Revised Concept Paper

Alternative Approach to Addressing the Ecological Component of Sustainability in the 2001 Draft of the Forest Service Planning Rule

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Alternative Approach to Addressing the Ecological Component of Sustainability in the 2001 Draft of the Forest Service Planning Rule

EXECUTIVE SUMMARY

The USDA Forest Service is preparing a new planning rule, which will replace the 1982 and the 2000 planning rule and provide guidance for future development and revision of land and resource management plans for National Forests. A draft of a revised rule, dated September 21, 2001, was prepared and reviewed by the Research & Development (R&D) Deputy Area.

Simultaneous with the request to the R&D Executive Team to review the 2001 draft rule, the Director of the Ecosystem Management Coordination (EMC) Staff requested R&D to develop a substantially new conceptual approach to conserving biological diversity that would serve as an alternative to the approach contained in subpart §219.13 of the 2001 draft rule.

To comply with this request, R&D assembled a ‘biodiversity option development team’ composed of ten individuals from the Washington Office, five Research Stations and the International Institute of Tropical Forestry (IITF). The team worked together to produce this concept paper, exchanging information, perspectives and draft written materials by conference call and e-mail.

Précis of Proposed Conceptual Approach
The full concept paper that follows describes the proposed conceptual approach, along with the underlying scientific rationale, that directs the Responsible Official to contribute to the conservation and restoration of biological diversity through an integrated assessment of ecosystem diversity and species diversity in the land management planning process. Conservation and restoration of biological diversity requires a holistic perspective that spans multiple spatiotemporal scales and organizational levels. Consideration and evaluation of ecosystem diversity constitutes the core approach to conserving biological diversity, and is the primary focus of analysis. Consideration and evaluation of species diversity is an essential and complementary approach that serves two purposes. First, within the overall context of ecosystem diversity, evaluation of species diversity (community-level analyses) seeks to determine whether conservation of ecosystem diversity is sufficient to conserve the pool of species expected to occur naturally in the planning or assessment area. Second, evaluation of species diversity (species-level analyses) seeks to determine whether planned management actions contribute to the conservation and persistence of individual species for which there exist clearly identified legal, ecological, social or management concerns. In addition, evaluation of species diversity may support or further elaborate the ecosystem diversity approach in order to address specific issues raised during the planning process. Both ecosystem diversity and species diversity must be considered and evaluated across an array of appropriate spatial scales. Consideration and evaluation of both ecosystem diversity and species diversity must also explicitly address the role of natural and human disturbances, the present state and structure of ecosystems and landscapes, and the land use history of the planning or assessment area.

Conceptual Framework for the Proposed Conceptual Approach
The proposed approach is based on an underlying conceptual framework comprised of five individual components.

Component 1: Develop and implement an ecosystem-focused approach to consideration and evaluation of biological diversity.

Component 2: Develop and implement a species-focused approach to consideration and evaluation of biological diversity. This approach has two complementary tracks: a community analysis track that focuses on conserving the species composition (i.e., available species pool) of ecosystems, and a species analysis track that focuses on conserving individual species for which there exist clearly identified legal, ecological, social or management concerns.

Component 3: Develop and implement a spatially explicit approach to consideration and evaluation of biological diversity. This approach should consider and evaluate management impacts on biological diversity at multiple spatial scales, including at least local, landscape, and regional scales.

Component 4: Consider and evaluate impacts of disturbances, both natural and human-induced, on biological diversity at appropriate temporal and spatial scales.

Component 5: In considering and evaluating biological diversity, explicitly consider the landscape context for assessments of biological diversity.

Operational Elements of the Proposed Conceptual Approach
In the context of the underlying conceptual framework and the five components of that framework, the proposed conceptual approach to conserving and restoring biological diversity is comprised of the operational elements described below. These elements are described in detail in the full concept paper.

Operational Elements: Consideration and evaluation of biological diversity. The Responsible Official must contribute to the conservation and restoration of biological diversity in the planning or assessment area with reference to the diversity characteristic of native ecosystems within the landscape or ecoregion that contains the planning or assessment area, taking into consideration current and recent disturbance (and climatic) regimes as well as the present structure, condition and land use history of the surrounding landscape or ecoregion. The Responsible Official must give explicit attention to the special role and unique opportunities of NFS lands in maintaining and restoring unique and rare elements of ecosystem and species diversity within the planning or assessment area. The planning process should integrate multiple spatial and temporal scales and levels of ecological organization, and must be based on an integrated evaluation of ecosystem diversity and species diversity.

At the ecosystem level, two interrelated sets of characteristics or attributes define the metrics for evaluating and assessing ecosystem diversity: (1) the ecological structure, composition, processes, extent, distribution and spatial relations of ecosystems; and (2) the climate, geology, topography, hydrology, soils, disturbance regimes (both natural and human induced), and habitats of the landscape or ecoregion that contains the planning or assessment area.

At the species level, two interrelated sets of characteristics or attributes define the metrics for evaluating and assessing species diversity: (1) the overall composition and richness of the pool of species expected to occur naturally in the planning or assessment area and the surrounding landscape or ecoregion, and (2) the relative population response and long-term persistence within the planning area of select species chosen for analysis based on clearly identified legal, ecological, social and management concerns.

Assessments and evaluations of biological diversity must be conducted across a range of appropriate spatial scales. Consideration and evaluation of biological diversity must explicitly address the role of natural and human disturbances, the present state and structure of ecosystems and landscapes and the land use history of the planning area. Consideration and evaluation of biological diversity requires the Responsible Official to use information from the activities and analyses listed in the full concept paper, tailored to the particular planning or assessment area and the specific issues identified for the planning process.

Key Differences from 2001 Draft Rule

The following key features distinguish the proposed alternative from the approach contained in the 2001 draft planning rule:

- The proposed alternative emphasizes the role that landscape context plays in shaping planning decisions and evaluations of biological diversity. Landscape context can play a significant role in limiting or facilitating the land manager's options for conserving and restoring biological diversity and ecosystem functions.

- The proposed alternative focuses explicit attention on addressing spatial scale, recommends evaluations of biological diversity at multiple spatial scales, and emphasizes the importance of analyses at large spatial scales.

