Appendix D

Sustainability through Ecosystem Restoration

Mark Twain
National Forest

Cover image: Post oak flatwoods

Photographer: Paul Nelson, Mark Twain National Forest

Appendix D

Sustainability through Ecosystem Restoration

Introduction

The ecosystem approach to management is a strategy for protecting biodiversity and maintaining species viability on the Mark Twain National Forest. The approach to managing for diverse and sustainable natural communities is:

- to restore their structural vegetative condition and maintain historical disturbance processes and functions under which natural communities evolved, and to which they are uniquely adapted.

Ecosystem management is the work of improving the integrity of ecologically distinct areas that contain remaining groups of restorable natural communities (basics of ecosystem management phases are described in Part VI below). The underlying concept is that a representative array of natural communities will include appropriate variations in habitat structure and plant species composition to accommodate most plant and animal species. Conserving an adequate representation of natural communities that harbor a broad diversity of plants and animals is an efficient approach to conserving biodiversity, which may protect the vast majority of all species (Hunter 1991, Groves 2003, Nigh 1992, Noss and Cooperrider 1994). In essence, ecosystem management is a proactive approach to prevent creation of threatened species rather than expend resources attempting to recover them (Hunter 1991).

The purpose of this section is to outline the ecological framework for programmatic decisions made and environmental consequences discussed in the FEIS. Six key components and questions that illustrate ecosystem-level analysis (presented in the Ecosystem Sustainability section of Chapter 3) are:

1. Identifying conservation targets: species and natural communities at risk.
   - What should be sustainable?
2. Developing an ecological hierarchal classification.
   - How do we organize biodiversity in a way we can compare and understand?
3. Establishing a reference range of natural variability for natural communities.
   - How did ecosystems and their associated plants and animals evolve and adapt?
4. Linking species viability assessment to ecosystem function and risk factors.
   - Why is ecosystem function and integrity important to species at risk? What are ecosystem dysfunctions?
5. Determining the spatial configuration of targets.
   - How can we most efficiently and effectively conserve biodiversity and address species viability? What and where are priority conservation opportunity areas?
6. Finally, outlining ecosystem management principles.

- How do we restore natural communities (implementation) and what are the measurable ecological indicators (monitoring) that tell us we are moving in the right direction?

The following documents and initiatives address these steps:

- Ozark Ecoregional Conservation Assessment (Ozark Ecoregional Assessment Team 2003)
- Atlas of Missouri Ecoregions (Nigh and Schroeder 2002)
- The Terrestrial Natural Communities of Missouri (Nelson 2005)
- The Missouri Biodiversity Report (Nigh et al. 1992)
- The Missouri Natural Areas Program
- Partners In Flight; Ozark-Ouachita Physiographic Region
- Ozark-Ouachita Highlands Assessment (USDA 1999)

We begin by referencing The Nature Conservancy's Ozark Ecoregional Conservation Assessment (OECA) that serves as a conservation blueprint, identifying those elements of a region's biological features that are of conservation significance from a biodiversity perspective. Selection of new project management areas for purposes of restoring significant ecosystems should be based on conservation assessments (Groves 2003, Baydack et al. 1999). Significant ecosystems are those distinctive, biologically intact landscapes that have a high probability (with management) of retaining their conservation targets (species and natural communities) over time. The OECA, along with other information provided by Partners in Flight, the Missouri Resources Assessment Partnership and the Missouri Natural Areas System, provides information to determine what is the least area of landscape needed to ensure sustainable conservation of this biodiversity (Ozark Ecoregional Assessment Team 2003). These dynamic landscapes have desired conditions specifically described in The Terrestrial Natural Communities of Missouri (Nelson 2005). Desired conditions are land or resource conditions that are expected to result if planning goals and objectives are achieved. For purposes of restoring ecosystems, desired conditions are described as key natural community elements or outcomes.

Opportunity areas become evident when conservation targets are identified, desired ecological conditions described, implementation methods outlined, and goals and objectives set. Management prescriptions 1.1 and 1.2 were developed in response to the identification of opportunity areas identified by The Nature Conservancy in the OECA report. Objectives result in outcomes (acres treated and moved toward the desired condition) describing what needs to be accomplished to achieve or maintain desired conditions. These targets, desired conditions and opportunity areas reveal options for projects. Management treatments or prescriptions are applied at a rate that trends toward meeting the desired condition over many decades.

To varying degrees, Alternatives 1 thru 4 focus on managing landscapes across Missouri's ecological subsections as a means of representing target natural communities and addressing minimum species viability needs. The alternatives generally use different measures of ecosystem management direction based on themes of each alternative, allocations of management prescription acres and projected activities. Some alternatives may rely more heavily on protected areas, while others put greater emphasis on management that may restore resources to conditions approaching the range of natural variability (RNV).

Part I. Identifying Conservation Targets at Risk

The first question in any conservation assessment is “What is sustainable?” This is answered by listing species, natural communities and ecological systems of distinctive significance from a biodiversity conservation perspective (Ozarks Ecoregional Conservation Team 2003). The Mark Twain National Forest developed a list of plant and animal species of conservation concern by their risk of extinction using a combination of internationally and nationally accepted ranking systems, each designed to assess extinction risk at different scales. The Mark Twain used a 2-step process to identify species-at-risk. The first step is to prioritize and categorize species based on risk. The listing and level of risk categories are as follows:

- Rangewide/national imperilment. Species listed by the U.S. Fish and Wildlife Service (USF&WS) as threatened or endangered, or are proposed for such listing. These are species for which the Forest Service is required to conduct Biological Assessments.
- USFWS candidate species and those ranked by the Natural Heritage Programs, including The Nature Conservancy list with global ranks of G1-G2.
- State and regional imperilment. Species listed by the Missouri Department of Conservation as state endangered, Missouri Species of Conservation Concern, Partners in Flight and examination of S1-S2 species.
- Regional Forester Sensitive Species (RFSS) may be at risk of extirpation at the planning level. These species are of concern in order to meet the requirement of maintaining species viability and distribution of all species within the planning area. The Mark Twain National Forest had 127 species on the RFSS list in 2004.
- Birds of conservation concern. USFWS has identified species, subspecies, and populations of all migratory non-game birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act of 1973.

The second step is review of this list to determine 1) if any species on the list is clearly secure within the planning area and therefore does not require further formal consideration, and 2) if there are additional species not on the list that are locally at risk that should be considered in detail in the Plan.

Next, the Mark Twain relied on information from the Ozarks Ecoregional Conservation Assessment, the Ozark-Ouachita Highlands Assessment, the Missouri Natural Heritage Database, Partners in Flight and The Terrestrial Natural Communities of Missouri to identify globally threatened ecosystem targets. These underrepresented natural communities are consistent with need for change issues relating to fire-adapted natural communities and in providing a wide diversity of wildlife habitats. The existing plan tends to focus on strictly structural timber age-class characteristics and does not provide for fire-adapted ecosystem characteristics.

Part II. Developing a Hierarchy of Ecological Units

Classification hierarchies provide structure for analysis of the parts and for synthesis of ecosystems as a whole. It answers the question “How do we organize natural resources or biodiversity in a way we can compare and understand?” Classification is useful for observing and comparing ecological elements in their context, and for understanding interdependence and interrelationships. Classification structure helps characterize ecosystems and identify patterns and processes at different ecological scales. Landscape delineation (the mapping or description of distinguishable ecological units at some scale) is essential in describing and characterizing Missouri's distinctive, recognizable ecosystems. The hierarchy concept allows us to define components of an ecosystem and their links between different scales of ecological organization. This systematic hierarchical approach, coupled with existing conservation assessments, offers a means for establishing the context of species viability, biodiversity and determining management objectives.

Spatial scale is determined using a hierarchical structure of landscape units based in part on the National Hierarchy of Ecological Units (Cleland et al. 1997). This approach consists of a series of levels in which areas, ranging from subcontinent to local vegetation are grouped based on similarities in climate, geology, soils, glacial history and vegetation. The actual ecological units for the Mark Twain are displayed in Table 1. The levels of domain, division and province are explained in Cleland et al. (1997) while sections and subsections are detailed in Nigh and Schroeder (2002).

