Protocol for Developing Terrestrial Ecosystem Current Landscape Condition Assessments

for the

Rocky Mountain Region of the USDA Forest Service

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Preface

The Species Conservation Project is a strategic effort by the Rocky Mountain Region of the USDA Forest Service to provide rigorous scientific tools that support ecological conservation on the National Forests and Grasslands. Such tools will allow us to create management programs that are explicitly designed to enhance the viability of at-risk plant and animal species and the integrity of ecosystems.

The Species Conservation Project is conducting *species assessments* of about 300 at-risk plants and animals and *ecosystem assessments* of multi-scaled ecological units. Ecosystem assessments are being done for both terrestrial and aquatic-riparian-wetland systems. Synthesis models will blend the results of both types of assessments to support the analysis of ecological tradeoffs and the development of conservation options.

Terrestrial ecosystem assessments define historic and current patterns of vegetation communities and landscapes, effects of natural and human disturbances, and ecological risks and restoration options. Terrestrial ecosystem assessments have two parts: historic range of variation assessments and current landscape condition assessments. Leading ecologists are writing *Historic Range of Variation Assessments* for 10 large ecological subregions and 4 key ecosystem types in the Region. Forest Service specialists are conducting the *Current Landscape Condition Assessments* on a few large ecological subregions per year.

This protocol describes how to conduct a Current Landscape Condition Assessment. It comprises four principal parts (in addition to several appendices):

- Chapter 1 is the introduction, which covers concepts, the regional approach, components, and goals.

- Chapter 2 describes the general information on the assessment approach including the conceptual background for the ecological drivers, the importance of landscape ecology, and the scale terminology and concepts.

- Chapter 3 explains the content of the assessment through seven modules, and describes how to assess specific ecological factors, define the data sources and analytical methods, the relevance to management applications, and a synthesis.

- Chapter 4 defines the implementing criteria to address cooperator selection, interagency involvement, data management, publication, and timelines.

This protocol and the assessments are intended to be living documents. They will be updated as additional experience is gained and as new knowledge arises. Eventually, the protocol will be peer reviewed and published. However, this current version is a working draft that will be updated and improved through the SCP Change Management Process.

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Chapter 1
Introduction

Terrestrial ecosystem assessments are one of several elements of the Rocky Mountain Region's Species Conservation Project (SCP). The project was initiated by the Regional Leadership Team, and chartered in January 2001, as a Region-wide coordinated approach to significantly improve the effectiveness of agency management of species, particularly species facing risks to viability, and to enhance management for ecological integrity and sustainability. The SCP focus is on developing and implementing approaches to improve the integration of species and ecosystem management in forest planning at multiple temporal and spatial scales as demanded by the National Forest Management Act (NFMA) and associated regulations. Approaches bring together several concepts developed over the past two decades within the context of ecosystem management science (Christensen et al. 1996; Grumbine 1997), conservation biology (Hunter 1991; Murphy and Noon 1991; Meffe and Carroll 1997; Scott and Csuti 1997), and recent efforts at improved implementation of the NFMA (Tongass National Forest Land and Resource Management Plan 1997; Northwest Forest Plan 1997; Sierra Nevada Forest Plan 2001). With this foundation in the current science of ecosystem management and conservation biology, the SCP reflects the ideas described in recent agency guidance (Holthausen et al. date; Undersecretary of Agriculture 2001; Deputy Chief USFS 2002; Liggett et al. 2003).

Elements of the SCP for Region 2 include identification of emphasis species, ecological assessments, species assessments, integration of the assessments, and interface with land management planning. These elements are linked in a framework that will be flexible, adaptive (Walters 1986), consistent, and comprehensive throughout Region 2 (Fig. 1.1). Through the SCP, Region 2 will increase efficiency, reduce redundancy, and address species and ecosystem management at appropriate spatial and temporal scales. Assessment products will provide a compilation, synthesis, and interpretation of current scientific information on species and ecosystems and will convert synthesized knowledge into a form that is useful to resource specialists and decision-makers.

By synthesizing information on how physical and biological features of the environment, natural disturbances, and human actions influence ecosystem processes, structure and composition, terrestrial ecosystem assessments form a critical foundation for the SCP. Scientists and resource managers recognize that management designed to sustain system function and processes over appropriate temporal and spatial scales, while meeting multiple resource objectives, must play an important role in land management. These ecosystem assessments will help biologists, ecologists, rangeland and forest managers, and planners understand the ecology of the dominant ecosystem types and will describe the current condition of the ecosystems. These assessments will provide an understanding of ecosystem dynamics and ecological context, critical elements in implementing ecosystem management (Grumbine 1997), in managing for species persistence (Groves et al. 2002), and in managing for sustainable resource conditions (Dale et al. 2000; Aber et al. 2000). Hierarchy theory highlights the importance of understanding the contextual framework that broad-scale processes and patterns establish for fine scale elements (Allen and Hoekstra 1992; King 1997; Urban et al.).

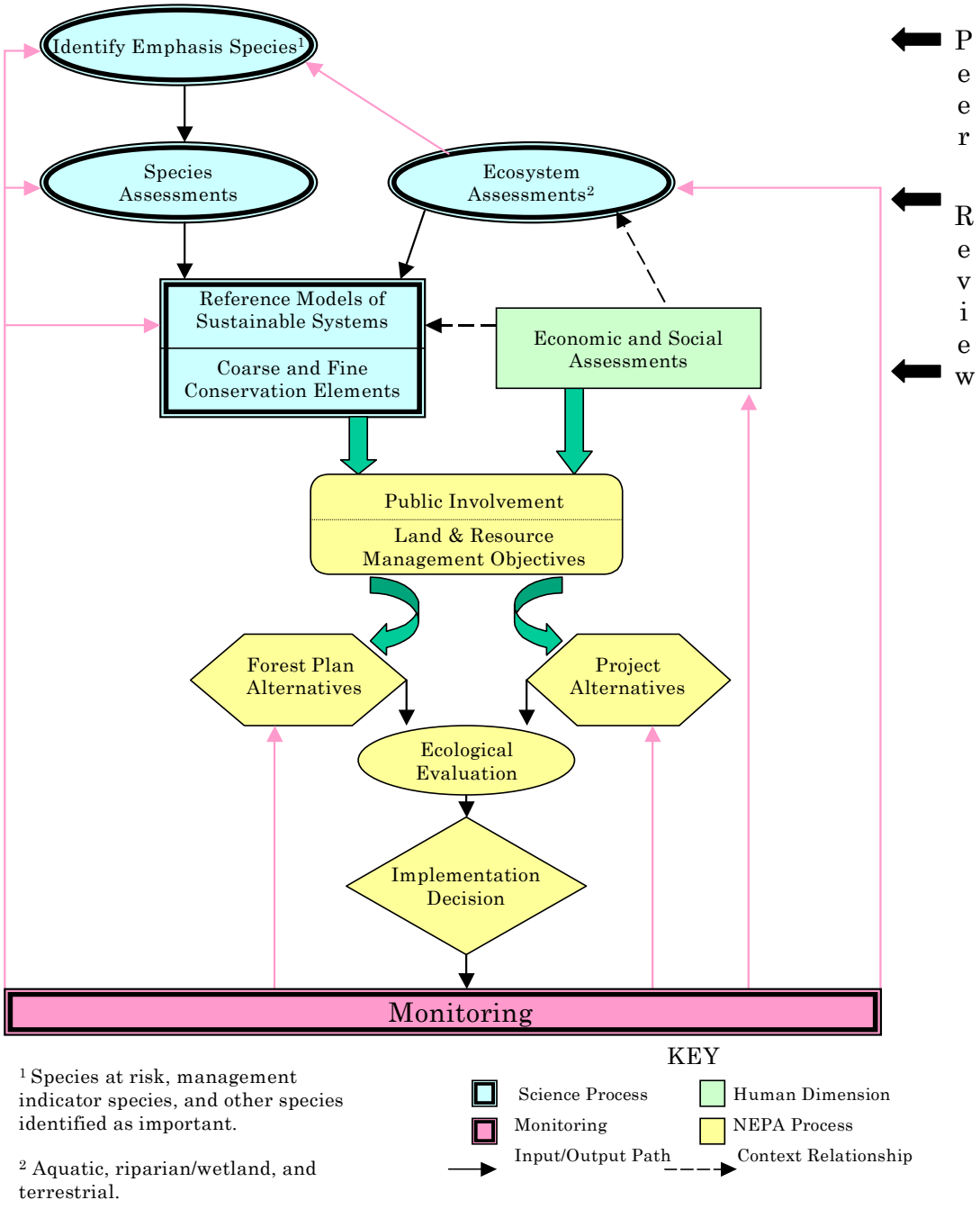

Figure 1.1. Conceptual model for the Species Conservation Project.

Both the synthesis of science and the understanding of current ecological conditions that together make up the terrestrial ecological assessments will offer the Forest Service and associated partners the opportunity to significantly improve land stewardship in the Rocky Mountain Region. Application of information from the assessments provides a scientific foundation for forest planning and project planning. However, productive use of the products goes far beyond these basic planning processes. Examples of how the terrestrial ecological assessments can be used include the following:

(1) Training and orientation of new (or transfer) employees regarding the ecology of terrestrial systems on National Forests and neighboring lands.

(2) Provide a common understanding of terrestrial vegetation dynamics and conditions for the education of the public and agency partners regarding ecological disturbances, ecological change, and current ecologic conditions.

(3) Provide the scientific basis for discussions with political officials regarding fire, insect, and disease processes in the Region.

(4) Provide the scientific basis to increase effectiveness and efficiency in development and application of the Accelerated Watershed Restoration Program (AWRP) by:

a. Improving classification of fire risk.
b. Improving prioritization of projects.
c. Clarifying an understanding of native disturbance processes and therefore increases understanding of the ecological constraints to meeting desired conditions.
d. Increasing public understanding of the historical patterns of forest vegetation and historic disturbance patterns in the Region.

(5) Provide a strong scientific foundation for Forest Planning by improving understanding of terrestrial systems at several stages in Forest planning, including:

Analysis of Management Situation: Terrestrial assessments provide a strong foundation for identifying restoration issues, determining the direction of forest change, and understanding the capability of the forest to produce desired resources.

G*oals and Objectives*: Terrestrial assessments aid in evaluating the efficacy of goals and objectives and aid in identifying unrealistic goals that are beyond the capability of the ecological system.

Forestwide Standards: Terrestrial assessments provide an understanding of ecological norms and variation in ecological conditions to improve framing of standards for ecological condition.

Alternatives: Terrestrial assessments aid in development of alternatives by establishing a sound basis for predicting the capability of the land.

Management Area Direction: Terrestrial assessments provide an understanding of current conditions and potential future change, which is critical to establishing direction for particular land areas.

EIS Affected Environment and Environmental Consequences: Terrestrial assessments are critical for evaluating the scientific foundation for the assumptions made in designing the selected alternative and for predicting effects of management actions on the terrestrial vegetation.

Monitoring: Terrestrial assessments aid in identifying those ecological characteristics that should be expected to change as a consequence of management and in identifying those that will be important to monitor.

(6) Provide a scientific foundation for project planning similar to that outlined above for Forest Planning but also:
   a. Provide understanding to facilitate identification of priority restoration opportunities.
   b. Aid in identifying projects that attempt to change ecological systems in directions that are counter to ecological development and therefore will require extra-continued management.

Terrestrial Ecosystem Assessment Components

Several ecosystem assessments written to support land use and resource management planning throughout North America were examined to identify relevant ecosystem components, data sources, and approaches in our effort (Sierra Nevada Forest Plan 2001; Interior Columbia Basin Ecosystem Management Project 1997; SAMAB 1996). As a result of the recognition of the need for ecosystem assessments to improve land management planning, recent literature has addressed assessment topics and methods (Jensen and Bourgeron 2001; Johnson et al. 1999). This information served as an important reference in framing the approach for the terrestrial ecosystem assessments in Region 2. As a result of a review of the agency assessment documents, the recent assessment literature, and the input of team members representing a variety of resource specialists, we identified the followng broad questions to be addressed by the terrestrial ecosystem assessments:

- What aspects of the social and economic environment are important in interpreting the current and future ecological condition?
- What are the physical, biological, and ecological characteristics of the current environment?
- What are the natural disturbance regimes and ecosystem dynamics of these systems?
- How have Euro-American settlement land use practices and management activities affected these systems?
- What are the limits in application and interpretation of the assessments?
- What are the major information gaps revealed by the assessments?
- What are the essential characteristics of a practical implementable inventory and monitoring system designed to detect changes in system conditions relevant to species conservation concerns?

These broad questions are addressed in the two major parts of the terrestrial ecosystem assessments: the *Historic Range of Variation Assessments* (HRV) and the *Current Landscape Condition Assessments* (CLC). The Historic Range of Variation Assessments provide background on system function with a focus on the insights historical ecology can provide on dominant disturbance agents and the influence these agents have on pattern and process. They help us understand the dominant processes influencing ecosystem dynamics, the resulting expected ranges in ecosystem condition, and the biophysical capabilities of systems (Swanson et al. 1993; Morgan et al. 1994; Holling and Meffe 1996; Landres et al. 1999; Swetnam et al. 1999). Current Landscape Condition Assessments describe the current status, probable trajectories, and integrity or sustainability concerns of ecological areas or systems of interest. The HRV Assessments contribute to the CLC Assessments by providing a basis for understanding the degree of departure in ecosystem composition, structure, and function from the ranges expected under historic disturbances regimes to the current condition which is influenced by alteration of disturbance regimes and land use practices since Euro-American settlement. This two-part approach of developing an understanding of ecological context is well grounded in the current ecosystem management and conservation biology literature (Christensen et al. 1996; Grumbine 1997; Aber et al. 2000; Dale et al. 2000; Groves et al. 2002).

Historic Range of Variation Assessments

The Species Conservation Project (SCP) is developing an understanding of the state of ecological systems in the Rocky Mountain

Region. With the current understanding of that systems are non-equilibrium or in dynamic equilibrium (Pickett et al., 1992; Fiedler et al. 1997), characterization of the ecological system to inform management cannot just present a static picture. It is important to understand the processes that create the observed patterns as well as spatial and temporal scales at which processes operate. Two major premises of ecosystem ecology characterize the SCP: 1) sustainable resource conditions can only be achieved within the constraints of ecosystem dynamics (Dale et al. 2000; Aber et al. 2000), and 2) the key to describing ecological context in a simplified but meaningful way is to focus on the dominant processes that structure the ecosystem and to describe the relationship between these processes and the selected species (Risser 1995) or ecosystem attributes (Holling 1992; Urban et al.). We are accomplishing the understanding of the expected variation in terrestrial ecosystem dynamics, pattern, and process through the Historic Range of Variation Assessments.

Most or all of our Rocky Mountain and Great Plains ecosystems are maintained by substantial variability in the frequency, intensity, and spatial pattern of major disturbance processes. The ecological insights developed from historical ecology (Swetnam et al. 1999) play an important role in understanding variability. Historical reconstruction of past ecological structure and disturbance regimes (e.g., assessment of historical range of variation) provides information about what is possible within the context of certain locations and times, and places current landscape conditions into this context (Swetnam et al. 1999). This knowledge provides insights into the potential causes of change and the ecological pathways that brought ecosystems to their current condition. Historical analysis can also suggest whether current conditions are anomalous and provide an understanding of the frequency, intensity, and interaction among dominant disturbance processes that influence the ecosystems we manage. Specifically, Historic Range of Variation (HRV) Assessments are important in providing a reference for evaluating the magnitude and significance of the changes in ecosystems that have resulted from 20th century fire exclusion, other alterations in disturbance regimes, and post-Euro-American settlement resource use. Besides providing the foundation for developing the ecological context and understanding of ecosystem function, the HRV Assessments will help us to identify the most urgent priorities for restoration and other treatments.

The SCP is producing HRV Assessments that are focused on questions relevant to the terrestrial vegetation for ten large geographic areas that roughly reflect eco-subregions (Fig. 1.2). In addition, we envision four additional HRV Assessments that are region-wide in extent but focus on particular ecosystems that will be most effectively examined at a Region-wide scale (e.g., riparian and wetland ecosystems, aspen forests, shrublands and grasslands, and alpine ecosystems) (Table 1.1). The HRV Assessments focus on expected ecosystem structure and function under historic disturbance regimes and is primarily developed by synthesizing information that exists in the peer-reviewed literature or that is readily available in unpublished data or reports. They generally address questions on 1) spatial and temporal variation in disturbance regimes, 2) Spatial variation in human alteration of disturbance regimes, 3) effects of disturbance interactions on vegetation responses as well as the occurrence and spread of subsequent disturbances, and 4) the influence of climatic variability on disturbance regimes and vegetation response to disturbance.

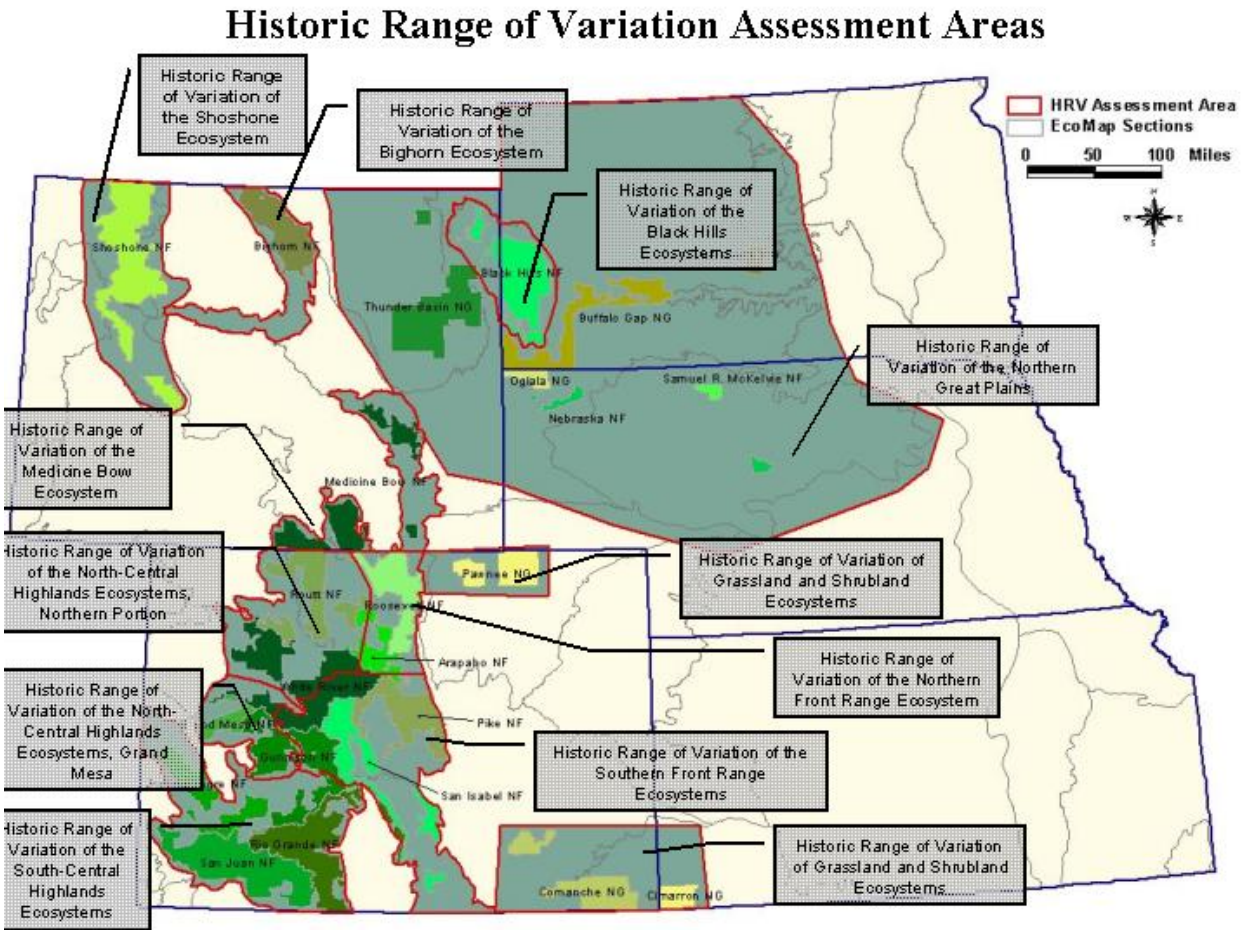

Figure 1.2. Map of the Historic Range of Variation Assessment Areas in Region 2.

Due to the complexity and difficulty in developing the historic range of variation information, and because the assessments require a comprehensive synthesis and interpretation of current knowledge, we are collaborating with leading university or agency researchers in developing the assessments. Our goal is to develop scientific documents of the highest quality and rigor. The products are peer reviewed through a process managed by the Ecological Society of America and resulting publications will appear in their entirety as Forest Service research General Technical Reports (GTR). These GTR will summarize a diverse array of literature and other information into accessible documents that will emphasize information critical to managers and policy makers.

Table 1.1. Historic Range of Variation Assessments being produced for the Rocky Mountain Region's Species Conservation Project.

Title	Principal Investigator	Forests
Historic Range of Variation of the Medicine Bow Ecosystem	Dr. Dennis Knight	MBNF (ARNF, Routt NF)
Historic Range of Variation of the Bighorn Ecosystem	Dr. Dennis Knight	Bighorn NF (Shoshone)
Historic Range of Variation of the Shoshone Ecosystem	Dr. Dennis Knight	Shoshone NF (Bighorn)
Historic Range of Variation of the Northern Front Range Ecosystem	Dr. Tom Veblen	ARNF (Routt, MBNF)
Historic Range of Variation of the Southern Front Range Ecosystem	Dr. Tom Veblen	PSINF (RGNF, GMUG)
Historic Range of Variation of the South-Central Highlands Ecosystem	Dr. Bill Romme	SJNF, RGNF (GMUG)
Historic Range of Variation of the North-Central Highlands Ecosystem, Grand Mesa	Dr. Tom Veblen	Routt, WRNF, GMUG
Historic Range of Variation of the North-Central Highlands Ecosystem, Northern Portion	Dr. Tom Veblen	Routt, WRNF, GMUG
Historic Range of Variation of the Black Hills Ecosystem	Parrish et al.	Black Hills NF
Historic Range of Variation of Aspen Ecosystems		Region-wide
Historic Range of Variation of Grassland and Shrubland Ecosystems	Dr. Jack Butler	Region-wide
Historic Range of Variation of Wetland and Riparian Ecosystems	Dr. David Cooper	Region-wide
Historic Range of Variation of Alpine Ecosystems		All grassland units

Current Landscape Condition Assessments

Current Landscape Condition Assessments are also planned for the ecosubregions in Region 2. These reports focus on a spatial characterization of current ecological condition and identify geographic areas or ecosystem characteristics with sustainability concerns. The goal of theses assessments is to describe the current ecological condition and to provide an ecological evaluation with particular consideration of the current condition in the context of the historic range of variation. These assessments are not just simple descriptions of biophysical patterns, but will attempt to offer a synthetic understanding of dynamics, interactions, future trends, and implications across appropriate spatial scales. The CLC Assessments, along with the Historic Range of Variation Assessments, are intended to provide an understanding of the ecological implications of terrestrial ecosystem conditions. They do not address the relevance of the current ecological condition to particular species, they are not the point where information is integrated from the aquatic, riparian, and wetland assessments and species assessments, and they are not intended to evaluate ecosystem effects of management scenarios. Nor are they an effort that is specifically focused on the design of a network of preserves (The Nature Conservancy 2000) but rather to complement that reserve-based conservation approach. Figure 1.3 shows the implementation steps for the CLC Assessment process.

In addition to the approaches for determining assessment content that were discussed earlier, the content and approaches of the CLC Assessment were further refined by input from Planners in Region 2 and by examining the ecosystem information needs indicated in the species assessments. The goal with the CLC Assessment is to ensure that most of the readily available broad ecosystem information is in place when biologists consider particular species issues in the context of ecosystem condition.

The CLC Assessments rely on: 1) information mapping and summarization of data from existing agency data sources, and 2) application of spatial or simulation models to identify areas of concern or to project probable system trajectories. They address the following broad topics for the assessment area:

(1) Ecological and socio-economic context (climate, physiography, vegetation, wildlife, demographic trends, land ownership patterns, resource use, etc.)
(2) Current vegetation condition (existing composition, structure, function, and spatial distribution of the vegetation of major vegetation types)
(3) Influences on landscape condition (wildfire, insects, and disease; and the management of forest and woodland ecosystems and grassland and shrubland ecosystems; invasive plant species; roads and trails; recreation and exurban development; and minerals, oil and gas exploration and extraction)
(4) Landscape patterns for forest and woodland ecosystems and grassland and shrubland ecosystems.
(5) Areas of special biodiversity significance.

Current Landscape Condition (CLC) Assessments will significantly improve the ability of Forest and District biologists developing programs to conserve species and evaluating the effects of activities by other programs. Currently, biologists must independently evaluate a broad array of disparate information to develop an understanding of the terrestrial system, which supports plants and animals on Forests and Districts. As a result, no synthetic resource is available because biologists lack the time or background to accomplish the task. The CLC assessments will provide an invaluable resource, increasing the efficiency and effectiveness of species conservation planning and implementation.

Without the benefit of CLC Assessments, biologists develop a portion of the resources contained in these assessments haphazardly over time, as particular information is needed for project planning and evaluation. For instance, maps of aspen forest distribution may be developed for one project and maps of mountain shrublands for another. The CLC Assessments organize this information in a product that puts this information into

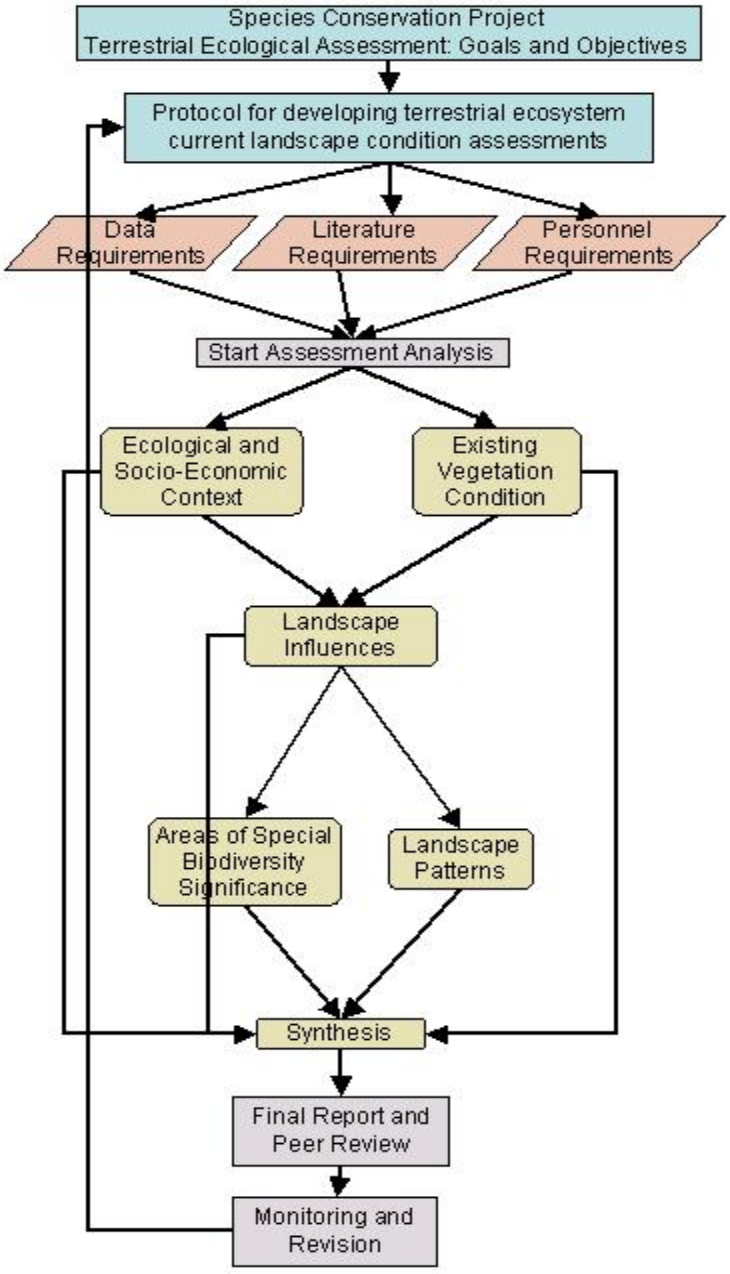

Figure 1.3. Flowchart of implementation steps for the CLC Assessment process.

context and includes a description of trend, discussion of important characteristics of certain ecological elements, and relates the current patterns of terrestrial vegetation with the dominant disturbance processes that are responsible for those, and future, patterns. The synthetic nature of the product will increase the common understanding of resource specialists on the forest and lead to more informed project designs, built from the foundation of credibility that will stem from the CLC Assessment. The broad nature of the assessments will aid in placing species conservation on a particular forest in the context of regional conditions. The assessment will illustrate the unique ecological characteristics of the forest – doing so helps focus planning on the niche each Forest can fill in forming regional and national conservation programs. Similarly, the focus of the CLC Assessment on Forest-wide conditions will facilitate conservation planning across the forest by revealing the separate contributions that each district can or cannot make to particular conservation efforts.

Examples of information from the CLC Assessment that will be useful to biologists developing species conservation programs include:

(1) Documenting the distribution and abundance of unique vegetation types on the forest – information critical to evaluating the potential for species management.
(2) Document the distribution and cover of major vegetation types on the forest.
(3) Description of stand age distributions for major forest types.
(4) Illustrating the distribution of roads relative to the distribution of major vegetation elements on the forest.
(5) Discussion of the condition of major vegetation types in relation to disturbance regimes – this information is critical to predicting future conditions on the forest, with and without active management.
(6) Description (including maps) of risk for major disturbance factors such as forest insects and disease that have potential to change forest structure.
(7) Distribution of invasive plant species and current trends.

Objectives of the Protocol

This protocol establishes direction for the development of Terrestrial Current Landscape Condition Assessments for the Rocky Mountain Region's Species Conservation Project. It contains information on the scope of the assessments, topics covered by them, and background on important concepts. It provides guidance on analytical approaches and data interpretation, treatment of uncertainty, validating and testing assumptions, and on identifying data gaps and information needs (Chapter 2). Specific topics, data sources, and details on GIS approaches or model application are identified for each of the chapters and modules comprising the assessment (Chapter 3 and Appendices). Guidelines for data management, for selecting investigators, and for formatting and delivery of assessment products are included (Chapter 4). A detailed outline describing the content of the assessments is provided (Appendix A).

Chapter 2
General Information on Assessment Approach

Conceptual Background

Ecological Drivers

Ecosystem composition, structure, and function and species diversity are controlled by numerous and complex factors that should be considered in the CLC Assessments (Table 2.1). Abiotic or physiographic factors not only drive vegetation distribution and function but are also important to biodiversity. Gradients in climate and soils influence patterns of vegetation cover and net primary productivity. The same gradients strongly influence where organisms are found. For example, habitats high in net primary productivity and structural complexity are much higher in bird abundance and species richness than less productive or structurally complex habitats (Hansen et al. 1998; Hansen and Rotella date).

Table 2.1. Factors driving ecosystem condition and species diversity. These drivers should be considered in developing the assessment of current landscape condition.

Ecological Driver Category	
• **Physiographic**	Climate (temperature, moisture, wind, etc.)
	Geology and soils
	Topography
	Geographic setting
• **Biotic**	Vegetation composition and structure
	Species interactions (competition, predation, parasitism, etc.)
	Primary Production
	Herbivory (livestock and wildlife)
• **Natural Disturbance**	Fire
	Insects
	Wind storms
• **Anthropogenic Activities**	Land allocation and roads
	Resource extraction (logging, grazing, mining, etc)
	Residential development
	Recreation
	Introduction of exotic species
	Alteration of natural disturbance regimes

Effects of natural disturbance are imposed on the physiographic and biotic template and may explain most of the natural variation that we see in ecosystem condition (Regan 1997; insert other references). In western ecosystems, fire may be viewed as the keystone process or the process that entrains all other processes (Swetnam references). Species dependent on post-disturbance habitat will respond favorably to disturbance while species dependent on late seral habitat may be negatively affected. In all cases, though, species in disturbance driven ecosystems have evolved with the dynamic mosaic of habitats created by natural disturbances operating within frequencies, intensities, and patterns expected under historic regimes.

Finally, patterns of land allocations and land uses interact with and influence current ecosystem condition as well as create legacies that will influence ecosystem trajectories and trends. These effects are central to consider in developing the ecosystem context for ecologically sustainable, conservation-focused planning.

Landscape Ecology

Landscape ecology offers the conceptual foundation for framing ecosystem assessments and the methodology for accomplishing them. Two aspects of landscape ecology distinguish it from other ecology sub-disciplines: 1) the importance of spatial configuration for ecological processes (e.g. movement of organisms, spread of disturbances, flow of nutrients or energy, etc.) is explicitly addressed and 2) spatial extents that are much larger than those traditionally examined are a focus (Turner 1989; Pickett and Cadenasso 1995; Turner et al. 2002). Other key features of the science center on the study of temporal dynamics in landscape patterns (Forman 1983), factors contributing to the development and dynamics of spatial heterogeneity (Risser et al. 1984), and the role of disturbance in ecosystems (Urban et al. 1987). Resource specialists involved in the development of the CLC Assessments should become familiar with the landscape ecology literature and skilled landscape ecology expertise is needed for ensuring that the best available science is employed in the assessments.

