Applying the 2012 Planning Rule to Conserve Species: A Practitioner's Reference

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Note:

This document is a technical and scientific reference
to aid field practitioners applying the 2012 Rule.

It does not represent policy or guidance.

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I. INTRODUCTION

The National Forest Management Act of 1976 (NFMA) directs managers of National Forest System (NFS) lands to "provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives." The mandate is challenging and is embraced by the Forest Service. At the heart of the challenge is maintaining ecosystem integrity and ecosystem processes while providing ecosystem services and renewable resources to society. Success requires understanding the interconnectivity of three major portions of the 2012 Forest Service Planning Rule (assessment, planning, monitoring) in relation to maintaining ecological integrity. Added complexity occurs when considering the ecosystems themselves, their complex organization and interactions, and in particular the multiple scales at which they operate and are influenced by society. This document examines the interface between at-risk species conservation and the broader planning rule, and how to use scientific approaches to ensure the conservation of at-risk species.

Based on input from the first Committee of Scientists (a group of scientists chartered by the NFMA to provide input on crafting the 1979 Planning Rule (44 Fed. Reg. 26599 (May 4, 1979)), the U.S. Department of Agriculture (hereafter, Department)[1] concluded in 1982 and again in 2012 that retaining native species was important and within the authority of the Department. The resulting language in the 1982 Planning Rule (Section 219.27, as amended in 1983) directs the agency to maintain biological diversity, and therefore to manage habitat to maintain viable populations of vertebrate species in the plan area. Similarly, the 2012 Planning Rule demands plan components provide ecological conditions necessary to maintain a viable population of each species of conservation concern (SCC) in the plan area (2012 Regulations 36 CFR Part 219, Subpart A 219.9(b)(2)).[2] The 2012 Planning Rule also contains important wording on ecosystem sustainability (36 CFR 219.8(a)) that relates directly to retaining species by managing ecosystem characteristics to maintain or restore ecological integrity. Thus, the 2012 Planning Rule considers species conservation within the context of overall diversity of plant and animal communities, managing ecosystems, and fulfilling the multiple-use objectives for the plan area.

Management of NFS lands to provide for 'diversity of plant and animal communities' has proven to be one of the most challenging requirements of the NFMA. The initial set of land management plans (hereafter, plans) was developed under the 1982 Planning Rule. All plan revisions through 2014 also used the 1982 Rule. Many different approaches were used to analyze and manage to conserve species. Administrative and legal challenges proliferated as the agency learned the new planning process. After 30 years, a new planning rule was issued ((USDA, Forest Service 2012; Federal Register Vol. 77, Nos. 68, Monday April 09, 2012), often called the 2012 Planning Rule) to incorporate new advances in land management planning and conservation science. Through the 2012 Planning Rule, the Forest Service is attempting to use more consistent approaches to manage for and assess species conservation.

Our objective is to provide a broad technical overview of at-risk species management under the 2012 Planning Rule and offer the associated scientific background. We emphasize SCC, but species designated under the Endangered Species Act (ESA) are also examined because the 2012 Rule provides specific direction for these species[3]. This document seeks to provide a practitioner's reference to maintaining

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[1] The terms 'regulation' and 'rule' both refer to the administrative law published in the Federal Register as the Code of Federal Regulations.

[2] The relationship between 'viability' and 'persistence' is addressed later in this introduction.

[3] Throughout this document, we follow the wording of the Directives and use "at-risk species" to reference federally recognized species with formal designation under the Endangered Species Act (ESA, i.e., threatened, endangered, proposed, or candidate species), and species of conservation concern ((36 CFR 219.9(c)) see FSH 1909.12, ch 10, sec. 12.5 in Directives for example during assessment phase).

diversity, promote understanding of changes in the Planning Rule, and facilitate dialogue that will result in more efficient and effective planning. The Rule and Directives provide policy; this document should not be read as new policy extending beyond the Rule[4]. Furthermore, our intent is not to duplicate excellent technical reviews of population viability analysis, or to propose any new developments in the field of species conservation. Rather, our core discussion is a review of the steps in planning where explicit and implicit consideration of species conservation can be integrated into the fabric of the broader plan and to highlight the technical or science considerations in executing those steps. We emphasize that maintaining and restoring **ecological conditions** supports maintenance of SCC and must be addressed as part of an integrated approach to land management planning. We suggest that effective application of the new Rule, particularly coordination among biologists and planners, can be facilitated by understanding the scientific and policy foundations of the Rule and Directives. Therefore, this document addresses the scientific and policy context for the new Rule in relation to species conservation. We also produced an abridged version of this document to offer a concise review of the most important concepts (Malcolm et al., in prep). This companion document is intended to function as a quick reference.

No single reference paper can address all the technical, science, or planning topics associated species conservation policy under the 2012 Rule thus we have limited the scope of this reference. We emphasize lessons learned from implementation of the 1982 rule and issues which emerged in early application of the 2012 Rule. Integrating species conservation into multiple use management, intersection with delivery of ecosystem services, approaches to evaluating ecological integrity, or the relationship with Regional Forester Sensitive Species lists are not considered; we expect they will be addressed in other venues.

This paper begins with a broad overview of the 2012 Forest Service Planning Rule particularly highlighting portions of the Rule and Directives concerning species conservation. We compare key areas of the 2012 and 1982 Rules to illuminate differences that will help biologists and planners carefully apply the new Rule. We examine elements of the conservation approach in the 2012 Planning Rule; specifically identifying, analyzing, managing, and monitoring at-risk species and associated portions of a plan that, together, represent the Department's strategy to ensure species persistence. Details regarding these same topics for plans revised under the 1982 Rule can be found in Anonymous (2001) and Liggett et al. (2003).

Key Characteristics of the 2012 Planning Rule

In this section we explore the characteristics of the 2012 Planning Rule as they relate to species conservation, including maintaining viable populations of species of conservation concern, and contributing to the recovery of species with federal status. We begin with a summary of the species conservation approach adopted by the 2012. This is followed by a comparison with the 1982 Rule – focusing on key differences between the Rules that we felt would lead to a better understanding of the species conservation approach specified in the new Rule.

2012 Planning Rule: Overview of Species Conservation Approach

The 2012 Rule adopts an approach to maintaining biological diversity that builds upon methods initially conceived for evaluating conservation reserve design described by Hunter (Hunter et al. 1989, 1990), referred to as the "coarse-filter/fine-filter" approach (see Groves 2003 for some evaluation). Application and modification of the approach to multiple use management involves considering both ecosystem properties and individual species characteristics. In particular, the 2012 Rule places increased attention on framing desired conditions that maintain and restore ecological integrity (i.e., composition, structure, function, and connectivity of aquatic and terrestrial ecosystems (the so-called coarse filter). This emphasis results in wording that directs plan components to maintain or restore ecological integrity and ecosystem

[4] Use of terms such as "should" or "shall" in this document must not be interpreted as policy. Rather they are used to avoid tortuous language that might be otherwise necessary to avoid sounding like policy.

diversity, (see sections 219.1(c) [Purpose] 219.8 [Sustainability] and 219.9 [Diversity of Plant and Animal Communities]) while also providing for social, economic, and ecological sustainability. Evaluation and management of ecological integrity, ecosystem diversity, and sustainability become the primary approach to meeting species conservation objectives. This point cannot be over-emphasized – management of ecosystem characteristics is the backbone of species conservation in the 2012 Rule. In the following paragraphs, we provide further detail on the role that ecosystem management plays in meeting species conservation objectives under the 2012 Planning Rule.

The planning process begins with an assessment and extends through the development of plan monitoring program questions and indicators. In the assessment, the responsible official evaluates the status of key ecosystems and ecosystem characteristics – using this evaluation to identify what needs to change in the plan. Based on the "need for change," the responsible official develops plan components (goals, desired conditions, objectives, suitability of lands, standards and guidelines) to maintain and restore ecosystem integrity. Plan monitoring also emphasizes evaluating the status of ecosystem integrity.

One approach (see FSH 1909.12; ch 10,12.14 for alternatives) to evaluating ecosystem integrity involves an analysis of ecosystem dynamics and connectivity, particularly disturbance processes and temporal variation in system condition, through consideration of natural range of variation (NRV) information (see Wiens et al. 2012 for a comprehensive overview). Analysis of NRV to understand ecosystem dynamics is one example of the strong emphasis the 2012 Planning Rule places on managing ecosystem characteristics. The Planning Rule further employs the concept of NRV by suggesting that development of desired conditions, objectives, and other plan components that maintain or restore composition, structure, function, and connectivity of key ecosystem features represent the most effective approach to providing the ecological conditions necessary for most species to persist over the long term. For instance, management of degraded shrub-steppe environments to restore conditions for greater sage grouse (*Centrocercus urophasianus*) may focus, in part, on extending fire return intervals to facilitate development of shrubland in priority locations. Managing disturbance is particularly important to maintain and restore *Artemisia spp*., which provides critical sage-grouse habitat. Hence, restoration for this species is strongly rooted in understanding of the disturbance ecology of the shrub steppe system. Similarly, management of cold-water stream environments for Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) often builds on understanding of historical ecology and resulting insights regarding the connectivity of stream networks (e.g., Novinger and Rahel 2003).

The 2012 Planning Rule, particularly in section 219.9, stresses the need to approach species conservation by first developing plan components for ecosystem characteristics (structure, function, composition, and connectivity) and then including plan components for individual species as needed (36 CFR 219.9). Hence, the 2012 framework for persistence lies in analyses and plan direction that focus on both approaches, but with a primary emphasis on system properties that result in ecological sustainability and integrity. Species-specific plan direction is reserved for those cases where the responsible official has determined (using available science) that plan components for ecosystem characteristics are inadequate to assure persistence (or to contribute to recovery) of at-risk species in the plan area.

Three major parts of the 2012 Rule together result in plan components that meet the NFMA provision to "provide for diversity of plant and animal communities" in the following sections:

- 36 CFR 219.8(a) Ecological Sustainability
- 36 CFR 219.9(a) Ecosystem plan components
- 36 CFR 219.9(b) Additional, species-specific plan components

Under *Ecological Sustainability*, the 2012 Rule establishes that "plans must include plan components, including standards or guidelines, to maintain or restore the ecological integrity of terrestrial and aquatic ecosystems and watersheds in the plan area, including plan components to maintain or restore structure, function, composition, and connectivity". This emphasis establishes a strong focus on the idea that maintaining species depends significantly on ecosystem condition. The *Ecosystem plan components* provisions of 36 CFR 219.9(a) re-iterate what appeared under the *Ecological Sustainability* provisions – namely, to require "plan components, including standards or guidelines to maintain or restore the ecosystem integrity of terrestrial and aquatic ecosystems and watersheds in the plan area". *Species-specific plan components* are required when *Sustainability* and *Ecosystem plan components* are insufficient to provide the ecological conditions to: "contribute to the recovery of federally listed threatened and endangered species, conserve proposed and candidate species, and maintain a viable population of each species of conservation concern within the plan area." (36 CFR 219.9(b)(1)).

SCC are defined as:

> *"a species, other than federally recognized threatened, endangered, proposed, or candidate species, that is known to occur in the plan area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area."* (36 CFR 219.9(c)).

The 2012 Planning Rule stipulates that plan components are designed to provide for the maintenance or restoration of ecological conditions to maintain a viable population of each SCC within the plan area (36 CFR 219.9(b)(1)).[5] The Rule specifically addresses situations where it is not possible to provide ecological conditions to maintain a viable population of SCC because doing so is: (*i*) "beyond the authority of the Forest Service"; or (*ii*) "not within the inherent capability of the plan area" (36 CFR 219.9(b)(2)). In these cases, the responsible official must identify the SCC, document the basis for the determination, and include plan components that "contribute to maintaining a viable population of the species within its range" (36 CFR 219.9(b)(2)(ii)). This may be the case for species, particularly in the face of a changing climate and accelerating anthropogenic pressures beyond the boundaries of NFS plan areas. There is also a general requirement that all plan components must be within the fiscal capability of the unit (36 CFR 219.1(g)).

The definition for "viable population" employed in the 2012 Rule communicates a clear distinction from the application of sensitive species (FSM 2670) prior to this Rule. The 2012 Rule (36 CFR 219.9(b)) requires that plan components provide ecological conditions necessary to maintain "a viable population" of each SCC and defines a viable population as:

> *"A population of a species that continues to persist over the long term with sufficient distribution to be resilient and adaptable to stressors and likely future environments."* (36 CFR 219.19).

and defines persistence as:

"Continued existence." The definition of a viable population emphasizes two elements, persistence and resilience. Much of the technical discussion throughout this practitioner's reference focuses on these two important elements, both of which are also examined extensively in the primary ecological literature. While our review of these two elements is broad, we make no attempt to provide a comprehensive review of either. Both relate to complex ecological concepts and analyses. We rely, in part, on the strong science-delivery of agency specialists, collaborators, and partners to interpret and apply conservation science as appropriate to each unique planning environment.

Forest Service planning under the 2012 Rule employs focal species (see Caro 2010) as a small subset of species whose status is monitored to permit inference to the state of the ecosystem (e.g., integrity) and/or

[5] The Rule uses the terminology "maintain a viable population" to explicitly reference a single population. In the preamble the Rule indicates that "individuals of a species of conservation concern that exist in the plan area will be considered to be members of one population of that species." (77 FR 21217, April 9, 2012)

sustainability of biodiversity (36 CFR 219.12 and FSH 1909.12, ch 30). Focal species are used to evaluate effectiveness in maintaining or restoring ecological conditions, including conditions deemed important to providing for plant and animal diversity. This concept emphasizes the species' functional role in the system. Focal species are not mentioned in the 2012 Planning Rule or planning directives outside of the context of the monitoring program (36 CFR 219.12 and FSH 1909.12, ch 30) and the associated feedbacks between assessment and monitoring (FSH 1909.12 ch 10 12.13 (4)(d)). The subject of focal species is therefore beyond the scope of this reference.

1982 Diversity Provisions: Overview of Species Conservation Approach

The 1982 diversity provisions were documented primarily in 36 CFR 219.19, 219.20 and 219.26 (now rescinded). The 1982 Planning Rule established two species conservation approaches along with habitat management that together represented the primary elements in a fabric of conservation. Agency shorthand for the two species-specific elements was "*species viability*" and "*management indicator species*" (MIS). These two elements were supported by a plethora of planning requirements to meet the broad biodiversity objective of NFMA.

The concept of species viability established in the 1982 Planning Rule was operationalized by a requirement for administrative units (i.e., national forests, grasslands, and recreation areas) to provide habitat in order "to maintain viable populations of existing native and desired non-native vertebrate species in the planning area" (36 CFR 219.19). Additional direction (FSM 2670.22) extended this mandate to include vascular plants. FSM 2670 established "Sensitive Species" and planning direction to support the conservation of those Sensitive Species.

Viability in the context of the 1982 Planning Rule required that habitat be provided to support a minimum number of reproductive individuals and that habitat be well distributed so that those individuals could interact with others in the planning area (36 CFR 219.19). Analysis of plans included an evaluation of the viability of species listed under the ESA as threatened or endangered, and following the publication of FSM 2670, of Sensitive Species identified by the Regional Forester.

The 1982 Planning Rule used a second approach, MIS, as a specific mechanism to focus on outcomes for species beyond those vulnerable to extinction. Sensitive Species focused attention toward development of species conservation options before species require the "emergency room attention" indicated by listing under the ESA (Tear et al. 1993, Yaffee 2006). In contrast, MIS were envisioned, in part, to focus attention on a subset of species that were of interest, but not necessarily in need of special attention to maintain viability (see Anonymous 2001, Hayward et al. 2004, Owen 2010).

Certain provisions of the 1982 Planning Rule and associated manual direction related to species diversity were difficult to implement (e.g., Raphael and Marcot 1994). This is not surprising, as even the First Committee of Scientists acknowledged that species diversity was "one of the most perplexing issues dealt with in the draft Regulations", and that "there remains a great deal of room for honest debate on the translation of policy into management planning requirements..." (Committee of Scientists 1979; 44 Fed. Reg. 26599 (May 4, 1979)). Several of these difficult elements were clarified through experience. The 2012 Planning Rule provides an alternative approach consistent with experience of land management planning over 30 years under the 1982 Planning Rule.

Comparisons between the 2012 and 1982 Planning Rules

Despite broad similarities between the 2012 and 1982 Planning Rules and Directives, operationally important differences exist. Some relate directly to managing for species conservation (Table 1); for those familiar with the 1982 Rule, understanding these differences will aid in recognizing key characteristics of the 2012 Rule.

The 2012 Rule does not employ MIS. This is a change in conservation planning from the 1982 Rule (see 77 FR 21162 page 21233). Several roles of MIS under the prior Rule, however, are integrated into the

2012 Rule. One important component is the emphasis on social and economic sustainability and ecosystem services. Many species identified as MIS under the 1982 Rule were hunted, fished, and trapped. These species may be examined directly during the assessment and, if needed, specific plan components may be designed to meet societies' interest in species conservation under the 2012 Rule. The former role of MIS related to management of 'secure species' is now addressed through the combination of "Sustainability" and "Ecosystem plan components" (36 CFR 219.8, and36 CFR 219.9) and the direction for multiple uses (36 CFR 219.10 (a)(1)). Prior to the 2012 Rule, reference to focal species in the context of Forest Service management has generally been associated with MIS or Sensitive Species (FSM 2670). Focal species served the need to consider management options for a tractable number of species (e. g. Wiens et al. 2008, Suring et al. 2011). As noted above, focal species serve a specific role in monitoring under the 2012 Rule.

Comparison of the Rules also demonstrates that the 2012 Planning Rule takes a slightly different approach to manage for native species persistence. The 2012 Planning Rule relies on a conservation approach that emphasizes plan elements focused on ecosystem characteristics. In particular, it underscores maintaining and restoring ecological integrity and ecosystem diversity, and providing for sustainability as the primary elements for effective and efficient species conservation. Species conservation requires management of NFS lands so they "are ecologically sustainable" and "consist of ecosystems and watersheds with ecological integrity and diverse plant and animal communities" (36 CFR 219.1 (c)). Promoting ecosystem sustainability, ecological integrity, and ecosystem diversity via the maintenance of ecosystem composition, structure, function, and connectivity represents the primary approach to species conservation.[6] It is useful to note that "connectivity" was not explicitly described in the 1982 Rule but the concept provides an additional consideration related to ecological processes in the 2012 Rule.

Maintaining species diversity occurs under both Rules when species populations are viable. Definitions for viability in the 1982 and 2012 Planning Rules differ. The 1982 Rule (36 CFR 219.19) defines a viable population as one:

> *"which has the estimated numbers and distribution of reproductive individuals to ensure its continued existence is well distributed in the planning area."*

and explicitly describes how viability could be maintained:

> *"In order to insure that viable populations will be maintained, habitat must be provided to support, at least, a minimum number of reproductive individuals and that habitat must be well distributed so that those individuals can interact with others in the planning area."* (36 CFR 219.19)

Under the 2012 Rule, the definition for a viable population (see above on page 4) in combination with acknowledgement of limitations placed on conservation by the inherent capability of the plan area and limits of Forest Service authority are of particular note. These result in policy that aligns with real-world, unavoidable problems associated with the development of plan components and analysis of effects. In the past, there was some confusion; did the Forest Service have a responsibility to address the "well distributed" requirement and produce habitat for species beyond the ecological capability of the plan area? The 2012 Rule clarifies this issue.

The Directives for land management planning (FSH 1909.12, ch 20, 23.13c) further defines several important terms associated with the concept of viability, clarifying differences between Rules. These terms include *population*, *persist over the long-term*, *sufficient distribution*, *resilient,* and *adaptable*. For instance, the individuals of a species that exist in the plan area are considered members of one population

[6] The 2012 Rule emphasizes ecological sustainability, integrity, and diversity. Rather than mentioning all three when discussing management goals, objectives, and desired conditions, we generally mention one with the intent of referencing all three.

(see 77 FR 21162 page 21217, FSH 1909.12, ch 20, 23.13c(1)(b)).

The 2012 Rule references viability specifically when defining requirements to manage SCC. Persistence is referenced when explaining the Department's intent of adopting complementary ecosystem and species-specific approaches (so-called, coarse filter/fine filter) to maintain diversity and persistence of native species and when defining a viable population. From the perspective of conservation science, the expanded focus from viability in the 1982 Rule to persistence in 2012 is small. The differences, however, have important symbolic significance. Most conservation practitioners or scientists would agree that a viable species or population will likely persist. The change in perspective that comes from considering species persistence is most clearly understood from an appreciation of the history of conservation science. Early methods focused on "minimum viable populations" (MVP) to evaluate species status (Shaffer 1981, Trail et al. 2007). However, a focus on a minimum number of individuals influences perspective, and can be limiting (Soule et al. 2003, Flather et al. 2011a) because the analysis of MVP centers on a single state – an individual population size. More importantly, the minimum provides managers a target that, by definition, rests on the verge of failure (loss of viability or, at the extreme, extinction), – a proposition that motivates substantial expenditure of resources and political controversy (Ruggiero et al. 1994, Scott et al. 2010). On the other hand, consideration of "persistence" motivates analyses that compare alternatives and acknowledges that viability and persistence are both measured with uncertainty and most effectively represented as probabilities. Therefore, while viable and persistent species (or populations) are ecologically identical, because of the historical development of conservation science, the two terms can motivate different approaches to evaluation. Ultimately, however, conservation planning under both Rules involved evaluation of species conservation status and thus examination of viability/persistence to determine if there is reason for conservation concern as described in more detail later in this document.

Table 1. Comparison of key elements for species conservation between the 2012 and 1982 Planning Rules and associated policy (e.g., Directives).