Ecological units provide information for natural resource planning, management and analysis, which will assist in the comparison of the range of natural variability with current conditions. Ecological units can be described, mapped or modeled as natural communities and/or ecological landtypes.

The hierarchical framework of ecological units being used by the Mark Twain National Forest (Table 1) incorporates the national framework (Cleland et al. 1997), Missouri's ecological sections and subsections (Nigh and Schroeder 2002) and terrestrial natural communities (Nelson 2005).

Table 1 - Hierarchical Framework of Ecological Units Used by Mark Twain National Forest

Planning and Analysis Scale	Ecological unit	Purpose, objectives and general use	General size and range
Global, continental	Domain, Division	Broad application to conservation assessments	1,000,000s to 10,000s of sq miles
Regional	Province	Assessment of dominant potential natural vegetation	10,000 sq miles
Subregion (within and adjacent to Missouri)	Section	Statewide planning, multi-agency analysis	1,000 sq miles
Subregion (within Missouri)	Subsection	Mark Twain National Forest plan analysis, setting resource management objectives, resource characterization	1,000s to 100s of sq miles
Landscape	Subtypes of Landtype associations	Forest or area-wide project planning	100s of sq miles
Land unit	Ecological Land Type (ELT)	Forest or area-wide project planning at the stand level (may be remodeled)	100s of sq miles
Land unit	Natural Communities	Desired condition descriptions and objective targets	1,000s to less than 10 acres

Domain

Domains are sub continental with similar climates. All of Missouri lies within the Humid Temperate Domain.

Divisions

Divisions are determined by isolating areas of different vegetation and life forms, broad soil categories and regional climates. The majority of the Mark Twain occurs within the Hot Continental Division, with a small portion (Cedar Creek) situated in the Prairie Division.

Provinces

Provinces are determined by broad vegetation regions that are controlled by length and timing of dry seasons and duration of cold temperatures. The Ozark Broadleaf Forest Province encompasses most of the Mark Twain in the Ozarks while Cedar Creek occurs in the Prairie Parkland Province.

Sections

The Ozark Broadleaf Forest Province in Missouri is wholly occupied by the Ozark Highlands Section while Cedar Creek occurs in the Central Dissected Till Plains Section. Sections are areas of similar geographic origin, geomorphic process, rock formations, drainage networks, topographic similarities and climate.

Ozark Highlands Section

The Ozark Highlands Section is a geologically, ecologically and culturally distinct area of North America. Historically, the region was a diverse blend of forests, woodlands, savannas, glades, wetland, caves, riparian and aquatic natural communities. High levels of geologic, soil, topographic and hydrologic diversity results in a wide range of habitat types. These habitats and natural communities are home to more than 5,000 species of plants and at least 20,000 species of animals. These species occur in 85 terrestrial natural communities (Nelson 2005) and 67 aquatic faunal communities (Pflieger 1989). More than 160 endemic plant and animal species are documented from the Ozark Highlands Section (Ozark Ecoregional Assessment Team 2003).

Subsections

The Ozark Highlands Section is divided into sixteen subsections. Subsections are distinguished by differences in topography, relief, the relative occurrence and patterns of natural communities, geology and hydrology. These differences often have characteristic plant and animal species ranges, many natural communities and social/economic land use patterns. The 1.5 million acres of public lands making up the Mark Twain National Forest are widely distributed across Missouri’s ecological units with portions of the Mark Twain touching or including 10 of 16 subsections within the Ozark Highlands Section and portions of the Claypan Till Plains Subsection, Central Dissected Till Plains Section north of the Missouri River (Table 2). Ten subsections occurring on the Mark Twain are described in detail in Nigh and Schroeder 2002. Because the Forest Plan is programmatic, objectives for projected management treatments are set at the subsection level for specific target natural communities.

Table 2 - Ecological Subsection Delineations for Mark Twain National Forest Lands

	Total acreage	Acres on NFS Lands	% on NFS Lands	% of total NFS Lands	Ranger Districts
Ozarks Highlands Section					
Black River Ozark Border Subsection	682,000	133,200	20%	9%	Poplar Bluff
St. Francois Knobs and Basins Subsection	1,283,500	97,200	8%	6%	Potosi, Fredericktown
Current River Hills Subsection	3,826,900	508,600	13%	34%	Salem, Doniphan/ Eleven Point
Central Plateau Subsection	7,011,300	73,400	1%	5%	Salem, Doniphan/ Eleven Point, Willow Springs, Houston/Rolla
White River Hills Subsection	4,599,700	309,700	7%	20%	Ava/Cassville/ Willow Springs
Gasconade River Hills Subsection	2,290,600	172,400	8%	12%	Houston/Rolla
Meramec River Hills Subsection	1,830,000	176,700	10%	12%	Potosi
Outer Ozark Border Subsection	4,544,800	13,400	0.3%	<1%	Cedar Creek
Inner Ozark Border Subsection	2,495,800	8,400	0.3%	<1%	Fredericktown
Central Dissected Till Plains Section					
Claypan Till Plains Subsection	Not available	3,100		<1%	Cedar Creek

Landtype Association Groups

Landtype Associations (LTA's) are ecological landscapes that have recognized local characteristics of topography, geography, soils, ecological processes and natural vegetation. LTA groups are groupings of similar LTA's. There are 25 for the State; 9 for the Ozark Highlands, one additional for Cedar Creek, and one that touches the Poplar Bluff Ranger District. The Forest may apply LTA group characteristics as part of conservation planning and project evaluation/implementation.

Terrestrial Natural Communities

Technical experts representing the Mark Twain National Forest, Missouri Department of Conservation, Missouri Department of Natural Resources, The Nature Conservancy and National Park Service served on a workgroup beginning in 1997 to revise and update the Terrestrial Natural Communities of Missouri classification system. This revised system includes in-depth descriptions for 85 terrestrial natural communities in which at least 65 (Table 3) occur on the Mark Twain. The 1986 Forest Plan cross-references terrestrial natural communities and ecological landtypes. The present assignment of ELT's to stand layers is obsolete and in need of updating.

Table 3 - Primary Natural Community Types for Mark Twain National Forest

Natural Community Type	# of natural communities*	Estimated statewide historic acreage	# of natural communities on MTNF	Equivalent historic vegetation**	Percent canopy cover**
Forest	15	13 million	14	Forest	> 80%
Woodland	18	11 million	13	Open Woodland	20-50%
				Closed Woodland	50-90%
Savanna	6	6.5 million	3	Barrens/shrubland	< 20%
Prairie	12	13 million	2	Prairie	Per surveyor maps
Glade	5	500,000	4	Not analyzed	NA
Cliff/Talus	9	No estimate	9	Not analyzed	NA
Stream Edge	3	No estimate	2	Not analyzed	NA
Wetland	13	4.8 million	9	Not analyzed	NA
Cave	2	5,800 sites	2	Not analyzed	NA

**Detailed in Nelson 2005.*
***Equivalent historic vegetation refers to the range of canopy openness analyzed by the Geographic Resource Center (GRC), University of Missouri in 2004.*

A synopsis of the characteristic ecological systems is given in the Ozarks Ecoregional Conservation Assessment (TNC 2003) and Nigh and Schroeder (2002). These natural community descriptions were used to set objectives for treatment of respective natural communities during the next decade (see MP 1.1 and 1.2 objectives).