- This proposal clarifies relations between evaluations of biological diversity at ecosystem and species levels, and places different emphasis on evaluations at these two levels. We place primary emphasis on evaluation of ecosystem diversity as the core approach to conservation and restoration of biological diversity and ecosystem functions. Evaluations of species diversity complement the ecosystem approach, and are bounded and conducted within the context of broader ecosystem diversity analyses.

- Evaluations of species diversity are divided into two complementary tracks. Community-level analyses evaluate whether conservation of ecosystem diversity leads to conservation of the pool of species expected to occur naturally in the planning area. Species-level analyses evaluate the relative population response and long-term persistence of selected species for which there exist clearly identified legal, ecological, social or management concerns.

- The approach proposed here does not focus explicit attention on nor set a standard for population viability. We recognize that viability analyses are a potentially useful tool that can be used to inform planning and management decisions. Recognizing the limitations of such analyses, however, we do not prescribe the specific approach for viability analyses, and do not artificially bound the species for which viability analyses might be appropriate.

- The approach *does not* imply a higher level of risk for species persistence. Rather, conservation and restoration of biological diversity within the plan area is achieved through an integrated approach, including analyses of ecosystem and species diversity, spatial scale, disturbance regimes and landscape context; development of rigorous monitoring plans; and effective implementation of adaptive management based on careful consideration and analysis of monitoring results.

FULL CONCEPT PAPER

Introduction

The Task: Charge to Research & Development
The USDA Forest Service is preparing a new planning rule, which will replace the 1982 and the 2000 planning rule and provide guidance for future development and revision of land and resource management plans for National Forest System lands. A draft of a revised rule, dated September 21, 2001, was prepared and reviewed by the Research & Development (R&D) Deputy Area.

Simultaneous with the request to the R&D Executive Team to review the 2001 draft rule, the Director of the Ecosystem Management Coordination (EMC) Staff requested R&D to develop a substantially new conceptual approach to conserving biological diversity that would serve as an alternative to the approach contained in the 2001 draft rule. Specifically, R&D was asked to develop an alternative conceptual approach to that reflected in the 2001 draft rule that addresses the ecological component of sustainability as contained in subpart §219.13. This alternative approach should:

- Comply with the statutory requirement, contained in the National Forest Management Act (NFMA) of 1976, 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 and … to the degree practicable … preserve the diversity of tree species similar to that existing in the region controlled by the plan..." (Section 6(g)(3)(B));
- Be scientifically credible; and
- Be based on a concept other than the 'viability concept' as used in the 1982 and the 2000 planning rule. The 2000 rule defined the 'viability concept' as follows: "Plan decisions affecting species diversity must provide for ecological conditions that the responsible official determines provide a high likelihood that those conditions are capable of supporting over time the viability of native and desired non-native species well distributed throughout their ranges within the planning area…."

Furthermore, the conceptual approach proposed here must include a substantive standard that addresses the statutory requirements of NFMA as well as analytical standards to guide the planning process.

Biodiversity Option Development Team: Membership and Process
In order to comply with this request, R&D assembled a 'biodiversity option development team' composed of ten individuals from the Washington Office, five Research Stations and the International Institute of Tropical Forestry (IITF) (see Appendix). The team worked together to produce this concept paper, exchanging information, perspectives and draft written materials by conference call and e-mail. The team submitted a brief Interim Status Report to the Director of EMC on October 12, 2001, and a 'final concept paper' on October 19.

Several individuals not involved in development of the proposed approach or concept paper, including members of the writing team that developed the 2001 draft rule, provided independent review comments on the 'final concept paper'. This 'revised concept paper' was prepared to respond selectively to the review comments received. Should the new conceptual approach proposed here be judged worthy of further development, the intent is for both this conceptual approach and the approach contained in the 2001 draft rule to be released for public review during the upcoming public comment period planned for the 2001 draft planning rule.

Ecological Sustainability in the 2001 Draft Planning Rule

To provide context for the presentation of the conceptual approach proposed herein, we summarize the organization and elements of the 'ecological component of sustainability' (subpart §219.13(b)) as contained in the 2001 draft rule (September 21, 2000 draft).

Based on language in the 2001 draft rule, the goal of managing National Forest System (NFS) lands is to sustain in perpetuity the productivity of the land and its natural resources, thereby meeting the present and future needs of human communities. Sustainability is conceived as being composed of three interdependent elements: social, economic and ecological.

Concern for the ecological component of sustainability is focused on the diversity of plant and animal communities, and on soil, water and air resources. With specific reference to diversity concerns, the Responsible Official is directed to consider and assess both ecosystem diversity and species diversity at relevant scales of space and time. The draft rule argues that evaluation of ecosystem diversity (coarse scale filter or analysis) should provide for the maintenance (= conservation?) of most species of plants and animals. For those species or species assemblages for which this is not the case, a finer scale evaluation of species diversity will be required (fine scale filter or analysis).

The draft also notes that a land management plan cannot provide absolute assurance that biological diversity will be conserved. Rather, a plan provides an overall framework for addressing the diversity of plant and animal communities in order to meet multiple use objectives while sustaining the productivity of the land. In terms of ecosystem diversity, plan decisions should provide a framework for maintaining or restoring ecological conditions that support the diversity of plant and animal communities and other characteristics of ecosystem diversity. At the level of species diversity, plan decisions should provide a framework that will help establish ecological conditions that provide a 'high likelihood' of supporting over time the "viability of native and desired non-native vertebrates and vascular plants well distributed within their ranges in the plan area." The draft also specifies that plan decisions should provide a framework that contributes to recovery of federally listed or proposed species consistent with the Endangered Species Act of 1973, and should incorporate terms and conditions and address 'reasonable and prudent measures' as specified in biological opinions pertinent to the plan area.

The draft rule enumerates the types of ecological information and analyses to be undertaken, and the characteristics of ecosystem diversity and species diversity to be considered in these analyses. The rule notes that assessing ecosystem diversity and species diversity may require different levels of analysis commensurate with issues identified for analysis, risks to sustainability and availability of information. Among the characteristics of ecosystem diversity to be considered, the draft lists description of principal ecological processes, ecosystem structure, ecosystem composition, and soil, air and water resources. Characteristics of species diversity to be considered include numbers of species, and distribution and geographic ranges within the plan area.

