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Original article

A review of protocols for selecting species at risk in the context of US Forest Service viability assessments

Sandy J. Andelman [a,*], Craig Groves [b], Helen M. Regan [a,c]

[a] National Center for Ecological Analysis and Synthesis, University of California Santa Barbara, 735 State Street, Suite 300, Santa Barbara, CA 93101, USA
[b] Greater Yellowstone Program Coordinator, Wildlife Conservation Society, 2023 Stadium Drive Suite, 1-A, Bozeman, MT 59715, USA
[c] Department of Biology, San Diego State University, 5500 Campanile Drive, San Diego, CA 92182-4614, USA

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Abstract

In December 2000, the USDA Forest Service (USFS) commissioned a review of their process for conducting viability assessments under the National Forest Management Act (NFMA). The objectives of the USFS review were to establish the scientific basis for geographic and temporal scales used in the assessment of viability, to identify and improve approaches that could be used to assess species viability within the context of NFMA, and to describe the strengths and limitations of the approaches used in the viability assessment process. In this paper, we present one aspect of this overall review: methods available and in use for selection of species at risk for the viability assessment process. A representative group of methods includes threatened and endangered species protocols such as the IUCN protocol, the Heritage ranks, the method devised by Millsap et al. (1990) to identify threatened and endangered species in Florida, as well as protocols for narrower taxonomic and geographic ranges. We provide a description of each of the nine protocols reviewed and compare them in terms of their taxonomic and geographic range, biological attributes, consideration of threats and population trends, data requirements, reliability and robustness, transparency and ability to deal with uncertainty. We found that all threatened and endangered species protocols are useful for classifying species at risk, however, those that explicitly include current and future threats are of most use in determining which species will be adversely affected by proposed management actions. We recommend that Heritage ranks be used to identify an initial set of candidate species for assessment of viability considerations, with further refinement and supplementation based on species distributions, relative to the scale of the planning area.

Keywords: Viability assessment; Threat; Forest management; US Forest Service; Endangered species

1. Introduction

The USDA Forest Service (USFS) manages the lands and resources of the US National Forest System, which include 192 million acres of land in 42 states, the Virgin Islands, and Puerto Rico. The System comprises 155 National Forests, 20 national grasslands, and various other lands under the jurisdiction of the Secretary of Agriculture (Federal Register, 2000, 65, 67514). Several laws guide the management of the National Forest System. These include the Multiple Use Sustained Yield Act (MUSYA), the Endangered Species Act (ESA), the National Forest Management Act (NFMA), and the National Environmental Policy Act (NEPA).

In December 2000, the USFS commissioned a review of their process for conducting viability assessments under the National Forest Management Act (NFMA). This review was to form part of a larger process within the agency intended to simplify, clarify and improve the scientific basis for viability assessments. The objectives of the USFS in commissioning the review were to:

- Establish the scientific basis for geographic and temporal scales used in the assessment of viability.
- Identify approaches that could be used to assess species viability within the context of NFMA, recognizing the need to make long-term (50–100 years) projections of future conditions, the requirement to deal with a broad array of taxa, and the reality of limited information for most species.

* Corresponding author.
E-mail address: andelman@nceas.ucsb.edu (S.J. Andelman).

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- Describe the strengths and limitations of each approach, including an overall comparison of the range of approaches.

The NFMA planning regulations (Federal Register, 2000, 65, 67580–67581) define species viability as:

> "A species consisting of self-sustaining and interacting populations that are well distributed through the species' range. Self-sustaining populations are those that are sufficiently abundant and have sufficient diversity to display the array of life history strategies and forms to provide for their long-term persistence and adaptability over time."

