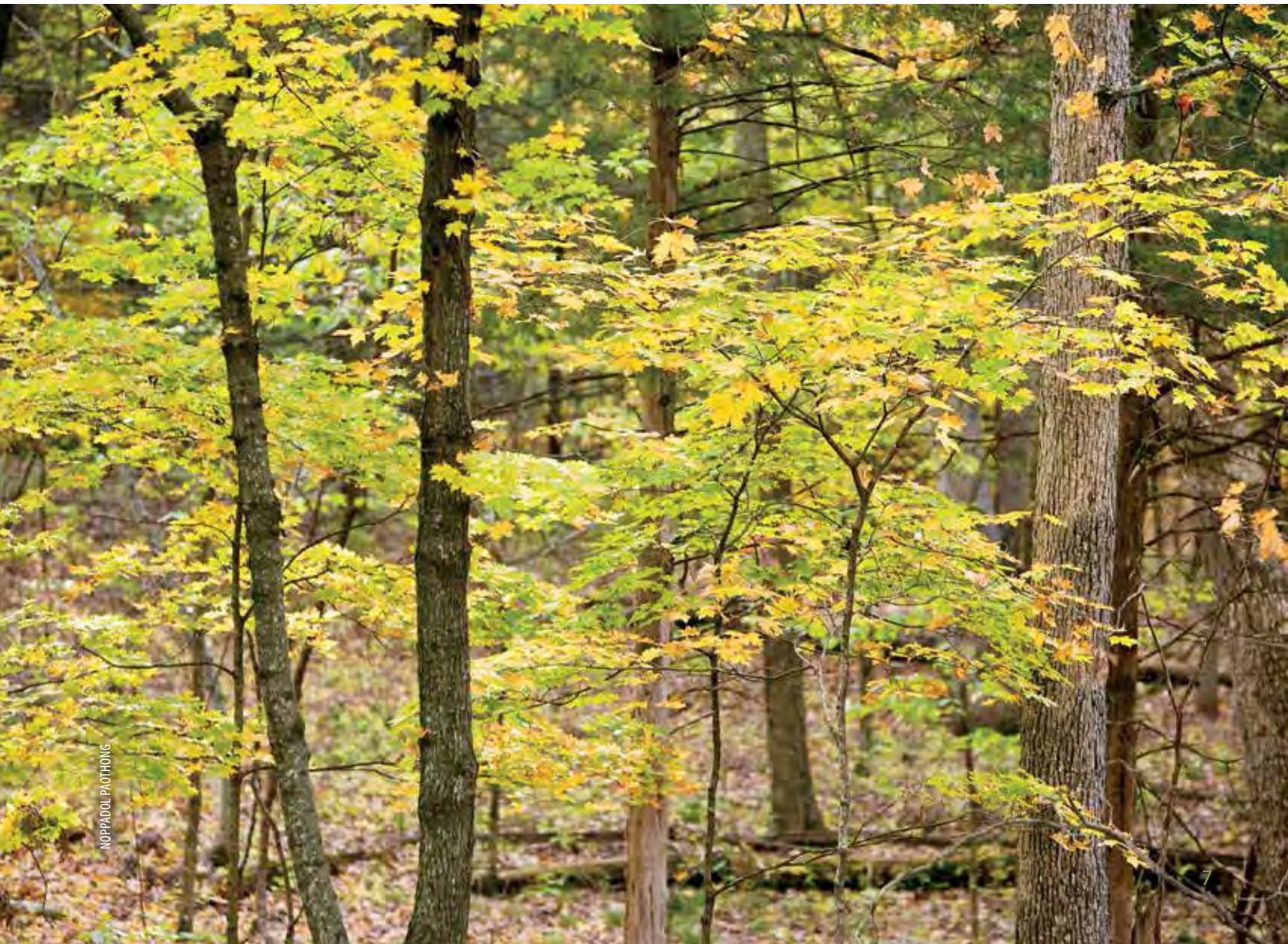
UNIT I:

Background Resource Elements



NOPPADOL PAOTHONG

CHAPTER 1

Missouri Forest Resources

NOPPADOL PAOTHONG

Topics Covered

- Forest Types and Extent
- Environmental Forest Values
- Economic Forest Values
- Social Forest Values

Missouri has a unique and significant forest resource: unique because of where the state sits within the North American continent, and significant for the host of environmental, economic, and social values it continues to provide for Missouri's citizenry.

Forest Types and Extent

Geographically, the state is located at the juncture of four major land types — the prairies of the west, the glacially scoured landscapes of the north, the ancient Ozark Mountain range of the south, and the expansive Mississippi bottomlands in the far southeast. Prior to early settlement, roughly 30 million acres of forest were found in these four distinct regions, encompassing a wide diversity of forest types.

Forests, Woodlands, and Savannas

The terms forest and woodland are often used interchangeably to describe land covered predominately by trees. In Missouri, a state which supports prairie, forest, and all points in between, there is a growing body of evidence that many natural communities combining features of both forests and prairies existed historically. The historical prevalence of these unique ecosystems and increased interest in their conservation have led to classification systems that recognize a variety of "woodlands" and "savannas" as parts of Missouri's natural heritage. Savannas have been recognized as a distinct community type in Missouri since at least the mid-1980s. However, only since the early 2000s have woodlands been treated as a community type different from forests. Below are definitions for forest, woodland, and savanna that will help to distinguish them from one another.

Forest: an area dominated by trees forming a closed canopy, which is often composed of multiple overlapping layers (understory, midstory, and overstory). The midstory and understory of a forest is also dominated by trees and shrubs. Herbaceous vegetation is present in the understory but rarely forms a continuous layer.

Woodland: an area supporting trees with 30–100 percent canopy closure, a sparse understory or midstory of woody plants, and a dense ground flora rich in forbs, grasses, and sedges. The near absence of an understory or midstory of woody plants enables more sunlight to reach the understory of a woodland, which, in turn, favors the development of a dense layer of ground flora.

Savanna: an area of grassland interspersed with open-grown trees with less than 30 percent canopy cover occurring as scattered individuals, groups of trees, and shrubs.

Historically, infrequent lightning-caused fires and more frequent Native American-caused fires had a profound influence over the character of forests in the different areas. In the prairie region, fire served to confine tree cover to riparian areas. In the north and as prairies transitioned to the east, sparsely treed upland savannas became parts of the forest landscape. In the Ozarks, riparian areas continued to support fairly dense stands while the ridges were more open woodlands. The bottomlands of the Missouri Bootheel saw significantly less fire activity and were heavily forested.

Today, forests in the north, west, and bottomland portions of Missouri have been mostly converted to agriculture. More than 15.5 million acres of forest cover remain in the state, with most of it found in the Ozarks.

MDC FILE

SUSAN FARRINGTON

FRANK LONCARICH

Figure 1.1. *(top to bottom) Oak forest, woodland, and savanna*

The most prevalent forest type is a mixture of oak and hickory. Mixed forests of oak and pine can also be found, as can stands of elm, ash, black walnut, and cottonwood. Eastern red cedar is a common species on lands reverting from pasture back to forest and on historical glades where fire has been excluded. Sugar maple is frequently found in high numbers within the hilly landscape that abuts the state's largest rivers.

A large number of other species that are more typically associated with other parts of the country are also native to the state. These include more western species such as Osage orange; wetland species like bald cypress and water tupelo; eastern species such as tulip-poplar, black cherry, and American beech; and the more northerly-prone aspen.

Although the Ozarks has retained most of its historical forest acreage, the land has been significantly influenced by human activity over the past 100 years. Intensive logging around the turn of the 20th century removed nearly all of the shortleaf pine and then the oak. Subsequently, lands were heavily burned and grazed well into the early 1960s, leaving few pine and a predominance of low-quality, defective oak. Eventually a law was passed banning open range, and over time uncontrolled burning has been substantially reduced.

Missouri's forests contain a large percentage of standing trees that show damage from past land use practices. High-grading, the practice of only harvesting the best trees from a stand and leaving everything else, has been an all-too-common practice. It leaves poor-quality, defect-prone trees on the landscape, taking up scarce water and nutrients that could otherwise be used to grow more desirable trees.

Additionally, the exclusion of fire has served to increase more shade-tolerant species, such as sugar maple, in some areas. These shade-tolerant species can sometimes find a place in the wood products market. Their more noted impact, however, is that they replace less tolerant oaks, a critical source of hard mast for Missouri wildlife.

The majority of Missouri's forestland is privately owned by an estimated 339,000 families or individuals. Combined, these properties account for more than 80 percent of the forested acreage. Many private landholdings are less than 50 acres in size, but the majority of the state's 12.7 million privately owned acres are in holdings that are greater than 50 acres. The U.S. Forest Service and other federal agencies own roughly 2 million acres, while state and local governments own approximately 795,000 acres.

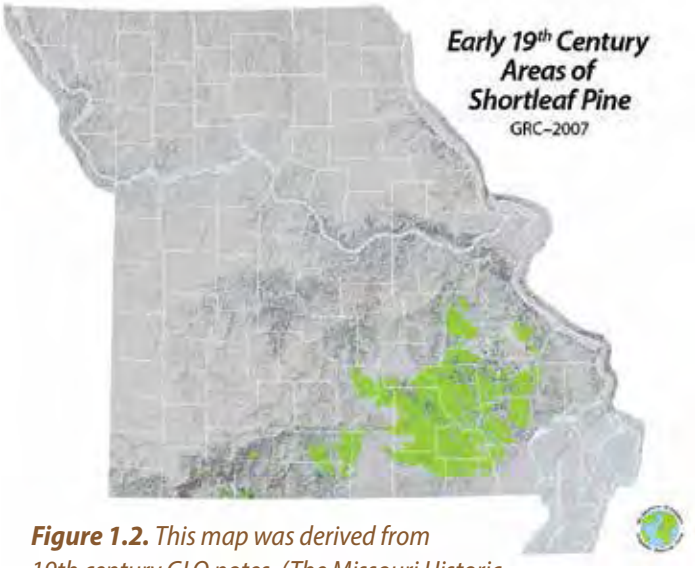


Figure 1.2. *This map was derived from 19th century GLO notes. (The Missouri Historic Land Survey Project Geographic Resources Center Department of Geography, University of Missouri-Columbia, James D. Harlan, Primary Investigator)*

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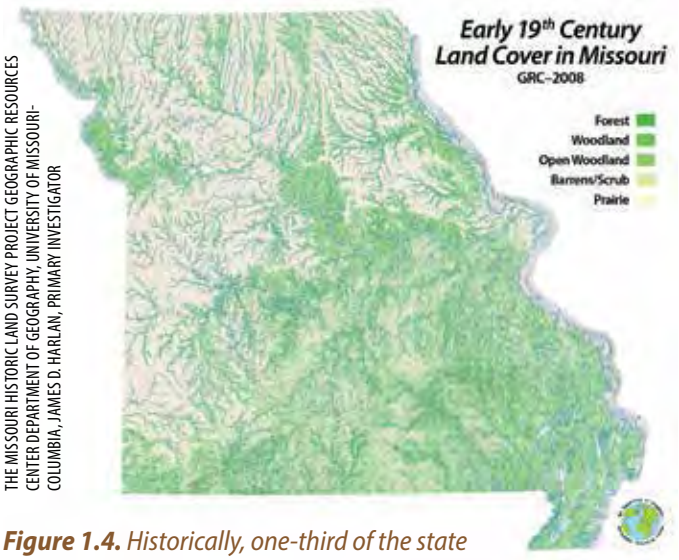
Figure 1.3. *Two photos shot from the same location — cutover Ozark forest (north of Eminence) in 1934 and present (Notice large rock in foreground.)*

Environmental Forest Values

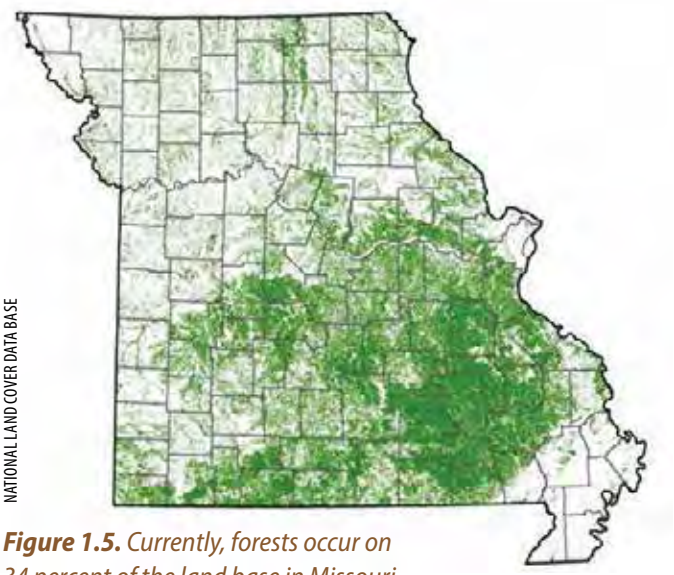
From an environmental perspective, Missouri's forests play a critical role in protecting water quality, supporting a rich biological diversity, maintaining soil productivity, and storing carbon.

Water from forested landscapes is cleaner than that from any other category of land use. The filtration and runoff control provided by a forest not only maintains water quality but also regulates the amount of flow in water bodies — keeping high water extremes to a lower level and low water flows to a higher level than what would be expected from a less protected watershed. The cost-effectiveness



THE MISSOURI HISTORIC LAND SURVEY PROJECT GEOGRAPHIC RESOURCES CENTER DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF MISSOURI-COLUMBIA, JAMES D. HARLAN, PRIMARY INVESTIGATOR

Figure 1.4. *Historically, one-third of the state was in prairie vegetation primarily in the western and northern regions. The remainder of the state occurred as forests, woodlands, or savannas depending on the disturbance regime. Shortleaf pine, once prominent on 6 million acres in the eastern Ozarks, now occurs on only 600,000 acres. The Missouri Bootheel once supported productive bottomland forests that contained species typical of more southern floodplains but is a major crop-producing area today. This map was derived from 19th century GLO notes.*



NATIONAL LAND COVER DATA BASE

Figure 1.5. *Currently, forests occur on 34 percent of the land base in Missouri.*

of forests as providers of clean water is such that some municipalities view forest watershed investments as a critical component of their drinking water infrastructure.

An extensive list of plant and animal species depend on Missouri forests as their primary habitat. They are as varied as the types of forests found here. They include high-profile game species like deer and turkey, neo-tropical migratory birds, unique amphibians, and endangered bats. There are understory plants of economic note such as ginseng, pawpaw, and goldenseal; rare orchids; uncommon trees like butternut and yellow-wood; and aesthetically important understory species like dogwood, chokecherry, and sumac. Given their positive impact on water quality, forests are equally important to most of Missouri's fish species.

The forest functions that protect water quality also serve to maintain soil productivity by preventing erosion. With proper attention to leaving appropriate amounts of logging residue, forest management involving regular harvests can still build, or at least maintain, soil nutrient levels, organic matter, and microorganisms. Appropriate harvest practices also minimize compaction and other physical changes to soil properties that might occur under other land uses.

It is estimated that forests in the state store upward of 840 million tons of carbon. Carbon is a greenhouse gas, and is cited as a principal cause of man-induced global climate change when it's released into the atmosphere. Not only do trees sequester carbon, they are also a potential renewable energy source. Nonrenewable energy sources such as coal, oil, and gas add to the overall carbon imbalance in the atmosphere, while the carbon released from using wood efficiently can eventually be offset by the additional carbon stored from growing trees.

Economic Forest Values

In terms of economic benefits, Missouri's forest products industry contributes nearly $8 billion annually to the state. The industry supports approximately 42,500 jobs and is responsible for more than $78.5 million in state sales tax revenue. Railroad ties, pallet lumber, charcoal, wood chips for pulp and biofuel, hardwood lumber, and flooring are common products derived from the state's forested acreage. In addition, hunting leases are becoming a growing revenue source for Missouri forest landowners, and Missouri's tourism industry is closely connected to the attractiveness of the state's forested landscapes.

Social Forest Values

In terms of social benefits, forest-related recreation is a highly valued aspect of Missouri's quality of life. Camping, hiking, hunting, fishing, sightseeing, mushroom collecting, and nature viewing all depend on this resource for the best opportunities. These activities occur on both public and private lands. Although most private lands are not available to the public for on-site activities, scenic drives are enjoyed by all and are available regardless of ownership. Aesthetic values, no doubt, are the one forest benefit that directly impacts the greatest number of people.

Taken in their totality, all of these benefits combined have tremendous importance to the citizens of Missouri. Although not every single benefit is delivered equally on every single acre, the state's diverse set of owners and conditions ensures that a broad balance of values is offered across the broader landscape. By applying appropriate practices, our forest resource and its benefits can be sustained for many generations to come.

CHAPTER 2
Wildlife Habitat


NOPPADOL PAOTHONG

Topics Covered

- Dens, Snags, and Super Canopy Trees
- Mast Production
- Water Sources
- Coarse Woody Debris and Slash
- Habitat Connectivity and Continuity / Forest Interior Bird Species
- Early Successional Habitat
- Edge
- Glades and Forest Openings
- Game Species Management

The term "habitat" refers to the various types of foods, cover, and other factors needed by a species in order to survive and reproduce. Approximately 191 native species of vertebrates (80 breeding birds, 42 mammals, 69 herptiles) utilize Missouri's forests, woodlands, and savannas as key habitat for part or all of their life cycle. Climate, soils, topography, geology, and hydrology as well as land-use and natural disturbances determine the types of wildlife habitats found across the state.

Groups of plants and animals that occur repeatedly in time and space within specific locations are defined as natural communities. Land is classified by natural community type to help guide management decisions. In Missouri, 85 different terrestrial natural community types have been described. Since highly mobile wildlife species are not tied to one specific natural community, these species are usually described in association with the broad categories of community types.

The purpose of this chapter is to provide general site-level guidance on forest-dependent terrestrial and amphibious wildlife. These habitat guidelines are written to give practical, scientifically based site-level guidance, but it is impractical to include all wildlife habitat improvement techniques, however. For further information, refer to the additional resources at the end of the chapter or contact a professional wildlife biologist.

Forest management practices impact various wildlife species differently. Some species respond favorably to a silvicultural practice such as even-aged regeneration harvests (clear-cuts) while others respond negatively. Still, forest and wildlife management can be complementary. What is required is an understanding of the habitat needs of desired species and the effect that forest practices can have on creating those conditions within different natural community types.

For example, species that depend on hard mast like acorns can benefit from forest management practices that encourage the continuation of oak species. This is most efficiently accomplished on lands where the natural community type features oak as a prominent tree in the overstory. On a bottomland community where, for instance, cottonwood is the dominant species, managing for a hard mast producer may be difficult or even infeasible.

Missouri's wildlife species generate important benefits. In and of themselves, they are a key component of healthy ecosystems. Ensuring that populations remain at viable levels correspondingly generates economic and social benefits. In 2011, residents and nonresidents spent approximately $2.8 billion on wildlife recreation (fishing, hunting, and wildlife watching). From a social perspective, hunting and fishing are integral to Missouri's culture as an outdoor enjoying state. Additionally, knowing that unique species such as bald eagles, or even bats, are being protected is important to most people.