Issue	2012 Rule and Directives	1982 Rule and Directives
Taxa Addressed for Viability	Native taxa screened to identify Species of Conservation Concern (SCC).	All existing native and desired non-native plants, fish, and wildlife species (see Departmental Regulation 9500-4).
Plant and Animal Diversity	Complementary ecosystem and species-specific approaches to maintain the diversity of plant and animal communities and the persistence of native species in the plan area.	Provided for diversity of plant and animal communities and tree species consistent with the multiple-use objectives of the planning area. (219.26 ; also see 219.27(g))
Species Viability and Conservation Guidance	Plan components provide the ecological conditions necessary to: contribute to the recovery of federally listed threatened and endangered species, conserve proposed and candidate species, and maintain a viable population of each species of conservation concern within the plan area (if within the authority of the Forest Service and within the inherent capability of the plan area).	In order to ensure that viable populations will be maintained, habitat must be provided to support, at least, a minimum number of reproductive individuals and that habitat must be well distributed so that those individuals can interact with others in the planning area
Viability and Species Conservation Framework	Explicit integration of ecosystem and species approaches: - Ecosystem Diversity: Plan components provide the ecological conditions to maintain the diversity of plant and animal communities - Species Diversity: Plan components provide ecological conditions for at-risk-species.	Built on an approach combining outcome of: a) contributing to recovery of threatened and endangered species, b) evaluating taxa as Sensitive Species and managing habitat for viability of those taxa, c) managing the ecosystem to meet goals and objectives associated with Management Indicator Species (MIS) and d) identifying species of local interest for additional at-risk species.
Representative Species	Focal Species - Species selected to monitor status of ecological integrity - Provides meaningful information regarding the effectiveness of the plan in maintaining or restoring the ecological conditions to maintain the diversity of plant and animal communities in the plan area. - Selected on the basis of their functional role in ecosystems.	Management Indicator Species [Note: only one of five categories of MIS represented multiple species] - Develop objectives for the subset of MIS specifically identified as representing multiple species - Estimate the effects of each alternative on certain fish and wildlife populations (MIS)
Monitoring	Monitor a select set of ecological conditions that: - Include key characteristics of terrestrial and aquatic ecosystems - Indicate the degree to which land management is contributing to recovery of T&E, conserving proposed and candidate species, and maintaining the viability of SCC.	Population trends of MIS will be monitored and relationships to habitat changes inferred. No specific requirements for monitoring at-risk species

Species Conservation and the Broader Planning Process

Meeting the mandate of the 2012 Planning Rule to maintain species persistence requires thoughtful consideration of species and ecosystem management at multiple steps in planning. Here we briefly highlight major stages in land management planning that together provide for ecological conditions necessary to meet objectives for at-risk species under the 2012 Planning Rule (36 CFR 219.9(b)). We elaborate on the analysis, evaluation, and planning associated with at-risk species later in the paper (see section III: Process to Promote Native Species Conservation).

ASSESSMENT

- Evaluate ecosystem status in the plan revision assessment with an emphasis on ecosystem integrity, ecosystem sustainability, and species diversity which will provide context for considering species-specific plan components outlined below (FSH 1909.12 ch 10 12.1 – 12.3).
- Identify formally recognized threatened and endangered, proposed, and candidate species under the ESA, and identify potential SCC; species for which there exists scientific evidence indicating substantial concern for the species capability to persist over the long term in the plan area. (FSH 1909.12 ch 10 12.5).
- Assessment of the status of at-risk species including consideration of risk factors and limiting factors. These may have been documented in recovery plans for ESA species but may need to be determined and reported for SCC (FSH 1909.12 ch 10 12.55).

PROPOSED PLAN DEVELOPMENT

- Regional Forester identifies SCCs based on the rationale and documentation for potential species of conservation concern provided by, and in coordination with, the Responsible Official (see FSH 1909.12, ch 20, 21.22a(1)). Note that the final SCC list approved by the Regional Forester will usually occur during the planning phase, but may occur at any time.
- Consider plan components (broad and fine scale) that would provide the ecological conditions for, and/or contribute to, conservation of at-risk species by addressing the primary risks and limiting factors. This step should begin by examining ecosystem plan components. Write species-specific plan components only when approaches emphasizing system properties are not sufficient to meet objectives for at-risk species. Note that the process of developing plan components, evaluating plan components, and analyzing potential effects of alternatives is an iterative process (see FSH 1909.12 ch 20, 23.13). In some cases the deciding official may determine that an external science review is useful at this stage, during the assessment or during effects analysis (FSM 1909.12 zero code 07.2).

ALTERNATIVES

- Craft plan alternatives that represent a range of potential conservation approaches (FSH 1909.12 ch 20 23.13) considering a range of spatial and temporal scales. Under the 2012 Rule, this process may proceed employing an iterative or incremental process that leads to refinement of a dominant alternative.

NEPA EFFECTS ANALYSIS

- Examine projected effects of plan alternatives on at-risk species. The examination may:
    - provide well-reasoned evaluation of the likelihood that plan components as a whole provide ecological conditions suitable to maintain or restore ecological conditions to support at-risk species (FSH 1909.12 ch 20 23.13 (2)).
    - consider a timeframe that is adequately long to allow the expression of plan direction on populations;

- consider effects of predominant risk factors, stressors, and limiting factors pertinent to the species;
- consider both cumulative effects (as referenced in the National Environmental Policy Act NEPA) and the contribution of NFS management to species persistence;
- use currently accepted scientific information (also called best available scientific information); and
- clearly portray uncertainty surrounding the effects, including uncertainty due to gaps in knowledge.

FINAL PLAN AND DECISION

- Provide clear reference to portions of the assessment or specialist reports, that document the process used to select SCC and identify other at-risk species (FSH 1909.12 ch 10 12.5).
- Describe and document, in the record of decision (ROD), the basis for judging that the proposed action satisfies the diversity of plant and animal communities requirements of the 2012 Planning Rule (see Assessing Effects of Alternatives in Section III of this document and Appendix 1 for more detail (36 CFR 219.14(a)(2)). It will be helpful when referencing the best available scientific information, to highlight divergent scientific perspectives held by respected scientists and to document the reasons for accepting one view over the other.

MONITORING

- Clearly document the rationale for selecting the particular ecological conditions to monitor associated with at-risk species (FSH 1909.12 ch 30 32.13b).

Development of plan direction for threatened, endangered, candidate, and proposed species will differ from SCC. Formal listing decision documents and designation of critical habitat are likely to have defined conservation strategies for species identified through the ESA. Therefore, actions listed in recovery plans and conservation strategies should be considered in developing plan components that could contribute to the recovery of federally-listed species by specifying appropriate plan components. In contrast, plan components for SCC are unlikely to have been developed by any other agency.

II. CONCEPTUAL FOUNDATION FOR EVALUATING SPECIES STATUS

Management decisions for at-risk species are made in the context of a risk assessment. A number of difficult science-based and policy issues must be confronted during any evaluation of species conservation status. Decisions made in response to these key considerations significantly influence the outcome of the risk evaluation process. In this section, we highlight critical elements of determining the status of species in the context of the 2012 Rule. To a large extent, Threatened, Endangered, Candidate, and Proposed species status is determined by other agencies (they evaluate status/viability).Determining

Conservation Objectives for At-risk Species:

- *Threatened and Endangered under ESA* – provide ecological conditions necessary to contribute to their recovery
- *Proposed and Candidate under ESA* - contribute to preventing them from being federally listed
- *Species of Conservation Concern* - maintain a viable population of each species of conservation concern within the plan area

whether these species occur on the plan area is the necessary step for the NFS. Therefore, this section refers primarily to evaluating potential SCC. We briefly discuss several of the key scientific (ecological) elements that will be confronted in the process of evaluating the status of species as outlined in the directives ((FSH 1909.12 ch 10 12.5 – 12.55) also see Appendix 1).

Evaluating viability

Evaluation of population viability or persistence does not result in a dichotomous outcome –an analysis cannot conclude that a population is viable or is not viable. Despite past discussion of Minimum Viable Populations (MVP) there is not a single, fixed population size above which a species is viable and below which it will become extinct (Boyce 1992, Flather et al. 2011a); there is no MVP. Rather, populations of any size have an unknown probability of going extinct at some point in the future. Recent literature discusses the efficacy of applying a rule of thumb and generally concludes that the ecological conditions and dynamics, nature of threats, dynamics of particular species, and management actions all influence probability of persistence (see alternative views in Reed et al. 2003, Flather et al. 2011a, Flather et al. 2011b, Brook et al. 2011). Given the unknown probability of persistence (and therefore viability), the goal of an evaluation is to estimate the probability of persistence, whether quantitatively or qualitatively. Consequently, viability is best expressed through varying levels of risk. Level of assurance becomes a policy or legal issue.

Focus on limiting factors and threats

The risk assessment employed to evaluate species status is most strongly framed with a focus on limiting factors and threats which demands a keen understanding of ecosystem dynamics and species natural history. This evaluation should integrate what Caughley (1994) characterized as the 'small population paradigm' and the 'declining population paradigm' by considering the influence of stochasticity on very small populations but emphasizing the causes of population decline or peril. Consideration of species life history in the context of current ecosystem dynamics will provide insight into potential limiting factors. An understanding of management direction, environmental history, and current ecosystem status in light of potential limiting factors provides insight into threats. We provide more detail regarding status assessment later in this paper and a rich library of species assessments produced by the Rocky Mountain Region provides practical examples of this process (http://www.fs.fed.us/r2/projects/scp/assessments/).

Temporal scale

Evaluating the conservation status of a species or population is generally focused on some biologically-meaningful period of time (e.g., Shaffer 1981). Recent papers have measured time in units of 'generations' as a way to standardize across species with very different life histories (e.g., Reed et al. 2003, Flather et al. 2011a). Because the 2012 Planning Rule requires that plan components provide ecological conditions to support populations "with sufficient distribution to be resilient and adaptable to stressors" (36 CFR 219.19), it is not adequate in Forest Service evaluations to simply project species persistence until some arbitrary point in time. Ecological conditions are defined as including habitat and human uses, infrastructure for humans, connectivity, and invasive species (36 CFR 219.19). The evaluation includes assessment of both short-term and long-term risks. The timeframe over which long-term risks are projected should be based on ecosystem dynamics, ecology of the species (e.g., inherent volatility, generation time, recolonization capability) and on the time needed for conditions to respond to proposed management (dynamics of the ecosystem and nature of potential management). Assessments over management-specific timeframes are important to effectively evaluate effects of management on ecosystems and species. Such assessments should include cumulative effects. Finally, by acknowledging that uncertainty increases rapidly as the time period lengthens practitioners can balance the motivation to look at long-term risk with the reality of increased uncertainty.

Geographic scale

The spatial scope of the species status evaluation should reflect the scale at which biological populations operate (Wiens 1989, Ruggiero et al. 1994, Wiens 1996) and Rule requirements regarding the spatial extent of the plan area (FSH 1909.12 ch 10 12.53 (6) and (7)). Explicit consideration of geographic scale will motivate careful consideration of the potential influence of metapopulation dynamics, dynamics of patchy populations, and the influence of the species at spatial extents beyond the plan area ((36 CFR 219.8(a)) all of which help establish context for the status of species in the plan area. Considerations of scale and species distribution (e.g., metapopulations, patchy populations) will inherently involve evaluation of connectivity, an explicit requirement of the Rule. Thus, species status at broad geographic extents should be disclosed as part of the process of considering status in the plan area (particularly for SCC, see Appendix 1 for further discussion). The 2012 Rule recognizes the critical role of scale in species conservation and directs managers to maintain or contribute to conservation of at-risk species depending on the inherent capability of the land within and beyond FS management. Evaluation of the status of at-risk species and the effectiveness of plan components to maintain or restore ecological integrity should include consideration of the relationship between species distribution, life history, and the geography of the plan area.

The 2012 Planning Rule specifies the geographic scale of interest for some steps in planning for at-risk species. For example the definition for SCC specifies evaluation of status across the plan area (36 CFR 219.9(c)). For evaluating SCC, the preamble to the Planning Rule holds that “In making this evaluation, it is the Department’s expectation… that all individuals in the plan area will be considered a single population” (see 77 FR 21217, April 9, 2012). The Directives provide more detail indicating that “groups of individuals in the plan area may be known, or highly suspected to be, reproductively isolated and separate from the rest of the individuals. These individuals or groups may need to be considered when evaluating “sufficient distribution” (ch 20, 23.13c.1.b). See FSH 1909.12 ch 20 23.13c.1d for further discussion of consideration of sufficient distribution. Because of the critical importance of scaling issues in ecological processes (see references above and broader literature on scale), we strongly encourage practitioners to carefully disclose how characteristics of species distribution (and therefore connectivity), combined with other factors (see Appendix 1) resulted in determination of conservation status. Doing so will motivate productive review of conclusions and facilitate the public collaboration intended by the 2012 Rule.

Level of Assurance

Considering assurance levels for status evaluations of at-risk species involves a complex mix of technical understanding, policy, and risk assessment. Quantitative or qualitative evaluation of population dynamics in light of ecological circumstances is the foundation for the evaluation. However, the decision regarding level of assurance ultimately depends on data quality used in the risk assessment, quality of the risk assessment, and policy decisions regarding the level of risk that is acceptable in light of the particular planning environment. Here we review a tiny slice of case law and past experience to provide an understanding of the application of risk assessment to species evaluations. While the case law represents decisions made in response to the 1982 Rule, similarities in the two rules suggest that past legal decisions and lessons learned will be important in the future.

Court decisions relative to the 1982 Rule found that the assurance of viability must be compatible with key multiple-use considerations. In ruling on the Northwest Forest Plan, the District Court (Seattle Audubon Society v. Lyons, 871 F. Supp. 1291 (W.D. Wash. 1994)) stated that “the selection of an alternative with a higher likelihood of viability would preclude any multiple-use compromises contrary to the overall mandate of the NFMA”. However, the Ninth Circuit also made it clear that there is a substantive requirement to provide habitat that will maintain viability of species. In an earlier ruling in the Pacific Northwest (Seattle Audubon Society v. Moseley, 798 F. Supp. 1473, 1484, and 1494 (W.D. Wash 1992)), the District Court commented on a viability rating that had been made by an outside report on the

Forest Service preferred alternative. Here, the court commented that “if the medium-low viability rating were admittedly the Forest Service’s own rating, summary judgment under NFMA would be entered now... An adopted plan cannot be one which the agency knows or believes will probably cause the extirpation of native vertebrate species from the planning area.”

The definition for SCC specifies the level of assurance for identifying SCC as “substantial concern for persistence” (36 CFR 219.9 (c)). The Directives suggest evaluation should be framed in the “context of risk and uncertainty, no matter what evaluation method is used” (1909 ch 20 23.13(2)(b)(5)). Effective and consistent application of a risk analysis may require training as well as discussions among practitioners from national, regional, and individual planning units.

Inherent ecological dynamics

Species populations and the environments where they occur are dynamic. The dynamic nature of systems and the extinction and colonization of populations within patches of habitat are well recognized by ecologists as illustrated by the rich literature on disturbance dynamics (e.g., Wiens 1996, Wiens et al. 2012), metapopulation dynamics (e.g., Hanski and Gilpin 1997), and dynamics of patchy populations (e.g., Stacey et al. 1997). Long-term studies, such as the classic work by Peter and Rosemary Grant on the Galapagos Finches, illustrate the complex dynamics of species persistence even in relatively simple island systems (Grant and Grant 2003). Consequently, scientists recognize that changes in abundance are the norm for populations, and short-term increases or decreases in abundance indicate little about status for all but the smallest populations. Status must be evaluated based on the intersection of deterministic trends in populations based on the ecological context and on threats to the species interacting with stochastic dynamics of the population and its environment (see Morris and Doak 2002)

III. PROCESS TO PROMOTE NATIVE SPECIES CONSERVATION

This section describes the broad process to develop plans that integrate ecosystem and species-specific plan components to provide conditions to conserve native species as outlined in the 2012 Rule. Our focus is on at-risk species which include federally recognized species under the ESA (including proposed, candidate, threatened and endangered species), along with SCC (see definition at 36 CFR 219.9 (c)) (see page 4). We begin this section with an overview of the key conservation elements that forms the foundation for species management in the 2012 Rule (8 elements reviewed immediately below) and then examine the association between conservation of at-risk species and the major stages in plan revision. We highlight these 8 elements to demonstrate how conservation of at-risk species involve every stage of planning. We also include dominant planning stages outlined on pages 10 and 11 to illustrate, in general, where each element fits in planning, recognizing that some stages of planning can be iterative. Analysis, evaluation, and plan development addressed at one stage often feeds into other stages of planning.

ASSESSMENT

1) describe the ecological conditions of the plan area (in the assessment) (FSH 1909.12 ch 10 12.1)
2) identify and evaluate at-risk species (this step is often concurrent with step 1), (FSH 1909.12 ch 10 12.52 and FSH 1909.12 ch 20, 21.22a)

PROPOSED PLAN DEVELOPMENT

3) collect information on at-risk species and evaluate current plan components (FSH 1909.12 ch 10 12.53)
4) identify potential species groups, when necessary to facilitate planning (FSH 1909.12 ch 10 12.53)

ALTERNATIVES

5) describe potential conservation approaches, based largely on management of ecosystem properties while integrating species-specific elements, (FSH 1909.12 ch 20, 23.11b and 23.13)

6) develop plan alternatives, (FSH 1909.12 ch 20, 23.11b and 23.13)

NEPA EFFECTS ANAYSIS & FINAL PLAN DECISION

7) evaluate effects of plan alternatives on rule requirements for maintaining or restoring diversity of plant and animal communities, and (FSH 1909.12 ch 20, 23.11b and 23.13)

MONITORING

8) monitor (FSH 1909.12 ch 30, 32.13b).

These eight elements focus existing science on species conservation while complying with the provisions of both NFMA and the National Environmental Policy Act (NEPA). These eight elements should be integrated with the broader Planning process (e.g., outreach, public meetings). Before reviewing these eight elements, we first present our conceptual overview of how species conservation planning is represented in the 2012 Planning Rule.

Conceptual Model for Species Conservation in the 2012 Rule and Directives

The 2012 Rule develops a species conservation model from the fundamental idea that species occurrence, species recovery, and population viability are determined largely by characteristics of the environment as expressed by features such as composition, structure, function, and connectivity of ecosystems, and the status of key ecosystem drivers (Figure 1). The Rule's species conservation model expands Hunter's (Hunter et al. 1989, 1990) coarse filter/fine filter approach and evaluates the capability of broad landscapes to support the occurrence of species and the recovery/persistence of populations based on the integrity of associated ecosystems. Consequently, land management units with ecosystems exhibiting a high level of integrity or with plans that maintain and restore ecosystems are assumed to support the conservation of the vast majority of species.

Species conservation is accomplished (under this Rule) largely by restoring and maintaining the array of ecosystems across the planning area. Species-specific analysis and management generally considers a set of at-risk species, identified through a rigorous process evaluating conservation status, and other species identified as important to local economies or important for delivery of ecosystem services (FSH 1909.12 ch 10, 13.35).

Evaluation and conservation of at-risk species relies first on considerations of ecological integrity and ecological sustainability. This stems from the fundamental focus on ecosystem integrity/sustainability as a foundation for planning under this Rule. Here we expand on the planning process for at-risk species building on the outline of the process developed above. The bullets highlight dominant tasks outlined by the Rule for conservation of at-risk species. This bulleted outline is followed by a more substantive review that provides details regarding the many portions of the planning process that interface with managing at-risk species.

- Identify a list of at-risk species including taxa formally recognized through the ESA, and potential SCC identified by the responsible official (FSH 1909.12, ch 10 sec. 12.52): This list of potential SCC (or in some cases final SCC identified by the Regional Forester prior to the assessment) will be described in the assessment but may be modified at any time based on science developments and public input (FSH 1909.12, ch 20, sec. 21.22a). The process of identifying

SCC represents a risk analysis (as described later).

- For each at-risk species, evaluate existing information to understand stressors, threats, risk factors and the ecological conditions necessary to sustain them. This assessment, which may focus on individual species or species groups (FSH 1909.12 ch 10, 12.54), will be comprehensive enough to develop a conservation approach for the species or species group and to develop plan components to implement the conservation approach.
- Develop proposed plan direction for each at-risk species: Conservation of at-risk species will be achieved largely through development of ecosystem plan components to “maintain or restore the ecological integrity of terrestrial and aquatic ecosystems and watersheds in the plan area” (36 CFR 219.9(a)(1)) and to “maintain or restore the diversity of ecosystems and habitat types throughout the plan area” (36 CFR 219.9(a)(2)). Species-specific plan components are appropriate, to the extent that plan components for system characteristics have been determined to be insufficient to “provide the ecological conditions necessary to: contribute to the recovery of federally listed threatened and endangered species, conserve proposed and candidate species, and maintain or contribute to a viable population of each species of conservation concern within the plan area.” (219.9(b)(1).
    - Regardless of the need for species-specific vs. ecosystem plan components, communication will be aided through explicit statements of desired conditions for at-risk species. These desired conditions will be most effective when integrated with desired conditions for other features of the environment. The desired conditions should answer the question: What is the goal for the species – maintaining current distribution and abundance, increasing distribution and abundance? For listed species, the recovery plan will help in establishing desired conditions.
    - Consider the range of potential plan components (desired conditions, objectives, suitability of areas, standards, and guidelines), beginning with approaches that emphasize management of ecosystem properties.
    - Evaluate the characteristics of the preferred alternative to verify that the necessary ecological conditions are being provided for at-risk species.
- Once the plan is approved, evaluate the success of the plan in conserving at-risk species: Evaluation of the performance of the plan for species-specific conservation is accomplished by identifying ecological indicators associated with some or all of the at-risk species (FSH 1909.12 ch 30 32.1). This monitoring is developed as part of the plan monitoring program and should complement or use monitoring elements identified for other monitoring topics (see later portion of this practitioner’s reference for extensive discussion of monitoring).