The regulations further state that a species is well-distributed when individuals can interact with each other in the portion of the species' range that occurs within the planning area One of the first tasks in the viability assessment process is the identification of species at risk of loss of viability due to forest management actions. The NFMA planning regulations define species at risk as "federally listed endangered, threatened, candidate, and proposed species, and other species for which loss of viability, including reduction in distribution or abundance, is a concern within the plan area. Other species-at-risk may include sensitive species and state-listed species. A species-at-risk also may be selected as a focal species" (Federal Register, 2000, 65, 67580). Currently, the USFS has deferred the implementation of the 2000 planning regulation and has reverted to the 1982 rule, while considering implementation of a new rule. Although the considerations we present here were motivated by the 2000 planning regulations, they are generally relevant to the issue of species viability considerations on managed lands.

Federal agencies, such as the USFS, are legally required to make efforts to protect and recover species listed as endangered or threatened under the Endangered Species Act. However, identifying the full set of species that may be at risk from proposed future management activities is more complex and there is no universally accepted approach (Raphael and Marcot, 1994; Holthausen et al., 1999). Numerous methods for classifying species according to their risk of extinction are used by management agencies and governments throughout the world. Some are intended to be applied within a local region or state (e.g., Millsap et al., 1990; Lunney et al., 1996; Breininger et al., 1998), while some have national (e.g., Molloy and Davis, 1992; Czech and Krausman, 1997; MER, 2000) or international status (e.g., IUCN, 2000), or are used at multiple political scales (e.g., USFWS, 1983; Master, 1991; Master et al., 2000). Yet others have been developed to apply to specific taxonomic groups (Wade, 1998; Carter, 2000). These protocols share many attributes and use similar information, such as population size, extent, number of populations, and trends in at least some of these variables. All result in an assessment of threat, couched in words that reflect the probability of decline or loss of a taxon within some time period.

There also are significant differences among these methods, including the extent to which they consider management variables, taxonomic status, recoverability, and assessments of past or future trends. They also employ different logical systems to interpret data, treat missing data differently, and apply arbitrary weights to the variables. Typically, a particular protocol has been developed with particular management, regulatory and administrative processes in mind. Thus, the operation of any particular method and the kinds of variables it employs reflect assumptions about management context, although these assumptions usually are implicit, not explicit.

The USFS has used a range of methods to identify sensitive species and species at risk. Sensitive species, as defined by the USFS, are species known to occur on National Forests, for which population viability is a concern, as evidenced by significant current or predicted declines in population numbers or density, or significant current or predicted declines in habitat capability that would reduce a species' existing distribution. Within the agency, there is no single consistent process for identifying sensitive species at the scale of a National Forest or region. While there have been efforts to establish a consistent approach, these largely have been unsuccessful because of the decentralized nature of USFS management. Instead, a range of information sources typically is used, including, but not restricted to federally listed threatened and endangered species, US Fish and Wildlife Service or National Marine Fisheries Service candidates for federal listing under the US Endangered Species Act; and state lists of endangered, threatened, rare, endemic, unique, or vanishing species, especially those listed as threatened under state law. Several regions (Regions 1, 2 and 4) have adopted multi-criteria, point-scoring schemes to identify potential species for inclusion on sensitive species lists. The criteria used include: abundance, distribution, level of threat of habitat loss, population impacts, specialized habitat, ecological amplitude and declining population trends. If the total score for a species is greater than a threshold, then the species is nominated for sensitive designation. Other regions base sensitive species lists on US Fish and Wildlife Service candidate listings and Heritage ranks. The lists of species at risk resulting from these processes often number in the hundreds (SNFPA-FEIS, 2001) to over a thousand (Thomas et al., 1993a,b) for the National Forests and Bureau of Land Management lands in the Pacific Northwest (Meslow et al., 1994).