The management guidelines described in this chapter address site-level recommendations for the important habitat elements, but the contribution of an individual site should be considered in the context of the surrounding landscape. For example, many cavity-dependent species have home ranges that are larger than the typical harvest or management unit, so planning to meet the needs of these species requires a broader look, both spatially and temporally, at the forest community on a landscape scale. If adequate suitable habitat exists adjacent to a harvest site, then retention or promotion of those habitat elements within the management unit may not be as critical as when the elements are lacking on the impacted landscape. Land managers have opportunities to enhance wildlife habitat characteristics through careful planning and management at the site level, as well as through coordination with adjacent and surrounding landowners and managers.

NOPPADOL PAOTHONG

Figure 2.1. *Post oak snag with a cavity*

Dens, Snags, and Super Canopy Trees

Den trees (live cavity trees) and snags (dead standing trees) with cavities provide wildlife with shelter and habitat for roosting, foraging, nesting, and hiding. A total of 89 vertebrate wildlife species in Missouri utilize cavity trees or snags for all or part of their life cycle. At least 54 species use the cavities in live or dead trees. About 59 percent of wildlife species will use cavities in either live trees or dead trees, but 13 percent prefer cavities in live trees, and 28 percent prefer cavities in snags. Cavity users are defined as primary excavators, those that make cavities such as woodpeckers and chickadees, or secondary users, which use cavities produced by others or by decay. Snags are about six times more likely to have cavities than live trees. Snags are also very important to invertebrate and fungi species. Twenty-two percent of Missouri's breeding bird species are cavity nesters. Screech and barred owls use snags and den trees for nesting and resting. They are also important to gray and fox squirrels, black bears, white-footed mice, Indiana bats, gray tree frogs, southern flying squirrels, raccoons, pileated woodpeckers, red-headed woodpeckers, and wood ducks. A number of songbirds including eastern bluebirds, nuthatches, chickadees, and wrens utilize snags and den trees for part of their life cycles as well.

"Wolf" trees are a particularly valuable type of live den (cavity) tree. They are large diameter, often open-grown, old-aged, hollow trees that provide cavities and are frequently a source of hard or soft mast. Oaks, hickories, and sycamore are all preferred den tree species. In regeneration harvests, it is important to reserve snags, den trees, and wolf trees either individually or in clumps. Large diameter snags and den trees — those greater than 18 inches diameter at breast height — are particularly important wildlife habitat features to retain. Saving trees with holes located high in the tree is also an important consideration. Typically, holes located at least 20 feet above ground are the most beneficial. Where there is a shortage of snags, it may be desirable to girdle some leave trees to accelerate their development into suitable habitat.

The fundamental idea is to retain some structure for snag- and cavity-dependent species on a site or maintain the potential to produce such structure as a stand grows and develops (see Chapter 15). If suitable habitat already exists next to a harvest site, then leave trees may not be as critical if the habitat values in those adjacent stands are to be maintained. Managers of larger landholdings may be able to plan for sufficient cavity-dependent wildlife habitat on portions of their property (such as riparian reserves) and reduce leave tree/snag requirements on other portions. From a temporal standpoint, consideration must be given to the time it takes for a regenerating stand to produce trees of a size and a degree of decay that represents suitable structure. Looking at adjacent stands, it is also important to think about how they may in fact change over time in relation to the changes expected within the stand being treated.

Super-emergent or super-canopy trees are large diameter trees with crowns that extend well above the plane of the forest canopy: ideally at least 50 to 75 percent of the crown or 20 to 25 feet. Such trees are of high importance in bottomland forests and riparian areas to provide nesting sites for bald eagles and other raptors, for heron rookeries, and as potential large cavity trees. On average, two to four super-emergent trees per acre, or those that have the potential to become such trees, should be retained to provide the needed structural diversity. Preferred tree species include oak, cottonwood, and sycamore.

Mast Production

Mast is the wildlife food provided by the seeds and nuts of trees. Fruit such as acorns, hickory nuts, and walnuts are considered hard mast and are valuable because of the length of time they remain available to wildlife. Soft mast includes dogwood berries, maple seeds, or similar fruits that may not stay nutritional as long but are still important because of their availability at other times of the year.

The high levels of fat, protein, and carbohydrates in mast contribute to energy stores critical for migration or hibernation, as pre-breeding conditioning nutrients, and for the survival of newly independent young. Some birds and mammals depend heavily on mast during peak production periods in late summer and early fall. During winter, some sources remain available on trees and shrubs, under snow, or stored in caches.

Mast production is generally favored by increased mast species diversity, crown exposure to light, crown size, maturity of trees or shrubs, increased soil nutrients, tempered microclimates (especially during flowering), and adequate soil moisture. Riparian edges often contain a higher concentration and richness of mast-producing species. Production on a site and within various species of trees and shrubs tends to vary considerably from year to year. Most shrub species will regenerate well and produce mast after cutting, burning, or soil disturbance. Mast-producing species often depend on animals for their dispersal and reproduction.

Although certain dominant tree species such as oak are particularly important, other mast species also provide key benefits. Retention of all food-producing tree types should be prioritized in accordance with the local abundance of each tree species. In areas of least abundance, greatest attention should be applied to retention. Planning silvicultural treatments to increase mast-producing trees should be performed in accordance with silvicultural guidelines.

In Missouri, oaks are the foundation species for many wildlife species. Squirrels, white-tailed deer, black bears, eastern chipmunks, eastern wild turkeys, wood ducks, white-footed mice and red-headed woodpeckers are just some of the species heavily dependent on oak mast. The production of 100 pounds of oak mast per acre is needed to sustain reasonable

wildlife densities. This is roughly equivalent to a basal area of 25 to 30 square feet per acre in oaks that are above 10 inches diameter. Most oak species begin mast production at around 20–25 years, but yields are not maximized before age 40 or 50. Thinning can enhance mast production by increasing diameter and canopy size on good mast-producing trees.

Oak mast production is highly variable from year to year. There are also significant differences in flowering and acorn production among species in the red oak group (scarlet, cherrybark, shumard, pin, black, and northern red oaks) versus those in the white oak group (post, chinkapin, burr, and white oaks). Species in the white oak group require one growing season to complete their reproductive cycle, and species in the red oak group flower every year but require two growing seasons for the acorns to mature. The white oak group can produce every year but may only have abundant crops sporadically. Year-to-year fluctuations in acorn production tend to be less extreme for the red oak group. In a year with a late spring hard freeze, acorn production may be comprised of only acorns produced by the red oaks during the previous growing season. Therefore, managers should retain a diversity of both red and white oak species across the landscape to ensure overall adequate mast production for wildlife species.

There are important differences in nutritional and palatability values between red oaks and white oaks. Acorn-dependent wildlife select acorns low in tannin levels in autumn when energy requirements are low and food is relatively abundant. In contrast, in the winter when energy requirements are high, these same wildlife species select acorns with higher lipid levels even when they contain higher amounts of tannin. Since the red oak group species tend to have higher concentrations of tannins, these acorns tend to be most heavily utilized later in the winter when nutritional needs are highest. Due to these differences, it is important to manage for both white and red oak species in oak-dominated natural communities.

Soft mast-producing shrubs and small trees are also important food sources for white-tailed deer, many songbirds, numerous small- and medium-sized mammals, and some reptiles. Species include serviceberry, pawpaw, hackberry, sugarberry, dogwoods, hawthorns, persimmon, elm, ash, spicebush, red mulberry, black gum, black cherry, wild plums, sumacs, Carolina buckthorn, gooseberries, wild roses, blackberries, raspberries, dewberries, elderberry, sassafras, green briars, coral berry, blueberries, grapes, hollies, pokeweed, and poison ivy.

Soft mast production is enhanced by timber harvesting and/or thinning. Clear-cut and shelterwood harvests produce abundant soft mast the first few years after harvest. Group cuts made at more frequent intervals can provide moderate amounts of soft mast annually. Prescribed burning can also enhance production from shrub species if adequate light is available.

Land managers in regions with low mast availability have opportunities to enhance wildlife habitat characteristics by careful management of mast species on their land. Some wildlife species may forage over significant distances. The black bear, for example, may travel 10 miles to obtain mast. Breeding birds will often relocate family groups to wetland edges or areas with increased levels of berries during late summer before migration.

Water Sources

Many wildlife species are dependent upon surface water. For example, one pond, stream, or other water source per 160 acres of land can enhance turkey habitat, and deer require a sufficient water source per square mile. Developing a fishless shallow pond for deer and wild turkey can also benefit amphibians, particularly in heavily wooded, upland karst topography where standing water is not a common occurrence.

In the Missouri Ozarks, 17 species of amphibians utilize fishless ponds: salamanders (ringed, spotted, marbled, eastern

NOPPADOL PAOTHONG

Figure 2.2. *Regeneration areas provide a variety of soft mast food sources.*

TERRY THOMPSON

Figure 2.3. *This installed shallow fishless pond will provide many wildlife benefits.*

tiger, central newt, and four-toed), toads (eastern American, eastern narrow-mouthed, Fowler's), and frogs (Cope's gray tree frog, eastern gray tree frog, Blanchard's cricket, northern spring peeper, western chorus, pickerel, southern leopard, and wood). In addition, turtles and water snakes will benefit from these shallow ponds.

Guidelines on the construction and maintenance of shallow ponds for amphibians are available from the Missouri Department of Conservation. Note that many small wildlife ponds developed in the past may not be ideally suited for amphibians if they contain fish. Timbered buffers that are 50 feet in radius should be located near artificially created wildlife watering holes, and 200-feet-radius buffers should be used around other isolated wetlands such as sinkhole ponds, springs, fens, and seeps (see Chapter 15 for specific recommendations). All of these habitats can be important amphibian breeding sites.

Coarse Woody Debris and Slash

Standing dead trees, fallen trees, large decomposing roots, stumps, and treetops with limbs larger than 6 inches make up coarse woody debris. Coarse woody debris has many roles such as providing seed germination sites, acting as reservoirs of moisture during droughts, and serving as habitat for a number of forest organisms. Snags and down logs are important in cycling nutrients and energy, in providing habitat for invertebrates and fungi, and in soil development and watershed protection.

At least 66 vertebrate species in Missouri utilize down woody material such as rotting logs, dead limbs, and brush piles. Large fallen trees can provide important habitat for chipmunks, salamanders, and frogs for up to 50 years. They also provide drumming sites for ruffed grouse. Fallen logs located on steep north-facing slopes in the southern half of the state are especially valuable to the western slimy salamander, Ozark zigzag salamander, southern red-backed salamander, ringed salamander, marbled salamander, and spotted salamander. Many predators, ranging in size from shrews to black bears, rely on the food they find in coarse woody debris.

In Missouri and throughout the Midwest, old-growth forests (>175 years) typically contain larger amounts of coarse woody debris than mature second-growth forests (70–90 years.) Coarse woody debris is an important structural element for maintaining biodiversity in eastern deciduous forests. Managing for old-growth forests and woodlands on a variety of sites will ensure adequate coarse woody debris reservoirs across the landscape. Ensuring that adequate snags and reserve trees are left during regeneration harvests is also critical to maintaining coarse woody debris levels through time (see Chapter 15 for specific recommendations).

Habitat Connectivity and Continuity / Forest Interior Bird Species

Fragmentation results when forestland is interspersed with other land uses such as agricultural or residential development. It can also be caused by road building where rights of way are particularly wide.

The subsequent impact to natural communities can range from the increased introduction of exotic species to songbird nest parasitism. Forest tracts permanently isolated by fragmentation, particularly in northern Missouri or the Bootheel, are frequently too small to prevent brown-headed cowbirds and nest predators from parasitizing and depredating the nests of interior bird species. As a result, forest interior songbird populations have poor reproduction in these regions. Similarly fragmented landscapes create more desirable conditions for the invasion of a variety of unwanted, nonnative plants or animals into remaining woodlands.

Even-aged regeneration harvests (clear-cuts) within the context of large contiguous blocks of timber do not constitute fragmentation though they may result in a temporary change

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Figure 2.4. *A large decaying log will provide habitat and food sources for many wildlife species.*

of habitat and of wildlife that use them. Smaller 2–20 acre clear-cuts in extensively forested landscapes like the southeast Missouri Ozarks have not been found to increase songbird nest predation or parasitism rates.

To encourage reproduction of forest interior songbird species such as ovenbird, wood thrush, worm-eating warbler, cerulean warbler, black-and-white warbler, Kentucky warbler, and others, forest landscapes should be at least 10,000 acres in size. A 12-mile-diameter landscape should be at least 70 percent forested in order to qualify for adequate forest interior conditions. The forested landscape should contain a variety of successional stages with core 2,000-acre mature or old-growth timbered tracts.

Bottomland forests in particular have been extensively converted to agricultural uses and are the most fragmented of forest types in the state. Efforts to reforest floodplains are very valuable for forest interior bird species. As an example, prothonotary warblers in an agriculture-dominated landscape require bottomland forest tracts that are at least 7,000 acres in size, in order to support a viable source population of 500 breeding pairs. Cerulean warblers require even larger bottomland forest tracts in order to support a viable source population.

JIM RATHERT

Figure 2.5. *Prothonotary warblers need large bottomland forests to thrive.*

Early Successional Habitat

Early successional habitat is dominated by shrubs and saplings less than 15 years old. It is an important habitat component for some species such as white-tailed deer, wild turkey, ruffed grouse, and eastern cottontail rabbit, as well as for songbirds like prairie warbler, blue-winged warbler, field sparrow, eastern towhee, white-eyed vireo, hooded warbler, indigo bunting, and yellow-breasted chat. It can be created with regeneration harvests on forest sites and is also present in old fields as well as glades and woodlands managed with thinning and prescribed fire.

As with old-growth, early successional stands are under-represented in most of Missouri's forested landscape. In large timbered blocks (>500 acres) it is desirable to have around 10 percent (5–15 percent) in some form of temporary structure such as regeneration areas or natural openings (e.g. glades) to provide early successional habitat. Managers should evaluate the abundance of habitat in the landscape and adjust treatments to enhance early successional habitat quantity and distribution.

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Figure 2.6. *Regeneration areas can provide early successional habitat for many wildlife species.*

Edge

Edge is the transition zone between habitat types. It can include "hard" edges between a forest and a crop field, or "soft" edges between a forest and the temporary regeneration opening created by a clear-cut. Edges can also be natural, such as those between a woodland and a glade or between a bottomland forest and a slough. They typically provide an abundance of grasses, forbs, shrubs, vines, and small trees that provide food and cover for many wildlife species (especially deer, rabbit, turkey, and quail). A seed-producing herbaceous layer of vegetation attracts a diversity of insect life, which can reduce the need for artificial food plots and reduce the wildlife population tie to cyclic mast production.

Edge feathering is a technique that can effectively create better edge habitat at the border between timbered lands and crop fields or old fields by cutting trees in a 15–30 foot swath along these borders. Another wildlife practice that can be done in conjunction with edge feathering is the creation of

brush piles. Brush piles offer good heavy cover and are utilized by rabbits and other small mammals, reptiles, salamanders, insects, and a host of bird species.

Large forested tracts often lack openings and therefore lack soft edge. Soft edge in these landscapes is not as critical to wildlife as is early successional habitat, though both are created through regeneration harvests. Glades and natural windthrow openings also provide similar habitat.

Care must be taken when creating or enhancing edge habitat, or when conducting a harvest operation, to avoid introducing invasive exotic species such as sericea lespedeza or bush honeysuckle. These invasive exotics are extremely aggressive and can rapidly colonize disturbed areas. Where stand treatments will open the canopy, assess the site and spot treat existing invasives prior to operation. Dense stands of honeysuckle can eliminate desired regeneration and can completely overtake the stand if left untreated. Roads and utility corridors may also provide edge habitat, but particular care should be taken in these situations with regards to invasives because these sites are common entry points for invasives across the landscape and into opened stands. See Chapter 9 for more information on invasive species.

SARAH EGLY

Figure 2.7. *Edge feathering is a technique that can improve habitat for species such as bobwhite quail.*

Glades and Forest Openings

Openings in forested landscapes can be either natural openings, such as glades that exist due to shallow drought-prone soils, or openings created through intentional clearing. Where glades exist, they provide distinct and important habitat type that many species utilize and benefit from. They are most often found on south and west-facing slopes or ridge tops.

The native species that occur on glades are very drought tolerant. It is recommended that glades be managed to promote these species by controlling cedar encroachment and using prescribed fire as needed. Nonnative species of grasses and forbs seldom survive the naturally dry conditions and are not recommended for these areas. Never attempt to grow a grain or green browse plot in a glade as any soil disturbance will likely lead to excessive soil erosion and unsuccessful plant growth.

Artificial clearings in the forest created to stimulate annual weeds, grasses, forbs, or grain can provide feeding sites for a variety of wildlife species and thus wildlife viewing opportunities. In most cases, these objectives can be achieved through normally planned forest management practices.

SUSAN FARRINGTON

Figure 2.8. *A restored dolomite glade in Shannon County*

Intentionally created openings, such as food plots that will be disked and planted each year, need to occur on a fairly level location to avoid excessive erosion. As woody growth begins to reinvade openings, a combination of mechanical, chemical, and/or prescribed burning practices may be used to maintain them.

Game Species Management

The term "game management" is reflective of a time in history when wildlife populations as a whole were taken for granted. Some species were driven to extinction and many others extirpated from the majority of their historic ranges as a result of habitat destruction and over-harvest. The concept of game management arose from a collective realization that natural resources (in general) and wildlife resources (more specifically) were not inexhaustible and that they had to be actively managed if they were to be retained. Much of the original concern was centered upon species that were hunted for recreation and consumption because declines among these were the most apparent. However, as the science of wildlife management has advanced, focus has shifted toward managing for diverse habitats that support the full range of native plants and animals.

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Figure 2.9. *Landowners can enhance wildlife habitat and abundance by implementing well-planned forest management.*

Since the inception of game management, food plots have been popular with landowners. From a science-based perspective, they do little to increase wildlife numbers. However, from a social perspective they can create opportunities to spot game species like deer, turkey, or quail, and they can serve to create ideal hunting locations for increasing hunter satisfaction. Concentrating wildlife for easier viewing is a reasonable landowner objective, but it is a choice that should be made with full knowledge that broader scale management to improve overall habitat diversity is a more effective way to enhance the full spectrum of wildlife populations, including those considered game species.

References to Other Chapters

- Mast trees should be protected and enhanced during tending operations. See Chapter 13 for more information.
- Wildlife habitat should be protected during road construction activities. See Chapter 14 for BMPs for road planning and design, removing creek gravel, minimizing infrastructure, roads in wetlands, and protecting soil productivity and water quality.
- Timber harvesting can help improve and enhance wildlife habitat. See Chapter 15 for BMPs for retention of snags, dens, and super canopy trees, wildlife enhancement, retaining leave trees, slash management, coarse woody debris, maintaining mast, protecting residual trees, wetland protection, and protecting natural features.
- Prescribed fire can be used to enhance and promote specific types of wildlife habitat. See Chapters 11 and 17 for more information.

Additional Resources

Wildlife Management for Missouri Landowners, third edition. Missouri Department of Conservation. 2000. Available at ***mdc.mo.gov/node/5354***.

Forest Management for Missouri Landowners, revised edition. Missouri Department of Conservation. 2007. Available at ***mdc.mo.gov/node/5574***.

