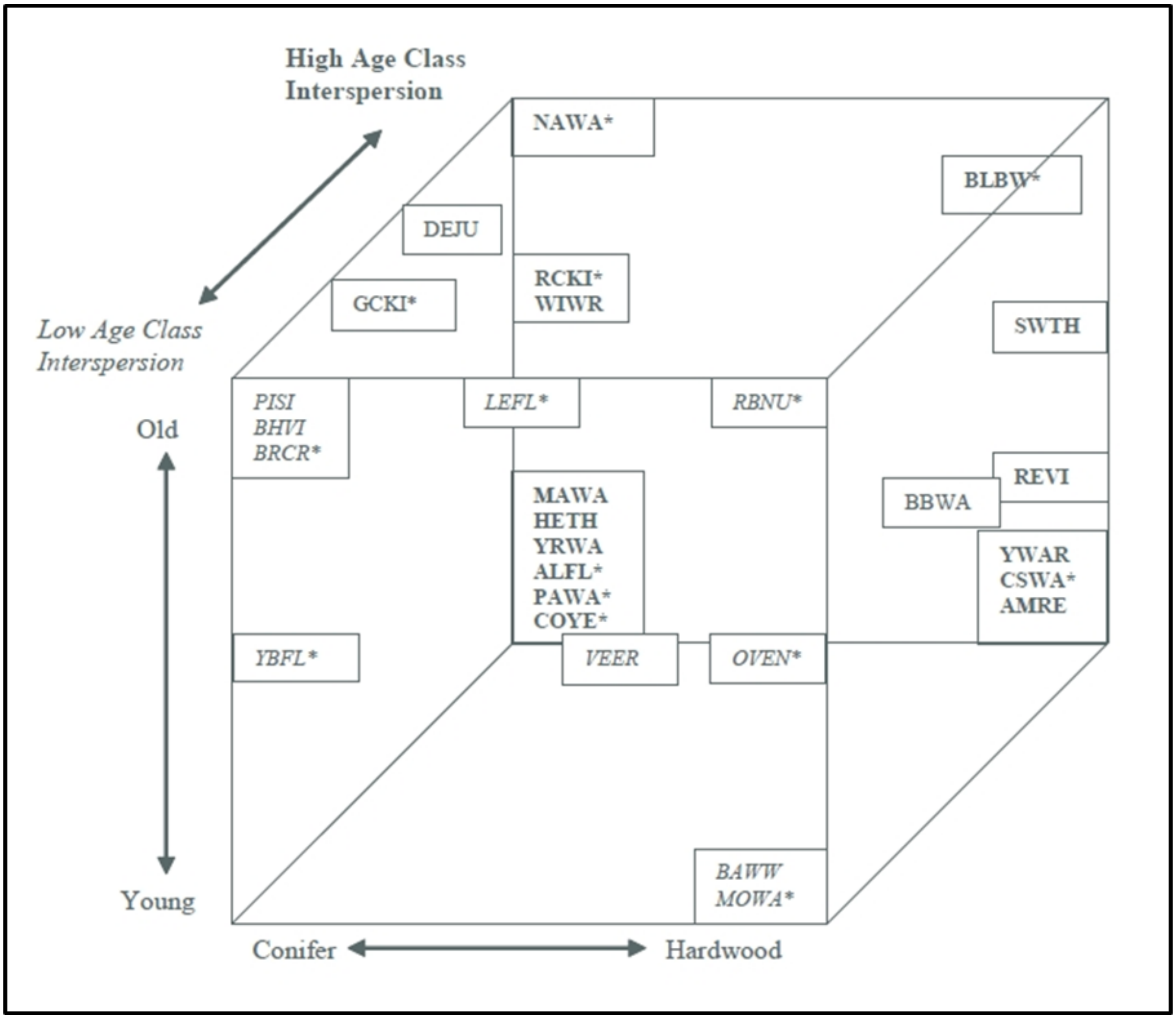


Figure 1. Habitat niche space model with focal bird species selected (*) to represent specific habitat conditions within a boreal forest matrix (Rempel and Donnelly 2010). The idea is that selecting species on the edges and corners (most demanding of aspects of the habitat, area, etc.) as surrogates and managing for them, will accommodate all the species in the interior of the box that are less demanding.