Part III. Reference Range of Natural Variability

The range of natural variability (RNV) is a term used to reference the variation in physical and biological conditions within an area as influenced by climate and disturbances regimes as they occurred prior to European settlement (early 1800s) (Swamson et al. 1994). RNV is useful in describing and comparing current conditions of the Mark Twain NF to those of the past. Ecosystems, or natural communities, are described in terms of composition, structure, physical characteristics and function (disturbance processes, animal interactions, predation, etc). Ecosystems are dynamic and these attributes are constantly changing. However, composition, structure and function are constrained within the limits of how historical fires, floods, animals and even indigenous people (prior to European settlement) interacted. Sustainable management uses historical information as a reference for restoring and maintaining patterns and processes characteristic of the historical landscape. Studying RNV gives some indication of the sustainability of ecosystems and identifies those components that may need management attention, especially fire-adapted natural communities.

The assemblages of plants and animals that occurred at or prior to European settlement are the benchmark from which to measure today's array of threatened and endangered species. Based on a study of the nation's 1,880 imperiled plant and animal species, habitat destruction and degradation rank as the most pervasive threats to biodiversity in the United States, affecting 85 percent of species analyzed (Wilcover and Rothstein et al. 2000). Early botanists, biologists and naturalists described and documented the abundance, patterns and scales of plants and wildlife during the settlement period, and their subsequent destruction/extinction. Beginning in the early 1970's, ecologists and biologists were trained to systematically assess ecological health across the landscape by conducting a series of natural features inventories. These comprehensive county inventories (some 20 listed in Nelson 2005) identified areas of remaining biological integrity by ranking ecological health.

These inventories and subsequent conservation assessments describe the degree to which plant and animal species, and terrestrial/aquatic habitats are today threatened.

For clarification, emulating natural disturbance processes is about balancing the severity, scale and frequency of disturbance processes with the management-assisted recovery of ecosystem conditions, and their subsequent sustainable use. The current condition for most of the Ozark Highland ecosystems is much different when compared to the historic condition. It is a goal of the Mark Twain National Forest and mission of the U.S. Forest Service to provide forest products to meet society's demands for renewable resources in a manner that sustains resources. Emulating natural processes means conducting management activities (timber harvest, grazing, etc) in ways that best mimic or balance the presumed historic extent of natural communities (see Forest Research Information Paper No. 149; Emulating Natural Forest Landscape Disturbances: Concepts and Applications (2002).

Assumptions and Limitations of RNV

RNV is determined by studying the ecological history of an area. A description of RNV is limited by the availability of information on past landscapes and a means of cross-referencing current data to it. Missouri is fortunate to have data/information derived from historic land survey records and many fire history studies. Assumptions and limitations include:

- Species are adapted to certain historical environmental conditions, can tolerate and may even require a range of disturbances to sustain viable populations.
- Many Missouri natural communities are fire-adapted and dependent on fire to maintain their attributes.
- Missouri's climate has remained relatively stable for at least 4,000 years (see Wettstaed in Nelson 2005 for a brief discussion on climate during the Holocene).
- Native Americans maintained widespread expanses of prairie and savanna, and freed up much of the forest from underbrush prior to and at the time of settlement (Pyne 1982 and others). Their role and impacts on RNV is discussed in Nelson (2004).
- Without active management to maintain RNV for these fire-adapted natural communities, species of conservation concern and sensitive species may decline.
- Precise RNV descriptions for local areas of the Mark Twain NF are obscured by 150 years of vegetation change resulting from resource exploitation during initial stages of European settlement. However, over 30 years of comprehensive natural features inventories have led to classification, characterization and location of benchmark quality natural areas depicting the RNV for ecosystem characteristics.
- Projections regarding the movement of current condition toward RNV are based on quantitative and qualitative plant and animal studies, and vegetation monitoring of the restoration and management of target natural communities in natural areas, conservation areas, state parks, national parks and portions of Forest Service lands.

Historic Vegetation

An historical reconstruction of vegetation structure and disturbance regimes informs us about what is possible within certain locations and times, and places current conditions into this context. This provides insights into major disruptive changes that have altered Missouri ecosystems, and what management is essential in recovering them.

In this context, the methods used to compare historic conditions to present ones provides a broad assessment of land conditions for developing programmatic objectives. As part of the analysis, the Mark Twain used GIS databases of historic vegetation coverage, and map products for respective ranger districts. Showing percent canopy cover and dominant tree associations helps set desired condition objectives for natural communities within Management Prescriptions 1.1 and 1.2.

The field notes of early land surveys, conducted between 1815 and 1853, are extremely valuable because they include qualitative and quantitative information on cultural and natural environment at times before major impacts of permanent settlement occurred. With a grid cell covering virtually every square mile of the public domain, field survey notes form a systematic collection of reasonably objective information obtainable from no other source. Since 1993, the Geographic Resources Center's Historic Vegetation Project at the University of Missouri has been active in building datasets for test regions of Missouri as well as investigating and testing different methodologies for analyzing and interpreting the data provided by the original notes. The Historic Vegetation Project analyzed land survey records to develop two primary map/spatial data products. Land cover maps are expressions of the relative openness of vegetation that correlate with broad natural community type descriptions. Vegetation class cover maps identified and mapped principle vegetation associations, which in turn correlate with the dominant/characteristic tree canopy and other structural vegetation stages described for natural communities. The Forest's Combined Data System (CDS) data was compared to the Historic Vegetation Project data. Present day dominant vegetation cover of shortleaf pine, post oak, white oak, red and black oak and red cedar were chosen in response to the need for change issues. Table 4 shows the total percent of historic vegetation cover for primary vegetation groups in respective ecological subsections.

Table 4 - Historic Vegetation by Subsection on MTNF Lands Only

	Prairie	Savanna (shrub/ barren)	Open Woodland	Closed Woodland	Forest	Total
Subsections of Ozarks Highlands Section						
Black River Ozark Border	0	15,200	38,700	50,800	28,700	133,400
Percent of subsection		11%	29%	38%	22%	
St. Francois Knobs & Basins	0	3,000	25,800	39,200	29,200	97,200
Percent of subsection		3%	27%	40%	30%	
Current River Hills	200	19,900	169,700	249,600	62,700	502,100
Percent of subsection	<0.1%	4%	34%	50%	12%	
Central Plateau	1000.	10,800	28,300	26,100	6,900	72,200
Percent of subsection	1%	15%	40%	36%	9%	
White River Hills	500	29,100	123,300	110,100	46,500	309,500
Percent of subsection	0.3%	9%	40%	36%	15%	
Gasconade River Hills	500	26,400	80,500	55,600	9,300	172,300
Percent of subsection	0.03%	15%	47%	32%	5%	
Meramec River Hills	100	15,400	63,100	63,300	34,900	176,800
Percent of subsection	<0.1%	9%	36%	36%	20%	
Outer Ozark Border	0	500	4,600	5,400	2,800	13,300
Percent of subsection	0%	3%	35%	41%	21%	
Inner Ozark Border	0	300	3,200	3,500	1,400	8,400
Percent of subsection	0%	4%	38%	42%	16%	
Subsections of Central Dissected Till Plains Section						
Claypan Till Plains	100	100	1,300	1,300	300	3,100
Percent of subsection	3%	3%	42%	42%	10%	
Total Acres	1,500	120,700	538,500	612,900	222,700	1,488,300
Percent of NFS Lands	1%	8%	36%	41%	15%	

Source: Geographic Information Center, University of Missouri, Columbia 2004.

Table 5 compares the percentage of current forest types, taken from CDS database, to historic vegetation cover. The left column lists the historic vegetation type, and the other columns show what percent is currently in various forest type groups. For example, 60% of what was historically in pine is now dominated by red or black oak.