In this paper, we focus on systematic approaches for classifying species at risk, with the aim of identifying a scientifically sound, yet practical approach that can be used by the USFS to meet its obligations for identifying species at risk under the NFMA planning regulations. In addition to methods for ranking species, similar methods have been used to rank environments or habitats for their capacity to support particular species (e.g., Lindenmayer and Possingham, 1996; Hanski, 1999a). While there have been some previous reviews comparing ranking systems, these have either addressed a subset of the protocols, or have addressed the applicability of the protocols to a limited number of taxa (e.g., Burgman et al., 1999; Alvo and Oldham, 2000). Here we review a comprehensive set of existing protocols for classifying species according to their risk of extinction, and evaluate the protocols according to criteria relevant to the USFS planning and management process. Finally, we consider additional criteria for identifying species at risk, as a function of the spatial distribution of populations and its relevance to the scale of USFS management activities.

2. Existing protocols

The classification systems described here are an illustrative sample of the variety of methods available to categorize species according to some direct estimate of the risk of extinction or an indirect estimate using factors associated with the risk of extinction. Classification systems vary significantly, depending on the objectives of the system, the relevant species, the data available, and the scale of consideration (Root, 2002). These factors need to be considered explicitly when selecting a protocol for prioritizing species for population viability analysis.

2.1. IUCN (2000)

The IUCN classification system (Mace and Lande, 1991; IUCN, 2000) is a rule-based approach to classifying species according to their risk of extinction at a global scale. Four categories of risk are specified: critically endangered, endangered, vulnerable, and lower risk. The criteria are quantitative and based on principles of population biology. Species are classified by population size and number; population growth trends, distribution, degree of fragmentation, and estimates of extinction risk within given time frames. Each parameter has sub-criteria with numerical thresholds or qualitative conditions. Species do not have to satisfy all of the criteria to be placed in a class, just a minimum number of them. The IUCN 2000 protocol differs from the previous IUCN 1994 protocol in that the 2000 revision permits more stringent thresholds of decline, as long as causes of decline have ceased, are understood and are reversible. IUCN 2000 also limits to 100 years the time frames over which declines and extinction risks may be considered, considers extreme fluctuations in conjunction with population size as well as range size, and addresses skewed population structure. The IUCN protocol has been applied to 1714 species in the U.S. covering a broad range of taxonomic groups. For a full list of ranked species see http://www.redlist.org/search/search-basic.html.

2.2. Heritage ranks

The Heritage Global (G) and State (S) ranking protocols (formerly known as The Nature Conservancy G and S ranks) also were designed to classify species based on their risk of extinction. The classification scheme (Regan et al. in preparation; modified from Master, 1991 and Master et al., 2000) uses the following factors: number of occurrences and number of occurrences with high viability; population size; extent of occurrence; area of occupancy; short- and long-term trends in population size and geographic range; scope, severity and imminence of threats; number of appropriately protected and managed occurrences; and intrinsic vulnerability. Most of the factors involve explicit numerical criteria; these criteria may be derived from both empirical data and expert opinion. There are five classes: critically imperiled; imperiled; rare or uncommon; apparently secure; and secure. Unlike the IUCN classification scheme, all of the criteria are taken into account in the classification of a species. The Heritage protocol also incorporates information about current and future threats to populations. It is designed to be flexible across many scales. The Heritage protocol has been applied to 8164 vertebrate and selected invertebrate species (http://www.natureserve.org/datasets_zoo/overview.htm) and to 29579 vascular and non-vascular plant species from a broad range of taxonomic groups in the US and Canada. However, most of these species have been classified according to the scheme in Master (1991) and Master et al. (2000), rather than the modified version of the protocol (Regan et al., in preparation), which explicitly incorporates threats. It currently is unknown how many species have received ranks under the modified protocol. NatureServe™ (http://www.natureserve.org) provides data, and Heritage conservation status and US ESA ranks for over 46,000 plant and animal species and subspecies in the US.