For example:

Cold Water Resources

Cutthroat trout – requires coldest water… managing steams for viable cutthroat trout populations will also accommodate:

- Other native trout
- Native minnows
- Salmon fry
- Native salamanders
- etc. – list all SCI species that would be accommodated by managing streams for bull trout

Stream Connectivity

Sturgeon – most demanding of stream connectivity for breeding/migration, managing stream systems for viable populations of sturgeon will accommodate these other species that also require steam connectivity:

- Salmon
- Steelhead
- Anadromous cutthroat
- Native crayfish
- American pipet
- Amphipods
- etc. – list all the SCI species that would be accommodated by managing streams for connectivity for sturgeon

Terrestrial Area Requirements and Connectivity

Black bear – most demanding of area and connectivity of this landscape, managing for viable populations of black bear will accommodate the area and connectivity needs of:

- Deer
- Elk

- Native rabbits
- Bobcat
- Native rodents
- Toads
- Beetles
- Endangered plants
- etc. – list all the SCI species whose area needs would be met by managing for black bear

In completing the list, it is found that there are some species whose area requirements are not covered by the requirements for black bear, so the panel adds another species that requires large areas and high landscape connectivity to compliment the areas selected for bears. They continue adding surrogate species in this way until all species area and connectivity needs are met. For example, maybe managing for black bears and mountain lions together is needed to accommodate the full set of species with similar but lesser demands. So mountain lions are added as a surrogate for area and connectivity requirements:

Mountain lion – area needs for viable population not completely encompassed by black bear area, so need to manage for both, which will accommodate these additional species:

- Jumping mice
- Screech owl
- Gopher snake
- etc. – list all species who are accommodated by adding mountain lion as a surrogate

The panel also list species that are most demanding for specialized habitat conditions along with the species whose needs would be met in managing for them:

Old Growth Forest

Pileated Woodpecker – managing old growth for self-sustaining populations of pileated woodpeckers will accommodate these other species:

- Shrews

- Owls
- Breeding habitat for migratory birds
- Salamanders
- Ferns
- Butterflies
- etc.

This would be repeated for other specialized habitats such as grasslands, riparian areas, etc.

The committee repeats this approach until all habitat types are accounted for and all SCI species in a landscape are either listed as a surrogate species or a "background species" accommodated by managing for the suite of selected surrogate species.

The committee finds that there are some species that have very unique habitat requirements that are not considered when planning at this landscape scale. For instance, a highly endemic spring snail is not accommodated by managing for the requirements of any of the selected surrogate species, so they are added to the list of species for targeted management to sustain viable populations.

The result of this process is a list of species that management action will be targeted towards (surrogate species and species with special needs), a list of all the SCI species that will explicitly be accounted for in managing for the functional landscape using surrogate species. It is important that all SCI species are on the list, so that there are no gaps in the conservation plan for the landscape and the species in it. The list can be used to design monitoring programs to test surrogacy assumptions (Table 1).

Surrogate Species	Background Species	Landscape Feature
Cutthroat trout	Shiner minnow	Cold water resources
	Rainbow trout	
	Amphipods	
Black bear	Black-tailed deer	Area and connectivity
	Bobcat	
Etc…		

To design the required landscape features in such a way as to support this list of surrogates and species with special needs, the expert panel starts the design with already protected lands or surrogate species population centers and determines what habitats need to be added, protected or managed in order to support self-sustaining populations of each surrogate and special needs species. They take into account the landscape connectivity requirements, minimum habitat sizes, juxtaposition of habitats, and processes (e.g., disturbance regimes) that are required to support viable populations of the selected species. They also consider how the landscape may change in the future with climate change, urbanization, energy extraction, etc., and plan for self-sustaining surrogate populations in the face of these changes.

The result of this planning process is a design that is required to maintain Landscape X as a functional landscape defining what type, where, how much and in what configuration habitat conditions need to exist to support self-sustaining populations of all SCI species. The committee uses this information for strategic acquisitions or leases of land to secure or enlarge needed habitat types, or provide connectivity. Region A uses the information to determine how to manage different habitat patches within the very large refuges; what proportions of different habitats and what juxtaposition habitat patches need to be in to meet the needs of the surrogate species. The information is also used to suggest the best role of smaller refuges in Landscape X, given the habitat and configuration needs of the species therein, and given their mandate to consider the refuge's importance to refuge, ecosystem, national, and international landscape scales of biological integrity, diversity, and environmental health (601 FW 3.9.D).