Table 5 - Current Condition of Historic Vegetation

Historic Vegetation Group	Current Condition based on stand data information: Open lands	Lowland Hardwoods mesic forest	Pine	Post oak	White oak	Red or black oak	Red cedar
Scrub/Barren Prairie	8%	1%	23%	15%	8%	39%	6%
Elm Associations	18%	14%	7%	3%	13%	39%	4%
Pine Associations	1%	1%	33%	2%	8%	60%	<1%
Post oak Associations	7%	1%	15%	13%	8%	50%	1%
White oak Associations	6%	4%	10%	7%	9%	57%	7%
Red oak Associations	13%	5%	4%	10%	14%	38%	16%
Red cedar Associations	0%	0%	0%	0%	0%	0%	100%

Historical Disturbance Regimes: Fire, Climate, Flooding, Animals and Diseases

This information helps describe changes in the modern landscape, and develop alternatives regarding effects on ecosystems and their biological diversity. Fire, wind, tornadoes, rain, snow, ice, hail, floods, drought, lightning, earthquakes and animals were among the many disturbance processes that shaped Missouri's natural communities through the centuries. Each disturbance type had its own range of variability measured in intensity, frequency, duration, scale and timing. This variability influenced composition, structure, distribution and dynamics of natural communities before European settlement. Frequent natural fires and large grazing and browsing animals contributed to complex mosaic patterns of oak savannas, woodlands and tallgrass prairies. Catastrophic fires and tornadoes were severe enough to level forests and woodlands, setting the stage for regeneration of oaks, shortleaf pine, and shrubs. Intense solar radiation and lack of moisture contributed to the formation of dwarf woodlands associated with bluff tops and open glades. Dynamic patterns of vegetation along stream gravel washes and river sandbars responded directly to flooding.

When thought of in human terms, these disturbance events can be destroyers of human values. However, in an ecological context, many of these events shape natural communities and influence evolution and adaptations of plants and animals within them. A forest destroyed in human terms (for lumber, recreation and other values) is renewed in ecological terms to regenerate a forest, recycle nutrients, create habitat diversity and stimulate plant/animal production.

These disturbance processes formed "regimes." Whether a fire regime, flooding regime or tornado regime, each resulted in a total pattern over time and affected vegetation, plant and animal adaptations and their distributions. Managers and researchers often describe each disturbance regime separately, but they are intricately interwoven.

So what were the historic disturbance regimes that shaped natural communities on the Mark Twain National Forest?

Climate

Mid-continental climate strongly influences the distribution of Missouri's terrestrial natural communities, primarily because it sets the stage for many of the disturbance events that shape them. Certain disturbances, which interact with variable landform characteristics, directly influence distributional patterns, and structure and composition of natural communities.

Missouri's mid-continental location in the western half of the Humid Temperate Domain determines its overall climate regime of four seasons with strong annual cycles of precipitation and temperature. Summers are relatively hot while winters range from mild to bitterly cold. Spring and fall are transition periods when dry cold air masses clash with warm, humid gulf air. Tropical and polar air masses regulate the state's climate at a coarse scale with most precipitation coming from rising moist air along cyclonic fronts.

Three major climate regimes, roughly correlated with geographic regions, characterize our state: the prairie climate, the Ozark climate and the Mississippi Lowlands climate. However, boundaries of these climatic patterns are spread out. Prairie climate is characterized by hot summers and cold winters. Average annual temperatures are 51 to 55 degrees F and mean annual precipitation is 34 to 42 inches. Nearly two-thirds of the precipitation occurs during the growing season, the average length of which is 200 to 210 days. This climate influences the environment of the Cedar Creek unit north of the Missouri River. The Ozark climate, influencing most of the Mark Twain National Forest, has hot summers and moderately cold winters. Average annual temperatures are 54 to 57 degrees F and mean annual precipitation is 42 to 49 inches. At least half of the precipitation occurs during the growing season, which is 210 to 230 days. Hot summers and mild winters characterize the Mississippi Lowlands climate, which primarily affects the Poplar Bluff and southernmost portions of the Doniphan/Eleven Point Ranger Districts. Average annual temperatures are 57 to 59 degrees F; mean annual precipitation is 48 to 51 inches. Precipitation occurs fairly evenly throughout the year. Average length of the growing season is 230 to 250 days.

Weather Disturbances: wind, tornados, ice storms, snow storms, hail storms, lightning

Missouri's climate is marked by dramatic changes in weather. The state is centrally located in the North American continent, a region characterized by mixtures of warm, moist, gulf air; cold, dry, arctic winds; and arid, southwestern desert heat. These air masses collide, causing violent windstorms, heat storms, hail storms, tornados, heavy rain and snow, lightning, blizzards, drought and cold waves. In 1981, the National Oceanic and Atmospheric Administration began publishing a report entitled "Storm Data," the official record of extreme weather in the United States. Precise accounts of Missouri's extreme weather events provide a benchmark from which to study effects on natural communities (Table 6). These records reinforce historical accounts of climatic events and provide strong evidence that climatic events significantly influence vegetation patterns and contribute to habitat heterogeneity.

The following weather events contribute to the variable shape, texture and character of natural communities:

- Severe ice storms occur along with heavy wet snows that break tree limbs and increase ground fuels;
- Solar heating on south- and west-facing slopes increase light intensity, increase evapotranspiration, increase soil temperatures (and freeze-thaw cycles) and dry fuels rapidly;
- Solar shadows on north- and east-facing slopes inhibit evapotranspiration, lessen soil temperatures and slowly dry fuels;
- Rainfall patterns contribute to various flood regimes depending on watershed characteristics;

- Tornadoes flatten forests and woodlands, creating tip-up mounds and high fuel loads; a tornado can affect any one point in Missouri every 5,000 years (Grazulis 2001);
- Drought causes plant mortality;
- Drying winds and low humidity create conditions for spread of fire;
- Lightning damages trees and contributes to wildfires.

Table 6 - Selected Recorded Climatic Extremes and Effects on Natural Communities

Date	Place	Event	Effects
1974	Locust Creek Natural Area, Pershing State Park	Tornado	Leveled extensive areas of old-growth mixed bottomland forest resulting in an impenetrable growth of vines
June 1980	Meramec Upland Forest Natural Area, Meramec State Park	Thunderstorm squall with winds in excess of 100 mph	Effected extensive areas of old-growth woodland and forest canopy, leaving sheered trees, tip-up mounds and large canopy openings.
July-August 1980	Johnson's Shut-Ins Natural Area, Johnson's Shut-Ins State Park	Heat storm	Extended drought and 100 + degree F temperatures damaged or killed woody vegetation on igneous glades.
1982	Coonville Creek Natural Area, St. Francois State Park	Wet snow 25-30 inches	Sheered and toppled trees, especially red cedar
October 16, 1983	Niawathe Prairie Natural Area	Hailstorm	Hail pulverized and flattened prairie vegetation; recorded animal deaths included 16 prairie chickens, one marsh hawk, hundreds of small birds and rodents.
February 1984	Van Meter Forest Natural Area, Van Meter State Park	Ice storm	One inch of ice coated trees and herbaceous vegetation causing severe limb breakage, often down to the trunk.
Summer 1993	Missouri River valley	Flood	Heavy prolonged rainfall resulted in record bluff-to-bluff flooding lasting for 30 days and scouring new chutes, blueholes and depositing many feet of sand and silt. Resulted in set aside wildlife refuges.
April 2002	Poplar Bluff Ranger District, Mark Twain National Forest	Tornado	F-3 tornado leveled more than 7,000 acres of mixed pine and oak woodland resulting in many tip-up mounds.

Source: Nelson 2005

Small Gap Wind Disturbance

Canopy gaps occur when strong downdraft winds associated with thunderstorms or strong storms break off large branches or treetops. These events also cause blowdowns with corresponding tip up mounds, especially in older age class stands. One Missouri study shows that thunderstorm or high wind blowdowns create small forest/woodland canopy gap patches that disturb over 1% of the landscape per year (Rebertus 2001). This is consistent with results of other wind gap analysis for the Midwest (USDA 2004). Severe ice storms also contributed to breakage of tree limbs and increased ground fuels (Rebertus et. al 1997).

There appears to be a correlation between limb breakage or tree damage severity and the age of trees. Younger, less brittle and more pliable trunks are less susceptible to breakage. Given this, the relative average age class distribution across the Mark Twain National Forest determines what areas are more prone to creating diverse habitat associated with gaps created by blowdowns or ice storms. The lower mean average age of the forest as a whole, the more uniform the stand. This has implications in providing a heterogeneous stand structure for wildlife, sun-loving herbs and regeneration.