Finally, the draft rule notes that evaluations of ecosystem and species diversity should be conducted at the 'scope and scale' deemed appropriate by the Responsible Official. In terms of ecosystem diversity, evaluations should focus on ecosystem composition, structure and process; and should include status of the characteristics of ecosystem diversity specified above; description of effects of human activities on ecosystem diversity; risks to ecosystem health; evaluation of air and water quality and soil productivity; and estimation of current and future water needs. Similarly, evaluations of species diversity should identify species at risk, their habitat requirements, and factors contributing to identified risk(s). Evaluations should include evaluation of risks to species viability. Such analyses may be qualitative, and may be simplified by use of species groups or surrogate species.

The treatment of 'ecological sustainability' in the 2001 draft rule is considerably streamlined as compared with the 2000 rule. Also, the 2001 draft rule does not fully consider several key issues deemed important by this 'biodiversity option development team.' Each of the following issues motivated by the 2001 draft rule was considered explicitly in developing the alternative conceptual approach proposed here:

- Clarifying relationships between evaluations of ecosystem diversity and species diversity;
- Evaluating factors beyond the control of the federal land manager that may impact ecosystem diversity and species diversity;
- Providing explicit treatment of spatial scale as it impacts the analyses and evaluations to be completed; and
- Providing explicit recognition of the impact of land use history and present landscape condition, structure and context on the range and likely outcomes of management actions available to federal land managers.

Statutory and Scientific Underpinnings of the Proposed Alternative

Since it was adopted nearly twenty years ago, implementation of the 1982 Planning Rule has produced a rich history of application and case law. In their review of fish and wildlife conservation on NFS lands, Catton and Mighetto (1998) demonstrate the importance of NFMA, the 1982 Planning Rule and the species viability concept to the conservation of individual species and overall biological diversity on public forest lands. Similarly, OGC (2000) recently completed a review and analysis of the large body of case law associated with NFMA, the 1982 Planning Rule and the species viability concept. A key element of the charge to this 'biodiversity option development team' was to avoid being constrained by specific language or elements contained in the 1982 or the 2000 planning rule, and to take a fresh look at possible novel approaches to providing for ecological aspects of sustainability. Consequently, the team did not review the extensive historical or legal record associated with NFMA and the 1982 Planning Rule. Nevertheless, the extensive bodies of historical and legal precedent, as well as the legislative history of NFMA, provide important background to development of a new conceptual approach to conserving and restoring biological diversity as part of a revised planning rule.

To provide a basis for development of the new approach, this section of the concept paper briefly reviews underlying statutory requirements contained in NFMA and related laws that provide the basis for the approach proposed, and briefly summarizes aspects of current scientific understanding of relationships between the biological diversity of ecosystems, their resilience and function, and their ability to produce in a sustainable manner the goods and services valued by human communities. These ideas underpin development of the new conceptual approach to conserving and restoring biological diversity and to the ecological component of sustainability proposed herein.

Statutory Requirements of NFMA and Related Laws

The key statutory requirements of NFMA require that management of National Forests shall 'provide for diversity of plant and animal communities' and 'to the degree practicable … preserve the diversity of tree species similar to that existing in the region controlled by the plan.'

In addition to these requirements, the Endangered Species Act (ESA) requires federal agencies such as the Forest Service 'to carry out programs for the conservation of endangered species and threatened species,' and to work to conserve 'the ecosystems upon which endangered species and threatened species depend.'

These provisions of NFMA and ESA provide the statutory basis for conserving and restoring biological diversity on public forest lands, and for proposing a conceptual approach to ecological sustainability that establishes a combined focus on ecosystem diversity and species diversity. The 2001 draft rule (subpart §219.2(b)) lists additional specific statutes to which planning and management of National Forest System lands must adhere.

Scientific Understanding of Biological Diversity-Ecosystem Function Relations

There is a long history of fundamental research in the ecological sciences on factors regulating biological diversity and its relations to the functioning and resilience of ecosystems (e.g., Risser 1995, Silver et al. 1996, Naeem 1998). In spite of this research history, we currently lack a comprehensive understanding of biological diversity and its relations to ecosystem functions (Loreau et al. 2001). We understand that relations of biological diversity to ecosystem functioning are complex and nonlinear. Ecosystem function is clearly insensitive to some range of variation in biological diversity and composition. Indeed, turnover in biological structure and composition frequently appears to represent a sort of functional redundancy that maintains ecosystem function within some identifiable operating range while allowing species adaptation to environmental change in space and time. But, we cannot yet uniquely and clearly differentiate between situations in which variation in biological composition and diversity represents this sort of function-maintaining redundancy, and those in which loss or change in biological diversity is associated with a fundamental alteration or degradation of ecosystem functions and reductions in the ability of ecosystems to provide goods and services valued by human societies. Nor do we have full understanding of the full range of functions provided by individual species, or of the many ways in which species contribute to and influence ecosystem functions and the goods and services they provide to humans.

The National Research Council recently recognized the incomplete state of scientific knowledge regarding relations between biological diversity and ecosystem function as one of eight 'grand challenges in environmental sciences' (NRC 2001). In the words of NRC: "The challenge is to understand the regulation and functional consequences of biological diversity, and to develop approaches for sustaining this diversity and the ecosystem functioning that depends on it." The NRC report argues that indiscriminant use and alteration of ecosystems and landscapes can lead to severe degradation and species extinction, threatening ecosystems and their functioning. Such losses are risky, in that humans depend critically on ecological systems at various scales for valued goods and services. Science does not yet fully understand the sensitivity of the ecosystem goods and services that humans value to changes in the diversity of species and ecosystems. According to NRC, we have 'limited appreciation' of what is at risk, of time scales over which losses occur, and of the many ecological and environmental consequences of 'simplifying and mixing the earth's biota.'