2.3. USFWS

The Endangered Species Act of 1973 (ESA) (USFWS, 1983) states that five factors determine whether or not a species should be listed as endangered or threatened (Nicholopoulos, 1999): the present or threatened destruction, modification, or curtailment of the species' habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; the inadequacy of existing regulatory mechanisms; and other natural or man-made factors affecting the species' continued existence. In addition, the US Fish and Wildlife Service developed guidelines for determining a listing priority number which assigns a listing priority status rank to species proposed as candidates for potential listing as either endangered or threatened under the ESA. There are no numerical thresholds or criteria and the classification system is primarily subjective. This system is intended to be quick and straightforward to expedite determination of a species' status. It involves collecting the best available commercial and scientific data, and ordering listing decisions about the status of a species based on the magnitude and immediacy of threats to species and on their taxonomic uniqueness. Approximately 1260 species from a broad range of taxonomic groups have been classified as endangered or threatened under the USFWS guidelines (http://ecos.fws.gov/tess/html/boxscore.html). The National Marine Fisheries Service (NMFS) also lists species under the ESA, however, they use a different protocol (Ruckelshaus, NMFS, personal communication).

2.4. Millsap et al. (1990)

The Millsap et al. (1990) classification system was designed to categorize vertebrate species in Florida, based on their risk of extinction. The scale is regional rather than global or national. A series of scores is assigned for a range of parameters. These include: population size, population trend, range size, distribution trend, population concentration, reproductive potential, and ecological specialization. Each criterion has a number of subclasses, defined as either numerical thresholds, or as subjective criteria. Scores for each parameter are summed to give a "biological score." A separate set of criteria that includes rankings based on the current state of knowledge of distribution, population trend, limiting factors and the current extent of conservation efforts designates an "action score." The protocols then can be used to rank species to prioritize conservation efforts. The absolute scores also can be used to differentiate between endangered and vulnerable species. Recent and potential threats are not explicitly taken into account. The Millsap et al. scheme has been applied to 668 vertebrate species (up to 1990) for a broad range of taxonomic groups in Florida (excluding marine fish species).

2.5. Lunney et al. (1996)

This classification scheme (Lunney et al., 1996) is a modification of the Millsap et al. (1990) protocols for the purpose of systematically evaluating the conservation status of all mammals, birds, reptiles and amphibians in New South Wales (NSW), Australia, in accordance with the NSW National Parks and Wildlife Act of 1974. Parameter definitions are modified to address the geography of NSW, which is five times larger than Florida, and the time since European settlement (which is shorter than European settlement in Florida). An additional question on threatening processes was added to satisfy the criteria listed in the Act. The variables are weighted to reflect reliability of available information. Greater weight is given to the ecological attributes of population size and trend, and area of distribution and trend, as these provide estimates of changes in populations. Species are ranked according to their relative summed scores and classified as threatened or vulnerable with one of three knowledge grades: adequate, limited, or inadequate. Modifications to suit NSW geography and the time since European settlement in Australia restrict the applicability of these protocols to NSW, however, further modification can extend their utility to a range of geographic scales and timelines. The Lunney et al. scheme has been applied to 883 vertebrate species (up to 1996) for a broad range of taxonomic groups in NSW, Australia. Although it could be applied to species in the US, this has not been done.

2.6. Partners in flight

This classification scheme was originally created to address declining populations of Neotropical migratory songbirds, but it was hoped that it could be applied consistently to any group of species in any geographic region (Carter et al., 2000). Like the Millsap et al. scheme, a series of scores is assigned to parameters, many of which have sub-categories defined by numerical criteria. There are seven parameters: breeding distribution, non-breeding distribution, relative abundance, threats to breeding, threats to non-breeding, population trend, and area importance. Scores are based on quantitative and objective data where possible, however, subjective assessments based on expert opinion also are permissible in the absence of empirical data. The protocols reflect recent and predicted threats that may put a species at risk of decline or extirpation from an area. There is flexibility in the way scores for each parameter can be used to assess risk. The sum of all scores is one indication of priority status, however, parameters also can be weighted if some parameters are considered more important than others. A categorical approach can be applied that sorts species primarily according to thresholds of scores for population trend, relative abundance and threats. The notion of "area responsibility," which highlights an area's contribution to long-term conservation of species, also has been introduced as a way of using the PIF protocols. Between 100 and 300 bird species have been classified according to the PIF protocols in the US.