Catastrophic Wind Disturbance: tornados and severe thunderstorms

Tornadoes flatten forests and woodlands, creating tip-up mounds and high fuel loads. We have no methods for confirming the return interval for how often and to what extent tornados and severe thunderstorms repeatedly occur through time and space. This may be important from the standpoint that these events, coupled with all other events, might limit the age class distribution of old growth trees to a certain percentage of total forest/woodland cover. Many examples occur in which old growth timber suffers severe damage from tornados and catastrophic windstorms. Many old growth stands remaining in Missouri appear to consist of even-age classes suggesting that historical catastrophic events remove large portions of stands.

Fire

Fire was a profound shaper of Missouri's natural communities. Evidence is present in historical accounts, aboriginal burning, fire scars, lightning ignitions, adaptations of plants and animals, fire modeling, understanding the nature of natural fuels and response to applied management.

Many early explorers in Missouri chronicled numerous accounts of periodic fires. Ladd (1991), Nigh (1992) and McCarty (1998) are sources of information specific to the history and presence of fire in Missouri. Add to this the overwhelming, universal and pervasive evidence for historic fires as presented in many other documents across North America (Williams 2000, Nowacki 2002, Wettstaed previously stated) and it becomes clear that the influence of fire is the primary explanation for the observed presence of otherwise fire-dependent natural communities distributed across the Missouri landscape.

Fire scars provide valuable records in establishing fire regimes. Guyette and others reconstructed fire histories by tree-ring analysis of red cedar and post oak for various regions of the Ozarks (Guyette and McGinnes 1982, Guyette 1989, Guyette and Cutter 1991, and Guyette and Dey 1997). Their results showed evidence of frequent fires occurring during the last 500 years in the Ozarks, with intervals generally ranging from 3.2 to 35 years, depending on the study area. Guyette conducted several fire history studies specifically on the Mark Twain NF. Historical records indicate that most fires occurred in fall with less frequent fires occurring in spring, and a few taking place in winter or summer. Studies indicate that the historical, widespread presence of shortleaf pine-dominated natural communities in the Ozarks was regulated by historical fire (Stambaugh 2001, Batek et al.1999).

Nearly 25 years of prescribed burning across Missouri to restore savannas, open woodlands, glades, prairies and wetlands have revealed that many plant species and natural communities are adapted to or dependent upon fire. Missouri's present-day precipitation and sub-humid climate, in the absence of fire, favor advancement of woody vegetation, especially in damaged and degraded ecosystems. Without fire, woody vegetation will encroach into prairies, savannas and open woodlands. Both shade and accumulating deep leaf litter smother and reduce or eliminate otherwise sun-loving flora and associated fauna (McCarty and Hassien 1984). Vegetation monitoring also shows that species density and richness improves following prescribed burning.

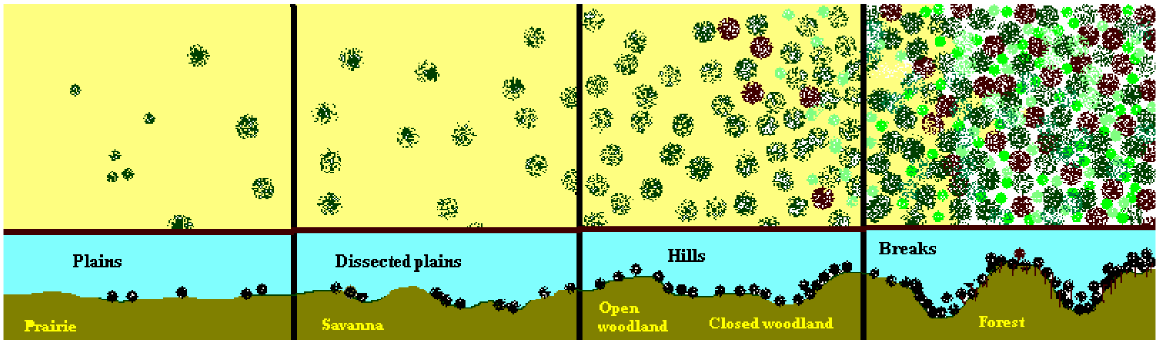
Modeling fire behavior involves conducting intensive calculations using data collected on fuels, weather and topography. Fire behavior is largely dictated by local topography. In general, fire spreads more quickly and intensely on flat ground. In contrast, fires spread more slowly and with relatively less intensity over steeper lands often broken by streams and rivers (Guyette et al. 2002; Swanson et al. 1994). Fires often creep slowly or burn less intensely on north-facing steep slopes. This shows a strong correlation between prairies and savannas occurring on level lands resulting from more frequent and widespread fires. Mesic forests occur in deeply dissected landscapes on shaded, steep north- and east-facing slopes. Landscapes broken by wetlands, swamps and/or the fire-shadows along major streams and rivers also suppress fires.

Prior to European settlement, the widespread presence of grass/forb-dominated natural communities created a more flammable landscape. Fuel type often determines how fires behave. Fuels associated with high quality prairie, woodland and savanna natural communities are prone to drying quickly and burning efficiently. These fires are low intensity, but flashy and spread rapidly. More than 100 years of livestock grazing has changed or altered the condition of this once widespread fuel type; deciduous leaf litter now dominates. Now shaded by a densely overstocked canopy, compacted leaf litter takes more days to dry. Despite changes in the historical fire regime, present-day wildfires occur with great frequency from a variety of ignition sources. For example, over 6,295 wildfires are recorded on the Mark Twain National Forest between 1954 and 2003. This does not include many more thousands of wildfires reported to the Missouri Department of Conservation, other local fire departments and those that go unreported.

Fire by Natural Community Type

How fire burns is a function of the fuel, topography and weather. Fire ecologists call this the fire environment. Certain fire behavior patterns characterize a locale or region; if the incidence of fire remains the same for a broad region, the fire regime will vary for different locations within it. Different terrain, aspects, slope positions, soil moisture characteristics, and vegetation patterns create vastly different fire environments. On the landscape scale, high prairie plains of the Ozarks prior to European settlement were well exposed to sun and wind. Their fuels dried quickly, there were few barriers to fire spread, and vegetation was highly flammable. Fires were frequent, burning fast and hot across long spaces. However, off to the sides of all these prairie plains lay river valleys with dissected hills and many north- or east-facing slopes leading down to them. They were covered in woodlands that were more sheltered and shaded, had lower average temperatures and wind speeds, higher average humidity and fuel moisture, a much less flashy fuel and multiple barriers to fire spread. Understanding the fire environment becomes important in Plan analysis because when and where fire is applied on the Mark Twain for purposes of restoring natural communities becomes a function of understanding local area fire history and the presence of natural community indicators. Likewise, behavior of fire upon the landscape is likely the best explanation for why certain natural communities were historically distributed in distinctive patterns across the Ozarks in relationship to vegetation and topography (Figure 1)

Figure 1 - Relative Canopy Openess Breaking Points for Major Natural Community Types



This diagram suggests relative canopy openness breaking points for major natural community types within the historic range of natural variability. The top boxes show aerial view while the bottom represents a horizontal cross section profile of landforms associated with changes in vegetation. Canopy openness and landform appear related to the historical fire regime. Prairie and savanna occur on relatively level to gently undulating topography while woodland and forest are strongly associated with hills and breaks respectively (Nelson 2005).

Determining fire effects and regimes for all the various permutations of landscapes across the Forest will be evaluated at local, project level Plan implementation. In general, the historic fire regime for the Missouri Ozarks was one of frequent light surface grass/forb fires occurring as often as each year for prairies to as infrequently as 25 years or more in forests for portions of the deeply dissected breaks (Guyette and Dey 2000). These were likely combined with sporadic small scale, long interval stand-replacing fires or high intensity surface fires. Patterns of modeled historic vegetation cover and canopy openness suggest that large patches measuring in the hundreds to thousands of acres were subject to more intense fires that limited tree growth but favored oak/pine and shrub regeneration (oak thickets and barrens) prior to European settlement (Schroeder 1981).