To enhance current understanding of relations between biological diversity and ecosystem functions, NRC calls for expanded research in several areas: improving tools for rapid assessment of diversity at all scales; producing a 'quantitative, process-based theory of biological diversity' across multiple scales; elucidating relationships between diversity and ecosystem functioning; and – of particular relevance to this activity – "developing and testing techniques for modifying, creating, and managing habitats that can sustain biological diversity, as well as people and their activities."

This discussion is relevant to the work of the 'biodiversity option development team,' in that development of an alternative approach to 'providing for the diversity of plant and animal communities' must acknowledge the present incomplete state of knowledge regarding factors regulating diversity and its relations to ecosystem functions. Recognizing the present state of knowledge, we propose an alternative that is based upon an integrated focus on ecosystem diversity and species diversity. Development and implementation of a planning and management framework that seeks to conserve and restore both species diversity within ecosystems, and ecosystem diversity within landscapes at various scales, will contribute to the ability of the biological components of natural and managed forest ecosystems on public lands both to adapt to changing environmental conditions in space and time, and to provide in a sustainable manner the goods and services that human societies value. [Brief note on terminology: we recognize that NFS lands contain many ecosystem types, including forest, grassland, riparian and aquatic ecosystems. Where we are making a general point about ecosystems on NFS lands, we may occasionally use the term forest ecosystem generically. In cases where it is important to distinguish the specific ecosystem type or types, relative to the features or attributes being discussed, we do so.]

Conceptual Framework and Operational Elements of the Proposed Alternative Approach

Previous sections of this paper establish the context and rationale for the proposed alternative to dealing with the ecological component of sustainability, and specifically with the diversity of plant and animal communities, in the revised planning rule. In this section we outline the conceptual framework for and operational elements of the proposed conceptual approach.

Conceptual Framework for the Proposed Approach

The intent and meaning of the diversity focus in NFMA (i.e., 'provide for the diversity of plant and animal communities') appears straightforward – the concern is to maintain biotic variety within the forest, grassland or prairie landscape at various spatial scales and organizational levels. Further, biological diversity interpreted as biotic variety is meant to be a relative concept; that is, biological diversity or variety of the land area under consideration at a given spatial scale is to be evaluated with reference to that expected for native ecosystems characteristic of the landscape or ecoregion in which it is embedded at a larger spatial scale (i.e., consideration of landscape context).

Given this intent, we outline the components of a conceptual framework for considering and evaluating biological diversity in the context of developing and revising land management plans. Specifically, we propose a conceptual approach that directs the Responsible Official to contribute to the conservation and restoration of biological diversity through an integrated assessment of ecosystem diversity and species diversity in the land management planning process. Conservation and restoration of biological diversity requires a holistic perspective that spans multiple spatiotemporal scales and organizational levels. Consideration and evaluation of ecosystem diversity constitutes the core approach to conserving biological diversity, and is the primary focus of analysis. Consideration and evaluation of species diversity is an essential and complementary approach that serves two purposes. First, within the overall context of ecosystem diversity, evaluation of species diversity (community-level analyses) seeks to determine whether conservation of ecosystem diversity is sufficient to conserve the pool of species expected to occur naturally in the planning or assessment area. Second, evaluation of species diversity (species-level analyses) seeks to determine whether planned management actions contribute to the conservation and persistence of individual species for which there exist clearly identified legal, ecological, social or management concerns. In addition, evaluation of species diversity may support or further elaborate the ecosystem diversity approach in order to address specific issues raised during the planning process. Both ecosystem diversity and species diversity must be considered and evaluated across an array of appropriate spatial scales. Consideration and evaluation of both ecosystem diversity and species diversity must also explicitly address the effects of natural and human disturbances, the present state and structure of ecosystems and landscapes, and the land use history of the planning or assessment area.

The following components collectively comprise the proposed conceptual framework:

Component 1: Develop and implement an ecosystem-focused approach to consideration and evaluation of biological diversity. Ecosystems involve the circulation, transformation and accumulation of energy and matter through the medium of living things and their functional processes (Evans 1956). Ecosystems are functional ecological units that both sustain and depend for their functioning upon biological diversity. In the abstract, ecosystems are size independent and function across the entire array of spatial and temporal scales that define the Earth's biota. We identify target ecosystems for analysis and management by specifying the spatial and temporal scales of the analysis and the relevant management issues at those scales. This identification, in turn, leads to specification of the dynamics, functions, components and attributes of ecosystems relevant to the chosen scales of analysis. While it is difficult to map the functional attributes of ecosystems, we can map their structural or physiognomic characteristics at the specified scales and the physical conditions that regulate their functions. It is also possible to identify natural and human-induced disturbances of ecosystems at comparable scales. We can also define hierarchies of ecological organization to assure consideration of *all* manifestations of biological diversity – from populations to landscapes – during the planning process. These considerations lead to an ecosystem approach to conserving and restoring the biological diversity of the planning or assessment area. Szaro et al. (1999), particularly the chapters on biological and ecological dimensions, provide information on this approach and its relations to ecosystem management.

Discussion and Analytical Approaches: Mapping conditions under which ecosystems function requires various GIS layers – at a minimum, climate and geology for broad scales; soils and topography for finer scales. Combinations of geoclimatic zones emerge at broader scales. Conditions for stands, communities, or plant associations emerge at finer scales. Watershed boundaries are required for planning exercises at the watershed level, including aquatic, riparian and wetland ecosystems. Overlapping plant communities, vegetation age classes and developmental stages allow even finer scales of analysis. Natural and human-induced disturbances, including land use history where available, are components of the analysis. Disturbances alter and influence ecosystem states, successional pathways, and species composition. Disturbances can alter the direction of succession to ecosystem states that are new and different from historical ones. Succession on these altered sites sometimes leads to new ecosystems with novel species combinations. Time is required before these new species combinations adjust to changing environmental conditions.

Science has not yet arrived at a universally accepted approach to mapping ecosystems or defining target ecological units for analysis at various scales. Disagreements are strongest at the finest scales. For example, watershed boundaries might work well for aquatic or riparian issues, but do a poor job of distinguishing breaks in vegetation. Especially at fine scales, planners will need to define units appropriate for important issues and concerns raised in the planning process. For many terrestrial issues, identification and quantification of composition (ecosystem type), vegetation age class, structure (horizontal and vertical), and successional or developmental stage, will remain the basis for evaluating elements of ecosystem diversity.