Scale Terminology and Concepts

Scale of observation is perhaps the most important consideration in developing an ecological assessment because it influences the conclusions drawn from the observations and the application of the results to other locations (Turner et al. 2002). Several significant scale-related considerations will contribute to the value of assessments. With increasing human influences, ecological concerns are manifested over larger areas so that assessment areas should be sufficiently large to adequately provide the necessary ecological context. In addition, the answers to any ecological question depend strongly on the scale of observation so that the multiple scales necessary to fully address the topics must be addressed (Fig. 2.1). Finally, biological processes occur at characteristic scales and interactions in the environment occur at multiple scales. Ecological and biological processes or attributes have characteristic spatial and temporal scales and interactions in the environment occur at multiple scales (Urban et al. 1987). Figure 2.2 illustrates these spatial and temporal relationships among several potential processes or ecosystem attributes of interest.

Theoretical and academic attention to the topic has focused on the hierarchical structure in nature and positive correlations in spatial and temporal scales of varying processes (Allen and Starr 1982; Delcourt et al. 1983; O'Neill et al. 1986). In ecology, hierarchy theory is concerned with understanding the relationships among levels of ecological organization (e.g., organism, population, community, ecosystem) and among scales of pattern and process. Turner et al. (2002) summarize important concepts from hierarchy theory that suggest:

(1) The importance of considering at least three hierarchical levels in any study (Fig. 2.3).

(2) Shifts in the relative importance of the variables often occur with a change in scale although the variables may or may not change with scale.

(3) Multiple scales of pattern will exist in landscapes because of the multiple scales at which processes are acting.

Hierarchy theory tells us that it is difficult to directly apply knowledge resulting from fine-scaled studies to broad-scale ecological problems and requires that an understanding of landscape-level dynamics can only be gained through examination of the landscape (Turner et al. 2002).

The terminology used to discuss scale-related concepts is often misapplied. It is critically important to understand scale terminology and be consistent and correct in its application in developing the assessment, in interpreting the results and drawing conclusions, and in communicating the assessment outcomes. Key terms are defined and explained in Table 2.2.

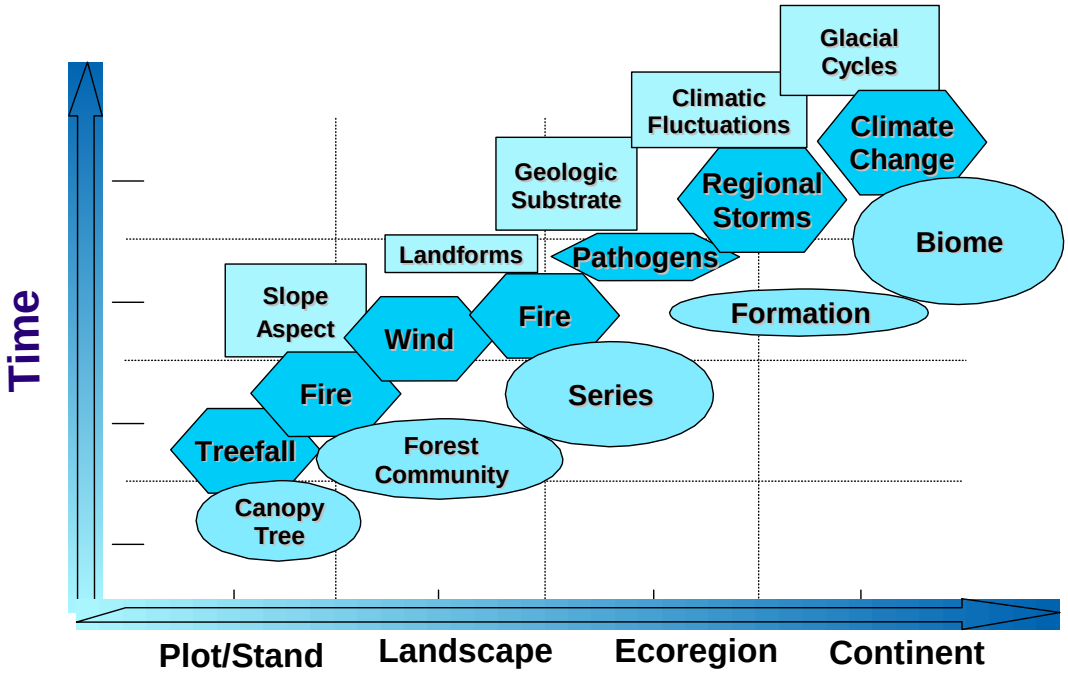

Figure 2.1. Spatial and temporal scale relationships among several potential processes or ecosystem attributes of interest.

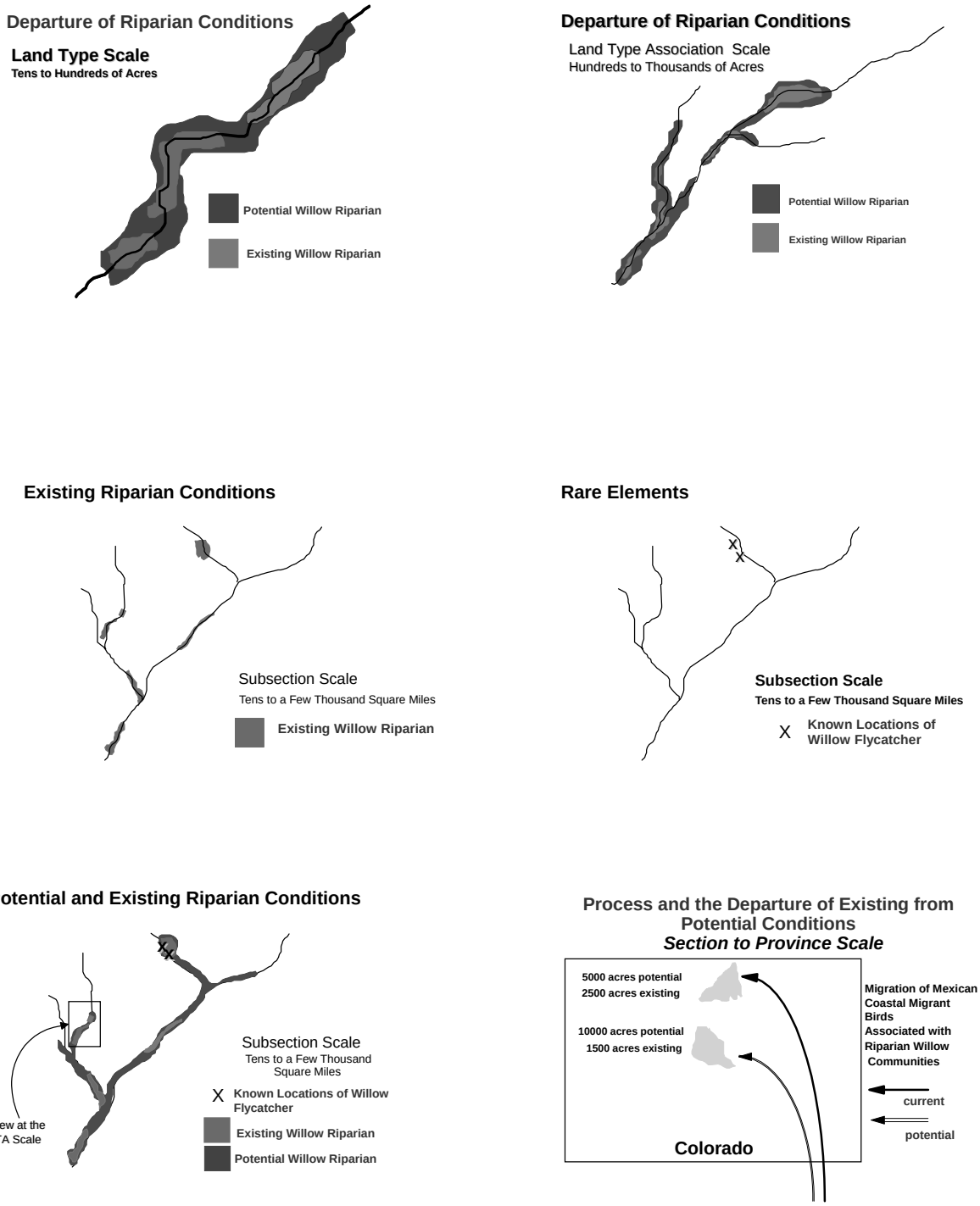

Figure 2.2. The importance of scale of observation in influencing information derived from ecological assessments. This illustrates how multiple scales of observation are required to adequately describe the ecological conditions influencing a riparian dependent migratory bird.

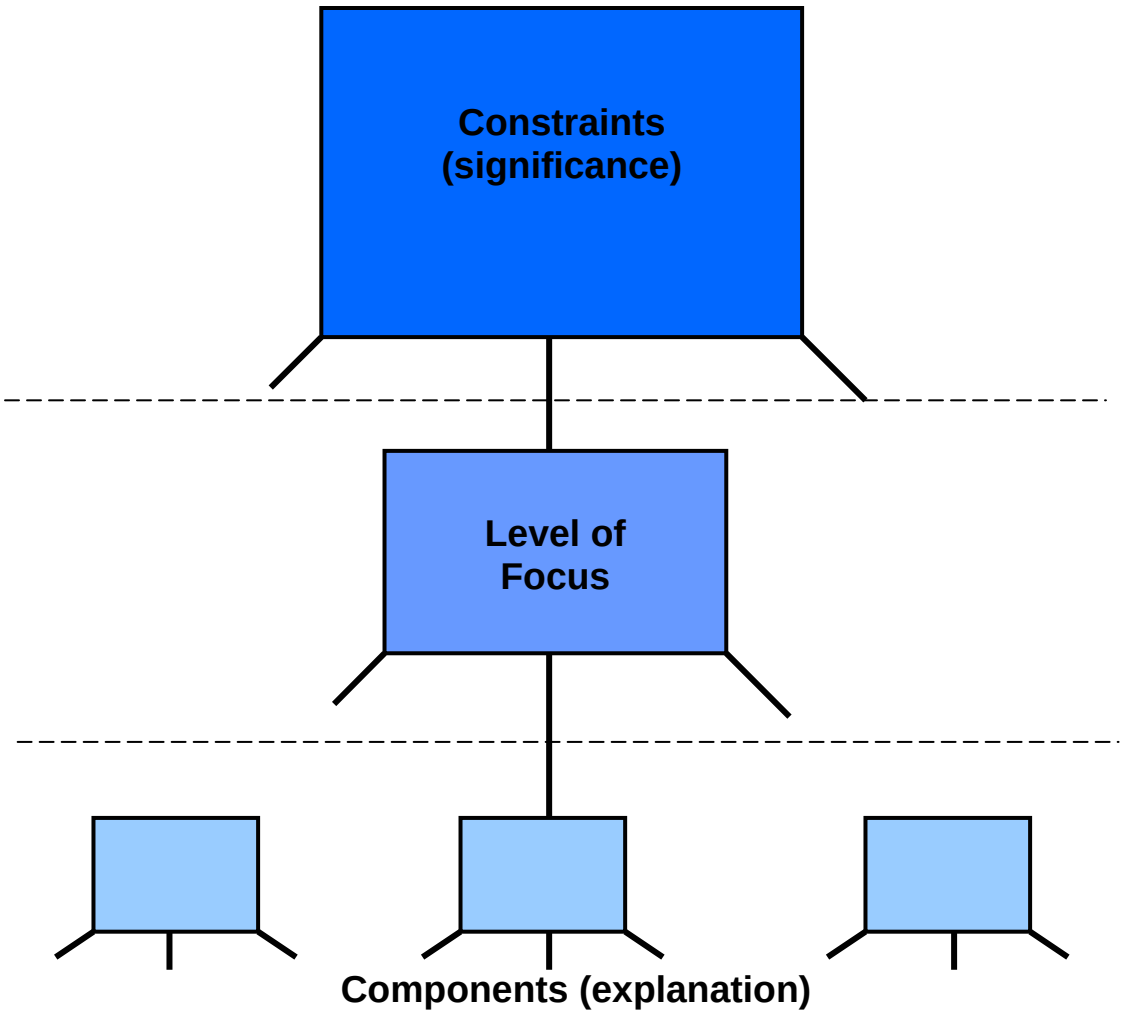

Figure 2.3. Three hierarchical levels should be considered in any study, the level of focus plus the higher level and the lower level. The highest level encompasses those attributes or processes that constrain the level of focus and provides a context for understanding the significance of the focus. The lower level encompasses those attributes that are the components of the level of focus and provides information that explains the focal condition.

Table 2.2. Definitions of scale-related terminology and concepts.

Term	Definition	Explanation or Example
Scale	The spatial or temporal dimension of an object or process, characterized by both grain and extent.	The size of an area or the length of time. In ecology, fine scale refers to minute resolution or small study area, and broad scale refers to coarse resolution or large study area.
Level of organization	The place within a biotic hierarchy.	Organism, population, community, ecosystem, landscapes. Scale and level of organization are often confounded when "ecosystem" is equated with "large-scale." Levels are distinctions about the kinds of interactions being considered while scale is a matter of the dimension of the analysis or study.
Cartographic scale	The degree of spatial reduction indicating the length used to represent a larger unit of measure; ratio of distance on a map to distance on the earth surface represented by the map.	Usually expressed in terms such as 1:10,000. In geography, large scale refers to small resolution.
Resolution	Precision of measurement: grain size, if spatial.	High resolution implies fine details; low or coarse resolution implies less detail. Usually, as we increase the scale of reference we typically sacrifice detail, so scale and resolution are inversely related.
Grain	The finest level of spatial resolution possible with a given data set.	Pixel size for raster data. The size of an individual map cell determines the spatial grain of the map. One pixel of a TM image usually represents a 30 x 30-meter area on the ground. One pixel of CVU data represents area on the ground.
Extent	The size of the study area or the duration of time under consideration.	For example, Section M331B, the extent of the Bighorn Current Landscape Condition Assessment, is 410 m^2, roughly 11 miles by 67 miles in dimension, and is 262,378 acres.
Extrapolate	To infer from known values; to estimate a value from conditions of the argument not used in the process of estimation	Information may be transferred (a) from one scale to another (either grain size or extent) or (b) from one system (or data set) to another system at the same scale.
Critical threshold	The point at which there is an abrupt change in a quality, property, or phenomenon.	For example, landscape ecology theory suggests the existence of a threshold level of habitat connectivity that influences the spread of disturbance and its effects on the landscape.
Absolute scale	The actual distance, direction, shape, and geometry.	Two points (a1 and a2) on the landscape may be closer to each other in absolution distance than two other points (b1 and b2). See relative scale
Relative scale	A transformation of absolute scale to a scale that describes the relative distance, direction, or geometry based on some functional relationship.	For example, the relative distance between two locations based on the effort required by an organism to move between them. Points a1 and a2, while closer than points b1 and b2 in absolute distance, may be farther apart in relative scale. Points a1 and a2 may be separated by a large peak that would require much energy to traverse while points b1 and b2 are separated by easily traversed level ground or favorable habitat.

Hierarchy of Ecological Units

The Current Landscape Condition Assessment approach relies heavily on defining the spatial aspects of ecological context within the landscape stratification offered by the National Hierarchy of Ecological Units (ECOMAP 1993). This framework provides a standardized method for classifying, mapping, and describing ecological units at multiple geographic planning and analysis scales. It is accepted agency wide and commonly used for organizing terrestrial assessment work. Further, the team of ecologists charged with preparing ecological sustainability directives to support the revised planning rule strongly endorsed the use of the hierarchy in framing ecological assessments and the concept appears in the draft handbook (draft FSH 1909.12, chapter 40).

The National Hierarchical Framework of Ecological Units (Table 2.3), as described by ECOMAP (1993), provides a regionalization, classification, and mapping system for stratifying the Earth into progressively smaller areas of increasingly uniform ecological potentials. Ecological types are classified and ecological units are mapped based on associations of those biotic and environmental factors that directly affect or indirectly express energy, moisture, and nutrient gradients that regulate the structure and function of ecosystems. These factors include: climate, physiography, water, soils, air, hydrology, and potential natural communities. The units are areas of similar expected ecological response, at multiple scales, to predominant driving factors, identified in Table 2.4 as map unit design criteria.

Table 2.3. National Hierarchy of Ecological Units (ECOMAP 1993).

Planning and Analysis Scale	Ecological Units	Purpose, Objectives, and General Use	General Size Range
Ecoregions			
Global Continental Regional	Domain Division Province	Broad applicability for modeling and sampling RPA assessment. International planning	1,000,000's to 10,000's of square miles
Subregions	Sections Subsections	RPA planning multi-forest, Statewide, and multi-agency analysis and assessment	1,000's to 10's of square miles
Landscape	Landtype Association	Forest or area-wide planning, and watershed analysis	1,000's to 100's of acres
Land Unit	Landtype Landtype Phase	Project and management area planning and analysis	100's to less than 10 acres

Table 2.4. Principal Map Unit Design Criteria of Ecological Units (ECOMAP 1993). Criteria used to differentiate each ecological unit in the national hierarchy are presented.

Ecological Unit	Principal Map Unit Design Criteria[1]
Domain	• Broad climatic zones or groups (e.g., dry, humid, tropical).
Division	• Regional climatic types (Koppen 1931, Trewartha 1968) • Vegetational affinities (e.g., prairie or forest). • Soil order.
Province	• Dominant potential natural vegetation (Kuchler 1964) • Highland or mountains with complex vertical climate-vegetation-soil zonation.
Section	• Geomorphic province, geologic age, stratigraphy, lithology. • Regional climatic data. • Phases of soil orders, suborders, or great groups. • Potential natural vegetation. • Potential natural communities (PNC)[2].
Subsection	• Geomorphic process, surficial geology, lithology. • Phases of soil orders, suborders, or great groups. • Subregional climatic data. • PNC-formation or series.
Landtype Association	• Geomorphic process, geologic formation, surficial geology, and elevation. • Phases of soil subgroups, families, or series. • Local climate. • PNC-series, subseries, plant associations.
Landtype	• Landform and topography (elevation, aspect, slope gradient, and position). • Rock type, geomorphic process. • Phases of soil subgroups, families, or series. • PNC-plant associations.
Landtype Phase	• Phases of soil families or series. • Landform and slope position. • PNC-plant associations or phases.

[1] The criteria listed are broad categories of enfironmental and landscape components. The actual classes of components chosen for designing map units depend on the objectives for the map.

[2] Potential Natural Community Vegetation that would develop if all successional sequences were complete under present site conditions.

Domains

Domains are subcontinental areas of broad climate similarity. All of the Rocky Mountain Region is within the Dry Domain (Figure 2.4). This Domain is characterized by a relatively dry climate in which annual losses of water through evaporation at the earth's surface exceed annual water gains from precipitation (Bailey 1995).

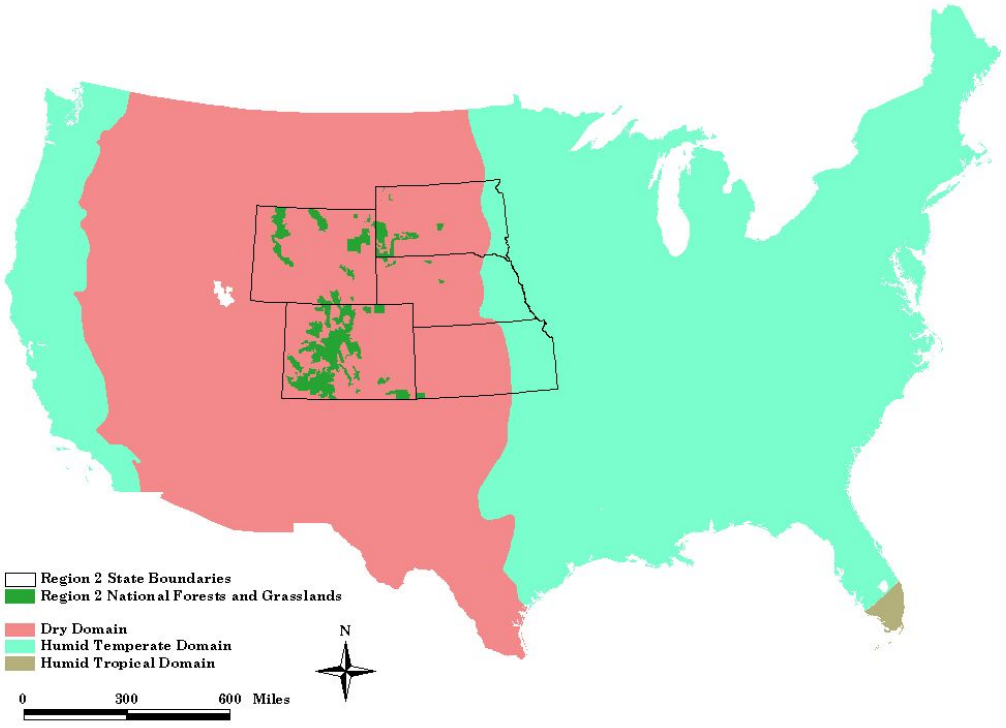

Figure 2.4. The Rocky Mountain Region Relative to the Dry Domain (map source: *http://www.fs.fed.us/colorimagemap/ecoreg1_domains.html*)

Divisions

Domains are further partitioned into Divisions. Isolating areas of differing vegetation, broad soil categories and regional climates delineate divisions. The ecologically diverse Rocky Mountain Region intersects four Divisions, the Temperate Steppe Division, the Temperate Desert Division, the Tropical/Subtropical Regime Mountains, and the Temperate Steppe Regime Mountains (Figure 2.5). Much of Region 2 is within the Temperate Steppe Regime Mountains and is characterized by a semi-arid continental climatic regime with the mountains displaying altitudinal zonation (Bailey 1995).

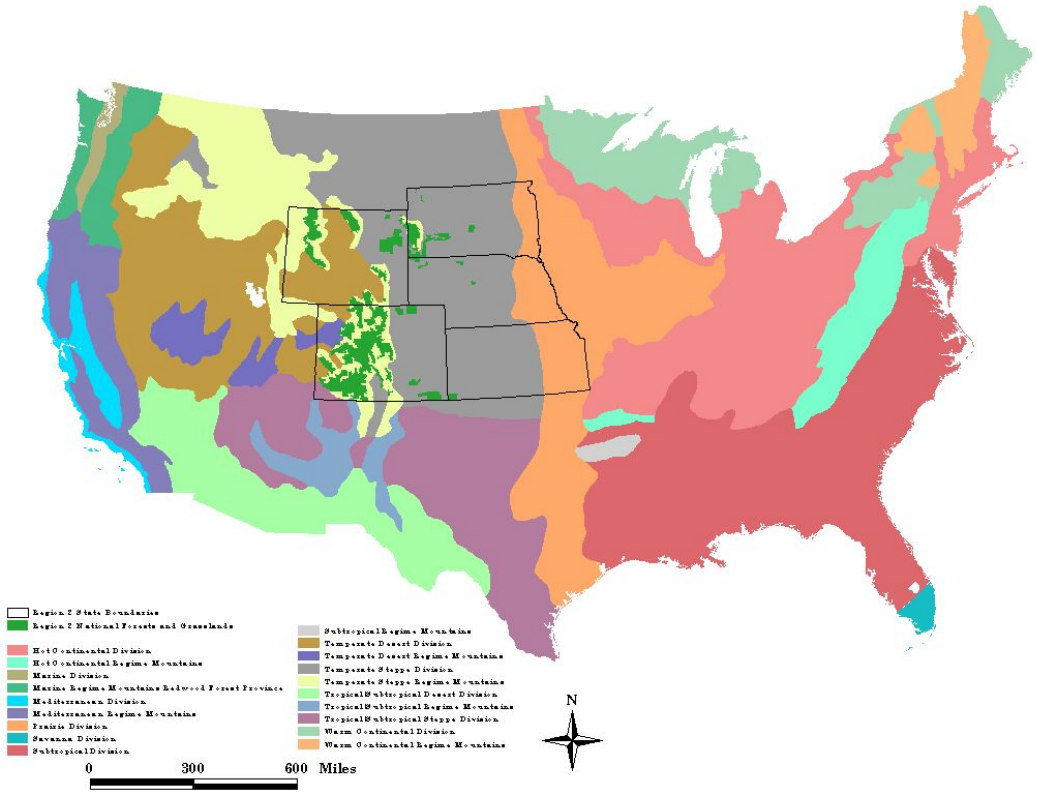

Figure 2.5. The Rocky Mountain Region relative to ECOMAP Divisions (map source: (*http://www.fs.fed.us/colorimagemap/ecoreg1_divisions.html*).

Provinces

Divisions are further subdivided into Provinces. Broad vegetation regions that are primarily controlled by length and timing of dry seasons and the duration of cold temperatures determine provinces. Provinces are also characterized by similar soil orders and by similar potential natural communities as mapped by Kuchler (1964). The Rocky Mountain Region intersects seven of the Provinces (Fig. 2.6) but is primarily influenced by the Southern Rocky Mountain Steppe - Open Woodland - Coniferous Forest - Alpine Meadow Province (M331), the Great Plains-Palouse Dry Steppe Province (331), and the Black Hills Coniferous Forest Province (M334). Detailed descriptions of these Provinces are found in (Bailey 1995).

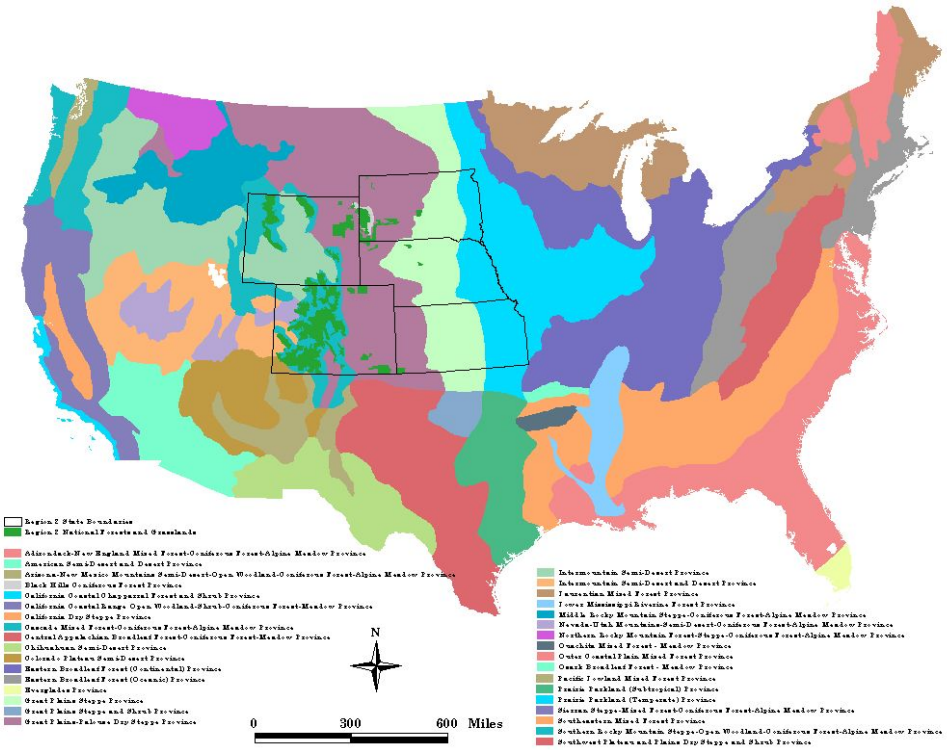

Figure 2.6. The Rocky Mountain Region relative to the ECOMAP Provinces (map source: *(http://www.fs.fed.us/colorimagemap/ecoreg1_provinces.html).*

Sections

Provinces are further subdivided into Sections. Sections are broad areas of similar geologic origin, geomorphic process, stratigraphy, drainage networks, topography and regional climate. Sections are typically inferred by relating geologic maps to potential natural vegetation "series" groupings as mapped by Kuchler (1964). The Forests and Grasslands of the Rocky Mountain Region intersect 22 Sections, although six of the Sections are trivial in their representation in Region 2 lands. Many units in Region 2 intersect with multiple Sections while others reside within one Section. For example, the Bighorn National Forest resides within one Section, the Bighorn Mountains (M331B) (McNab and Avers 1994). Figure 2.7 shows the spatial relationship of the Bighorn National Forest and Section M331B in the broader geographic context. Detailed descriptions of the Sections are found in McNab and Avers (1994).

Subsections

Sections are further subdivided into Subsections. They are based upon geology, geomorphic process, soils, regional climatic data and vegetation. For example, the Bighorn Section is divided into three subsections as follows: 1) Bighorn Mountains, Sedimentary Subsection (M331Ba), 2) Bighorn Mountains, Granitic/gneiss Subsection (M331Bb), and 3) Owl Creek Mountains Subsection (M331Bc) (Figure 2.7). Detailed description of these Subsections can be found in [subsection citation].

Landtype Associations

Each Subsection is further divided into Landtype Associations (LTAs) based on similarities in geology, soils and plant associations. Repeatable patterns of soil complexes and plant communities are useful in delineating map units at this level. Landtype Association descriptions are in a tabular format and can be found [LTA citation]. Figure 2.8 shows an example of the distribution of LTAs within a Section.

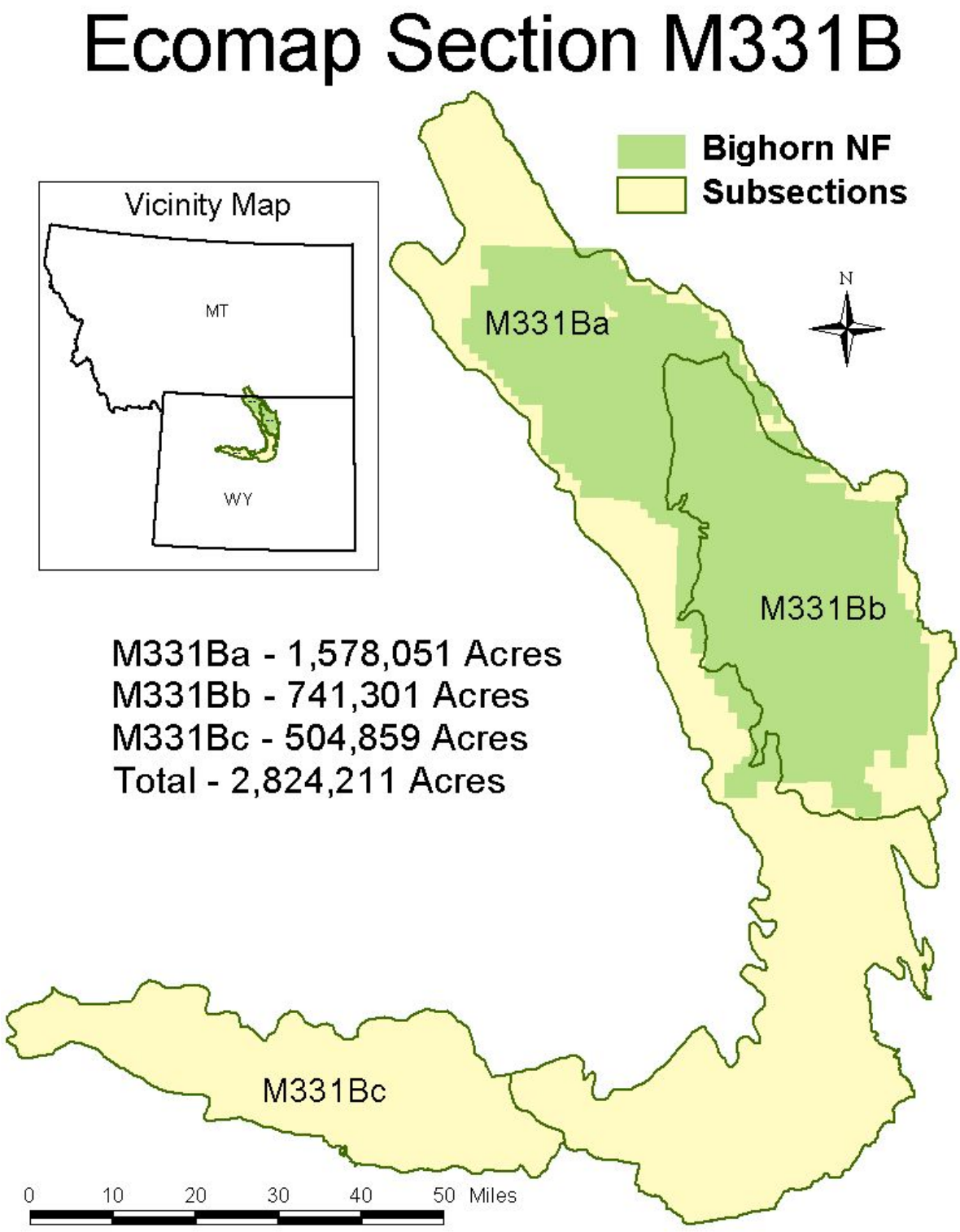

Figure 2.7. The Bighorn National Forest relative to the Bighorn Mountains Section (M331B) and its three associated Subsections.