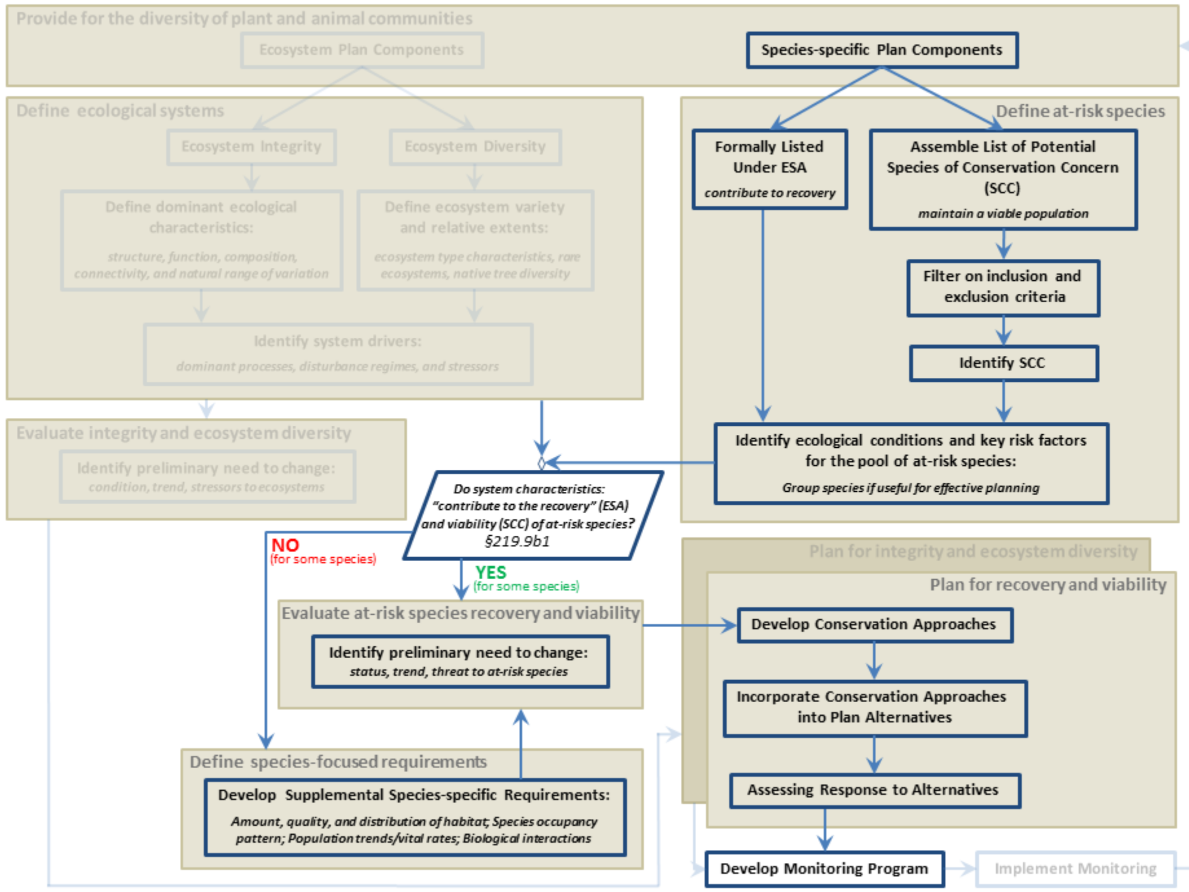

Figure 1. Conceptual model for species conservation employing the 2012 Rule illustrating the dominant stages in planning that relate to at-risk species. Particularly note the emphasis on identifying ecosystem elements that are important to evaluating ecological integrity and ecosystem diversity. Both ecosystem characteristics and species-focused requirements inform 1) developing conservation approaches, 2) evaluating outcomes, and 3) forming monitoring protocols. The parallelogram in the center of the figure emphasizes the important task of evaluating whether ecological conditions (ecosystem integrity and ecosystem diversity) contribute to the recovery (formally listed species) or viability (species of conservation concern) of at-risk species. This is a complex task that may involve identification of ecological characteristics that extend beyond the particular at-risk species under review to the habitat needs or other ecological requirements of important competitors, predators, or prey. Note that the flow illustrated in this figure does not precisely match the linear steps described in the text. This is deliberate. The approach taken in any planning exercise will not be linear and will most often be iterative. The figure displays portions of planning that are the focus of this paper in clear print, whereas supporting steps in planning are dimmed.

Elements of Planning for At-Risk Species

To meet the requirements of 2012 Planning Rule the agency will ultimately document, in the plan record and ROD, how plan components provide ecological conditions to maintain persistence of native species in the plan area using the combination of ecosystem and species-specific plan components. For many species (those that are common, associated with common habitats, and for which there are no significant threats), such demonstration is implicit based on the ecological assessment and the process to identify at-risk species. The 2012 Rule suggests that management for 'ecological sustainability' (36 CFR 219.8) along with 'ecosystem plan components' to maintain and restore ecosystem integrity (36 CFR 219.9 (a)) are intended to provide appropriate conditions to maintain most species. These two Rule provisions represent direction that is sometimes referred to as the coarse-filter approach to land management (Hunter 1990). Specific documentation, and increased conservation emphasis, will be necessary for a subset of species that are identified as at-risk within the plan area. In this section we briefly examine each of eight elements in the planning process and indicate how analysis and documentation relate to designing plan components to maintain or restore the ecological conditions necessary to maintain a viable population of a species of conservation concern in the plan area. We focus largely on SCC because the approach for these species is easily applied to the other at-risk species.

Eight italicized, numbered headings below name the elements in the planning process examined in this section. The Table of Contents also serves as an effective outline to track each of the planning elements included here.

1. Describe the Ecological Characteristics of the Plan Area (FSH 1909.12 ch 10 12.1)

An understanding of ecological systems provides a critical foundation for species management. The importance of understanding the ecological context for land management planning has become clear as agency practices and policies evolve to implement ecosystem management (Grumbine 1997, Dillon et al. 2005, Wiens et al. 2012) and are reflected in the Directives (see FSH 1909.12 ch 10 12.1 thru 12.3). Reviews of land management planning suggest that sustainable resource conditions can only be achieved within the constraints of ecosystem dynamics (Dale et al. 2000, Aber et al. 2000). Because species persistence depends on the state of ecological systems (at both broad and fine scales), an understanding of system dynamics, pattern, and process provides critical insights into the design of conservation approaches and sustainable resource management.

Although ecosystems are complex, Holling (1992) postulated that each ecosystem is governed by small sets of processes that operate at particular spatial and temporal scales - a perspective which should give practitioners confidence that their task is tractable. At a spatial scale of tens to hundreds of miles and a temporal scale of decades to centuries, the structuring processes tend to be disturbance events such as human activity, fire, and insect outbreaks. At larger spatial and temporal scales, geomorphological processes and climate are the dominant structuring forces (Holling 1992). Thus, the key to describing ecological context in a simplified but meaningful way is to focus on the dominant processes that structure ecosystem and to describe the relationship between these processes and selected species within the context of both current conditions and historical processes (Risser 1995, Wiens et al. 2012). Hierarchy theory highlights the importance of understanding the contextual framework that broad-scale processes establish for more fine scale elements (King 1997) and can be helpful in establishing spatial and temporal focus for assessments. For instance, in south-central Alaska, broad-scale deglaciation has occurred for the past 14,000 years leading to gradual afforestation and development of coastal rainforest and boreal forest across millions of acres. This directional development of forest provides important context for evaluating the influence of more local disturbances like fire, avalanche, and changing snowline on the distribution of rare plants (see Hayward et al. n.d.). This example emphasizes the need to consider multiple temporal and spatial scales when evaluating the extent to which ecosystems are providing for species persistence.

As implied by Figure 1, an in-depth discussion of approaches to characterize the ecological systems is beyond the scope of this paper. Future paper(s) on the 2012 Planning Rule may focus explicitly on effective approaches to efficiently characterize such elements of system status as ecosystem diversity; ecosystem integrity; the composition, structure, function, and connectivity of systems; historical and natural range of variation; dominant processes including natural and human stressors; all within the context of a changing climate. For the purposes of this reference paper, we briefly examine this topic to emphasize the interface between broader ecological considerations and species-specific evaluation.

Historical Ecology, Natural Range of Variation, and Connectivity Assessments to Provide Context

The 2012 Rule defines ecological integrity with specific reference to historical ecology, clearly establishing the importance of temporal variation in system dynamics (36 CFR 219.19 Definitions):

> *Ecological integrity.* The quality or condition of an ecosystem when its dominant ecological characteristics (for example, composition, structure, function, connectivity, and species composition and diversity) occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence.

Studies of systems maintained by disturbance indicate substantial variability in the frequency, intensity, and spatial pattern of major disturbance processes. In fact, it appears that variability in these attributes contributes to maintaining biodiversity -- some species may require a longer disturbance interval or lower intensity disturbance than the average found within the system in order to persist (Clark 1996). Thus, a description of the ecological context (both within and outside the planning unit) should include discussion of variability. The ecological insights developed from historical ecology (Swetnam et al. 1999, Wiens et al. 2012) play an important role in understanding ecosystem variability. According to Swetnam et al. (1999:1201) a historical evaluation of past disturbance regimes (e.g., assessment of natural range of variation, NRV) "informs us about what is possible within the context of certain locations and times, and places current conditions into this context." Romme et al. (2012) provides an extremely accessible approach to conduct the evaluation of historical ecology within land management (see Table 17.1 and Figure 17.1 in Romme et al. 2012). Knowledge regarding temporal patterns of disturbance provides insights into the potential causes of ecosystem change and the ecological pathways that brought systems to their current condition. Maybe more important, historical analysis can suggest whether current conditions are anomalous and provide an understanding of the frequency, intensity, and interaction among dominant disturbance processes that influence the ecosystems we manage (e.g., Shedd et al. 2012, Veblen et al. 2012, and other chapters in Wiens et al. 2012).

NRV assessments, especially those using a narrow temporal scope, do not necessarily describe a target condition (FSH 1909.12 ch 10 12.14a), but an understanding of past variation in pattern and disturbance processes that can provide a basis for predicting future variability (Swetnam et al. 1999, Keane et al. 2009, Hayward et al. 2012). It may not be appropriate or possible to recreate the historical range of variability due to long-term changes in land use patterns and climate (Landres et al. 1999). For example, historical conditions based on a “presettlement” period likely extend into the climatic period known as the Little Ice Age that occurred from roughly AD 1400-1900 (Millar and Woolfenden 1999), but insights from both short- and long-term history demonstrate an array of ecological processes important for imagining patterns of ecological change in the future (Safford et al. 2012, Jackson 2012).

By using NRV to understand ecosystem dynamics, an ecological assessment can play a strong role in the development of plan components, analysis of alternatives, and development of monitoring programs. NRV assessments can be used to ask questions about the potential stability of current conditions and to make inferences regarding the intensity of management that may be necessary to move a system from current to desired conditions. For instance, if a NRV assessment of a landscape suggests the forest system experiences infrequent but high intensity fire, but the desired condition is a complete absence of high intensity fire (e.g., because of proximity to structures), then the NRV helps managers understand that significant management (expenditure of funds and activity) will be necessary to meet the desired condition and prevent intensive fire.

Decisions regarding the temporal extent to examine in NRV assessments depend on the ecosystems of interest and the resource management questions of greatest importance (those most strongly influencing ecological integrity). It is useful to adopt a sliding time scale for different processes and attributes. The choice of temporal scales considers the extent and grain of the ecological elements of interest. In order to provide critical context, the range of temporal scales should extend beyond the interval necessary to capture important dynamics in the elements of interest. In many cases, some understanding of paleoecology will provide new insights into the types and severity of disturbances that could be experienced and the ecological patterns that may be most stable. Deep historical ecology provides an understanding of the temporal dynamics of systems for processes that occur rarely (Jackson 2012, Hayward et al. 2012). Human induced climate change provides one motivation for looking backward at rates of change, geographic synchrony in those changes, and the ecological patterns and processes associated with climate drivers. Casting aside NRV while developing resource plans in a world of changing climate is analogous to developing plans for migratory corridors without insights from landscape ecology. See Wiens et al. (2012), particularly the chapter by Romme et al. (2012), for further understanding regarding the strengths and limitations of NRV assessments.

Connectivity is a concept introduced in the 2012 Rule (absent from the 1982 Rule) to characterize ecological integrity. We briefly discuss what it means to be a connected system, reviewing its relationship to species conservation, and providing some case examples of where connectivity has been assessed for terrestrial and aquatic systems, and where the focal taxa are both vertebrate and invertebrate species. Like NRV, an important consideration in assessing the degree to which systems have integrity involves evaluating the degree to which ecological processes and entities are and have been (or have not been) linked across landscapes. Connectivity measures the degree to which landscape elements facilitate or constrain the flow of abiotic elements (e.g., water, nutrients), the spread of disturbances (e.g., fire, pathogens), or the movement of organisms (e.g., dispersal, migration). Whether an ecosystem possesses its characteristic degree of connectivity is dependent on the ecosystem and the species of interest (D'Eon et al. 2002, Rudnick et al. 2012). Returning to our greater sage-grouse example from earlier in the document (see. p. 3) – although habitat loss is the primary threat associated with range-wide declines in this species (Schroeder et al. 1999), there are also conservation concerns associated with maintaining the ability of individuals to move among patches of suitable habitat. Such movements are critically important to facilitate recovery from disturbance, to allow expansion into unoccupied suitable habitats, and to enable individuals to track shifting habitat conditions (see, Shirk et al. 2015).

Similar considerations and concerns are shared among aquatic conservation practitioners where the dendritic structure of drainage systems suggests the use of network analysis techniques to evaluate connectivity (Peterson et al. 2013, Isaak et al. 2014). These techniques have also been particularly useful in large-scale rapid assessments (Carnie et al. 2015). Relevance of these techniques to broad-scale analyses bodes well for their use in support of the Planning Rule's assessment phase.

Even among organisms with relatively low vagility (e.g., plants, adult-phase freshwater mollusks), characterizing connectivity remains an important consideration because the dispersal or drift of propagules (e.g., seeds, larval life-history stages) affect demography, colonization of suitable habitats, as well as community composition and diversity (Bilton et al. 2001, Minor et al. 2009). Among plants, consideration of connectivity in time is particularly important given that propagules can remain dormant in the seed bank for many decades (Finch-Savage and Leubner-Metzger 2006). Planners need to be aware of such lag effects among plants because it can lead to a decoupling of the current characterization of spatial connectivity and the current pattern of plant species occupancy or community diversity (Lindborg and Erkisson 2004). Thus the distribution and abundance of targeted plants may be more a function of past than current ecosystem conditions.

Climate Vulnerability Assessments as Context

The climate vulnerability assessments currently being developed for many NFS units and adjacent lands represent an obvious source of information for evaluating current and future conditions. Approaches range from those that focus on species attributes (e.g., turnover attributed to climate change, Lawler et al. 2009), or vulnerability (Williams et al. 2008, Bagne et al. 2011, Davison et al. 2012) to those that are based on more synthetic indices of ecosystem vulnerability or climate stress (Joyce et al. 2008, Gonzalez et al. 2010, Finch 2012).

We suggest NFS units focus largely on assessments that approach climate change (and socio/political factors) from a scenarios framework – evaluating the consequence of climate change from a perspective of uncertainty and therefore examining a range of potential future climates (Peterson et al. 2003). As climate models improve, adjustments in assessment methodology will also improve. Climate assessments are unlikely to be available for the full array of at-risk species or species groups. We suggest biologists employ considerable caution using output from generalized indices when evaluating potential consequences of climate change for at-risk species (e.g., NatureServe Climate Vulnerability Index, http://www.natureserve.org/conservation-tools/climate-change-vulnerability-index). These tools provide a reasonable first look at vulnerability to stimulate more rigorous consideration based on understanding of species life history, limiting factors, other stressors, and ecological trends that are not incorporated into the generalized tool. We suggest that useful evaluations can be developed rather quickly by local experts, including agency biologists, by formulating conceptual ecological models and asking how at-risk species are likely to respond to the dominant changes in climate expected on individual NFS units based on downscaled models developed regionally (*for approach*, see Cross et al. (2012)).

Ecosystem Management Meets NRV

An understanding of ecosystem processes can highlight system-based strategies for designing plan components to maintain appropriate ecological conditions that contribute to viability of species (Bisson et al. 1997; Hunter et al. 1989; Samson 2002). Species are more likely to persist under the conditions that remain most similar to the conditions under which they persisted in the past (Landres et al. 1999, Samson 2002). Many species are at risk due to changes in ecological processes that have affected vegetation composition and structure and altered species interactions (Knopf and Samson 1997, Wilcove 1999). In the Columbia Basin, Wisdom et al. (2000) assessed change from historical to current times in availability of habitat for selected vertebrate species. They concluded that habitat had declined significantly for many at-risk species, and that the greatest declines had occurred in fire-maintained, late-seral ponderosa pine forests. Saab and Dudley (1998) projected effects on cavity-nesting birds in ponderosa pine forests based on changes in fire regimes from historical conditions. Management approaches that are based on such information and provide for maintenance of ecosystem conditions and ecological processes within the expected range of variability contribute to maintaining viability of species (Samson 2002, Romme et al. 2012).

2. Identify At Risk Species (FSH 1909.12 ch 10 12.51 and 12.52)

The 2012 Rule identifies three categories of at-risk species; 1) federally listed threatened and endangered species under ESA, 2) federally identified proposed, and candidate species under the ESA, and 3) SCC (see for examples 36 CFR 219.9(b)(1)).

Identifying Federally Recognized Species (under ESA)

A catalogue of the federally listed threatened, endangered, proposed, and candidate species is necessary to inform plan development. Identifying these species relies primarily on obtaining the current list from the two agencies that administer the act – the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) – and then and evaluating the relationship between species distribution and plan area boundaries. This is a straight-forward, collaborative process with other federal agencies and further elaboration is unnecessary in this document.

Identifying Species of Conservation Concern

The definition for SCC provides considerable insight into the process for identifying an appropriate list for a plan area:

> *"a species, other than federally recognized threatened, endangered, proposed, or candidate species that is known to occur in the plan area and for which the Regional Forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area"* (36 CFR 219.9(c).

The Directives provide criteria for selection of potential SCC specifying that all species with status ranks of G/T1 or G/T2 on the NatureServe ranking system be evaluated along with all species that were removed within the past 5 years from the Federal list of threatened or endangered species, and other delisted species that the regulatory agency still monitors. Species with G/T1 or G/T2 ranks are "expected to be included unless it can be demonstrated and documented that known threats for these species … are not currently present or relevant in the plan area" (FSH 1909.12 ch10, 12.52d).

While species highlighted through the above process "must be considered" as SCC, there is an extensive list of additional categories that the directives indicate "should be considered: It is important to note that when the directives use the word *should*, the "action is mandatory, unless a justifiable reason exists for not taking action." Further, "the use of 'should' or 'ought' signals that the directive originator recognizes that extenuating circumstances are likely to occur at times" (FSM 1110.8 Exhibit 01). The list of species categories the directives indicate "should be considered" includes the following (FSH 1909.12 ch10, 12.52d):

1) Species with G/T-3 or S1 or S2 on the NatureServe ranking system.
2) Species listed as threatened or endangered by relevant States, federally recognized Tribes, or Alaska Native Corporations.
3) Species identified by Federal, State, federally recognized Tribes, or Alaska Native Corporations as a high priority for conservation.
4) Species identified as SCC in adjoining National Forest System plan areas,
5) Species that have been petitioned for Federal listing and for which a positive "90-day finding" has been made.
6) Species for which the best available scientific information indicates there is local conservation concern about the species' capability to persist over the long term in the plan area due to:
    a. Significant threats, caused by stressors on and off the plan area, to populations or the ecological conditions they depend upon (habitat). Climate change is to be considered among possible threats.
    b. Declining trends in populations or habitat in the plan area.
    c. Restricted ranges (with corresponding narrow endemics, disjunct populations, or species at the edge of their range).
    d. Low population numbers or restricted ecological conditions (habitat) within the plan area.

Concerns were raised during the 2012 Planning Rule public comment period that the viability requirement associated with SCCs would be too expensive and cumbersome to implement (FR 77(68):21216) compared to the 1982 rule which was focused on native and desired non-native vertebrates. The Department's response indicated that the 1982 rule could result in consideration of hundreds of vertebrate species, whereas the 2012 rule specified a much more rigorous set of criteria for defining SCC. It is important to acknowledge, however, that a more rigorous set of criteria may not reduce the sheer number of species that would have to be reviewed in the process. A simple query of NatureServe's central databases of species that are ranked G/T1-G/T3 (a subset of categories that should be considered for potential SCC), have an occurrence record on or within a 2 km buffer of a national forest or grassland, and are not currently covered under the Endangered Species Act indicated that nearly 3,580 species will likely be considered as a potential SCC (Table 2). Nationally, most of these species are plants (61%) or invertebrates (27%). The total number, and taxonomic mix of potential SCCs varied substantially among Forest Service regions – being particularly numerous in the South (Region 8) and the arid and Mediterranean regions of the Southwest (Region 3) and California (Region 5). Reviews describing the geographic distribution of at-risk species illustrate the geographic concentration of designated species in particular areas and the relative paucity in others (e.g., Flather et al. 1998, Flather (in press)).

The species that result from exercising the above criteria might be thought of as a list of species for consideration. This list is then evaluated based on two criteria defined in the Directives (FSH 1909.12, ch 10, sec. 12.52c; see two bullets immediately below). This screening process is designed to confront this list with evidence from the literature, species experts, or local information to determine if each species is clearly at risk (substantial concern for persistence) within the plan area and therefore deserves management attention through plan components. Risk classification systems, such as that developed by the International Union for the Conservation of Nature (IUCN; Hilton-Taylor 2000; Mace and Collar 1995; Mace and Lande 1991), provide insights into the process of evaluating the status of potential SCC. The following two criteria provide standards for the review process (FSH 1909.12 ch10, 12.52c):

- "The species is native to, and known to occur in, the plan area".
  As elaborated upon in the Directives, one criterion to consider is that the "species is established or becoming established in the plan area". Furthermore the species is not an "accidental" or "transient." (FSH 1909.12 ch 10, 12.52c)
- "The best available scientific information about the species indicates substantial concern about the species' capability to persist over the long term in the plan area." The directives provide further discussion of this criterion at FSH 1909.12 ch10, 12.52c, and direction to evaluate species at FSH 1909.12 ch10, 12.53, FSH 1909.12 ch10, 12.55.

As illustrated in Table 2, evaluating species to identify SCC based on the two criteria will be a substantial endeavor in areas with high biodiversity. The process involves a risk assessment to review the conservation status of species (determine if there is substantial concern for persistence) based on well recognized norms (see 1909.12 ch 10 12.53 and 1909.12 ch 10 12.55). Appendix 1 illustrates one approach to perform the risk assessment.