CHAPTER 3

Natural Heritage Resources

DAVID STONNER

Topics Covered

- Species of Conservation Concern
- Natural Communities of Conservation Concern
- Major Natural Communities of Missouri
- Natural Heritage Resources — Protecting Fragile Ecosystems
- Heritage Reviews
- Special Considerations for Natural Areas and High Conservation Value Forest (HCVF)
- Significant Natural Heritage Resources
  - Isolated Wetlands
  - Karst Features
  - Old-Growth Habitat
- Threatened and Endangered Species (T&E species)
  - Terrestrial Species
  - Federally Listed Bat Species
  - Aquatic and Wetland Species
- What Can Landowners Do to Help Rare and Endangered Species?
- Potential Indicators of Species and Natural Communities of Conservation Concern

Missouri's natural landscape has changed greatly in the last 200 years. Agriculture, urban sprawl, dams and reservoirs, mining, stream channelization, land clearing, and other activities have had an impact on virtually all of the state's lands. High-quality intact natural areas are rare. However, many of Missouri's forests and woodlands currently retain significant natural quality and provide habitat for important natural communities and species.

Areas with high-quality, significant natural features, communities, or species give us an appreciation for the diversity and strikingly rich and beautiful landscapes that were once prevalent. It is important to conserve these areas for their biodiversity. These elements of Missouri's natural heritage are valuable assets from cultural, aesthetic, and practical perspectives. Their status and management can add intrinsic worth to properties, and they should be carefully considered when managing lands.

Natural heritage resources include populations of native plants and animals and healthy natural communities and ecosystems. They are the result of thousands of years of selection and adaptation to the specific processes and conditions that characterize Missouri. Natural heritage resources include terrestrial, aquatic, and geologic features as well as habitats for species of conservation concern. Caves, sinkholes, limestone cliffs, sandstone canyons, springs, seeps, forested wetlands, glades, riparian areas, and old growth timber are some examples of natural heritage elements.

Forests, glades, springs, rivers and streams, savannas, wetlands, prairies, and caves each support a different combination of plants, animals, and microorganisms. Considering how management impacts these systems and lessening or mitigating degrading actions is important when conducting management in forested lands.

Species of Conservation Concern

In the brief time since European settlement of Missouri, many plants and animals have declined to levels of concern, and some have disappeared entirely. One of the primary components of natural heritage resources is species of conservation concern. The rarity of these plants and animals makes them vulnerable to extirpation from the state. Currently, 18 percent of native vascular plants, 14 percent of nonvascular plants, and 28 percent of the vertebrate animals in Missouri are considered species of conservation concern.

The Department of Conservation maintains two references relating to the status of listed plants and animals in Missouri: the *Missouri Species and Communities of Conservation Concern Checklist* and the *Wildlife Code of Missouri*. Native animal species, including invertebrates, have legal protection under the *Wildlife Code*. All animal species in the state of Missouri are protected as biological diversity elements unless a method of legal harvest or take is described in the *Wildlife Code*. Species listed in the *Wildlife Code* under 3CSR10-4.111 are protected by the State Endangered Species Law 252.240. Some of the plants and animals in the checklist also appear in the *Wildlife Code* and are afforded special legal protection. All federally endangered and threatened plants and animals are protected by the Endangered Species Act of 1973 (ESA) and by the Missouri State Endangered Species Law.

Best management practices for many species of conservation concern can be located by accessing the Missouri Department of Conservation's web page at ***mdc.mo.gov/node/4067***.

Natural Communities of Conservation Concern

Natural communities are groups of native plants and animals and their associated physical environment that occur in repeatable patterns across the landscape and have been least impacted by modern society. In addition to species of conservation concern, terrestrial natural communities can be rare natural heritage resources in and of themselves. Terrestrial natural communities consist of interrelated assemblages of plants, animals, and other living organisms interacting with their physical environment and shaped by climate and other natural processes. High-quality terrestrial natural communities provide diverse assemblages of native species and represent the best remaining examples of ecosystems that existed prior to European settlement. These natural communities frequently provide habitats for Missouri species of conservation concern. On public land many of these areas have been designated Missouri natural areas.

A list of species and natural communities of conservation concern are found at ***mdc.mo.gov/node/4070***.

Rankings are assigned to natural communities using established criteria. These include total number of occurrences, number of occurrences as related to overall quality (or grade), total acres, number of counties in which the community type occurs, number of protected occurrences, and threats.

Natural communities can be either terrestrial or aquatic. There are 85 different terrestrial natural community types and 35 different aquatic natural community types recognized in Missouri. These 120 different communities can be generally grouped under nine major terrestrial natural community types and seven major aquatic natural community types. These are described below.


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Major Natural Communities of Missouri

Forests are dominated by trees that form a closed canopy reaching more than 70 feet high at maturity. Forests have multi-layered understories of shade-tolerant trees, shrubs, vines, ferns, and herbs.

Woodlands have a more open canopy than forests. Trees are often gnarled and reach less than 70 feet at maturity. Beneath the open understory the ground is covered with a dense growth of forbs, grasses, and sedges.

Savannas are transitional zones between woodlands and prairies. They have a scattering of trees interspersed with a thick ground cover of prairie grasses and forbs.

Prairies are native grasslands dominated by perennial warm-season grasses and forbs with scattered shrubs. The biodiversity of most prairies is staggering, with more than 200 native plant species often occurring on as little as 40 acres.

Glades form on shallow soils or open bedrock where drought-adapted grasses and herbs dominate. Few trees grow on glades. Many plants and animals found here occur nowhere else in Missouri.

Cliff and talus natural communities are characterized by exposed rock. Cliffs are vertical expanses of bedrock dotted with sparse vegetation. Talus defines areas of loose rocks, cobbles, and boulders that collect below cliffs.

Stream edges are riparian zones, such as gravel washes and stream banks that are affected by rushing water. Species that occur here are adapted to frequent flooding.

Wetlands are dominated by plants and animals adapted to periodic or constant soil saturation or flooding. Wetlands include fens, marshes, seeps, and swamps.

Caves are natural openings in the Earth's surface large enough for a person to explore beyond the reach of daylight. Caves include terrestrial and aquatic natural communities. On most natural areas, cave access is restricted to protect these fragile ecosystems.

Springs produce a continuous flow of water from the ground that follows a well-defined channel. Springs are fed by groundwater that is typically 58 degrees Fahrenheit year-round.

Headwater creeks are the smallest, uppermost segments of streams. They occur along the first six miles of a stream where surface runoff coalesces into a single channel. Here, stream gradients are fairly high and valleys are often shallow. Flow is often intermittent. Many natural areas contain headwater creeks.

Creeks occur from 7 to 31 miles downstream of where a stream begins. These natural communities have permanent pools, but riffles may dry out occasionally. The stream gradient is moderate with deeper valleys than those found in headwaters.

Small rivers flow from 32 to 96 miles downstream of where a stream begins. Water flows over riffles at all times. In the Ozarks, large springs contribute to the water flow of many small rivers.

Large rivers occur 97 or more miles downstream from where a stream begins. In the Ozarks, large rivers have relatively deep valleys. In other parts of the state, they have wide valleys.

Great rivers in Missouri are represented by the Missouri and Mississippi rivers.

Overflow waters are oxbow lakes, sloughs, blew holes, abandoned stream channels, and other standing waters that are connected to streams during floods.

NOPPADOL PAOTHONG

Figure 3.1. *Natural areas, such as Mill Mountain, are places throughout the state that have been recognized for their unique habitats or features.*

Natural Heritage Resources — Protecting Fragile Ecosystems

Land managers can find it daunting to determine whether natural heritage resources may be affected by management activities. The Missouri Department of Conservation routinely requires heritage reviews for state land management initiatives and infrastructure development projects to ensure heritage resources are protected from unintentional harm. Heritage reviews are also provided when assisting private landowners with stewardship planning for their property. Heritage reviews ensure that endangered species, species of conservation concern, and rare natural elements are conserved to the fullest extent possible. Heritage reviews utilize the state's Natural Heritage Database to determine whether any known occurrences of priority natural communities or species exist at the site in question. Heritage reviews are informational in nature and result in a document informing a requestor of the presence (or absence) of known heritage resources in or near a proposed project site. In addition, potential concerns in the project area (e.g. we don't know that an endangered species is present, but the location seems to fit its habitat needs) are identified.

It is Missouri Department of Conservation policy not to reveal detailed locations of known heritage sites. Identifying sites with precision could expose them to damage from collectors or visitors. Moreover, with 93 percent of Missouri land in private ownership, many heritage records are on private property. Private landowners often are willing to share information only if they feel comfortable such cooperation will not direct unwanted visitors or trespassers to their land.

Heritage Reviews

Heritage reviews are normally sought by private or public entities for projects seeking federal funding or permits. Such projects are required to investigate and plan for potential impacts to rare or endangered species in accordance with the federal Endangered Species Act or other statutes. A heritage review is normally the first step in this investigation and planning process.

Missouri citizens have repeatedly shown their concern for conserving our natural resources. Anyone about to undertake a project and wanting to know if natural heritage database records indicate occurrences of species or natural communities of conservation concern may request a heritage review for his or her own lands.

To obtain a heritage review, send a project description, map, and township/range/section description to:

Missouri Department of Conservation
Attention: Resource Science Division
PO Box 180
Jefferson City, MO 65102–0180

Preliminary natural heritage reviews are available online through the Missouri Department of Conservation's public website. If no species of concern or sensitive communities are indicated by the database, the requestor receives a clearance letter. In the event the search results in a possible positive, given landowner permission, the project site will be evaluated internally by biologists to ascertain possible impacts and options.

For more information about the natural heritage database and heritage reviews, including how to request a review, visit ***mdc.mo.gov/node/16757***.

Special Considerations for Natural Areas and High Conservation Value Forest (HCVF)

In Missouri, some high-quality natural communities and geologic features have been designated as Missouri natural areas by the Missouri Natural Areas Committee (MoNAC), an interagency group consisting of the Department of Conservation, the Department of Natural Resources, the U.S. Forest Service, the U.S. Fish and Wildlife Service, The Nature Conservancy, and the National Park Service. The Missouri natural areas system is composed of designated natural areas throughout the state of Missouri. These areas are the highest quality natural communities, representative of the pre-settlement Missouri landscape.

Natural areas are protected and managed for the purpose of preserving their natural qualities. The goal of the natural areas system is to designate, manage, and restore high-quality examples of every extant natural community in each of Missouri's natural sections.

Natural areas are defined as natural communities or geologic features that represent the natural character, diversity, and ecological processes of Missouri's native landscapes. Natural communities are groups of plants and animals and the landscapes, such as forests or prairies, that they inhabit — and that occur repeatedly throughout the state. While most designated Missouri natural areas occur on state and federal land, some exemplary sites have been designated on private lands at the request of the landowner.

Natural areas are a type of natural resource containing relatively undisturbed native habitats. They are important reference areas for comparison with more modified habitats and provide places to study ecosystems, plants, animals, and their interrelationships. They are models for natural community management. They are also genetic reservoirs of living species of potential use to man. They can be home for rare, threatened, or endangered species. Natural areas can also serve as valuable outdoor classrooms, settings for nature interpretation activities, and places for individual nature study and appreciation.

In addition, natural areas are part of our cultural heritage. They represent the environment of the Native Americans — an environment that Spanish, French, and American explorers and pioneers fought, overcame, and in many instances, destroyed. A region's history and culture are influenced by the surrounding natural environment.

Along with state designated Natural Areas, "high conservation value forests" (HCVF) is a term recognized by some certification bodies to indicate sites with especially high ecological and/or social value. They are intrinsically valuable for the number of different plant and animal species they support (biodiversity) and the ecological functions they provide. Maintaining these species and functions is generally recommended as the highest priority use for these areas, to the extent that other uses such as timber management may not be considered compatible. In Missouri, high-quality forested natural communities may be considered for natural areas status. Many high conservation value forests are present within the natural areas system. There are also many examples of potential HCVF sites on private lands throughout the state.

As land managers and stewards it is important to sustain or enhance the quality of ecosystems. Conserving unique natural heritage resources often requires active management. Prescribed fire, selective cutting, and herbicide application are utilized to dynamically restore natural communities. Invasive species management, water level manipulation, and the provision of adequate buffer land are other management methods used in natural area and natural community maintenance and restoration.

For more information about natural communities, the natural areas system, or high conservation value forests, contact a professional forester, a Missouri Department of Conservation private land conservationist, or a Missouri Department of Conservation natural history biologist.

Significant Natural Heritage Resources

Isolated Wetlands

Wetland natural communities are particularly sensitive to disturbance and have been greatly impacted by human activity. Wetlands have been drained and destroyed in

MICHAEL BILL

Figure 3.2. *An isolated sinkhole pond*

alarming numbers over the last 50 years. The most recent surveys indicate that more than half of the wetlands in the United States have been lost as a result of drainage and filling, and many of our remaining wetlands have deteriorated in quality because of siltation, pollution, and alterations. Wetland protection and restoration is certainly one of conservation's biggest challenges today.

When managing forested lands, isolated wetland features should be specially considered since these features can be limited in size and so easily adversely impacted. Wetlands such as springs, seeps, fens, shrub swamps, and swamps may be protected under the Clean Water Act (CWA). Hydrologically isolated wetlands, like some sinkhole ponds and isolated fen natural communities, while not always protected by federal law, are natural heritage resources that provide critical habit and watershed benefits.

Land managers should assess the wetland resources present on a property, looking for such features as springs, streams, oxbow lakes, fens, seeps, and sinkhole ponds. Wetlands are particularly fragile, and careful consideration and planning of management projects must be undertaken specifically if wetlands cannot be avoided by the work at hand. See Chapter 15 for best management practices for protecting wetlands.

In Missouri, wetlands data is readily available for land managers through the National Wetland Inventory (NWI); a U.S. Fish and Wildlife Service national mapping project of the wetland resources throughout the United States. A web-based utility known as Wetland Mapper (***fws.gov/wetlands/Data/Mapper.html***) integrates digital map data with other resource information to produce timely and relevant management and decision support tools. Wetland Mapper allows land managers to determine what mapped NWI wetlands are present within an area of interest.

Potential wetland resources assessment through Wetland Mapper coupled with a natural heritage review can provide a clear picture of the heritage resources present on a project. Wetlands often support species of conservation concern or may themselves be natural communities of conservation concern. Identifying wetlands and carefully considering management actions that may influence them can assist managers with regulatory permit processes or dictate what best management practices are pertinent to protect the wetland features present.

Karst Features

Karst features range from sinkholes, cave openings, losing streams, and springs to complex underground drainage systems and caves. It is of utmost importance that construction projects and forest management activities in known karst topography (including sinkhole plains) be extremely sensitive to the potential biological and environmental impacts that may occur, and that all possible precautions are taken to prevent or reduce those impacts.

Buffer zones should be maintained on all sides around cave openings, springs, and sinkholes. See Chapter 15 for more information. Since karst features are frequently connected to groundwater sources, general applications of fertilizers, pesticides, or herbicides should be excluded from the buffer area. Spot application of wetland/aquatic approved herbicides in the buffer zone is acceptable. Appropriate erosion and sediment controls should be installed during any earth-disturbing projects in karst areas. Where appropriate, a riparian corridor should be designated from caves with springs to water courses with permanent flow or intermittent flow with permanent pools.

STEVE PAES

Figure 3.3. *Caves are unique resources and require special protection.*

These features can be home to unique species and communities, and Missouri species of conservation concern should be adequately accounted for during management planning and, specifically, as part of timber sale planning. The regional natural history biologist can be consulted in order for landowners to gain information on species of conservation concern and sensitive natural communities. See Chapters 14 and 15 for guidance on how to protect karst features specifically.

Old-Growth Habitat

The term "old growth" has been applied variously in the context of forest resources and is typically exemplified by tree (or stand) age and/or size class. Old-growth management has often been assumed to require a hands-off approach, with little or no human intervention, even if the systems evolved in a human context such as aboriginal fire regimes. From an ecological perspective, old growth codified by these measures is not a particularly useful concept. A better approach would be to consider old growth in the context of site continuity and system sustainability that includes:

- Biological integrity and diversity
- Continuity of site conditions and landscape character
- Stability of process regimes that emulates the landscape of pre-European settlement (i.e. fire, hydrology, etc.)
- Ability to prevent adverse impacts such as invasive species, hydrological alterations, and human-caused site degradation

Old growth is essentially a living linkage to what are often the most sensitive and rare phases of a forest system, providing continuity that facilitates the conservation of biological diversity and the interactions that characterize healthy ecological systems.

Under the concept, old-growth systems are more likely to be managed to sustain their rare characteristics, including providing habitat for viable populations of species with sensitive ecological requirements and serving as a reservoir for the eventual repopulation of nearby suitable areas.

This approach prevents management from being driven by a single-minded focus on old or large trees and instead focuses on sustaining a biological system that accommodates all of the elements of late successional communities.

Where some age reference point is helpful, forests that are at least 100–175 years old are generally considered potential old-growth candidates. They should also be structurally complex and contain large amounts of coarse woody debris. There should be trees with larger than average diameters for that particular species and site, cavities in live trees, standing snags, multilayered vegetation structure, dead and down woody material, decadence evident in tops and boles of large trees, tree-fall gaps formed by windthrow, and characteristic herbaceous species for the community type.

Mesic old-growth forests support abundant and diverse populations of salamanders and land snails. In Missouri about 87 species of wildlife depend heavily on old-growth forest and woodland habitat. Characteristic old-growth forest birds include pileated woodpecker, hooded warbler, cerulean warbler, ovenbird, barred owl, and wood thrush.

Very few true old-growth forest stands occur across Missouri (perhaps less than 10,000 acres), but the potential is high for many stands currently at economic maturity (110± years) to pass into an old-growth stage within the next 50 years. Many stands dominated by long-lived trees such as oaks in the white oak group, shortleaf pine, sugar maple, sweet gum, hickories, sycamore, black gum, and bald cypress could be allowed to develop into old-growth stands. Providing for permanent old-growth forests and woodlands may best be accomplished by identifying larger units, primarily on public land, that can be managed as old growth. These could be in designated Missouri natural areas, natural community emphasis areas, research areas, and sensitive sites (steep slopes, wetlands). Utilizing extended rotations of 200 years on appropriate sites could provide excellent old-growth attributes.

STEVE PAES

Figure 3.4. *Old growth white oak stand*

Threatened and Endangered Species

Private landowners play an integral role in the conservation and recovery of the state's most imperiled species because many of Missouri's rare and endangered species are closely associated with Missouri's forests. Management of forests can be mutually beneficial for landowners and endangered species. Forests that are managed for recreational or commercial purposes can provide valuable habitat for rare plants and animals. Often, the specialized habitat requirements of rare plants and animals can be met with a little extra consideration when planning forest management activities. Forest management can accommodate rare and endangered species through modifications such as the timing of harvest, buffering nest locations, strategically locating gaps and residuals, locations of landings and roads, and careful planning of post-harvest treatments.

The Endangered Species Act (Act) was passed by Congress in 1973 in an effort to protect declining species and recover species in peril to the point that they no longer need protection. The Act is not intended to stop any commercial, urban, or industrial development or prevent management of public or private lands. Since its passage, the Act has heightened public awareness of endangered species, the threats to their survival, and the consequences of species extinction to humans. Such recognition has resulted in the development of conservation programs and laws to protect rare plants and animals in nearly every state.

Missouri is home to 39 federally-endangered or threatened species, one candidate species, and two species proposed for listing under the Act. Missouri also has 34 additional state-endangered species. These 75 species are found throughout the state and include birds, mammals, plants, insects, crustaceans, fish, reptiles, amphibians, and mollusks that are associated with habitats ranging from rivers and streams to prairies and forests. (See the list on the following page.) Twenty-six of the 42 federal species (65 percent) are dependent on forests to complete all, or a portion of, their life cycle.