2.7. Method for evaluating the risk of extinction of wildlife in Mexico (MER)

This is a point scoring method for assigning categories of threat to species in Mexico (MER, 2000). It has four parameters, each of which is assigned sub-categories and criteria. Two of the parameters have numerical thresholds, while two have qualitative criteria. The four parameters are: distribution size of the taxon in Mexico; the condition of the habitat with respect to the natural development of the taxon; intrinsic biological vulnerability of the taxon; and the impact of human activities on the taxon. The impacts and tendencies of threats from general human activities such as urban development, fragmentation of habitat, contamination, commerce, traffic, change in land use, and introduction of exotic species are explicitly considered. There are two categories of threat, based on the final sum of the scores. These are "in danger of extinction" and "threatened." There is an implicit default classification of low risk if a species is not classified in either of the risk categories under the protocols. The MER was published in the Mexican Federal Register in 2000, and we do not know how many species have been classified using this protocol.

2.8. CITES

The aim of CITES is to ensure that international trade in specimens of wild animals and plants does not threaten species survival. Animal and plant species are listed in one of three Appendices, according to the level of protection needed. Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances. Appendix II includes species not necessarily threatened with extinction, but for which trade must be controlled to ensure utilization levels are compatible with their survival. Appendix III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade (http://www.cites.org/). A set of rule-based criteria exist for listing species on Appendices I and II (see http://www.cites.org/eng/resols/9/9_24.shtml#annex, for full details). These criteria are similar to those for the IUCN Red List categories. For listing on Appendix I species must satisfy a trade criterion ("Is or may the species be affected by trade?") and at least one of four criteria relating to population size and number; population growth trends; distribution; degree of fragmentation. While the protocol does not stipulate quantitative thresholds, it does provide some numerical guidelines for levels of decline that are cause for concern. For listing on Appendix II, species must satisfy the trade criterion and one of the criteria directly related to effects of trade or harvest on the species. The listing criteria are currently under review (expected to be complete in October 2004) and draft criteria are being evaluated which will slightly change the criteria currently used. Currently 1310 species in the U.S. are listed on Appendices I and II. For a full list of CITES-listed species see http://www.cites.org/eng/resources/species.html.

2.9. Committee on the Status of Endangered Wildlif e in Canada (COSEWIC)

COSEWIC is a system for prioritizing species at risk of extinction or decline nationally. Species are initially placed on a "Prioritized Candidate List" for more detailed assessment through the preparation of a COSEWIC status report. Candidate species are selected from a range of sources including the General Status of Wild Species in Canada, the Heritage ranks, jurisdictional monitoring, the IUCN Red List, input from the COSEWIC species specialist subcommittee (SSC), and expert knowledge and judgment of SSC Co-chairs (http://www.cosewic.gc.ca/htmlDocuments/PrioritCan_e.htm). Candidate species may be placed in one of three categories: high, medium or low priority. Status reports are then compiled to determine whether a species should be classified in one of the five risk categories: extinct, extirpated, endangered, threatened, or special concern. There are two other categories, data deficient and not at risk. Status reports are supposed to include information on the distribution, population size, habitat requirements, population and habitat trends, biology and behavior of the species, threats, significance of the species and existing protection or status designation (e.g. Heritage ranks, IUCN, CITES classifications). While quantitative data are strongly encouraged, there are no specific quantitative criteria, guidelines or thresholds. As of May 2003, 612 species had been assessed in one of the seven categories (including data deficient and not at risk) and approximately 180 species had status reports in preparation.