Table 7 - Estimated of Fire Frequency by Natural Community Type

Natural community type	Landform	Restoration Fire Frequency	Maintenance Fire Frequency
Prairie	Broad level plains	1-3 years	2-4 years
Savanna	Rolling plains	1-4 years (lower intensity	3-5 years
Open woodland	Dissected plains and hills	1-3 years	3-7 years
Closed woodland	Hilly	2-3 years	3-10 years
Forest	Hills and breaks	5-25 years*	10-25 years
Glade	Dissected plains and hills	2-3 years	4-10 years
Fen	Hills, breaks, floodplains	1-3 years	2-6 years
Riparian zones	Bottomland floodplains	3-10 years*	5-15+ years

**Due to their relatively poor ecological condition or lack of experience, these figures are approximations only and need further research.*

Estimates of restoration fire frequency intervals are extrapolated and inferred using information from known fire studies and applied fire frequency/interval responses using prescribed burning to restore fire-adapted natural communities. Desired conditions for glades, savannas, open and closed woodlands, expressed in restoration of structure and ground cover flora, were achieved by applying prescribed burning at select yearly intervals. State and federal agencies and non-profit private conservation organizations including The Nature Conservancy and Missouri Prairie Foundation have now applied prescribed burning in the restoration of fire-adapted natural communities for at least 25 years.

Maintenance fire frequency is shown for comparison. Most areas subject to ecosystem restoration activities have not reached stable age class structure, vegetation pattern diversity, and high species richness for groundcover flora. This is also analogous to Condition Class I fuels and often takes at least 25 to 30 years to achieve.

Water and Flooding

Water is a primary force critical to shaping natural communities. Both flooding and precipitation absorbed into the water table on the Ozark karst landscape played a major role in stream system functioning and the availability of groundwater and spring flows. Historically, healthy soils played a major role in storing and releasing precipitation into streams and the water table. Missouri's emerald springs and crystal-clear Ozark streams inspire us. People watch as a barge transports goods on the Missouri or Mississippi River, or fish one of many artificial ponds and lakes. Despite these pleasures, most people are unaware of how water functioned in the formation of rivers, springs, streams, groundwater and vibrant wetlands 200 years ago. Today's flooding patterns, spring flows, and the ability of soil and vegetation to hold moisture is dramatically different from the time when Meriwether Lewis and William Clark, Henri Brackenridge and Henry Rowe Schoolcraft first described Missouri's water resources in the early 1800s.

How water influences today's natural communities is perhaps best understood in the context of its historical role. Historical accounts and present-day studies of high quality watersheds all seem to share similar characteristics. How water is accepted in the hydrological cycle depends on the frequency, duration, seasonality and intensity of precipitation events, interactions and ecological health of the local landscape and vegetation, and climatic conditions.

The Ozark Highlands boasts the largest concentration of springs in the United States. Springs, sinkholes and losing streams are features of an ancient uplifted plateau underlain by porous limestone and dolomite rock fractured by millennia of uplifts. Despite the rugged, steep Ozark landscape, much of the 40 to 45 inches of annual rainfall percolates down through porous chert rock residuum, drains internally through sinkhole basins, or is captured by soil and vegetation cover.

Characteristics of spring flows and quality of water chemistry are primarily a function of the ability of the land surface to capture rainwater. The historic condition of natural vegetation cover and ability of intact soils to absorb moisture are critical to flow characteristics of nearby springs. Any disturbance to either will adversely affect water infiltration rates, spring flow outputs and stream flows. Additionally, dead woody material in streams once provided stabilization against strong currents, provided habitat for fish, invertebrates and microorganisms, and captured in-stream detritus that stimulated the aquatic food chain. Studies (Dey et al. 2003) show that some dead large trees still remaining submerged in Ozark streams have functioned in this capacity for over 4,000 years.

The current Ozark Highland landscape has changed dramatically since the time that settlers sought small springs for dependable, fresh water sources. Smith (2003) chronicles the loss of once lush, fire-mediated grass and forb cover that mantled the Ozarks at the time of European settlement. With original vegetation stripped away by a century of domestic livestock overgrazing, runoff increases in streams and rivers, and less precipitation filters into the water table to supply aquifers and springs. Many springs went dry (Rafferty 1980, Jacobson and

Primm, 1994). Because of denser second growth flush of woody vegetation now covering the once open Ozark woodlands, a flattened mat of accumulated leaf litter now replaces a lush cover of deep rooted, water-absorbing forbs and grasses. The water-holding capacity of this “new forest” is not like that of the former vegetation.

To what degree that streams and rivers of the Ozarks (particularly those of conservation concern outlined in the OECA) are functioning as natural systems is partly supported in documentation of their historic condition, past and present developments and current use. We know that:

- many aquatic species are in jeopardy,
- watershed quality is declining in some areas,
- physical and chemical conditions of streams and rivers are degraded due to historical logging,
- open-range livestock grazing and clearing of virtually all tillable bottomland natural communities for croplands and grazing has removed most bottomland hardwood forests,
- in-stream woody structure is lacking,
- most streams and rivers suffer sediment overburden and
- banks devoid of quality vegetation cover are scoured and eroded.

Watershed assessments (see website) outline these threats and risks to stream and river water quality and to aquatic organisms resulting from watershed conditions. For the most part, the Mark Twain NF does not own or control the majority of watershed acreage for those major Ozark streams and rivers traversing or dissecting its lands. Most land use affecting water quality and aquatic flora and fauna is beyond control of the Mark Twain.

Animal Disturbances

Before European settlement, great numbers of American bison, elk and white-tailed deer roamed freely throughout Missouri. Houck (1908), Beilmann and Brenner (1951) credit abundance of wildlife at the time of European settlement to intact and highly productive open woodlands covered in seed and fruit-bearing grasses, wildflowers, open-grown oaks and shrubs—all linked to the replenishing influence of fire. Beaver inhabited most waterways, felling trees on their banks and creating natural dams and wetlands. The roosting activities of now-extinct passenger pigeons may have caused widespread breakage of tree limbs, tree mortality creating canopy gaps, fuel accumulations that could have increased fire intensity and possibly maintenance of white oak, bur oak and black oak. Bison, elk, and white-tailed deer, among others, fell prey to the black bear, coyote, mountain lion and gray wolf.

Since that time, humans have greatly altered or eliminated these animal populations through direct harvesting or habitat destruction. Missouri's free-roaming elk and bison are gone. The passenger pigeon, Carolina parakeet and ivory-billed woodpecker are extinct. Habitat fragmentation, roads, fences and competition with exotic species including domestic livestock have altered or eliminated historic migrations of abundant wildlife. While the black bear population is increasing and state conservation officials have confirmed the recent presence of mountain lions, their predatory role in controlling large numbers of white-tailed deer and other prey is currently ineffective. Elimination of large native grazers and large predators, along with imbalances of native and non-native animals constrained by fragmentation is far removed from the historic range of variability.

Part IV. Associating Species at Risk with Natural Communities

More than 700 species of vertebrate animals occur in Missouri, many which are found in the Ozark Highlands. Historical abundance of wildlife and plant species associated with complex, high integrity and diverse patterns of continental-scale natural communities are now endangered; primarily by fragmentation, degradation and disruption of disturbance processes associated with these former ecosystems. We have analyzed species at risk in the context of their associated linkage to natural community/habitat associations and risk/threat factors. Looking at species that share similar risk factors has the advantage of placing species in categories that can be affected by similar management actions. The resulting categories can be used to organize an effects analysis, and to propose particular management alternatives that directly alter the perceived threat. As such, risk factor groupings can provide a framework for development of effective mitigation measures. Presumably, many species in a risk category would respond to the perceived risk in a similar way, facilitating evaluation of effects. However, this assumption will not be universal and some species placed in a common category by risk factor may respond in different ways.