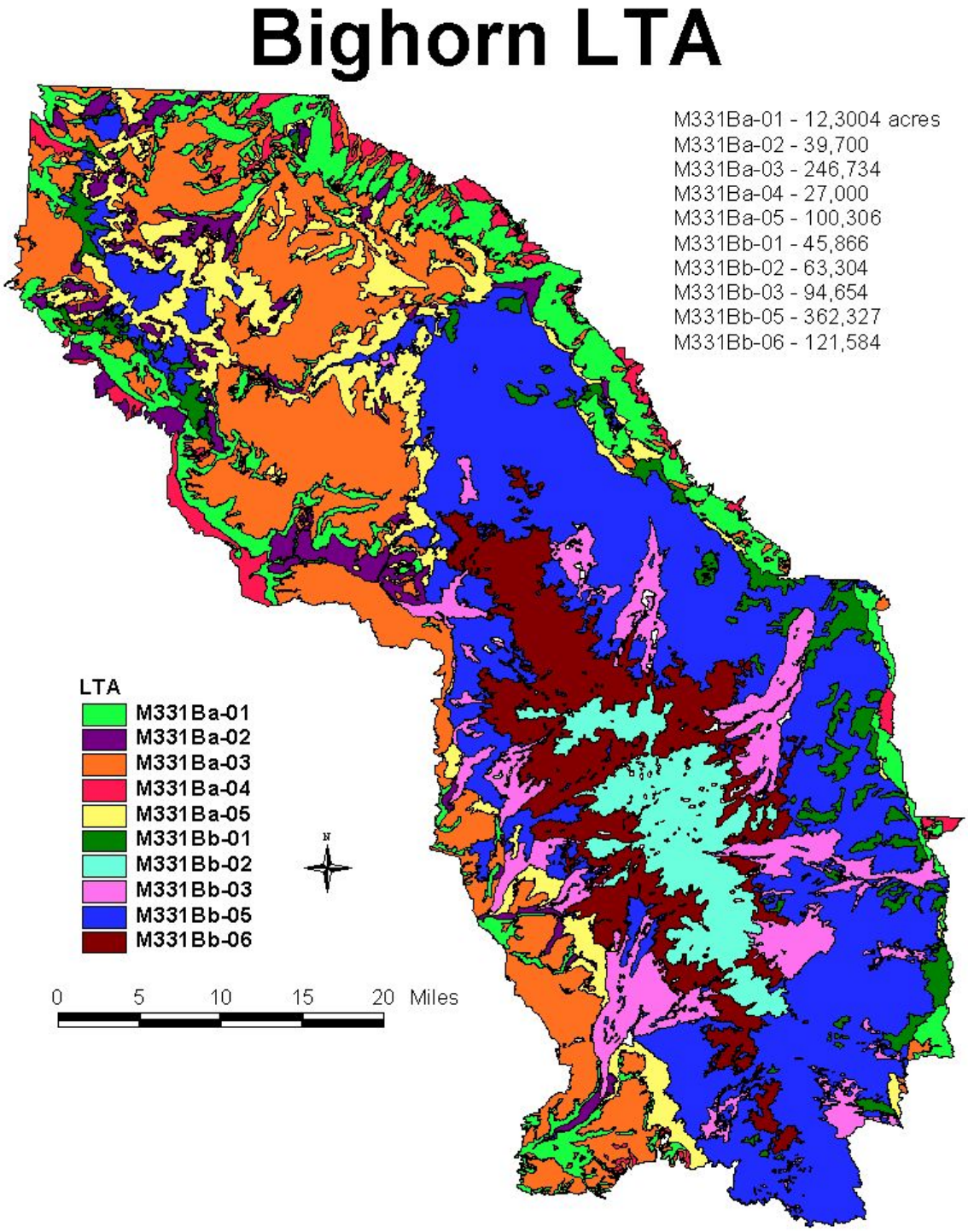

Figure 2.8. Landtype Associations for the Bighorn National Forest.

Scope of the Assessment

The first step for the assessment team is to define the scope of the assessment. This includes delineating the assessment area, identifying broad ecological issues relevant to the assessment area, defining appropriate spatial stratification units for data summarization, and arriving at the content topics. All of these tasks should be aided and guided by this protocol, but there likely will be need for modification tailored to local needs and unique characteristics (local changes should be conducted according to the SCP Change Management Process). The concepts presented here can also be used to guide more finely scaled or focused assessments.

Assessment area delineation should follow ecological rather than administrative boundaries. The area should be sufficiently large to provide an adequate ecological context for wide-ranging terrestrial species and to incorporate the ecological processes known to influence the administrative area of interest. We suggest the Section in the ECOMAP hierarchy as the appropriate ecological unit to define the spatial extent of the assessment area (Fig. 2.9). The characteristics of the Section should be evaluated within the context of the broader ecological unit (the Province) and the variation within the Section should be explained within the context of the finer ecological unit (the Land Type Association) (Fig. 2.10). The assessment should discuss the national and the regional significance of both the ecological area and the National Forest.

The CLCs are focused on current condition but require incorporating information about departures from historic disturbance regimes (from HRV assessments) and 20th century land use practices. In addition, in synthesizing assessment results, projections about future trends in ecosystem or landscape condition should be suggested if possible. Resource practitioners often make the mistake of applying a relatively limited temporal perspective in evaluating ecological condition. It is important to consider a historical temporal extent that sufficiently incorporates extreme anthropogenic influences and that incorporates the frequencies of dominant ecological processes. It is also important to recognize that ecosystem response to certain influences may be slow so the future trends for some attributes should be considered on similar temporal extents.

Next, the assessment team should identify broad ecological issues relevant to the assessment area. These should be known issues related to either species conservation or ecosystem sustainability and will drive the specific content of each component of the assessment. Examples of probable issues are biological diversity, species viability, forest and rangeland health, risk associated with natural disturbances, vegetation management influences, and roadless or other special areas. These issues can be linked to forest plan revision or amendment topics or other planning topics. The assessment topics should be broadly enough defined to encompass the known significant ecological issues in the assessment area. They should also be substantive enough to reveal ecological issues or areas of concern previously unrecognized

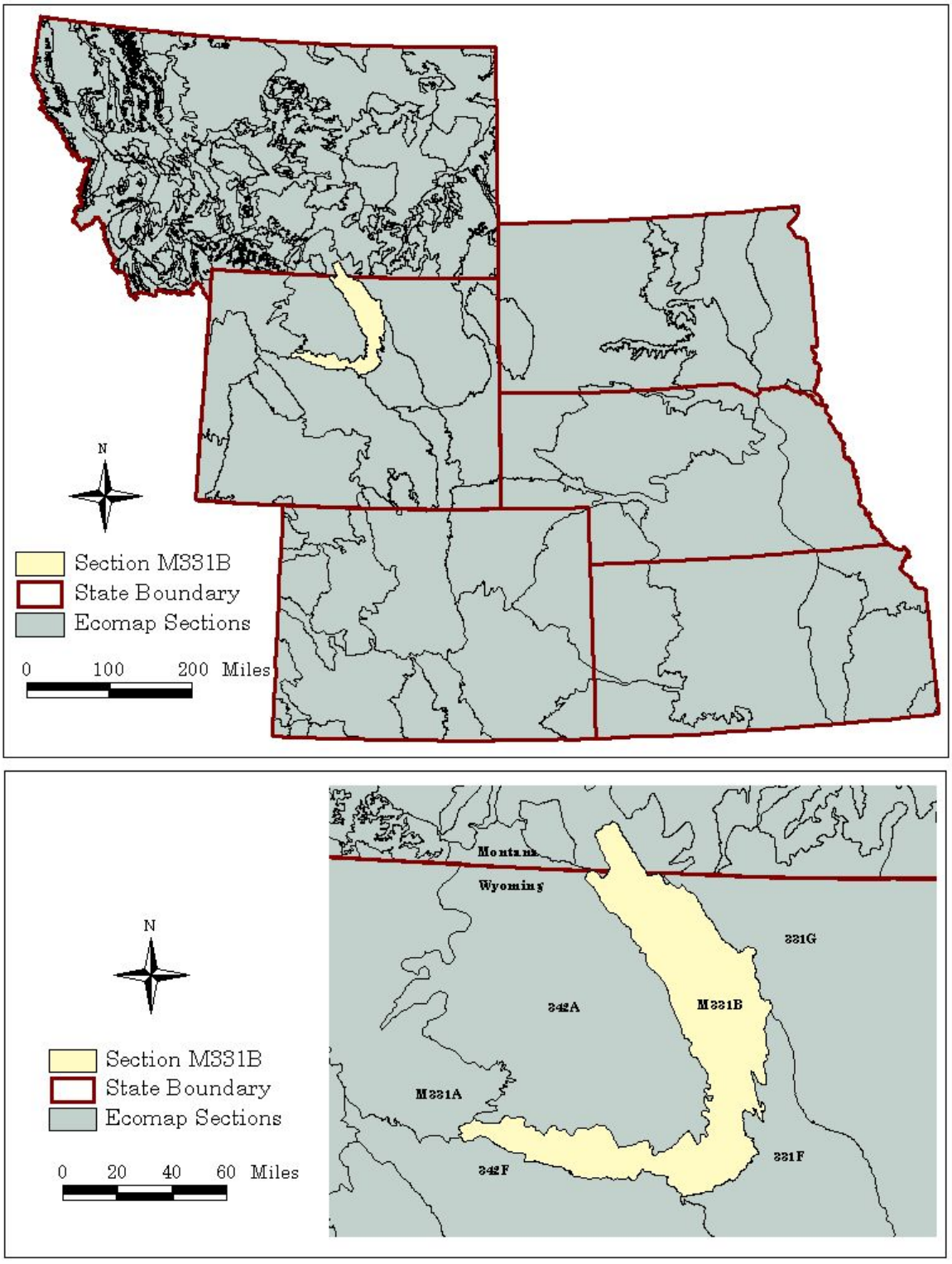

Figure 2.9. Ecomap Section M331B, which is an example of appropriate assessment area extent. The location of the assessment area within the broader geographic area of Region 2 is illustrated.

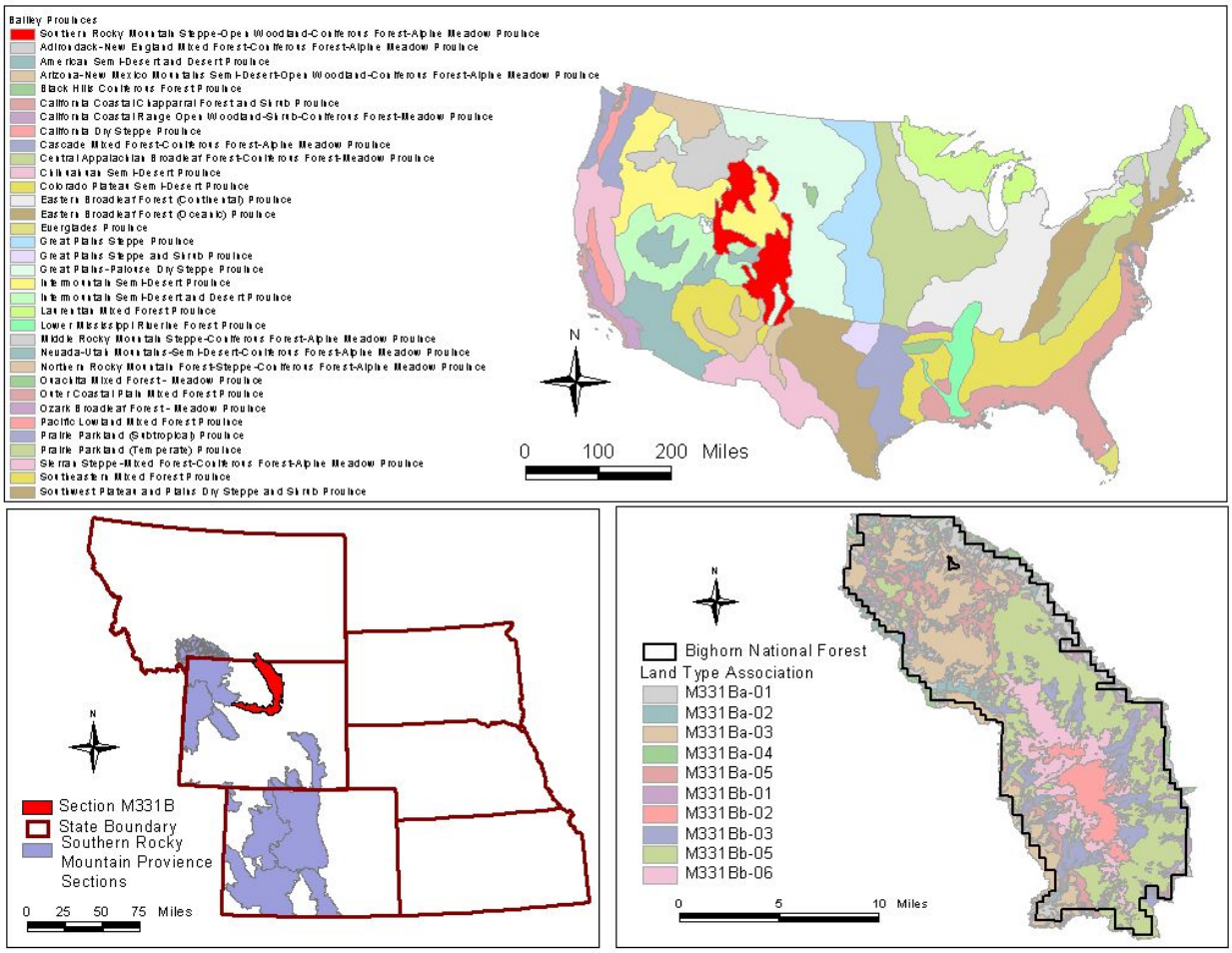

Figure 2.10. Land Type Associations are ecological stratification units used to describe variation within the assessment area. The characteristics of the Section should be evaluated within the context of the broader ecological unit (the Province).

Data are summarized and analyzed at two major scales (Table 2.5). The broadest scale is the ecosubregion and is equivalent to the extent of the assessment area (e.g. ECOMAP Section) or the National Forest. Broad scale analyses should be completed for the entire Section to the extent possible. However, much of the data are not available for the entire Section so many analyses can only be done for the National Forest. This broad scale provides an overall perspective and a context for evaluating the mid-scale. At the broad scale, the following should be provided:

(1) Narrative description of existing conditions for key biophysical components.
(2) General trends and rates of change in resource condition.
(3) Coarse information on the spatial pattern of resources.
(4) Coarse information on disturbance regimes and their relationships to resource values.

Table 2.5 Analysis scales required to accomplish the Current Landscape Condition Assessment.

Assessment Unit	Map Scale Range	Average Polygon Size
Section	1:500,000 – 1:100,000	Up to100s sq miles
National Forest	1:500,000 – 1:100,000	Up to100s sq miles
Ecological Landscapes	1:250,000 – 1:24,000	1000s acres or less
Management Landscapes	1:250,000 – 1:24,000	1000s acres or less
Stands	1:24,000 or larger	100s of acres or less

The mid-scale is the primary focus of the CLC Assessment and should be centered on ecological landscapes (e.g., ECOMAP Land Type Associations) and management landscapes (e.g., mid-scale planning units such as watersheds or geographic areas). The mid-scale approach allows for a better representation of the variation with the assessment area for all planning applications. The mid-scale provides more detail on the variation in:

(1) Temporal and spatial patterns of vegetation composition and structure.
(2) Condition of other key ecosystem elements and processes.
(3) Land management issues of specific locations.

Stand level data (the next finest scale) are utilized in the mid- and broad-scale summaries. While the assessment is more coarsely scaled than would be expected in a plot or stand level description, data on finely scaled attributes generally observed at the plot level may be summarized over the broader scales. However, the CLC Assessment should not accomplish stand-specific descriptions or analyses. These finer-scaled analyses should be done in project analysis work and those analyses should be aided by this protocol and the resulting assessment.

The landscape of the assessment area may be stratified in a number of ways, depending on the specific questions or analysis objectives, to accomplish data summarization. For example, if stand density data are summarized for all stands across an entire Forest, then the stratification unit is the Forest. If stand density data are summarized for a vegetation type across the Forest, however, the unit is the vegetation type. Suggested stratification units are illustrated in Figure 2.11. These serve as reporting units in the assessment. More detailed information on the data reported for various stratification units is presented in Chapter 3 of the protocol.

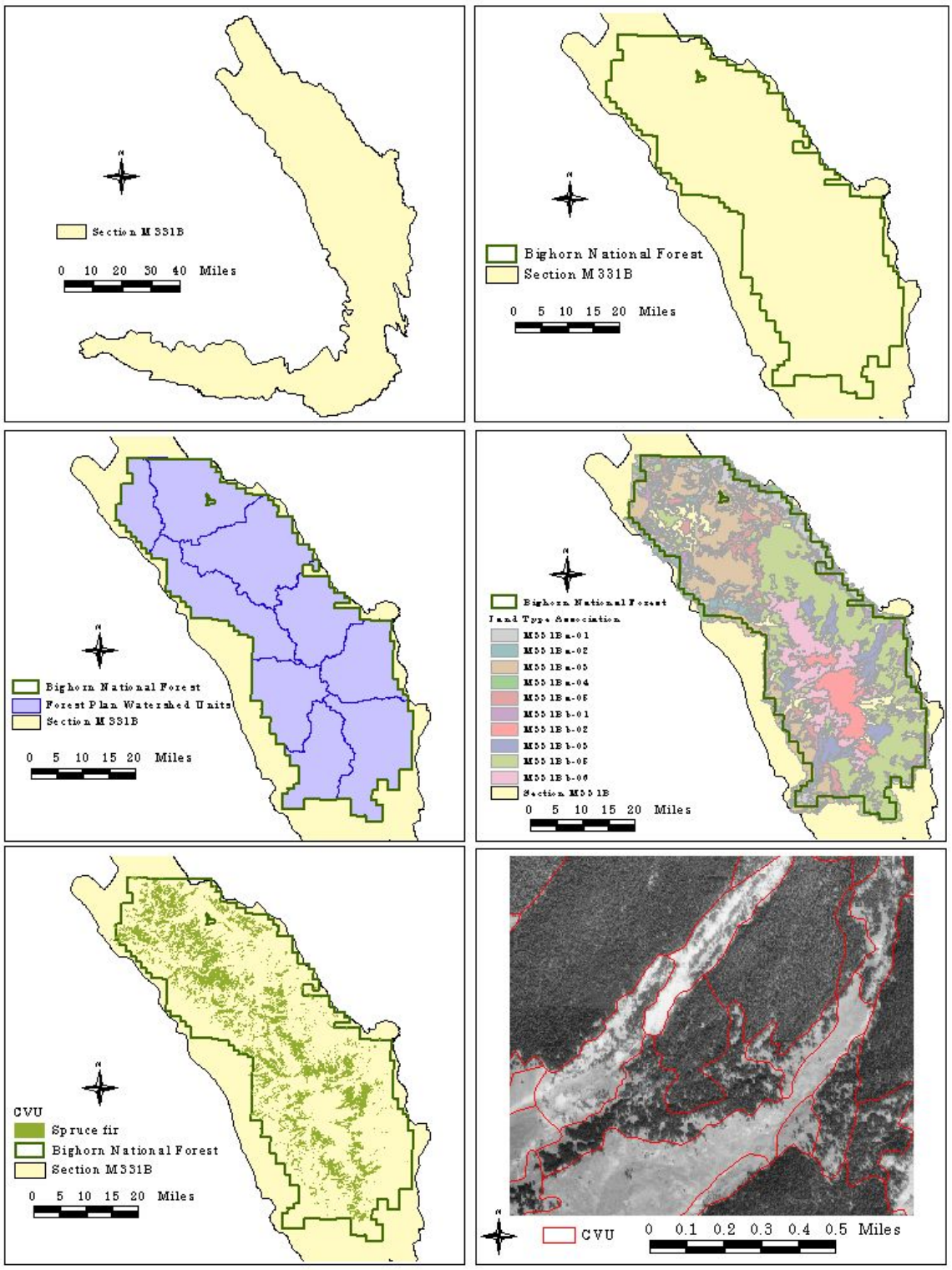

Figure 2.11. Stratification units for the CLC Assessment may range from the Section, the National Forest, mid-scale planning units, Land Type Associations, and vegetation cover types. Stand level data will be used but summaries are not presented for specific stands in the CLC Assessment.

Rationale for Assessment Organization

The assessment content is organized into the following seven major components:

I. Introduction
II. Ecological and Socio-economic Context of the Assessment Area
III. Existing Vegetation Condition
IV. Influences on Landscape Condition
V. Landscape Patterns
VI. Areas of Special Biodiversity Significance
VII. Synthesis

The Introduction (I) provides the framework for the CLC as part of the Region 2 Species Conservation Project and the link between the CLC and other assessments that are part of the Species Conservation Project. The Introduction also defines the objectives and assessment area of the CLC.

In order to fully appreciate the current landscape condition of the BNF, ecological and socio-economic contexts (Chapter II) are provided. The ecological context of the assessment area addresses a combination of the environmental, physiographic, and biological drivers. An understanding of the current ecological condition is not complete without the knowledge of previous and current human interaction with the ecosystem as well as future demands. Therefore, the socio-economic context of the assessment area is provided to address the historic and current human influences in the area including land ownership allocations and resource uses. The socio-economic portion of Chapter II is not designed to be a complete, independent socio-economic assessment. Its purpose is to simply summarize and present socio-economic information relevant to the current ecological condition. Without this portion, a complete and holistic understanding of current landscape would not be possible. These ecological and socio-economic components provide the foundation for comprehension and assessment of the current landscape condition.

The Existing Vegetation Condition (Chapter III) component of the assessment is an ecosystem-level analysis intended to provide detailed descriptions of individual major cover types identified within the assessment area. This component is divided into two modules (3A. Forest and Woodland and 3B. Grassland and Shrubland) to account for differing author expertise, differing data availabilities, etc. Chapter III is unlike other chapters in that it is organized by major cover type. This is to focus on the features of vegetation that can be considered one type at a time (or stand level features). The features of the landscape that transcend individual vegetation types, such as wildfire, invasive species, or landscape structure, are discussed in Chapter IV and V – Influences on the Landscape and Landscape pattern.

The Landscape Influences (Chapter IV) component of the assessment evaluates current and potential influences on landscape condition. It is divided into seven modules (A. Wildfire, Insects, and Disease; B. Forest and Woodland Vegetation Management; C. Grassland and Shrubland Vegetation Management; D. Invasive Species; E. Roads and Trails; F. Recreation and Exurban Development; G. Minerals, Oil, and Gas). Although some of the influences may be associated within individual cover types, the focus of the analysis is from a landscape ecology perspective. This means that the influences are discussed in the context of multiple temporal (annual to decadal to centennial) and spatial (stand to ecosystem to landscape) scales. These various analysis scales need to include at least one analysis following ecological boundaries as well as management defined boundaries to fully analyze the affects of these influences on the landscape and discover impacts that may focus on particular ecological land type associations or on management defined geographic areas.

The Landscape Patterns (Chapter V) component combines the ecological and socio-economic context information with existing vegetation condition and landscape influences to give a broad scale pattern of ecosystems on the landscape. The landscape patterns component has two modules –forested and woodland vegetation and grassland and shrubland vegetation. This is done to look at specific issues relating to how management practices and natural disturbance are affecting key features of the landscape pattern

that are relevant to the particular life form. Additionally, it will allow for the work on the landscape patterns component to capitalize on authors with the appropriate expertise to work on the appropriate modules.

Areas of Special Biodiversity Significance (Chapter VI) focuses on vegetation or areas located within the assessment area that have been identified as unique, at risk, or habitats of special biodiversity significance. This is a landscape level analysis that is intended to draw attention to specific details, thus adding to the landscape pattern component. The value of each area is discussed as it relates to the current vegetation condition, landscape influences, and landscape pattern.

The Synthesis (Chapter VII) component evaluates the current landscape condition from an ecological integrity and sustainability perspective by synthesizing key points from each of the modules.

The specific content of each module is detailed in chapter 3 of this protocol.

Data Sources and Analytical Considerations

Several sources of information will be used to build the assessments. Since these assessments are descriptions of the current condition of specific areas and have a significant spatial component, the primary source of *foundational* data will be USFS and other agency inventory data sets (e.g., IRI and NRIS). Other likely sources of information include the relevant historic range of variation assessments, peer-reviewed and published literature, gray literature, data from reference areas, and other unpublished data and reports from agency files. A portion of the foundational data required for each CLC Assessment has already been compiled by the Region's SCP. We emphasize that the CLC Assessments should rely on already available foundational data from a variety of entities rather than on new development of foundational data. If foundational data do not exist to address a particular protocol component or assessment question, a data gap should be identified in the assessment report. There is no expectation that new inventories will be conducted to implement this protocol. In some cases, surrogate data may be used for the attribute of interest as long as appropriate qualifications are stated (e.g. when an old-growth inventory is unavailable, other inventory data representing older forests should be used rather than just eliminating any consideration of old-growth). *Analysis* data will be developed through reduction of foundational data or through modeling approaches such as those described in the appendices. *Observational* data will result from the synthesis and interpretation of the findings of each module as well as the overall synthesis that will result when considering all module findings.

The information from each foundational data source as well as the analysis and observational data will vary in quality. The reliability of data and other information must be clearly described and approaches or rationale used to arrive at analysis data should be clearly documented and included in the assessment product. Analyses should be appropriate for the level of data quality. Procedures for validating or testing the assumptions and results of modeling applications should also be documented in the assessment report. In addition, the interpretations drawn from the information must be commensurate with the quality of the data and the inferences developed must be appropriately qualified. The report should clearly state the difference between conclusions that are directly supported by the data and conclusions that are inferred from the data. Explicitly stating the assumptions made in drawing conclusions, the strength of the conclusions, and the degree of uncertainty is a critical requirement.

Data interpretation should be substantive and relative to important management-related questions. The assessment should do more than just summarize data. It should synthesize the complex information into clear pictures of the ecological condition and should draw conclusions about the ecological implications of that condition. The assessments should generate new information through a new understanding of the ecology of the analysis area. A comprehensive and substantive assessment of ecological data will reveal information gaps. These should be clearly identified and critical information

needs should be prioritized in the assessment reports.

When supportive information is available, the assessment reports should involve a substantive discussion of the management implications of ecological conditions. For example, consequences of management activities to ecological integrity, ecosystem sustainability, and species conservation should be addressed if possible. In many cases, the effects of management activities are unknown so that the magnitude of management influence is all that can be addressed. And management approaches known to have demonstrated positive ecological effects should be identified. However, management recommendations, personal value judgments, and opinions about acceptable levels of risk must be avoided (Appendix B).

Chapter 3
Assessment Content

Ecological and Socio-economic Context of the Assessment Area

The objective of the Ecological and Socio-economic Context module is to describe the ecological context of the assessment area by identifying the predominant physical or biological factors that create ecological patterns. This description is linked to the companion Historic Range of Variation (HRV) Assessment by including a brief summary of the nature of important natural disturbances and anthropogenic influences.

This module also describes the social and economic context of the assessment area so that known socioeconomic factors that influence ecological condition in significant ways are identified. In this description, general spatial and temporal human geographic patterns are presented as well as important broad scale patterns of resource management and land uses that influence vegetation condition, landscape pattern, and ecosystem function. The social and economic components of this module should not be considered a substitute for a comprehensive socio-economic assessment. Rather, the presentation should draw upon information from existing socio-economic assessments and should just identify the predominant socio-economic components relevant to interpreting current and future ecological condition. The HRV Assessment for the area should provide a historical context for land use patterns.

This module along with the HRV Assessment describes physical and biological templates along with the disturbance processes and socio-economic factors acting on these templates, which are pertinent to understanding and interpreting the current ecological conditions.

The following topics are addressed in the Ecological and Socio-economic Context Module:

(1) Biogeographic significance of the assessment area.
(2) Climatic influences and important patterns of climate change.
(3) Physiography and ecogeography.
(4) Potential natural vegetation and historic disturbance regime summary.
(5) Wildlife influences.
(6) Socio-economic and anthropogenic influences.
(7) Summary of significant information gaps

Details on the content of each topic are reflected in the assessment outline (Appendix A).

Data and Analytical Requirements

The data required to develop this module are largely available in the Rocky Mountain Region's Integrated Resource Inventory (IRI) data or other resource data sets, from other agencies or entities, from published literature, and from the HRV Assessment(s) relevant to the assessment area. Developing maps of Potential Natural Vegetation (PNV) may require additional analytical work (Appendix C). Table 3.1 details descriptions of these data and sources of the information.

Potential Natural Vegetation Classification

Classifications of potential natural vegetation (PNV), and maps representing the classifications, should reflect the most current knowledge of relationships between vegetation and land units. They should be based on appropriate research and the current literature, and should be presented at a scale most appropriate to the assessment. Kuchler's Potential Vegetation Classification of the United States (1964) and the Bighorn National Forest are represented by very coarse resolution maps in Figures 3.1a-b.

More appropriate to the scale of analysis in the assessment are the Forest-wide PNV classifications and associated maps. Forest Service research, universities, The Nature Conservancy, State Heritage programs, and efforts by individual Forests have developed

Table 3.1. Data required for describing the ecological and socio-economic context of the Current Landscape Condition Assessment (Module II).

Ecological Context Attribute[1]	Spatial Extent of Description or Analysis[2]	Data Resolution	Ecosystem Stratification Unit[4]	Data Source[5]
Climate				
Influences (macro-topographic)	Ecosubregion	1:500,000	Section	Locally relevant published literature: 1) Hoffman and Alexander (1976), 2) Despain (1973), 3) Girard et al. (1997), and 4) Nesser (1986)
Precipitation	Ecosubregion	1:500,000	Section	Locally relevant published literature: 1) Hoffman and Alexander (1976), 2) Despain (1973), 3) Girard et al. (1997), and 4) Nesser (1986). Locally relevant web data: *http://www.ocs.orst.edu/prism/prism_new.html* and *http://www.wrcc.dri.edu/summary/climsmwy.html*.
Temperature	Ecosubregion	1:500,000	Section	Locally relevant published literature: 1) Hoffman and Alexander (1976), 2) Despain (1973), 3) Girard et al. (1997), and 4) Nesser (1986). Locally relevant web data: *http://www.ocs.orst.edu/prism/prism_new.html* and *http://www.wrcc.dri.edu/summary/climsmwy.html*.
Wind	Ecosubregion	No map	Section to Sub-province level	Locally relevant web data: *http://www.wrcc.dri.edu/summary/lcd.html*
Historic Climate Changes	Ecosubregion	No map	Section to Sub-province level	Locally relevant published literature: Meyer and Knight (2001).
Geology				
Formation	State	1:500,000	Section	State Geological Survey
Parent Material	National Forest	1:24,000	Subsection; LTA	Forest IRI data – Common Land Unit (CLU) data
Soils				
Suborder/Great Group	State	1:500,000	Section	State Surgo Soils Map
Suborder/Great Group	Section	1:500,000	Section	National Ecological Hierarchy (TEUI), Forest IRI Common Land Unit (CLU) data
Great Group/Subgroup	Section	1:500,000	Subsection	National Ecological Hierarchy (TEUI), Forest IRI Common Land Unit (CLU) data
Family/Series	National Forest	1:62,000	Subsection; LTA	National Ecological Hierarchy (TEUI); Forest IRI CLU data
Family/Series	National Forest	1:24,000	3-4 order soil map unit	NRCS / USFS Soil Map and Forest CLU data

Table 3.1 (continued). Data required for describing the ecological and socio-economic context of the Current Landscape Condition Assessment (Module II).

Ecological Context Attribute[1]	Spatial Extent of Description or Analysis[2]	Data Resolution	Ecosystem Stratification Unit[4]	Data Source[5]
Geography (Eco-hierarchy)				
Domain	Ecoregion	Subcontinental	Domain	Bailey (1995); *http://www.fs.fed.us/colorimagemap/ecoreg1_domains.html*
Division	Ecoregion	Regional	Division	Bailey (1995); *http://www.fs.fed.us/colorimagemap/ecoreg1_divisions.html*
Province	Ecoregion	Regional	Province	Bailey (1995); *http://www.fs.fed.us/colorimagemap/ecoreg1_provinces.html*
Section	Ecosubregion	Regional	Section	McNab and Avers (1994).
Subsection	Ecosubregion	Subregional	Subsection	Locally relevant published literature: Reiners et al. (1999).
Landtype Association	Landscape	Local	LTA	Forest IRI-CLU data.
Landtype Association	Land Unit	Local	LTA	Forest IRI-CLU data.
Potential Natural Vegetation Model Components				
Existing Dominant Vegetation Series	National Forest	1:24,000	Vegetation Type	National Ecological Hierarchy (TEUI), Forest IRI CVU data
Existing Soil Conditions	National Forest	1:24,000	LTA	Forest IRI CLU data
Elevation	Statewide	30m	Section	30m DEM
Land Type Association	National Forest	1:24,000	Subsection or LTA	Forest IRI data
Wildlife				
Wildlife species composition changes (historical/present)	Ecosubregion		Section	Literature, websites, old FS files, State game and fish data
Population changes	Ecosubregion		Section	Literature, websites, old FS files, State game and fish data

Table 3.1 (continued). Data required for describing the ecological and socio-economic context of the Current Landscape Condition Assessment (Module II).