Table 1summarizes and compares the parameters used in each of the classification schemes outlined above, whereas Table 2 compares each of the methods according to a list of criteria. The criteria are relevant for categorizing species at risk in a forest management context. Since the USFS uses a range of sources for designating species as sensitive (including IUCN, USFWS, Heritage and tailored point-scoring schemes), rather than any single approach, the USFS is

Table 1
Comparison of protocols with respect to a set of key parameters that are commonly used as surrogates of risk of extinction

Parameters	Protocols								
	IUCN (2000)	CITES	Heritage	USFWS	Millsap et al. (1990)	Lunney et al. (1996)	PIF	COSEWIC	MER
Population size	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Population trend	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Number of populations	Yes	Yes	Yes	No	No	No	No	Yes	No
Abundance relative to other species	No	No	No	No	No	No	Yes	No	No
Reproductive potential	No	No	No	No	Yes	Yes	No	Yes	No
Population concentration	No	Yes	No	No	Yes	Yes	No	No	No
Area of occupancy	Yes	No	Yes	No	No	No	No	Yes	No
Extent of occurrence	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Range trend	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No
Extreme fluctuations	Yes	Yes	No	No	No	No	No	Yes	No
Area importance	No	No	No	No	No	No	Yes	No	No
Habitat condition	No	Yes	No	No	No	No	No	Yes	Yes
Fragmentation	Yes	Yes	No	No	No	No	No	Yes	No
Vulnerability to threats	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Current or future threat occurrence	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No
Ecological specialization	No	No	No	No	Yes	Yes	No	Yes	No
Intrinsic vulnerability	No	Yes	Yes	No	No	No	No	Yes	Yes
Number of protected occurrences	Yes	No	Yes	No	No	No	No	Yes	No
Risk of extinction	Yes	No	No	No	No	No	No	No	No
Rule-based scheme	Yes	Yes	Yes	No	No	No	No	No	No
Point-scoring scheme	No	No	Yes	No	Yes	Yes	Yes	No	Yes

Table 2
Comparison of threatened and endangered species protocols based on a number of biological and data quality criteria. L = local, state or regional scale; N = national scale, and G = global scale

System	Scale	Quantity/ accessibility of information required	Current/ future management	Future population trend	Ecological specialization	Range of taxonomic groups and life histories	Geographic distribution	Threats	Uncertainty	Repeatability	Trans-parency
IUCN 00	N/G	Low	Yes	Yes	No	High	Yes	No	Yes	High	Yes
CITES	N	Low	Yes	Yes	No	High	Yes	Yes	No	High	Yes
Heritage	L/N/G	High	Yes	Yes	Yes	High	Yes	Yes	Yes	High	Yes
USFWS	N	Low	Yes	No	No	High	No	Yes	No	Low	No
Millsap et al. 90	L	High	Yes	Yes	Yes	Medium	Yes	No	Yes	Medium	Yes
Lunney et al. 96	L	High	Yes	Yes	Yes	Medium	Yes	Yes	Yes	Medium	Yes
PIF	G	Medium	Yes	No	Yes	Low	Yes	Yes	Yes	High	Yes
COSEWIC	N	High	Yes	Yes	Yes	High	Yes	Yes	No	Low	No
MER	N	Medium	Yes	No	Yes	High	Yes	Yes	Yes	Low	Yes

excluded from both Tables 1 and 2. The criteria used in Table 2 are:

Geographic scale: what is the scale at which the protocols can be applied? Are they to be applied at a local, state or regional level (L); at a national level (N); or globally (G)?

Quantity/availability of information: how much data is required to classify a species in a category of threat? Is this information generally available for most species? Low: an assessment can be made with up to two parameter values (or pieces of information) that are generally available for most species. Medium: an assessment can be made with three to seven parameter values (or pieces of information) that are generally available for most species. High: an assessment requires more than seven parameter values.

Current/future management: are current or future management activities explicitly considered in the protocols in the form of projected impacts to population size, geographical distribution or other population-level parameters? Yes/No.

Future population trend: do the protocols incorporate future trends in population size as a result of the underlying population dynamics, impacts of threats, catastrophes or human activities, or response to other ecological processes? Yes/No.