This completes the biological planning phase of SHC to develop a conservation design for Landscape X to support self-sustaining populations of plants, fish and wildlife, for the continuing benefit of society. The next step in SHC is to implement management actions for the habitat conditions required to support viable populations of the surrogate and special needs species using adaptive management designed to test the assumptions of surrogacy and the adequacy of the design of the landscape. As conditions change (e.g., due to climate change or energy or urban development), and as the managers learn more about the system over time, the surrogate species, the landscape design, and the management actions may need to be adjusted.

In addition to designing for a functional landscape capable of supporting self-sustaining populations of plants, fish and wildlife; there are other conservation goals the committee has that are not addressed via this approach to conservation planning. They may want to add to the design of the landscape to favor a huntable surplus of a particular species. They may want to select a species that invokes a positive response from the public and build a marketing campaign around that species and add to the design of the landscape favoring that species to increase public support of their conservation work. They may decide to use a surrogate species approach to monitor some aspect of the environment or landscape change (e.g., climate change, invasive species, water quality). If so, they could use the information collected in the biological planning stage described here and select species that are most sensitive to the stressors they anticipate and design a monitoring program to monitor these species. Some of these species may be the same ones selected for designing the functionality of the landscape, so this monitoring could be used to detect change and to test the landscape design. They might decide to use a structured decision making process to determine which and how many of these additional species to use, based upon their capacity and monitoring goals. Once these species are selected, they would be employed in the appropriate monitoring and implementation phases of SHC (see Figure 1 in the Guidance).

Appendix D – Hypothetical Example #2 of Biological Planning to Select Surrogate Species

Region A of the USFWS and States B and C agree to use a subset of species to provide a simplified framework for planning landscape-scale conservation for Landscape X. Landscape X is contained within States B and C. It contains a large river valley, bounded at one end by the ocean and elsewhere by mountains. It contains a wide variety of habitats, from coastal wetlands to alpine forests and headwater streams. Over 500 species call it home, most occurring in adjacent landscapes. There is one ESA-listed rodent and several listed seabirds that spend at least some part of their life history in Landscape X. Dozens of nonnative plants and animals are established. There is a patchwork of urban, suburban, rural agricultural and protected land uses, and 20 percent of the landscape is protected as part of a larger national park.

Setting the Stage: A partnership of conservation organizations convenes to initiate conservation planning for Landscape X using biological objectives for a subset of species. Based on an affiliated climate change forecasting effort for the region that projects conditions for the year 2100, the partnership agrees to use the same temporal scale for their planning effort. They also agree to use a 1980 comprehensive statewide fish and wildlife conservation assessment as their primary baseline.

The group forms a steering committee of all partners to oversee the effort, and decides to use a series of expert panels to characterize the landscape, develop criteria for surrogate species selection, and select species and associated population objectives. A limited number of organizations are represented on these panels based on the relevant expertise desired, but the group develops a process to obtain review of each major product by all interested stakeholders identified for Landscape X. A data and document management tool is developed to track all of the information considered and the associated decisions.

Using the 1980 assessment and more recent published documents and gray literature, along with expert opinion, a geo-referenced database and associated GIS layers are produced describing:

- Composition and extent of habitat types in 1980
- Current composition and extent of habitat types
- Existing corridors for migratory species on the landscape, including fish passage
- Existing invasive species infestations in Landscape X and projected distributions in 2100
- Current patterns of land use, including urban, rural, and protected natural areas, as well as new wind, solar, and wave energy project sites.

- Projections of future landscape conditions based on 2100 climate forecasting and additional modeling of urban development

Narrative information also is compiled on existing physical disturbance regimes and how those may be different in 2100; habitat succession rates; and other major existing and projected landscape threats (particularly contaminants and wildlife diseases).