Social / Economic Context Attribute[1]	Spatial Extent of Description or Analysis[2]	Temporal Scale of Description or Analysis[3]	Data Resolution[4]	Ecosystem Stratification Unit[5]	Data Source[6]
Historical Context					
Logging	Subregion, Landscape	20th century	1:24,000	Section, LTA	Historical records, Forest Plan monitoring data and activities databases
Grazing	Subregion, Landscape	20th century	1:24,000	Section, LTA	Historical records; Forest Allotment Boundaries and range inventory data in 2210 allotment folders
Current Resource Uses					
Logging	National Forest	Current Forest Plan Period	1:24,000	LTA, Cover Type	Forest Plan monitoring data and activities databases
Grazing	National Forest	Current Forest Plan Period	1:24,000	LTA, Cover Type	Forest Allotment Boundaries and range inventory data in 2210 allotment folders
Recreation	National Forest	Current Forest Plan Period	1:24,000	LTA, Cover Type	Forest Plan monitoring data and activities databases. Forest Travel Routes data
Social and Economic Trends					
Social and Economic Data[7]	State, County	Past decade, Current, Next decade	1:500,000	County	US Census Bureau, State Economic Information Agencies (*http://eadiv.state.wy.us/index.html http://ceic.commerce.state.mt.us/Census2000.html)*
Population Trends	Regional	Recent past and 10-50 years into future	1:500,000	State	*http://www.centerwest.org/futures/development*
Land Ownership	Subregion, Landscape, National Forest	Current time	1:500,000	Section,LTA, County	GAP Land Ownership data- State GAP Programs – *www.gap.uidaho.edu,* State and local ownership data

[1]Social / Economic Context Attribute is the specific map layer or piece of data required to assess the different topics.
[2]Spatial Extent of Description or Analysis is the geographic extent used in the assessment, which defines the overall area encompassed in the assessment.
[3]Temporal Scale of Description or Analysis is the time period used in the assessment.
[4]Data Resolution is the "grain" of the data. Grain refers to the size of the individual units of observation that are necessary to observe the process or characteristics of interest (Wien 1989). Grain is often reflected in the mapping scale, the minimum mapping unit, or some descriptive feature of the system.
[5]Ecosystem Stratification Unit defines the geographic units used for data summarization in the assessment.
[6]Data Source gives suggestions or references that can be used to find more information related to the assessment.
[7]Social and Economic Data includes population, age, employment, income, education, poverty, ethnicity, etc.

PNV classifications under various inventory efforts. The consistency among classifications and understanding of the PNV concept vary within Region 2. Johnson (19__) provides a literature review of Region 2 classifications but was not based on an analysis of data sets. The Nature Conservancy has defined a classification framework and defined the first iteration of U.S. plant communities within Region 2 and continues to work with agency and other partners to refine the classification (Anderson et al. 1998; Grossman et al. 1998; Maybury et al. 1999). The Ecological Society of America has an ongoing program to standardize vegetation classification and coordinate vegetation classification activities (http:// *www.esa.org/vegweb*). USFS guidance on developing existing vegetation classification and mapping is also being developed (Brewer et al. 2002).

Recent national Terrestrial Ecological Unit Inventory (TEUI) criteria identify the need for developing adequate PNV maps but, until recently, they have neglected the much needed updating of classifications. The approach now emphasizes the value of developing vegetation classifications before developing maps of ecological units (Winthers et al. 2001).

In most cases, Forests in Region 2 will currently have available PNV maps of varying quality. In some cases, classifications and other literature sources are not available and in other cases available information has not been incorporated into PNV layers in Forest Service resource data sets. Therefore, an adequate representation of PNV will not be readily available for many assessment areas.

In developing a Current Landscape Condition Assessment, the assessment team should assess the suitability of existing PNV layers. If existing maps are inadequate in reflecting available classifications and other literature, they can be strengthened with a simple GIS modeling approach described in Appendix C. The suggested approach depends on local expert knowledge, couples IRI Common Land Unit (CLU) and IRI Common Vegetation Unit (CVU) and other appropriate data (e.g., including knowledge of successional stages), and develops a "series" level PNV map that can be cross-walked to available existing vegetation coverages, and presents information at a scale suitable for the assessment. An example is shown in Figure 3.1c for the Bighorn National Forest.

Relevance to Management Applications

An important objective of the Current Landscape Condition Assessment is the identification, location, and description of the ecological features of the landscape. Module II provides the basis for meeting this objective. In addition, to developing the analytical and synthetic portions of the assessment, it is critical to have a fundamental understanding of underlying factors that drive ecosystem pattern and that define the ecological capabilities of systems. Several analytical aspects of the assessment rely on knowledge built into this module. For example, the development of the PNV map is dependent on an understanding of several factors including soil patterns and productivity. The development of a map of historic fire regimes is based on a spatial representation of PNV. Further, it is impossible to make determinations about the ecological integrity of existing systems without a basic understanding of ecological potential. And, it is difficult to develop sustainable designs for future landscapes without this understanding at all of the relevant scales (Bailey 2002).

The 270 million citizens of the United States own the National Forest System lands. These lands have been used by humans for thousands of years as a source of food and fiber, and continue to be prized today for wood products, outdoor recreation opportunities, clean water and many other "multiple uses." The variety of historical and contemporary uses have created legacies in ecosystem composition, structure, and function that are important to consider in evaluating the current and expected future ecological condition (Romme et al. 2000). In addition, expected future trends in human demographic patterns and resource uses should be factored into developing an understanding of realistic expectations regarding future ecological condition (Riebsame 1997). Management decisions for National Forest System lands today must be made with the knowledge of people's previous and current interactions

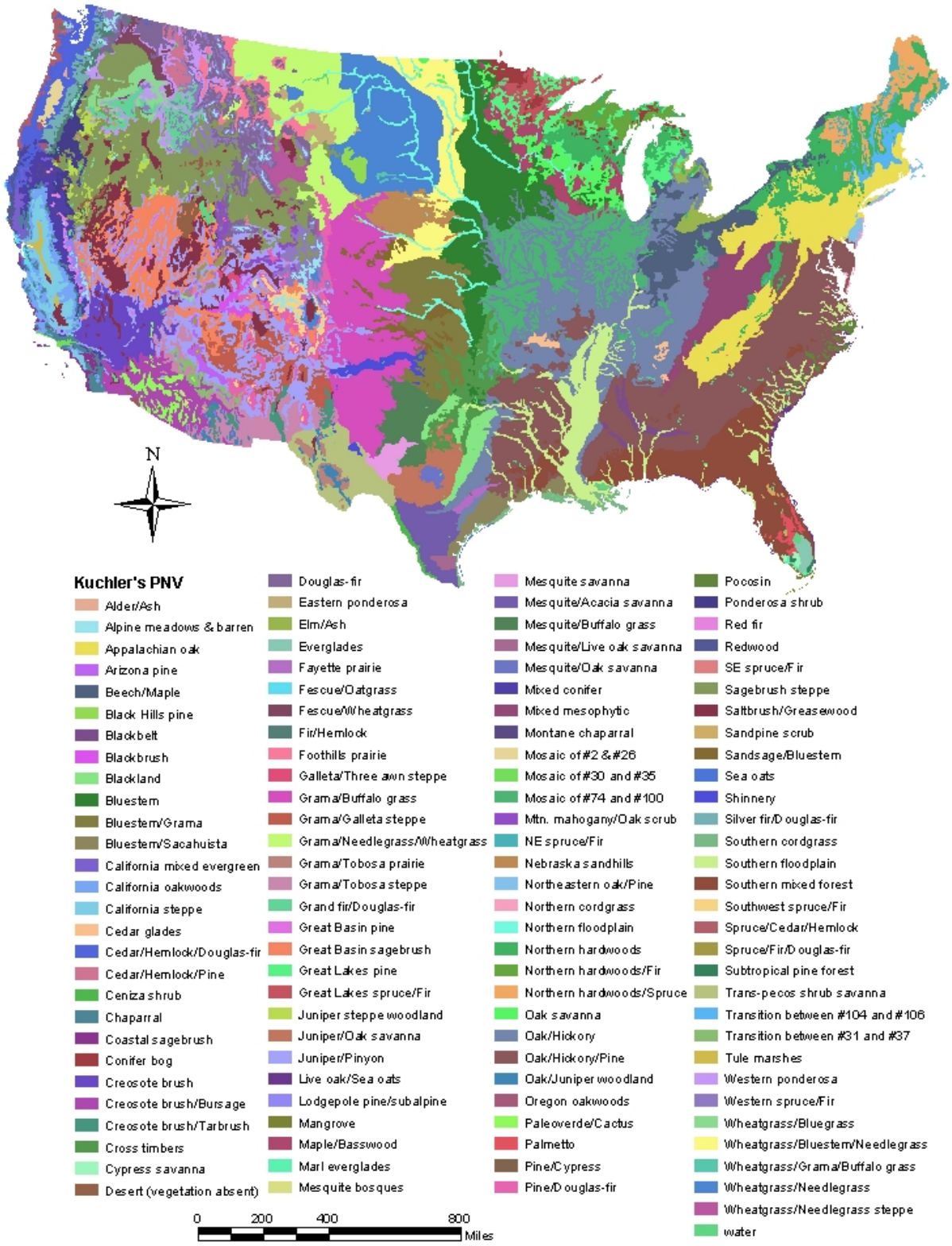

Figure 3.1a. Kuchler's Potential Natural Vegetation Map of the United States.

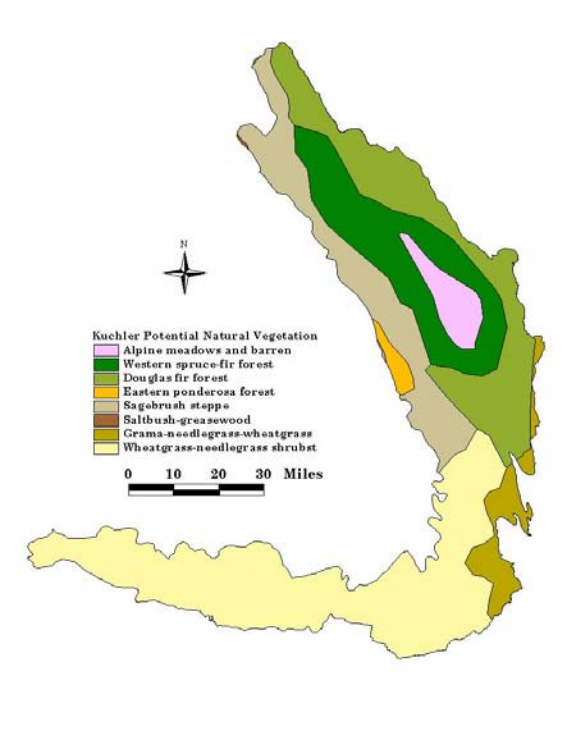

Figure 3.1b. Kuchler's Potential Natural Vegetation Map of the Bighorn National Forest.

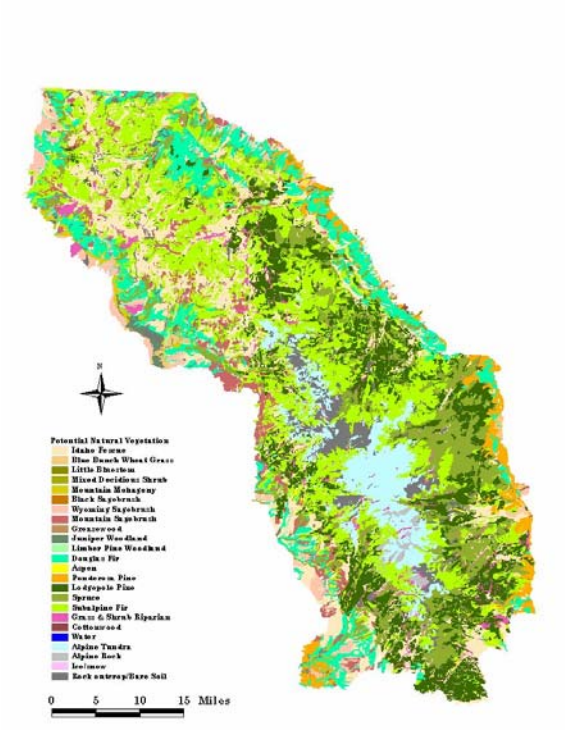

Figure 3.1c. Potential Natural Vegetation Map of the Bighorn National Forest generated by the Bighorn Ecosystem Assessment Team.

with the resource, and some idea of future societal demands. The variables and uses explored in this module provide a context in which to consider human interactions within our National Forests.

Existing Vegetation Condition

Module 3A: Forests and Woodlands
Module 3B: Grasslands and Shrublands

This section provides an evaluation of the current vegetation condition within the assessment area and is divided into two modules: (A) Forests and Woodlands and (B) Grasslands and Shrublands. The objectives of these modules are to describe the current composition, structure, spatial distribution, and key functional aspects. This component should also include an evaluation of the current condition in the context of what is known about ecosystem capability and the historic range of variation e*xcept* in those cases where this was already accomplished by the Historic Range of Variation (HRV) Assessment.

Modules 3A and 3B are organized by major vegetation types so that the assessment contains an existing vegetation description for each major type. Existing vegetation condition is primarily focused on a consideration of those features of the vegetation that are typically considered as stand-level attributes or can be considered one vegetation type at a time. Landscape-level attributes that may transcend a particular vegetation type and specific analyses of natural disturbance or management influences are addressed in later assessment components. The following topics are addressed for each vegetation type described in the Existing Vegetation Condition Module:

(1) Composition - spatial distribution in the assessment area, characteristic dominant species and associates in each type, known plant associations, and successional characteristics.
(2) Structure – spatial distribution of habitat structural stages, stand ages, and old-growth (or old) forests and patterns of variation within stand structural components such as snags, coarse woody debris, and canopy cover.
(3) Function – general patterns of functional characteristics such as ecosystem productivity, carbon storage, and habitat.
(4) Ecological integrity – degree of presence or absence of expected elements of the vegetation.
(5) Summary of key findings and significant information gaps.

Details on the content of each topic are described in the assessment outline (Appendix A). Table 3.2 defines the analysis components needed to provide a comprehensive description of the current forest and woodland, and grassland and shrubland vegetation condition.

Table 3.2. Analysis components required to describe the existing vegetation condition of each major vegetation type in an assessment area (Modules 3A and3B).

Scale	Analysis Components
Ecosubregion: Section	• Map reflecting current distribution of the vegetation type in the section. • Brief narrative description of the vegetation type (composition, physiognomy, etc). • Summary of importance or extent of the vegetation type within the section. • Narrative description of habitats occupied by the vegetation type.
Ecosubregion: National Forest	• Map reflecting current distribution on the Forest. • Summary of importance or extent of the vegetation type within the Forest. • Comparison of current distribution with potential distribution across the Forest. • Broad compositional characteristics of the vegetation type. Described plant associations known to occur on the Forest. • Expected successional trajectories of each major vegetation type under various disturbance influences. • Important functional attributes of each major vegetation type (e.g., carbon storage, net primary production NPP), and natural disturbance processes). • Broad structural characteristics of the vegetation type. For Forest and Woodland module, maps reflecting habitat structural stage distribution stand age distributions, and old-growth (or old) forest distributions for each cover type. For Grassland and Shrubland Module, maps reflecting age or height classes of shrublands, if known. • Land uses or management practices influencing the vegetation type. Summary of spatial and temporal variation in these influences.
Ecological Landscape: Land Type Association	• Compositional characteristics of the vegetation type within each LTA. Relative proportions of major species in each vegetation type. • Important functional attributes of each major vegetation type (e.g., NPP). • For Forest and Woodland Module, summary of variation in structural condition, developmental stage (e.g., old-growth or older forest). • Seral stage distribution between LTAs. • For Forest and Woodland Module, summary of patterns of and variation of within stand structures (e.g., snag density, coarse woody debris, age, diameter distributions, etc.) between LTAs.
Management Landscape: Mid-scale Planning Units	• Compositional characteristics of the vegetation type within each mid-scale planning unit. Relative proportions of major species in each vegetation type. • For Forest and Woodland Module, summary of variation in structural condition, developmental stage (e.g., old-growth or older forest). • Seral stage distribution among mid-scale planning units. • For Forest and Woodland Module, summary of patterns of and variation in within stand structures (e.g., snag density, coarse woody debris, age, diameter distributions, etc.) among mid-scale planning units.
Stand	• Species composition measured in density, cover, or some measure of abundance. • Within stand measures of structural complexity (e.g., snags, coarse woody debris, canopy layers, canopy cover, etc.). • For Forest and Woodland Module, within stand age-class and diameter distributions.

Data and Analytical Requirements

The data required in the Existing Vegetation Condition Module are largely available in the Rocky Mountain Region's (Region 2) IRI data or other resource data sets, from other agencies or entities, from published literature, and from any Historic Range of Variation Assessment(s) done in the assessment area. Where data do not exist to address a component, the information gap should be identified as an inventory or research need. Table 3.3 defines the data and sources of the information required for this component.

Relevance to Management Applications

When land management decisions are intended to meet multiple resource objectives, approaches designed to sustain system function and processes over appropriate temporal and spatial scales play a critical role in providing for ecosystem and species conservation (Groves et al. 2002). Understanding of ecosystem processes and the resulting patterns of composition and structure can suggest system-based strategies for maintaining appropriate ecological conditions that contribute to species viability (Bisson et al. 1997; Hunter et al. 1989; Samson 2002). Many species are at risk due to changes in ecological processes that have affected vegetation composition and structure and altered species interactions (Knopf and Samson 1997; Wilcove 1999). The Existing Vegetation Condition component of this assessment intends to generate the detailed understanding of current structural and compositional conditions of the forest vegetation that is required to evaluate the habitat quality of each vegetation type within the assessment area. To the extent that structural and compositional data are available for the assessment, habitat requirement information from the species assessments can be considered in the context of the Existing Vegetation Condition product to make determinations about the adequacy of the current condition in providing for particular species or groups of species.

Table 3.3. Data required for the Existing Vegetation Condition Modules of the Current Landscape Condition Assessment (Modules 3A and 3B).

Current Vegetation Condition Attribute[1]	Spatial Extent of Description or Analysis[2]	Data Resolution[3]	Ecosystem Stratification Unit[4]	Data Source[5]
Composition				
GAP land cover of each type	Section	1:500,000	Vegetation Type	Locally relevant published data: {Wyoming GAP (Merrill et al. 1996) and Montana GAP (Fisher et al. 1998)}. State GAP Programs – *www.gap.uidaho.edu*
CVU cover of each type	National Forest	1:24,000	Vegetation Type	Forest IRI Data – Common Vegetation Unit (CVU)
Described plant associations	LTA		Vegetation Type	Locally relevant published data: Welp et al. (2000); USDA Forest Service (1986); Mueggler and Stewart (1980); Tweit and Houston (1980). Locally relevant web data: *http://svinet2.fs.fed.us/database/feis/*
Dominant/important species	LTA		Vegetation Type	Locally relevant published data: Welp et al. (2000); USDA Forest Service (1986). Locally relevant web data: *http://svinet2.fs.fed.us/database/feis/*
Structure				
Habitat structural stage	National Forest	1:24,000	LTA	Forest FIA, FSVEG, and IRI-CVU data
Stand age distributions	National Forest	1:24,000	LTA	Forest FIA and FSVEG data
Diameter-class distributions	National Forest	1:24,000	LTA	Forest FIA, FSVEG, and IRI-CVU data
Stand Density	National Forest	1:24,000	LTA	Forest FIA and FSVEG data
Snag Density	National Forest	1:24,000	LTA	Forest FIA and FSVEG data
Coarse Woody Debris	National Forest	1:24,000	LTA	Forest FIA and FSVEG data
Canopy Complexity	National Forest	1:24,000	LTA	Forest FIA and FSVEG data
Function				
Carbon Storage				Published literature
Productivity	National Forest	1:24,000	LTA	Forest IRI CLU and locally relevant published data: USDA Forest Service (1986); local range inventory data in 2210 allotment folders; Mueggler and Stewart (1980; 1981), USDA NRCS (1988). Locally relevant web data: *http://svinet2.fs.fed.us/database/feis/*
Disturbance processes	LTA	1:24,000	Section	Locally relevant published data: Welp et al. (2000). Locally relevant web data: *http://svinet2.fs.fed.us/database/feis/*

Table 3.3 (continued)

Management Influences				
Grazing	National Forest	1:24,000	Subsection LTA	Forest Allotment Boundaries and range inventory data in 2210 allotment folders; locally relevant published data: Meyer and Knight (2001)
Silviculture	National Forest	1:24,000	Subsection; LTA	Forest Activities and Forest Plan monitoring databases; published literature; soil survey Timber Activities Database

[1]Current Vegetation Condition Attribute is the specific map layer or piece of data required to assess the different topics.
[2]Spatial Extent of Description or Analysis is the geographic extent used in the assessment, which defines the overall area encompassed in the assessment.
[3]Data Resolution is the "grain" of the data. Grain refers to the size of the individual units of observation that are necessary to observe the process or characteristics of interest (Wien 1989). Grain is often reflected in the mapping scale, the minimum mapping unit, or some descriptive feature of the system.
[4]Ecosystem Stratification Unit defines the geographic units used for data summarization in the assessment.
[5]Data Source gives suggestions or references that can be used to find more information related to the assessment.

Influences on Landscape Condition

The existing vegetation condition and landscape pattern of a forest is a culmination of historic natural disturbance, anthropogenic management, and anthropogenic uses, therefore this section provides a detailed description of these influences on the landscape. These influences are addressed at the landscape level rather than by vegetation type to reveal a clearer picture of landscape pattern and assessment area condition than would be possible with a focus on a particular vegetation type. This component is a compilation of seven modules:

A. Wildfire, Insects, and Disease;
B. Management of Forest and Woodland Ecosystems;
C. Management of Grassland and Shrubland Ecosystems;
D. Invasive Plant Species;
E. Roads and Trails;
F. Recreation and Exurban Development;
G. Minerals, Oil, and Gas Exploration and Extraction.

Each module has its own separate objective, analysis components, and data sources as described below.

Module 4A: Wildfire, Insects, and Disease

The objective of this module is to provide a spatial representation of the current landscape condition associated with fire, insects, and disease. A map of expected historic fire regimes is developed. The current condition of the landscape with respect to fire is then displayed as a measure of the departure from historic conditions, as a measure of the probable hazard of severe fire, and as a measure of the probability of wildfire occurring. Maps reflecting current fire hazard conditions under different climate scenarios should be evaluated. Areas of ecological risks associated with wildfire hazard are determined based on intersections of high HRV departure, high fire hazard, and high fire probability and specific resource values of interest. Maps of areas of recent insect activity as well as maps of areas of high risk of insect activity are presented and the intersection of wildlife hazard and insect risk is displayed. The following topics are addressed:

(1) Spatial distribution of historic fire regimes.
(2) Spatial patterns of departure from historic fire regime.
(3) Spatial patterns of fire hazard conditions.
(4) Spatial patterns of ecological risks associated with fire.
(5) Spatial patterns of insect activity and insect risk.
(6) Identify and discuss risks associated with the interaction of fire with old growth or older forests.
(7) Spatial patterns of interaction between risks associated with insects and fire.

Details on the content of each topic are reflected in the assessment outline (Appendix A). Table 3.4 illustrates the analysis needed to provide a comprehensive description of the current landscape condition with respect to natural disturbance processes and an evaluation of the ecological risks associated with that condition. The ecological risks associated with fire and soil erosion, sedimentation, and other measures of watershed sensitivity are addressed in the *Conceptual Framework and Protocols for Conducting Multiple Scale Aquatic, Riparian, and Wetland Ecological Assessments* (Winters et al. 2003).

Table 3.4. Analysis components required to address the spatial patterns of wildfire, insects, and disease on the ecological condition of the terrestrial ecosystem (Module 4A).

SCALE	Analysis Components
Ecosubregion: Section	• Narrative description of important natural disturbance agents currently acting on ecosystems of the assessment area. • Narrative summary of expected disturbance effects on landscape pattern.
Ecosubregion: National Forest	• Map reflecting fire regimes (frequency and severity) based on expected patterns under historic range of variation. Narrative description of spatial variation of historic fire regimes. • Narrative description and map of current condition as measured by departure from historic fire regime (e.g., the degree of effect of fire exclusion on the current vegetation condition). • Narrative description and map of the current condition of probable wildfire hazard under contrasting climate scenarios. • Table showing the probability of wildfire occurring in short and in long interval fire regimes within the next 10 years. • Narrative description and maps of areas of recent insect activity and levels of risk of disturbance from insects. • Narrative description and maps of areas of recent disease occurrences and levels of risk.
Ecological Landscape: Land Type Association	• Summaries of variation in departure from historic fire regime and of probable wildfire hazard, organized by major vegetation type. • Summaries of variation in insect activity and risk. • Summaries of intersection of areas of high fire regime departure, high hazard of severe wildfire, and insect activity or risk, by major vegetation type.
Management Landscape: Mid-scale Planning Units	• Map of intersection of areas of high fire regime departure, high hazard of severe wildfire, and insect activity or risk. • Summaries of variation, by vegetation type, in departure from historic fire regime, probable wildfire hazard, and risk associated with insect activity. • Map depicting the last 100 years of large fire history. • Maps and summaries reflecting ecological risk associated with natural disturbance and vulnerability to invasive species. • Maps and summaries reflecting ecological risk associated with natural disturbance and old growth or older forests. • Maps and summaries reflecting ecological risk associated with natural disturbance and conservation sites. • Maps and summaries reflecting ecological risk associated with natural disturbance and existing or potential Research Natural Areas.
Stand	• Measures of historic fire regimes (e.g., frequency, extent, and patterns of severity). • Stand age structures and successional status. • Timber harvest or grazing activities that may influence natural disturbance processes. • Historic and contemporary occurrences of natural disturbance events.

Data and Analytical Requirements

The data required to develop Module 4A are largely available in the Rocky Mountain Region's IRI data or other resource data sets, from other agencies or entities, from published literature, and from the Historic Range of Variation Assessment(s) relevant to the assessment area. Where data specific to the assessment area do not exist to address a component, data from similar ecosystems can be used for purposes of the assessment but the information gap should be identified as an inventory or research need. Maps of historic fire regimes, departure from historic fire regimes, wildfire hazard, and insect risk require additional analytical work based on simple GIS-based modeling and/or available simulation models that are described in detail in Appendix E. Table 3.5 details descriptions of the data and sources of the information.

Our approach to incorporating fire ecology and fire hazard information into the assessment is intended to improve locally the national effort being done at a coarse scale and recognizes that ecological restoration concerns are not always congruent with fire hazard concerns. The fire ecology modeling to support Module 4A is conceptually similar to approaches taken to produce national maps of historic fire regime and current ecosystem condition in support of the National Fire Plan (Hardy et al. ; other Fire Plan related citations). These national or broad regional maps are very coarse in resolution, however, and do not sufficiently account for the variation in fire regimes to be applicable in our Current Landscape Condition Assessments (Figs. 3.2a-d). The fire ecology modeling results in an identification of where we might have ecological restoration concerns associated with departure from historic fire regimes. However, there may be many places on the landscape where disturbance processes are operating well within what would be expected under historic fire regimes but that may be at high risk of severe fire. These high fire hazard areas must also be identified to adequately evaluate the ecological resource concerns associated with fire.

Relevance to Management Applications

Results of this module will have three major management applications that will assist in developing vegetation management priorities and in creating landscape management prescriptions. First, the module will identify areas in need of ecological restoration due to a significant departure of current disturbance regimes from those expected under historic patterns. This will assist in prioritizing ecological restoration activities across the landscape. Second, the module will identify areas that are at high risk of ecological degradation associated with high hazards for natural disturbance. This information will further refine our understanding of management needs for mitigating disturbance hazard. Finally, the analysis will aid in an understanding of the spatial interactions among the dominant natural disturbance agents, fire, and insects.

Table 3.5. Data required for the Wildfire, Insects, and Disease Module for the Current Landscape Condition Assessment (Module 4A).

Current Natural Disturbance Condition Attribute or Risk Model Component[1]	Spatial Extent of Description or Analysis[2]	Data Resolution[3]	Ecosystem Stratification Unit[4]	Data Source[5]
Pre-European Fire Regime Map				
PNV Vegetation	National Forest	1:24,000	Vegetation Type	PNV Model Appendix C
Elevation	Section	30 meters	Vegetation Type	DEM
Departure Class Map				
Pre-European Fire Regime Map	National Forest	1:24,000	Vegetation Type	PNV Model and DEM; published literature; expert input
Map depicting the last 100 years of large fire history.	Section	1:24,000	LTA	Fire Records from the Forest and Surrounding Area; Forest Fire Atlas
Timber Activities	National Forest	1:24,000	Vegetation Type	Forest Activities Database
Wildfire Hazard Map				
Fuel Model	National Forest	1:24,000	Vegetation Type	RIS/FSVEG Data
Elevation	Section	30 meters	Vegetation Type	DEM
BEHAVE	National Forest	1:24,000	Vegetation Type	Behave Plus: Fire Modeling System (Andrews et al. 2001)
Wildfire Probability Table	National Forest		Vegetation Type	Historic Fires, Probacre – version 1.1 Witala, USFS
Insect Risk and Activity				
Current Insect Activity	National Forest	1:24,000	Vegetation Type	Forest Health and Monitoring Data
Insect Risk	National Forest	1:24,000	Vegetation Type	Forest IRI –CVU data

[1]Current Natural Disturbance Condition Attribute or Risk Model Component is the specific map layer or piece of data required to assess the different topics.
[2]Spatial Extent of Description or Analysis is the geographic extent used in the assessment, which defines the overall area encompassed in the assessment.
[3]Data Resolution is the "grain" of the data. Grain refers to the size of the individual units of observation that are necessary to observe the process or characteristics of interest (Wien 1989). Grain is often reflected in the mapping scale, the minimum mapping unit, or some descriptive feature of the system.
[4]Ecosystem Stratification Unit defines the geographic units used for data summarization in the assessment.
[5]Data Source gives suggestions or references that can be used to find more information related to the assessment.

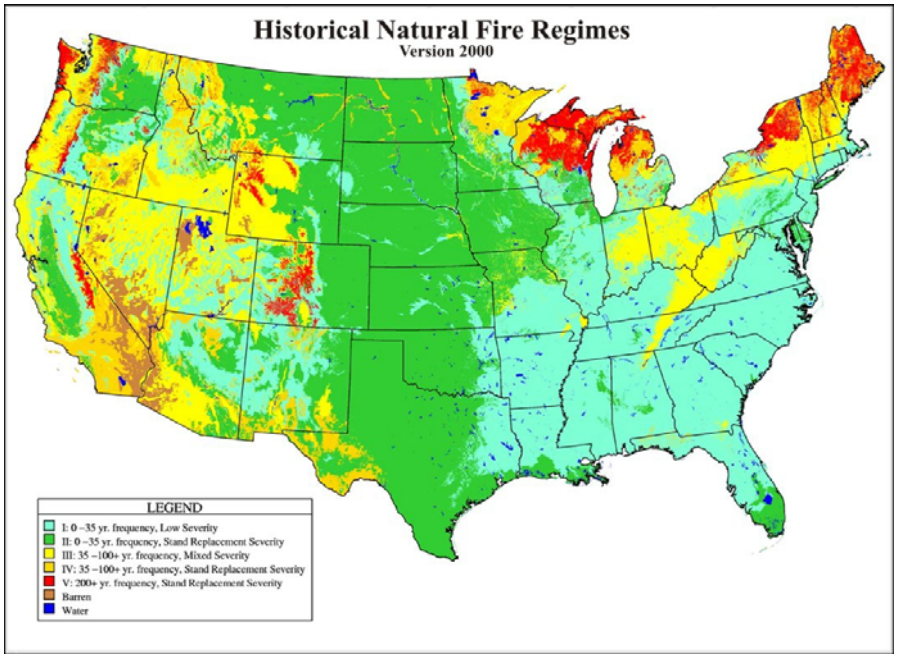

Figure 3.2a. National Fire Regime Map.

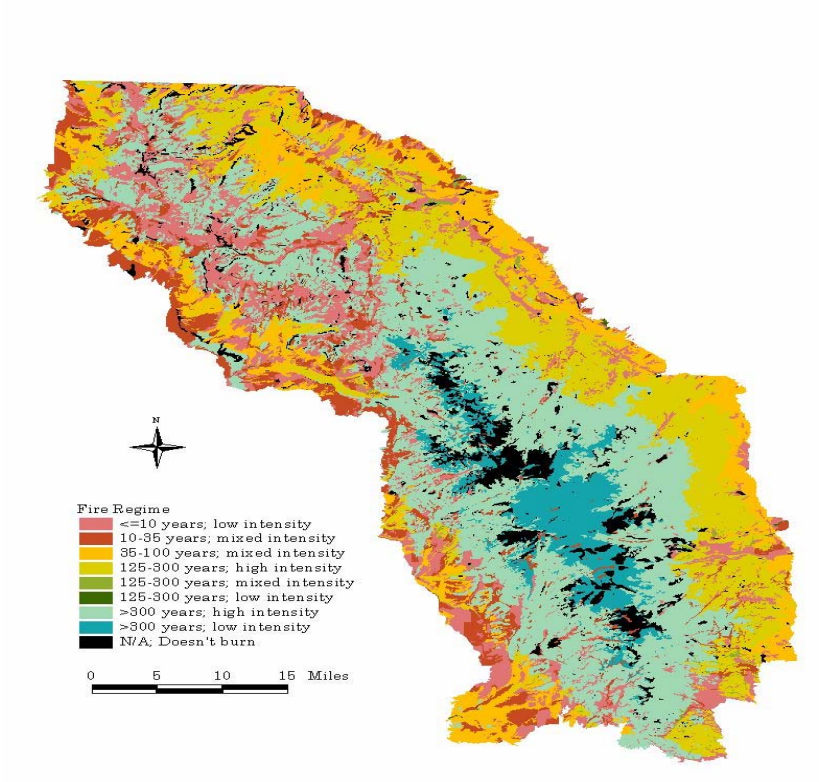

Figure 3.2b. Bighorn National Forest Fire Regime Map.