JEFF BRIGGLER

JIM RATHERT

USFWS

JIM RATHERT

Figure 3.5. *Rare and endangered species in Missouri include plants and animals that live in forests, as well as those that live in streams and wetlands, and can be directly affected by forest management practices.*

Federal and State Threatened and Endangered Species in Missouri

Plants

Decurrent false aster *(Boltonia decurrens)*
Eastern prairie-fringed orchid *(Platanthera leucophaea)*
Geocarpon *(Geocarpon minimum)*
Mead's milkweed *(Asclepias meadii)*
Missouri bladder-pod *(Physaria filiformis)*
Pondberry *(Lindera melissifolia)*
Running buffalo clover *(Trifolium stoloniferum)*
Small whorled pogonia *(Isotria medeoloides)*
Virginia sneezeweed *(Helenium virginicum)*
Western prairie-fringed orchid *(Platanthera praeclara)*

Mollusks

Curtis' pearlymussel *(Epioblasma florentina curtisi)*
Ebonyshell *(Fusconaia ebena)*
Elephantear *(Elliptio crassidens)*
Fat pocketbook *(Potamilus capax)*
Higgins' eye *(Lampsilis higginsii)*
Neosho mucket *(Lampsilis rafinesqueana)*
Pink mucket *(Lampsilis abrupta)*
Rabbitsfoot *(Quadrula cylindrica)*
Scaleshell *(Leptodea leptodon)*
Sheepnose *(Plethobasus cyphyus)*
Snuffbox *(Epioblasma triquetra)*
Spectaclecase *(Cumberlandia monodonta)*
Tumbling creek cavesnail *(Antrobia culveri)*
Winged mapleleaf *(Quadrula fragosa)*

Crustaceans

Cave crayfish *(Cambarus aculabrum)*

Insects

American burying beetle *(Nicrophorus americanus)*
Hine's emerald dragonfly *(Somatochlora hineana)*

Fish

Arkansas darter *(Etheostoma cragini)*
Central mudminnow *(Umbra limi)*
Crystal darter *(Crystallaria asprella)*
Cypress minnow *(Hybognathus hayi)*
Flathead chub *(Platygobio gracilis)*
Goldstripe darter *(Etheostoma parvipinne)*
Grotto sculpin *(Cottus specus)*
Harlequin darter *(Etheostoma histrio)*
Lake sturgeon *(Acipenser fulvescens)*
Longnose darter *(Percina nasuta)*
Mountain madtom *(Noturus eleutherus)*
Neosho madtom *(Noturus placidus)*
Niangua darter *(Etheostoma nianguae)*
Ozark cavefish *(Amblyopsis rosae)*
Pallid sturgeon *(Scaphirhynchus albus)*
Redfin darter *(Etheostoma whipplei)*
Sabine shiner *(Notropis sabinae)*
Shovelnose sturgeon *(Scaphirhynchus platorynchus)*
Spring cavefish *(Forbesichthys agassizi)*
Swamp darter *(Etheostoma fusiforme)*
Taillight shiner *(Notropis maculatus)*
Topeka shiner *(Notropis topeka)*

Amphibians

Eastern hellbender *(Cryptobranchus alleganiensis alleganiensis)*
Ozark hellbender *(Cryptobranchus alleganiensis bishopi)*

Reptiles

Western chicken turtle *(Deirochelys reticularia miaria)*
Blanding's turtle *(Emydoidea blandingii)*
Yellow mud turtle *(Kinosternon flavescens)*
Mississippi green water snake *(Merodia cyclopion)*
Eastern massasauga *(Sistrurus catenatus catenatus)*
Western massasauga *(Sistrurus catenatus tergeminus)*

Birds

American bittern *(Botaurus lentiginosus)*
Bachman's sparrow *(Peacaea aestivalis)*
Greater prairie-chicken *(Tympanuchus cupido)*
Interior least tern *(Sterna antillarum athalassos)*
King rail *(Rallus elegans)*
Northern harrier *(Circus cyaneus)*
Peregrine falcon *(Falco peregrinus)*
Piping plover *(Charadrius melodus)*
Red knot *(Calidris canutus rufa)*
Snowy egret *(Egretta thula)*
Swainson's warbler *(Limnothlypis swainsonii)*
Whooping crane *(Grus americana)*

Mammals

Black-tailed jackrabbit *(Lepus californicus)*
Gray bat *(Myotis grisescens)*
Indiana bat *(Myotis sodalis)*
Northern long-eared bat *(Myotis septentrionalis)*
Ozark big-eared bat *(Corynorhinus townsendii ingens)*
Plains spotted skunk *(Spilogale putorius interrupta)*
Gray wolf *(Canis lupus)*

NOTE: *Federally-listed, candidate, and proposed species are in bold.*

All threatened and endangered species found in a natural forest play important roles in ecosystem health and function. Below are some of the reasons for considering the full suite of species in an area during planning and management activities:

- Rare and endangered species have innate conservation values.
- Rare and endangered species play a critical role in ecosystem function.
- Rare and endangered species include animals and fungi responsible for nutrient recycling and soil enhancement.
- Management that benefits rare and endangered species facilitates actions that mimic natural disturbances.
- Management that favors rare and endangered species can deter invasion by aggressive, non-native invasive species.
- Conservation of rare and endangered species maintains genetic strains that are adapted to local climate and site conditions.
- Rare and endangered species have aesthetic and recreational values.
- Rare and endangered species may produce economically-valuable products or provide eco-tourism benefits.
- Rare and endangered species have scientific and educational benefits.

Terrestrial Species

Terrestrial species, those plants and animals that live predominately or entirely on land, that use forested habitats can benefit from management of forests that are overstocked or unhealthy. The timing, methods, and desired endpoint of habitat management are all important considerations for landowners, land managers, and wildlife professionals providing technical assistance. Numerous species depend on forests for feeding, breeding, roosting, nesting, and sheltering. Most species are especially sensitive to habitat disturbance during times when they are breeding or rearing young. Loss, fragmentation, and degradation of forest habitats are major causes of decline for forest-dependent species throughout the state.

Federally Listed Bat Species

Habitats for imperiled bat species should be considered when conducting timber management activities. Missouri is home to three federally-endangered bat species (**gray bat**, **Indiana bat**, and **Ozark big-eared bat**) and one bat species (**northern long-eared bat**) that is proposed for listing under the Act. All four species of bats depend on forests. The Indiana bat and northern long-eared bat roost and form maternity colonies in the summer in live or dead trees with exfoliating bark, cracks, or crevices. The gray bat and Ozark big-eared bat roost in caves within forested landscapes year-round and forage along forested riparian corridors. Landowners who conduct activities around potential hibernacula, like caves, need to consider smoke management, maintenance of habitat buffers, and disturbance during harvest.

Retaining and maintaining over the long term a supply of large diameter, mature trees is essential for the Indiana bat and northern long-eared bat, whereas maintenance of continuous, healthy riparian corridors is important for all forest-dependent bat species. Retention of suitable roosting trees is preferred, and selective tree removal and retention can be used to avoid habitat loss for these species. If removal of suitable roost trees cannot be avoided, it is best to remove these trees during the inactive season when bats are hibernating in caves to avoid directly killing bats that might be present.

For more information about Indiana bats, their habitats, and stressors, visit the U.S. Fish and Wildlife website at ***fws.gov/midwest/endangered/mammals/inba/index.html***.

For information about gray bats, visit ***fws.gov/midwest/endangered/mammals/grbat_fc.html***.

Aquatic and Wetland Species

Aquatic species are those plants and animals that live predominately or entirely in water. Wetland species depend on saturated soil for at least one component of their life cycle. Although the association with aquatic and wetland species and forests might not seem obvious, there is a direct connection with riparian forest management and the health and persistence of this suite of species. Aquatic species, such as the **pink mucket** and **spectaclecase** mussels, **Niangua darter**, and **Ozark hellbender**, are highly vulnerable to changes in water flow and water quality. Changes to patterns of water flow can occur in the absence of vegetated areas along streams and rivers. Naturally occurring, occasional flash flooding can become more frequent and intense without adequate vegetation to act as a buffer and slow overland flow into water courses. Degradation of water quality can occur due to influx of chemicals and sediment in the absence of a vegetated filter. Sediment loads increase in waterways when tree and plant roots are not present to stabilize banks and soil in adjacent riparian areas. Unnaturally high sediment loads in water bodies are known to negatively affect reproduction and feeding of aquatic species.

Hine's emerald dragonfly is dependent upon fens for breeding and habitat for larval and nymph stages. Fens are a type of wetland that are permanently saturated by mineralized groundwater percolating through dolomite or limestone and include mucky soils that are inhabited by Devil's crayfish. Hine's emerald dragonfly larvae occupy crayfish burrows until they

USFWS

Figure 3.6. *A type of wetland called a fen provides habitat for Hine's emerald dragonfly.*

USFWS

Figure 3.7. *Clear, naturally-flowing streams and rivers are necessary for populations of mussels, fish, and hellbenders.*

MDC FILE

Figure 3.8. *Well-managed woodlands can be maternity habitat for bats.*

MDC FILE

Figure 3.9. *Forests provide food and shelter for numerous species including bats and migratory birds.*

emerge as adults. Threats to Hine's emerald dragonfly habitat include impacts to sensitive fens from heavy equipment, all -terrain vehicles, improper grazing by livestock, alterations of local hydrology, fire suppression, and encroachment of woody vegetation. Problems with water flow and quality can easily be avoided through adequate protection of riparian areas and wetlands.

What Can Landowners Do to Help Rare and Endangered Species?

Missourians interested in protecting rare plants and animals on their property should first determine the kinds of habitat present. The presence of suitable habitat only suggests the potential for rare and endangered species occurrence.

Conduct an on-site inspection. The presence of rare or endangered species can only be determined by an on-site inspection by a qualified biologist. Qualified biologists can help landowners evaluate their property for suitable habitat and potential presence of rare and endangered plants and animals. In the absence of a site visit, biologists can determine if rare and endangered plants and animals occur in the county or nearby areas.

Work with a wildlife professional to develop a land management plan. Qualified biologists can provide site-specific technical assistance regarding ways to manage forested habitat that meet landowner goals and maintain or improve habitat for wildlife. Wildlife professionals that specialize in private land conservation can help landowners secure cost-share funds to accomplish on-the-ground conservation projects. The Partners for Fish and Wildlife Program of the U.S. Fish and Wildlife Service and the Private Lands Division of the Missouri Department of Conservation

have biologists to assist landowners. Contact information can be found in the Resource Directory.

Appropriately apply pesticides. Some pesticides may harm endangered and threatened species. Pesticides should be applied according to label instructions in the appropriate quantity and location. Only pesticides approved for aquatic use should be applied in or near waterways and groundwater inputs. Special care, such as alternate methods of application, should be taken when applying herbicides in areas of known occurrence for rare plants. See Pesticide Use (Chapter 16).

Control non-native invasive species. Non-native invasive species upset the balance of a natural ecosystem. They can out-compete native species for food and space. Statewide control and eradication efforts are ongoing and are a coordinated effort between land management agencies and private landowners. Control and eradication on private land is essential to the success of these programs. See Forest Health (Chapter 9) and Best Management Practices to Slow the Spread of Invasive Species (Chapters 13, 14, 15, 16, and 17).

Follow BMPs for rare and endangered species and their habitats. A wildlife professional with specific knowledge of threatened and endangered species and their habitat requirements can make recommendations to landowners about the most appropriate set of best management practices for their property and project. Implementation of best management practices will allow landowners to achieve their management and production goals while protecting and conserving habitat for rare and endangered plants and animals.

Learn more about endangered species and their habitats. Information can be accessed online through the U.S. Fish and Wildlife Service's Endangered Species Program in the Upper Midwest or through the Missouri Department of Conservation's Help Endangered Wildlife or Endangered Species web pages. Refer to the additional resources at the end of the Chapter.

Speak with an endangered species specialist! Contact the U.S. Fish and Wildlife Service's Missouri Ecological Services Field Office or the Missouri Department of Conservation office in your area. Contact information can be found in the Resource Directory.

Potential Indicators of Species and Natural Communities of Conservation Concern

Before conducting forest management activities, conduct an on-site evaluation of the project area to see if there are any wetland features, geologic features, unique natural communities, imperiled wildlife and/or plant species (species of conservation concern), or important wildlife habitats that may need special care or protection during management actions.

During the on-site evaluation, look for:

- Landforms or other features of significant geologic interest that may require special management, such as unusual karst or geologic features including sinkholes, sinkhole ponds, caves, cliffs and escarpments, talus slopes, shut-ins, natural bridges, rock formations, and outcrops.
- Natural communities of conservation concern, natural areas, or unique natural communities. Natural communities may include glades, woodlands, forests, cliff and talus, creeks and streams, caves and karst features, springs, and wetlands.
- Species of conservation concern and types of wildlife or plants rarely seen.
- Aggregations or colonies of wildlife, which may include heron rookeries (large nests in the tops of trees, especially near water), bat colonies or suitable snag tree habitats, bee trees, mussel beds, beaver dens or lodges, etc.
- Very large trees or very old trees uncharacteristic of the regional timber quality, often referred to as old-growth stands. Look for open grown characteristics, a gnarled and twisted appearance, large buttresses, and complicated or expansive crowns.
- Wetland features should be carefully scouted for during on-site evaluations, being specifically observant for isolated wetlands, fens, seeps, springs, spring runs, and any areas where hydric soils indicate subsurface flow. Wetlands may be very small in size and isolated from streams and other water bodies.

References to Other Chapters

For the Protection of Rare and Endangered Terrestrial Species:

- BMPs for wildlife enhancement such as the retention of snags, dens, and super canopy trees, retaining leave trees, and maintaining habitat connectivity/continuity can help protect rare species and should be planned during management activities. See Chapters 2 and 15.
- Silvicultural practices such as even-aged and uneven-aged regeneration methods, prescribed fire, regeneration and tending methods applicable to woodlands, and low-intensity management for non-timber values can be used to promote and enhance rare species habitat. See Chapters 11 and 17 for more information.
- The regeneration of tree species is important to promote and improve specific wildlife habitat. See Chapter 12 for regeneration of common Missouri forest species.

For the Protection of Rare and Endangered Aquatic Species and Wetland Species:

- For information on the importance of forested watersheds and BMPs for protecting soil productivity and water quality see Chapters 5, 7, 13, 14, 15, and 17.
- For BMPs for roads in wetlands, wetland protection, streamside management zones, and stream crossings see Chapters 14 and 15.
- For guidance on the proper use of pesticides see Chapter 16.

Additional Resources

MDC BMPs for Indiana Bat and Gray Bat. Available at ***mdc.mo.gov/node/9491***.

MDC BMPs for Arkansas Darter, Niangua Darter, Ozark Cavefish, Topeka Shiner, and Neosho Madtom. Available at ***mdc.mo.gov/node/9569***.

MDC BMPs for Curtis Pearlymussel, Fat Pocketbook, Neosho Mucket, Pink Mucket, Sheepnose, Snuffbox, and Scaleshell. Available at ***mdc.mo.gov/node/9570***.

MDC resources on endangered species and species of conservation concern. Available at ***mdc.mo.gov/node/4067***.

MDC BMPs for Hellbender. Available at ***mdc.mo.gov/node/9492***.

MDC BMPs for Hines-Emerald dragonfly. Available at ***mdc.mo.gov/sites/default/files/resources/2010/08/9581_6519.pdf***.

The U.S. Fish and Wildlife Service's Endangered Species Program: ***fws.gov/endangered***

NatureServe: ***natureserve.org***

The Missouri Breeding Bird Atlas: ***extra.mdc.mo.gov/nathis/birds/birdatlas/index.htm***

Nelson, Paul W. 2010. *The Terrestrial Natural Communities of Missouri*, revised edition, second printing. Jefferson City, MO: The Missouri Natural Areas Committee. 550 p.

Pflieger, W.L. 1989. *Aquatic Community Classification System for Missouri*. Aquatic Series No. 19. Jefferson City, MO: Missouri Department of Conservation. 70 p.

CHAPTER 4
Visual Quality


KOPPADOL PAOTHONG

Topics Covered

- Value of Visual Quality
- Benefits of Visual Quality Management
- Visually Sensitive Areas
- The Value of Recognizing Sensitive Areas

NOPPADOL PAOTHONG

Figure 4.1. *Scenic landscapes are an important part of sustainably managing forests and need to be considered when conducting management activities.*

Value of Visual Quality

Missourians value their forest lands as places to live and work and to spend their vacation and recreation time. Amenities such as scenic beauty, peace and quiet, observation of forest wildlife, clean air, and clean water rank high among the benefits that people desire from forests. These lands also provide economic benefits related to birding, fishing, harvesting, hiking, hunting, and a variety of emotional, spiritual, and sensory experiences that make living in or visiting forests deeply personal.

Missouri forests are vitally important to the health of two industries: tourism and forest products. While many of the demands from these two industries are compatible and complementary, concern about the specific impact of various forest management practices on visual quality warrant the use of guidelines that can help mitigate these issues. Generally the guidelines address roads; however, management activities near rivers, lakes, and hiking trails are also addressed and are important aspects of presenting a high-quality visual experience.

More than 80 percent (12.7 million) of Missouri's approximately 15.5 million forested acres are privately owned, mostly by individuals and farmers. Private forest owners are a key to providing visually appealing landscapes. Consistent themes foresters experience when working with landowners are respect for the land and concern for its appearance during and following harvesting and other forestry practices. There are many techniques that can be applied to enhance visual quality.

Benefits of Visual Quality Management

Visual quality is one important aspect of the broad, multifaceted concept of integrated forest resource management. When visual quality management is implemented, it can:

- Provide for a thriving tourism industry.
- Encourage public acceptance of forest management and timber harvesting for a healthy forest products industry.
- Provide for a better public understanding of forestry practices resulting in healthy forests.
- Minimize the visual and audible impacts of forest management activities on residents, tourists, and recreational users.
- Minimize visibility of harvested areas.
- Minimize the impact of logging slash.
- Minimize the impact of landing operations.
- Minimize visual contrast created by snags and broken or leaning trees.
- Reduce the impacts associated with the construction and use of forest roads.
- Enhance the appearance of timber stand improvement activities.
- Reduce the impacts of dead or dying vegetation resulting from prescribed fire or herbicide use.

CLIFF WHITE

Figure 4.2. *Hiking trails are one example of visually sensitive areas.*

Visually Sensitive Areas

Visually sensitive areas range from large-scale vistas to a localized rural residences. Overlooks, scenic highways, residential areas, traditional hunting camps, hiking trails, bluffs and hills facing rivers and lakes, roads to river accesses, lands designated as national and state parks, natural areas, and wilderness areas all represent places where forest management activities should consider the visual impacts that may be created. On privately owned forests, the owners may designate visually sensitive areas that meet their objectives, for example, along the primary access to their property.

Sensitive areas are typically frequented by people having an expectation that the forest is healthy and an attractive place to visit. They may be in that locale solely to observe the color of spring or fall foliage or to view other amenities.

Visually sensitive areas may benefit from forest management practices such as prescribed fire, harvest, and tree planting to enhance native vegetation and animal communities. In these areas the visual quality guidelines can be followed to help provide a satisfying environment for people using the forest.

DAVID STONNER

Figure 4.3. *A scenic rural road*

Some examples of recommended practices include:

- Using slashing techniques or firewood harvest to remove or reduce logging debris height
- Retaining or planting trees or shrubs with showy flowers or good fall color (see below)
- Discussing proposed management activities with neighbors and other interest groups
- Cutting stumps low during timber stand improvement activities to reduce the visual impact
- Modifying timber stand improvement practices along ridge tops and valley floors, where hunters normally walk, by girdling or using stem-applied herbicide treatments
- Retaining trees within regeneration areas

Chapters 12–18 give specific guidelines for reducing the negative visual impacts related to each management activity.