Ecological specialization: are there parameters relating to the degree to which a taxon is dependent on environmental factors (e.g., responses to decreases in availability of preferred food types, breeding sites, or other ecological or behavioral specializations)? Yes/No.

Taxonomic range: can the protocols be applied to a range of taxonomic groups and life histories? Low: the protocols can be applied only to terrestrial vertebrates; Medium: protocols can be applied to terrestrial and aquatic vertebrates; High: protocols can be applied to terrestrial and aquatic vertebrate, invertebrate and plant species.

Geographic distribution: do the protocols include parameters related to the geographic distribution of the species, e.g. the size of the area over which the species is distributed, the total size of the area occupied by the species, and the trend in the geographic distribution? Yes/No.

Threats: are recent or future threats that result from direct or indirect impacts of human activity, or irregularly occurring catastrophes taken into account in the protocols? Yes/No.

Uncertainty: can the uncertainty associated with each of the parameters be dealt with in the protocols, either with existing methods, or by straightforward modification to the protocols? Yes/No.

Repeatability: is the classification method repeatable? Can different assessors achieve identical conservation status when ranking the same species using the same quantitative data? Is ambiguous or vague language used that can lead to vastly different interpretations of criteria? Are definitions provided for each criterion? Yes/No.

Transparency: are the definitions of the criteria clear and easy to apply to any species? Is it clear how a final assessment was achieved? Is it possible to ascertain which parameters contributed significantly to the overall assessment? Yes/No.

3. Discussion and recommendations

All of the classification systems outlined here focus on a species' risk of extirpation at some spatial scale. The scale of application among the schemes ranges from global (e.g., USFWS, 1983; Mace and Lande, 1991; Master, 1991; IUCN, 1994, 2000; Carter et al., 2000; Master et al., 2000) to national (Master, 1991; Master et al., 2000; MER, 2000; IUCN, 2003), to local or regional (USFWS 1983; Millsap et al., 1990; Lunney et al., 1996; IUCN, 2003). None of the protocols was designed specifically for application to populations, the most likely unit of management consideration for the USFS. However, IUCN recently developed a protocol for regional Red List assessments that is explicitly intended for use with populations (IUCN, 2003). Other protocols that operate at broad scales (i.e. globally or nationally) will address populations when applied at a national or regional scale if the entire range of the species is within the nation or region of application.

Seven of the methods, namely Lunney et al., MER, Heritage, USFWS, PIF, CITES, and COSEWIC explicitly address the impact of recent or potential threats. This is important for determining which species are most likely to be adversely affected by management activities. The protocols considered here have a range of data requirements. Rule-based methods, such as the IUCN protocol, generally require less data than point-scoring methods. Point-scoring methods require input for every parameter to establish an overall score. All species must have an equivalent amount of data, either empirical or subjectively assigned by an expert. This makes point-scoring methods less useful than rule-based methods for quick assessments when data are limited. Although none of the point scoring protocols incorporate explicit treatments for missing data, in principle, there are several possible approaches for accommodating missing data (e.g., set missing values to zero, use the maximum value, the median of other parameter values, etc.) (Burgman et al., 1999). Of the methods outlined here, six are point-scoring methods (Heritage, PIF, CFG, MER, Millsap et al., Lunney et al.), two are rule-based (IUCN, CITES), and two have little structure (USFWS, COSEWIC). Currently, the USFS uses a combination of methods.

There are well-known criticisms of multi-attribute point-scoring methods (e.g., Beissinger et al., 2000). Some of these are: they are regarded as ad hoc, arbitrary and often pay little attention to biological principles; the sensitivity of the ultimate rank to the weights given to individual parameters or criteria typically is unknown; e.g., it is assumed all parameters contribute equally to extinction risk; parameters are treated as if they are independent, even when there are clear correlations and dependencies; and the relationship of the aggregated score to extinction risk is unclear. Beissinger et al. (2000) recommend that, rather than aggregating scores, scores for each variable in the PIF prioritization scheme should be used to place species into a category related to conservation priority in much the same way as for the IUCN scheme. They assert that close correlation between variables is not a problem when variables are considered separately in categorizing risk because the variables represent different ways a species might be of conservation concern.