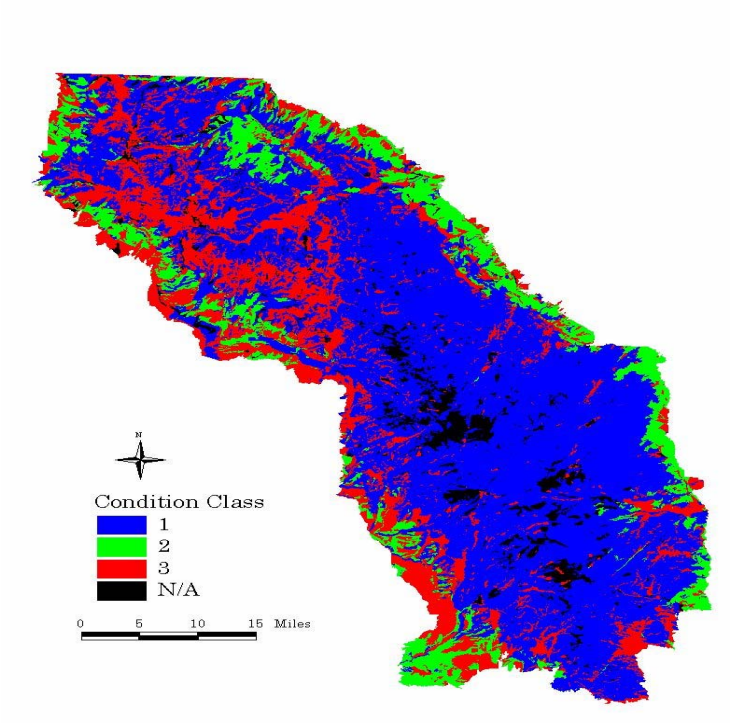

Figure 3.2c. Bighorn National Forest Condition Class Map.

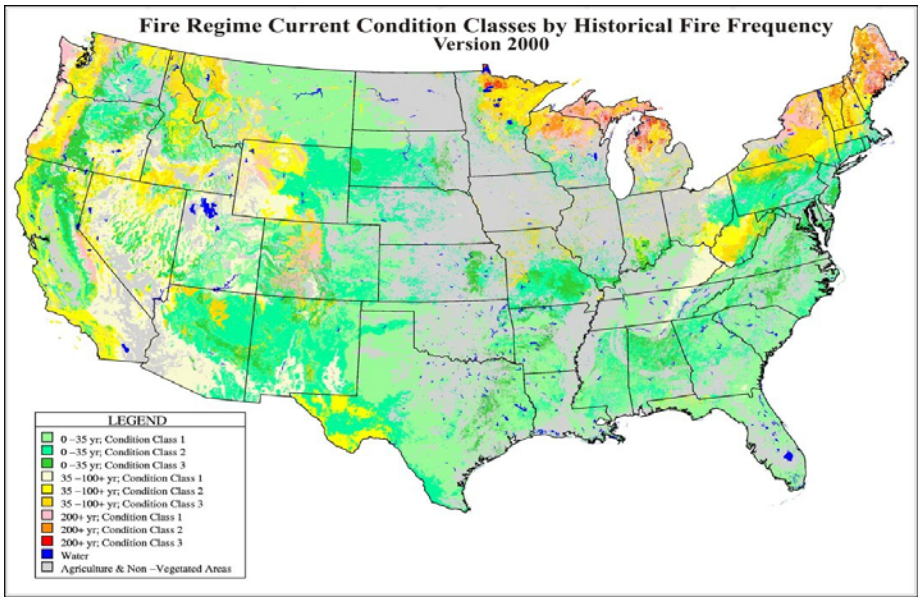

Figure 3.2d. National Condition Class Map.

Module 4B: Management of Forest and Woodland Ecosystems

The objective of Module 4B is to describe the magnitude and pattern of influences of management practices on forest and woodland ecosystems within the assessment area. The Module 4B narrative should include a discussion of current and historic silvicultural practices. To the extent that information on historic silvicultural information is available, the companion HRV Assessment should address them and can be used as a context for evaluating the effects of these practices on the assessment area. It is beyond the scope of the Current Landscape Condition (CLC) Assessment to evaluate the functional effects of these vegetation management patterns on individual species. The species-specific information contained in the species assessments must be considered against the knowledge of current condition generated by the CLC Assessment to evaluate habitat quality for a particular species. The following topics should be covered in Module 4B:

(1) Spatial and temporal patterns of current and historical timber harvest activities and various silvicultural influences.
(2) Identify and discuss dynamic interaction between risks associated with silviculture and wildfire, insects and disease.
(3) Magnitude of influences of forest and woodland vegetation management on major vegetation types.

Details on the content of each topic are reflected in the assessment outline (Appendix A). Table 3.6 illustrates the analysis needed to provide a comprehensive description of the management influences on the forest and woodland landscape condition and evaluation of the ecological integrity of that condition.

Data and Analytical Requirements

The data required for Module 4B are largely available in the Rocky Mountain Region's IRI and Activities databases or other resource data sets, from other agencies or entities, from published literature, and from the Historic Range of Variation Assessment(s) relevant to the assessment area. Where data do not exist to address a component, the information gap should be identified as an inventory or research need. Table 3.7 details descriptions of the data and sources of the information.

Relevance to Management Application

Module 4B is focused on identifying areas with probable or potential impacts from forest and woodland vegetation management activity. The information, when used in conjunction with information produced by species assessments, may aid in identifying areas of concern from a species conservation perspective or may aid in evaluating a species conservation status. This information may aid in prioritizing areas in need of ecological restoration and it may assist in designing management approaches that are most consistent with ecological constraints. The results may have particularly important applications in identifying opportunities for compatibility among ecological restoration and resource utilization goals.

Table 3.6. Analysis components required to address the spatial patterns and magnitude of the influences of management practices on forest and woodland ecosystems (Module 4B).

Scale	Analysis Components
Ecosubregion: Section	• Brief narrative description of management activities on the forested and woodland landscapes of the ecosubregion and the role of the forest.
Ecosubregion: National Forest	• Summaries of acres harvested, by silvicultural system applied, for each forest type. These summaries should reflect the overall importance of treatments (e.g., acres treated compared to total acres) in terms of acres harvested. Display maps of clearcut harvests. • Summaries reflecting temporal pattern of silvicultural treatments.
Ecological Landscape: Land Type Association	• Summaries reflecting the relative importance of influence of silvicultural practices on major vegetation types (e.g., are there disproportionate influences?). • Map and narrative describing the dynamic interaction between risks associated with silvicultural practices and wildfire.
Management Landscape: Mid-scale Planning Units	• Summaries reflecting the relative importance of influence of silvicultural practices on major vegetation types (e.g., are there disproportionate influences?). • Maps and summaries, including relative proportions, of each vegetation type and habitat structural stage permanently excluded from logging.
Stand	• N/A for an assessment of landscape condition. Relevant for analyses to support project planning.

Table 3.7. Data required for the Forest and Woodland Vegetation Management Module of the Current Landscape Condition Assessment (Module 4B).

Forest and Woodland Attribute[1]	Spatial Extent of Description or Analysis[2]	Data Resolution[3]	Ecosystem Stratification Unit[4]	Data Source[5]
Timber Harvesting Influences				
Maps reflecting spatial and temporal pattern of clearcuts	National Forest	1:24,000	LTA; Vegetation Type	Timber Activities database
Temporal patterns in silvicultural practices by vegetation type	National Forest	1:24,000	Vegetation Type	Timber Activities database
Maps reflecting the interaction between risks associated with silvicultural practices and wildfire	National Forest	1:24,000	Vegetation Type	Forest IRI – CVU data, Timber Activities database, fire hazard model (Module IV A), current condition class (Module IV A), and fire regimes (Module IV A)
Proportion of each vegetation type permanently excluded from logging	National Forest	1:24,000	Vegetation Type	Forest IRI – CVU data, Timber Activities database
Summary of forest and woodland vegetation management impacts on major vegetation types	National Forest	1:24,000	Vegetation Type	Forest IRI – CVU data, Timber Activities database

[1]Forest and Woodland Attribute is the specific map layer or piece of data required to assess the different topics.
[2]Spatial Extent of Description or Analysis is the geographic extent used in the assessment, which defines the overall area encompassed in the assessment.
[3]Data Resolution is the "grain" of the data. Grain refers to the size of the individual units of observation that are necessary to observe the process or characteristics of interest (Wien 1989). Grain is often reflected in the mapping scale, the minimum mapping unit, or some descriptive feature of the system.
[4]Ecosystem Stratification Unit defines the geographic units used for data summarization in the assessment.
[5]Data Source gives suggestions or references that can be used to find more information related to the assessment.

Module 4C: Management of Grassland and Shrubland Ecosystems

The objective of Module 4C is to describe how management practices, with a focus on livestock grazing, influence grassland and shrubland ecosystems. The Module 4C narrative should include a discussion of current and historic livestock grazing practices. To the extent that information on historic livestock grazing information is available, the companion HRV Assessment should address them and can be used as a context for evaluating the effects of livestock grazing in the assessment area. Details on the specific content of Module 4C are below. The complete assessment outline is in Appendix A.

(1) Spatial and temporal patterns of current and historic management activities, with a focus on livestock grazing.
(2) Relevant summary information from HRV Assessment.
(3) Summary of key findings and significant information gaps.

Table 3.8 illustrates the analysis needed to provide a comprehensive description of grassland and shrubland vegetation management focusing on the influence of livestock grazing.

Data and Analytical Requirements

The data required to develop Module 4C are largely available in the Rocky Mountain Region's IRI data or other resource data sets, from other agencies or entities, from published literature, and from the Historic Range of Variation Assessment(s) relevant to the assessment area. Table 3.9 details descriptions of the data and sources of the information.

Relevance to Management Application

Module 4C is focused on identifying areas with probable or potential impacts from livestock grazing activity. This information may aid in prioritizing areas in need of ecological restoration and it may assist in designing management approaches that are most consistent with ecological constraints. The results may have particularly important applications in identifying opportunities for compatibility among ecological restoration and resource utilization goals.

Table 3.8. Analysis components required to describe the influences of grassland and shrubland vegetation management in the assessment area (Module 4C).

Scale	Analysis Components
Ecoregion: Province	• Brief narrative description of grassland and shrubland management within the Province and the role of the forest.
Ecosubregion: Section	• Narrative summary of livestock grazing practices for the section. Relate these practices to the livestock grazing practices conducted on the forest and discuss significance.
Ecosubregion: National Forest	• Describe historical livestock grazing conditions and contrast them with current conditions.
Ecological Landscape: Land Type Association	• Map of range allotments and narrative describing domestic livestock stocking rates. Describe the geographic areas that are heavily stocked and the affected vegetation (if detailed vegetation data are available). • Describe the changes in the pattern of seral conditions over time. Summarize the significance of changes.
Management Landscape: Mid-scale Planning Units	• Map of range allotments and narrative describing domestic livestock stocking rates. Describe the geographic areas that are heavily stocked and the affected vegetation (if detailed vegetation data are available). • Map showing the proportion of major vegetation types permanently excluded from domestic livestock use. Describe the changes in the pattern of seral conditions over time. Summarize the significance of changes. • Map (if available) and brief summary of the vegetation type conversions that have been documented or are strongly suspected.
Stand	• N/A for landscape patterns.

Table 3.9. Data required for the Management of Grassland and Shrubland Ecosystems Module for the Current Landscape Condition Assessment (Module 4C).

Grassland/Shrubland Pattern Attribute[1]	Spatial Extent of Description or Analysis[2]	Data Resolution[3]	Ecosystem Stratification Unit[4]	Data Source[5]
Type conversions	National Forest	1:24,000	Vegetation Type	Forest range allotment data; IRI-CVU data, PNV Model (CVU, DEM, GAP)
Allotment data	National Forest	1:24,000	LTA	Forest range permit data, actual use data, and allotment/inventory data

[1]Grassland / Shrubland Pattern Attribute is the specific map layer or piece of data required to assess the different topics.
[2]Spatial Extent of Description or Analysis is the geographic extent used in the assessment, which defines the overall area encompassed in the assessment.
[3]Data Resolution is the "grain" of the data. Grain refers to the size of the individual units of observation that are necessary to observe the process or characteristics of interest (Wien 1989). Grain is often reflected in the mapping scale, the minimum mapping unit, or some descriptive feature of the system.
[4]Ecosystem Stratification Unit defines the geographic units used for data summarization in the assessment.
[5]Data Source gives suggestions or references that can be used to find more information related to the assessment.

Module 4D: Invasive Plant Species

The objective of Module 4D is to identify areas of concern regarding the distribution of exotic or invasive plant species. Current distributions of invasive plant species are identified based on known occurrences. Then, the degree of vulnerability to invasion by weedy plant species, determined by physiographic characteristics, is modeled. Existing conditions or land use factors known to contribute to invasibility are incorporated into the model to identify critical concern areas. The ecological consequences of the current condition and probable trends in invasive species distributions are described in a narrative summary. The following topics are addressed in the Invasive Plant Species Module:

(1) Map of known occurrences and current distributions.
(2) Identification of biophysical and anthropogenic influences contributing to invasibility.
(3) Geographic areas of probable vulnerability to invasion.
(4) Identification of the invasive species critical concern areas.
(5) Identification of the interaction between risks associated with invasive plant species and fire and grazing.
(6) Discussion of ecological consequences.

Details on the content of each topic are reflected in the assessment outline (Appendix A). Table 3.10 illustrates the analysis needed to provide a comprehensive description of the current landscape condition and evaluation of the ecological integrity of that condition.

Data and Analytical Requirements

Weed occurrence data are generally available from USFS resource data sets, the Forest Health Monitoring Program data, and state or county inventories. However, weed distribution maps and inventory data may be completely unavailable for some areas and are far from complete for most places. Therefore, we developed an approach to model ecosystem invasibility and to identify areas of concern due to invasibility and the presence of factors known to contribute to weed concerns. The weed vulnerability assessment and maps of areas of critical concern are developed from a GIS-based modeling approach described in Appendix D. Examples of model output are shown in Figures 3.3a-d. The data required to develop the models are largely available in the Rocky Mountain Region's IRI database and from the published literature. Table 3.11 details descriptions of the data and sources of information.

Relevance to Management Applications

Invasive species have the potential to cause serious ecological degradation and may have serious consequences on already imperiled species (Wilcove et al. 1998). Exotic and weedy species can change the composition of natural communities, threaten native biodiversity, and alter ecosystem functions such as nutrient cycling and disturbance regimes (Vitousek et al. 1997; Mack et al. 2000). Weedy plants are known to alter the natural fire regime in some ecosystems (D'Antonio and Vitousek 1992). Weedy plants may be especially problematic in rangelands where they out compete native species and reduce forage for wildlife and livestock. The impact of non-native species introductions on our ability to conserve native species is illustrated by almost half of the threatened and endangered species listed under the endangered Species Act being listed due to competition with or predation by non-native species (Pimentel et al. 2000). Human activities that disturb native plant communities and that alter natural disturbance regimes may promote the spread of weedy species. Many of the other elements of global change, such as climate change and habitat fragmentation, interact with the spread of invasive species to exacerbate the problems (Mooney and Hobbs 2000).

Table 3.10. Analysis components required to address the influence of invasive species on the ecological condition of the terrestrial ecosystem (Module 4D).

Scale	Analysis Components
Ecosubregion: Section	• Narrative description of invasive plants occurrence, distribution, and trends over time. • General description of ecological effects of invasive species including an evaluation of the extent of detrimental effects. • General discussion of effects of management practices and treatments on invasive species responses.
Ecosubregion: National Forest	• Maps of known occurrence of invasive plants. • Acres of invasive plants, spatial distribution, and trends over time. • Risk assessment that identifies areas vulnerable to invasion and spread, modeled using physiographic attributes and disturbances known to contribute to ecosystem invasibility. • General narrative describing occurrence, risk, and potential impacts.
Ecological Landscape: Land Type Association	• Summary of acres by risk category for each land type association and major vegetation type. Discussion of physiographic variation in risk. • Map and narrative describing the dynamic interaction between risks associated with domestic livestock grazing and invasive plant species.
Management Landscape: **Mid-scale Planning Units**	• Summaries of invasive plant inventory data (known occurrences and trends). • Summary of acres by risk category for each major vegetation type. Identification of geographic areas of invasive species concern. • Map of areas of critical concern and summary of acres of contributing factors. • Narrative discussion of relationship between land use or management practices and areas of risk.
Stand	• Invasive plant occurrence and abundance data. • Trend data on invasive species response to management activities. • Measures of changes in native or desirable vegetation communities and changes in effective ground cover/bare soil due to invasive species.

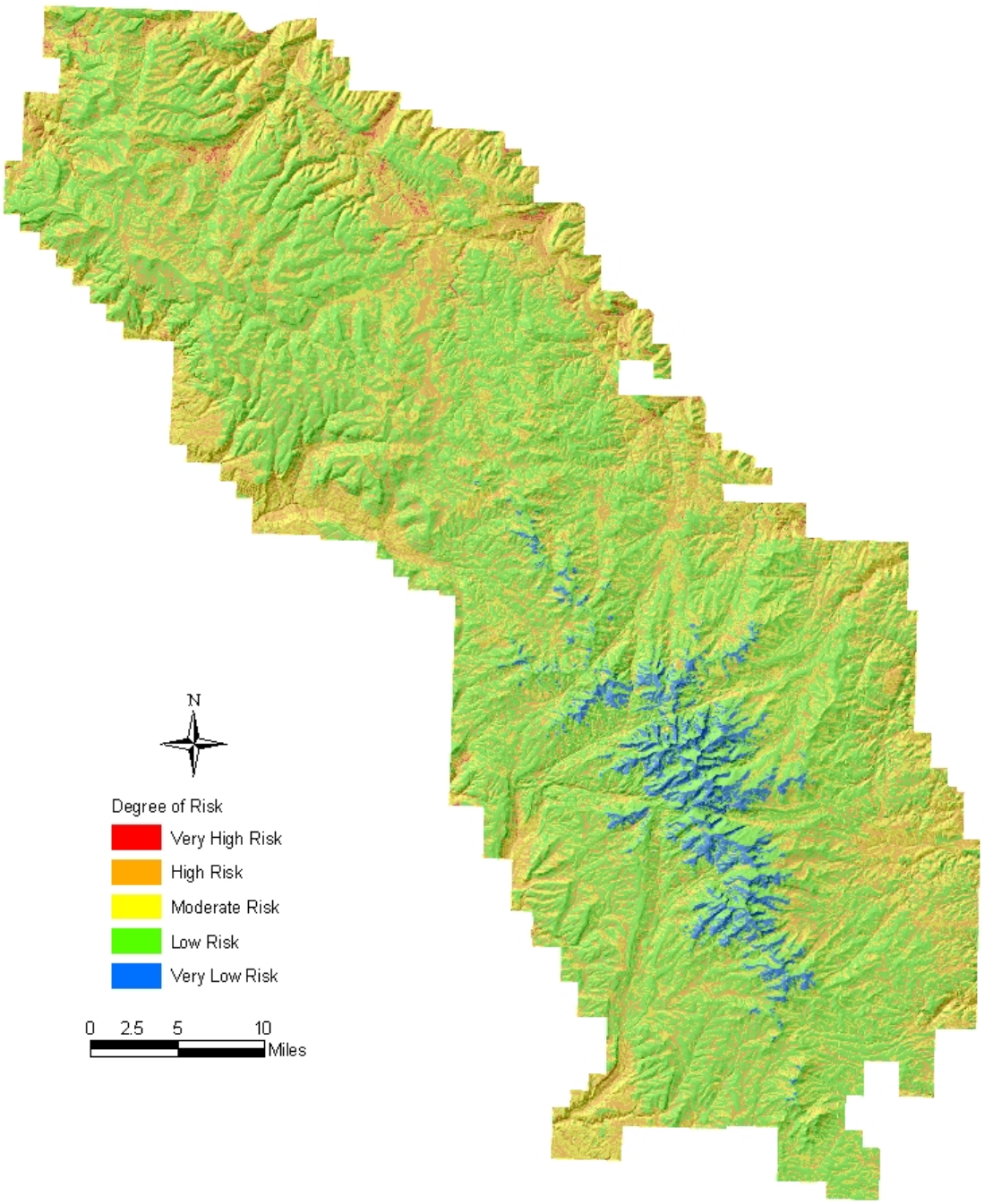

Figure 3.3a. Map showing the modeled patterns of vulnerability to invasive plant species on the Bighorn National Forest.

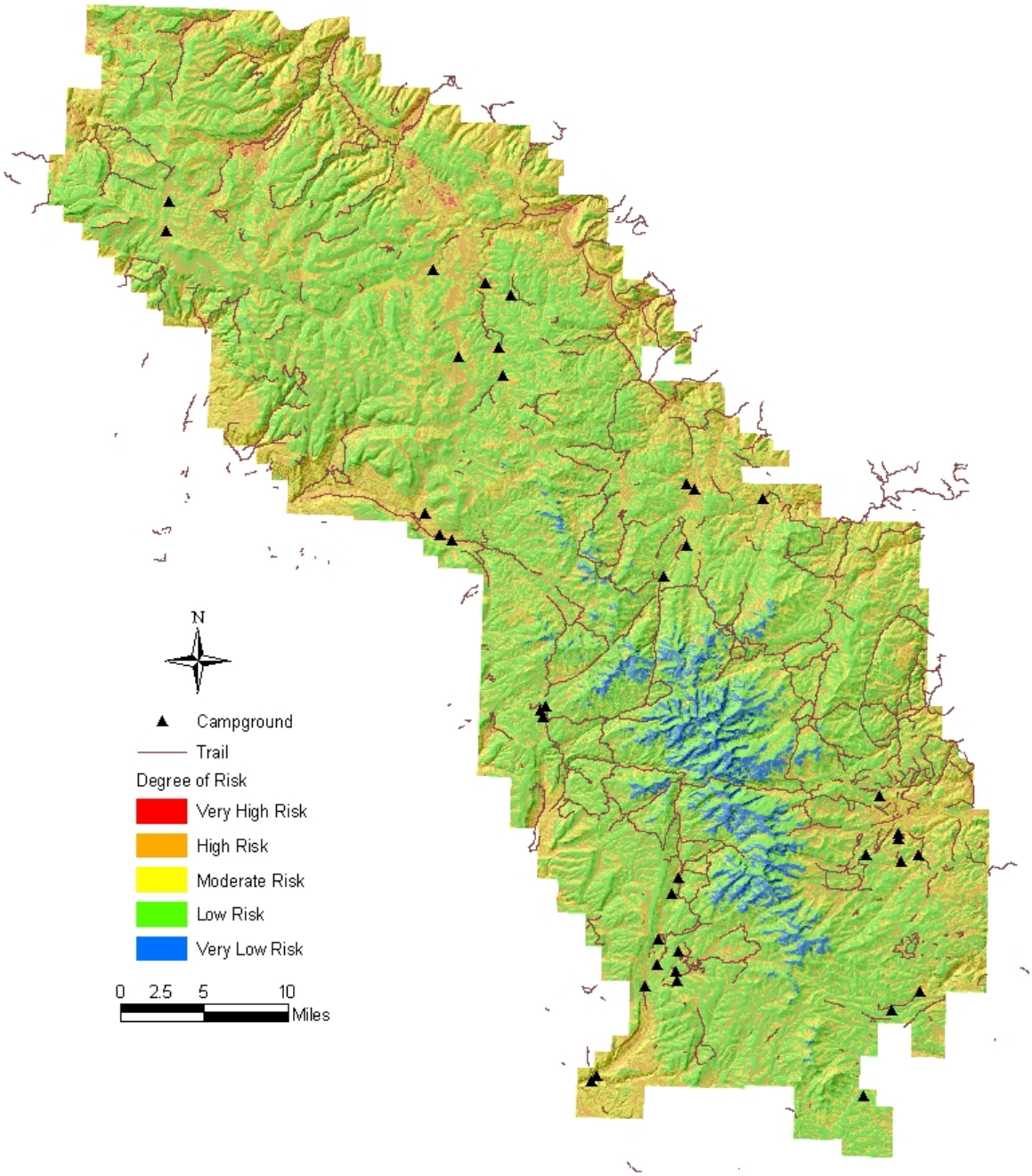

Figure 3.3b. Map showing the risk of weed invasion associated with campgrounds and trails in the Bighorn National Forest.

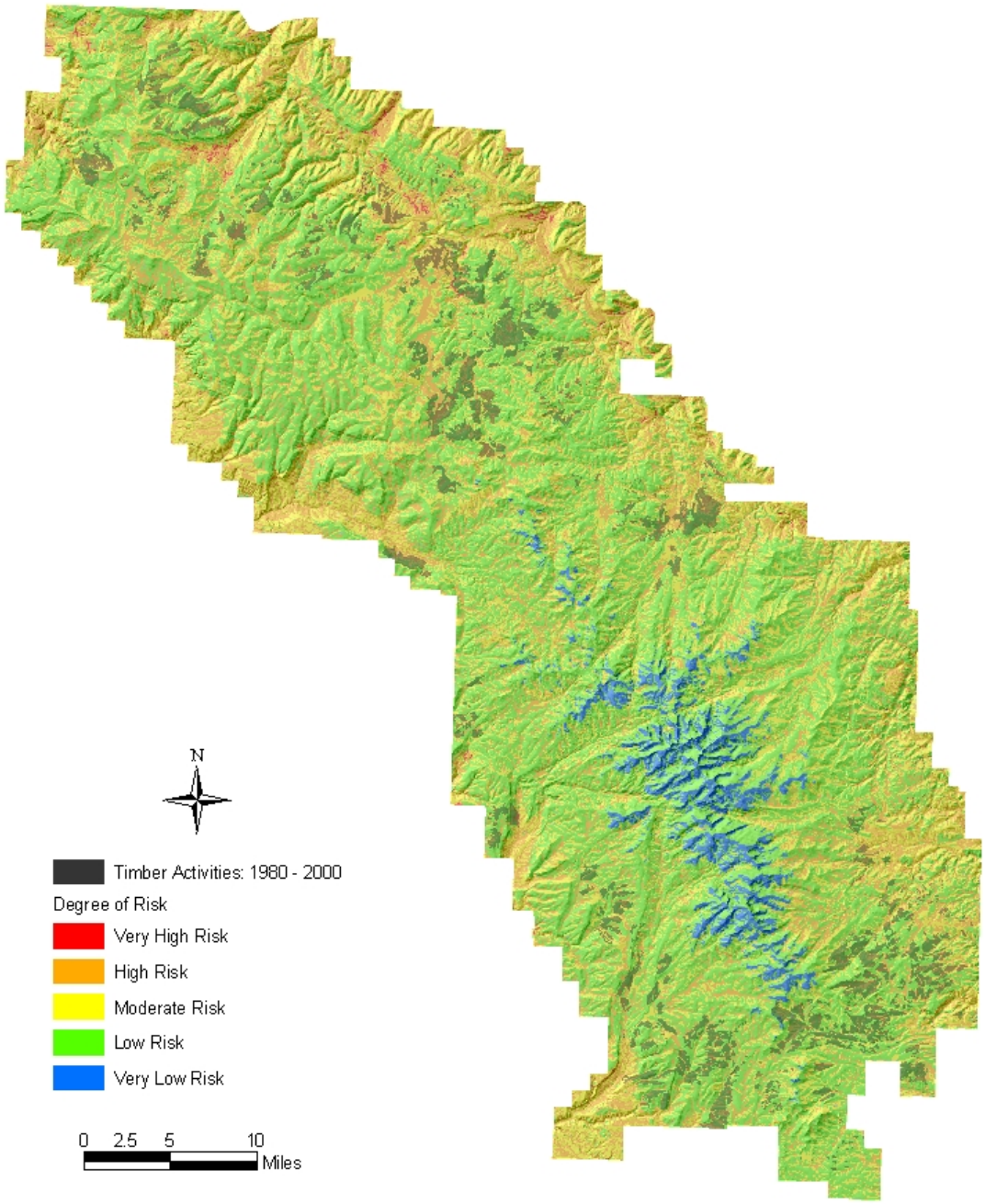

Figure 3.3c. Map showing the risk of weed invasion due to recent timber activities in the Bighorn National Forest

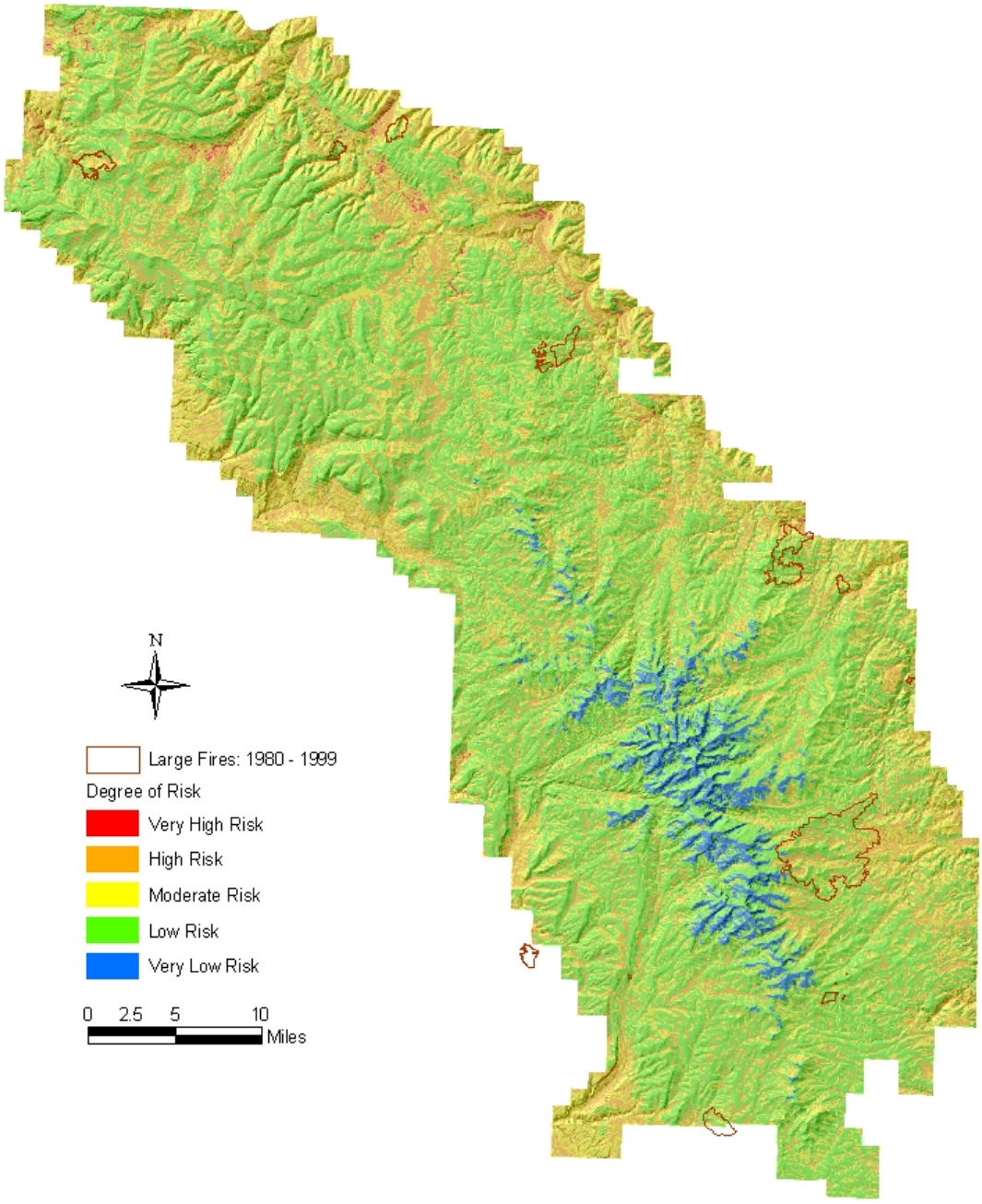

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Figure 3.3d. Map of the risk of weed invasion associated with recent large fires in the Bighorn National Forest.

Table 3.11. Data required for the Invasive Plant Species Module of the Current Landscape Condition Assessment (Module 4D).

Current Invasive Species Condition Attribute or Risk Model Component[1]	Spatial Extent of Description or Analysis[2]	Data Resolution[3]	Ecosystem Stratification Unit[4]	Data Source[5]
Occurrence Data				
Forest weed inventory – point occurrences	National Forest	1:24,000	LTA	Forest Health Monitoring Data; FIA data; or other local agencies
Other weed occurrences data	**Section**	1:24,000	LTA	Other Local, State or Federal Agencies
Trend Data	Section	1:24,000	LTA	Forest Health Monitoring Data; FIA data; or other Local, State, or Federal Agencies
Model Components				
Elevation	Statewide	30m	Section	30m statewide DEM
Canopy cover	National Forest	1:24,000	National Forest	Forest IRI data – CVU coverage
Topographic position -Aspect	Statewide	30m	Section	30m statewide DEM
Roads and Trails	National Forest	1:24,000	National Forest	Forest Travel Routes Data
Valley bottom	National Forest	1:24,000	National Forest	Valley Bottom Model
Burns	National Forest	1:24,000	National Forest	Large Fire History Coverage –from Forest
Livestock concentration	National Forest	1:24,000	National Forest	Use areas of high concentration from Livestock Preference Model
Intensive recreation	National Forest	1:24,000	National Forest	Trails from Forest Travel Routes Data, Campground, picnic area locations, ski area boundaries from Forest
Timber harvests	National Forest	1:24,000	National Forest	Forest Activities Database
Private inholdings	National Forest	1:24,000	National Forest	Forest boundary data, summer home location from Forest

[1]Current Invasive Species Condition Attribute or Risk Model Component is the specific map layer or piece of data required to assess the different topics.
[2]Spatial Extent of Description or Analysis is the geographic extent used in the assessment, which defines the overall area encompassed in the assessment.
[3]Data Resolution is the "grain" of the data. Grain refers to the size of the individual units of observation that are necessary to observe the process or characteristics of interest (Wien 1989). Grain is often reflected in the mapping scale, the minimum mapping unit, or some descriptive feature of the system.
[4]Ecosystem Stratification Unit defines the geographic units used for data summarization in the assessment.
[5]Data Source gives suggestions or references that can be used to find more information related to the assessment.