An important consideration when evaluating if there is substantial concern about the species' capability to persist over the long term is the relationship between each species and NFS actions. Regardless of the influence of NFS management on species, a species may be identified as an SCC if "the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area" (36 CFR 219.9). Neither the definition of SCC at (36 CFR 219.9) nor the Directives (FSH 1909.12 ch 10 12.52 thru 12.53) indicate that a species must be threatened by agency management to be identified as an SCC.

In most plan revision settings, after species evaluation based on these criteria, and following a process to engage stakeholders and consider public input (FSH 12.52(a) 4), SCC are identified by the Regional Forester (FSH 1909.12 ch20, 21.22a). It should be noted, however, that the Regional Forester may formally identify a list of SCC at any time during plan revision but doing so prior to publication of the Draft Environmental Impact Statement provides a mechanism to increase public dialogue and input. In some cases SCC will be identified by the Regional Forester outside the planning process (FSH 1909.12 ch 20, 21.22a (2)(g)).

The reviews and evaluations that determine the final list of at-risk species should be carefully documented including both why species were selected and, within the broader record, why other species were not selected (see, FSH 1909.12, ch10, 12.52b(3); FSH 1909.12, ch10, 12.52b(4); FSH 1909.12, ch 20, 21.22a(1)(f)).

Table 2. Number of species to review for consideration as Species of Conservation Concern (SCC) within specific geographic areas based on NatureServe G1/T1-G3/T3 designations (accessed January 2015). Totals are provided at several spatial extents from National to individual NFS units to demonstrate the range of species likely to be evaluated when developing the list of SCC. The list excludes taxa listed under the Endangered Species Act. Although these numbers will change over time, the table presents an example of geographic differences in the count of potential SCC's among Forest Service Regions. (The SCC identification process for any unit will review a large array of additional species beyond the G1/T1-G3/T3 included in this table (FSH 1909.12 ch10, 12.52d (3)).

Geographic Region	Plants	Fungi/ Lichen	Invertebrates	Amphibians	Birds	Freshwater and Anadromous Fishes	Mammals	Reptiles[1]	Total
National	2,172	48	972	62	37	158	95	35	3,579
Region 1	102	6	83	1	1	4	5	--	202
Region 2	188	--	26	3	3	9	13	2	244
Region 3	294	--	63	2	5	12	14	6	396
Region 4	473	1	111	1	3	17	14	1	625
Region 5	613	1	127	20	9	25	35	9	839
Region 6	263	34	101	11	9	27	8	1	454
Region 8	437	5	425	29	12	68	19	16	1,011
Region 9	99	3	145	4	4	30	11	5	301
Region 10	24	--	1	--	5	4	13	--	47
George Washington /Jefferson NF (R8)	59	--	162	8	3	12	7	2	253
Coronado NF (R3)	114	--	36	1	3	5	6	3	168

[1]Includes Crocodilians and Turtles.

Box A. CHALLENGES IDENTIFYING SPECIES OF CONSERVATION CONCERN

While criteria for identification of SCC are clearly stated in the Directives, two science dilemmas will challenge biologists as they evaluate potential SCC: 1) whether the species "*is known to occur in the plan area*", and 2) the standard of "*substantial concern about the species' capability to persist over the long-term in the plan area*".

Evaluating Native Species Occurrence: Identification of SCC requires careful consideration of the distributional status of species. The Rule indicates that SCC are limited to species "known to occur in the plan area" (36 CFR 219.9 (c)). This may present a dilemma in certain circumstances. Four particularly challenging situations are highlighted and addressed below:

a. A taxon was historically recognized as part of the flora/fauna but is known or suspected to be extirpated because of habitat management. This condition raises special consideration if an evaluation suggests the taxon could be re—established if habitat was restored.
b. A taxon was historically considered part of the flora/fauna of the area and may be present but never documented within the planning area because factors such as being cryptic limit its detectability.
c. A taxon is thought to be native to the area but was not detected during recent surveys,
d. A taxon has not been observed in the plan area but has been observed immediately adjacent to the plan area, in similar habitat.

The dilemma outlined in circumstance 'a' should be addressed by acknowledging the definition of SCC and an understanding that SCC are not identified to address all conservation issues. The definition excludes species not occurring in a plan area. The potential conservation need defined in circumstance 'a' can be highlighted and addressed directly through plan components aimed toward restoring habitat or other conditions necessary for the species without designating the taxa as an SCC.

The dilemmas raised in circumstances 'b', 'c', and 'd' require careful consideration but become tractable if considered through standard science practice – evaluating the available evidence regarding species occurrence. We suggest that evidence regarding the potential occurrence of each taxa be examined and decisions regarding occurrence made based on the weight of evidence. Therefore, the key question to answer may be: does the available evidence suggest the species occurs in the plan area or not?

In addition to the cases above, another dilemma will be faced by biologists in many regions. Species conservation policy under the 1982 Rule explicitly limited consideration of Sensitive Species status to plants and animals. However, the 2012 Rule and Directives do not indicate any taxonomic limitation for the range of species considered. Therefore, the process of identifying SCC extends to taxa not considered in the past. The prospective list of SCC may thus be substantial (see Table 2). More important, sources of input, particularly the public involvement process, may highlight a large number of taxa to review and consider. The definition of SCC ("… best available scientific information about the species indicates substantial concern about the species capability to persist…") provides the criteria on which to evaluate if those species that are considered should be identified as SCC.

Evaluating Substantial Concern: Just as no quantitative standard exists for identifying threatened or endangered species under the Endangered Species Act, no single objective standard is established to indicate when substantial concern for long-term persistence is warranted. This dilemma arises in all evaluations of species conservation status and is the motivation for numerous processes for evaluating conservation status (e.g., Master 1991, IUCN 2012). A single objective standard is impossible to establish because many factors together influence the persistence of species and these factors interact in complex ways. The task of evaluating 'substantial concern for persistence' is sometimes described as a risk assessment (Flather et al. 2011a). Therefore, we suggest biologists approach the problem similar to developing a case for a court of law or a scientific case – where does the weight of scientific evidence point you? Develop a supportable case using one of many standard approaches to evaluate whether the species should be an SCC. Later in this paper ("Techniques for evaluating Viability") we review a range of evaluation approaches.

The rich literature on factors associated with species extinction and conservation concern (e.g., Pimm et al. 1988, Terborgh and Winter 1980, Lande 1999, Caughley 1994) identify features to consider when evaluating the vulnerability of species. This literature is reflected in the Directives (FSH 1909.12 ch 10 12.53-12.55.).

Systematic consideration of risk factors and ecological conditions provides a repeatable approach to evaluate and record the evidence supporting a determination regarding long-term persistence, but the challenge of evaluation remains. Peer review and public involvement represent approaches to reduce uncertainty, add rigor, and bring multiple science perspectives into the decision.

Effective consideration of risk factors in light of conditions in the plan area involves integrating a thorough understanding of species life history with a strong background in population ecology. In particular, understanding both the dynamics of extinction and the interactions between life history and population dynamics are critical. Combining this information across risk factors forms a picture of the conservation status (level of concern for persistence) and trend for the species under review. Extreme conditions for any single risk factor should motivate careful consideration of the species' status, but should not be considered in isolation.

Population abundance and range size are common characteristics used to judge extinction risk (Gaston 1994). It has long been recognized that not all rare species are vulnerable species (Rabinowitz 1981) – an observation captured by the "rare-but-persistent" species label in Yenni et al. (2012). In the context of land management and climate change, however, rare species formerly considered secure because of relatively stable conditions may be at risk as a consequence of less stable habitat or changes in population resilience (e.g., influences of genetics, environmental stochasticity, and demographic stochasticity). Thus, judgement about membership in the set of species of conservation concern must consider rarity (and other individual criteria) in conjunction with information about a species' life history, its environmental context, its population dynamics, and the nature of population threats (Gaston 1994, Fagan et al. 2005, Knapp 2011, Fattorini et al. 2013). Consideration of risk factors will differ among taxa and by ecological context. Given the complexity of these determinations, conservation practitioners should resist the temptation to apply what have been billed as pragmatic 'rules of thumb' for setting universally applicable population targets for species persistence (see, Reed et al. 2003, Traill et al. 2010, Clements et al. 2011). For instance, Reed et al. (2003:23) suggest that "conservation programs, for wild populations, need to be designed to conserve habitat capable of supporting approximately 7000 adult vertebrates in order to ensure long-term persistence". These rules of thumb have been shown to provide limited insight and fail to account for the substantial variation in viability evaluations both within and among species (Flather et al. 2011a, b).

In the absence of sufficient population trend data or population viability evaluation, examining the literature for a well-studied, but similar species, a species with related life history characteristics, and species with similar stressors and limitations can be informative. Consulting population ecologists and modelers may inform evaluations, even when a quantitative analysis is not possible. In particular, consideration of genetics and long-term evolutionary processes are important when considering persistence in the face of changes such as climate change (Barrett and Kohn 1991). Similarly Pavlik (1996) emphasize the importance of life history characteristics in population viability evaluations and the role life history can play in either reducing, or increasing, persistence probabilities for populations with similar abundance.

A paucity of population trend information will be the norm for many NFS planning units. Nevertheless, careful examination of the 'weight of the scientific evidence' including input from scientific experts experienced with similar species, can result in effective evaluation of species. For instance, considering population trend data for locations off NFS lands can inform evaluations if those lands have similar conditions and management. Experts with experience in the taxonomic group can provide valuable context for evaluating vulnerability.

Finally, the evaluation of status is inherently a risk assessment. Humans have long been recognized to vary substantially in their perception of risk (e.g., Edwards 1961, Slovic 1987). Practitioners should work to develop a common perspective on risk assessment that builds from similar understanding of the standard for '*substantial concern for persistence over the long-term in the plan area*' (36 CFR 219.9 (c)). Jointly working through assessment of several species in a workshop setting can provide a mechanism to develop a more consistent evaluation of risk. This might be done in a workshop setting employing a structured process (see Appendix 1 as an example) where participants discuss the definition of SCC and the science related to species extinction processes with an emphasis on differences among taxa. Through dialogue, practitioners may develop a common approach to the risk assessment which will avoid conclusions that represent very different perceptions of risk. In some instances, the Responsible Official, Project Manager, or ID Team leader may choose to initiate a science review to support the quality and credibility of any scientific questions in the assessment or planning process (FSH 1909.12 zero code, 07.2).

3. Collect information on At-Risk Species (FSH 1909.12 ch 10, 12.53)

Integrating at-risk species into plan components with an emphasis on managing ecosystem properties requires understanding the ecology of at-risk species and how these species interact with ecosystems in the plan area. Consequently, during the assessment phase of planning, collect and evaluate existing relevant information on at-risk species. Assessment will draw from a variety of sources, including information from the literature, local information on occurrence and population status, and information gathered from local species experts including resource users (e.g., native knowledge (36 CFR 219.19) or traditional ecological knowledge). This step does not motivate new research but instead represents a synthesis of available information (FSH 1909.12 ch 10, 12.53). The focus of the effort should be on the pertinent information that will be needed throughout the planning process. Hence, to be successful the assessment will represent a succinct synthesis of the most relevant information suitable to evaluate the status of the species, identifying important ecological relationships and limiting factors, identifying threats, developing management strategies, and evaluating consequences of plan alternatives. Reviews of factors that can influence viability are found in Allendorf et al. 1997; Emlen 1995, Gilpin and Soule (1986); Holthausen et al. (1999); Lee and Rieman 1997; Marcot (1994); McElhany et al. 2000; Menges (1991); Noon et al. (1999a), Morris and Doak 2002, Beissinger and McCullough (2002), Reeves et al. (2006); Jamieson and Allendorf (2012), Flather et al. (2011a, b).

To the extent possible, the assessment should cite major works and summarize existing knowledge, rather than attempt to present a complete overview of species biology, ecology, conservation, and management. A focused treatment of material that informs development of plan components should be the goal.

It is important to emphasize that the effort expended to evaluate the status of at-risk species will inform several steps of the planning process. Here we briefly outline these again to demonstrate the importance of producing adequate assessments for those taxa that are identified as at-risk species:

a. Identification of at-risk species: An initial evaluation establishes the status of species as part of the at-risk pool.

b. Inform plan components: The assessment developed to support identification of at-risk species should be considered (and likely expanded) in light of the broader assessment of ecological integrity to set the stage for the development of restoration and conservation approaches. Such an evaluation would help identify key ecological conditions, stressors, and risk factors to be addressed through plan components. The species assessment along with understanding of ecological integrity may also be used iteratively to develop multiple conservation strategies.

c. Inform plan alternatives: The broader ecological understanding that results from combining species and ecosystem assessments can inform restoration actions to improve ecological integrity resulting in integrative alternatives (combining ecosystem and species strategies).

d. Set context to examine impacts: The EIS, or other analyses, will benefit from the assessments during examination and comparison of the contribution each plan alternative makes toward providing ecological conditions to maintain a viable population of each species of conservation concern and meet the requirements for other at-risk species.

4. Identification of Potential Species Groups (FSH 1909.12 ch 10, 12.54)

Patterns of species rarity differ across North America (Evans et al. 2016, Flather et al. 1998). Areas such as Alaska have few at-risk species, while others, such as the southeast or the west coast, have large numbers of species requiring active conservation. In areas with numerous SCC, it may be infeasible to consider all taxa individually in planning (e.g., Wiens et al. 2008, Suring et al. 2011). The information on ecological relationships is not available to manage or assess some species. In addition, developing plan components species-by-species may not result in effective management because of challenges related to implementing and evaluating large numbers of management elements (Suring et al. 2011). For these reasons FSH 1909.12, ch 10, 12.54 states:

> *"In some cases, it may be practical or efficient to group at-risk species for identifying and evaluating relevant information about them because they have similar ecological conditions and habitat needs. If used, groupings should be made based on the ecological conditions necessary to maintain or, in the case of federally listed threatened or endangered species, recover each group member. As a basic approach, groupings may be based on species' needs, for example, with respect to vegetation, successional stage of vegetation, stream size, valley bottom configuration, lake size, proximity, or access to groundwater, or wetland type. Such groupings should consider other key ecosystem conditions used by each species such as vegetation types, structural stages, and hydrogeomorphic factors. Grouping at-risk species in the assessment phase is strictly an analysis and evaluation tool that may be used to improve planning efficiency. When species are grouped in an assessment, the assessment must provide the rationale for doing so."*

Using species groups also has significant support in the literature (see Wiens et al. 2008 for a review; see Landres et al. 1988, Lindenmayer et al. 2002 and others for alternative views). The term "focal" species (Lambeck 1997) is sometimes used to characterize individual taxa identified as indicators within the context of a particular conservation system. Note that 'focal species' as used by Lambeck (1997), Suring et al. (2011), and others, is different from the application of 'focal species' in the 2012 Rule and from many applications of indicator species used to represent other species[7]. In Lambeck's system, species groups that are used in the evaluation of viability should be employed to identify ecological conditions that provide for viability, and not assumed to represent proxies for the population status of other species. Focal species, in this sense (not as defined in the 2012 Rule) are used to develop ecosystem management strategies that favor the continued existence or recovery of groups of species. We note this difference to be certain that practitioners do not confuse 'focal species' as defined in the rule, with the broader use of the term in the conservation literature.

There are a variety of approaches for identifying either individual species or groups of species to use as ecological indicators for crafting management and developing monitoring systems (Wisdom et al. 2000, Andelman et al. 2001, Manne and Williams 2003, Wegner 2008, Wiens et al. 2008, Suring et al. 2011). Several alternative approaches to develop species groups based on ecological characteristics and risk factors, are described in Appendix 2.

5. Develop Conservation Approaches (FSH 1909.12 ch 20, 23.11b and 23.13)

Once at-risk species (and in some cases species groups) are identified, conservation approaches designed to maintain or restore the ecological conditions that support each species or group should be developed (Noss and Cooperrider 1994, Caughley and Sinclair 1994, Noon et al. 2011). Conservation approaches should focus on limiting factors and key risk factors, and provide options (where available) to change those conditions in order to provide ecological conditions to maintain the viability of species or populations (Lee et al. 1997; Hilderbrand and Kershner 2000; Wisdom et al. 2000) and restore ecological function (Soule et al. 2003). Potential approaches should be designed to mitigate both short-term and long-term risks, and where feasible consider locating and scheduling management to ensure the greatest return on conservation investment (see Newburn et al. 2005, Naidoo and Ricketts 2006). There is a rich and developing area of conservation science that is focused on determining the best places and best times to implement conservation actions in both terrestrial (e.g., Thomson et al. 2009) and aquatic (e.g., Moilanen et al. 2007) systems. Existing conservation strategies (such as those developed in ESA recovery plans) and agreements (such as state/federal management partnerships) represent additional sources for conservation approaches.

[7] Note: informal guidance on 'focal species' is being written

At this stage in the planning process, restoration and conservation approaches are not plan components but could be used in developing proposed plan components. When plan alternatives are developed, conservation approaches may serve as sources of information to identify goals and objectives, frame desired conditions, and establish standards and guidelines. The alternatives considered in the planning process may differ in the way that they incorporate the elements of restoration and conservation approaches. The plan components that are incorporated into a plan become established when a record of decision is issued for the plan and must be within the fiscal capability of the unit ((36 CFR 219.1(g)). Restoration and conservation approaches that integrate with other resource objectives and focus on management of system processes to restore ecological integrity and species diversity will be most effective. The planning rule compels practitioners to integrate plan components for species into resource management for multiple-use, of which species conservation is a necessary consideration (36 CFR 219.10). Standards and guidelines, which generally act as constraints, represent a difficult approach to integrate management among multiple uses but may be the most straightforward tools to implement in projects. Desired conditions, goals, and objectives that describe ecological conditions to support persistence and recovery of at-risk species often integrate with other multiple use objectives through a common approach to achieve ecological integrity.

Considerations of species at-risk status

The 2012 Rule establishes different conservation provisions for the management of three classes of at-risk species (36 CFR 219.9 (b)(1)) [see FSH 1909.12, ch 20, section 23.13 for details in the Directives]. In particular, the 2012 Rule directs the responsible official to develop plan components to provide the ecological conditions necessary to:

- contribute to the recovery of federally listed threatened and endangered species
- conserve proposed and candidate species, and
- maintain a viable population of each SCC within the plan area.

The differing provisions demanded for the three classes of at-risk species may motivate considering different spatial scales and levels of biological organization. Note that the spatial scale of primary interest for the first two categories (species associated with the ESA) may extend beyond the plan area while the primary spatial focus for SCC will be the plan area. The Rule also indicates that: if the Agency determines that the viability of the SCC results largely from activities outside of Forest Service control, then the responsible official must include plan components "…that provide the ecological conditions in the plan area necessary to contribute to a viable population of that species in the broader landscape" (36 CFR 219.9(b)(2); 77 FR (21216, April 9, 2012) and to coordinate with entities that share similar planning requirements.

While Rule direction motivates particular considerations of spatial scale and level of biological organization, so too should ecological considerations. The current distribution, level of threat, and ecology of each at-risk species along with the integrity of associated ecological systems may focus attention on specific geographic extents and specific population segments of the taxa. Here we develop this idea further.

To the extent possible, management approaches should take into account the conditions of the plan area relative to the needs of an at-risk species across its entire range, or the portion of its range where it is considered at risk. For SCC, management approaches should particularly account for species needs within the plan area, and management approaches that contribute to persistence in the plan area while coordinating with neighboring planning areas to the extent necessary. Basic concepts underlying conservation should generally be consistent across the range of the species, but management approaches should then be tailored to specific geographic and ecological situations. Under some circumstances, it may be legitimate to experiment with management approaches to test effectiveness. Otherwise, species with similar threats and limiting factors should be managed with consistent methods both within and across NFS units. To achieve appropriate levels of consistency, management approaches are best developed at the ecoregional or bioregional scale. Ecologists and species experts within the scientific community may be involved in the formulation or review of restoration and conservation approaches. In certain situations, the development of management approaches can be made more manageable by grouping species as described in the previous step. Coordination can be facilitated by the Regional Forester and staff.

While the Rule specifies different objectives for the 3 classes of at-risk species, the remainder of this paper will speak generally about managing ecological conditions for species or population viability without particular reference to the 3 classes of at-risk species, except when necessary.

Determining when ecosystem approaches are insufficient

The 2012 Rule emphasizes the efficiency and effectiveness of managing biodiversity primarily through managing ecosystem characteristics. Species conservation fits well into this approach. But, how should practitioners determine when ecosystem plan components are insufficient? The Directives emphasize that evaluating the adequacy of ecological conditions and developing plan components is an iterative process (FSH 1909.12 ch 20 23.13 (1)) and closely reflects the process for evaluating the conservation status of species (see section 2 of this paper "*Conceptual Foundation for Evaluating Species Status"). Evaluating of the adequacy of ecosystem focused components, then, will examine species natural history/ecology and habitat relationships in light of* limiting factors, threats, and stressors (FSH 1909.12 ch 20 23.13 (2)) in light of ecosystem conditions. The evaluation will most often be based on general ecological principles and understanding of habitat associations but employ spatially explicit habitat models, population models, and input from experts when available. Examples of species-specific plan components (that compliment ecosystem plan components) include requirements to maintain snags for cavity dependent species or stream passage standards for at-risk fish.

Combine approaches focused on system and species characteristics

Development of management approaches should consider a combination of practices focused on both ecosystem characteristics and species-specific actions (sometimes referred to as coarse-filter/fine-filter, Hunter 1990). That is, some threats or some limiting factors may be addressed through broad, ecosystem management direction such as managing the successional trajectory of certain habitat, while other conservation needs may require species-specific direction such as collaboration with other agencies to reduce direct mortality due to roads. Understanding the ecological context for at-risk species, such as dominant disturbance processes for the ecosystem where they occur, trends in plant community development, and even ecosystem age (see Jackson 2012 and Betancourt 2012), provides information needed to design ecosystem management direction that effectively contributes to long-term viability. The development of conservation approaches should begin with understanding specific ecosystem conditions and threats that have placed species at risk, and should initially emphasize approaches for management of system properties that are designed to restore critical processes and patterns – directly addressing species threats and limiting factors. Such approaches may include strategies such as designation of reserves, restoration of ecosystem elements and processes (e.g., managing disturbance regimes, restoring stream continuity), or emulation of natural disturbance processes in the design of management activities. Strategies that result in appropriate ecosystem process and pattern may become the basis for alternatives developed for plan revisions.