The steering committee compiles information on species of conservation interest (SCI) that occur in Landscape X, drawing from the 1980 assessment, the states' Wildlife Action Plans, candidate and listed species under the Endangered Species Act, priority species in an associated National Fish Habitat Partnership, priority species identified by the associated Joint Venture, and information provided by two overlapping LCCs. This list consists of 70 invertebrates, 200 vertebrates, and 30 plants.

For each of the 300 SCI, one or more expert reviewers (based on taxonomic groups) complete a spreadsheet with summary information on:

- Unique life history traits
- Habitat requirements for each discrete life history stage
- Current range, and projected range in 2,100
- Spatial requirements for a viable population (area, connectivity, configuration)
- Limiting factors (related to both species and landscape) and goals and objectives related to their mitigation
- Documented population objectives
- Existing monitoring programs

At this point, the committee can proceed down a number of paths to achieve their conservation goals, some of which may involve using a surrogate species approach. There is no one "right path", but each has implications for the breadth of the conservation planning effort and the types of analysis and expertise employed. Described below is one approach.

Recognizing that the overarching vision is a landscape capable of supporting self-sustaining populations of the SCI, the committee considers the breadth of information gathered via the landscape assessment information and the SCI spreadsheet, and identifies five conservation challenges for Landscape X that pertain to that overarching vision (note: in this example, the

Committee is using existing knowledge gained from previous or ongoing conservation efforts in the landscape):

1. Aquatic habitat connectivity
2. Corridors for terrestrial species movement
3. Coastal forest habitats
4. Climate change impacts resiliency
5. Invasive species impacts

Next, the committee holds a workshop to determine which (if any) surrogate species approach(es) can enhance their ability to address the identified conservation challenges, and how to select the most suitable species for each approach. Initially, the workshop focuses on the function of using a subset of species to represent the landscape features needed to support self-sustaining populations of the larger set of SCI, focused on the first three conservation challenges. Given the last two challenges, workshop participants also determine the value of using subsets of species for two other functions: indicating the vulnerability of the larger set of SCI to climate change impacts; and garnering public support and involvement for reducing the spread and impact of invasive species that limit the capacity for self-sustaining populations of SCI in Landscape X. The workshop also generates selection criteria for each function, with recognition that some surrogate species may have overlapping roles.

These decisions feed into structured decision-making workshops to select preliminary sets of surrogate species associated with the three designated functions. The workshops also identify any species, landscape features, or specific threats to landscape function that may not be addressed by the surrogates and therefore require special management attention. The following summary document is produced (a much more detailed set of documents are developed that fully describe the basis for decisions, associated assumptions that will drive future research needs, etc.):

Species	Surrogacy Role
Trout (native)	Represent aquatic habitat connectivity needs of other freshwater SCI, and garner public support for invasive species management
Black bear (native)	Represent terrestrial corridor needs of other SCI
Suite of warblers (native)	Represent coastal forest habitat needs of other SCI
Salamander (native)	Represent coastal forest habitat needs of other SCI; indicate vulnerability of the larger set of SCI to climate change impacts

Butterfly (native)	Indicate vulnerability of the larger set of SCI to climate change impacts
State flowers (native)	Garner public support for invasive species management
Suite of endangered seabirds	N/A: Needs Special Management Attention
Threatened rodent	N/A: Needs Special Management Attention

The steering committee then works with a local university to conduct a modeling exercise to evaluate the suitability of the preliminary set of surrogates. Based on the analysis, the steering committee replaces the proposed butterfly species with a different species.

Once the surrogate species have been selected, associated population objectives are also needed to define the scope of subsequent conservation efforts, and subsequently measure progress. For Landscape X, a series of expert panels is convened to define the following associated population objectives for each surrogate species within Landscape X:

Species	**Population Objective(s)**
Trout (native)	500 adults/stream
Black bear (native)	Maintain current distribution
Suite of warblers (native)	Maintain existing abundance
Salamander (native)	20,000 total
Butterfly (native)	400,000 total
State flowers (native)	15% increase in areal extent
Suite of endangered seabirds	62% nest success
Threatened rodent	1.4% population increase/year

Appendix E – Framework for Joint Selection of Surrogate Species by the U.S. Fish and Wildlife Service and State Fish and Wildlife Agencies, June 6, 2013

This framework provides a way for the U.S. Fish and Wildlife Service (Service) and State Fish and Wildlife Agencies (States) to work together in the selection of species to serve as surrogates in landscape conservation design. We believe that this framework accomplishes a path forward on several important points:

- It establishes a peer-to-peer relationship between the Service and the States

- It respects the different authorities and responsibilities of States and the Service

- It clarifies the decision-making roles of the States and the Service

- It helps define the role of LCCs, not as decision bodies, but rather as forums providing significant additional capacity, information, and tools to assist States and the Service with approaches to landscape-scale conservation in their geographies.