Module 4E: Roads and Trails

The objective of Module 4E is to describe the current patterns of distribution of roads and trails in the assessment area. Module 4E displays and summarizes the relationship between these patterns and distribution of major vegetation types and should identify the interaction between the risks associated with roads, trails, and invasive plant species. The product should discuss the ecological significance of these patterns, display their spatial distributions, and evaluate the ecological implications of the current condition.

Details on the content of each topic are reflected in the assessment outline (Appendix A). Table 3.12 illustrates the analysis needed to provide a comprehensive description of the current patterns of road and trail distribution and an evaluation of the magnitude of influence to each vegetation type in the assessment area.

Data and Analytical Requirements

Data to complete Module 4E are largely available in the Rocky Mountain Region's IRI data or other resource data sets, from other agencies or entities, from published literature, and from the Historic Range of Variation Assessment(s) relevant to the assessment area. Table 3.13 details descriptions of the data and sources of the information.

Relevance to Management Applications

Extensive road networks may be predominant features in some portions of the assessment areas. There are several potential negative ecological implications of roads, including serving as conduits for invasive or undesirable species (Tysor and Worley 1992), serving as barriers to mobility of some native species (Fahrig et al. 1995; Foster and Humphrey 1995), fragmenting interior habitat (citations), increasing human access to levels that may have negative species effects (Lyon 1983; Van Dyke et al. 1986; Mech 1989; Bordy and Pelton 1989; McClellan and Shackleton 1988), and increasing the sedimentation effects of surface erosion and landsliding (citations). Assessing ecological condition for biodiversity or ecosystem sustainability concerns must include a description and evaluation of the current status of road miles, density, and road-edge effects. Other human developments may have consequences similar to the effects of roads and must also be considered in the assessment.

Table 3.12. Analysis components required to address the relationship between roads and trails and the ecological condition of the terrestrial ecosystem (Module 4E).

Scale	Analysis Components
Ecosubregion: Section	• Map of roads in the assessment area. • Summary of proportional impact of roads and development on GAP landcover vegetation types.
Ecosubregion: National Forest	• Map of forest roads and trails, by class of use. • Map of buffered roads to reflect a gradient of road impact. • Summary of proportional impact of roads and trails on CVU vegetation types. • Proportion of major vegetation types at a given distance from roads and trails and buffered roads.
Ecological Landscape: Land Type Association	• Road and trail densities, summarized over all vegetation types and within vegetation types. • Proportion of major vegetation types at a given distance from roads and trails and buffered roads.
Management Landscape: Mid-scale Planning Units	• Road and trail densities, summarized over all vegetation types and within vegetation types. • Proportion of major vegetation types at a given distance from roads and buffered roads.
Stand	• N/A at the landscape level.

Table 3.13. Data required for the Roads and Trails Module of the Current Landscape Condition Assessment (Module 4E).

Roads and Trails[1]	Spatial Extent of Description or Analysis[2]	Data Resolution[3]	Ecosystem Stratification Unit[4]	Data Source[5]
Roads of the assessment area	Section	1:100,000	National Forest	TIGER Roads Database
Roads and trails of the Forest	National Forest	1:24,000	National Forest/Watersheds	Forest Travel Routes Database
Interface with Vegetation				
GAP land cover	Section	1:500,000	Vegetation Type	GAP land cover data – State GAP Programs – *www.gap.uidaho.edu*
Forest-wide vegetation cover	National Forest	1:24,000	Vegetation Type	Forest IRI-CVU data

[1]Roads is the specific map layer or piece of data required to assess the different topics.
[2]Spatial Extent of Description or Analysis is the geographic extent used in the assessment, which defines the overall area encompassed in the assessment.
[3]Data Resolution is the "grain" of the data. Grain refers to the size of the individual units of observation that are necessary to observe the process or characteristics of interest (Wien 1989). Grain is often reflected in the mapping scale, the minimum mapping unit, or some descriptive feature of the system.
[4]Ecosystem Stratification Unit defines the geographic units used for data summarization in the assessment.
[5]Data Source gives suggestions or references that can be used to find more information related to the assessment.

Module 4F: Recreation and Exurban Development Patterns

The objective of Module 4F is to describe the current patterns of distribution of recreation and exurban development features in the assessment area. Module 4F summarizes the relationship between these patterns and distribution of major vegetation types. Identification of the interaction between risks associated with recreation, exurban development and invasive plant species should be evaluated. The product should also discuss the ecological significance of these patterns, display their spatial distributions, and evaluate the ecological implications of the current condition.

Details on the content of each topic are reflected in the assessment outline (Appendix A). Table 3.14 illustrates the analysis needed to provide a comprehensive description of the current landscape condition and evaluation of the ecological integrity of that condition.

Data and Analytical Requirements

Data to complete Module 4F are largely available in the Rocky Mountain Region's IRI data or other resource data sets, from other agencies or entities, from published literature, and from the Historic Range of Variation Assessment(s) relevant to the assessment area. Table 3.15 details descriptions of the data and sources of the information.

Relevance to Management Applications

Recreation and exurban development may be the predominant features in some portions of the assessment areas. There are several potential negative ecological implications of recreation and exurban development that are similar to roads and include: serving as conduits for invasive or undesirable species (Tysor and Worley 1992), serving as barriers to mobility of some native species (Fahrig et al. 1995; Foster and Humphrey 1995), fragmenting interior habitat (citations), increasing human access to levels that may have negative species effects (Lyon 1983; Van Dyke et al. 1986; Mech 1989; Bordy and Pelton 1989; McClellan and Shackleton 1988), and increasing the sedimentation effects of surface erosion and landsliding (citations). Assessing ecological condition for biodiversity or ecosystem sustainability concerns must include a description and evaluation of the current status of recreation and exurban development areal coverage, density, and edge effects.

Table 3.14. Analysis components required to address the relationship between recreation and exurban development patterns and the ecological condition of the terrestrial ecosystem (Module 4F).

Scale	Analysis Components
Ecosubregion: Section	• Map(s) of recreation and exurban development features (including residential and commercial development, developed recreation sites such as ski areas, utility corridors, and other infrastructure) in the assessment area. • Summary of proportional impact of recreation and development on GAP landcover vegetation types.
Ecosubregion: National Forest	• Map of forest recreation and exurban development. • Summary of proportional impact of recreation and development on CVU vegetation types.
Ecological Landscape: Land Type Association	• Summary of proportional impact of recreation and exurban development on major vegetation types.
Management Landscape: Mid-scale Planning Units	• Summary of proportional impact of recreation and exurban development on major vegetation types.
Stand	• N/A at the landscape level.

Table 3.15. Data required for the Recreation and Exurban Development Module of the Current Landscape Condition Assessment (Module 4F).

Development Attribute[1]	Spatial Extent of Description or Analysis[2]	Data Resolution[3]	Ecosystem Stratification Unit[4]	Data Source[5]
Housing or commercial developments	Section	1:24,000	National Forest/Watersheds	Forest datasets or data from other local agencies
Ski areas	National Forest	1:24,000	National Forest/Watersheds	Forest datasets or data from other local agencies
Developed recreation sites	Section	1:24,000	National Forest/Watersheds	Forest datasets or data from other local agencies
Utility corridors	Section	1:24,000	National Forest/Watersheds	Forest datasets or data from other local agencies
Interface with Vegetation				
GAP land cover	Section	1:500,000	Vegetation Type	GAP land cover data – State GAP Programs – *www.gap.uidaho.edu*
Forest-wide vegetation cover	National Forest	1:24,000	Vegetation Type	Forest IRI-CVU data

[1]Development Attribute is the specific map layer or piece of data required to assess the different topics.
[2]Spatial Extent of Description or Analysis is the geographic extent used in the assessment, which defines the overall area encompassed in the assessment.
[3]Data Resolution is the "grain" of the data. Grain refers to the size of the individual units of observation that are necessary to observe the process or characteristics of interest (Wien 1989). Grain is often reflected in the mapping scale, the minimum mapping unit, or some descriptive feature of the system.
[4]Ecosystem Stratification Unit defines the geographic units used for data summarization in the assessment.
[5]Data Source gives suggestions or references that can be used to find more information related to the assessment.

Module 4G: Minerals, Oil, and Gas Exploration and Extraction

The objective of Module 4G is to describe the current patterns of the distribution of mineral, oil, and gas extraction in the assessment area. Evaluation of the relative impacts of these patterns to each of the vegetation types in the assessment area is discussed. Both historic and current locations and the key industrials and ecological integrity concerns are evaluated. Details on the content of each topic are in the assessment outline (Appendix A).

Landscape Patterns

The objective of this component is to describe key features of the spatial pattern of landscapes of the assessment area. The narrative associated with this section should include a discussion of the dynamic nature of pattern and the probable ecological implications of varying patterns. To the extent that information on historic landscape patterns is available, the companion HRV Assessment may address them and can be used as a context for evaluating the departure from conditions expected under historic disturbance regimes. In most cases, information on historic landscape patterns is not available but can be developed. Due to differing availability of data for landscape pattern analyses this component of the assessment is divided into two modules:

A. Forest and Woodland
B. Grassland and Shrubland

Module 5A: Forest and Woodland

Data and tools are available for quantitative descriptions of forested landscape pattern. The following topics should be covered in Module 5A:

(1) Current ecoregional and eco-subregional patterns of forest and woodland distribution.
(2) The relative abundance or rarity of forests and woodlands at different scales and the importance of the National Forest lands in providing for these habitats.
(3) Patterns of distribution of forest and woodland cover types and habitat structural stages among various land ownerships and land use allocations.
(4) Expected ranges in variability of the amount of each habitat structural stage of dominant cover types under historic disturbance regimes.
(5) Current descriptions of landscape structure patterns (of cover types and stand development stage) and expected variation in these patterns under historic disturbance regimes and varying silviculture scenarios.

Details on the content of each topic are reflected in the assessment outline (Appendix A). Table 3.16 illustrates the analysis needed to provide a comprehensive description of the current forest and woodland landscape condition and evaluation of the ecological integrity of that condition.

Table 3.16. Analysis components required to address the influence of forested landscape patterns on ecological condition of the terrestrial ecosystem (Module 5A).

Scale	Analysis Components
Ecosubregion: Section	• Narrative description and tabular summaries reflecting the abundance (or rareness) of the dominant forest and woodland vegetation types of the Section relative to the rest of the Province. • Summaries of the importance of the dominant forest and woodland vegetation types by ownership and land use allocation within the Section.
Ecosubregion: National Forest	• Narrative description and tabular summaries reflecting the abundance (or rareness) of the dominant forest and woodland vegetation types of the Forest relative to the rest of the Section. • Brief narrative description of the role the forest appears to play within the ecoregion and ecosubregion in providing woodland and forest vegetation types. • Map reflecting habitat structural stage distribution over all forest types within the National Forest. • Summaries of total acres within each habitat structural stage over all forest types within the National Forest. • Summaries of relative proportions of each habitat structural stage over all forest types within the National Forest. • Summaries reflecting relative importance of each habitat structural stage by each dominant forest type within the National Forest. • Estimated expected range of variability in forest and woodland landscape structure, measured as ranges in amount of each structural or successional stage, under historic disturbance regimes. • Summaries reflecting distribution of habitat structural stages, for each dominant forest and woodland type, among land use allocations.
Ecological Landscape: Land Type Association	• Map and narrative description reflecting known distributions of existing and recruitment old-growth or older forests. Summary of relative proportions of old-growth (or old) acres and total acres for each forest type. • Current descriptions of landscape structure patterns[1] with and without the influence of roads. • Expected ranges of variation in landscape structure and wildlife habitat patterns under varying natural disturbance regimes and logging scenarios (RMLANDS model output).
Management Landscape: Mid-scale Planning Units	• Map and narrative description reflecting known distributions of existing and recruitment old-growth or older forests. Summary of relative proportions of old-growth (or old) acres and total acres for each forest type. • Current descriptions of landscape structure patterns[1] with and without the influence of roads. • Expected ranges of variation in landscape structure and wildlife habitat patterns under varying natural disturbance regimes and logging scenarios (RMLANDS model output).
Stand	• N/A for landscape patterns.

[1] There are five major spatial components to habitat loss and fragmentation: (1) habitat extent, (2) habitat subdivision, (3) patch geometry, (4) habitat isolation, and (5) habitat connectedness. Landscape structure patterns should be measured to reflect these components and can be quantified using a variety of metrics and tools. Recommendations are discussed in the appendix.

Data and Analytical Requirements

The data required for Module 5A are largely available in the Rocky Mountain Region's IRI database or other resource data sets, from other agencies or entities, from published literature, and from the Historic Range of Variation Assessment(s) relevant to the assessment area. Table 3.17 details descriptions of the data and sources of the information.

A qualitative estimate of expected ranges of variability in forest and woodland landscape structure, measured as ranges in amount of each structural or successional stage under historic disturbance regimes, can be developed using published literature and local knowledge (Table 3.18). Assumptions about the influences of climatic scenarios on fire should be incorporated into these estimates. A detailed description of the approach applied in the Bighorn National Forest Assessment is in Appendix F. Expected ranges of variation in landscape structure and wildlife habitat patterns under varying natural disturbance regimes and logging scenarios can be modeled using RMLANDS, a tool being developed for application in Region 2 using IRI data (Fig. 3.4). More information on RMLANDS application and status of model availability is in Appendix G. Current conditions of landscape structure can be quantified using Fragstats (McGarigal citation). Suggested approaches and metrics are addressed in a draft manuscript under development and available for internal use (McGarigal et al. date).

Relevance to Management Application

Landscape ecological studies have revealed several insights into the relationships among organisms, ecosystem processes, and spatial pattern (Turner et al. 2002). The results of Module 5A will assist in understanding expected ranges of landscape pattern and will identify elements of landscape pattern that indicate ecological integrity, sustainability, or conservation concerns. For example, the analysis may reveal specific concerns about the amounts and spatial distributions of important habitats. Forest fragmentation concerns may be highlighted or the analyses may reveal no concerns due to fragmentation. Results may indicate the influence of landscape condition on the potential spread of disturbance or the movement of materials that might be of ecological concern. The results may be useful in designing landscape prescription templates.

Table 3.17. Data required for the Forested and Woodland Landscape Pattern Module of the Current Landscape Condition Assessment (Module 5A).

Forest and Woodland Landscape Pattern Attribute[1]	Spatial Extent of Description or Analysis[2]	Data Resolution[3]	Ecosystem Stratification Unit[4]	Data Source[5]
Ecoregional and subregional patterns				
Map of dominant forest and woodland types - ecoregion	Section	1:500,000	Vegetation Type	GAP Vegetation Data – State GAP Programs – *www.gap.uidaho.edu*
Map of dominant forest and woodland types – ecosubregion	Section	1:500,000	Vegetation Type	GAP Vegetation Data – State GAP Programs – *www.gap.uidaho.edu*
Map of dominant forest and woodland types – Forest	National Forest	1:24,000	Vegetation Type	Forest IRI – CVU data
Vegetation type by land ownership	Section	1:500,000	Vegetation Type; Watershed	GAP Vegetation Data GAP Land Ownership Data; State GAP Programs – *www.gap.uidaho.edu*
Vegetation type by land use allocation	National Forest	1:24,000	Vegetation Type; Watershed	Forest IRI – CVU data Forest Management Area data
HSS distribution, by vegetation type and over all vegetation types	National Forest	1:24,000	Vegetation Type; Watershed	Forest IRI – CVU data
Timber harvesting influences				
Maps reflecting spatial and temporal pattern of clearcuts	National Forest	1:24,000	LTA; Vegetation Type	Timber Activities database
Temporal patterns in silvicultural practices by vegetation type	National Forest	1:24,000	Vegetation Type	Timber Activities database
Proportion of each vegetation type permanently excluded from logging	National Forest	1:24,000	Vegetation Type	Forest IRI – CVU data, Timber Activities database
Landscape structure patterns				
Existing old-growth or older forest distributions	National Forest	1:24,000	Vegetation Type	Forest IRI – CVU data, Old Growth Inventories, Old Growth Score Cards
Recruitment old-growth or older forest distributions	National Forest	1:24,000	Vegetation Type	Forest IRI – CVU data
Existing landscape structure patterns	National Forest	1:24,000	Vegetation Type	Forest IRI – CVU data
Variation in landscape structure patterns due to natural disturbance and logging	National Forest	1:24,000	Vegetation Type	Forest IRI – CVU data, Timber Activities database,

[1]Forest and Woodland Landscape Pattern Attribute is the specific map layer or piece of data required to assess the different topics.
[2]Spatial Extent of Description or Analysis is the geographic extent used in the assessment, which defines the overall area encompassed in the assessment.
[3]Data Resolution is the "grain" of the data. Grain refers to the size of the individual units of observation that are necessary to observe the process or characteristics of interest (Wien 1989). Grain is often reflected in the mapping scale, the minimum mapping unit, or some descriptive feature of the system.
[4]Ecosystem Stratification Unit defines the geographic units used for data summarization in the assessment.
[5]Data Source gives suggestions or references that can be used to find more information related to the assessment.

Table 3.18. Estimated range of natural variability in landscape structure on the Bighorn National Forest, Wyoming, prior to 1900. Estimates are for a 100,000 ha subalpine landscape on granitic substrates dominated by lodgepole pine and spruce-fir forests.

Structural Stage on the Bighorn National Forest (note the suggested cross-classification and apparent overlaps in structural stages)	Percentage of the subalpine landscape during "ordinary" climatic conditions [1]	Maximum/minimum % of the landscape for several decades after "extreme" fire events [2]	Maximum/minimum % of the landscape towards the ends of very long fire-free periods [3]
Grass/Forb	5 – 15%	50% maximum	3% minimum
Shrub/Seedling	5 – 15%	50% maximum	3% minimum
Sapling/Pole (<40% crown cover)	5 – 45%	50% maximum	3% minimum
Sapling/Pole (40-70% crown cover)	15 – 45%	50% maximum	5% minimum
Sapling/Pole (>40% crown cover)	15 – 45%	50% maximum	5% minimum
Trees >9" DBH (<40% crown cover) [4]	N/A	N/A	N/A
Trees >9" DBH (40-70% crown cover)	15 – 50%	15% minimum	50% maximum
Trees >9" DBH (>40% crown cover)	15 – 50%	15% minimum	50% maximum
Old Growth/older forests	15 – 30%	15% minimum	40% maximum

[1] "Ordinary" climatic conditions are those that prevail most of the time. In Yellowstone National Park (YNP), "ordinary" conditions prevailed throughout the twentieth century -- *except* in 1988.

[2] "Extreme" fire events are exemplified by the 1988 Yellowstone fires or by the extensive fires that occurred in YNP in the early 1700s and 1860s).

[3] Very long fire-free periods occur naturally high-elevation Rocky Mountain forest systems, e.g., from the late 1700s – mid 1800s in YNP, and from the late 1700s – early 1800s in Colorado. "Fire-free" in this context refers only to the absence of *large* fires. Fires still are ignited every year, but never grow to large size, probably because of wet weather conditions.

[4] This type probably is controlled by edaphic conditions rather than disturbance, and occupies a more or less constant proportion of the landscape over time.

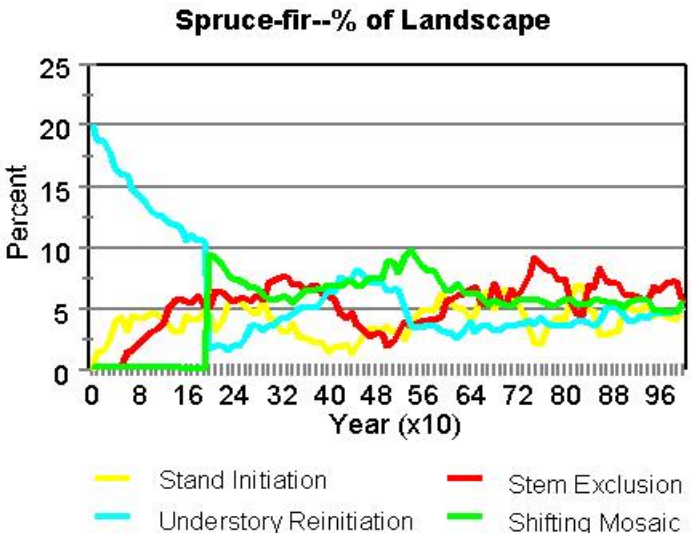

Figure 3.4. Landscape Dynamics Simulation Model showing the preliminary results of the fire module for landscape structure dynamics.

Module 5B: Grassland and Shrubland

The objective of Module 5B is to describe key features of grassland and shrubland spatial patterns on the landscapes. This module should also identify the effects of land uses and management activities on landscape pattern. Due to lack of data availability, Livestock Preference and Rangeland Resilience Models were developed to describe existing rangeland pattern and condition. The dynamic nature of pattern and the probable ecological implications of varying patterns should be discussed in this module. Identification and mapping the ecological risks associated with disturbance risk (e.g., vulnerability to invasive plant species, areas of special significance, etc.) should also be done. Details on the specific content of Module 5B are listed below. The complete assessment outline is in Appendix A.

(1) Current patterns of grassland and shrubland distribution at different scales.
(2) Current grassland and shrubland landscape condition.
(3) Proportion of major grassland and shrubland vegetation types permanently protected from livestock grazing.
(4) Dynamics of the forest and woodland/grassland and shrubland ecotone.

Table 3.19 illustrates the analysis needed to provide a comprehensive description of the current grassland and shrubland landscape condition and evaluation of the ecological integrity of that condition.

Data and Analytical Requirements

The data required to develop Module 5B are largely available in the Rocky Mountain Region's IRI data or other resource data sets, from other agencies or entities, from published literature, and from the Historic Range of Variation Assessment(s) relevant to the assessment area. Table 3.20 details descriptions of the data and sources of the information.

Patterns of livestock use are approximated by considering allotment-stocking rates coupled with the application of the Livestock Preference Model described in Appendix H (Fig. 3.5). This model results in maps and summary descriptions of areas where livestock are expected to concentrate based on preference patterns and is specific to either cattle or sheep. Spatial variation in susceptibility to negative impacts of livestock grazing is approximated using the Rangeland Resilience Model (Appendix H) (Fig. 3.6). Output from this model reflects a gradient of resilience to livestock grazing impacts based on physiographic attributes. A combination of output from the two models delineates areas of potential concern due to livestock grazing.

Relevance to Management Application

Module 5B is focused on identifying areas with probable or potential ecological integrity or sustainability concerns. This information may aid in prioritizing areas in need of ecological restoration and it may assist in designing management approaches that are most consistent with ecological constraints. The results may have particularly important applications in identifying opportunities for compatibility among ecological restoration and resource utilization goals.

Table 3.19. Analysis components required to describe the grassland and shrubland landscape condition in the assessment area (Module 5B).

Scale	Analysis Components
Ecoregion: Province	• Map reflecting the geographic position of the forest within the larger Province area. • Describe the abundance (or rareness) of the dominant vegetation types on the forest relative to the rest of the Province.
Ecosubregion: Section	• Map reflecting the geographic position of the forest within the larger Section area. Show broad elevation bands within the Section for a relief context. • Brief narrative description of the role the forest appears to play within the Section (is it isolated or part of contiguous habitat?) Describe whether the forest contains a disproportionate amount of higher elevational vegetation communities. • Provide a summary of land ownership and land-use allocation for the Section. Describe the patterns that emerge and their significance (if any). • Describe the GAP vegetation type pattern for the Section. Relate this pattern to the land ownership pattern and discuss significance.
Ecosubregion: National Forest	• Describe the major cultural and biological influences on the forest's landscapes. • Describe historical conditions and contrast them with current conditions (e.g., human influences on: a) fire regime, b) domestic livestock numbers, and c) wildlife numbers and any species extirpations).
Ecological Landscape: Land Type Association	• Map and describe domestic livestock preference (e.g., areas where livestock tend to concentrate). • Map and describe rangeland resilience in order to understand which areas are more likely to be susceptible to domestic livestock impacts. • Map showing the proportion of major vegetation types permanently excluded from domestic livestock use. • Map (if available) and describe the degree of woodland and shrubland expansion or decline.
Management Landscape: Mid-scale Planning Units	• Map and narrative describing domestic livestock preference (e.g., areas where livestock tend to concentrate). • Map and narrative describing rangeland resilience in order to understand which areas are more likely to be susceptible to domestic livestock impacts. • Map showing the proportion of major vegetation types permanently excluded from domestic livestock use.
Stand	• N/A for landscape patterns.

Table 3.20. Data required for the Grassland and Shrubland Landscape Pattern Module for the Current Landscape Condition Assessment (Module 5B).

Grassland/Shrubland Pattern Attribute[1]	Spatial Extent of Description or Analysis[2]	Data Resolution[3]	Ecosystem Stratification Unit[4]	Data Source[5]
Current grassland and shrubland upland landscape condition				
Importance of the Forest in the larger ecoregional landscape.	Ecoregion	1:500,000	Vegetation Type	Bailey's Ecoregion publication; State GAP Programs – *www.gap.uidaho.edu;* State Heritage Program data – *www.natureserve.org*
Land ownership and land-use allocation summary for the Section.	Section	1:500,000	Vegetation Type	State GAP Programs – *www.gap.uidaho.edu*
Cultural and biological influences on these landscapes with an emphasis on livestock grazing				
Historical to present day perspective (e.g., fire, grazing, wildlife).	**Section**	1:500,000 through 1:24,000	Section and Subsection	Published literature; Forest records; State wildlife records; IRI-CVU data, allotment data, fire model, fire data
Changes in pattern of seral conditions	National Forest	1:24,000	Vegetation Type	Forest range allotment data; IRI-CVU data, PNV Model (CVU, DEM, GAP)
Livestock Preference and Rangeland Resilience – A Modeling Approach				
Livestock Preference Model	National Forest	1:24,000	LTA	Published literature; Forest range allotment/inventory data; IRI-CVU data; soil survey. Valley bottom model
Rangeland Resilience Model	National Forest	1:24,000	LTA	Published literature; Forest range allotment/inventory data; IRI-CVU data; soil survey.
Proportion of major vegetation types permanently excluded from livestock	National Forest	1:24,000	Vegetation Type	Current Forest Land and Resource Management Plan; IRI-CVU data; Forest allotment map.
Ecotones	National Forest	1:24,000	Vegetation Type	Forest range allotment data; IRI-CVU data

[1]Grassland / Shrubland Pattern Attribute is the specific map layer or piece of data required to assess the different topics.
[2]Spatial Extent of Description or Analysis is the geographic extent used in the assessment, which defines the overall area encompassed in the assessment.
[3]Data Resolution is the "grain" of the data. Grain refers to the size of the individual units of observation that are necessary to observe the process or characteristics of interest (Wien 1989). Grain is often reflected in the mapping scale, the minimum mapping unit, or some descriptive feature of the system.
[4]Ecosystem Stratification Unit defines the geographic units used for data summarization in the assessment.
[5]Data Source gives suggestions or references that can be used to find more information related to the assessment.

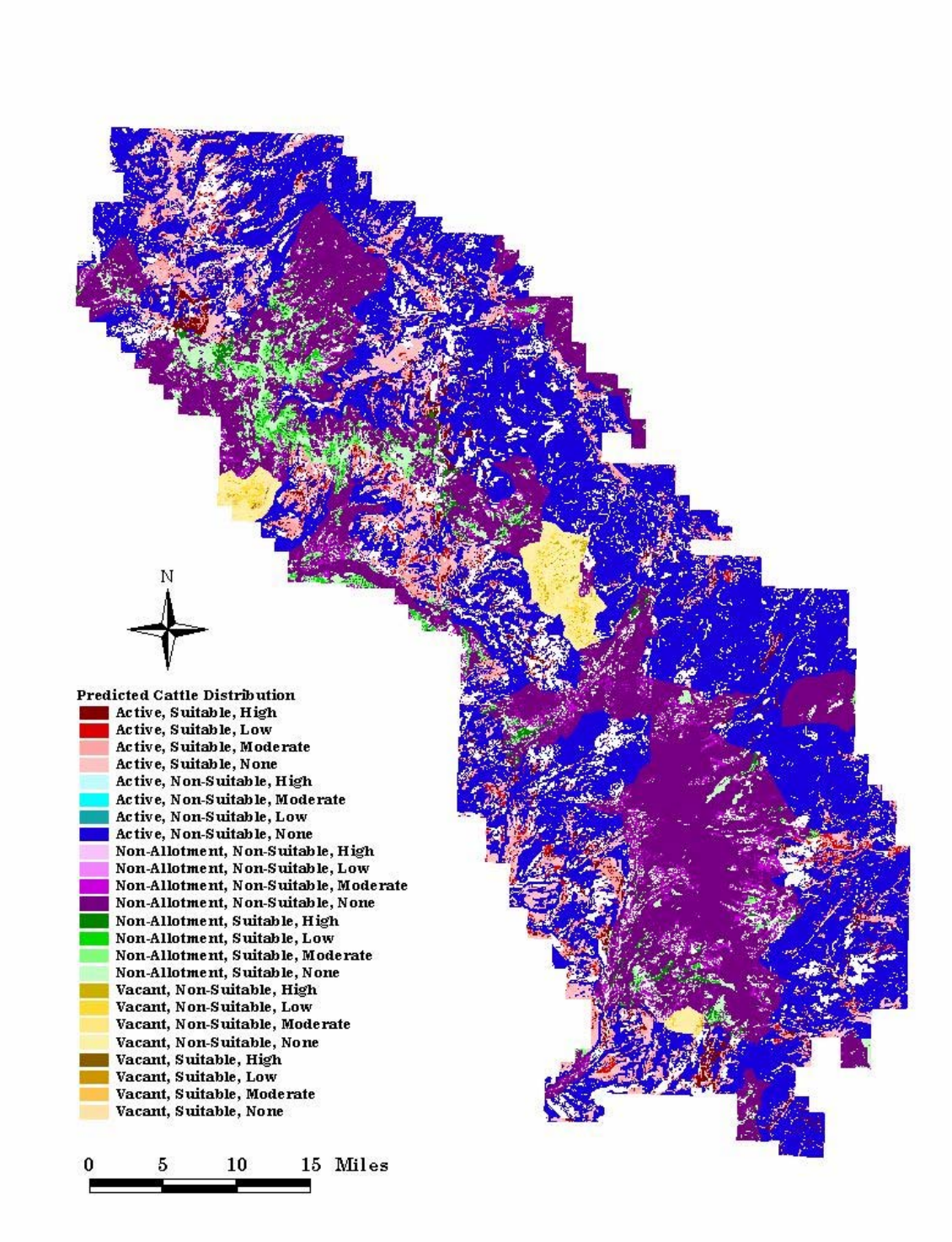

Figure 3.5. Map of the Livestock Preference Ratings for cattle on the Bighorn National Forest (source BNF resource data).

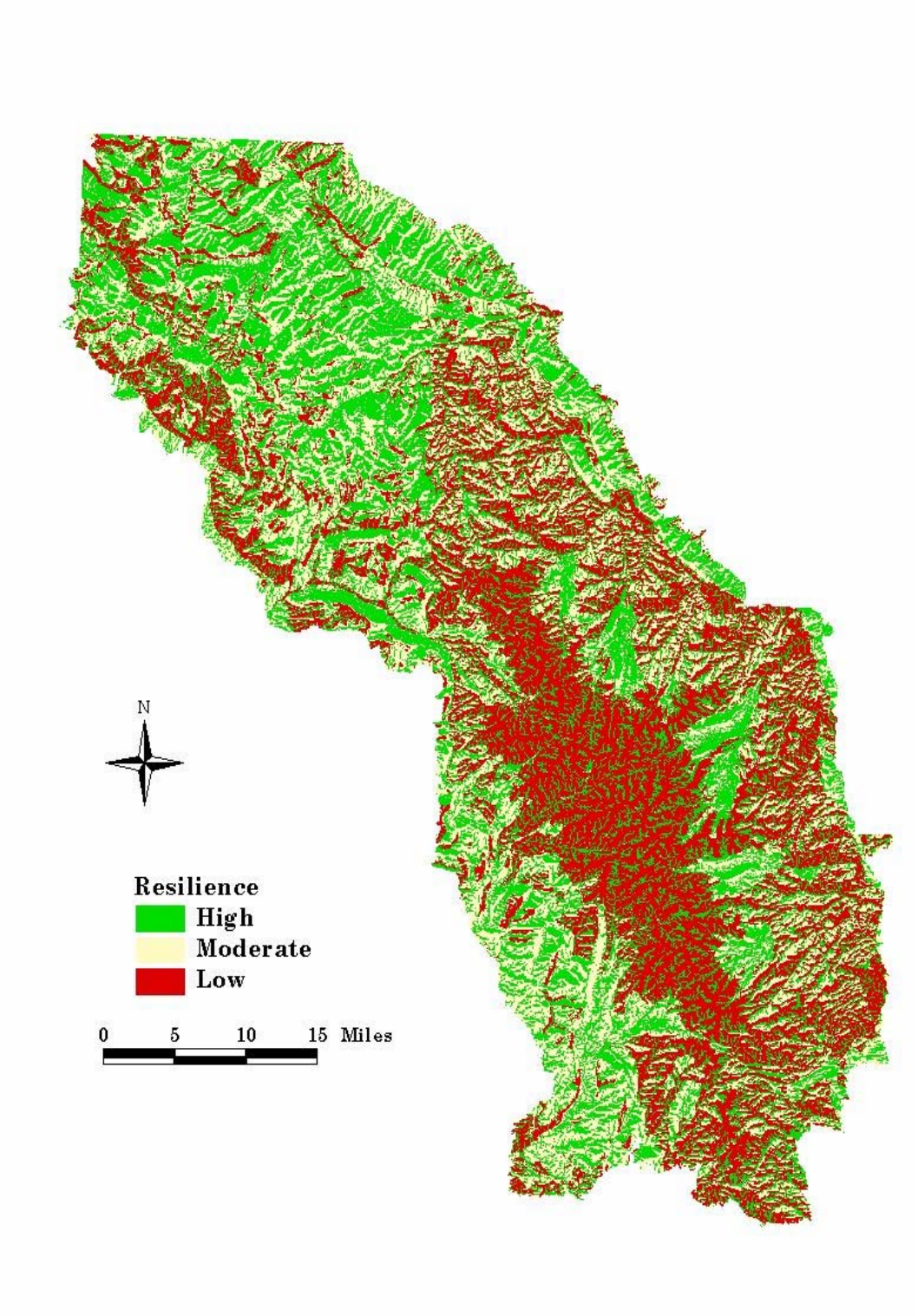

Figure 3.6. Map of the Rangeland Resilience on the Bighorn National Forest (source: BNF resource data).