When deciding how to modify a management activity in order to mitigate visual impacts, it is useful to consider the length of time that various activities remain visible. Table 4.1 below outlines how long it takes for a forest area to return to its pre-treatment visual condition following the implementation of different practices.

Table 4.1

Practice	1 year	Up to 5 years	6–10 years	11–20 years	21+ years
Tops to decay — with treatment		X			
Tops to decay — no treatment			X		
Timber Stand Improvement (TSI), intermediate harvest or uneven-aged harvest			X		
Shelterwood harvest				X	
Regeneration harvest					X
Stumps <4" diameter		X			
4–10" diameter				X	
>10" diameter					X
Herbicide treatment	X				

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Figure 4.4. *This photo sequence shows a tree top decaying over a 10 year period.*

Trees and Shrubs that Enhance Visual Quality

Colorful Native Flowering Trees and Shrubs

Ohio buckeye (*Aesculus glabra*)
Serviceberry (*Amelanchier arborea*)
Catalpa (*Catalpa speciosa*)
Eastern redbud (*Cercis canadensis*)
Fringe tree (*Chionanthus virginicus*)
Flowering dogwood (*Cornus florida*)
Hawthorn (*Crataegus* spp.)
Honey locust (*Gleditsia triacanthos*)
Kentucky coffee tree (*Gymnocladus dioica*)
Yellow poplar (*Liriodendron tulipifera*)
Wild plum (*Prunus americana*)
Black cherry (*Prunus serotina*)
Chokecherry (*Prunus virginiana*)
Sassafras (*Sassafras albidum*)
American basswood (*Tilia americana*)

Good Fall Color Native Trees and Shrubs

Red maple (*Acer rubrum*)
Sugar maple (*Acer saccharum*)
Pignut (*Carya glabra*)
Shellbark hickory (*Carya laciniosa*)
Shagbark hickory (*Carya ovata*)
Mockernut (*Carya tomentosa*)
Flowering dogwood (*Cornus florida*)
White ash (*Fraxinus americana*)
Sweet gum (*Liquidambar styraciflua*)
Yellow poplar (*Liriodendron tulipifera*)
Black gum (*Nyssa sylvatica*)
Black cherry (*Prunus serotina*)
Swamp white oak (*Quercus bicolor*)
White oak (*Quercus alba*)
Scarlet oak (*Quercus coccinea*)
Northern pin oak (*Quercus ellipsoidalis*)
Shingle oak (*Quercus imbricaria*)
Overcup oak (*Quercus lyrata*)
Swamp chestnut oak (*Quercus michauxii*)
Pin oak (*Quercus palustris*)
Red oak (*Quercus rubra*)
Shumard oak (*Quercus shumardii*)
Post oak (*Quercus stellata*)
Black oak (*Quercus velutina*)
Sassafras (*Sassafras albidum*)
Bald cypress (*Taxodium distichum*)

DAVID STONNER

Figure 4.5. *Managing for a variety of tree species can help enhance visual quality.*

The Value of Recognizing Sensitive Areas

Recognizing visually sensitive areas helps the landowner, forest manager, and logger choose the visual quality guidelines that help meet the objectives and expectations of the owner, forest manager, or area user.

Timber sale contracts should reflect which visual quality guidelines will be used, their location, and how they will be implemented. It is important to understand that when implementing visual quality guidelines there will be associated costs that could be reflected in lower stumpage paid to the landowner and higher contracting costs to perform management activities, such as Timber Stand Improvement (TSI) or prescribed burning.

Some examples of increased costs for visual quality guidelines include:

- Time and labor to reduce the height of logging slash
- Placing gravel on logging roads
- Maintaining a scenic vista along a heavily traveled highway
- Time spent explaining visual quality goals to logging crews
- Signage and outreach to communicate forest health needs to area users

Managing Missouri's forests for visual quality involves an integrated effort by forest owners, public land managers, leaders in the wood products and tourism industries, and forest users.

NOPPADOL PAOTHONG

Figure 4.6. *On the right side of the photo, a timber harvest recently occurred; several visual quality best management practices were applied to reduce the visual impact.*

References to Other Chapters

- For best management practices for protecting visual quality during management activities see Chapters 12, 13, 14, 15, 16, 17, and 18.

Additional Resources

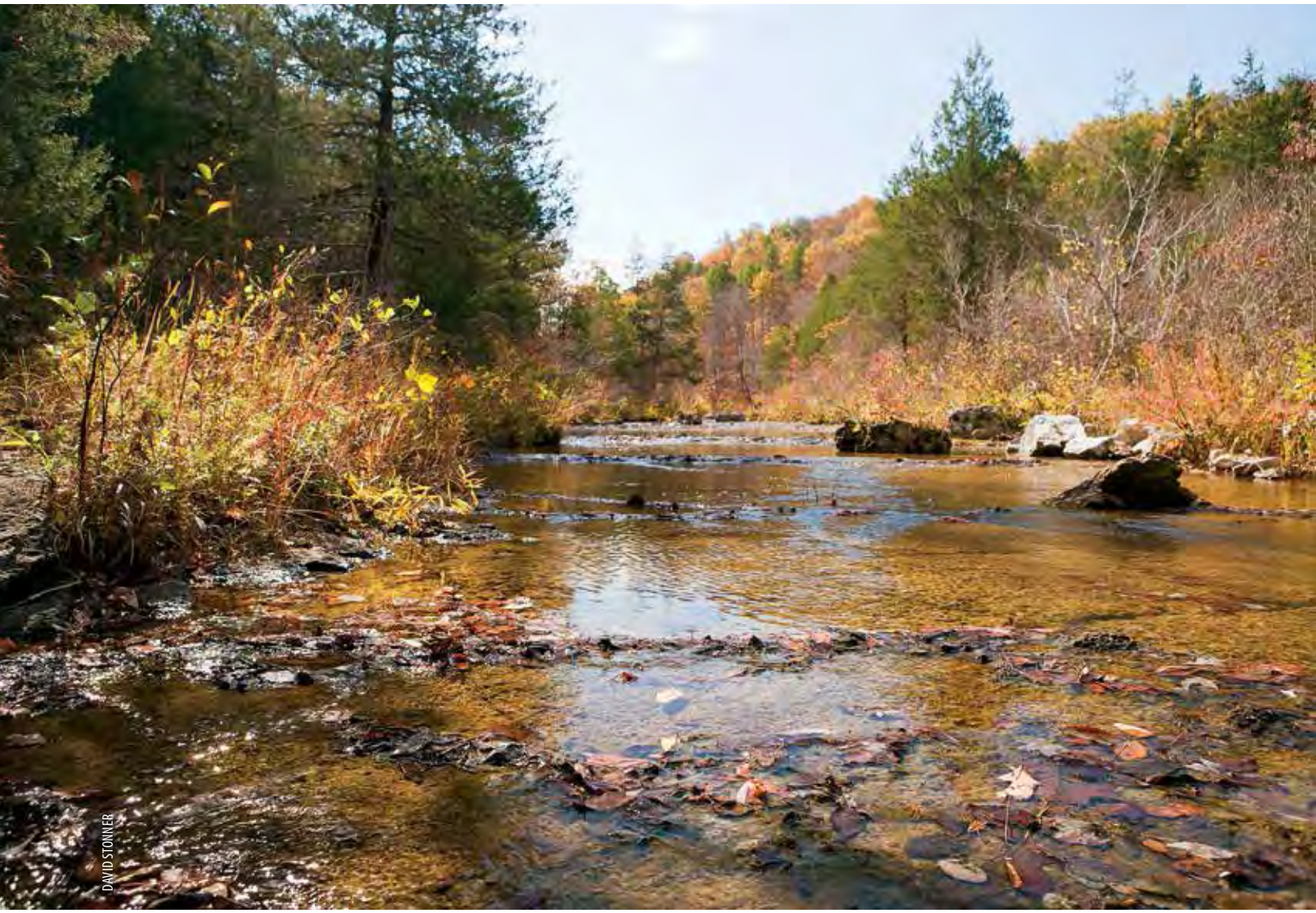
Jones, Geoffrey T. *A Guide to Logging Aesthetics: Practical Tips for Loggers, Foresters and Landowners*. Northeast Forest Resources Council Series. 1993.

Missouri Department of Conservation. *Forest Management for Missouri Landowners,* revised edition. Missouri Department of Conservation. 2007. Available at ***mdc.mo.gov/node/5574***.

Missouri Department of Conservation. *Missouri Woody Biomass Harvesting Best Management Practices Manual*. Missouri Department of Conservation. 2009. Available at ***mdc.mo.gov/node/9806***.

CHAPTER 5

Forested Watersheds



DAVID STONNER

Topics Covered

- Watersheds
- Stream Channel Connectivity
- Stream Channel Identification
- Streamside Management Zones
- Floodplains
- Riparian Forest
- Wetlands
- Forested Wetlands

Missouri is a stream state. More than 110,000 miles of streams drain our diverse landscape. The characteristics of these streams are the product of the land surrounding them. Watersheds, which consist of uplands, floodplains, stream channels, springs, and wetlands, all interact to affect the quality of stream habitat and adjacent terrestrial communities. Natural characteristics of a watershed define the properties of a healthy stream. Unobstructed floodplains provide areas into which floodwaters may enter and reduce the erosive pressures on the rest of the stream system. Densely vegetated stream corridors contribute a multitude of direct benefits to the stream channel; they buffer surrounding lands from the effects of floods and provide wildlife habitat. Stable channels balance the force of flowing water with the surrounding physical and vegetative conditions. All these parts must be in balance for a healthy, stable hydrologic and biological system to operate.

Watersheds

For these guidelines, a "watershed" is defined as the total land area that contributes runoff to a body of water. This includes surface runoff and groundwater discharge. Watersheds can vary from a few acres to thousands of square miles.

Watershed conditions influence stream hydrology, groundwater recharge, and the quantity and quality of the water. Healthy watersheds trap pollutants, soil particles, and excess runoff. Excessive watershed runoff increases water quantity, reduces water quality, contributes to an increase in stream channel size, and delivers excess sediment to the stream, generally resulting in stream-bank erosion and filling of the stream channel. Intact watersheds also provide high-quality terrestrial habitat and foraging areas for migratory and resident wildlife and high plant diversity of both woody and herbaceous species.

Stream Channel Connectivity

Streams do not function in isolation from adjacent terrestrial landscapes; rather, the stream is connected to them and is determined by them. Stream channels are a product of the energy of flowing water (from the slope of the channel), sediment (from the watershed), and water quantity (from climate-watershed interactions). Altering these factors through upland, floodplain, streamside corridor, or channel activities can cause a stream to adjust to form a new balance between energy, sediment, and water quantity. For example, timber harvesting and forest road construction activities conducted without the use of Water Quality Best Management Practices (BMPs) can result in roads and skid trails that funnel water moving at a high rate of speed, which has energy to erode sediment from the landscape and deposit it directly into the stream. This can result in water quality problems as well as negative environmental and biological impacts.

Conversely, using BMPs ensures that barriers to water movement such as waterbars, turnouts, and revegetation slow the movement of runoff water to streams from forest management activities, such as roads and skid trails, allowing sediment to be deposited before reaching the water so that streams will remain healthy and intact. Restoring historically forested communities can also benefit stream channels by decreasing erosion and sedimentation. As streams maintain a balance between the water and sediment coming into them, it is natural for them (as well as beneficial to fish and wildlife habitat) to meander and adjust in size and shape. Straightening or locking a stream in a fixed position by channelization or other means can cause a variety of problems, which can then extend well beyond the project site. These activities require permits from the U.S. Army Corps of Engineers.

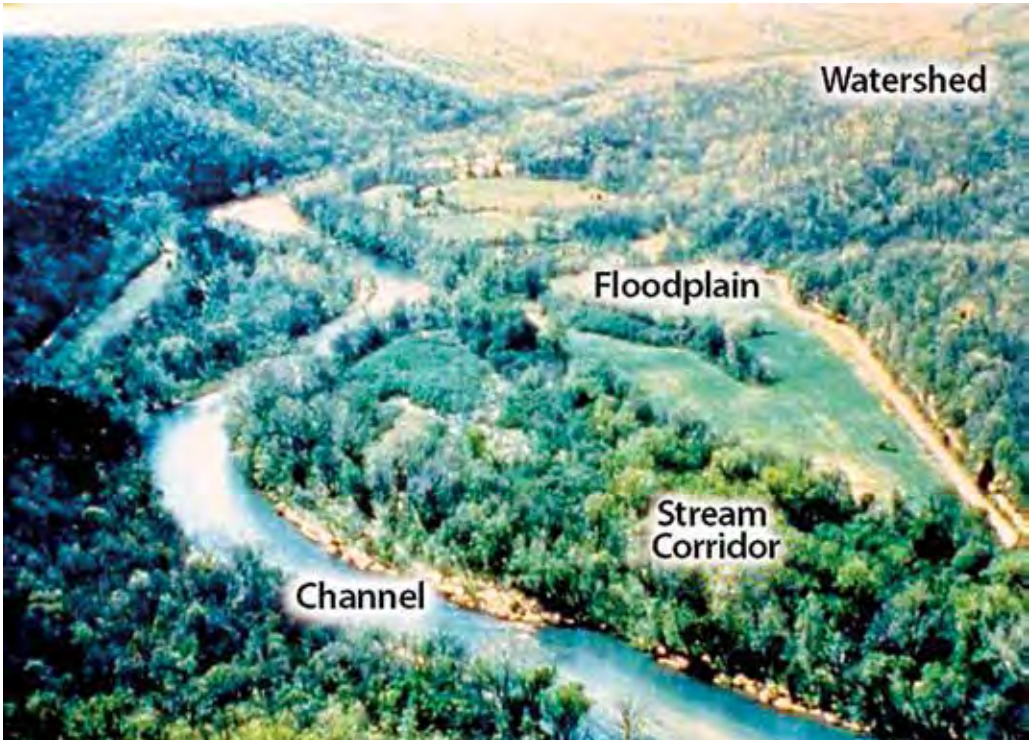


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Figure 5.1. *Streams are connected to the adjacent landscape.*

Stream Channel Identification

The active channel and adjacent high-flow channels convey all non-flood stream flows and a portion of flow during flood events. The stream channel consists of the area between both banks (Figure 5.2). Stream types are often classified by their flow, which is determined by their groundwater connection (Figure 5.3):

- **Perennial streams** flow year-round and have well-defined banks and natural channels; the water table is above the streambed.
- **Intermittent streams** only flow during wet seasons but still have well-defined banks and natural channels. They may contain seasonal pools during dry periods; the water table is above the streambed at certain times but not always.
- **Ephemeral streams**, or storm-water courses, only flow with runoff from rain or snowmelt. The water table never reaches the streambed of these streams. Because they are typically in the uplands, they can have steep slopes and therefore have the potential to carry high sediment loads during runoff events to the larger stream channels.

Identifying the type of stream is important to determine the level of protection needed. Specific information regarding how to protect different classifications of streams is located in Chapters 14 and 15. Forest owners will usually be familiar enough with a stream's flow patterns to identify the stream. If forest owners are uncertain as to which type of stream they have, they should consult a professional forester or other qualified natural resource professional. Always use the most protective measures when unsure.

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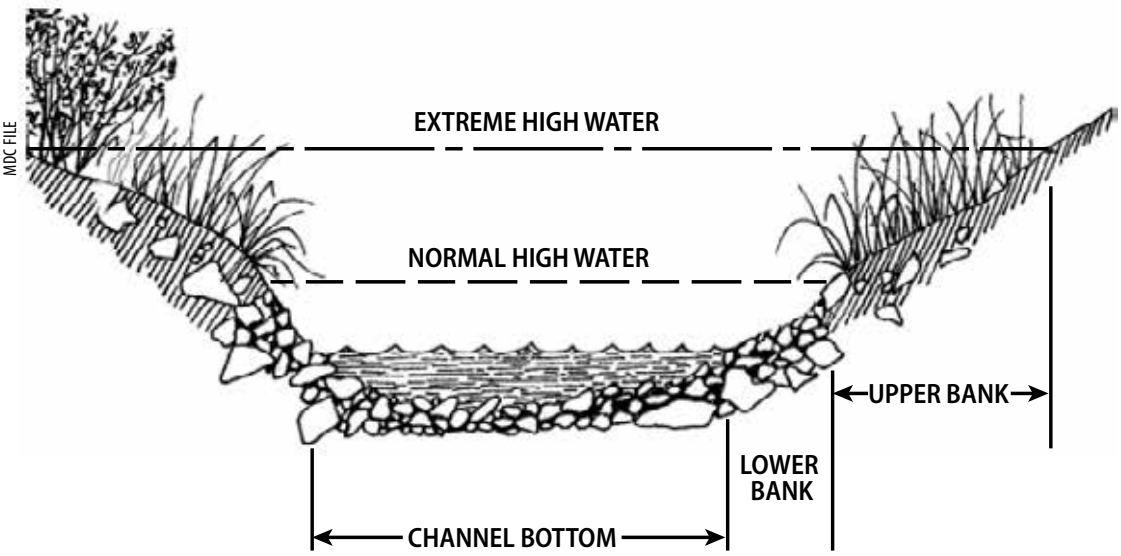
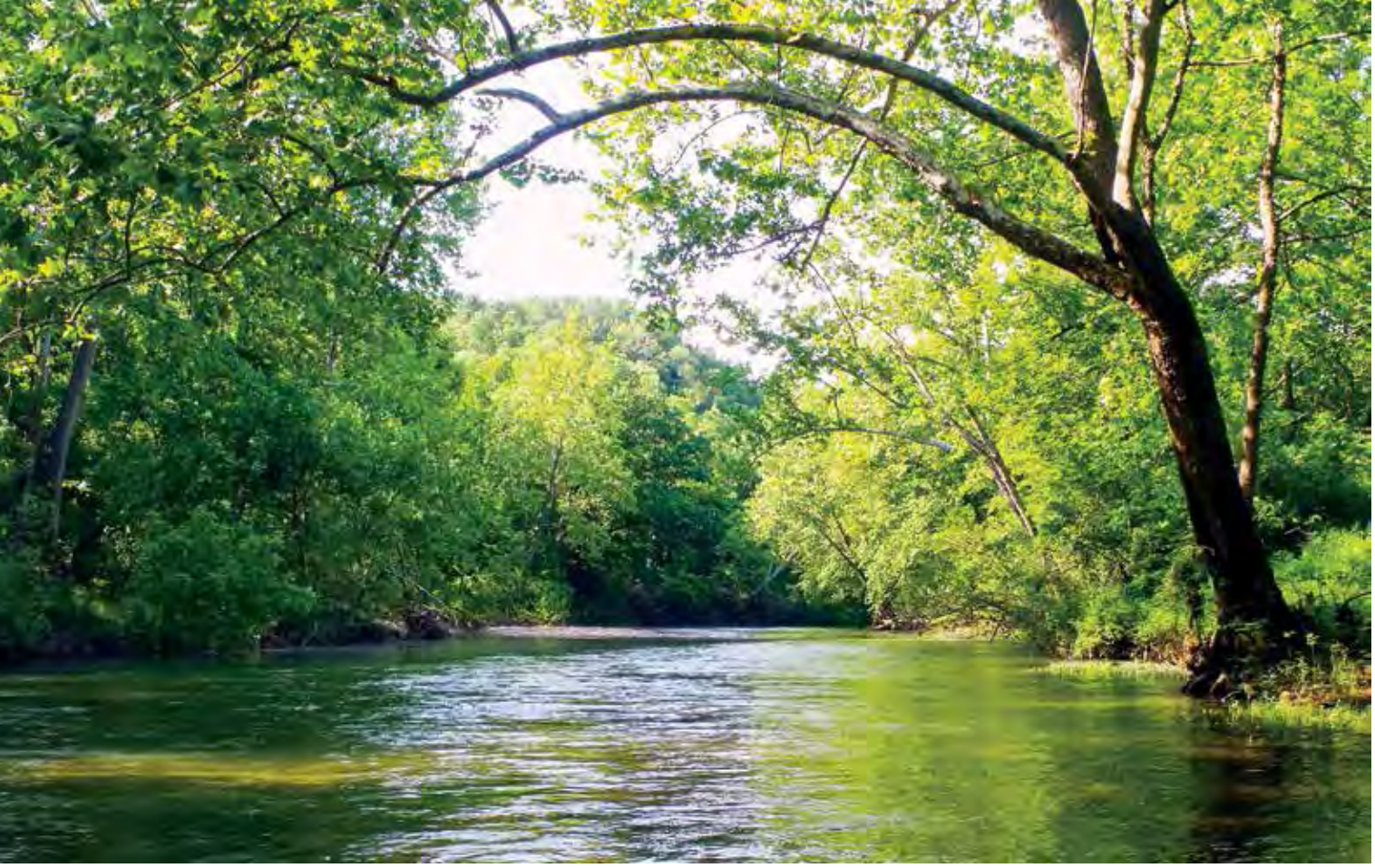


Figure 5.2. *Stream channel diagram*

COURTESY OF THE SOUTH CAROLINA BEST MANAGEMENT PRACTICES BOOKLET

Figure 5.3. *Stream type identification.* ***Note:*** *This does not necessarily represent typical forest management activities in Missouri.*



HANK DORST, MARK TWAIN FOREST WATCHERS

Figure 5.4. *Streamside management zones help protect stream health and water quality.*

Streamside Management Zones

Streamside Management Zones (SMZs) or Riparian Management Zones (RMZs) are areas along streams and rivers that are important in maintaining water quality. Both the trees and other vegetation within the SMZ work together to benefit the stream and, in turn, the entire watershed. Trees in riparian areas that eventually become decadent and fall out of the canopy can also provide important in-stream habitat. Streamside Management Zones require special treatment when harvesting forest products and conducting other forest management activities to ensure that they continue to provide these important functions. Specific information on how and when to apply SMZs is found in Chapter 15.