Rule-based classification schemes such as the IUCN categories are not without their own concerns. Even though they provide clear definitions for each of the categories, the true relationship between the probability of extinction and the adopted proxies is not known, but is likely to be taxon dependent. Furthermore, such schemes are usually biased towards certain taxa, see Keith (1998) and Swaay et al. (1999) for proposed amendments of the IUCN categories for application to vascular plants and butterflies, respectively), although this criticism could be made of all classification schemes, both rule-based and point-scoring. Another criticism of rule-based methods is that, while they can be applied with very little data, they do not always use all the available data, they don't necessarily distinguish among types of data, and missing data, particularly for the most sensitive parameter, can have unintended consequences (Keith et al., 2000). Hence, a species with a small population size and distribution could be assigned the same conservation status category as a species with the same distribution, but with a much larger or unknown population size. Regardless of the various criticisms of point-scoring and rule-based methods, all have merit in identifying species at risk and all are routinely used for different purposes.

All of the methods described here, except the USFWS protocol, allow for the treatment of uncertainty. For the IUCN protocol, a bounding method has been implemented which allows parameter estimates to categorized as lowest, best and highest estimates (Akçakaya et al., 2000). Fuzzy logic is then employed through the rules to give a classification within plausible bounds. This type of treatment can be applied to all rule-based methods that use quantitative and/or qualitative criteria similar to the IUCN categories. Bounding methods also can be applied to all of the point-scoring methods because they numerically grade (or score) species attributes from lowest to highest risk. Best estimates within upper and lower bounds can be given for each score, depending on the uncertainty associated with each input parameter. This type of treatment is implemented in Lunney et al. (1996) to deal with the uncertainty resulting from many expert opinions.

All of the methods described here are useful for classifying species at risk. Those that explicitly include current and future threats and a species' response to those threats are particularly useful in determining which species will be adversely affected by proposed management actions. Despite similarities among the protocols, each was designed for a different purpose. It is important to maintain consistency throughout any viability assessment process. The best method for identifying species at risk will depend on the management scenarios proposed, the amount of data available, the time frame within which the assessment must be completed, and the scale at which the assessment is to be made (Lehmkuhl et al., 2001).

Viability is defined in the regulations at a local scale. Although the approaches outlined here are useful, they are not completely sufficient for identifying species at risk on USFS land because these methods were designed for application at much larger scales. Hence, using any one method in isolation to identify at-risk species in the context of the NFMA will not appropriately address viability concerns at the requisite scale. Furthermore, existing approaches only will be useful for viability concerns if there are data to support them, and if consideration of future threats and impact of forest management practices is feasible. For these reasons, and because Heritage global ranks already exist for almost all species on USFS land, and the Heritage database is readily available to the USFS, the Heritage protocols for global and state ranks may be the most suitable of existing protocols for identifying species at risk. There are two caveats, however. First, issues of scale need to be handled appropriately. Second, while the Heritage protocol explicitly deals with the severity, scope, and imminence of threats, many species on USFS land were assigned Heritage ranks using an earlier version of the Heritage protocol which did not incorporate explicit weightings for threats. Ideally, species should be re-ranked, using the current Heritage protocol or the IUCN regional assessment protocol. To reconcile the incompatibility of the scale at which classification schemes are intended for application and the scale at which the USFS operates, we suggest using either the IUCN regional protocol or the Heritage protocol in conjunction with the USFS sensitive species lists. This will increase the likelihood that at-risk species not identified by the Heritage protocol still receive some attention. An approach that uses both Heritage ranks and sensitive species lists compiled using a variety of methods is already used by Regions 1 and 2 of the USFS. We see this as a flexible approach that makes the necessary (although not always ideal) compromise between biological justification, data needs and considerations of scale.

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