Areas of Special Biodiversity Significance

The objective of this module is to describe plant communities of special concern or other unique or imperiled features or habitats of biodiversity significance within the assessment area. In addition, Module 6 identifies high quality areas or examples of more commonly occurring vegetation types. Module 6 products discuss the ecological significance of these special places, display their spatial distributions, identify anthropogenic influences or risk factors, and evaluate the ecological implications of the current condition. The following topics are addressed:

(1) Plant communities of special concern.
(2) Unique habitat features (e.g., caves, cliffs, talus).
(3) Conservation sites
(4) Existing and potential Research Natural Areas.
(5) Other areas as relevant within the assessment area (e.g., roadless areas, wilderness, wildlife corridors, etc.).

Details on the content of each topic are reflected in the assessment outline (Appendix A). Table 3.21 illustrates the analysis needed to provide a comprehensive description of the current landscape condition with respect to these areas of special significance.

Data and Analytical Requirements

Data to complete Module 6 are largely available from USFS resource data sets, other agency resource data sets, Research Natural Area Ecological Evaluations, State Heritage Program data inventory and abstract data (Welp et al. 2000), and The Nature Conservancy Ecoregional Plans [insert citation]. Table 3.22 details descriptions of the data and sources of the information.

Relevance to Management Applications

The identification of areas of special biodiversity significance may contribute to a total, whole-landscape approach to ecological and species conservation planning (TNC citation, Groves et al. citation). A place-based approach is consistent with island biogeography theory, once the prevailing paradigm guiding the design of conservation reserves (McArthur references). With contemporary ecological theory (e.g., metapopulation theory, Levins references), we are aware of the need for more complex approaches to ensure conservation. However, these early ideas remain important in conservation planning. More recently, Hunter (citations) has proposed that the protection of areas representing characteristic ecosystems and processes may ensure the protection of biodiversity (e.g., Hunter's coarse-filter approach). These areas might be similar to reference landscapes. The Module 6 analysis may be helpful in contributing to an understanding of what components should be encompassed in reference landscapes or they may actually serve as reference landscapes. Potential Research Natural Areas or Special Interest Areas may be evaluated through this analysis. Module 6 should contribute to information needed to meet two specific principles of land use planning for conservation (Duerksen et al. 1997): 1) it may contribute to an identification of habitats known to constrain the distribution and abundance of species, and 2) it may provide information necessary to contribute to the regional persistence of rare species by protecting some of their habitat locally.

Table 3.21. Analysis components required to address the relationship between special or unique areas and ecological condition of the terrestrial ecosystem (Module 6).

Scale	Analysis Components
Ecosubregion: **Section**	• Narrative description of unique or rarely occurring vegetation types or landscape features expected in the assessment area. • Narrative description of vegetation types, landscape features, or other ecological components that may highly imperiled.
Ecosubregion: **National Forest**	• Narrative descriptions and distribution maps of plant communities of special concern. • Narrative descriptions and maps of existing and potential Research Natural Areas.
Ecological Landscape: **Land Type Association**	• Narrative descriptions and maps of caves, cliffs, and talus features. • Narrative descriptions and maps of existing and potential Research Natural Areas. • Narrative descriptions and maps of high quality examples of representative, commonly occurring vegetation types.
Management Landscape: **Mid-scale Planning Units**	• Narrative descriptions and maps of Heritage program Biological Areas or Conservation Sites or TNC Ecoregional Planning Portfolio sites.
Stand	• Occurrences of species of concern. • Occurrences and community composition of unique or imperiled plant communities. • Occurrences and community composition, structure of high quality representative plant communities.

Table 3.22. Data required for the Special Areas Module of the Current Landscape Condition Assessment (Module 6).

Unique or Special Areas Attribute[1]	Spatial Extent of Description or Analysis[2]	Data Resolution[3]	Ecosystem Stratification Unit[4]	Data Source[5]
Plant Communities				
List and description of plant communities of special concern	National Forest	1:100,00	LTA	Wyoming Natural Diversity Database, Colorado Natural Diversity Database Program, other State Heritage Programs – *www.natureserve.org*
Map of plant communities of special concern	National Forest	1:100,000	LTA	Wyoming Natural Diversity Database, Colorado Natural Diversity Database Program, other State Heritage Programs – *www.natureserve.org*
Unique Landscape Features				
Caves, cliffs, talus	Section	1:24,000	LTA	Forest data; Cliffs can be estimated using DEM – Slope data
Research Natural Areas				
Existing RNAs	National Forest	1:24,000	National Forest	Forest management areas coverage
Potential RNAs	National Forest	1:24,000	National Forest	Forest potential RNA coverage; Potential RNA ecological evaluations
Conservation Sites				
Heritage Program Biological Areas	National Forest	1:100,000	LTA	Wyoming Natural Diversity Database, Colorado Natural Diversity Database Program, other State Heritage Programs – *www.natureserve.org*

[1]Unique or Special Areas Attribute is the specific map layer or piece of data required to assess the different topics.
[2]Spatial Extent of Description or Analysis is the geographic extent used in the assessment, which defines the overall area encompassed in the assessment.
[3]Data Resolution is the "grain" of the data. Grain refers to the size of the individual units of observation that are necessary to observe the process or characteristics of interest (Wien 1989). Grain is often reflected in the mapping scale, the minimum mapping unit, or some descriptive feature of the system.
[4]Ecosystem Stratification Unit defines the geographic units used for data summarization in the assessment.
[5]Data Source gives suggestions or references that can be used to find more information related to the assessment.

Synthesis

The objective of Chapter VII is to develop a synthetic understanding of the ecological condition of the assessment area and to summarize critical information gaps and data needs. First, the key findings of the assessment are summarized and, where applicable and possible given available information, the ecological implications are discussed. Second, the assessment area landscape is characterized by rankings of "ecological integrity" by mapping areas considered to have high ecological integrity as well as areas of concern. Third, areas where current conditions or activities or the intensity of activities may threaten future ecological integrity are noted. Fourth, places that may serve as reference areas for developing ecological restoration approaches and monitoring are identified. Finally, key information gaps and data needs that might contribute to better addressing the original assessment questions and assist managers in decision-making are identified.

The analytical components required to accomplish the synthesis are highlighted in Table 3.23.

Key assessment findings are summarized in narrative form by major management issues or land use categories of the assessment area such as:

- Forest and Woodland Vegetation Management
- Grassland and Shrubland Vegetation Management
- Recreation, Exurban Development, and Roads/Trails
- Minerals, Oil, and Gas Development

Defining Ecological Integrity (file to be inserted)

Mapping Ecological Integrity

Areas of High Ecological Integrity

Details for generating ecological integrity maps are described in Appendix I. We consider a particular location on the assessment area to have high ecological integrity if it is characterized by six or seven of the nine high-integrity indicators listed above. Similarly, we consider a particular location on the assessment area to have moderately high ecological integrity if it is characterized by four or five of the nine high-integrity indicators. This is a conservative approach in terms of allowing for the absence of as many as three of the high integrity indicators while still being mapped as high integrity (e.g., as many as three activities or characteristics that suggest ecological integrity concerns can be present in an area mapped as high integrity). An example of ecological integrity mapping is shown for the Bighorn Nation Forest (Fig. 3.7). To evaluate how the landscape is patterned with respect to the ecological integrity rankings, summaries should be prepared by mid-scale analysis units. By using mid-scale planning units (e.g., Forest Plan Watershed Units on the Bighorn National Forest), variation among broad management units is described (Fig. 3.8) and the proportion of these areas in high integrity condition can be highlighted (Table 3.24). In addition, overlays of high integrity with features of interest such as Heritage Program Conservation Sites (Fig. 3.9) or potential RNAs (Table 3.25) should be developed.

Table 3.23. Analysis components required for the development of a synthetic understanding of ecological integrity and ecological sustainability concerns of the assessment area (Chapter VII).

Scale	Analysis Components
Ecosubregion: Section	• Summary of key findings for the section and the role of the Forest • Summary of ecological integrity and sustainability issues within the section
Ecosubregion: National Forest	• Summarize key findings from Chapters 1 - 6 • Identify and summarize key issues of ecological integrity and sustainability on the Forest • Identify spatially areas of ecological integrity concerns on the forest and summarize findings • Identify spatially areas of high ecological integrity on the forest and summarize findings
Ecological Landscape: Land Type Association	• Maps and summaries of ecological concerns within the Forest • Maps and summaries of high ecological integrity areas within the Forest
Management Landscape: Mid-scale Planning Units	• Maps and summaries of ecological concerns within the Forest • Maps and summaries of high ecological integrity areas within the Forest
Stand	• N/A for synthesis

Table 3.24. Area of each forest plan watershed unit having high- and moderately high ecological integrity. Proportion of each unit is shown in parentheses.

FPWS	Acres having 6-7 components	Acres having 4-5 components	Total
Clear/Crazy Woman Creek	57,947 (37.2)	88,992 (57.1)	146,940 (94.3)
Devil's Canyon	18,073 (29.6)	39,898 (65.3)	59,771 (94.9)
Goose Creek	66,194 (56.6)	46,768 (40.0)	112,962 (96.6)
Little Bighorn	30,476 (21.5)	101,627 (71.8)	132,103 (93.3)
Paintrock Creek	48,828 (45.2)	55,453 (51.4)	104,281 (96.6)
Piney/Rock Creek	69,659 (63.2)	40,579 (36.8)	110,238 (100.0)
Shell Creek	57,571 (41.1)	77,033 (55.0)	134,604 (96.1)
Tensleep Creek	48,058 (47.5)	40,635 (40.2)	88,693 (87.9)
Tongue River	51,585 (29.1)	108,931 (61.5)	160,515 (90.6)

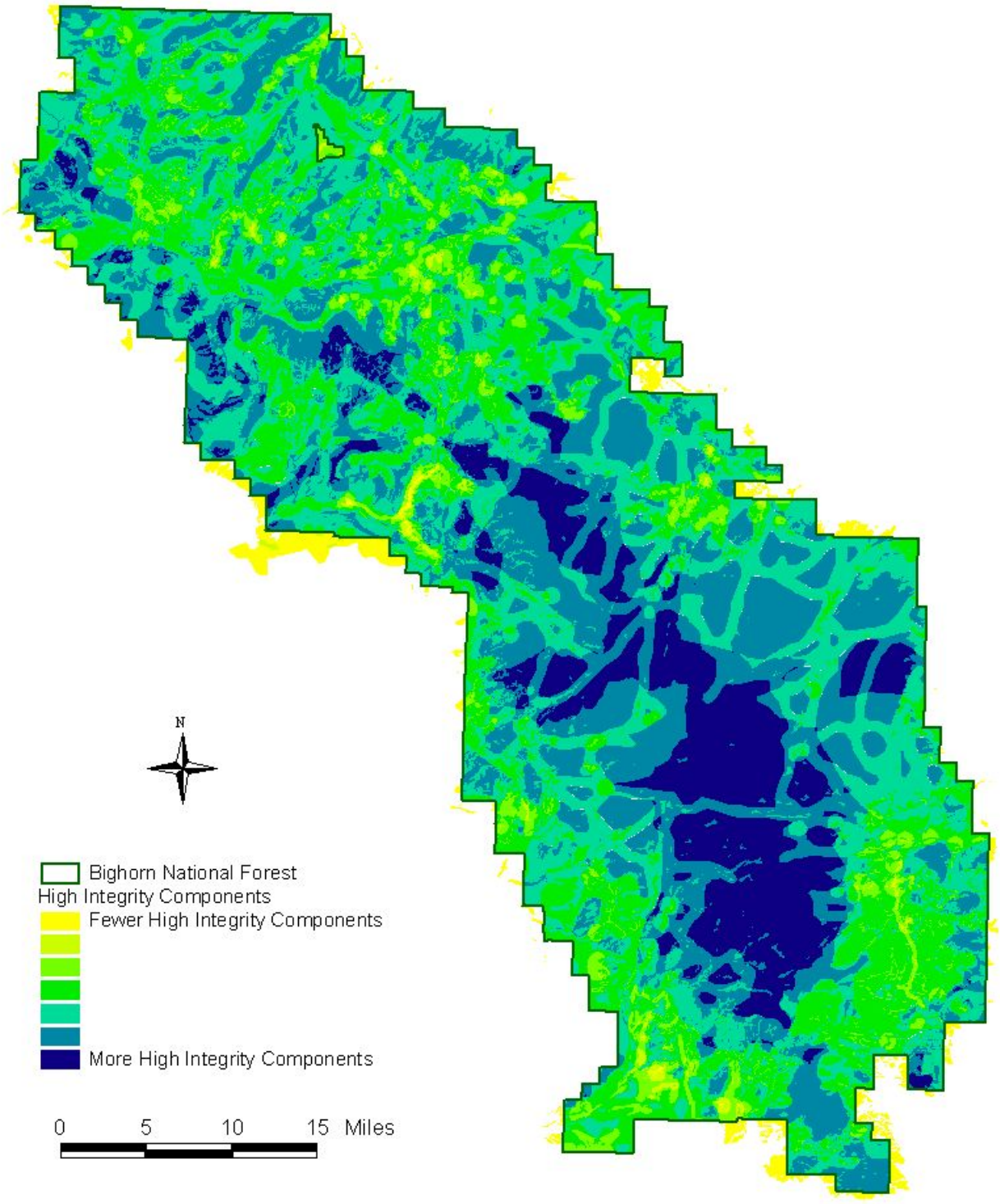

Figure 3.7. Areas of high ecological integrity on the Bighorn National Forest. Cooler colors represent areas having more components of high ecological integrity.

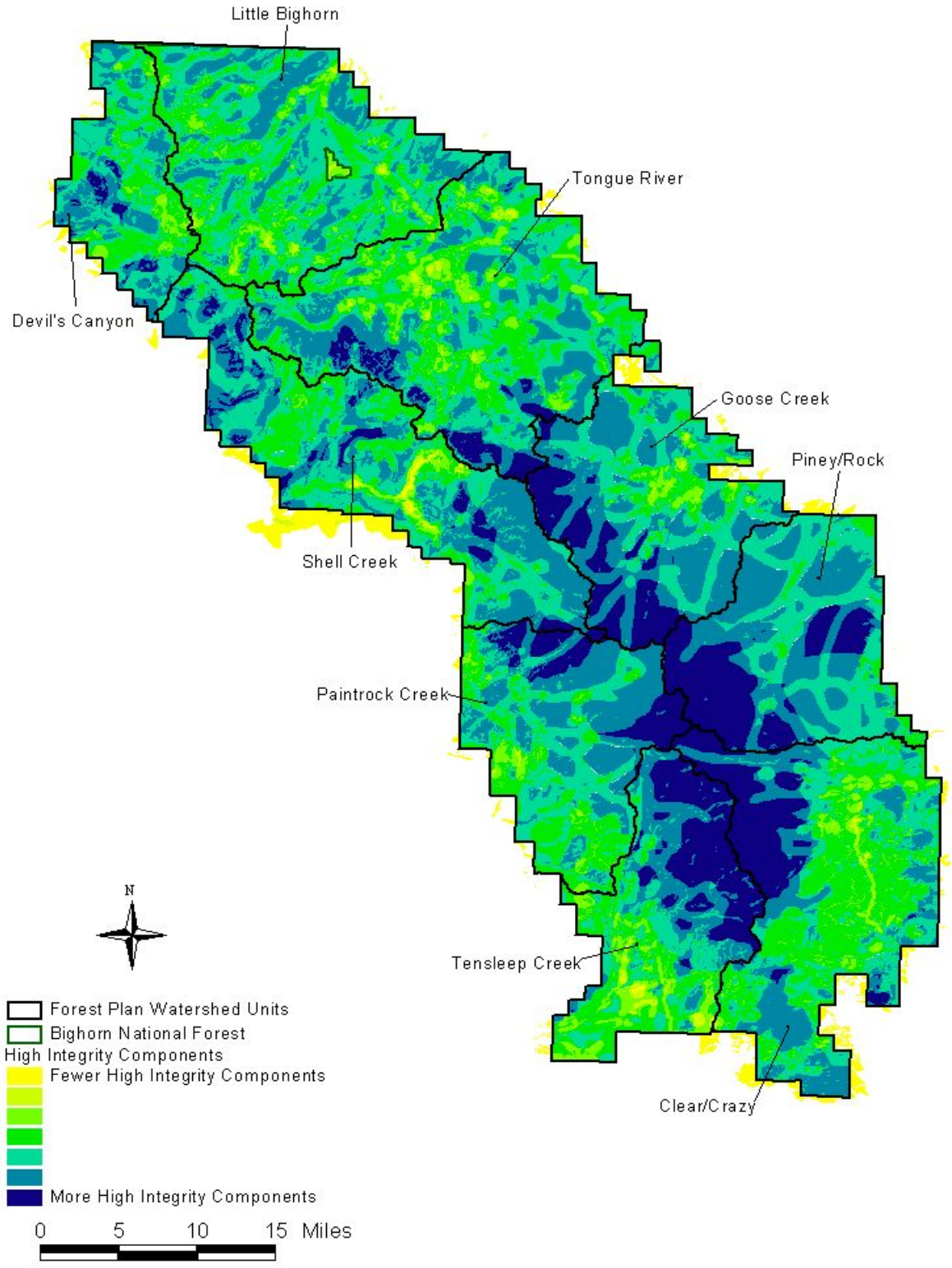

Figure 3.8. Areas of high ecological integrity by Forest Plan Watershed Units (e.g., a mid-scale planning unit) on the Bighorn National Forest. Cooler colors represent areas having more components of high ecological integrity.

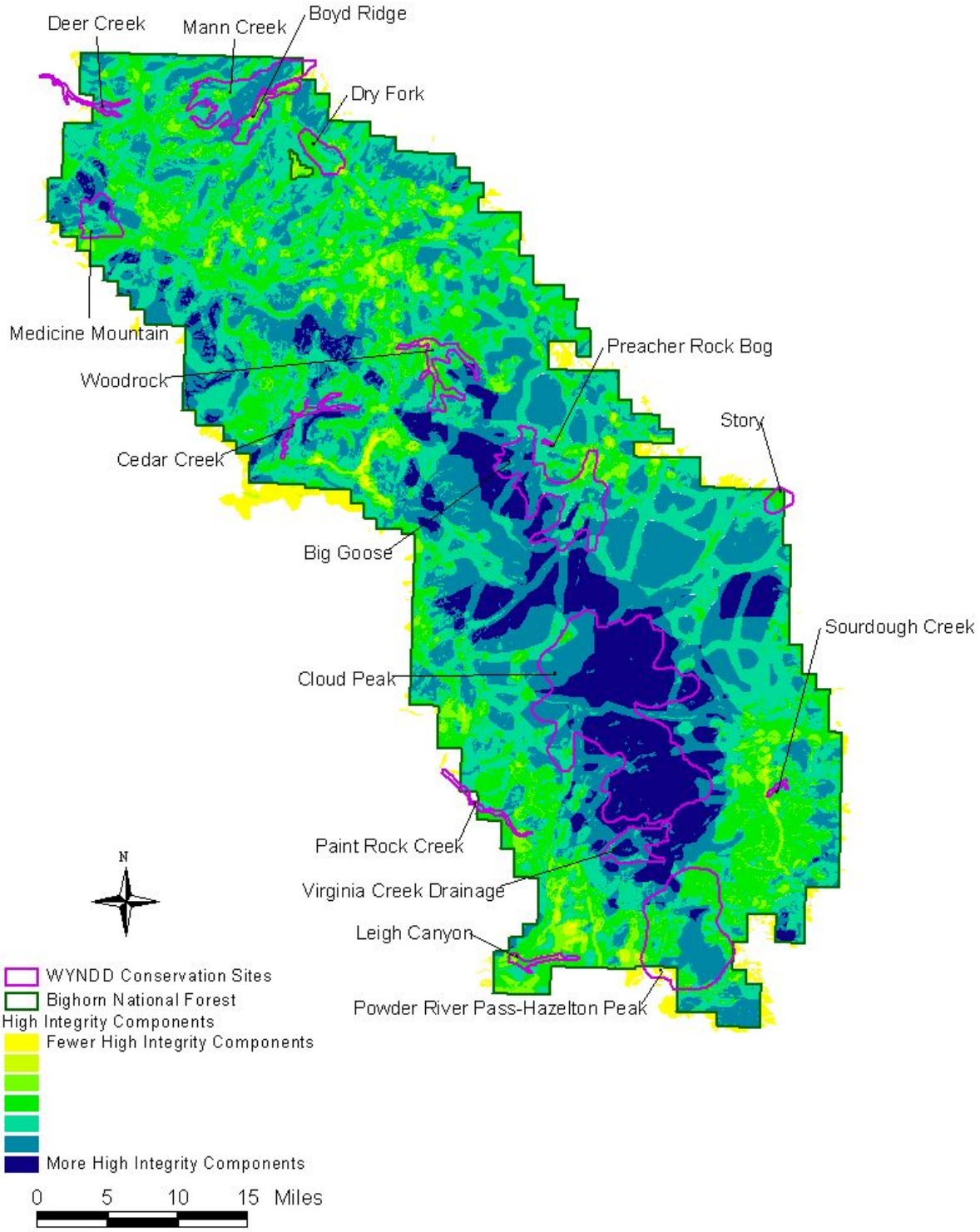

Figure 3.9. Areas of high ecological integrity by Wyoming Natural Diversity Database conservation sites on the Bighorn National Forest. Cooler colors represent areas having more components of high ecological integrity.

Table 3.25. Area of each potential natural research area on the Bighorn National Forest having high- and moderately high ecological integrity. Proportion of each site is shown in parentheses.

Potential RNA	Acres having 6-7 components	Acres having 4-5 components	Total
Crazy Woman Creek	374 (23.5)	1,214 (76.4)	1,588 (99.9)
Devil's Canyon	4,249 (51.3)	4,037 (48.7)	8,287 (100)
Dry Creek	1,355 (11.9)	8,605 (75.3)	9,960 (87.2)
Elephant Head	5,161 (54.0)	4,390 (46.0)	9,551 (100)
Lake McClain	9,274 (97.3)	259 (2.7)	9,533 (100)
Mann Creek	5,929 (51.9)	5,294 (46.4)	11,223 (98.3)
Petes Hole	1,682 (59.2)	1,160 (40.8)	2,842 (100)
Pheasant Creek	7,460 (79.3)	1,944 (20.7)	9,403 (100)
Poison Creek	1,684 (72.3)	645 (27.7)	2329 (100)
Tensleep Canyon	319 (10.2)	2,007 (64.2)	2,326 (74.4)
Tongue River	446 (7.5)	4,940 (83.6)	5,386 (91.1)

Areas of Ecological Concern

Similar to our criteria for identifying high-integrity areas, we consider a particular location on the assessment area to have low ecological integrity (and thus to be a potential "area of concern") if it was characterized by six or seven of the following: high road density, extensive silvicultural activity, a coincidence of low rangeland resilience, high preference, and high livestock stocking, high invasibility or occurrence of invasive species, high departure from historical disturbance regimes, high-impact recreation, the presence of utility corridors, high levels of exurban development, or high levels of mineral extraction activities. As before, we consider a particular location on the assessment area to have moderately low ecological integrity if it is characterized by four or five of the nine low-integrity indicators (Fig. 3.10). Maps of low ecological integrity rankings intersected with mid-scale analysis units and particular landscape features of interest should be developed as with the high-integrity analysis.

Mapping Reference Landscapes

Using the definitions of ecological integrity described above, identify reference landscapes on the assessment area having high ecological integrity (Appendix I). These large reference landscapes may be useful as a baseline for management where ecological integrity is an issue.

Reference landscapes (RLs) are chosen using a minimum size requirement that reflects the natural disturbance regime for that landscape. For example, since subalpine areas are dominated by large (> 100,000 acres/40,500 ha), infrequent disturbances (Romme and Despain 1989; Bessie and Johnson 1995; Agee 1997) and montane areas are characterized by smaller (< 10,000 acres/4,050 ha), more frequent disturbances (Cooper 1960; Veblen et al. 2000; Meyer and Knight 2001), we define high-integrity reference landscapes as having at least six components of high ecological integrity and as being > 5,000 acres (2,000 ha) in area. Reference landscapes should be delineated to encompass the major vegetation types of the assessment area if possible (Fig. 3.11 and Table 3.26). The GIS procedures for creating reference area maps are outlined in Appendix I.

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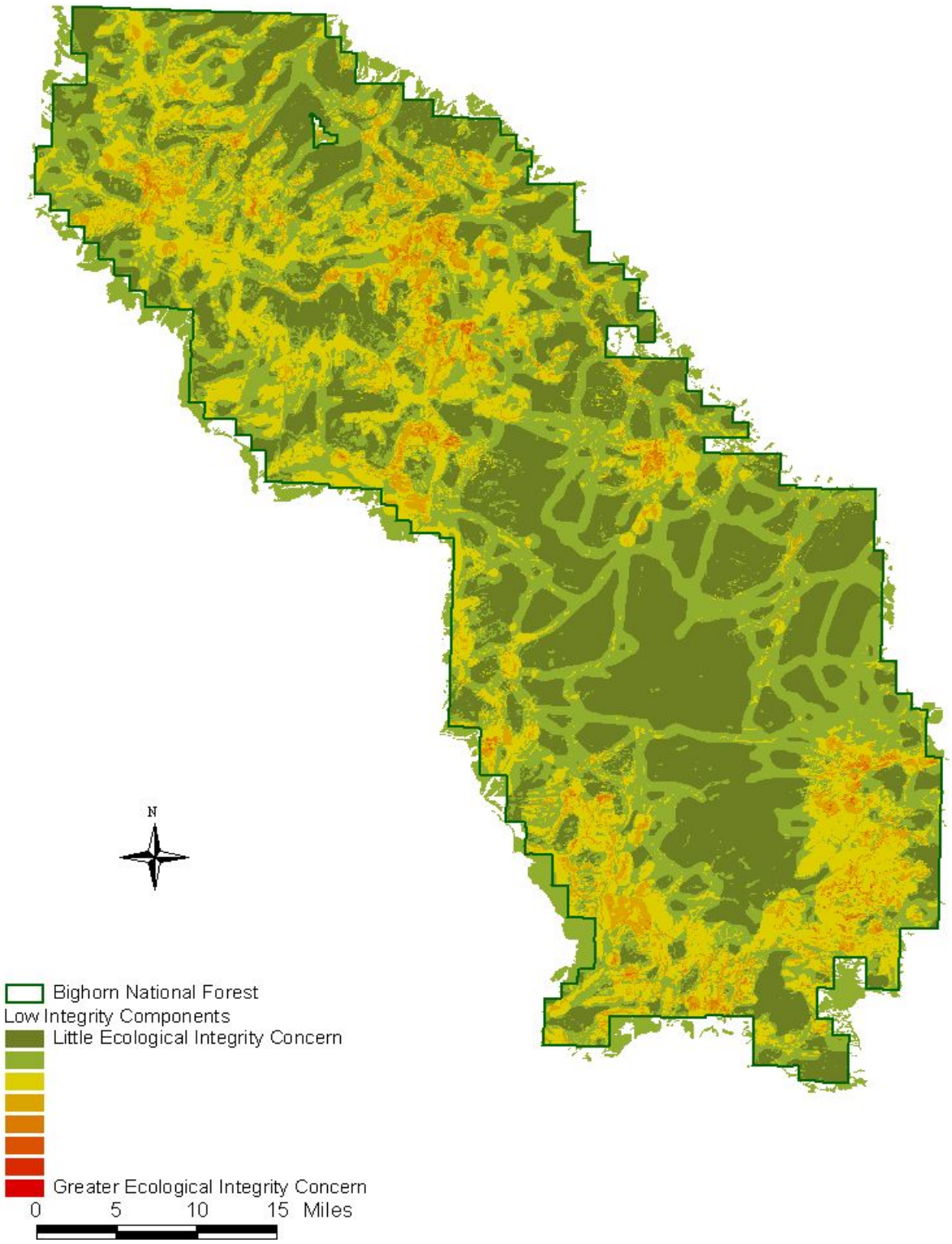

Figure 3.10. Areas of concern (low ecological integrity) on the Bighorn National Forest. Warmer colors represent areas having more components of low ecological integrity.

Figure 3.11. Vegetation cover types included within Reference Landscapes for high ecological integrity on the Bighorn National Forest.

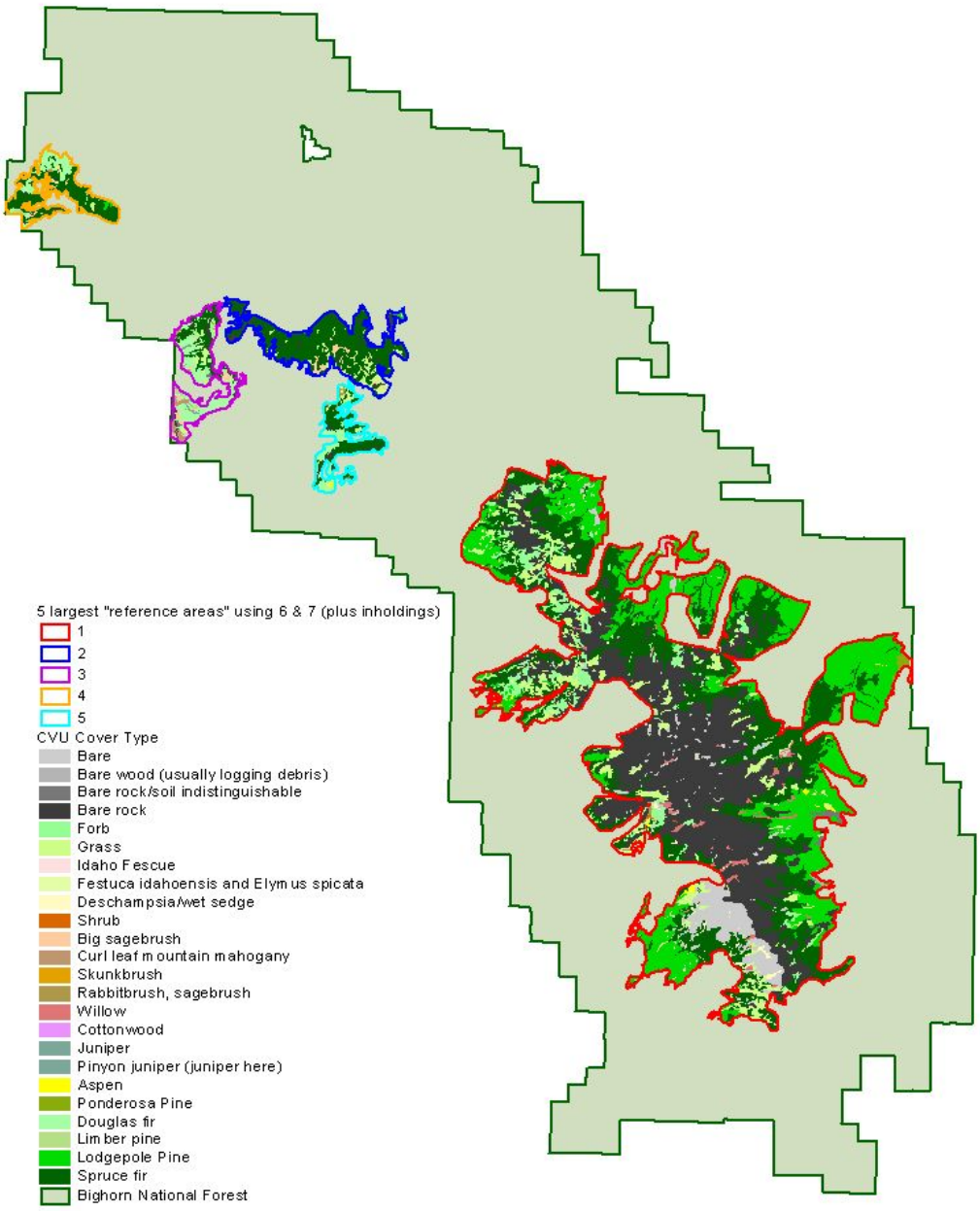

Table 3.26. Area (acres/ha) of major vegetation types (CVU) within reference landscapes on the Bighorn National Forest. Proportion of each vegetation type for each landscape is in parentheses.