SMZs have several major functions:

1. Slowing floodwater
2. Filtering and trapping sediment
3. Providing shade to cool stream temperature
4. Helping to create rich bottomland soil

Floodplains

A floodplain is the relatively flat land surface adjacent to a stream channel that is formed by erosion and sediment deposition during floods. Floodplains can be inundated annually or during large, less frequent flood events and comprise the above-bank area where floodwater enters during high flows. Thus, floodplains are characterized by soils and vegetation that developed under the influence of flooding. They can be identified by characteristic soils, landforms, vegetation, and on topographic maps.

Floodplains have several major functions:

1. The floodplain allows for the transport and temporary storage of water during flood events. This reduces the velocity and erosive capability of floodwaters and reduces the impacts of flood events on downstream areas. Floodplain vegetation can also help reduce the velocity of floodwater.
2. Floodplain vegetation filters and traps sediments and nutrients during storm events that would otherwise reach the stream and cause deposition, streambed siltation, and nonpoint source pollution problems.

3. Rainwater is retained in floodplains, and a portion of the water percolates into the ground. Depending on soils and local geology, this groundwater can augment base flows during drier periods.

4. Floodplains on large river systems are critical for some fish, for spawning and nursery habitat when inundated with floodwaters.

5. Floodplains contain wetland habitats that are heavily used by a number of animals, including fish and other aquatic life, waterfowl, shorebirds, reptiles, amphibians, and aquatic mammals.

6. Floodplains provide terrestrial habitat for migratory and resident wildlife with native vegetation, high plant diversity including both woody and herbaceous species, and an abundance of snag and cavity trees. They also provide corridors for wildlife movement and dispersal of plant species and are critical habitat for many Missouri species of conservation concern.

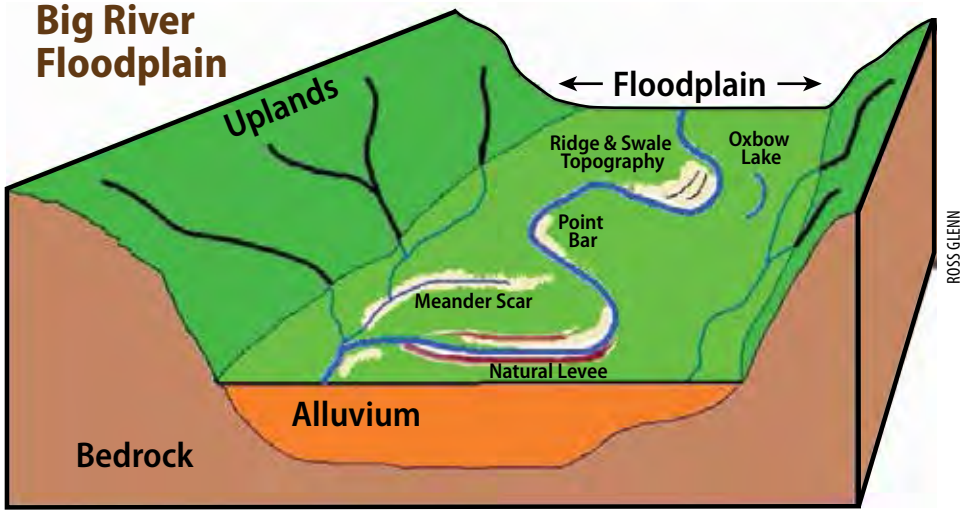


Figure 5.5. *Diagram depicting big river floodplains*

Historically, floodplain wetland communities were dynamic. Floods and natural stream meanders created new wetlands that gradually converted to terrestrial communities. Many larger river systems have been highly altered. Some of these changes have been natural, although most of these changes have been man-made for improved drainage and flood control, and to provide for river navigation. Over time this has resulted in long-term changes in bottomland forests and vegetation. Today's floodplain forests are much more fragmented or in some cases nonexistent due to clearing for agriculture and urbanization. Due to changes in the hydrology, the compositions of many of these forests have also changed to more flood-tolerant species or have issues with regeneration of desirable species. Many of these floodplains have reduced function, although they still provide some of the benefits of the large historic wetland.

Riparian Forest

Riparian forests are highly variable and can be located in large floodplains along major river systems or along narrow upland streams. The riparian forest significantly influences, and is significantly influenced by, the neighboring body of water. Of Missouri's 3.2 million acres of potential riparian forest buffer, approximately 1.8 million acres (55 percent) are currently forested. Reforesting much of the currently unforested riparian areas would significantly benefit soil and water resources.

Note: Although some Missouri streams were historically prairie streams and are best suited for prairie cover, a significant majority of stream riparian zones, including some in prairies, are best suited for forest or other woody vegetative cover.

Riparian forests have several major functions:

1. Riparian forests help armor stream banks with their root systems to keep them from eroding.

2. They provide roughness to the landscape, which slows down floodwaters from overland entering the stream and from the channel entering the floodplain; this allows them to capture sediment on the land and not in the stream channel and reduces water velocity, helping to control stream erosion.

3. They increase water infiltration rates into the ground, reducing runoff and increasing groundwater storage.

4. They filter pesticides, nutrients, and sediments before they can reach the stream.

5. They provide shade, which is important for maintaining water temperatures conducive to healthy aquatic ecosystem functioning.

6. Vegetation from riparian forests helps provide the food base and habitat needed by many aquatic organisms.

7. Riparian forests also provide important wildlife travel corridors and can be highly productive for forest products.

Wetlands

Wetlands can be found anywhere on the landscape, but generally in Missouri they are associated with floodplains or perennial streams. They are less frequently found in uplands in the form of fens or seeps or in depressions like sinkhole ponds. Depth, timing, and duration of water influences soil development and the type of plant and animal communities that inhabit wetlands.

Forested Wetlands

Forested wetlands in Missouri are dominated by deciduous trees and include swamps and wetland forests. Swamps are inundated for long durations and are rarely dry. Wetness duration in forested wetlands ranges from short-duration flooding (lasting a few days) to long-term seasonal saturation (lasting as long as three months). Seasonally, wetlands that are forested may appear to be fairly dry.

Throughout the 19th and 20th centuries, most of Missouri's historically forested wetlands were drained and converted to agriculture. A prime example is Missouri's Bootheel, which was historically dominated by forested wetlands and is now dominated by agriculture. Although most of Missouri's forested wetlands have been lost, the state still has some quality representatives of this forest type as well as many areas that have good restoration potential.

Forest wetlands have several major functions:

1. Many animals live in or use wetlands for food, nest sites, and cover. Many plants, animals, and wetland communities themselves are listed in the *Missouri Species and Communities of Conservation Concern Checklist*.

2. Wetlands also help moderate stream flow and minimize flooding potential by storing runoff from heavy rains or snowmelt and reducing flood peaks.

3. Forested wetlands filter out sediments, nutrients, fertilizers, and pesticides from within the watershed.

4. Some wetlands use surface water to recharge groundwater supplies. Other wetlands discharge groundwater to the surface, an important wetland function that helps to stabilize stream flows, especially during dry months.

Forest management activities in a wetland can be challenging. Wetland soils generally have low weight-bearing capacity, making them more susceptible to rutting and compaction compared to upland soils. In addition, it is common for water to be moving through the soil near the surface. The wetland BMPs are designed to prevent erosion, to minimize changes to the surface and below-surface water movement, and to strengthen or increase the weight-bearing capacity of the soil. Changes like rutting can interfere with water movement and result in vegetation changes and reduced wetland function, which can affect the health of the wetland ecosystem and the functions it performs. For specific information on best management practices for forest wetlands, refer to Chapter 15.

MICHAEL BILL

Figure 5.6. *Riparian forest along the Current River in Shannon County*

Wetland Identification and Regulation

Jurisdictional Wetlands

The U.S. Army Corps of Engineers, in Section 404 of the Clean Water Act, defines jurisdictional wetlands as "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." A jurisdictional wetland must exhibit all three characteristics: hydrology, hydrophytes, and hydric soils (US ACOE 1987).

The U.S. Fish and Wildlife Service National Wetland Inventory uses the Cowardin classification system. Cowardin defines wetlands as "transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water." Cowardin requires the presence of only one or more of the three wetland attributes required by the regulatory definition. Areas that function as wetlands ecologically may perform valuable functions but are not regulated by the Clean Water Act.

Forested areas within Missouri's watersheds provide many valuable resources and support a variety of activities.

NOPPADOL PAOTHONG

Figure 5.7. *Forest wetlands such as this cypress swamp require special protection.*

Landowners, resource managers, loggers, and contractors attempt to balance a variety of objectives when planning and conducting forest management activities. These activities include the production of timber, the support of recreational uses, the enhancement of scenic beauty, the improvement of wildlife habitat, and the protection of forest ecosystems.

Missouri's BMPs provide recommendations designed to protect both the forest and the hydrologic systems in Missouri's watersheds. Careful planning for forest management activities will lead to harvest operations that use BMPs, remove forest products efficiently and profitably, and promote sustainable forest growth.

References to Other Chapters

- For best management practices for protecting water quality and aquatic habitat during management activities see Chapters 13, 14, 15, 16, 17, and 18.

Additional Resources

Watershed and Stream Management Guidelines for Lands and Waters Managed by Missouri Department of Conservation. 2009.

Missouri Watershed Protection Practice: 2006 Management Guidelines for Maintaining Forested Watersheds to Protect Streams. Missouri Department of Conservation. 2006. Available at ***mdc.mo.gov/node/9331***.

CHAPTER 6

Cultural Resources

DAVID STONNER

Topics Covered

- What Are Cultural Resources?
- Examples of Cultural Resources
- The Value of Cultural Resources
- Cultural Resource Management (CRM) and the Law
- Potential Impacts to Cultural Resources
- Field Identification of Cultural Resources
  - Identification as a Low-Sensitivity Site
  - Identification as a High-Sensitivity Site
- Evaluation and Documentation
- When Accidental Discovery Occurs

MICHAEL BILL

Figure 6.1. *Cultural resources, like this family cemetery, require special protection.*

What Are Cultural Resources?

Cultural resources provide records of history and are important evidence that tell the story of the past. In the following guidelines, "cultural resource" means any site, building, structure, object, or area that has value in American history, archaeology, architecture, engineering, or culture. A cultural resource may be the archaeological remains of a 2,000-year-old Native American village, a pioneer homestead, or an old family cemetery. It may be of value to the nation or the state as a whole or important only to the local community. In order to be considered important, generally a cultural resource has to be at least 50 years old.

The people of Missouri are heirs to a unique legacy of cultural resources, many of which occur within the state's public and private forest lands. Generally, these cultural resources fall into five broad categories: historic structures, archaeological sites, cemeteries, traditional use areas, and historic areas.

Almost all Native American sites in Missouri predate 1800. While these sites are not common, tribes living in or passing through the state included the Osage, Iowa, Delaware, Shawnee, Kickapoo, Sac, Fox, and Cherokee.

Starting from the first European exploration of this territory in 1673 AD to the Civil War, Missouri's archaeological sites consist mostly of early trading centers, military occupations, river settlements, and rural farmsteads often associated with major rivers like the Mississippi. Mineral exploration by early prospectors looking to extract silver, lead, and gold also occurred in Missouri. Euro-American and African-American sites primarily originated after 1800 and are dated by coins, tombstone inscriptions, or maker marks on bottles. After the Civil War, historic sites reflect an increase in rural populations and farming activities.

In the forest-dominated portions of Missouri, primarily the Ozarks and the southeast lowlands, the timber industry significantly shaped the landscape, leaving numerous potential cultural resource sites. These include logging camps, narrow gauge railroad beds, and large sawmill sites. Large blocks of standing virgin timber were exploited, and afterward lands were sold to settlers and speculators for farming.

Examples of Cultural Resources

Examples of cultural resources include but are not limited to historic structures, unique examples of architectural style, railroad beds associated with early logging, pottery shards or arrow heads, middens and cache pits from Native American villages, and cemeteries. Vegetation or plantings of historic significance as well as old foundations from early settlements can also be cultural resources. For a listing of common cultural resource types, see Appendix B.

The Value of Cultural Resources

As scarce and nonrenewable parts of the environment, cultural resources by their very nature provide physical links to the past, along with a sense of national community and personal identity. Historic structures, historic areas, traditional use areas, and other aboveground cultural resources provide environmental diversity, while some structures and artifacts have intrinsic value as works of art. Perhaps most important, the conservation of cultural resources contributes to an understanding of history, fosters an appreciation for heritage, and stimulates learning at all education levels. Resources that connect the present with the past fulfill important nostalgic and spiritual instincts shared by large segments of modern society.

The premise that cultural resources have value and should be wisely managed is the underlying reason for including cultural resource management (CRM) as part of forest management. Cultural resources represent parts of an inheritance shared by all people. This heritage is of fundamental value to modern-day societies and is truly a gift from the past. Cultural resources are valued in a variety of ways. They often possess spiritual, scientific, and other values that are weighed differently by different cultures. The benefits of CRM are both tangible and intangible.

Today, CRM is increasingly seen as a necessary component of land stewardship. Forest managers and landowners should use CRM as a tool to minimize conflict between stewardship and economics and should treat cultural resources as assets rather than liabilities. While the intangible benefits of cultural resource management cannot always be easily defined, they are nevertheless important.

Cultural Resource Management (CRM) and the Law

Although these guidelines are designed to be voluntary, forest managers need to have an awareness of the nonvoluntary, regulatory side of CRM. Cultural resource laws in general are intended to ensure that significant resources will be taken into consideration when activities are planned that might damage their scientific or cultural values. Virtually all environmental legislation currently on the books includes protections for significant cultural resources as identified under the National Historic Preservation Act of 1966 (NHPA).

Administration and enforcement of environmental protection laws vary, but forest managers would do well to assume that whenever a government permit or license is required, some kind of CRM review and compliance may also be required. Federal and state laws, for example, require public land forest managers to consider the effects of their projects on cultural resources.

The legal basis for CRM is rooted in federal and state legislation concerned with natural resource conservation and environmental protection. The NHPA is the centerpiece of the national historic preservation program and has become an important component of state and local CRM programs in Missouri. The NHPA establishes the National Register of Historic Places and provides for state and tribal historic preservation officers to implement the national preservation program.

Section 106 of the NHPA requires that federal agencies consider the effects of their activities on cultural resources. NHPA Section 106 applies anytime there is an "undertaking" with federal involvement and an action that affects historic properties. How the statutory protection of cultural resources laws apply is determined by three factors: landownership, the source of funding being used for the activity, and any licensing or permitting authority that might be involved. Federal law applies whenever activity will take place on federal land, will use federal funds, or will require a permit or license issued pursuant to federal authority (an "undertaking").

When a cultural resource eligible for inclusion on the National Register is present, it should not be destroyed or damaged by forest management activities. On public land, public funds may be used to recover important historical, archaeological, or cultural data that would otherwise be lost.

Activities on private land may not be mandated by the NHPA if there is no federal undertaking; however, state law/regulations may still apply. Human burial sites are given special consideration under both federal and state law, requiring that all human burial sites in the state be protected from disturbance, regardless of age, ethnic affiliation, or landownership. Burial sites are a special category of cultural resources. Under sections of the Missouri Revised Statutes 194 and 214, all human burial sites are afforded the same legal protection as platted cemeteries, regardless of landownership. Similar protection applies to burial sites on lands under federal control. Many graves in pioneer cemeteries do not have markers, making identification and protection more difficult.

Potential Impacts to Cultural Resources

In general, cultural resources are fragile. Threats range from natural forces (erosion, flooding, weathering, and fire) to human action (logging, agriculture, mining, land development, and vandalism). Unlike wetlands and forest habitats, once lost, cultural resources cannot be mitigated or restored. Lack of awareness of the existence of a cultural resource is the main cause of damage. Use of these guidelines will encourage implementation of practices that will minimize unintentional damage to cultural resources.

BILL GOODWIN

MDC FILE

MDC FILE

MICHAEL BILL

Figure 6.5. (top) *Barns may be an example of a historic structure.* ***Figure 6.6. (bottom)*** *Stone fire place at an old home site*

MDC FILE

Figure 6.2. (top) *Burial mounds on public land in Missouri;* ***Figure 6.3. (middle)*** *Caves often were used for dwellings or temporary shelters by prehistoric and modern peoples. In addition to being important sites for cultural resources, caves often provide shelter to federally threatened and endangered species such as Gray and Indiana bats.;* ***Figure 6.4. (bottom)*** *Stone well cover and household debris on old building site*

Field Identification of Cultural Resources

It is important to assess project sites for cultural resource potential. Identification of cultural resources is fundamental for protection of those resources. The first step in cultural resource management (CRM) planning is to check existing cultural resource inventories to determine whether any important cultural resources are known to be present within a given area. Follow the check of existing inventories with a walkover examination. (See Appendix B: Best Management Practices for Common Cultural Resources.) In particular, landowners and forest managers are encouraged to check for recorded burial sites in management areas.