Component 2: Develop and implement a species-focused approach to consideration and evaluation of biological diversity. This approach has two complementary tracks: a community analysis track that focuses on conserving the species composition (i.e., available species pool) of ecosystems, and a species analysis track that focuses on conserving individual species for which there exist clearly identified legal, ecological, social or management concerns. Analyses focused on individual species and groups of species are important to developing a more complete understanding of the effects of proposed management actions on biological diversity. As such, analyses are conducted along two complementary tracks, one at the community level and the other at the species level. These tracks are not mutually exclusive in that species included in community-level analyses can also be the focus of species-level analyses. This two-pronged approach will increase confidence that forest plans explicitly provide for the diversity of plant and animal communities, as well as the persistence of threatened, endangered, and sensitive species (TES species), other high-profile species, species at risk and species of special management concern. Analyses of species diversity will also aid in development of rigorous monitoring plans for forest, woodland, grassland, desert, riparian or aquatic ecosystem conditions. These species-based analyses should occur at a variety of spatiotemporal scales and levels of aggregation, from local, single-species analyses to regional multispecies analyses of assemblages or communities, and various combinations in between. Community analyses can be constrained spatially, while analyses of single species can encompass broad areas. Large-scale conservation planning analyses have demonstrated that exchange of individuals among spatially isolated populations (i.e., metapopulation dynamics) is important in understanding regional and range-wide population dynamics of species that are of conservation concern (e.g., Keitt et al. 1997, Urban and Keitt 2001). Here, multispecies analyses refer to analytical approaches that address assemblages or communities while retaining the identity of component species. Community-level analyses may involve multispecies analyses (e.g., analyses of community integrity or completeness) or analyses of individual keystone or indicator species, as long as the objective of analysis is to evaluate the state of a collection of species. Following Fauth et al. (1996), we define a community to include all species occurring together at the same time and place, together with their interactions that structure the community, and use the more restrictive term, assemblage, to refer to phylogenetically related species within a community. As with ecosystem, these terms are not limited to a single spatial scale, but depend on the context in which they are used and the spatial and temporal scale of the analysis.

Discussion and Analytical Approaches. The combination of individual species and multispecies analyses enables the Forest Service to meet its principal species diversity obligations along two complementary tracks. The first track reflects concern for community diversity motivated by obligations under NFMA. Analyses developed for this concern evaluate whether planning and managing for ecosystem diversity is sufficient to maintain a mix of species ('species pool') at a given scale similar to that which would occur naturally in the planning or assessment area. These analyses may also identify individual species for which more focused analyses are justified. The second obligation derives from ESA and other legislative language that focuses on conservation of individual species, and motivates the second track. Analyses along this track seek to ensure that management activities contribute to the persistence of species of concern (i.e., conserve species as persistent, functioning members of the biota). Meeting this obligation often requires analyses that are focused on individual species, but lack of information may lead to use of more general multispecies methods. All such analyses must be conducted within a larger planning context framed by the consideration and evaluation of ecosystem diversity.

The trend towards planning at larger spatial scales has focused attention on the concept of biotic integrity and factors affecting shifts in species composition across landscapes (e.g., Karr 2000). Such analyses span the gap between single-species analyses and analyses at higher levels of organization (e.g., forest or community type), where elements are attributed such that no disaggregation is possible (e.g., a forest type such as 'mixed conifer' contains many species, but no mapping of mixed conifer forest can be used to generate individual species maps, nor would one necessarily choose to map mixed conifer forests based on a collection of species occurrences). Multispecies analyses can take many forms and serve a variety of purposes, but their main utility is to provide a rigorous means for making relative comparisons. For example, Lee et al. (1997) used presence/absence data on fishes in the Interior Columbia Basin to compare aquatic conditions in over 2,000 watersheds. Cam et al. (2000) used presence/absence data on birds in the mid-Atlantic region to calculate a measure of 'relative' species richness, where the metric compared the members of the current species assemblage with that expected under a regionally defined species pool. Explanations for spatial and temporal changes in species assemblages often focus on human-caused modification of habitat conditions, with sites harboring fewer species being interpreted as impoverished. If, however, the regional species pool from which the local community is drawn varies from place to place or over time, then a community comprised of fewer species may not necessarily be less complete.

In regards to individual species analyses, Thompson and Angelstam (1999) suggest that species should receive special attention based on their ecological role, sensitivity to change, economic importance, or utility in monitoring forest conditions. Following a similar logic, we suggest that candidate species for individual attention in the forest planning process should be based on clearly identified legal, ecological, social or management concerns. Based on the issues identified for a particular planning exercise, this would include some combination of 1) keystone species that have a disproportionate effect on other species and ecosystem dynamics, 2) indicator species that are sensitive to habitat change and might suggest shifts in species composition, 3) species at risk or of special management concern (including TES species), and 4) socially or culturally important species. The intent of the first two classes of species is primarily to use individual species to help understand impacts of resource management practices on community diversity. Species in classes 3) and 4) shift the focus to individual species and their relative abundance or continued persistence in the planning area.

The objective of species analyses should be to display potential outcomes of various management alternatives in terms of projected trends in species distribution and relative abundance, or trends in community composition and distribution. The method used depends on which of the four classes listed above best describes the species, their role in the overall planning process, and the availability of information. Uncertainty should be addressed explicitly. In examining keystone species, for example, the focus of analysis should be on dynamic interactions of the species of interest with the larger ecosystem, including other species. The concept of keystone species invokes the notion that removal of that species from the system would result in a significant change in ecosystem composition and function (Power et al. 1996). In contrast, indicator species should be selected based on empirical information that validates the strength of their association with the environmental conditions or the status and trends of the species they are intended to represent (Landres et al. 1988). Indicator species are an attractive component of monitoring, but must be accompanied by realistic expectations. Both the keystone species and indicator species concepts have received mixed reviews in the literature, suggesting that these concepts must be applied judiciously (Landres et al. 1988, Simberloff 1998). In regards to TES and socially important species, the scientific and gray literature provides extensive direction on how to conduct single-species analyses, and the pitfalls therein, which can provide a range of information useful to the planning decision-making process (e.g., Holthausen et al. 2001, Forest Service 2001, and references contained in each).