The environmental conditions to meet conservation goals for many at-risk species are only partially addressed through management of ecosystems, either because limiting factors and threats are not related to habitat or basic ecosystem function, or because direct management of ecosystem function does not adequately address certain fine scale habitat elements and features such as grouse leks, caves, seeps, bogs, spawning sites and nest sites that are essential for viability. When necessary, species-specific direction for such features, or for other non-habitat factors, should be developed to supplement system-focused management. This does not imply, however, that a separate approach is needed for each species. Development of common approaches for species groups should be feasible (Suring et al. 2011). We emphasize that species-specific plan components must be compatible with broader ecosystem plan components and vice-versa. The plan components must be internally consistent. One plan component must not directly conflict with another plan component or prevent its accomplishment. For example, a focus on seeps and bogs may be key to providing appropriate conditions for some wetland species. But, maintenance of those features is also dependent on overall direction for maintaining soil and hydrologic conditions. (Direction in 36 CFR 219.10 further emphasizes integration to support multiple resource objectives.)

6. Develop Plan Alternatives (FSH 1909.12 ch 20, 23.11b and 23.13)

Maintaining habitat to support species viability was a requirement of the 1982 Planning Rule and that requirement continues (modified to capture the broader ecological system) and must be a goal of every alternative for plans developed under the 2012 Planning Rule. However, not every alternative will achieve the goals for at-risk species with the same level of certainty. Alternatives will differ in the likelihood of maintaining a viable population for each SCC or contributing to the recovery of federally recognized at-risk species, and the risks of species extirpations. In a similar fashion, alternatives will differ in the degree to which they accomplish other goals. In plan revisions, the effects of the current plan on ecological conditions that support population viability and other resources should serve as the basis for deciding how much change is needed. All plan alternatives should: (1) comply with law, regulation, and policy; (2) be within Forest Service authority; (3) be informed by best available scientific information; (4) be within the fiscal capability of the unit; and (5) be within the inherent “capability” of the plan area (ecologically practical).

Plan alternatives may differ in strategy to manage ecosystem properties and the species-specific direction that is incorporated. These two elements of conservation planning are sometimes referred to as the coarse- and fine-filter approaches. As noted by Samson (2002), there is no established process for linking coarse- and fine-filter approaches. Furthermore, as highlighted by Groves et al. (2002), the effectiveness of the coarse-filter approach has “never been tested empirically”. Conceptually, the fine-filter or species-specific approach is applied to taxa for which management of system pattern and process does not provide adequate assurance of maintaining viability. Note that differences in ecosystem management direction (the so-called coarse filter) may result in different sets of species needs that must be addressed through species-specific direction (the so-called fine filter). The design of plan alternatives may incorporate different applications of ecosystem and species specific plan components. For example, some alternatives may rely more heavily on reserves, while others may place greater emphasis on active management designed to change system structure, composition, or processes to reduce threats or influence disturbance processes or particular limiting factors. Proposed ecosystem plan components should build from an understanding of NRV as a basis for developing desired conditions. Evaluating which species are adequately addressed by the combination of ecosystem diversity plan components may be completed and documented in a variety of ways. It may be helpful to clearly describe the elements of habitat necessary for each species (or for sets of species), and then evaluate the extent to which ecosystem diversity direction is likely to successfully provide these elements. Such an array would provide a guide to the elements needed in additional species-specific direction. The actual evaluation of viability would be conducted for complete plan alternatives (see following section) with the most complete evaluation for the preferred alternative.

7. Evaluate Effects of Alternatives (FSH 1909.12 ch 20, 23.11b and 23.13)

Evaluating the effects of alternatives may be the most difficult step in addressing at-risk species in plans. The 2012 Planning Rule indicates that the plan must have plan components that provide ecological conditions that contribute to the recovery of federally listed species, conserve proposed and candidate species, and maintain a viable population of species of conservation concern. Each of these goals may require a different form of analysis. The evaluation (1909.12 ch 10 12.5) should provide the ecological background and references to the scientific information used in this evaluation.

Federally Designated Species

The task of evaluating whether an alternative contributes to the recovery of federally listed species motivates careful review of the recovery plan and potentially an ESA Section 7(a)(1), conservation review. When the recovery plan specifies particular actions related to management of ecological conditions, evaluation may be straight-forward although the approach used to contribute to recovery may be indirect and will likely address only a portion of the recovery elements. In the absence of a detailed recovery plan, proposed actions can be evaluated by integrating the species ecology and the ecological conditions anticipated by the plan. Evaluate both short- and long-term outcomes. Important benefits in the long-term may require projects or activities that result in short-term negative outcomes for ecological characteristics that are important to listed species.

As outlined in the Rule, conserving proposed and candidate species involves developing plan components focused on ecological conditions, and to the extent necessary, species-specific threats to conserve candidate and proposed species, reducing risks to those species and providing for the maintenance or restoration of needed ecological conditions.

Species of Conservation Concern

The evaluation of SCC will take the form of considering scenarios describing the outcome of plan direction for ecological conditions influencing SCC and making inferences regarding the resulting status of the SCC[8]. In virtually all situations, botanists and biologists lack the information needed for quantitative evaluation of the resulting probability of long-term persistence. While they do not specify the type of evaluation, the combined intent of the provisions of 36 CFR 219.9(b) and the Forest Service NEPA procedures (36 CFR 220, FSM 1950, FSH 1909.15) require that effects on species be disclosed. In most situations a mix of qualitative approaches may be appropriate. Guidance for evaluating species conservation status under alternatives include (FSH 1909.12 ch 20 23.13c) and are reflected in the process of identifying species (FSH 1909.12 ch 10 12.5):

- Evaluation of effects should be framed as a risk and uncertainty assessment of each scenario (Cleaves 1994), rather than an either/or determination of whether ecological conditions support a viable population.
- The evaluation includes assessment of both short-term and long-term risks and benefits. Despite the 10 to 20 year horizon for individual land management plans, the timeframe over which long-term conditions are evaluated should be based on ecology of the species (e.g., generation time, response time to changed conditions) and on the time needed for its ecosystem to respond to proposed management. Disclose uncertainty in the risk assessment, particularly uncertainty that stems from the extended timeframe of evaluation. Generally, as time frames or spatial scales increase so does uncertainty.
- The spatial scale of the evaluation will reflect the scale of the plan area and the scale at which biological populations of the species operate (Wells and Richmond 1995, Wiens 1989, Ruggiero et al. 1994). Evaluations will often include broad and finer-scale landscapes. Broad scale evaluations (beyond the plan area) provide context for understanding the role of the plan area in

[8] While similar evaluation is necessary for species with ESA designation, the recovery plan and other documents provide significant guidance. Furthermore, as described earlier, the Rule establishes different requirements for SCC and species with ESA status.

maintaining SCC and contribute to understanding cumulative effects of other land ownerships and of projected actions on non-NFS lands.

- In addition to disclosing potential future conditions, analyses will address current conditions within a context of historical ecological conditions. Describe the current trajectory of the ecosystem, including taxa of interest, and identify the disturbances (natural and human) or processes that are leading to the conclusion regarding status.
- The SCC obligation is to design plan components that provide ecological conditions promoting species persistence with 'sufficient distribution to be resilient and adaptable to stressors and likely future environments' in the plan area, within the capability of the area'. The plan area is defined as NFS lands covered by a plan (36 CFR 219.19). Thus, the evaluation considers the likelihood that appropriate conditions for the species will be provided on NFS lands for those life history requisites associated with NFS lands. For example, the plan cannot influence habitat in the wintering area for Neotropical migratory birds so evaluation of the adequacy of the plan will focus on requisites for breeding rather than wintering habitat. If ecological conditions to promote species persistence are not likely to be achieved, the conditions leading to a low probability of persistence should be evaluated to determine whether the plan area could support a viable population and how management could be improved to result in those conditions.
- For most species, the only practical quantitative analysis is evaluation of habitat and other ecological conditions (extent, distribution) and in many cases, this analysis will combine qualitative and quantitative features and will consider a range of potential outcomes. When considering the relationship between persistence and habitat, develop a clear connection between habitat conditions and population consequences, even if this connection has to be established through general ecological principles. Conceptual ecological models (e.g., envirogram) can aid in illustrating dominant ecological linkages (Andrewartha and Birch 1984, Cross et al. 2012). Given the many elements of uncertainty, an illusion of quantitative precision should be avoided. Rigor should stem from careful ecological consideration rather than from an appearance of quantitative precision and be clearly displayed for public understanding.
- The assessment of conditions that provide "sufficient distribution" will be based on the species natural history and, to the extent possible, historical distribution, the potential distribution of its habitat, and recognition that habitat and population distribution are likely to be dynamic over time.
- Risk assessments are to be logical, consistent, consider relevant information, and disclose both risks and levels of uncertainty (Tenny 2001). Document important sources of uncertainty, including environmental stochasticity, climate change, and changes outside the control of the agency (36 CFR 219.3).
- Peer review of evaluations will highlight gaps in the information considered and contribute to rigor and credibility (Government Accounting Office 1997).

Consider Viability in a Risk Analysis Framework

In reviews of plan appeal decisions, the Department of Agriculture (Tenny 2001, Liggett et al. 2003) stated that effort focused on analysis of viability should be commensurate with the levels of risk. The specific direction issued by the Department, and subsequently by the Forest Service (Collins 2001), follows:

> *"In cases where population and habitat trends are believed to be in significant decline throughout the planning area, and substantial habitat disruption is allowed by the forest plan, a more rigorous approach to maintaining viability is indicated. In cases where habitat and population trends are believed to be within the range of historic variation, and the forest plan allows little additional habitat disturbance, a much less rigorous analysis is warranted. In such*

cases, a more qualitative approach to factors such as trend analysis may suffice, as long as the approach considers the relevant factors and demonstrates sound judgment, including a rational explanation for the level of analysis conducted."

This policy indicates that the following factors be considered in viability assessments:

- Species habitat needs and how they are affected by plan components.
- Trends in the quantity, quality, and distribution of habitat.
- Trends in species abundance and distribution, to the extent such data are available.

While this input referenced planning under the 1982 Rule and was written in response to a specific appeal, the basic structure of the planning problem has not changed with adoption of the 2012 Rule. Hence the approach described in Collins (2001) and operationalized in Liggett et al. (2003) represents sound advice for the future under the 2012 Rule.

What viability standard is required for Species of Conservation Concern?

The 2012 Rule establishes a hierarchy of provisions (or standards) for persistence of SCC depending on the capability of the plan area to provide ecological conditions to maintain a viable population. By examining viability in light of the capability of the plan area, the Rule addresses an issue experienced when implementing the 1982 Rule. Biologists recognized that some NFS lands lie at the edge of species' range, may inherently support low quality habitat, or may provide ecological conditions to support a species only during a portion of the year. Regardless of conservation or restoration efforts, the plan area may be incapable of contributing significantly toward maintenance of viable populations for certain species. Recognizing this reality, the 2012 Rule states that when it is "beyond the authority of the Forest Service or not within the inherent capability of the plan area" to provide conditions to maintain a viable population, then management for that SCC must "contribute to maintaining a viable population … within its range [emphasis added]" through provision of suitable ecological conditions (36CFR 219.9 (b)(2)((ii))). The important point is that ecological conditions must be managed to contribute to the maintenance of "a viable population of each species of conservation concern" on the plan area (36CFR 219.9 (b), FSH 1909.12 ch 20 23.13c). This provision (to acknowledge that providing for viability is constrained by agency authority or the ecological capability of the land) must be considered rigorously.

Note that in both cases, the defining criterion is not a viable population. Rather plan components that provide ecological conditions necessary to contribute toward, or maintain a viable population, are emphasized. This does not suggest that consideration of population status is not of interest. Rather it suggests that that evaluation be done with primary consideration of the ecological conditions necessary to support a viable population. This motivates careful consideration of the relationship between ecological conditions and the resulting population status of the SCC. In this context, it is important to re-emphasize that the "individuals of a species of conservation concern that exist in the plan area will be considered to be members of one population of that species." (77 FR 21217, April 9, 2012).

Based on the above criteria, evaluation of SCC and the sufficiency of the plan to maintain them must consider the ability of the plan components to provide the ecological conditions to meet the biological and ecological needs of the species and the potential viability of the population supported by those ecological conditions. Below we evaluate several critical considerations in evaluating the sufficiency of the plan for management of SCC. These considerations are parallel to those considered when implementing the viability standard of the 1982 Rule. We follow this overview by placing the evaluation of 'viability' in a risk management context.

What is a species with "**sufficient distribution to be resilient and adaptable to stressors and likely future environments**?"

The 1982 Regulations required ecological conditions to support species in a "well-distributed" pattern throughout its range within the plan area. Similarly, the 2012 Regulations require that species have '*sufficient distribution*' to be resilient and adaptable to stressors and likely future environments'. This requirement refers to the geographic distribution of the species and its habitat, and the biological interactions within that distribution. The concept of well-distributed is based on the species' natural history and historical distribution, the potential distribution of its habitat, and recognition that habitat and population distribution are dynamic over time. 'Sufficient distribution' is most easily illustrated for broadly distributed and relatively common species. For such species, a well-distributed pattern is one in which the species has a relatively continuous dispersion across its range, or is distributed in a pattern that allows dispersal among local populations. For other species, such as local endemics, or those tied to naturally scarce or spatially disjunct habitats, an understanding of 'sufficient distribution' reflects the inherent constraints on the distribution as a result of ecological capability. Management on NFS units should not be expected to provide broadly or evenly distributed habitat for all species. Appropriate standards for species should be based on their life history characteristics (habitat associations, home range size, dispersal capability, effect of habitat on dispersal, seasonal use patterns, etc.), historical distribution, potential habitat distribution and current conditions. This does not imply any requirement to match historical species distributions. Rather past distributions provide insights into assessment of 'sufficient distribution'. Appropriate application of these concepts will result in conservation of populations that are on the periphery of the species' range, in addition to populations at the core (Channell and Lomolino 2000, Lesica and Allendorf 1995).

What is an adequate level of analysis?

Earlier we considered this question in reference to the Tenny decision (Tenny 2001, Liggett et al. 2003). Insight can also be found in court decisions that have consistently ruled that agencies have discretion in determining the appropriate level and form of analysis, as long as that analysis is logical, makes use of currently accepted science, and addresses important contrary views of respected scientists. In the decision on the Northwest Forest Plan [Seattle Audubon Society v. Lyons, 80 F. 3d 1401, 1404 (9^{th} Cir. 1996)], the Ninth Circuit upheld Forest Service analysis and determination of viability saying:

> "*the record demonstrates that the federal defendants considered the viability of plant and animal populations based on the current state of scientific knowledge. Because of the inherent flexibility of the NFMA, and because there is no showing that the federal defendants overlooked any relevant factors or made any clear errors of judgment, we conclude that their interpretation and application of the NFMA's viability Regulation was reasonable.*"

In a previous ruling in the Pacific Northwest, the District Court had commented on the need for viability analysis (Seattle Audubon Society v. Moseley, 798 F. Supp. 1473, 1484, and 1494 (W.D. Wash 1992)), stating "The Forest Service argues that it should not be required to conduct a viability analysis as to every species. There is no such requirement. As in any administrative field, common sense and agency experience must be used." It added, "the court has repeatedly made clear that the agency is not required to make a study or develop standards and guidelines as to every species." In a ruling in Arkansas (Sierra Club v. Robertson, 784 F.Supp. 593 (W.D. Ark. 1991)), the court noted, "the agency's judgment in assessing issues requiring a high level of technical expertise, such as diversity, must therefore be accorded the considerable respect that matters within the agency's expertise deserve."

Relationship of Forest Service viability evaluations to population viability analysis (PVA)

Forest Service approaches to management for at-risk species evolved at the same time as important advances were made in scientific applications of population viability analysis (PVA) (Beissinger and Westphal 1998; Boyce 1992; Emlen 1995; Lee and Rieman 1997; Menges 1991; Shaffer 1981; Shaffer and Samson 1985, Morris and Doak 2002, Beissinger and McCullough 2002, Flather et al. 2011a, Jamieson and Allendorf 2012). While Forest Service approaches generally follow concepts described in the scientific literature on PVA, several key distinctions emerge:

- Definitions of a viable population in the scientific literature focus on the probability of population persistence for a biologically-meaningful period of time. For example, Shaffer (1981) defined a minimum viable population as “the smallest isolated population having a 99% chance of remaining extant for 1000 years despite the foreseeable effects of demographic, environmental, and genetic stochasticity, and natural catastrophes.” More recent papers place time in the perspective of ‘generations’ as a way to standardize across life histories (e.g., Morris and Doak 2002). The role of PVA, then, is to provide an assessment of the likelihood of species persistence over some temporal scale. The definition for SCC establishes both the spatial and temporal scale of interest by naming the “plan area” and “long-term”. Long-term is undefined and will differ among species and ecosystems.

- Because the 2012 Planning Rule focuses on plan components providing ecological conditions on NFS lands within the plan area, Forest Service evaluations partition the effects of ecological conditions on the plan area from other effects. This need to separate effects of National Forest management creates additional challenges for Forest Service evaluations and highlights the need to address both immediate and cumulative effects.
- Discussions of PVA in the scientific literature generally refer to quantitative assessment of risk factors (e.g., Boyce 1992, Morris and Doak 2002), with significant focus on demographic analyses (Beissinger and Westphal 1998, McElhany et al. 2000, Menges 1991, Ralls et al. 2002, Morris and Doak 2002, Yates and Ladd 2010, McCaffery et al. 2014, Shryock et al. 2014). Ralls et al. (2002) suggest that PVA be defined as “an analysis that uses data in an analytical or simulation model to calculate the risk of extinction or a closely related measure of population viability”. However, Forest Service evaluations are usually accomplished in support of decision-making when information is scarce and quantitative analysis not feasible (Noon et al. 1999a, Rieman et al. 1993, Ruggiero et al. 1994, Flather et al. 2011a). Such evaluations should nonetheless be formally structured using available information (Boyce 1992; Noon et al. 1999a) with the objective of estimating (albeit qualitatively) the likelihood that taxa will persist over the long-term. Given the realities of scarce information and limited time, they will often depend on techniques such as expert panels and the application of general ecological principles by agency experts using conceptual models and logical argument.

To reflect the differences between Forest Service evaluations of viability and PVAs described in the scientific literature, we use the phrase ‘species viability evaluation’ for those conducted in support of land management planning (e.g., Iverson et al. 1996, Raphael et al. 2011). These analyses focus on evaluating whether ecological conditions are likely to exist over the long-term under the proposed plan to support persistence. Use of the term PVA should be reserved for those analyses that meet conditions described in the literature (e.g., Ralls et al. 2002).

Evaluating Whether Plan Components Provide Ecological Conditions to Support a Viable Population of SCC

To be clear, consideration of population viability is accomplished to support evaluation of the extent to which ecological conditions will be maintained or restored to support a viable population of SCC (36 CFR 219.9 (a) and (b)). Therefore, the ‘viability evaluation’ associated with land management planning can be framed as the following scientific challenge (FSH 1909.12 ch 20 23.13):

- Describe the potential outcome(s) of plan direction based upon resulting ecological conditions.
- Using the environmental scenario(s) above, consider the probability that the amount, quality, distribution, and connectivity of environmental features will support a viable population of SCC.

The evaluation may begin with a ‘conceptual model’ of the future environment based on plan direction. Based on that model, the evaluation can progress toward an understanding of potential distribution and abundance of SCC from which inferences regarding the probability of persistence and the level of certainty underlying that probability are drawn. Hence, the challenge for determining population status results from the direct and indirect effects of the environmental scenarios developed through the plan. The challenge is considerable for land managers and should be approached with humility from a clear understanding of two considerations:

- Courts have acknowledged that management decisions are made in the context of uncertainty. Evaluations associated with land management decisions do not demand development of new studies to establish the relationship between species and ecological conditions. Rather, a reasoned evaluation, clearly describing limitations and uncertainty, is conducted to support the necessity to make management decisions. The evaluation considers the best available scientific knowledge, requires clear judgment and logic, and when necessary, addresses important contrary views. Therefore, there is no expectation that the resulting evaluation meet any particular quantitative or qualitative standard. Land management decisions must be made with incomplete knowledge and acknowledgement of uncertainty. Planning processes associated with active adaptive management (Walters 1986) and scenario planning (Peterson et al. 2003) represent two of several approaches for decision making in the face of uncertainty.
- Rarely, even in well-funded research settings, have scientists completed quantitative analyses predicting persistence probabilities for species based on well framed scenarios of future environmental conditions (but see Garton et al. 2011). Hence, land managers will usually lack definitive analytical results and must use the best information available to them.

To meet the scientific challenge within the fiscal and personnel constraints of the NFS unit will require careful allocation of effort and effective use of available evaluation techniques. This is especially true in cases when a NFS plan involves many at-risk species and evaluation becomes more complex. It will be important to set evaluation priorities and employ the best evaluation approaches immediately available to the staff within the timeline for the plan decision. Priorities may be set based on a qualitative ranking of the conservation status of the set of SCC, the potential for plan direction to influence SCC either positively or negatively, and the amount of information available about each SCC.

Effective evaluation of at-risk species will often employ different approaches for various species. In most NFS planning settings, the information needed to complete quantitative population viability analysis is lacking (Lee and Rieman 1997; Noon et al. 1999a; Ruggiero et al. 1994; Samson 2002, Morris and Doak 2002, Beissinger and McCullough 2002). Even where substantial information is available, analysis can be complicated by the need to understand factors influencing year-to-year variability, population size, and demographics, and whether current stressors are likely to continue in the future (Beissinger and Westphal 1998). Recent reviews and PVA analyses emphasize the complexity of translating demographic patterns from the past into estimates of future status (e.g., Flather et al. 2011, Garton et al. 2011). Natural histories of some taxa result in particularly difficult assessments. For example estimates of reproduction can be highly variable and poorly understood for plants that have long-lived seed banks.

A number of techniques were successfully used to evaluate plan direction for at-risk species under the 1982 Planning Rule. These ranged from qualitative evaluations by individual experts to complex simulation models linking habitat and population dynamics.