Identify resources, features, and site conditions that may require special attention, such as family cemeteries, Native American campsites, sawmill sites, and pioneer cabin sites. While other inventories exist (such as those maintained by

local units of government and county historical societies), the cultural resources inventories available through the State Historic Preservation Office (SHPO) are the most comprehensive databases, and professional staff can provide assistance. Most of the statewide cultural resource inventories maintain "hard copy" site maps that show specific cultural resource locations, as well as areas that have been surveyed for cultural resources. A formal written request is not necessary. Requests may be made by phone, and requested information is most often available within a few days.

A visual examination during a walk-over inspection of the management area may reveal unrecorded cultural resources. If possible, a visit during winter or fall when leaves are off trees enables a better evaluation. Forest managers, landowners, and others following these guidelines can undertake a preliminary assessment of a site's cultural resource potential. A walk-over inspection can be done at the same time as other field activities, such as timber inventory or timber sale preparation. Background information gathered during the cultural resource assessment process may provide some clues as to what kinds of cultural resources might be present and where to look for them. Consider doing additional research on the history of the project area, especially if existing cultural resource inventories contain no information about the area. Such research efforts may include checking existing maps, aerial photos, and printed historical information as well as contacting individuals who are knowledgeable about local history or archaeology.

Certain landforms were naturally attractive to Native Americans and early European settlers. Elevated, well-drained sites with easy access to water sources such as a springs or perennial streams were historically used by Native Americans and early settlers as dwelling sites. Good places to camp for Native Americans and early settlers included islands and river overlooks. Landforms such as elevated natural levees adjacent to major streams that rarely flood were attractive to early inhabitants. Caves or rock overhangs were preferred shelters and are good sites for potential cultural resources.

Other potential cultural sites include abandoned river channels (oxbows and sloughs) and sites at the mouths of streams, stream inlets, and any elevated solid dry land around large wetlands like marshes or swamps. Good fishing spots like traditional fish spawning beds, rock riffles where walleye spawn, deep pools where paddlefish congregate during spawn, or other fish gathering pools attracted Native Americans and early settlers alike.

Good indicators of potential cultural resources can be landscape anomalies such as clearings in the woods, objects in or attached to trees, and blazed trees. Areas near community centers such as towns and villages, especially in combination with old transportation routes like old trails, roads, and railroad beds, may have cultural significance or may harbor artifacts. (Many modern roads follow old trails and wagon roads.)

The presence of old farmsteads often is indicated by isolated stands of trees in an otherwise open landscape. The presence of domesticated plant species such as silver poplar or lilacs, fruit trees, irises, or daffodils often indicates homesteads or cemeteries. Trash dumps containing antique items or fence materials (wood posts, metal posts, wire) and tin cans may indicate a potentially significant cultural resources site.

The presence of any "surface" artifacts (anything man-made) such as arrowheads, broken clay pottery, and stone tools, as well as manufactured items, is a good indicator of cultural resources. Look for relics like foundation stones, rock- or brick-lined cisterns, depressions that may have been icehouse pits, wells, or storm shelters.

For standing structures and buildings, ask yourself: How old is it? Who owned it? Who designed it? What condition is it in? Is it associated with an important person or event? Is it an unusual architectural style? How much has it been altered from the original?

Identification as a Low-Sensitivity Site

More often than not, significant cultural resources will not be present on a work site. If no cultural resources have been recorded and the pre-field review and walk-over inspection yielded no indications of important cultural resources, the site likely has low sensitivity, which means there are no important cultural resources located there. You may proceed with the management activity without further review.

Identification as a High-Sensitivity Site

If cultural resources are known to exist, or if the pre-field review and walk-over inspection indicate their presence, the site has high sensitivity. In this case, the forest manager has several alternatives to consider, of which the following are recommended in order of preference. Private land compliance is voluntary unless a federal undertaking exists.

- Safeguard the condition of the cultural resource by preventing further damage, loss, or deterioration.
- Investigate and document the cultural resource in order to determine its significance and conservation potential.
- Adjust work schedules to allow time for data recovery or other mitigation measures (including following the appropriate cultural resource guidelines).
- Avoid the highly sensitive areas identified within the project area.
- Fill over the area either temporarily or permanently to avoid disturbance.
- Conduct a more extensive archaeological examination of the area, enlisting the services of a trained professional archaeologist to determine if the site is significant. (This may incur considerable expense.)

Evaluation and Documentation

Evaluation uses the information generated during cultural resource identification to determine whether a particular cultural resource is eligible for inclusion on the National Register of Historic Places (NRHP). All cultural resources are not equal. Only cultural resources qualifying for listing under the NHPA are protected. See Appendix B for information on the National Register Criteria for Evaluation of Cultural Resources.

Even though documentation of cultural resources discovered during forest management activities is not required under the National Historic Preservation Act, sharing a record of cultural resources discoveries is valuable to future generations. Information shared with the State Historic Preservation Office is private and confidential and is not available to the general public.

When Accidental Discovery Occurs

If a human burial site is accidentally discovered during operations, cease operations immediately in the vicinity of the discovery. This is mandatory whether it be on private or public land. Halt operations and contact the State Historic Preservation Office and your local law enforcement agency for sources of information and assistance.

For accidental discovery of other types of cultural resources (such as archaeological artifacts), temporary suspension is not required on private land, but it is recommended, and if a federal undertaking exists, it is mandatory. Suspending operations in the immediate vicinity of the cultural resource will allow time to contact a cultural resource professional or develop plans to initiate procedures to avoid or reduce damage to the cultural resource. When cultural resources are discovered during forest management activities, the following procedures are recommended:

- Safeguard the condition of the cultural resource by preventing further damage, loss, or deterioration.
- Investigate and document the cultural resource in order to determine its significance and conservation potential.
- Adjust work schedules to allow time for data recovery or other mitigation measures.

National Historic Preservation Act Glossary

Undertaking as defined in Section 106 of the National Historic Preservation Act (1966) means a project, activity, or program funded in whole or in part under the direct or indirect jurisdiction of a federal agency, including those carried out by or on behalf of a federal agency, those carried out with federal assistance, and those requiring a federal permit, license, or approval. If an activity is an undertaking, the agency then determines whether it is "a type of activity that has the potential to cause effects on historic properties." (36 CFR § 800.3[a])

Effect means alteration to the characteristics of a historic property qualifying it for inclusion in or eligibility for the National Register. (36 CFR § 800.16[i])

References to Other Chapters

- For best management practices for protecting cultural resources during management activities see Chapters 12, 13, 14, 15, 16, 17, and 18.
- See Appendix B for best management practices for common cultural resources.

Additional Resources

Missouri State Historic Preservation Office website: ***dnr.mo.gov/shpo/index.html***
State Historic Preservation Office, PO Box 176, Jefferson City, MO 65102. 800–361–4827, 573–751–7858. E-mail: ***moshpo@dnr.mo.gov***.

CHAPTER 7

Soil and Sustainable Forestry

HANK DORST, MARK TWAIN FOREST WATCHERS

Topics Covered

- Obtaining Soil Information
- Sustaining Soil Productivity and Quality
- Soil Quality Indicators
- Physical Properties and Forest Management Impacts
- Soil Compaction
- Rutting
- Soil Erosion and Sedimentation
- Chemical Properties and Forest Management Impacts
- Biological Properties and Forest Management Impacts

Soil is defined as a natural, three-dimensional body at the Earth's surface. It is capable of supporting plants and has properties that are the result of climate, topography, and living organisms acting on parent material over time (Figure 7.1).

Soil is a fundamental resource in the pursuit of sustainable forestry. Along with other environmental factors, it provides a foundation and a medium for growth and productivity. Forest growth is largely governed by the availability of water and nutrients provided by the soil. A minimum understanding of how soil nutrient and water availability is characterized, how soils function, and how soil can be impacted is essential to understanding what forest practices are most sustainable.

A soil's health as measured by physical, chemical, and biological properties can be influenced by forest management. Alterations to these soil properties will impact plant growth and the ability to manage for the long term. Implementation of practices that protect the physical, chemical, and biological soil properties will improve the potential for long-term sustainability of the forest.

Because soils are quite variable, it is important for forest managers to evaluate each management unit separately. This information is used to develop prescriptions that ensure productive capacity is not reduced as a result of forest management activities.

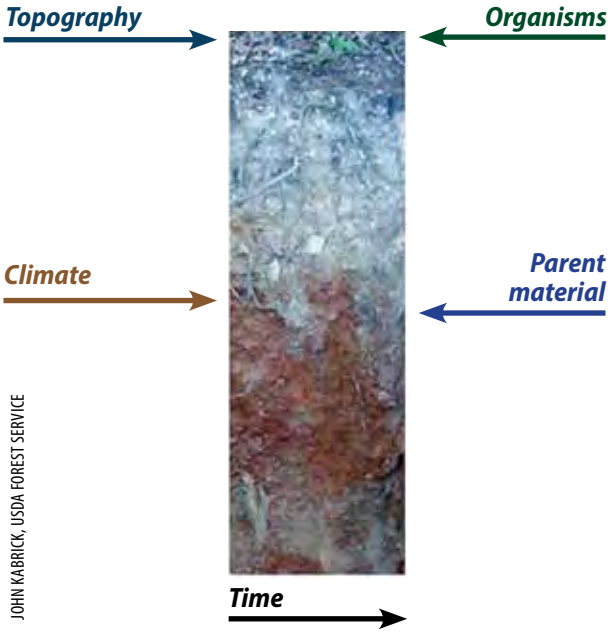


Figure 7.1. *Soil is a function of climate, topography, and organisms acting on parent material over time.*

Obtaining Soil Information

Soil information and technical assistance are available from the USDA Natural Resources Conservation Service (NRCS), the Missouri Department of Natural Resources (MDNR), or the University of Missouri Extension Service.

Maps of the soils for specific properties are available online from the NRCS Web Soil Survey, at ***websoilsurvey.nrcs.usda.gov/app/HomePage.htm***.

Figure 7.2. *Missouri Land Resources Area (MLRA) This map can be found at* ***www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_010610.pdf****. The extent and description of these areas are found in the NRCS publication* Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin, *U.S. Department of Agriculture Handbook 296, at* ***www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053624****.*

107 Iowa and Missouri Deep Loess Hills
108 Illinois and Iowa Deep Loess and Drift, Western Part
109 Iowa and Missouri Heavy Till Plain
112 Cherokee Prairies
113 Central Claypan Areas
115B Central Mississippi Valley Wooded Slopes, Western Part
115C Central Mississippi Valley Wooded Slopes, Northern Part
116A Ozark Highlands
116B Springfield Plains
116C St. Francois Knobs and Basins
131 Southern Mississippi River Alluvium
134 Southern Mississippi Valley Loess

General information concerning the soils of Missouri is described by physiographic regions known as Major Land Resource Areas (MLRA). Missouri has 12 MLRAs. These were used in the development of the regional layers, called ecological sections, for Missouri's Ecological Classification System (ECS). See Chapter 11 for more information.

Soils are also a fundamental data layer in most forest ecological site classification systems. Site classification systems generally integrate key soil information with other information about the climate, geology, geomorphology, and native vegetation from stand to ecoregional scales. Site classification systems, along with a soil survey, are other important tools for sustainably managing forest ecosystems because they integrate a number of factors related to site nutrient capital, water supply, and site productivity (see Chapter 11).

Managers that desire to have more detailed on-site soils information to prepare a forest management plan can contact private consultants. Site-specific information will help the manager develop prescriptions to maintain the forest's productive capacity.

Sustaining Soil Productivity and Quality

Soil productivity is defined as the capacity of soil, in its normal environment, to support plant growth. Soil productivity is reflected in the growth of forest vegetation or the volume of organic matter produced on a site. In forest management, soil productivity is most often measured in volume of trees produced. However, other methods of determining productivity exist, including forest community assessments.

Soil quality is defined as a soil's capacity to function for its intended use. In forest ecosystems, this not only includes sustaining forest productivity but also includes sustaining the soil's ability to support a diversity of native plants and animals, to store carbon and cycle nutrients, and to regulate the storage, flow, and quality of water. Another important function of forest soils is protecting the environment by filtering and detoxifying contaminants.

There are forest management activities that impact soil productivity and quality. Identifying and reducing impacts to the soil is an essential strategy in sustainable management. A certain amount of soil impact is inevitable, but many of the recommended practices are aimed at keeping this impact to a minimum level.

Soil Quality Indicators

The ability of a soil to function is evaluated with specific properties called soil quality indicators (Table 7.1). Some indicator soil properties are "inherent," meaning that they are not readily altered by management but can be changed relatively slowly. Examples include the texture class of individual soil horizons, the types of minerals found in the soil, soil depth, water-holding capacity, and the drainage class. Other soil properties are much more "dynamic," meaning that they can be altered rapidly by management or natural disturbances during a single growing season or year. Examples include bulk density, porosity, and water infiltration.

YURY CHENDEV, BELGOROD STATE UNIVERSITY

Figure 7.3. *Soil scientist evaluating the soil profile in a soil pit*

Forest management activities can affect both inherent and dynamic soil properties. Consequently, BMPs are designed to mitigate the negative impacts on both inherent and dynamic soil properties in order to maintain soil quality.

Soil quality indicators are allocated into the categories physical, chemical, and biological properties. Physical properties include texture, structure, porosity, density, water infiltration, and water-holding capacity. Chemical properties include nutrient concentrations or quantities, pH, soil organic matter content, and cation exchange capacity (see glossary). Biological properties include the number and kinds of fungi, bacteria, invertebrates, and vertebrates that live in the soil. Soil properties and functions are highly interdependent. A change in one soil property can affect other soil properties within or among these three categories as well as affect a number of different soil functions.

Table 7.1. Examples of Soil Quality Indicators and Their Potential Influence on Soil Functions for Forested Ecosystems

SOIL QUALITY INDICATOR	SOIL FUNCTION				
	Sustain plant diversity	Sustain production of forest fuel and fiber	Regulate water movement and solute flow	Store and cycle nutrients and carbon	Filter, buffer, and detoxify water
Texture	✘	✘✘	✘✘	✘✘✘	✘✘✘
Structure	✘✘	✘✘✘	✘✘✘	✘✘	✘✘✘
Bulk/Density Porosity	✘✘	✘✘✘	✘✘✘	✘✘✘	✘✘✘
Infiltration	✘✘	✘✘	✘✘✘	✘✘✘	✘✘✘
Water-Holding Capacity	✘✘✘	✘✘✘	✘✘	✘✘	✘✘✘
Nutrient Concentrations or Quantities	✘	✘✘✘	✘	✘	✘
pH	✘✘✘	✘✘	✘	✘	✘
Cation Exchange Capacity	✘✘✘	✘✘✘	✘	✘✘✘	✘✘
Soil Invertebrate and Vertebrate Populations	✘✘✘	✘✘✘	✘✘✘	✘✘✘	✘✘✘

✘ Means there is a relatively weak relationship between this particular indicator of soil quality and a soil's ability to provide that specific function

✘✘ Moderate indicator relationship

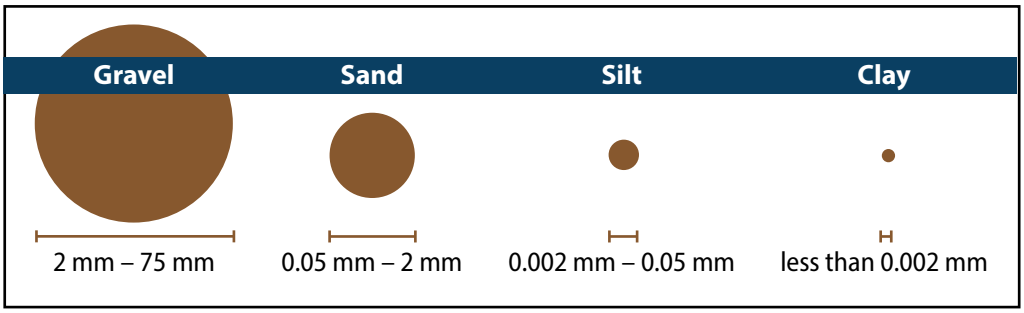
✘✘✘ Strong indicator relationship

Physical Properties and Forest Management Impacts

Soil physical properties are important determinants of productivity, erodibility, the kinds of fauna inhabiting the soil, water infiltration (water moving into the soil) and percolation (water moving through the soil), and nutrient cycling rates. "Texture" refers to the percentage of sand, silt, and clay in the soil. Soils are grouped into soil texture classes by the relative amounts of sand, silt, and clay (Figure 7.4). "Structure" refers to the arrangement of the sand, silt, or clay particles into aggregates (called peds). Together, texture and structure greatly affect many other soil properties and functions.

Texture greatly affects the soil's ability to hold and supply water. Clayey soils hold more water than silty or sandy soils. However, clays hold some of the water so tightly that the roots of trees and other forest plants are unable to absorb it. Texture classes having a mixture of sand, silt, and clay, such as silt loams, loams, and silty clay loams, provide the most water to plants and tend to be the most productive.

Soils that contain particles that are strongly aggregated, especially those with strong granular structure, are less vulnerable to erosion. Texture also influences a soil's susceptibility to erosion. For example, soils with high silt content tend to be more vulnerable to erosion. This is because, unlike clay-sized particles, silt-sized particles do not form strong aggregates and because silts are much smaller and lighter than sand-sized particles. This allows the silt-sized particles to be readily detached and transported during rainfall compared to clay-sized or sand-sized particles.



INFORMATION COURTESY OF USDA.GOV

Figure 7.4. *Soil particle sizes and texture classes*

The space around the soil particles and the soil aggregates (peds) is referred to as the pore space, and the relative volume of the pore space is the porosity. Pores are very important for the movement of water and air into and through the soil. Decreasing the volume of the pores reduces the amount of air and water that can move into and through the soil. Water and air move through large pores much more readily than through small pores. These large pores are called macropores and are defined as pores greater than 0.002 inches in diameter; smaller pores are called micropores. A small reduction in the number of macropores greatly reduces infiltration and percolation, aeration, and drainage.

Soil porosity is also directly and inversely related to soil density (referred to as bulk density). In addition to the porosity, the soil bulk density affects the extent of rooting by trees and other plants. For a given texture class, increasing the bulk density decreases root penetration. Decreasing root penetration reduces the amount of water and nutrients that can be taken up by trees and other forest plants, ultimately decreasing productivity.

The drainage class of a soil — a measure of the frequency and duration of soil saturation — is also related to total porosity and pore size distribution. Poorly aggregated soils or soils with a high proportion of micropores generally have poorer drainage than well-aggregated soils and soils with a high proportion of macropores.

Abrupt changes in the pore sizes among different horizons or layers within the soil, due to differences in texture or structure, also affect soil drainage. The presence of a fragipan (a dense and compact subsurface layer) or a claypan (a dense, slowly permeable soil layer of high clay content) can impede soil drainage.

Soil drainage also affects species composition and productivity. In forest ecosystems, plant species naturally align themselves along soil drainage gradients by their ability to tolerate wetness or dryness. Although some tree species are well adapted to poorly drained soils, tree productivity generally decreases with increasing (prolonged) soil saturation. Saturated soils are also much more vulnerable to damage caused by the heavy weight of skidders and other harvesting equipment.