Component 3: Develop and implement a spatially explicit approach to consideration and evaluation of biological diversity. This approach should consider and evaluate management impacts on biological diversity at multiple spatial scales, including at least local, landscape, and regional scales[1]. A spatially explicit approach to biological diversity includes consideration of factors such as the abundance, extent, patch size, condition, and distribution of forest, aquatic, riparian, and grassland ecosystems. It focuses on lines and patches – age classes, stream networks, plant communities, populations, land use classes, habitats, road density classes, and other features, as well as their sizes, shapes, and spatial relationships. It includes analysis within the planning area itself and consideration of ways in which the planning area contributes to biological diversity at scales that transcend the boundaries of the planning area (see Component 5). Current theory refutes the notion that diversity at large scales is maintained or increased when diversity is maximized at local scales, so that interpretation of data on spatial pattern will require recognition of important contributions made by rare or unique spatial elements.

Discussion and Analytical Approaches: Many spatial concerns involve analyses of forest fragmentation, element size or extent, and spatial linkages and relations. These are areas of current work in the ecosystem sciences, and implementation should recognize the limitations of currently available data and analysis tools, which may vary by region. Plans must contain explicit statements of tools used, assumptions made, and uncertainty associated with analyses. Measures should include the distributions of patch sizes, shapes and linkages among patches. As

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[1] In this document, the local scale refers to the planning area or the National Forest, landscape scale refers to the subsection or section level of the ecological hierarchy, and regional refers to the level of the most appropriate large-scale assessment if available or an area of equivalent size if not. Regional may also refer to the ecoregion in which the planning or assessment area is embedded.

science supports interpretation of the degree of aggregation, dispersion, interspersion, juxtaposition, and linkages for ecosystem types and age classes at multiple scales, these should also be assessed. Within the limitations of available data and knowledge, populations and distributions of threatened, endangered, rare and sensitive species, and communities, age classes, or developmental stages that are rare, ecologically important or at risk, should be identified. Data to make these assessments at a local scale will typically be stronger than data available for larger scales of landscapes and ecoregions.

Science consistency reviews will ensure that available tools are used. Thoughtful, well-designed monitoring plans should be designed to test the validity of assumed relationships and projections and adapt management to changing science and unexpected outcomes.

Special attention should be given to analyses at large spatial scales, even scales that transcend the planning area of individual NFS administrative units or Regions. Some pertinent evaluations of biological diversity, such as for widely ranging avian or mammalian species or for cumulative impacts on biological diversity, may commonly play out at these larger scales, requiring cooperation in planning across NFS units or even Regions.

Component 4: Consider and evaluate impacts of disturbances, both natural and human-induced, on biological diversity at appropriate temporal and spatial scales. Land management plans do not alter the climate, topography or geology that produce the fundamental environmental gradients underlying the distribution of species and communities in areas covered by the plan. Plans do influence disturbance regimes within the planning area, as well as the vulnerability of ecosystems and species to future disturbances. Disturbances occur at various spatial and temporal scales, altering ecosystem structure and influencing species relative abundance and distribution. Plans provide for specific human disturbances (i.e., management actions), but must also anticipate other human disturbances, particularly those on adjacent non-federal lands, as well as natural disturbances. In the context of a land management plan, management actions may alter the impacts of natural disturbance regimes, and in some cases, plan decisions can be viewed as decisions to let 'natural' disturbance predominate in specified areas. Taking all disturbances into consideration, the plan can be conceived of as the shifting mosaic of conditions created by the disturbances across the area covered by the plan and across the planning time horizon.

Discussion and Analytical Approaches. This focus on disturbance regimes, natural and human, helps clarify the manager's decision space. The challenge becomes one of designing a plan in which the disturbances contemplated in the plan, individually and collectively, in terms of their spatial distribution and extent, their temporal distribution and their type and intensity, provide for the diversity of plant and animal communities in the area covered by the plan. Specific planned disturbances, such as silvicultural activities, must be identified. The knowledge base associated with these disturbances typically allows projections of temporal change. Other disturbances are more problematic with respect to predictability, but still should be identified and modeling approaches developed as a basis for projecting future change.

Component 5: In considering and evaluating biological diversity, explicitly consider the landscape context for assessments of biological diversity. This component is necessary to meet the intent of Congress for evaluating biological diversity as a relative measure. Considering landscape context implies several interrelated things simultaneously. First, it implies giving explicit attention to the current state, structure and land use history of the landscape containing the planning area. Such factors represent a human legacy on the landscape that affects the land manager's options for conserving or restoring biological diversity and ecosystem functions. Second, landscape context requires that explicit consideration be given to differences in the condition or relative state of the forest, grassland, riparian and aquatic ecosystems, between NFS lands and other ownerships. Identification of such differences may reveal unique opportunities for conserving or restoring certain levels or types of biological diversity on federal lands, as well as factors that may limit a land manager's future options in managing NFS lands to achieve biological diversity objectives.

Discussion and Analytical Approaches: The consideration of landscape context involves addressing the following questions. 1) How do the amount, condition, and distribution of forest, grassland, aquatic and riparian ecosystems on NFS lands compare to those on nearby lands? 2) What are the implications of differences in the composition of forest and other ecosystems to that for other lands in terms of biotic variety? 3) What are the landscape and regional dynamics (gains and losses) for these ecosystems over the last several decades? 4) What do these regional trends suggest for managing forest, grassland, aquatic and riparian ecosystems on NFS lands? 5) What unique opportunities exist on NFS lands to increase regional ecosystem diversity? 6) What elements of biological diversity are most at risk in forest, grassland, aquatic and riparian ecosystems at the regional scale?

Numerous sources provide contextual information. They include Forest Inventory and Analysis (FIA) databases and various regional assessments (e.g., Southern Appalachian Assessment, Great Lakes Assessment), as well as information gathered as part of the Resource Planning Act (RPA). It is important to note that as part of land management planning, the actual measurement of biological diversity will typically remain within the boundaries of NFS administrative units or planning areas, and existing information will be used for developing the ecological (and for that matter, the social and economic) context for local management.