Seral/structural stages as well as natural communities may be used when grouping species by habitat, because the viability of some species may be dependent on a particular stage that is underrepresented or in poor ecological condition. By using seral stages to define species groups, conservation strategies and the analysis of effects can be made more specific. For example, the current list of Regional Forester Sensitive Species contains a grouping of at least ten plant and animal species, along with at least ten more S1 or S2 ranked species, associated with limestone/dolomite glades. One conservation approach for glades on the Forest is to change management area direction to restore and maintain large glade complexes and adjust standards and guides to manage glades. This change would thus accommodate nearly 15% of the RFSS list, and other conservative species associated with glade habitat.

If plant and animal species are selected in this way, we can legitimately defend them as being representative of ecological requirements of a larger group of species, and generally link them to natural communities. However, even where species have very similar ecological requirements, it is not an expectation that their population dynamics would parallel each other. This process requires use of detailed information on species habitat requirements, and that a relatively large and diverse grouping of species was needed to provide insight into requirements of all species.

The Mark Twain National Forest has selected management indicator species that represent other species in healthy ecosystems. For example, the summer tanager is a characteristic species associated with dry, open post oak/white oak and/or shortleaf pine woodlands. Managing to restore and maintain open woodlands through various silvicultural practices and prescribed burning should result in an increase in this species abundance. Along with this increase, other associated plant and animal species at risk grouped with this same natural community should increase or remain stable in abundance. Add to this variable management practices designed to mimic disturbance processes and natural patterns of vegetation, this should create a broad range of variability in structure, age classes, composition, and percent cover that will reproduce similar conditions described for the underrepresented natural community.

It may not be necessary, nor is it practical to have detailed information about all organisms and processes in an ecosystem to develop a management scheme based on maintaining the integrity of systems of natural communities (Hunter 1991). The ecosystem management approach is one employed in management of statewide natural areas, which is moving toward design of larger natural area designations with the goal of representing areas of distinctive, characteristic landscapes by ecological subsection.

Species-specific management

The viability of some species is only partially addressed through broad direction for management of ecosystems, either because the causes for concern are not related to habitat, or because those approaches do not adequately address certain fine scale habitat components. Fine-scale features such as fens, caves, seeps, spawning sites and raptor nest sites are often essential for viability. The existing Plan standards were examined with regard to species-specific direction for such features and developed to address newly identified habitat needs, non-habitat factors, or supplement broad-scale management as necessary. While species-specific direction should generally be compatible with overall direction, some exceptions are necessary. For example, management activities directed at recovering igneous glade habitat for Mead's milkweed may alone not suffice to stimulate successful seed production. This may require more specific actions (see SVE analysis for Mead's milkweed).

In the context of conducting effects analysis, grouping by degree of risk provides a framework to focus the analysis on those species for which management actions may result in significant consequences -- a significant trend toward extinction or a trend toward recovery. Species in high-risk categories are not likely to have strong ecological similarities, and examining effects of management on one species is unlikely to provide strong insights into the specific effects on other species in the same risk category.

Part V. Conservation Planning

What do we want? How can we most efficiently and effectively conserve biodiversity and address species viability? What and where are priority conservation opportunity areas? Our approach to meeting ecosystem sustainability goals includes planning or priority setting, developing conservation strategies, taking action on the ground, and measuring our success through long-term monitoring. Ecoregional planning addresses fundamental questions in the science of conservation biology and landscape ecology. For example, what group of species, communities, and ecosystems could we "target" to represent all biodiversity? How should we evaluate the ecological "health" or "integrity" of these targets? Can we identify the best places that would secure ecological integrity of the entire ecoregion while allowing for multiple human uses?

The Mark Twain NF shares the common need along our partners to find answers to these questions. Nationwide, the US Forest Service and The Nature Conservancy (TNC) are working together to develop conservation strategies for conserving biodiversity. Likewise, the Mark Twain National Forest is working with the Missouri Chapter of The Nature Conservancy to gather information on conservation areas and discuss the results of the Ozark Ecoregional Conservation Assessment. The analysis is strongly linked to this effort in three ways: first, it allows the Mark Twain to focus conservation planning and management efforts on specific opportunity areas on Forest lands, also known as "portfolio sites", through development of Management Prescriptions 1.1 and 1.2. Second, specific outcomes were developed by discussing results of the OECA. We formulated minimum/maximum viability targets for natural community complexes in MP 1.1 and 1.2 that allowed us to set management activity objectives to move critical ecosystems toward desired conditions.

This approach parallels goals of the Comprehensive Wildlife Strategy (CWS), which is to identify a set of conservation opportunity areas that best represent native species, ecosystems and ecological processes in Missouri's ecoregions. The Forest has provided the Missouri

Department of Conservation with spatial layer coverage for MP 1.1 and 1.2 to add to statewide information gathered from conservation partners during the process.

When we compare current conditions with the range of natural variability, opportunities for what needs work and where show up. The viability process groups species sharing similar habitat characteristics and a range of reference management solutions into categories. These approaches range from maintaining riparian habitat in-stream structures, prescribed burning for fire-adapted natural communities, to protection of specific locations for species at risk.

Part VI. Ecosystem Management Principles

Management Premises

Sustainability is important to land management. Foundational to this are four assumptions (adopted from Manley 1995):

1. Ecosystems adapted over extended time periods provide the best chance for sustainability. For biological systems, this would be systems evolved through evolutionary time.

In this context, the Mark Twain National Forest has adopted the period prior to European settlement as a reference point from which to set desired conditions and compare historical conditions to present ones. This period chronicles evidence that points toward a landscape characterized by essentially unfragmented, high integrity natural communities (Nelson 2005). Missouri's climate has remained relatively stable for 3,000 and 4,000 years (see Wettstaed in Nelson 2005). The creation of large biodiversity landscapes managed to restore mosaics of natural communities in the context of historical natural processes could enable species and natural communities to respond to long-term environmental changes and stresses, such as global warming (Nigh et al. 1992).

2. Our best predictions of ecosystem response to management actions and anticipated disturbance represent a reasonable basis for management planning and projections.

Predictive capabilities of applied management are measured in the successes and failures of respective agencies and organizations employed the past 30 years in restoring and sustaining ecosystems. Many federal and state agencies based in Missouri have pioneered ecosystem restoration efforts and their findings serve as reference benchmarks from which to monitor ecosystem restoration progress.

3. Management designed to maintain or reproduce key ecosystem components, structures and processes is the management approach most likely to sustain ecosystem integrity and productivity.

There appears to be no realistic alternative management method managers can use to duplicate the complex effects of fire for sustaining Missouri's fire-adapted natural communities. This is based on our current understanding of how natural communities function, how post-European settlement has impacted and changed them, and how deviations from the range of natural variability has affected species and ecosystem viability. Most all present indications of risk factors and threats discovered in the species viability process point toward loss of biodiversity caused by ecological degradation and loss of historical disturbance processes.

4. Attention given to the intense efforts of restoring ecosystems in MP 1.1 and 1.2 must not ignore the broader and socially diverse role of other MP's in the conservation scheme.

The new management philosophy and approach for other portions of the Mark Twain National Forest specify that modified desired conditions may lie within or close to the range of natural variability for natural communities. Many plant and animal species of conservation concern, unique special habitats or natural communities lie outside the boundaries of MP 1.1 and 1.2.

Recommended Management Variability

In applying the ecosystem management premise of restoring and maintaining key components to produce quality natural communities, we need to manage environmental indicators within an acceptable range (Manley 1995). A range of natural variability exists for desired conditions and associated historical disturbances regimes including fire, flooding, insects, diseases and weather. Environmental indicators include measures of an element used to describe a natural community. Examples include outbreaks of severe armillaria root rot diseases, infestations of oak wood borers measured in numbers of insects per tree, intensity of wildfires, ice storm damage, siltation and non-native invasive plant species.