The most common approach focuses exclusively on inventories and projections of the amount and distribution of suitable habitat to make ecological inferences regarding viability. This approach dovetails with the 2012 Rule and its emphasis on plan components providing ecological conditions to support a viable population. This approach relies on three assumptions: (1) that attributes of suitable habitat are known well enough to identify areas that meet the life requisites of the species; (2) that the amount, condition or quality of suitable habitat is closely related to species' fitness attributes (Gawler et al. 1987; Van Horne 1983; Wilcove et al. 1998); and (3) that habitat is limiting so that changes in amount of suitable habitat play a strong role shaping population status. Viability assessments based on habitat inventories and projections (e.g., using a scenario approach) are useful to the degree that these assumptions are met. Biologists need to rely on ecological expertise and make inferences regarding the assumptions; a common practice in these types of analysis (Raphael et al. 2001).

In many situations, broad scale patterns in habitat will be the only substantive information available on the status of species (Raphael et al. 2011). Habitat inventories and suitable GIS frameworks may not exist for the plan area. Despite the lack of information on direct population consequences, habitat evaluation is often useful to suggest that a species status is likely to decline, improve, or remain unchanged. This is reasonable because relationships between most taxa and habitat are known. Furthermore, the level of uncertainty may be acceptable based on risk assessment. When necessary, habitat modeling can be combined with other techniques, such as expert panels or demographic gaming, to provide a more rigorous analysis. For example, developments in remote sensing, GIS analysis, and machine learning inferential approaches provide opportunities to substantially improve evaluation of species distributions and changes in habitat extent. For many species, detailed presence/absence data is unavailable to employ standard statistical methods to model habitat associations; absence data, in particular, is often lacking. In the face of limited presence/absence data but reasonable GIS coverage of environmental characteristics, Maxent and other machine learning approaches provide a mechanism for characterizing a species' ecological niche and estimating its geographic distributions even with presence-only data (Philips et al. 2006). Maxent has been particularly effective in supporting conservation status evaluations for plants and animals (e.g., Philips and Dudik 2008, Crall et al. 2013, Syfert et al. 2014). Although machine learning approaches represent an efficient modeling tool when data is sparse, the importance of sampling considerations (Hernandez et al. 2006) and choosing both model type and predictor variables that fit the goal of species modeling are demonstrated in recent studies (Gogol-Prokurat 2011, Bradley et al. 2012, Yackulic et al. 2012).

Evaluations based on habitat will be strengthened by evaluating current and future conditions in the context of historical patterns (Wisdom et al. 2000, Suring et al. 2011; also see multiple chapters in Wiens et al. 2012). The use of historical ecology is discussed earlier in this paper and represents an important tool to understand disturbance dynamics, ecological variation, and the temporal dynamics of systems. Without some reference to NRV information, other tools of historical ecology, or ecological inference to system dynamics, it is difficult to imagine a how an evaluation based solely on habitat could make reasonable ecological inferences regarding the capability of the ecological system to support a viable population.

Below we examine a number of species evaluation approaches including:

- combining habitat and risk assessment
- using population status and demographic characteristics
- Population trends based on census and presence/absence data
- Genetic considerations
- Expert-based assessments
- Incidence functions, Bayesian belief networks, and simulation models

Evaluations combining habitat and risk assessment:

Habitat loss and degradation are primary threats to vertebrates regardless of whether they are terrestrial or aquatic (Pimm et al. 1988, Wilcove et al. 1998, Harrison and Stiassny 1999, Burkhead 2012). However, there are other risk factors that can interact with or be more important than loss of habitat, thereby decreasing persistence probabilities for SCC. One risk factor to species on federal lands is roads, barriers to stream networks from roads, and road-related effects that extend beyond loss of habitat (Anderson et al. 2011, Fahrig and Rytwinski 2009, Wisdom et al. 2000). Anderson et al. (2011) found road density to be the dominant correlate of extinction risk in birds, and a strong correlate of extinction risk in mammals. Other risk factors may include invasive species, pollution, overexploitation, and disease (Pimm et al.

1988, Pimm et al.1995, Wilcove et al. 1998, Rahel 2002, Burkhead 2012). Salafsky et al. (2008) present a unified classification of threats to biodiversity.

Suring et al. (2011) identified risk-factors that had the potential to result in reductions in habitat availability, habitat effectiveness, population size, or fitness. These risk factors included roads and road-related effects, grazing, and invasive species. Chilcote et al. (n.d.) examined the influence of changes in patterns of snowfall and glacier melt on the vulnerability of Pacific salmon using a combination of downscaled climate models, watershed classification, and understanding of hydrologic processes. Gaines et al. (2003) identified effects of roads and trails on wildlife species including: increased hunting, collecting and poaching; reductions of snags and down wood; routes for competitors, predators and invasive species; and negative stress responses.

Conservation strategies and plan components can be developed to address risk factors that are within agency authority to eliminate, reduce, or mitigate. For example, road closures are an obvious way to reduce road-related risk factors. Robinson et al. (2010) and Hendrickson et al.(2008) present an approach for assessing and mitigating effects of roads.

Evaluations based on population status and demographic characteristics

In cases where there is poor understanding of the link between a species and particular habitat, but information is available on populations characteristics, evaluations focused on population status and demographic characteristics may be helpful and may motivate discussions with partners regarding future monitoring. The most powerful information on current population status is derived from estimates of vital rates combined with population trend or a good time series of population abundance (Dennis et al. 1991, Dennis et al. 2006). Estimates of vital rates result from mark-recapture (Pollock et al. 1990) or other demographic studies and can include estimates of age-specific survival and fecundity, immigration, emigration and trends in these parameters (Caughley 1977, Lebreton et al. 1992). This information can be used to estimate past rates of population increase or decrease (Caswell 1989; McDonald and Caswell 1993; Morris et al. 1999; Rieman and McIntyre 1993; Silvertown et al. 1993, Morris and Doak 2002, Brown and Giles 2007, Miranda and Bettoli 2007) and to examine the demographic properties of the population (e.g., Forsman et al. 2011).

Although demographic information can be compelling and represents the most direct measure of population status, several considerations should also be recognized. First, the goal of the evaluation is to determine if the plan will result in ecological conditions to support a viable population. Hence, an evaluation based largely on demography must draw the logical link to ecological conditions. Second, gathering data on demography and population trend tend to be expensive and it is unlikely that reliable demographic data will be collected for many species. Furthermore, the scope of inference from the demographic data must be addressed directly and the argument linking the analysis to the future made clear. In a strict sense, the demographic pattern observed relates only to the geographic area and the time period within which the data were collected. Vital rates can be used to estimate population viability only if an assumption is made that rates either remain constant, or change in some specified way (see section on *Simulation models* and Morris and Doak (2002) for a thorough treatment of approaches to quantitative demographic analysis). Knowledge of the limitations of demographic analysis should be used to temper conclusions drawn from quantitative analyses. Even with the most rigorous demographic analysis, evaluation of the trend in habitat, influence of plan alternatives on habitat trend, and analysis of the relation of those habitat changes to demography will be necessary to link population performance with habitat trends.

Population trend based on census and presence/absence data

Population count data and presence/absence data can be used to estimate population trend over time. Several summaries of techniques for conducting these analyses have been published (Morris et al. 1999, Thompson et al. 1998; see especially Dennis et al. 1991, Dennis et al. 2006). Such analyses are subject to some of the same limitations as analysis of demographic rate information. Morris et al. (1999) recommend that a minimum of seven years of data be used in estimating population trend. As with the use of demographic rates to estimate population trend, the results are specific to the characteristics of the environment and population stressors at the time and geographic area within which the data were collected. Conclusions regarding future population status require assumptions of stable population parameters or specific changes in vital rates. Similar to employing other demographic methods, effective use of these approaches in plan evaluation will depend on linking understanding of population trend to projected trends in habitat. Carefully conducted research provides the knowledge to make these links.

Genetic considerations

Knowledge of genetic variation may contribute to PVA but conclusions should consider the specific natural history of species under consideration and both the short- and long-term history of the population. Long-term isolation of populations can result in restriction of gene flow and loss of genetic variation sometimes leading to increased risk of inbreeding depression and genetic drift, which may increase risk of extinction (Nelson and Soule 1987; Barrett and Kohn 1991; Frankel and Soulé 1981). We do not know, however, how much and what type of genetic variation is most important to population growth (Caughley and Sinclair 1994, Landweber and Dobson 1999), and efforts to incorporate genetics in PVAs for land-management decisions have met with limited success. Past efforts to use genetic information to evaluate species status revealed important caveats and suggest poor understanding of the role of genetic diversity in demographic processes (Caughley and Sinclair 1994). Biologists should be careful of casual reference to genetic threats to viability (Jamieson and Allendorf 2012).

Despite the cautions emphasized in the preceding paragraph, practitioners should be aware that technical and analytical developments in genetic science may result in approaches useful for population viability assessments for land management applications. Leberg (2005) provides a susinct review of genetic approaches for estimating effective population size while Hare et al. (2011) provide further perspective on developments in this area.

Expert-based assessments

The vast majority of evaluations of NFS plans will be conducted with limited quantitative information and in an environment of high uncertainty. Furthermore because quantitative PVAs have important shortcomings (Beissinger and Westphal 1998, Flather et al. 2011a), management decisions most often depend on information provided by qualitative assessments of the population condition linked to habitat condition. Therefore most SCC evaluations will be accomplished with some form of expert-based assessment. It is important that assessments be clear in the logic used and be transparent to readers. Although these assessments have been criticized for lack of scientific rigor (Boyce 1992; Ruggiero and McKelvey 2000), they carry significant weight in management decision-making and represent the best evaluation of population status available to decision makers. This should not be surprising as expert judgement is an accepted approach in applied sciences (e.g., Powell 2002, Penciner et al. 2011). Hence, it is important to discuss ways that such assessments can be made as informative as possible given the reality of scarce information. The alternative is decision making in the absence of meaningful input regarding the status of populations.

Information gathered from panels of experts in a carefully structured process, has been used in several large-scale viability assessments (Lehmkuhl et al. 1997; Shaw 1999; Thomas et al. 1993a; Thomas et al. 1993b). Guidelines for the use of such panels were described by Cleaves (1994) and Andelman et al. (2001). Among the points emphasized by these authors were 1) the need for careful selection of experts to participate in the process; 2) the value of clear definition of the outcome metrics used in the expert judgment process; 3) the need for careful management of the assessment process to minimize bias (task, motivational, and cognitive); 4) the importance of separating the assessment process from the determination of "acceptable" risk; and 5) the need to explain and document the assessment process so that it is not misinterpreted by decision makers. Expert opinion assessments may be improved following initial development through the collection of additional data. In this way expert opinion is replaced with evidence based analytical tools (Johnson and Gillingham 2004, Pullin et al. 2004 Cook et al. 2009, Drolet et al. 2015).

Several additional practices may improve the credibility and utility of expert judgments. First, breaking the judgment into component parts has several advantages (Andelman et al. 2001). Experts are likely to have a clearer understanding of individual components; reviewers can better understand the basis for judgments; and individual components are more easily tested through later monitoring efforts. Second, requiring experts to provide documentation that supports their judgment would improve the rigor and credibility of the judgment and understanding of the basis for conclusions. Third, combining expert judgement with other techniques should improve the quality of judgments. For example, if demographic and habitat analyses are used as input to expert judgment processes, the quality of the resulting judgments is likely to be high.

Incidence functions, Bayesian belief networks, and simulation models

Incidence functions are based on the tendency for occupancy of habitat patches to increase with size of the patch and proximity to other patches, and to decrease as patch size declines and/or patch isolation increases. They may be useful for assessing viability of species whose habitat requirements are well known and for which habitat is patchily distributed. Incidence functions can be estimated from data on the presence/absence of a species in habitat patches of varying size and isolation (Herkert 1994, Hanski 1994). Similar to other demographic analyses, the approach is complex and will likely be practical only in those cases where risk is exceptionally high and rigorous, time-consuming analysis is both necessary and is possible because of available data.

Bayesian belief networks (BBNs) are a form of influence diagram (Oliver and Smith 1990) that can be used to depict the causal relationships among factors that influence the outcome of some parameter of interest. BBNs have been applied to a variety of problems in ecology and forest management (Haas 1991; Haas et al. 1994; Lee and Rieman 1997; Olson et al. 1990). BBNs have several characteristics that make them useful in assessing species viability (Marcot et al. 2001): 1) they require the user to clearly display the major factors that influence species viability, and interactions among those factors; 2) they combine categorical and continuous variables; 3) they allow the combination of empirical data with expert judgment (Heckerman et al. 1994); and 4) they express predicted outcomes as likelihoods. BBNs make use of expert judgement and add rigor to expert opinion assessments clearly displaying the use of expert statements. Second, by combining expert judgement with empirical data, and structuring them into models, they improve repeatability of assessments. This is especially useful for iterative analysis of possible management alternatives. Examples of BBN models can be found in Raphael et al. (2001), Rieman et al. (2001), and Suring et al. (2011). The approach requires significant expertise and independence of the panel from the line officers, and will likely be used primarily in high risk situations.

Demographic information can be linked to habitat change to produce effective evaluations for high priority analyses through simulation models (Akçakaya et al. 1995; Holthausen et al. 1995; Lefkovitch 1965; Raphael et al. 1994). Models examining plan direction will link population attributes (size, birth, and death rates) to habitat conditions, and base future population performance on projected future habitat conditions (e.g., Akçakaya 1992, Schumaker et al. 2014) but are extremely complex. Simulation models using the relationship of demographic performance to habitat can yield a number of different measures of risk, defined as the likelihood of population extinction by some specified time under various management scenarios. In virtually all cases, there will be incomplete knowledge of the relationships of demographic rates to habitat or other ecological conditions. However, simulation models can be used to test model sensitivity to various assumptions about the relationships of demographics and habitat (Holthausen et al.

1995). Although simulation models can be very useful, and may be one of the only methods to evaluate population response to projected broad scale changes in ecological conditions, users should understand the limitations of the models and the effort necessary to build and test them. Results are dependent on the structure of the model, the assumptions used to parameterize the model, and the input data (including the representation of the land management action being evaluated; Beissinger and Westphal 1998). A summary of the challenges and approaches specific to plant population viability modeling is provided by Menges (2000).

Use of species viability evaluations in decision-making

Determination of whether alternatives meet the requirements of NFMA is made through NEPA decision-making processes and associated with development of an Environmental Impact Statement and the Record of Decision. These determinations are based on all information presented in the species viability evaluation (assessment) along with other assessments examining the potential outcomes of proposed management. Determinations that integrate the results from multiple techniques provide more insight than those dependent on a single approach. The determination may apply to a single plan area or to a group of plan areas that are included within the same planning effort, and should take into account the historical, current, and projected future conditions for a species. The evaluation should tier to any determinations or assessments made at broader scales by acknowledging the contribution of broader geographic areas to the local conditions and expectations for persistence in the plan area. The determination should discuss specific features of the proposed action that affect the likelihood the plan components will provide ecological conditions to support a viable population, including any trade-offs made to meet other goals or trade-offs resulting from budget constraints. Uncertainty associated with the determination should be explicitly documented, and plan direction that will be employed to deal with uncertainty should be described.

Expressing the determination as likelihood differs from approaches employed in some effects analysis. However, approaching the problem using likelihoods acknowledges the ecological/biological reality of the assessment. At the time of the analysis, the outcome of the proposed management (or of alternatives) is unknown. Similarly, changes in the environment from factors outside the control of the agency are uncertain. Even under the most optimal conditions, there is some chance that a population will not persist. Hence communicating results of the assessment to the decision-maker is most effectively accomplished by relating the probability or likelihood of the outcome, even if communicated qualitatively.

8. Monitoring (FSH 1909.12 ch 30, 32.13b)

Monitoring is one of three planning phases described in the 2012 Rule; together with plan development/amendment/revision and assessment, these phases create a framework for integrated planning (2012 Rule, Fed. Reg. p 21162). Without a well-designed monitoring program, the effectiveness of the plan in meeting its objectives remains unknown. The 2012 Rule emphasizes monitoring by explicitly associating plan direction with evaluating the achievement of outcomes. As outlined below, this connection results in direct linkages between monitoring at-risk species and plan components.

Box B. MONITORING FOCAL SPECIES VS AT-RISK SPECIES

Under the 2012 Rule, monitoring objectives differ for focal vs. at-risk species. In the Rule, a limited number of focal species - at least one per monitoring program - are selected specifically to make "*inference to the integrity of the larger ecological system to which it belongs and provides meaningful information regarding the effectiveness of the plan in maintaining or restoring the ecological conditions to maintain the diversity of plant and animal communities in the plan area*." (36 CFR 219.19) (Also see: Fed. Register p. 21175; see section "2012 Regulations: Overview of Species Conservation Approaches") Unlike direction for at-risk species, the Directives state that monitoring indicators for focal species may include affected attributes such as presence, occupancy, reproductive rate, and population trend (ch 30, 32.13c). Focal species may also be SCC (see section "*Identifying At-risk Species*"), but this is unlikely. Focal species will typically be more common than at-risk species, such that monitoring programs developed for focal species can be readily implemented. Monitoring for at-risk species relies on a select set of ecological conditions, and is not required for every designated SCC. In general, focal species will represent only a small part of the monitoring program and will be used to examine ecological sustainability or diversity of plant and animal communities (32.13c).

Monitoring to address species conservation under the 2012 Planning Rule is part of the larger plan monitoring program, which informs resource management in the plan area and improves the integration and scalability of monitoring information (FSH 1909.12, ch 30, 30.2). By definition, monitoring implies repeated measures of conditions and is not equivalent to a one-time inventory or assessment (Johnson 2012, Rowland and Vojta 2013). Thus, a monitoring program entails a commitment to sampling over time to assess trends in status of ecological conditions. In the planning cycle, monitoring plays a key role by providing the foundation for "continuous improvement" of the plan and adaptive management (FSH 1909.12, ch 30) by providing information for future plan assessments. It also provides feedback by testing relevant assumptions, tracking relevant conditions over time, and measuring progress toward reaching desired conditions and objectives (36 CFR 219.12). The knowledge gained through the adaptive management framework informs decisions about whether changes in plan components or management activities are warranted. All monitoring requirements must link to a plan component.

In this section we describe monitoring for at-risk species under the 2012 Rule, focusing on ecological conditions for SCC as prescribed under the new Rule and associated Directives. We begin by reviewing monitoring requirements in the Rule (CFR 219.12) and Directives (FSH 1909.12, ch 30). We then list and elaborate upon several principles for monitoring, followed by a description of steps used to craft a monitoring program. We conclude with additional considerations for monitoring at-risk species, such as time lags and scale.

At-risk Species Monitoring Requirements

Monitoring at-risk species in the 2012 Planning Rule represents a significant departure from plan monitoring under the 1982 Planning Rule. Monitoring of MIS under the 1982 Rule focused on population trends and their relation to changes in habitat conditions and the Directives did not require habitat or population monitoring of Sensitive Species or federally listed species. By contrast, the 2012 Rule requires monitoring the outcomes of management for at-risk species primarily through evaluating ecological conditions. Specifically, the new Rule dictates that each plan monitoring program must contain at least one monitoring question -- and associated indicators -- that address:

> *"The status of a select set of the ecological conditions required under 36 CFR 219.9 to contribute to the recovery of federally listed threatened and endangered species, conserve proposed and candidate species, and maintain a viable population of each species of conservation concern."* (36 CFR 219.12 (a) (5) (iv)).

Elaborating on the Rule, the Directives further specify that:

> *"The Responsible Official has discretion to choose a select set of ecological conditions to be monitored for ecosystems and at-risk species. The "select set" should be important ecological conditions, including key ecosystem characteristics that may be monitored in a direct and efficient way. Monitoring questions are not required for every plan component for at-risk species, nor are species-specific monitoring questions required for every at-risk species. Monitoring a select set of important ecological conditions required by a select set of species at risk, along with monitoring for ecosystems and watershed conditions, will give the Responsible Official information about the effectiveness of the ecosystem and species-specific plan components related to the ecological conditions monitored. The monitoring indicators should measure the effectiveness of plan components (both ecosystem and species-specific components) designed to maintain or restore the ecological conditions and key ecosystem characteristics necessary to provide for diversity of plant and animal communities and contribute to the recovery of, conserve, or maintain the viability of at risk species within the plan area"* (FSH 1909.12, ch 30, sec. 32.13b)."

Note that monitoring conditions to maintain viable populations is only explicitly mentioned in relation to SCC, whereas monitoring for other at-risk species addresses conditions required to "contribute to the recovery of" (federally listed T&E species) or "conserve" (proposed and candidate species) (CFR 219.9.12 (a)(5)(iv)). For simplicity, we focus here on monitoring ecological conditions to sustain population viability for SCC. However, concepts and protocols to monitor ecological conditions for SCC are also relevant for other at-risk species.

Guiding Principles for Monitoring At-risk Species

Efficient monitoring of at-risk species within the fiscal capability of the agency represents challenging scientific and conceptual problems (see Box C), but also can be accomplished with pragmatic and effective approaches. Here we outline a framework to meet the monitoring challenges of the 2012 Rule. Monitoring at-risk species under the Rule must be considered in light of relevant agency policy and laws that establish the responsibility of the Forest Service and direct the appropriate use of public funds, as described above. These considerations lead to several important principles, which we list here and describe more fully below:

- Ecological conditions, i.e., habitat and other influences on the species (36 CFR 219.19), are the foundation for monitoring at-risk species in the 2012 Rule.
- Monitoring, like other activities, must be conducted "within Forest Service authority, the inherent capability of the plan area, and the fiscal capability of the unit" (36 CFR 219.1).
- Monitoring plans should explicitly acknowledge and address the inherent role of uncertainty in land management and the need for the responsible official to make decisions within that climate of uncertainty (FSH 1909.12, ch 30).
- The mandate of the National Forest System is to manage lands mindful of current knowledge, but does not include a research program.