Operational Elements of the Proposed Alternative

In the context of the conceptual framework elaborated above, and the five components of that framework, we describe here the operational elements of the proposed approach to conserving biological diversity within the planning or assessment area. These operational elements specify the standards that guide the planning process, the characteristics or attributes of ecosystems and species to be considered and evaluated in the planning process, and the analyses and related activities to be completed.

Operational Elements: Consideration and evaluation of biological diversity. The Responsible Official must contribute to the conservation and restoration of biological diversity in the planning or assessment area with reference to the diversity characteristic of native ecosystems within the landscape or ecoregion that contains the planning or assessment area, taking into consideration current and recent disturbance (and climatic) regimes as well as the present structure, condition and land use history of the surrounding landscape or ecoregion. The Responsible Official must give explicit attention to the special role and unique opportunities of NFS lands in maintaining and restoring unique and rare elements of ecosystem and species diversity within the planning or assessment area. The planning process should integrate multiple spatial and temporal scales and levels of ecological organization, and should be based on an integrated evaluation of ecosystem diversity and species diversity.

At the ecosystem level, two interrelated sets of characteristics or attributes define the metrics for evaluating and assessing ecosystem diversity: (1) the ecological structure, composition, processes, extent, distribution and spatial relations of ecosystems; and (2) the climate, geology, topography, hydrology, soils, disturbance regimes (both natural and human induced), and habitats of the landscape or ecoregion that contains the planning or assessment area.

At the species level, two interrelated sets of characteristics or attributes define the metrics for evaluating and assessing species diversity: (1) the overall composition and richness of the pool of species expected to occur naturally in the planning or assessment area and the surrounding landscape or ecoregion, and (2) the relative population response and long-term persistence within the planning area of select species chosen for analysis based on clearly identified legal, ecological, social and management concerns.

Assessments and evaluations of biological diversity must be conducted across a range of appropriate spatial scales. Consideration and evaluation of biological diversity must explicitly address the role of natural and human disturbances, the present state and structure of ecosystems and landscapes and the land use history of the planning area. Consideration and evaluation of biological diversity requires the Responsible Official to use information from the following activities and analyses, tailored to the particular planning area and the specific issues identified for the planning process:

- Define and identify the variety of ecosystem types, their relative abundance or extent, and their spatial distribution and arrangement including distribution of patch sizes and linkages, based on a hierarchical ecological classification. Characterize the ecological structure, composition and processes of these ecosystems. Include terrestrial, aquatic and riparian ecosystems within the planning or assessment area, at appropriate spatial scales.
- Define and identify the distribution of ecosystem types, the distribution of vegetation age classes, and the distribution of developmental (or successional) stages and unique structural elements, within the planning area.
- Characterize to the extent possible the land use history and natural disturbance regimes (type, spatial scale, periodicity, and intensity) of the planning area and surrounding landscape.
- Characterize the quality and condition of soil, water and air resources, including the health and condition of stream networks and channels and of watersheds.

- Identify species (or other appropriate taxonomic groupings) found within the planning area and surrounding landscape or ecoregion, including both native and non-native species. Compile information on species status, spatial distribution, relative abundance and population trends, where feasible.
- Identify unique areas, including rare ecosystem types or vegetation age classes, habitats, developmental stages, structural elements and ecosystems at risk.
- Identify a subset of species for analysis that includes keystone species, indicator species, species at risk including TES species, and socially and culturally important species. These species should be selected judiciously based on clearly identified legal, ecological, social and management concerns, or where analyses address specific issues identified during the planning process. Match species with appropriate and available data and analytical methods.
- Identify ecosystem components, such as species, hydrologic processes, or age classes at risk, the specific or general threats to these components, and special measures required for their conservation. Pay special attention to the unique role and special opportunities of NFS lands to contribute to the conservation and recovery of these components, including species at risk or of special management concern. Evaluate terms and conditions and address reasonable and prudent measures specified in biological opinions pertinent to the planning area.
- Using multispecies methods, analyze the composition and distribution of communities and species assemblages across the planning area and ecoregion. Relate community or assemblage metrics to biophysical conditions, with particular attention to attributes affected by management actions.
- Identify linkages between ecosystem diversity and species diversity. Evaluate the importance of keystone species and the utility of indicator species. Examine linkages between ecosystem diversity and species at risk or of special management concern.
- Project the spatial and temporal distribution of disturbances implicit in management alternatives, including management actions and other natural and human-induced disturbances.
- Describe impacts of management alternatives and other natural and human disturbances on ecosystems, communities and select species in the plan area, and project future conditions created by these alternatives and disturbances. Compare projected conditions with current and desired future conditions. Include estimates of uncertainty in all projections, and identify sources of uncertainty.
- Evaluate impacts of proposed management activities on the long-term productivity of the land, including long-term soil productivity.
- Monitor ecosystem components and states, and ecological conditions that sustain them.

Ecological classification plays a key role in this approach; its implementation is critically dependent upon definition of a series of reference distributions: (1) distributions of ecosystem types (amount and areal extent), (2) distributions of spatial arrangement for each ecosystem type (patch size, shape, dispersion, etc.), and (3) distributions of disturbance regimes (types of disturbance, frequency, severity, spatial extent, timing). Conservation strategies for habitats that sustain communities, species and populations are included in the analysis because an ecosystem approach considers the full hierarchy of biological and ecological complexity. The hierarchy of ecological complexity is also useful for guiding monitoring activities. The various ecological components that constitute biological diversity are the focus of monitoring activities.

Additional thoughts on plan analyses. The bulleted items above enumerate and describe the analyses to be conducted as part of the planning process. The specific analyses employed during any specific planning exercise should be specifically tailored to the particular planning area and the scope and scale of the issues identified for the planning process. If the new conceptual approach proposed here is developed further, specific guidance will need to be developed on appropriate methods and techniques, as has been done for the current alternative in the 2001 draft rule. Several existing white papers provide relevant information that can be modified and further developed to meet this need (e.g., Forest Service 2001, Holthausen et al. 2001). Although originally developed to provide detailed guidance for implementation of the 2000 planning rule, these papers provide information pertinent to the analyses listed above. Aber et al. (2000) and Hunter (1999) provide a wealth of information pertinent to conserving and restoring biological diversity and ecosystem functions on NFS lands in the U.S.