For the purposes here, federal trust species are migratory birds, federally endangered and threatened species, some marine mammals, and interjurisdictional fish. State trust species include all other species of fish and wildlife. State and Federal roles and authority are described in 43 CFR 24[1], which provides general jurisdictional principles at § 24.3 (a):

> "In general the States possess broad trustee and police powers over fish and wildlife within their borders, including fish and wildlife found on Federal lands within a State. Under the Property Clause of the Constitution, Congress is given the power to "make all needful Rules and Regulations respecting the Territory or other Property belonging to the United States."

§ 24.3 (a) further sets out exceptions to this general jurisdictional principle such as when Congress has specifically given authority to the Secretary of the Interior to manage fish and wildlife resources, such as endangered and threatened species, migratory birds, certain marine mammals, and some anadromous fish.

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[1] 43 CFR 24 is available at:

http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&sid=5717b12bf35a7700b537919492cd2b5e&tpl=/ecfrbrowse/Title43/43cfr24_main_02. tpl

Framework

- The Service and States will work together to decide the initial pool of species to be represented and the initial pool of surrogates. While input may be obtained from others, the decision on the final suite of surrogate species selected rests with the States and the Service. State Wildlife Action Plans are a valuable starting point and resource for discussions.

- The Service will not select State trust species as surrogates without concurrence from the State(s) involved.

- The initial scale for selection of surrogate species could be within the geographic boundaries of Landscape Conservation Cooperatives (LCC's). Sometimes the scale will need to be smaller than an LCC boundary and sometimes species and landscapes will transcend multiple LCC geographies. When the appropriate scale is determined, whether smaller or larger than an LCC geography, the Service and States will work together to coordinate across all administrative boundaries.

- If a State or group of States agrees on using a State trust species as a possible surrogate, the surrogate population objective will be identical to the State population objective or combined State objectives. If population objectives do not exist, the State(s) will develop population objectives in a consistent and coordinated manner with the Service. If the State(s) do not choose to develop population objectives, the State(s) and the Service will discuss.

- If no population objectives exist for federal trust species, the Service will develop population objectives in a consistent and coordinated manner with the affected State(s).

- The Service and the States will jointly decide the monitoring, data management, and reporting protocols necessary for surrogate species, subject to approval of such protocols, for state trust species, to the states involved.

- The Service and States may reach out to and use LCCs or other sources for scientific expertise on issues like decisions of scale, which species are best suited as surrogates, the development of robust monitoring protocols, and other topics. This input may inform the ultimate decisions made by the States and the Service.

Additional Considerations

- We acknowledge that existing efforts around the country are moving forward at different paces, and we are comfortable with those moving forward as long as the framework outlined here is followed.

- We desire some sort of formalized mechanism for FWS and States to move forward together in this context and make decisions together (a possible example might be a “decision council” patterned after the flyway councils). A joint State-FWS team could address this need further, including discussing details that need to be worked out. The desire is for a forum(s) that could be seen as a way that the States and Service make decisions over time that is more formal than single personal contacts and can transcend changes in people and relationships over time. Another example of a potential mechanism is agenda time specifically put into each of the regular regional meetings of the State and Service directors of the Fish and Wildlife Associations.

  This mechanism should address the following decision points:

  scale(s) for selecting
  surrogates, selection of
  surrogates,
  setting population goals for
  surrogates, agreement on monitoring
  protocols,
  evaluating the approach taken and determining if adjustments are
  needed.

  This mechanism will define roles and responsibilities, including potential roles for LCCs. The team should plan to report out no later than the September 2013 AFWA meeting.

- This joint surrogate species approach might inform, or could be a first step in, a larger joint approach to the Strategic Habitat Conservation paradigm for landscape -scale conservation.