- The 2012 Rule emphasizes:
  - Maintaining and restoring ecological integrity and ecological sustainability (Fed. Register p. 21167);
  - Documentation of how best available scientific information is used in plan monitoring (FSH 1909.12, ch 30, 31.1); and
  - Actively engaging in collaboration to leverage the success of the NFS in planning and monitoring (FSH 1909.12, ch 20, 30).
- Pragmatic prioritization for monitoring is essential; conditions for all at-risk species will not be monitored.
  - Setting priorities for monitoring species acknowledges both the need to reduce uncertainty (improve knowledge) and the requirement to manage within fiscal constraints.
  - Testing relationships between ecological conditions and species status represents important research. As such, priorities should be identified through close cooperation between research and management. Appropriate agencies and organizations with the capability, authority, and responsibility to conduct research should be strongly encouraged to do so - ultimately reducing uncertainty in management.
- Priorities for monitoring/research/collaboration may develop from considering:
  - Species most affected (directly or indirectly) by management.
  - Species most at risk; and
  - Species with shared ecology.

The 2012 Rule focuses on monitoring ecological conditions for at-risk species to determine if progress is being made toward attaining desired conditions. This habitat/system-centric focus aligns with the role of the Forest Service as steward of >193 million acres of federal land. Fortunately standardized protocols have been well-described for wildlife habitat monitoring on Forest Service and other lands (e.g., McComb et al. 2010, Rowland and Vojta 2013). The emphasis on ecological conditions also responds to the clear policy of the Rule to emphasize ecological integrity. In many plan areas, comprehensive monitoring of ecological conditions for all identified SCC would require enormous expense and entail significant unrecognized costs. The Directives acknowledge fiscal constraints and state that the scope, scale, and priorities for monitoring, including monitoring methods and questions, must fall within the financial and technical capability of the Administrative Unit (FSH 1909.12, ch 30).

Efficiencies can be gained by considering requirements for monitoring ecosystems (i.e., terrestrial, riparian, and aquatic) in tandem with status of at-risk species; the same monitoring questions and indicators may at times support both requirements. Grouping species also may help reduce monitoring costs (Suring et al. 2011, Hayward and Suring 2013, Wiens et al. 2008; see “Identification of Potential Species Groups” and Appendix 2). Likewise, longer monitoring intervals (e.g., every 5 vs. 3 years) may better reflect the temporal scale of ecological change and lead to substantial savings on monitoring programs. Use of best available scientific information, including thorough evaluation of sampling designs, power analysis, and careful consideration of whether the monitoring question can be answered with the anticipated data, can inform the process so that monitoring dollars are not wasted.

Monitoring ecological conditions without concurrent population monitoring will be most effective for species whose populations are sensitive to habitat change (Hayward and Suring 2013; see “Evaluations relying only on habitat information”) and the linkages are known. Such monitoring is less useful when habitat and population dynamics are poorly linked, particularly when habitat is abundant but the species is more geographically restricted or does not occupy all identified habitat (Hayward and Suring 2013). This is often true for rare plants, and thus monitoring abundance or spatial distribution is more appropriate (Elzinga et al. 1998). Monitoring ecological conditions is also ineffective for species with poorly understood environmental requirements; however, monitoring ecological conditions for these species may increase understanding of species-habitat relationships (Carroll et al. 1999).

Uncertainty is part of land management, and "acknowledging potential uncertainties is critical to adequately inform the responsible official …during the planning process" (Fed. Register 2012:21193). Uncertainty helps frame the monitoring questions: Is there uncertainty associated with management assumptions? Are there information gaps? Have changes occurred in the plan area that indicate progress toward desired conditions? (FSH 1909.12, ch 30, 32.11; see section "Address Uncertainty" below). Uncertainty also helps frame management action and is a critical component of risk analysis. Effective land managers embrace uncertainty and recognize that reducing uncertainty requires difficult priority setting to identify which areas of uncertainty can be addressed through monitoring and which cannot. Some critical areas of uncertainty require research, an endeavor not under the authority of the National Forest System. Forming partnerships, collaborations, and motivating interest by others is necessary to address knowledge gaps and certain uncertainties. Forming an effective program to reduce uncertainty, therefore, links monitoring with programs in other deputy areas of the agency; coordination can occur with Forest Service Research and Development, as well as State and Private Forestry (FSH 1909.12, ch 30, 32), academia, and with nongovernment organizations.

Box C. CHALLENGES OF MONITORING AT-RISK SPECIES THROUGH ECOLOGICAL CONDITIONS

The approach for monitoring SCC developed in the 2012 Rule is based on a strong theme in the Rule – land management will focus primarily on ecosystem integrity. Consistent with this theme, the Rule and Directives (32.13b) instruct planners to develop monitoring programs that integrate monitoring of ecosystem integrity with monitoring of at-risk species and emphasize indicators of ecosystem integrity. Therefore, monitoring of at-risk species will be accomplished largely by examining ecological conditions. Because neither the Rule nor the Directives explicitly preclude measuring the occurrence, distribution, abundance, or other population parameters of at-risk species as an indicator of plan effectiveness, we suggest that planners follow the philosophy outlined in the Directives for focal species to set priorities for monitoring at-risk species when affordable. Therefore:

- Rank at-risk species and monitor priority species (in most cases by tracking ecological conditions).
- Set priorities by considering relative status, threats, and potential for management influence on status.
- Consider the array of potential ecological conditions and species-specific indicators (or a combination) to evaluate the effectiveness of plan components in meeting conservation objectives.
- Explicitly consider trade-offs and fiscal realities of costly monitoring programs, especially those that include population metrics.

Crafting Effective Monitoring for At-Risk Species

In this section we describe important steps in developing a plan monitoring program for at-risk species and examine some of the more difficult decisions associated with monitoring.

1. *Select and prioritize among species for monitoring*. Perhaps the most difficult task in developing a monitoring program is establishing priorities that are within the fiscal and personnel capabilities of the unit, because doing so clearly identifies monitoring objectives and species that will *not* be addressed. Setting meaningful priorities requires an understanding of monitoring objectives, the cost of meeting those objectives, and often, the potential for altering objectives slightly to reduce costs of some monitoring elements in order to examine a broader range of key management uncertainties. Establishing monitoring objectives and setting priorities should be seen as an iterative process – each step informing the other. Careful prioritization ensures efficient use of resources and avoids redundancies with other monitoring efforts. The process of setting priorities begins with a clear

understanding of the resources (funds and personnel) available to monitor with and designs programs within that constraint.

A key criterion in selecting species for monitoring is the species' sensitivity to management actions. Species whose status is driven primarily by ecological processes or environmental attributes that are not generally affected by land management activities or will not change over time - such as the size of rocks in talus slopes - are not good candidates for plan monitoring. Other criteria include a species' conservation status, the relationship between species distribution and protected areas, species most sensitive to assumptions supporting plan components, and the range of threats influencing the status of the species. If there are concerns about population persistence in the plan area, the species' key ecological conditions are likely good candidates for monitoring but may already be evaluated through other monitoring programs (e.g., USFWS recovery monitoring). Ecological trends in the plan area also may inform the selection process; if certain ecosystems are trending away from desired conditions, then monitoring conditions for SCC that are associated with these ecosystems may be a high priority. Key species for monitoring also may include those whose habitat requirements do not align with desired conditions in the plan area, resulting in tradeoffs; for example, habitat for species relying on closed canopy forests may decline in quality or quantity to meet conditions for resilient (i.e., open canopy) forests that are more fire-resistant. Other considerations include whether habitat requirements identified for the species are closely aligned with other SCC; if so, then grouping species by any number of criteria can be used to gain efficiencies in monitoring (Caro 2010 and Appendix 2). Holthausen et al. (2005) present additional criteria for selecting species in plan monitoring, such as social or economic interest or the species' influence on other species or portions of the ecosystem.

2. *Identify and prioritize across ecological conditions.* For priority species, a set of the ecological conditions and/or key ecosystem characteristics that "maintain the viability of at risk species in within the plan area" requires identification. Development of a conceptual model that identifies 1) species habitat requirements and stressors, and 2) links between habitat elements, stressors, and population metrics, will help focus monitoring on those conditions most likely to provide new knowledge and reduce key uncertainties (Hayward and Suring 2013). These monitoring elements can be ranked and prioritized, considering 1) how they link to other plan components, e.g., will they provide information about multiple SCC or ecological integrity in the plan area, and 2) how feasible the conditions are to monitor (e.g., costs, logistics). Consideration of multi-unit (broader scale) monitoring will be useful at this stage of planning and in the next (defining monitoring questions and indicators). Often, the geographic distribution and life history of at-risk species along with the monitoring question of interest imply that effective monitoring will require consideration of broad spatial extents. Coordinated monitoring among planning units or across entire regions should be considered throughout the process.

3. *Develop monitoring questions and indicators.* The monitoring questions and associated indicators are the foundation of the plan monitoring program and are used to determine whether "management is effective in maintaining or achieving progress toward desired conditions and objectives for the plan area" (FSH 1909.12 ch 30, 31). However, monitoring questions "are not required for every plan component for at-risk species, nor are species-specific monitoring questions required for every at-risk species" (FSH 1909.12 ch 30, 32.13b). Monitoring questions and at least one indicator per question are developed for the set of ecological conditions identified for the SCC. For example, a question might be "Is the spatial extent and pattern of cheatgrass (*Bromus tectorum*) within the plan area changing in a way that reduces area occupied by and the probability of persistence for greater sage-grouse in the plan area?" Indicators to evaluate this question may include elements such as the nearest neighbor distances among patches of cheatgrass over 5 acres, the overall spatial extent of cheatgrass in the plan area, and the change in average patch size for cheatgrass in the plan area.

Selection of indicators is a key requirement of successful monitoring (Hayward and Suring 2013, Holthausen et al. 2005, McComb et al. 2010, Noon et al. 1999b, Noss and Cooperrider 1994). Indicators obviously should match the chosen monitoring questions and be ones that can be "periodically measured and assessed to …determine their effectiveness in achieving desired plan conditions for…at-risk species" (FSH 1909.12, ch 30, sec. 32.13b). Asking the right question leads to appropriate indicator selection. Especially relevant are indicators that are responsive to changes in stressors that are monitored over the same period of time (Noon et al. 1999b, Ziemer 1998). Primary indicators for monitoring ecological conditions for SCC include the abundance, spatial distribution, trend, and quality of habitat or ecological conditions for selected species. Hayward and Suring (2013) outlined considerations in selecting key attributes for habitat monitoring, including the relationship of the attribute to habitat requirements, limiting factors, and threats; anticipated degree of change in the attribute over time; geographic scale; ease of measuring and quantifying the attribute; potential response of the attribute to management; and environmental context. Indicators that are common to many species are good candidates for a cost-effective monitoring program (Hayward and Suring 2013). Broad-scale indicators of ecological conditions for at-risk species could be as simple as area in specific land cover types used as habitat as in the sage-grouse example above.

4. *Monitor trends in selected ecological conditions.* A monitoring plan for trends in ecological conditions of selected SCC will clearly describe key components relevant to monitoring objectives: type of information needed, spatial extent, the desired precision at which elements will be monitored, what constitutes an effect size or minimum detectable change, and sampling period (e.g., twice yearly for 5 years) (Vojta et al. 2013). Wherever feasible and appropriate, existing corporate data, including that from out-of-agency data sources, should be used in the monitoring program to expedite monitoring and decrease or eliminate the necessity of collecting new, empirical data (Vojta et al. 2013). A wealth of FS data exists, e.g., data from the Forest Inventory and Analysis program, for use in habitat monitoring for wildlife (DeMeo et al. 2013). If the monitored ecological conditions are shown to be stable or improving, then management under the plan, has succeeded in contributing to the recovery of, conserving, or maintaining the viability of at-risk species within the plan area to the extent that can be indicated through monitoring. If uncertainty exists about this relationship, several approaches are available to reduce this uncertainty (see Step 5).

5. *Address uncertainty.* For many, or perhaps most, SCC selected for plan monitoring, uncertainty may exist about the relations between ecological conditions provided by plan components and effects of management or how ecological conditions relate to population parameters. Causal relationships between ecological conditions and management actions can be explored by monitoring selected indicators of those conditions on replicated management treatments and untreated control areas, preferably in partnership with FS Research and Development or other agencies such as USFWS or USGS (Rowland and Vojta 2013, Walters and Holling 1990). Careful consideration of priorities is critical because of the long-term commitment of significant resources required to gain reliable knowledge (e.g., northern goshawk (*Accipiter gentilis*): Woodbridge and Hargis 2006, Reynolds et al. 2005; northern spotted owl (*Strix occidentalis caurina*): Lint et al. 1999).

   Testing key assumptions is a pivotal component of the plan monitoring program, and documenting what scientific information was employed, why, and how it was applied will reduce uncertainty. For at-risk species, a key source of uncertainty is often which ecological conditions or other factors are primary drivers of population status. Employing conceptual ecological models, ecological theory, and sound natural history through a narrative can often result in better understanding, new insights, and reduced uncertainty. For high-risk SCC, where uncertainty and risk are high, and management-species interactions are likely, testing the relation between targeted ecological conditions and the desired outcome (i.e., contribute to recovery, conserve, or maintain viability of populations of at-risk species) may motivate direct field investigation. Regardless of the degree of motivation, a decision to employ NFS monitoring explicitly to test this relationship should consider whether adequate data are available for testing; few species can be adequately assessed via PVA (see section "Relationship of Forest Service evaluations to population viability analysis (PVA)"). Moreover, the rationale for selecting species for this kind of monitoring and the baseline information and identified knowledge gaps about species status/ecological conditions relations should be clearly articulated. Clearly described monitoring objectives and methods should be developed in association with a budget to carefully evaluate the high costs associated with this kind of monitoring.

Monitoring to reduce uncertainty is primarily validation or cause-and-effect monitoring, or research (Mulder et al. 1999, Holthausen et al. 2005; Box D). It is costly, requires careful research and statistical design to ensure efficient sampling, and is often difficult to execute for mobile species (Vojta et al. 2013). As noted earlier, a set of inferential tools (i.e., logical ecological arguments) can be employed for some subset of species to reduce uncertainty in lieu of prohibitively expensive field investigation. In cases with high uncertainty and high risk, collaboration is recommended with stakeholders and other agencies to understand the circumstances and seek information to reduce uncertainty.

6. *Evaluate monitoring outcomes.* Completing the monitoring cycle includes feeding information back into the larger planning cycle beginning with assessment of conditions, to evaluation of plan components, considering need for change, and ensuring that desired conditions are restored or maintained. A biennial cycle of evaluating monitoring results is prescribed in the Directives (FSH 1909.12, ch 30, 34). This evaluation must be limited to conclusions supported by data; however, stating that data are inconclusive is acceptable. The task of analyzing and synthesizing monitoring data, particularly from complex but efficient sampling designs, often requires sophisticated analytical skills that are seldom available on planning units. Inappropriate conclusions and critical analytical errors are likely if the appropriate estimators are not employed and if the relationship among measures are not understood.

Other Considerations in Monitoring At-risk Species

Time lags.--Time lags between management actions or human disturbances and the ecological responses to them may represent a non-trivial impediment to effective monitoring and adaptive management. For example, Walker et al. (2007) found a time lag between coal-bed methane development and disappearance of leks for greater sage-grouse in Wyoming. Similarly, forest management designed to facilitate development of old-forest characteristics may not result in desired conditions for many decades (Spies and Franklin 1991). Thus, before initiating the monitoring program an honest assessment should be made of its expected duration, consistency, and whether useful information can be derived in the desired time horizon, particularly to inform subsequent Forest Plan revisions. Regardless of how well-designed a monitoring program may be, resources will be ill-spent if continuity in the monitoring program cannot be maintained or if the information will not be available until long after management adjustments are needed or will be made. Agency commitment and central coordination are essential to ensure that a monitoring program persists through unstable budget cycles and other unforeseen obstacles (Vojta et al. 2013).

Scale.—Monitoring at-risk species under the Rule requires consideration of spatial scale, with a 2-tiered monitoring strategy described in the Rule (unit level and broader scale). For at-risk species with broad area requirements, it may be infeasible to develop monitoring indicators at the geographic scale of an individual plan area. Broader-scale monitoring programs may include elements related to recovery plans for federally listed species that occur across National Forests, such as red-cockaded woodpeckers (*Picoides borealis*). This monitoring may target populations of such species, rather than ecological conditions to maintain viability (ch 33.1). Broader-scale monitoring often involves multiple partners and data sources, given the intermingled land jurisdictions and the role of other agencies such as the USFWS in restoring or maintaining populations of these species. At the unit scale, monitoring measures may be tied to specific management actions to understand ecosystem, or specific species, responses. Mid-scale monitoring often spans multiple watersheds or larger areas such as entire Districts, or encompass adjacent non-NFS lands. (See sections "Temporal scale" and Geographic scale" for further considerations of scale in evaluating viability of at-risk species.)

Thresholds.--Threshold values, or triggers, for each monitoring indicator should be established when monitoring objectives are developed. When values of the indicator fall below or exceed the threshold (e.g., snags/acre), a review is initiated to evaluate the factors leading to the outcome, the influence of current management activities, and the potential effect on the species (Committee of Scientists 1999, Schultz et al. 2013, Vojta et al. 2013; figure 1). In addition to initiating reviews of management practices, thresholds may also prompt reviews of the monitoring program itself, focusing on the effectiveness and appropriateness of the monitoring protocols and indicators. For some indicators, setting a precise threshold value may be infeasible, due to knowledge gaps about relations between ecological conditions and species responses. A more meaningful solution may be to specify a range of expected values for the indicator that reflects the dynamic nature of ecosystems (Noon et al. 1999b). In these circumstances it may be useful to specify in the monitoring program that triggers will be refined based on knowledge gained during the first few cycles of monitoring. For some indicators, the threshold may be expressed as a percentage of change from baseline conditions rather than a specific value or range of values. Regardless of the degree of precision, the process of establishing threshold values is a good check on the utility and efficiency of the indicators: are they measurable, repeatable, sensitive to change, and able to trigger management policy review? Doubt about thresholds may suggest that a monitoring objective is inappropriate and that there is need for an administrative study or research.

Box D. FRAMING THE MONITORING CHALLENGE

When developing monitoring questions, it is helpful to consider the various classification systems that have been developed for Forest Plan monitoring. One system – compliance (or implementation), effectiveness, and validation monitoring – has traditionally been used by the Forest Service (Mulder et al. 1999). A more recent classification by Holthausen et al. (2005) focuses on broad-scale monitoring and describes targeted, cause-and-effect, and context monitoring. Both schemes offer useful concepts to sharpen the scope of viability monitoring. Under the first scheme, Forest Plans will most often develop effectiveness monitoring programs for at-risk species, which document the status and trends of resource conditions and evaluate whether the goals and objectives of the plan are being achieved (Mulder et al. 1999). In other words, are the ecological conditions that support at-risk species resulting from implementation of the Plan? Within the Holthausen et al. (2005) framework, viability monitoring is clearly aligned with targeted monitoring, which tracks the condition and response to management of species and habitats of concern. Extending the investigation by asking whether those conditions contribute to recovery, conservation, or viability of at-risk species is often beyond the scope of Forest Plan monitoring. By naming the type of monitoring for at-risk species typically prescribed in Forest Plans – targeted, effectiveness monitoring – we narrow the focus and thus better define the sampling approaches necessary to design an effective monitoring program.

Management response to monitoring

Monitoring is incomplete if the knowledge gained does not influence management. The primary purpose of monitoring at-risk species and associated ecological conditions is to determine whether management actions need to be modified. Monitoring results should motivate one of four actions: (1) modify the monitoring approach to improve detection of changes in ecological conditions or populations and to evaluate effects of management, (2) modify plan components in response to not meeting objectives or undesired effects, (3) modify both monitoring and plan components, and (4) document that no action is necessary because monitoring has worked effectively to meet the monitoring program objectives (Rowland and Vojta 2013).

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VI. GLOSSARY

At-risk Species: federally recognized species under the Endangered Species Act (threatened, endangered, proposed, and candidate species) and species of conservation concern.

Connectivity: Ecological conditions that exist at several spatial and temporal scales and provide landscape linkages that permit the 1) exchange of flow, sediments, and nutrients; 2) the daily and seasonal movements of animals within home ranges; 3) the dispersal and genetic interchange between populations; and 4) the long distance range shifts of species, such as in response to climate change (36 CFR 219.19).

Ecological conditions: The biological and physical environment that can affect the diversity of plant and animal communities, the persistence of native species, and the productive capacity of ecological systems. Ecological conditions include habitat and other influences on species and the environment. Examples of ecological conditions include the abundance and distribution of aquatic and terrestrial habitats, connectivity, roads and other structural developments, human uses, and invasive species (36 CFR 219.19).

Ecological integrity: The quality or condition of an ecosystem when its dominant ecological characteristics (for example, composition, structure, function, connectivity, and species composition and diversity) occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence (36 CFR 219.19).

Focal Species: a small subset of species whose status permits inference to the integrity of the larger ecological system to which it belongs and provides meaningful information regarding the effectiveness of the plan in maintaining or restoring the ecological conditions to maintain the diversity of plant and animal communities in the plan area. Focal species would be commonly selected on the basis of their functional role in ecosystems (36 CFR 219.19).

Inherent capability of the plan area: The ecological capacity or ecological potential of an area characterized by the interrelationship of its physical elements, its climatic regime, and natural disturbances (36 CFR 219.19).

Native species: An organism that was historically or is present in a particular ecosystem as a result of natural migratory or evolutionary processes and not as a result of an accidental or deliberate introduction into that ecosystem. An organism's presence and evolution (adaptation) in an area are determined by climate, soil, and other biotic and abiotic factors (36 CFR 219.19).

Natural range of variation (NRV): The variation of ecological characteristics and processes over scales of time and space that are appropriate for a given management application. In contrast to the general nature of historical ecology, the NRV concept focuses on a distilled subset of ecological knowledge developed from evaluating ecological history for use by resource managers; it represents an explicit effort to incorporate a understanding of the past into management and conservation decisions (adapted from Weins, et al., 2012). The pre-European influenced reference period considered should be sufficiently long, often several centuries, to include the full range of variation produced by dominant natural disturbance regimes such as fire and flooding and should also include short-term variation and cycles in climate. The NRV is a tool for assessing the ecological integrity and does not necessarily constitute a management target or desired condition. The NRV can help identify key structural, functional, compositional, and connectivity characteristics, for which plan components may be important for either maintenance or restoration of such ecological conditions.