Additional thoughts on scales of analysis. Central to the conceptual approach proposed here is the need to address explicitly spatial scale, and the requirement to complete evaluations of both ecosystem diversity and species diversity at multiple spatial scales, tailored to the ecological structure of the planning or assessment area and the surrounding landscape or ecoregion, and to the specific issues identified for analysis in the planning process. No universal set of scales will work for all forest planning processes, and different scales will be required for different analyses conducted during development of any single land management plan. In some cases the relevant scales will be defined by classification approaches applied to the terrestrial landscape. In many cases, and particularly for analyses of watershed health, hydrology, and aquatic and riparian ecosystems, scales may be defined with reference to watersheds defined at different geographic scales (e.g., 8-digit HUC codes). The specific suite of scales examined in any given plan must be selected based on the specific issues identified during the planning process and the ecological structure of the planning or assessment area and the surrounding landscape or ecoregion. Special attention should be placed on analyses at large spatial scales, larger than the scale of the planning area. It is at such scales that cumulative impacts should be evaluated, that the dynamics of wide-ranging vertebrate species and vegetation processes play out, and that impacts of management actions within the planning area influence the structure and components of the surrounding landscape or ecoregion. Consideration of such scales will often require collaborative planning processes that span the boundaries of one or more NFS units or Regions.

Summary of Key Differences from 2001 Draft Rule

Although broad similarities exist between the proposed conceptual approach and the approach contained in the ecological sustainability subpart of the 2001 draft planning rule, there are also clear differences. Among the most significant attributes that distinguish the proposed approach from the original are the following:

- The proposed alternative emphasizes the role that landscape context plays in shaping planning decisions and evaluations of biological diversity. Landscape context includes differences in the present state and structure of ecosystems and landscapes on NFS lands as compared with surrounding lands, as well as the land use history of the planning area. Landscape context can play a significant role in limiting or facilitating the land manager's options for conserving and restoring biological diversity and ecosystem functions.

- The proposed alternative focuses explicit attention on addressing spatial scale, recommends evaluations of biological diversity at multiple spatial scales as appropriate, and emphasizes the importance of large spatial scales, which may require collaborative planning actions that span the boundaries of several NFS units or Regions.

- Both the conceptual approach proposed herein and the 2001 draft require consideration and evaluation of biological diversity through integrated evaluations and analyses of ecosystem diversity and species diversity. In the present 2001 draft rule, the relations between the two are not clear. This proposal clarifies relations between these evaluations, and places different emphasis on evaluations at ecosystem and species levels. We place primary emphasis on evaluation of ecosystem diversity as the core approach to conservation and restoration of biological diversity and ecosystem functions. Evaluations of species diversity complement the ecosystem approach, with two interrelated tracks, community-level analyses and species-level analyses. Analyses of species diversity are bounded and conducted within the context of broader ecosystem diversity analyses.

- Evaluations of species diversity are divided into two complementary tracks, with different purposes. Community-level analyses evaluate whether conservation of ecosystem diversity leads to conservation of the pool of species, and hence overall species composition, expected to occur naturally in the planning area. Multispecies analyses and individual species analyses both fall under the community-level track so long as the objective of the analysis is to assess the state of a collection of species in the plan area. Species-level analyses evaluate the relative population response (e.g., increasing, decreasing, no change, in danger of local extirpation) and long-term persistence of selected species for which there exist clearly identified legal, ecological, social or management concerns. Analyses under both tracks may support and further elaborate the ecosystem approach to address specific issues raised in the planning process.

- In contrast to earlier planning rule direction, the approach proposed here does not focus explicit attention on nor set a standard for population viability. Viability is clearly related to the concept of species persistence. Viability analyses may be required or appropriate for some species, and represent a legitimate analytical approach for species thought to be vulnerable to extinction, globally or from the expected species pool in the planning area. Where such concerns exist for select species, they should be addressed directly in the planning process. Thus, we recognize that viability analyses, or other similar analyses, are a potentially useful tool that can be used to inform planning and management decisions. Recognizing the limitations of such analyses, however, we do not prescribe the specific approach or endpoint for viability analyses. Rather, we advocate a flexible approach shaped by the issues identified in the planning process and by the present state of conservation biology theory and practice. We also do not artificially bound the species for which viability analyses might be required. Species other than vertebrates and vascular plants might be selected for individual species analysis based on the identified planning issues and specific legal, ecological, social and management concerns identified during the planning process. All species-level analyses are conducted within the broader context of the ecosystem approach to the conservation and restoration of biological diversity.

- Finally, in advocating the new approach described herein, we do not suggest abdicating the agency's fundamental responsibilities for conserving species. Loss of native species from a significant portion of their range is not consistent with the intended outcome or standard of 'conservation and restoration of biological diversity in the planning or assessment area.' However, we do not view species viability per se as the ultimate target of analysis or as the primary criterion upon which the planning decision hinges. Moreover, lack of an explicit viability standard does not necessarily imply a higher degree of risk for loss of species from the planning or assessment area. Indeed, viability analyses in a planning context have often led to a false sense of security for conserving species, or have pushed ecosystems outside their 'normal operating ranges,' creating unsustainable conditions and causing problems for non-target species that depend on other sets of ecological conditions for their persistence. It is our contention that the comprehensive planning process described herein, based upon integrated analyses of ecosystem and species diversity, disturbance regimes, spatial scales, and landscape context, provides a more robust basis for conserving and restoring biological diversity than the approach reflected in the 2001 draft rule. To be successful in achieving the desired outcome, the proposed planning process must be combined with effective implementation of adaptive management – development and implementation of rigorous monitoring plans, thorough analysis and evaluation of monitoring results, and modification of management practices and standards based on comparison of current ecological conditions with desired conditions.

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APPENDIX

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