While historically, many of these factors were important in the evolution and distribution of ecosystems and their associated flora and fauna, we now have to manage in a more limited range. Today, we cannot manage the Forest in a manner that replicates nature's extremes, especially not those we can control. These include not allowing wildfires to spread under catastrophic drought conditions or insect infestations to damage or kill large portions of timber.

The purpose of this ecosystem management principle is to define an acceptable distribution of conditions that will sustain or enhance natural communities. Certain management activities will vary in effects across the Forest and by the alternatives. Some activities will fall along the margins or outside of the range of natural variability for vegetation across the Forest. Barriers toward the application of Range Natural Variability are recognized for this relatively new management concept (Baydack et al. 1999).

Ecosystem Restoration Programs and Projects

Fortunately for Missouri, all state and federal agencies and private land-managing conservation organizations have participated in one of the Midwest's oldest conservation partnerships, the Missouri Natural Areas Program. Overseen by The Missouri Natural Areas Committee (MONAC), the committee is made up of members from the Missouri Department of Conservation, Missouri Department of Natural Resources, US Forest Service, US Fish and Wildlife Service, National Park Service and The Nature Conservancy. These entities have cooperated in the Natural Areas Program for nearly 30 years to inventory, designate and manage representative examples of Missouri's biological diversity called Natural Areas. MONAC defines natural areas as "biological communities … that preserve and are managed to perpetuate the natural character, diversity and ecological processes of Missouri's native landscapes." This definition is consistent with ecological principles outlined in this discussion.

MONAC relies on the Missouri natural features inventories conducted between 1980 and 2001. These inventories established the data framework from which to not only protect and designate natural areas, but from which to assess the ecological health of natural communities including those on lands owned by the Mark Twain National Forest. Additionally, natural area owners have striven to apply ecosystem restoration practices in efforts to restore ecological health to many natural areas. These natural areas serve as benchmark references for natural communities that are managed within or close to their range of natural variability.

This RNV includes ecological health, recommended management practices, desired condition and species population studies (Bowles 1995, Templeton et al. 2001, Gerber 1996).

Part VII. Fundamentals of Ecosystem Management

How do we restore natural communities and to what time period? Using the pre-European settlement period as a reference point helps us understand the nature of quality, un-fragmented, stable natural communities that dominated millions of uninterrupted square miles across most of North America. Pre-European settlement is the ideal condition against which current altered landscape and composition are evaluated (Noss 1983). Plant and animal species gradually adapted and evolved into complex arrays of natural communities, or ecosystems, subject to thousands of years of disturbance processes. The scale and pattern of these processes, along with a relatively stable climate for the past 4,000 years or more, supported a diverse group of native plant and animal species (Lorimer 2001).

The assemblages of plants and animals that occurred at or prior to European settlement are the benchmark from which to measure today's array of threatened and endangered species. Based on a study of the nation's 1,880 imperiled plant and animal species, habitat destruction and degradation rank as the most pervasive threats to biodiversity in the United States, affecting 85 percent of species analyzed (Wilcove and Rothstein et al.2000). Early botanists, biologists and naturalists described and documented the abundance, patterns and scales of plants and wildlife during the settlement period, and their subsequent destruction/extinction. Beginning in the early 1970's ecologists and biologists were trained to systematically assess ecological health across the landscape by conducting a series of natural features inventories. These comprehensive county inventories (some 25 listed in Nelson 2005) identified areas of remaining biological integrity by ranking ecological health. These inventories and subsequent conservation assessments determine the degree to which plant and animal species, and terrestrial/aquatic habitats are today threatened.

European settlement severely disrupted North American ecosystems, plant and animal populations and historic disturbance processes with unprecedented magnitude and speed. Ladd (1991), Nigh (1992), McCarty (1998) and Yatskievych (1999) documented these effects. These sudden landscape alterations and disruption of historic disturbance processes have produced modern vegetation in structural, successional, and compositional disequilibrium (Eirvin et al. 1998).

When the term pre-European settlement is used in the context of restoring natural communities, or in classifying them, the primary reference is one of understanding what they were and how they functioned before the process of ecosystem degradation began. Ecologists are attempting to study and better understand effects of various management alternatives in the context of chronological rates of change in ecosystems. This comprehensive history of change in land use helps us identify the natural range of variability, which allows resource managers and administrators to make more informed decisions (Sisk 2004).

How do we manage ecosystems?

Ecosystem management is complex and challenging. Detailed natural community assessments, diagnoses and prescriptions are left to project planning and implementation guides. Prescriptions vary in complexity and intensity based upon existing ecological health, landscape design and available resources of a particular area. Many Midwestern States share similar management approaches toward restoring healthier natural communities (see Packard and Mutel 1999; Nelson 2005). These approaches begin with a classification system that describes distinctive natural communities, their range of vegetation variability, characteristic plants and animals, and those natural and human-caused processes by which they evolved.

Ecosystem management is the work of improving ecological quality of a given area in context of its historical condition. Ecosystem management can be divided into separate phases relative to forest management activities. These phases assume that distinctive natural communities are described (Nelson 2005) based on their historical occurrence and high quality characteristics. In that context, most of Missouri's unique ecosystems were relatively stable and highly diverse, and they possessed measurable characteristics in terms of vegetation structure, species composition and abundance, functional relationships, physical characteristics, and a range of disturbance processes. Understanding what these ecosystems were, where they occurred in relationship to different landscapes, and their current condition is critical in implementing ecosystem management. Comprehensive reports on statewide natural features inventories and data maintained in the Natural Heritage Inventory database (MDC) provide an assessment of ecological conditions for Missouri's landscape, including lands on the Mark Twain National Forest.

Types of Ecosystem Management

Restoration

Ecosystem restoration, sometimes called rehabilitation, needs to occur when natural vegetation exhibits the ability to achieve a given desired condition. It is the repair or re-establishment of natural community complexes. Diagnosis of ecosystem health compares current condition to the historic one using desired condition descriptions of natural communities, historic vegetation, site quality rankings and examples of high quality sites.

Reinstating historic disturbance processes should recover natural community structure, plant species composition and biological diversity that evolved in response to the physical environment. Management methods generally include thinning of undesirable woody species, prescribed burning, select treatment of non-native invasive plant species, and some reseeding – all prescribed using the effects of various disturbance regimes outlined previously. Restoration of natural communities generally takes two to three decades or more before achieving the maintenance stage of re-establishing grass/forb structure. Restoring canopy composition and structure may take a hundred years or longer!

Maintenance

Ecosystem maintenance includes the periodic prescribed application of management activities to retain structure, diversity and composition of select natural communities. This happens when the resource is nearing the desired condition; that is, once critical elements of community structure, physical processes or the environment are largely restored. Maintenance activities generally include prescribed burning to mimic historic fire, select silvicultural practices tailored to restoring woody structure, periodic checks and control of non-native, invasive species, and monitoring against risks and threats such as animal overpopulations, especially white-tailed deer, to ensure that their numbers do not exceed the balance and capacity of the natural community. The amount of land on the Mark Twain National Forest estimated to be approaching natural community maintenance (desired condition achieved) is less than 3,000 acres. This is not surprising as the majority of other public lands managed by the Missouri Department of Conservation, Missouri Department of Natural Resources, The US Fish and Wildlife Service, National Park Service and non-profit conservation organizations have not reached desired high integrity ecological conditions, primarily because all have inherited already heavily damaged or degraded lands following a century of post-European settlement resource exploitation. The recovery of diverse ecosystems first requires an in-depth understanding and agreement on what they were. Additionally, management experience demonstrates recovery, especially plant species accrual, is a long and slow process.

Reconstruction

Reconstruction is the re-establishment of a natural community or elements thereof that have been nearly completely destroyed. Management methods include site preparations to remove non-native invasive species, soil preparation, burning to prevent undesirable woody or non-native species invasion, planting and seeding. This phase is very labor intensive and usually very costly. Generally, the Mark Twain will not have to reconstruct glades, certain woodland natural communities, fens and forest types. Natural communities requiring reconstruction activities may include prairie, bottomland hardwood forests and woodlands, some fens and savannas.