See FSH1009.12 ch10 12.14a for more detail. The following is from that section:

> *The natural range of variation (NRV) is part of the definition of ecological integrity (FSH 1909.12, zero code, sec. 05). A description of the natural range of variation provides insight into the temporal dynamics and key characteristics of an ecological system and provides a context for assessing*

whether an ecosystem has integrity. For instance, the natural range of variation can be compared to existing conditions and recent disturbance processes, allowing the Interdisciplinary Team to identify important compositional, structural, and functional ecosystem elements for developing plan components (FSH 1909.12, ch 20, sec. 23.11a).

The natural range of variation does not represent a management target or desired condition. A description of the natural range of variation alone is not sufficient to determine whether there is ecological integrity.

Persistence: Continued existence (36 CFR 219.19).

Resilience: The ability of an ecosystem and its component parts to absorb, or recover from the effects of disturbances through preservation, restoration, or improvement of its essential structures and functions and redundancy of ecological patterns across the landscape.

Species of conservation concern: A species, other than federally recognized threatened, endangered, proposed, or candidate species, that is known to occur in the plan area and for which the Regional Forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area (36 CFR 219.9(c)).

Stressors: For the purposes of the land management planning regulation at 36 CFR part 219 and this Handbook, factors that may directly or indirectly degrade or impair ecosystem composition, structure, or ecological process in a manner that may impair its ecological integrity, such as an invasive species, loss of connectivity, or the disruption of a natural disturbance regime (36 CFR 219.19).

Viable population: A population of a species that continues to persist over the long term with sufficient distribution to be resilient and adaptable to stressors and likely future environments (36 CFR 219.19).

VII. APPENDICES

Appendix 1. Example of Species Evaluation Criteria

Experience managing Sensitive Species and other at-risk species under the 1982 Planning Rule resulted in several approaches to evaluating the conservation status of species. In the following pages we illustrate one approach that was employed in two FS regions (R2 and R10). Biologists using this approach expressed confidence in its application and outcome. Furthermore, development of the approach included review by outside organizations and agencies – hence the process benefitted from a broad range of input. This approach is presented to illustrate, not to recommend a process.

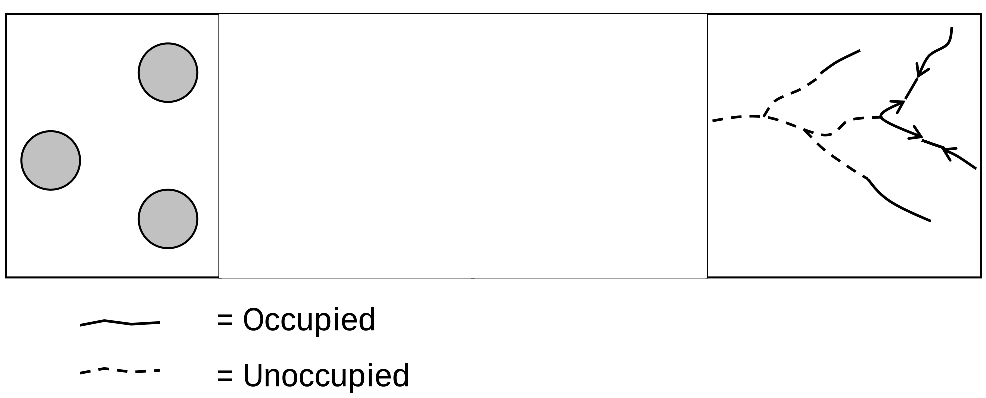
Species Evaluation Criteria and Systematic Approach to Evaluate Species Conservation Status

1. Geographic distribution within the NFS unit – Species that are present in only a few locations within the NFS unit may have a higher risk of extirpation, than those that have a broad distribution. Species with restricted distribution and limited interchange of individuals between populations may be more vulnerable to events (such as: disease, storms) that cause extirpation. Similarly, species associated with geographically limited habitats may be more extinction prone. If the current distribution pattern differs significantly from historical distribution, this change should be considered in evaluating the influence of geographic distribution on species persistence.

<u>Rankings for geographic distribution within the plan area:</u>

A = Scarce OR isolated. If a population or habitat meets any of the following conditions:

1. Habitat is scarce throughout the Forest, indicating strong potential for extirpations, and little likelihood of recolonization. or,
2. Habitat or population connectivity is limited due to factors such as environmental gradients, introduced species, disease, habitat loss, or habitat degradation. Dispersal among patches is limited or not possible. or,
3. Habitat is naturally distributed as isolated patches, with limited opportunity for dispersal among patches. Some local populations may be extirpated and rates of recolonization will likely be slow. or,
4. Pictorially if populations or habitat look like any of the following:

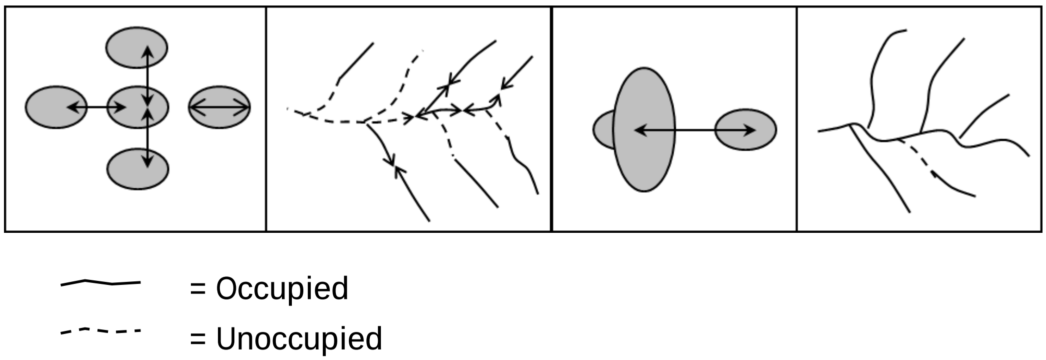


B = Patchy OR gaps. If a population or habitat meets any of the following conditions:

1. Habitat exists primarily as patches, some of which are small or isolated to the degree that species interactions are limited by movements between patches. Local sub-populations in

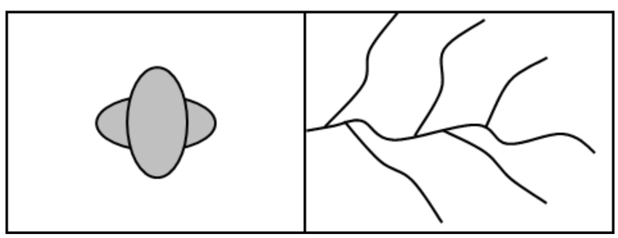
most of the species' range interact as a metapopulation[9] or patchy population, but some patches are so disjunct that sub-populations in those patches are essentially isolated from other populations, or,

2. Habitat is broadly distributed across the planning area but gaps exist within this distribution. Disjunct patches of habitat are typically large enough and close enough together to other patches to permit dispersal among patches and to allow species to interact as a metapopulation, or,
3. Pictorially if populations or habitat look like any of the following:



C = Contiguous. If a population or habitat meets the following conditions:

1. Habitat is broadly distributed across the Forest with opportunity for continuous or nearly continuous occupation by species, little or no limitation on interaction among populations, or,
2. Pictorially if populations or habitat look like either of the following:



D = Insufficient information to draw inferences about criterion.

2. Geographic distribution outside of the NFS unit – Species (or subspecies/varieties) that occur only in the NFS unit warrant a higher level of concern. A species (or subspecies/variety) that is mostly restricted to the NFS unit with a limited distribution outside of the Forest would have a moderate level of concern. The risk of extinction associated with activities in the NFS unit can be moderated by the potential for recolonization from populations existing elsewhere, although low recruitment from outside populations would reduce effectiveness of the rescue effect. A species with wide distribution outside the NFS unit would generally have a substantially reduced risk as a result of activities in the NFS unit.

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[9] Many spatially structured populations will not function as metapopulations. (The degree to which a particular species occurs as a metapopulation, or several, in the Forest will be unknown for most taxa).

<u>Rankings for geographic distribution outside the NFS unit:</u>

A = Only within the boundaries of the NFS unit (local or regional endemics).

B = Limited distribution outside the NFS unit, or widely disjunct taxa for which the main distribution is a significant distance from the NFS unit.

C = Wide distribution outside the NFS unit.

D = Insufficient information to draw inferences about criterion.

3. Capability of the species to disperse – Dispersal of individuals from a population may be limited because a species has low mobility or because barriers to dispersal exist. Species that do not disperse readily across large areas of unsuitable habitat may be at greater risk of extinction than species that disperse readily across a variety of habitats. Movements of aquatic species may be limited by barriers such as malfunctioning culverts, impoundments, or discontinuous stream networks. The ability of plants to disperse can depend on propagule dispersal agents and reproductive biology. Species that are mobile and for which dispersal is not limited will be assigned a value of no concern. Species that are able to disperse only within suitable habitat will be assigned a moderate level of concern. Species for which dispersal is limited by behavioral patterns or physical capability will be assigned a high level of concern.

In evaluating this criterion, the importance of dispersal to the life history of the species will be considered. For instance, dispersal is a critical characteristic of the life history of species that occupy ephemeral habitats or that occur early in succession after disturbance. In contrast, dispersal plays a less significant role in the population dynamics of some species that occupy stable habitats (such as cave-dwelling insects).

<u>Rankings for capability to disperse:</u>

A = Very limited dispersal ability (restricted dispersal capability coupled with ephemeral habitats).

B = Disperses only through suitable habitat (dispersal areas may or may not be corridors).

C = Readily disperses across landscapes with few habitat-related limitations.

D = Insufficient information to draw inferences about criterion.

4. Abundance (estimated number of individuals or populations) of the species on the NFS unit. – Population density or abundance is a primary factor in determining whether a species will persist following habitat loss. Generally, a lower abundance or density may increase the risk of extinction. Rankings will be based on categorical estimates of abundance relative to the expected abundance of that species in good habitat. This approach avoids problems associated with using population estimates or abundance estimates for widely diverse species. Base ranking on overall condition, but rationale should draw any contrasts between abundance on NFS lands vs. other ownerships.

<u>Rankings for abundance on the NFS unit:</u>

A = Rare - current abundance is low enough that stochastic and other factors could lead to potential imperilment.

B = Uncommon - current abundance is large enough that demographic stochasticity is not likely to lead to rapid local extinction, but, in combination with highly variable environmental factors, could pose a threat.

C = Common – current abundance is large enough that species persistence is not threatened by demographic stochasticity in combination with environmental variation.

D = Insufficient information to draw inferences about criterion.

5. Population trend in the NFS unit – Another primary factor indicating that persistence may be a concern is a long-term downward trend in population size. A consistently declining population is of concern even if current population size is large, although short-term declines should be interpreted cautiously due to inherent variability in populations and population structure.

An example may be snowshoe hares which have population highs and lows over about a 10 - 15 year period. For species with cyclic or irruptive population patterns three or more cycles may need to be considered before a population trend can be established. Results of local and national monitoring programs may be used to assign values for this criterion.

Rankings for population trend in the NFS unit:

A = Significant downward or suspected downward population trend.

B = Stable population.

C = Upward population trend.

D = Insufficient information to draw inferences about criterion.

6. Habitat trend in the NFS unit. – Another primary factor indicating that viability may be at risk is a persistent downward trend in habitat quality, quantity, or both. Trends in species' habitat can often be indicative of population trends. Base ranking on overall habitat condition, but explain the rationale used to contrast abundance on NFS lands vs. other ownerships. Ecological assessments of terrestrial, aquatic, wetland, and riparian systems may provide insights into habitat trends.

Rankings for habitat trend in the NFS unit:

A = Decline in habitat (quality, quantity, or both).

B = Stable amounts of suitable or potential habitat, relatively unchanged habitat quality.

C = Improving habitat quality or increasing amounts of suitable or potential habitat.

D = Insufficient information to draw inferences about criterion.

7. Vulnerability of habitats and populations on the NFS unit – Human-caused modifications of habitat in the NFS unit include energy development, recreation management, vegetation management, mining, water diversions, road construction, and other stressors. Ecosystem assessments may be useful in providing insights into natural patterns and dynamics of ecosystems, the processes that influence current habitat conditions, and the degree to which management actions result in patterns similar to natural disturbances and how those patterns relate to the natural range of variation (NRV). This criterion will evaluate recent and potential effects of habitat modification (in the broadest sense of all environmental conditions) on wildlife and plant species. In addition, this criteria will consider vulnerabilities that do not relate directly to 'habitat' but could become a limiting factor, stressor, or threat to the population, such as harvest or direct mortality of individuals. Base ranking on overall extent of habitat modifications and resiliency to modification AND on the spatial and temporal extent of any threat to the population.

Rankings for vulnerability of habitats in the NFS unit:

A = Substantial modification of habitat has occurred or is anticipated with conditions departing from expectations based on NRV, and/or habitat is impacted by modern stressors such as herbicides, nonnative invasive species, water diversions, recreation, etc.

B = Habitat modification is likely to result in ecological patterns similar to the range of historical conditions, but is being impacted by modern stressors.

C = Habitat resilient, changes are similar in frequency and intensity to those expected from NRV, and modern stressors not significant.

D = Insufficient information to draw inferences about criterion.

8. Life history and demographic characteristics of the species – Life history factors such as reproductive rate, relationship with disease organisms, interaction with mutualists or symbionts, food web dynamics, relationship with predators, or relationship with competitors, can affect population size and ability to rebound from stochastic or human-caused population reductions.

For vertebrates, examples of characteristics that might affect viability risk include: number of reproductive cycles/year, average number of young produced/breeding cycle, minimum age of first reproduction, age specific survival rates, and social organization.

Life history characteristics that affect viability in plants include lifespan and variation in life span of individuals (such as: annual vs. perennial), seed dispersal strategy, variation in germination rates, relationship with pollination agents, and susceptibility to herbivory. Annual variation in vital rates can also be important.

Species with strong mutualistic relationships, with low reproductive rates and which are highly susceptible to negative effects of disease, predation, or competition may have less ability to recover from population declines. Those species will be assigned a high level of concern. Species with higher reproductive rates have a greater ability to recover from losses caused by predation, disease, or competition; however, life-cycle analysis may be necessary to evaluate the extent to which reproduction vs. age-specific mortality influences population growth. Viability risk is also higher for populations depressed by introduced diseases or competitors, or that are susceptible to genetic introgression or inbreeding.

Rankings for life history and demographic characteristics:

A = Low reproductive rate **and** high mortality (such as: susceptible to disease, predation, or competition); OR life history characteristics that suggest populations may not recover rapidly from disturbance events or other demographic risk factors are of concern.

B = Low reproductive rate **or** high mortality (e.g., susceptible to disease, predation, or competition), but not both; OR life history characteristics that suggest populations have an intermediate ability to recover from disturbance events and no other demographic risk factors are known. Temper conclusions based on life-cycle considerations and whether population growth is likely to be more sensitive to changes in reproduction or age-specific mortality.

C = High reproductive rate **and** not especially susceptible to disease, predation, or competition; OR species has life history characteristics that suggest populations will have a high ability to recover from disturbance events and no other demographic risk factors are known.

D = Insufficient information to draw inferences about criterion.

In formulating a recommendation, consider the information provided for all 8 criteria, and the evaluator's uncertainty ranking (H-M-L). Threats to species persistence may interact in a non-linear way, and therefore the combination of factors influencing species should be reviewed and synthesized. Although it is possible that any one factor could justify SCC status, the information must provide a compelling argument that population viability is of concern as evidenced by known or predicted downward trends.

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Appendix 2. Approaches to developing species groups

Processes presented here are intended to help organize and simplify management of at-risk species to maintain species or population viability as demanded by the Rule. The goal of developing species groups is to 'reduce the dimensionality of the management problem' (Wiens et al. 2008). Just as ecologists use multi-variate approaches to organize and understand ecological systems made up of many factors, managers often must reduce the number of features (in this case species) that are considered when crafting management approaches or developing monitoring schemes. The following review examines a range of approaches that others have employed to effectively reduce dimensionality. Choice of approaches should depend on the how the resulting groups will be employed. Therefore, objectives should guide the choice of grouping approach. See Wisdom et al. (2000) and Wiens et al. (2008) as general references. We will not repeat these references throughout this appendix but recognize that they inform much of its text.

Grouping based on ecological characteristics

Grouping species on the basis of one or more ecological factors provides a strong foundation for developing conservation strategies for SCC, because the conservation strategies can then be ordered around ecological principles. Ecological groupings also make sense for evaluating the effects of planning alternatives. Groups should be based primarily on vegetation characteristics of habitat, such as vegetation type and successional/structural stage. Other ecological factors may be considered when grouping species; three are discussed here: 1) guilds; 2) home range size/body size; and, 3) categories of limitation.

Habitat associations

The concepts of community types, plant association, and seral (or structural) stages provided by plant ecologists form a foundation for grouping terrestrial species by similarity of habitats. Seral/structural stages as well as vegetation types should be used when grouping species by habitat, because the viability of some species may be dependent on a particular stage that is underrepresented or in poor ecological condition. Cushman et al. (2007) found more reliable predictions of bird abundance when vegetation type and structural stage were combined to indicate habitat. When seral/structural stages are used to define species groups, conservation strategies and the analysis of effects can be made more specific.

There are a variety of techniques to group species based on habitat associations. Short and Burnham (1982) illustrated a variety of clustering techniques to form groups of species to facilitate understanding of the composite environmental requirements of large sets of vertebrate species. Wisdom et al. (2000) used hierarchical cluster analysis to group at-risk species within the Columbia Basin. The same cluster analysis approach was used to group species for plan revision in northeastern Washington (Suring et al. 2011). Similar grouping approaches have been used to cluster fish communities (Lee et al. 1997). Other examples of grouping by habitat association are contained in the Southern Appalachian Assessment (SAMAB 1996) and the Northern Great Plains Assessment (Samson et al. 1999).

Guilds

Guilds are groups of species that share one or more life history characteristics. MacArthur and MacArthur (1961) classified groups of forest birds by the canopy characteristics occupied by each species. Root (1967) coined the term "guild" to identify groups of species with similar feeding ecology. A major criticism of the guild concept is that although guild members share life history characteristics, they may respond to environmental changes in distinctly different ways and therefore the guild may not be useful to predict the response of individual guild members (Morrison et al. 1992, Marcot et al. 1994). Guilds may, however, provide a useful way to further subdivide groups based on habitat associations. An example is provided in Wall (1999).

Home range size and body size

Home range size can be used in conjunction with habitat associations to provide further refinement of groups that use similar habitats but may operate at different scales. A number of ecologists have shown a relationship between body size or weight and home range size (McNab 1963, Harestad and Bunnell 1979, Holling 1992). This relationship may be useful for evaluating how species use habitats at different spatial scales. An application of these combined approaches was used in Ontario to select indicator species for habitat types and structural stages at three spatial scales (McLaren et al. 1998).

Categories of limitation

Species can also be grouped according to the primary limitations that have contributed to their decline. Lambeck (1997) proposed four categories for grouping species: area-limited, resource-limited, dispersal-limited, and process-limited. He also suggested that the area-limited group could be further divided according to major habitat types. This group may also be subdivided by using body size/home range size as an indicator of dispersal limitation. The resource-limited group can be subdivided by categories of key resources (e.g., caves, snags), and the process-limited group can be divided into types of processes (e.g., fire, hydrologic processes).

Grouping based on risk

Examination of the causes of species endangerment and extinction demonstrates that a limited number of risk factors contribute to a significant proportion of extinctions and population declines (Caughley 1994, Caughley and Sinclair 1994, Diamond 1989, Pimm et al. 1988, Wilcove et al. 1998).

Suring et al. (2011) identified risk-factors for SCC that had the potential to result in reductions of habitat availability, habitat effectiveness, population size, or fitness. Conservation strategies or plan components can be developed to address risk factors that are within the Agencies authority to eliminate, reduce, or mitigate. Presumably, many species in a risk category would respond to risks in a similar way, facilitating the evaluation of effects. However, this assumption will not be universal and some species placed in a common category by risk factor will respond in divergent ways. Grouping based on risk factors may be a useful way to further subdivide groups based on ecological characteristics such as habitat associations (Suring et al. 2011).

Defining species groups

It may be helpful to select individual species to represent the needs of the groups of SCC identified in the previous steps. Roberge and Angelstam (2004) found that using a systematic procedure for selecting "focal" species (defined differently than in the 2012 Rule) was a useful approach to multi-species conservation strategies. A process for identifying taxa to represent species groups follows. This process assumes that species are being classified and treated according to their ecological requirements and risk factors, and that the process is being carried out at the scale of a plan or at a bioregional scale. Note that the objective of the process presented here is to select a taxon that best represents the composite ecological requirements of some group of SCC.

- First, identify species groups associated with specific forest types and structures (e.g., late-successional, single-story ponderosa pine) or analogous groups associated with grasslands, shrub lands, or aquatic systems. Processes such as hierarchical cluster analysis will help in developing appropriate habitat-based groups (Wisdom et al. 2000, Suring et al. 2011). Habitat-based groups may be further divided by common risk factors.
- For each of the species in the group, array the following additional information:
    - Risk factors (if not used in grouping process)
    - Fine-scale features (e.g., snags)

- Home range and dispersal capability
- Additional ecological requirements (e.g., lack of human disturbance)
- Geographic range.

- Based on this information, select one or more species that best represent the full array of ecological requirements for all species in each of the habitat-based groups. It is recommended that species with the most demanding requirements be selected here. If their needs are met, then needs of other species within the habitat group should also be met. Several species may have to be selected to fully represent the requirements of all species within the habitat-based group, as well as all or key combinations of risk factors for the group. If some species within the habitat-based group use snags, then a species with the most demanding or limiting snag requirements should be selected. Similarly, within that same habitat group, it may be appropriate to select the species with the largest home range, and the species with the most limited dispersal capability to represent the group.

If species are selected in this way to represent a larger group, then a strong foundation is built to argue that they represent the ecological requirements of the larger group. Note however, that even where species have very similar ecological requirements, it is not an expectation that their population dynamics would parallel one another. Note also that this process requires the use of detailed information on species habitat requirements, and that a relatively large and diverse set of representative species may be needed to provide insight into the requirements of all species.

The above process emphasizes the selection of surrogate species through grouping of SCC. It is also possible in some cases that ecological requirements of SCC could be represented by a species that is not itself a SCC. For example, ecological requirements of predators that are identified to be at risk could be at least partially represented by common prey species.

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