CVU Cover Type	Reference Landscape 1	Reference Landscape 2	Reference Landscape 3	Reference Landscape 4	Reference Landscape 5
Bare rock/soil/wood	79,865/32,320 (35.9)	1,039/420 (6.8)	631/255 (6.8)	101/41 (1.3)	470/190 (7.2)
Forb	9,666/3,912 (4.4)	17.7/7 (< 1)	538/218 (5.8)	101/41 (1.3)	0
Grass	14,551/5,889 (6.5)	1,361/551 (8.9)	476193 (5.1)	129/52 (1.6)	598/242 (9.1)
Big sagebrush	0	573 (3.7)	570/231 (6.1)	174/70 (2.2)	28/11 (< 1)
Curl-leaf mtn. mahogany	0	0	656/266 (7.0)	2/1 (< 1)	0
Juniper	0	0	187/76 (2.0)	0	0
Limber pine	0	0	265/107 (2.9)	142/57 (1.8)	9/4 (< 1)
Douglas-fir	0	0	3,526/1427 (37.9)	1,714/694 (21.5)	1,604/649 (24.5)
Lodgepole pine	53,748/21,751 (24.2)	247/100 (1.7)	0	112/45 (1.4)	0
Spruce-fir	60,542/25,500 (27.2)	12,099/29,897 (78.8)	2,402/972 (25.8)	5,489/2,221 (68.8)	3,606/1,459 (55.1)
Other	4,047/1,638 (2.2)	40.5/16 (< 1)	48/19 (1.0)	22/9 (< 1)	229/93 (3.5)
Total Area	222,419/9,073	15,349/6,212	9,297/3,762	7,984/3,231	6,544/2,648

Identifying Information Needs

From the inception of the Species Conservation Project and the early discussions about assessment content, it was agreed that the identification of information gaps is one of the most important jobs of an assessment. This is not intended to highlight shortcomings of the Forest's inventory programs or to suggest that the USFS has responsibility for filling all of the information needs. There is no intent to place an unrealistic inventory burden on the unit producing an assessment. Understanding information gaps is necessary, though, to provide a context for the quality of the assessment and the strength of assessment interpretations. It is also necessary for highlighting information priorities for progressing in meeting species conservation and ecological sustainability objectives.

With each chapter or module report, there should be an identification of information gaps. The synthesis chapter presents an opportunity to highlight the highest priority information needs considering the assessment as a whole. These information needs should be presented by the following categories:

- Inventory and Assessment Needs
- Monitoring Needs
- Research Needs

Data and Analytical Requirements

The data required to prepare the Synthesis (Chapter VII of the assessment) are generally available from USFS resource data sets and the analytical products of the earlier CLC Assessment components. The data required are detailed in Table 3.27 and in Appendix A.

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Table 3.27. Data required for the synthesis chapter of the Terrestrial Ecosystem Assessment (Chapter VII)

Landscape Attribute[1]	Spatial Extent of Description or Analysis[2]	Data Resolution[3]	Ecosystem Stratification Unit[4]	Data Source[5]
Areas of Ecological Concern				
Road density	National Forest	1:24,000	LTA	Chapter 4, Module 4E
Timber harvesting	National Forest	1:24,000	LTA	Chapter 4, Module 4B
Campgrounds, ski areas, summer homes, resorts, cow camps	National Forest	1:24,000	LTA	Chapter 4, Module 4F
High stocking, high preference, and low resilience	National Forest	1:24,000	LTA	Chapter 4, Module 4C
High invasibility, high stocking, and high preference	National Forest	1:24,000	LTA	Chapter 4, Module 4D
High hazard, low resilience, high preference, high stocking	National Forest	1:24,000	LTA	Chapter 4, Module 4C
Condition class 3	National Forest	1:24,000	LTA	Chapter 4, Module 4A
Areas of High Ecological Integrity				
Road Density	National Forest	1:24,000	LTA	Chapter 4, Module 4E
Campgrounds, ski areas, summer homes, resorts, cow camps	National Forest	1:24,000	LTA	Chapter 4, Module 4F
Weed point and polygon coverages	National Forest	1:24,000	LTA	Chapter 4, Module 4D
Bighorn allotments	National Forest	1:24,000	LTA	Chapter 4, Module 4C
Condition classes 0 and 1	National Forest	1:24,000	LTA	Chapter 4, Module 4A
Utility coverage	National Forest	1:24,000	LTA	Chapter 4, Module 4F
Timber harvesting	National Forest	1:24,000	LTA	Chapter 4, Module 4B

[1]Landscape Attribute is the specific map layer or piece of data required to assess the different topics.
[2]Spatial Extent of Description or Analysis is the geographic extent used in the assessment, which defines the overall area encompassed in the assessment.
[3]Data Resolution is the "grain" of the data. Grain refers to the size of the individual units of observation that are necessary to observe the process or characteristics of interest (Wien 1989). Grain is often reflected in the mapping scale, the minimum mapping unit, or some descriptive feature of the system.
[4]Ecosystem Stratification Unit defines the geographic units used for data summarization in the assessment.
[5]Data Source gives suggestions or references that can be used to find more information related to the assessment.

Chapter 4
Criteria for Project Management and Product Delivery

Selecting Cooperators and Partners

The Species Conservation Project is producing state-of-the-art and current scientific documents intended to provide a foundation for increasing the quality, efficiency, and consistency of resource management in Region 2. Meeting these goals requires collaboration with scientists who are demonstrated experts in the ecology of the ecosystems under investigation. Selection of cooperators should heavily emphasize the experience the ecologist has and the degree to which peers recognize the ecologist as a leading expert. The following are factors to consider in selecting cooperators:

(1) Demonstrated expertise with the relevant ecosystems and topics (based on the record of publication or some other form of formal communication).
(2) Demonstrated credentials as an ecologist or other scientist from a relevant discipline (based on academic degree, record of communicating in the science, professional rank, and current professional involvement in the discipline).
(3) Demonstrated knowledge of the ecology of the Rocky Mountain Region.
(4) Demonstrated ability to cooperate with land management agencies.
(5) Demonstrated ability to meet deadlines.
(6) Demonstrated ability to provide an unbiased perspective.
(7) Demonstrated ability to provide an objective synthesis of data and literature, and to identify information gaps and uncertainty.

In addition to scientific partners, the assessment team may engage other agencies that may have a management interest in the assessment area or that may have data or other information relevant to the assessment. Key partners may include:

- Bureau of Land Management
- US Geological Survey – Biological Resources Division
- US Fish and Wildlife Service
- National Park Service
- The Nature Conservancy
- State Agencies
- Local Agencies

Document and Product Format

Review documents should be in text font Century Schoolbook, 12 cpi and should be double spaced, full page, and left justified. All margins should be 1 inch.

The standardized final document format to be used in the assessments is the following:

(1) The document text should be in Century Schoolbook font size 10.
(2) All margins should be 1 inch.
(3) The page layout should consist of two equal columns of text that are fully justified.
(4) Chapter headings should be Century Schoolbook font size 14 bold, Section headings should be Century Schoolbook font size 12 and 11 bold.
(5) The assessment should include a table of contents that includes entries for the first two heading levels.

Documents should be sent to the writer/editor complete with associated tables and maps. The role of the writer/editor is to compile the documents, merge writing styles, ensure consistent formatting, etc. In addition, the writer/editor is responsible for improving the writing style, ensuring technically correct writing, and enhancing the readability of the documents. The writing/editing tasks may require more than one individual to accomplish the spectrum of work. All products must be compatible with Microsoft Office 2000 software. All geospatial datasets must be compatible with ArcView 3.xx. This is to ensure compatibility between users. When complete, assessments should be

converted to Adobe PDF format. PDF documents are very user-friendly and much easier to search through than Microsoft Word documents.

The final assessment should be produced in hard copy and electronic copy. Electronic copies allow for easy and fast distribution. Supporting data, such as geospatial data, should be distributed along with the electronic copies of the assessment, if feasible.

Data Selection and Management

The best (e.g., highest quality, appropriate resolution, accuracy assessed, etc.) spatial data available to produce a continuous coverage of the assessment area should be selected. While all data formats accepted by ArcGIS and ArcView are suitable, coverages, shape files, and GRIDS are the preferred geospatial data formats to ensure compatibility between ArcGIS and ArcView users.

All data sources used in ecological assessments must be cited and the citation must be sufficient to obtain the data. If this is not possible, the dataset itself must be delivered with the assessment. All efforts should be made to meet FGDC metadata standards.

If a spatial data product is not a straightforward mapped result of an inventory or occurrence activity, then the analytical procedures used should be documented and delivered, or cited, with the dataset. Modeled datasets need to be fully documented in the assessment via written descriptions. The model's internal dynamics need to be captured, even if not spatially explicit. The description needs to be put into a spatial context or refer to a parameter that can be located within areas of concern in order to make the model useful to other applications. Assessments should also include specifics on the model's parameter dependencies.

Data should be stored on corporate servers for security and reliable backup. Data can be copied onto personal PC hard drives or CDs for faster access during analysis.

Map layouts should comply with a predetermined layout as closely as possible to ensure consistent and concise maps. The following figure standards should be met:

(1) Show only the layers needed to express the purpose of the map. For example, do not show subsection lines unless specifically needed.
(2) Do not include titles on the figures. Put this information into a figure caption. If needed, create a text file with the same name as the figure that can then be easily inserted as a caption into any document.
(3) Always shade background layers in the same color. For example, for section M331B we suggest pale yellow and for the Forest, pale green.
(4) Keep colors consistent for the same attributes or concepts. For example, areas of high fire hazard, high insect risk, or high weed risk should all be the same color, e.g., red.
(5) Create consistent and clean legends. Do not include ***.shp extensions and use the same terms and abbreviations. Keep legends in same position in all figures.
(6) Do not include data tables in figures.
(7) Keep scale and compass rose in a consistent format and in the same position.
(8) Keep all fonts in the figure consistent with the font in the document.
(9) One hard copy and an electronic copy (both CD and ftp access) of the products should be made available at the time of assessment completion.

Peer Review and Publication

All assessments prepared to meet requirements of the Species Conservation Project should be peer reviewed. These CLC assessments will be peer reviewed by a team of scientists and resource specialists managed by the SCP. The assessments will be web-published to allow for easy access and revision.

Glossary

abiotic:
The nonliving factors in the environment including climactic, geological, and geographical features that may influence ecological systems.

adaptive management:
A type of natural resource management that implies making decisions as part of an on-going process. Monitoring the results of actions will provide a flow of information that may indicate the need to change a course of action. Scientific finding and the needs of society may also indicate the need to adapt resource management to new information.

aggradation:
The process by which a stream's gradient steepens due to increased deposition of sediment.

algivorous:
Feeding on algae.

allochthonous:
Derived from outside a system, such as leaves of terrestrial plants that fall into a stream.

allotment (range allotment):
The area designated for use by a prescribed number of livestock for a prescribed period of time. Though an entire Ranger District may be divided into allotments, all land will not be grazed, because other uses, such as recreation or tree plantings, may be more important at a given time.

anadromous:
Ascending, especially of fish that ascend rivers to spawn.

animal unit month (AUM):
The quantity of dry forage required by one mature cow (1,000 pounds or the equivalent) for one month based on a forage allowance of 26 pounds per day.

anthropogenic:
An action by humans that influences species or ecosystem form, function or population dynamics.

antidunes:
Bedforms that form in fast shallow flows.

aquatic ecosystem:
Waters of the United States, including wetlands, that serve as habitat for interrelated and interacting communities and populations of plants and animals. The stream channel, lake or estuary bed, water, biotic communities, and the habitat features that occur therein.

areas of ecological concern:
Equivalent to areas of low ecological integrity.

ARWA:
Aquatic, riparian, and wetland assessment.

AUM:
See animal unit month.

austral limits
The southern or southerly extent.

autochthonous:
Any indigenous animal or plant.

autotrophism:
Literally, self-feeding, a method of obtaining nutrients in which the principle carbon source is inorganic, usually carbon dioxide. Organic materials are then synthesized using light energy or chemical energy. In the case of chemical energy, it is derived from the oxidation of an inorganic compound. Autotrophs are important ecologically as the primary producers of organic carbon for all heterotrophic organisms.

avulsion:
A separation by force. The sudden removal of a person's land by the action of water, as by flood or change in the course of a stream, without a resulting loss of ownership.

bedform:
The shape of the surface of a bed of granular sediment produced by the flow of air or water over the sediment. The nature of the bedform depends upon the flow strength and depth, and upon sediment grain size. For fine to medium sand, the typical sequence of bedforms produced under conditions of constant depth and increasing strength of unidirectional flow is: no movement; ripples; sand; waves; dunes; and an upper-flow-regime plane bed. In coarse sand a lower-flow-regime plane bed develops first, then ripples, followed by sand waves, then dunes, and an upper-flow-regime plane bed. At higher-strength flows, the upper flow regime plane bed is replaced by antidunes.

bedload:
Material moving on or near the stream bed by rolling, sliding, and sometimes making brief excursions into the flow a few diameters above the bed.

benthos:
Animals and plants living on or within the substrate of a water body (freshwater, estuarine, or marine).

biodiversity or biological diversity:
The number and abundance of species found within a common environment. This includes the variety of genes, species, ecosystems, and the ecological processes that connect everything in a common environment.

biogeography:
Study of geographical distribution of plants and animals.

biota:
All living things existing within a given area or on the Earth.

buffer:
A land area that is designated to block or absorb unwanted impacts to the area beyond the buffer. Buffer strips along a trail could block views that may be undesirable. Buffers may be set a side next to wildlife habitat to reduce abrupt change to the habitat.

canopy cover:
The percentage of ground cover by a vertical projection of the outermost perimeter of the natural spread of foliage of plants. Small openings within the canopy are included. The additive cover of multiple strata or species may exceed 100%. Source: Society of Range Management 1989, Natural Resources Conservation Service 1997. In CVU, the cover percent of each lifeform (e.g., tree, shrub, forb, grass) or ground surface class (e.g., barren, water) is weighted and summed across all the components recorded for a polygon. Source: Bighorn National Forest Integrated Resources Inventory, User's Guide; May 1999

cascade:
Habitat type characterized by swift current, exposed rocks and boulders, high gradient, and considerable turbulence and surface agitation, and consisting of a stepped series of drops.

clasts:
A rock particle or fragment.

clear cut:
A timber harvest method in which all trees are removed in a single entry from a designated area, with the exception of wildlife trees or snags, to create an even-aged stand.

CLC:
Current landscape condition.

CLU:
See common land unit.

coarse woody debris:
The residue left on the ground after a fire, storm, timber cutting, or other event. Woody debris includes unused logs, uprooted stumps, broken or uprooted stems, branches, bark, etc.

common vegetation unit (CVU):
Existing vegetation is mapped and attributed in IRI as the Common Vegetation Unit (CVU). Individual CVU polygons are generally single species in dominant lifeform, species composition, percent crown cover, size, vertical structure, and crown condition. Existing vegetation is what currently exists on a site. The CVU product is a single GIS map layer with associated tabular attribute data. Source: Bighorn National Forest Integrated Resources Inventory, User's Guide; May 1999.

common land unit (CLU):
An ecological unit based on the integration of geology, landform, soil, and potential natural vegetation. The CLU product is a single GIS map layer with associated tables, map unit descriptions, taxonomic unit descriptions, and interpretative tables. Source: Bighorn National Forest Integrated Resources Inventory, User's Guide; May 1999.

communities of concern:
Vegetation communities within the forest that are critically imperiled (G1) or imperiled (G2) due to extreme rarity (known from ≤5 extant occurrences) or rarity (known from 6-20 occurrences) or because some factor of a species' life history makes it vulnerable to extinction, as identified by The Nature Conservancy's Natural Heritage Network.

condition class:
Condition classes are a function of the degree of departure from historical fire regimes resulting in alterations of key ecosystem components such as species composition, structural stage, stand age, and canopy closure. One or more of the following activities may have caused this departure: fire exclusion, timber harvesting, grazing, introduction and establishment of exotic plant species, insects and disease (introduced or native), or other past management activities.

conservation site:
Areas within the forest that contain high concentrations of important taxa or representative vegetation communities identified by the Wyoming Natural Diversity Database.

conservation strategies:
Documented strategies developed to provide for the long-term sustainability of taxa and ecosystems. Typically taxa or ecosystems that are rare of at-risk of becoming extinct in the foreseeable future.

cover type (forest cover type):
Stands or a particular vegetation type that are composed of similar species. The aspen cover type plants distinct from the pinyon-juniper cover type. In CVU, the classification for trees is based on the SAF (Society of American Foresters) classification as interpreted using the CVU calculations. The calculations for shrublands, grasslands, and forblands are based on the SRM (Society of Range Management) classification. The resulting classifications are broad. As much as possible, cover type calculations are consistent with logic used for past Forest plans in Region 2 and with National standards. Calculations for cover type are based on first the lifeform and second on the species mix fields in CVU. Source: Bighorn National Forest Integrated Resources Inventory, User's Guide; May 1999.

CVU:
See common vegetation unit.

DCA:
Detrended correspondence analysis.

dendrogram:
A diagram, similar to a family tree, that indicates some type of similarity between different organisms.

detrital:
Loose natural material that results from the direct disintegration of rocks or organisms, often a mixture of the two.

detritivorous:
Feeding on detritus.

developed recreation:
Recreation that requires facilities that, in turn, result in concentrated use of the area. For example, skiing requires ski lifts, parking lots, buildings, and roads. Campgrounds require roads, picnic tables, and toilet facilities

diameter class:
Any of the intervals into which a range of tree diameters may be divided for classification.
For this assessment we used:
Tree size classes - measured at dbh, woodland species are measured at the root collar:
Established seedlings - Mostly comprised of individuals 0.0 – 0.9 inches in diameter at ground level or root collar
Small - Individuals 1.0 – 4.9 inches
Medium - Individuals are 5.0 – 8.9 inches Large - Individuals are 9.0 – 15.9 inches
Very Large - Individuals are 16.0 inches and larger
Shrub size classes:
Small – Shrubs are less than 2.5 feet tall
Medium – Shrubs are 2.5 – 6.4 feet tall
Large – Shrubs are greater than 6.4 feet tall
Unknown – Size class cannot be determined

dispersed recreation:
Outdoor recreation in which visitors are diffused over relatively large areas. Where facilities or developments are provided, they are primarily for access and protection of the environment rather than comfort or convenience of the user.

ecological drivers:
Environmental factors that exert a major influence on the fitness of individuals and species population size. These drivers can be considered as comprising the physico-chemical template of an ecosystem and the dominant expression of these drivers at a particular spatial scale influences the relative success of species and thus community composition at that scale.

ecological integrity:
Refers to an ecosystem that will function successfully and optimally under conditions characteristic of the locale. In addition to including optimal levels of energy flow, an ecosystem of high integrity should maintain a balanced, adaptive community having species composition, biodiversity, and functional processes naturally characteristic of the area. Ecological integrity also assumes an ecosystem's ability to withstand stress or exhibit resilience in the face of unexpected future perturbations to environmental conditions. It is also simply the maintenance of the community structure and function characteristics deemed satisfactory to society. The attributes of an ecosystem with integrity are inherently qualitative rather than absolute, but generally include ecosystem health, biodiversity, stability, sustainability, naturalness, wildness, and beauty.

ECOMAP:
A USDA Forest Service initiative to map ecological units and encourage their use in ecosystem-based approaches to forestland conservation, and management; a collaborative with many partners. It is coordinated at the national and regional levels by USDA Forest Service staff. It is implemented in cooperation with state forestry agencies and others; and the actual maps developed under this initiative.

ecoregions:
A general description of the ecosystem geography of the nation with areas designated as domains, divisions, and provinces.

ectothermic:
Animals that lack an internal system for body temperature regulation thus tend toward the temperature of their environment. They have evolved a wide array of behavioral mechanisms that enable them to control their temperature by using environmental cooling and heating. This situation is found in most animals other than birds and mammals. They have been called "cold-blooded" because their body temperature is often, though not always, cool relative to endotherms.

endemic:
Species restricted to a particular geographic area; for aquatic species, usually limited to one or a few small streams or a single drainage.

eutrophic:
Condition of a lake or pond where deleterious effects are caused by increased nutrients (nitrogen and phosphorous) and a decrease in oxygen. *Eutrophication* is a process whereby fresh water becomes enriched in nutrients, thus beginning the cycle of ecological succession. When this happens as a result of sewage or fertilizer runoff, the concentrated over stimulation of algal growth results in a bloom. When the excess dead algae are decomposed by aerobic bacteria at an abnormally high rate, oxygen is depleted from the water, causing aquatic animals such as fish to die of suffocation.

evapotranspiration:
The rate of liquid water transformation to vapor from open water, bare soil, or vegetation with soil beneath.

extirpation:
Extinction of a species from all or part of its range.

exurban development:
Dispersed, low-density areas of human development and associated infrastructure; for example, campgrounds, cow camps, homes, resorts, ski areas, and utility corridors.

fragmentation:
The splitting or isolating of patches of similar habitat but including other types of habitat. Habitat can be fragmented naturally or from management activities, such as road culvert construction.

fire hazard:
A fuel complex defined by kind, arrangement, volume, condition, and location that forms a special threat of ignition or suppression difficulty.

fire regime:
A summary description of the salient characteristics of fire occurrence and effects within a specified area, such as fire frequency, extent, interval season, severity and intensity.

GAP:
Gap Analysis Project (GAP) integrates remote sensing and geological information system (GIS) data to provide broad geographic information on the status of ordinary species (those not threatened with extinction or naturally rare) and their habitats at a cartographic scale of 1:100,000. One product of the GAP analysis used by the TEA is the land cover vegetation map, which provides consistent broad scale vegetation data on a state-wide level.

geochemistry:
Chemical composition of the Earth's crust.

geomorphic:
Pertaining to or like the form or figure of the earth. Geomorphology is the study of form, nature, and evolution on earth's surface.

GIS:
Geographic Information System.

grassland and shrubland:
For the Terrestrial Ecological Assessment it includes grassland, cropland, forbland, shrubland and areas dominated by rock or bare soil.

groundwater:
Generally all subsurface water as distinct from surface water; specifically, that part of the subsurface water in the saturated zone (a zone in which all voids are filled with water) where the water is under pressure greater than atmospheric.

habitat structural stage (HSS):
Habitat structural stage provides a coarse filter look at habitats provided by forests. It gives an indication of forest size and density, which can be interpreted for wildlife habitat suitability. Source: Bighorn Plan Revision: Final EIS.

heterotrophic:
A method of obtaining nutrients by feeding on other organisms. Heterotrophic organisms are *chemotrophic*, obtaining both their energy and carbon atoms by degrading ingested organic compounds. At least 95% of the organisms on earth (all animals, all fungi, and most bacteria and protests) live by feeding on the chemical energy fixed into carbon compounds by photosynthesis.

hierarchical classification:
A classification technique in which each, more detailed level, falls within the delineation of the next higher level class. Predictable and repeatable properties of a given level in the classification are defined by the next higher level.

historical fire regime:
Characteristic fire regime prior to significant impacts of Euro-American settlers.

historical range of variability (HRV):
Spatial and temporal variation in various ecosystem characteristics when the influences of Euro-Americans were minimal (1600-1890).

HUB:
Hydrologic unit boundaries as part of the development of a National Watershed Boundary Dataset that will replace HUCs.

HUC:
Hydrologic unit codes. Code cataloguing the watershed, developed by USGS.

hydroclimatology:
The geology of groundwater, with particular emphasis on the chemistry and movement of water.

hydrogeology::
The geology of groundwater, with particular emphasis on the chemistry and movement of water.

hyporheic zone:
The layer of stream channel substrate extending as deep as there is interstitial flow.

hypsometry:
The measurement of elevation relative to sea level.

in-situ:
Literally, "in place" or in original position.

integrated resource inventory (IRI):
IRI is a system to spatially locate, integrate, and describe water, land, and vegetation data. The finally result is three distinct themes called the Common Water Unit (CWU), Common Land Unit (CLU), and Common Vegetation Unit (CVU). These themes are related to each other as the principal components of a natural landscape, and they are a manageable project at a forest level Source: Bighorn National Forest Integrated Resources Inventory, User's Guide; May 1999.

invasibility:
The ability of invasive plants to establish and persist in an ecosystem.

invasive plant:
(1) Any non-native (to ecosystem of interest) species whose introduction does or is likely to cause economic or environmental harm or harm to human health. (2) Plant species that exhibit a tendency to spread out of control, once introduced, often thereby producing a monoculture that discourages the growth of other plant varieties, including indigenous plants.

IRI:
See Integrated Resources Inventory.

landtype association:
An ecologically driven classification of land area based on similarities in soil, climate, and elevation.

lentic:
An environment created by standing water for instance lakes, ponds, and permanent or temporary pools.

lithology:
Description or study of the outermost solid layers of the earth.

livestock preference:
Predicts where livestock are likely to be found on the landscape in relation to allotment status, slope, distance to water, and vegetation characteristics.

lotic:
Environments formed by running water, such as streams and rivers.

LTA:
See landtype association.

management area:
Areas within the National Forest that have been allocated by the Forest Plan. Each area has different resource goals and activity according to the Forest Service Standards and Guidelines.

mesotrophic:
This term is applied to clear water lakes and ponds with beds of submerged aquatic plants and medium levels of nutrients.

montane:
A cool, moist ecological zone usually located near the timberline and usually dominated by evergreen trees.

multiple scale assessment:
Assessments that evaluate the appropriate species and/or ecological characteristics and influences at more than one appropriate scale. Typically, the scales are hierarchical so reference can be made between scales.

natural disturbance:
Any natural event that alters the structure, composition, or function of an ecosystem.

NEPA:
National Environmental Policy Act.

NFMA:
National Forest Management Act.

NHD:
National Hydrography Dataset.

NRIS:
National Resource Information System.

NWI:
National Wetland Inventory.

old growth:
A forest stand with moderate to high canopy closure, a multi-layered, multi-species canopy dominated by large overstory trees, a high incidence of large trees with broken tops and other indications of dead or dying trees, numerous large snags, logs, and other downed woody material on the forest floor.

oligotrophic:
Lakes that are deficient in nutrients and consequently low in productivity**.**

overbank deposit:
Sediments (usually clay, silt, and fine sand) deposited on flood plain by river overflowing banks.

peatlands:
Contain partially reduced plant or wood material, containing approximately 60 percent carbon and 30 percent oxygen. An intermediate material in process of coal formation.

physiography:
Physical geography; topography description of natural phenomena.

plankton:
An ecological designation for various microscopic aquatic organisms that drift more or less freely in the upper regions of a water body.

palustrine:
Comes from the Latin word "palus" or marsh. Wetlands within this category include inland marshes and swamps as well as bogs, fens, tundra and floodplains. Palustrine systems include any inland wetland which lacks flowing water and contains ocean derived salts in concentrations of less than .05%.

patch:
A relatively homogenous nonlinear area that differs from its surroundings. The term patch can specifically describe forested patches, non-forest vegetation patches, rock/barren patches, or water patches.

physico-chemical:
Pertaining to both physical and chemical properties, changes, and reactions.

plane bed:
A near-horizontal surface of sand or gravel. Upper-stage plane beds are produced by the intense transport of sediment by high-velocity, shallow flows (upper-flow-regime conditions), and characterized by primary current lineation on the sediment surface. Lower-stage plane beds are produced only in coarse sands and gravels by flow conditions broadly similar to those which generate current ripples in finer sand. The lower-stage plane bed exhibits a series of shallow scours on the sediment surface. The accumulation of plane-bedded sediment gives rise to an internal sedimentary structure of horizontal lamination.

plankton:
The assemblage of microscopic organisms, (zooplankton), that drift passively in the surface waters of seas and fresh water. Their location is mainly dependent on currents and water clarity, as the plants require sunlight for photosynthesis. The diatoms, tiny algae, and small animals drift freely; larger animals swim independently. Plankton is the basis of all aquatic food-chains.

PNV:
See potential natural vegetation.

pool:
A portion of the stream with reduced current velocity, often with water deeper than the surrounding areas; frequently usable by fish for resting and cover. Or a small body of standing water, e.g., in a marsh or on the flood plain.

pool-riffle:
The alternating sequence of deep pools and shallow riffles along the relatively straight course of a river. The distance between the pools is 5-7 times the channel width.

potential natural vegetation (PNV):
The vegetation that would become established, if all successional sequences were completed without interference by man under the present climatic and edaphic conditions (adapted from Tuxen 1956 as cited in Mueller-Dombois and Ellenberg 1974). Concepts such as succession, site, and environmental factors are all part of potential natural vegetation. Existing vegetation is simply what is there at the time of sampling. PNV classifications are based on existing vegetation, succession and environmental factors (e.g., climate, geology, soil, etc.) considered together.

pRNA:
Potential Research Natural Area (RNA). An area being considered for RNA designation.

rangeland resilience:
The ability of the ecosystem to tolerate and recover from livestock grazing effects.

refugia:
Small isolated areas where extensive changes, most typically due to changing climate, have not occurred. Plants and animals formerly characteristic of the region in general now find a refuge from the new unfavorable conditions in these areas. An example might be a mountain summit projecting above a glaciated lowland region.

regolith:
The irregular blanket of loose, noncemented rock particles that cover the Earth.

research natural area (RNA):
A Forest Plan designated management area designated for the preservation of a naturally occurring physical and biological unit where natural conditions are maintained for the purposes of: (1) comparison with those lands influenced by man; (2) provision of educational and research areas for ecological and environmental studies; and (3) preservation of gene pools, typically rare and endangered plants and animals.

resilience:
The ability of an ecosystem to maintain diversity, integrity, and ecological processes following a disturbance.

riffle:
A shallow rapid where the water flows swiftly over completely or partly submerged obstructions to produce surface agitation, but standing waves are absent.

riparian:
Pertaining to anything connected with or immediately adjacent to the banks of a stream or other body of water.

riparian ecosystem:
The ecosystems around or next to water areas that support unique vegetation and animal communities as a result of the influence of water.

river continuum:
Gradual changes in the biological community of a river as energy sources and physical conditions change from headwaters to lowlands.

riverine system:
All wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens; and (2) habitats with water containing ocean derived salts in excess of 0.5 percent.

RNA:
See research natural area.

scale:
In ecosystem management, it refers to the degree of resolution at which ecosystems are observed and measured.

salmonids:
Fish of the family Salmonidae, the chars, trouts, salmons, and whitefishes.

section:
A subdivision of province and part of the National Hierarchical Framework of Ecological Units. Defined by broad areas of similar geologic origin, geomorphic process, stratigraphy, drainage networks, topography, and regional climate.

sensitive species:
Plant or animal species, which are susceptible to habitat changes or impact from activities. The official designation is made by the USDA Forest Service at the Regional level and is not part of the designation of Threatened or Endangered Species made by the US Fish and Wildlife Service.

seral:
The stage of succession of a plant or animal community that is transitional. If left alone, the seral stage will give way to another plant or animal community that represents a further stage of succession.

silivicultural system:
The cultivation of forests; the result is a forest of a distinct form. Silivicultural systems are classified according to harvest and regeneration methods and the type of forest that results.

siliviculture:
The art and science that promotes that growth of single trees and the forest as a biological unit.

snag:
A standing dead tree. Snags are important as habitat for a variety of wildlife species and their prey.

socioeconomic:
Pertaining to, or signifying the combination or interaction or social and economic factors.

species conservation project (SCP):
Designed to incorporate terrestrial and aquatic ecosystem assessments, species assessments, reference models, and species conservation strategies into an overall framework that will ensure a thorough evaluation of species viability. The assessments will serve planning by providing a strong science base from which to build plant alternatives without directing management. The SCP is designed to provide a regionally consistent set of information to identify species at risk and to provide for their viability.

stand:
A group of trees that occupies a specific area and is similar in species composition, age, and condition.

stand density:
The measure of the amount of tree vegetation on a unit of land area. It can be the number of trees or the amount of basal area, wood volume, leaf cover, or a variety of less common parameters.

suitable timber:
Refers to areas where timber harvesting is allowed on a regulated and sustained basis.

sustainability:
The ability to sustain ecological integrity over the long term, and leave the task of evaluating sustainability to the forest managers, who must do so within the context of their actions.

sustainable:
The yield of a natural resource that can be produced continually at a given intensity of management is said to be sustainable.

taxon:
The members of a particular taxonomic group such as a *class, family*, or *genus*. The members of the class *Mammalia* form a taxon. taxa (pl).

trophic level:
One of a succession of steps in the movement of energy and matter through a food chain in an ecosystem. Organisms are considered to occupy the same trophic level when the matter and energy they contain have passes through the same number of steps since their entrance by way of photosynthesis or chemosynthesis.

USFS:
United States Forest Service.

viable population:
The number of individuals of a species sufficient to ensure the long-term existence of the species in natural, self-sustaining populations that are adequately distributed throughout their range.

watershed:
The total area above a given point on a stream that contributes water to the flow at that point. Drainage basin, catchment basin, or river basin.

WBD:
National Watershed Boundary Dataset

wetlands:
The biome consisting of freshwater swamps, marshes, bogs, ephemeral ponds, and saltwater marshes. They are characterized by continual or seasonal standing water, which creates a specialized soil environment with very little oxygen, retarding decay. Although wetlands occupy only a small portion of Earth's land area, the organisms that have adapted to this environment are very specialized and perform important functions in the environment.

zoogeography:
Study of geographic distribution of animals.