In forests, most of the alterations to soil physical properties occur during harvesting operations. Felling, forwarding, and skidding operations with heavy equipment can cause decreases in porosity by compacting and rutting the soil surface, leaving the soil vulnerable to ponding and erosion. The susceptibility of soil to compaction is primarily dependent on soil texture and moisture content. Soils are most susceptible to compaction, ponding, and rutting when they are saturated. Such conditions occur during spring and early summer months, immediately following heavy rains, and in the fall after transpiration has ceased. Soils that have a high content of gravels, cobbles, and other coarse fragments tend to be less vulnerable to compaction than soils without coarse fragments. Limiting equipment traffic to drier seasons of the year is one way to reduce compaction and other types of physical damage to the soil. Soils that are solidly frozen are relatively resistant to compaction, so winter operations are an option for wetter sites.

Soil Compaction

Soil compaction is the decrease in soil volume and associated increase in bulk density caused by heavy weight or high pressure applied to the soil surface. Increasing the bulk density decreases the total porosity of the soil. The macropores are the most vulnerable to compaction, and they can be readily eliminated where traffic from forest harvesting is heavy. Because macropores largely govern the exchange of gases through the soil, reducing the number or volume of macropores greatly decreases soil aeration. Where soil aeration is diminished, oxygen is less available for respiration in tree roots. Concentrations of carbon dioxide and other toxic gasses can build up, injuring roots. Soil microorganisms that play a role in making nutrients available to plants are also negatively affected by the lack of oxygen and high levels of injurious gasses. Where soils are compacted, root penetration is reduced. This limits the amount of water and nutrients that can be absorbed by trees and other plants. This reduces tree growth and overall site productivity.

Because compaction reduces the number and volume of macropores, it reduces water infiltration and movement in soils. This ultimately leads to increased runoff on slopes and to increased ponding on level sites. Increased runoff causes less rainfall to enter and be stored in the soil for plant use. Instead, rainfall flows rapidly into nearby streams, causing stream water levels to fluctuate. The rapid water flow across the landscape surface increases the risk of erosion and sedimentation. On level slopes, ponding causes unfavorable conditions for plant growth. Seedlings and many herbaceous plants grow poorly in standing water. When the surface layer of soil is saturated, the strength of the soil is reduced and becomes more vulnerable to rutting by heavy equipment. In addition, soil particles become dispersed in water, and after they have dried and settled, the smaller particles form a crust on the surface. This further limits the productivity of the site.

In Missouri, soils that are most susceptible to compaction contain few coarse fragments and are fine- to medium-textured. This includes soils with silt, silt loam, clay loam, silty clay loam, silty clay, and clay textures. These soils are extensive in northern and western Missouri and in the Bootheel region and occur to a lesser degree throughout the remaining portions of the state. Soils with saturated zones or with perched water tables are particularly vulnerable, especially on level sites or in depressions where water cannot drain laterally. However, nearly all soils in Missouri are vulnerable to compaction when saturated such as after heavy rainfall. Care must be taken before beginning any harvesting operation.

Rutting

Rutting is the creation of depressions made by the tires of vehicles such as skidders, log trucks, and other equipment, usually under wet conditions. It occurs when soil strength is not sufficient to support the applied load from vehicle traffic. Rutting directly affects the rooting environment by physically wounding or severing roots, compacting and displacing the soil, and reducing aeration and infiltration. Also, rutting disrupts natural surface water hydrology. Ruts occurring perpendicular to the slope obstruct surface water flow, increasing soil wetness. Ruts that run parallel to a slope gradient can divert water flow away from a site, drying or draining it, but may also increase erosion and sedimentation. Rutting typically occurs under the same circumstances that create other physical soil impacts, including compaction and ponding.

Much like with compaction, soils susceptible to rutting contain few coarse fragments and generally are the fine- and medium-textured soils such as silts, silt loams, clay loams, silty clays, and clays. Soils with poor drainage are particularly vulnerable, such as those that have a claypan and those on level sites or in depressions. Soils that are well drained to excessively well drained and are very gravelly or cobbly such as those occurring throughout the Ozarks and outer Ozark border are less vulnerable to rutting. However, nearly all soils in Missouri are vulnerable to rutting when saturated, and care must be taken before beginning any harvesting operation.

MICHAEL BILL

Figure 7.5. *Logging during wet periods can cause rutting and negatively impact soil and forest productivity.*

BECKY FLETCHER

Figure 7.6. *Harvesting without the use of best management practices can negatively impact soil and water quality.*

Soil Erosion and Sedimentation

Soil erosion is not usually a major impact associated with forest management in most parts of Missouri, except when associated with roads and skid trails (see Chapter 14). Minimizing the number of haul roads and primary skid trails will reduce the chance for erosion and sedimentation to occur. Sedimentation can negatively impact water quality and aquatic habitat. Erosion seldom occurs on areas with established vegetative cover. Harvesting that temporarily removes all forest cover on steeper slopes, without the use of BMPs can result in accelerated erosion. However, harvesting used in conjunction with a silvicultural regeneration method (see Chapter 11) and BMPs will ensure that vegetative cover is reestablished quickly and the impact of skidding and hauling is minimized so that the soil is protected.

The application of prescribed fire temporarily removes leaf litter and ground vegetation, leaving soils vulnerable to erosion until new litter is deposited or the ground vegetation grows back. On steep slopes, managers should avoid using intense fires because they remove most of the forest floor, which protects the mineral soil from erosion. Also avoid intense burns during the late fall or early winter because of the risk that the soil will remain without litter or other vegetative cover until spring.

Soil erosion in livestock grazed forests can be many times greater than erosion in ungrazed forests. Large roots and hair-like feeder roots are easily damaged by trampling hooves as the soil erodes from around the base of a tree. Livestock also compact the soil, which has many negative impacts on trees. Pores in the soil that allow tree roots to get air and water are sealed off. Rainwater that should infiltrate into the ground simply runs off the surface, thereby contributing to erosion. The weakened trees are less drought tolerant and are more vulnerable to insects and disease.

In Missouri, soils with silt and silt loam textures are the most vulnerable to erosion. This is because silt-sized particles do not aggregate very strongly and thus are easily detached from each other and transported by wind or water. The silty textures are commonly associated with the parent material named "loess," which covers a portion of the land surface in the uplands near the Missouri and Mississippi Rivers and on gently to moderately sloping landforms throughout much of

northern Missouri and on broad ridges throughout the Ozark Highlands. Extra care should be taken on silt and silt loam soils, as these tend to erode more easily when disturbed or exposed, especially on long or steep slopes.

Chemical Properties and Forest Management Impacts

Forest growth depends on the supply of soil nutrients. Nutrient supply is the balance between nutrient accumulations and nutrient losses. In forested ecosystems, soil nutrients accumulate through a variety of mechanisms. Nutrients such as calcium, magnesium, potassium, and phosphorus are released through the weathering of primary or secondary minerals in the soil and become available in soil solution. Nitrogen is captured or "fixed" from the atmosphere by plants or soil microorganisms. Some of these nutrients occur in dust or in rainwater that falls on the forest.

Nutrients are also released through the decomposition of plant residues, and thus an important process operating in a forest is nutrient cycling, the nutrient exchange between the soil and the plants. This exchange of nutrients between soil and plants is particularly important for forest growth. Annually, more nutrients are cycled through the ecosystem than are released by mineral weathering or by atmospheric deposition.

Nutrients are lost from an ecosystem in a number of ways. Some are lost by leaching from the soil. Others are lost as gases during the decomposition of plant residues. Nutrients in biomass are removed from the forest during harvesting, and shortly after harvest they can be lost from the root zone through the leaching of nutrients released during the decomposition of large quantities of residues left behind. Elevated temperatures and moisture in soil following harvest can also enhance decomposition of the soil organic matter, thus further enhancing nutrient release and potential loss from the root zone.

Prescribed fires that are applied to reduce fuel loading or to favor desirable forest structures and species compositions can also cause nutrient losses. Burning leaf litter and organic matter on the soil surface causes nitrogen losses through vaporization. The ash left behind on the soil surface immediately following a prescribed fire is rich in calcium, magnesium, and potassium, but it is also highly vulnerable to leaching and runoff.

Nutrient depletion is greater with shorter rotations, shorter fire-return intervals, and greater harvest intensities. In forests managed with short rotations, the removal rate of nutrients in the harvested material can exceed inputs from the atmosphere and from mineral weathering in the soil. Similarly, a shorter fire-return interval may cause nitrogen losses to exceed nitrogen inputs. Increasing the harvest intensity by removing foliage and branches in addition to bole wood also increases nutrient removals. Where whole trees are harvested either for biofuel production or for limbing operations performed at log landings, greater nutrient removals occur compared to where branches and leaves remain well distributed in the forest. Nutrient concentrations also differ among tree species. For example, oaks have greater calcium concentrations in their boles and branches than do red maples or many species of pines. Consequently, greater calcium depletion occurs where more oaks are harvested relative to these other species.

Soils containing small quantities of available nutrients, and with a limited capacity to store nutrients or to resupply nutrients through mineral weathering, are the most vulnerable to accelerated nutrient depletion. Soils formed in highly weathered parent materials or in parent materials derived from sandstone or rhyolite generally have a low cation exchange capacity, which limits their ability to store nutrients and to provide them to plants.

These kinds of parent materials also contain few primary minerals capable of resupplying nutrients such as calcium, magnesium, or potassium when they weather. Soils containing large quantities of rocks comprised of chert or quartzite have a diminished supply of nutrients because these kinds of rocks reduce the volume of soil material capable of storing and supplying nutrients and because few nutrients are released from these rocks during the weathering process. Phosphorus supply is also limited in highly weathered soil because it becomes adsorbed to the surfaces of iron oxides or because it is converted into a mineral with either iron or aluminum that is resistant to release by weathering. Coarse-textured soils contain less organic matter and generally have a lower capacity to hold or supply nutrients.

In contrast, soils formed in parent materials such as glacial till, loess, residuum from limestone or shale, or in alluvium derived from these parent materials generally are rich in nutrients and have a large capacity to supply nutrients through mineral weathering.

In Missouri, oaks are the most abundant and commonly harvested species. Because oaks contain high concentrations of calcium, care should always be taken when planning and conducting harvesting operations to minimize unnecessary depletion of this nutrient. Depletion of calcium (and of other base cations) can decrease the soil pH, which in turn can lead to high levels of aluminum in the soil solution. Aluminum is toxic to many plants, and high levels of aluminum in the soil solution limits rooting depth, injures roots, and decreases the uptake of cations, increasing drought susceptibility and lowering plant productivity. Nitrogen losses can be minimized by increasing the rotation length or by decreasing fire-return intervals.

Soils most vulnerable to nutrient depletion are those that are highly weathered and contain high concentrations of cherty coarse fragments. These occur throughout the Ozark Highlands, particularly where the soils are formed in rocky colluvium (soil material moved by gravity) or residuum (soil material developed in place) derived from sandstone, rhyolite,

cherty limestones or dolomites, or acidic shale. Not all soils of the Ozark Highlands are equally vulnerable to nutrient depletion as some are formed in clayey residuum derived from limestone, dolomite, or calcareous shale or alluvium (soil material transported and deposited by water) and are rich in calcium and magnesium. The soils in much of central, northern, and western Missouri are derived from glacial till, loess, residuum from limestone or dolomite, or alluvium derived from these parent materials and are much less vulnerable to nutrient depletion.

A soil survey is useful for identifying the soils that are most vulnerable to nutrient depletion. Soils that are classified in the Soil Order Ultisols are the most vulnerable. Those that are least vulnerable are classified as Alfisols, Mollisols, Entisols, or Inceptisols.

Biological Properties and Forest Management Impacts

Biological characteristics of soil include the populations of plants and animals, including macrofauna (including small animals, worms, termites, ants, and other arthropods), microfauna (including nematodes, rotifers, protozoa), and microflora (including fungi, bacteria, algae, oomycetes). Macrofauna aid in the creation of macropores and also mix the soil, incorporating organic matter. Microfauna play an important role in regulating microbial populations and mineralizing the organic matter. Microflora mineralize organic substances or transform inorganic compounds, making nutrients more readily available to plants.

Fungi are particularly important microflora in forest soils. They decompose cellulose and lignin, which otherwise are very resistant to breakdown by other organisms. Some fungi — called mycorrhizae — have a beneficial relationship with plants. Mycorrhizae infection in the plant's roots helps the plant take up water and nutrients. Infection by mycorrhizae occurs most frequently in soils that are infertile. Other fungi are pathogenic, feeding on the roots of living plants and causing injury or death.

The number of organisms is generally greatest in the forest floor and in the volume of mineral soil directly associated with plant roots. The population of soil organisms (both density and composition) and how well that population thrives is dependent on many soil factors including moisture, aeration, temperature, organic matter, acidity, and nutrient supply.

Poor harvesting practices can favor soil organisms that cause disease or damage to standing timber. The reduced aeration and increased ponding and soil wetness associated with compaction and rutting favors the growth of Phytophthora. These thrive under saturated soil conditions where they feed on the fine roots of trees and other plants, causing growth reductions or death.

The wounding of tree roots and stems by skidders and other harvesting equipment or by prescribed fires increases susceptibility to Armillaria fungi. Some species of Armillaria are pathogenic, eventually killing trees that have been initially wounded during harvesting, prescribed burning, or other management activity.

Generally, protecting the soil from compaction, rutting, erosion, organic matter loss, and excessive nutrient depletion favors soil organisms that are the most beneficial for maintaining healthy forests. Implementing practices that protect the physical and chemical properties of the soil also protects the habitat of the soil organisms and sustains their populations.

TERRY TRUTTMANN

Figure 7.7. *Follow residual damage best management practices (Chapter 15) to reduce the occurrence of tree wounds.*

References to Other Chapters

- For best management practices for protecting soil productivity during management activities see Chapters 12, 13, 14, 15, 16, 17, and 18.

Additional Resources

NRCS Web Soil Survey. Available at ***websoilsurvey.nrcs.usda.gov/app/HomePage.htm***.

CHAPTER 8
Forest Products


NOPPADOL PAOTHONG

Topics Covered

- Common Forest Products and Species in Missouri
- Woody Biomass
- Carbon Sequestration and Biomass
- Encouraging Landowners to Produce Forest Products
- Encouraging Trust Among Landowners, Foresters, and Industry
- When to Harvest
- Maximizing Utilization and Product Values

Missouri's forest products industry is an important contributor to Missouri's economy and supports a number of economic, social, and environmental values. Ensuring that these values are maintained in the future means carefully balancing harvest and consumption rates with available growth and making sure that harvest practices account for long-term productivity and sustainability of all forest benefits and services.

Missouri's forests are an important supplier of numerous wood products that are used in our state and worldwide. Some of the many products originating from Missouri's forests are railroad ties, furniture and cabinets, flooring, barrels, tool handles, charcoal, pallets, shavings, paper, and firewood. Through the production of these and other wood products, Missouri's forest products industry contributes approximately $8 billion to Missouri's economy annually; it supports 42,500 jobs and generates $78.5 million each year in state sales tax.

Besides the social and economic benefits of Missouri's forest products industry, there are some less obvious benefits as well. When properly conducted, the harvest of forest products can provide an economical means of improving forest health and wildlife habitat. Harvesting can be used to mimic historic disturbances that maintained diverse forest structure and composition, important to both forest health and wildlife. Forest products can have several environmental advantages over alternative resources:

- Trees and forests are renewable resources. As trees are harvested, new trees quickly emerge and fill in the gaps left behind.
- Harvesting trees is generally much easier and leaves less of a human footprint compared to the extraction of other resources such as metals, coal, and oil.
- Forest products are generally biodegradable and/or recyclable.
- Forest products and biofuels help reduce greenhouse gases through carbon storage in forest products and through avoided use and extraction of fossil fuels. Carbon released from tree harvesting is quickly taken back up by new forest growth.

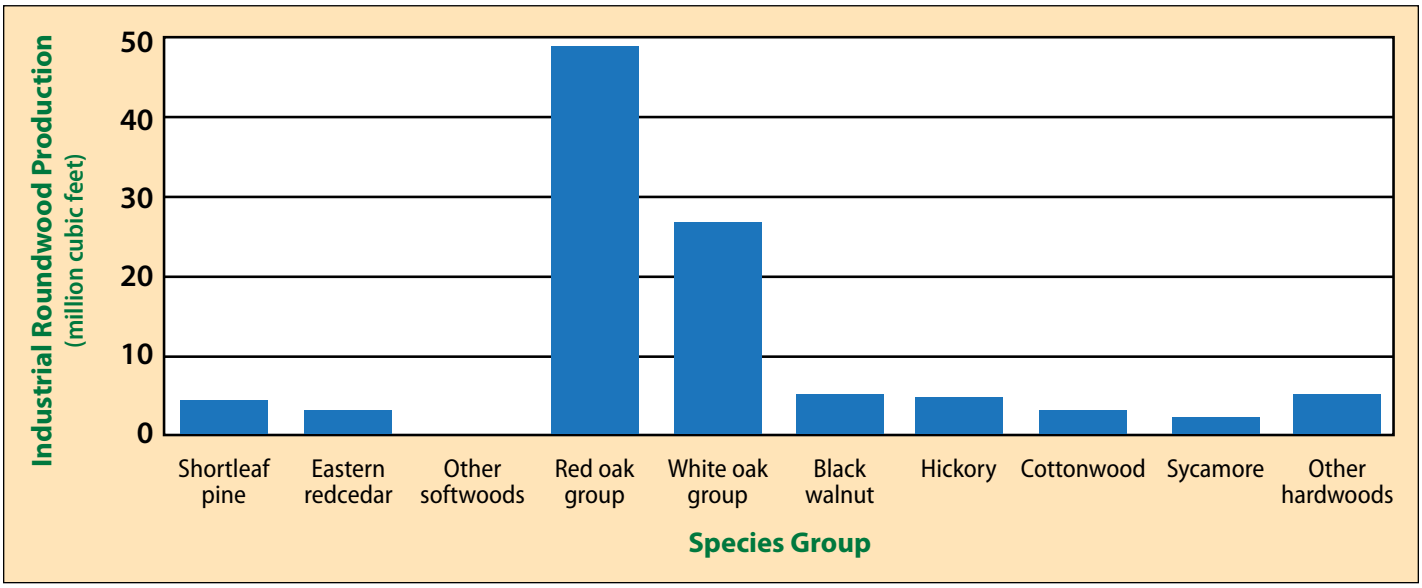
Despite all the benefits and opportunities associated with forest products, they have some limitations too. First, there is a limit to how much timber can be harvested without reducing opportunities for future generations. Second, the harvest of forest products is only beneficial if it is done using management practices that ensure the long-term health, sustainability, and productivity of the forest. Forest management decisions need to ensure that all of the benefits forests provide can be sustained into the future.

Common Forest Products and Species in Missouri

Saw logs will be made into pallets, blocking, flooring, railroad ties, grade lumber, and various other products. Typically the lowest quality logs are converted to pallet lumber and railroad ties. Modern technology has allowed flooring manufacturers also to use fairly small and/or lower quality logs. Grade lumber must meet specifications for size and lack of defect and requires better quality logs.

Veneer logs are very high-quality saw logs that are either sliced or peeled into very thin layers, which are used to cover less expensive wood in furniture making or for hardwood plywood. Logs must be nearly free of defect and of a sufficient size to produce useable slices or have enough veneer to be peeled economically.

Cooperage is white oak logs that are used to create barrels. Barrel staves must have zero defect. Seldom will a



INFORMATION COURTESY OF USDA FOREST SERVICE

Figure 8.1. *Industrial roundwood production by species group*

MFPA

MFPA

CLIFF WHITE

MFPA

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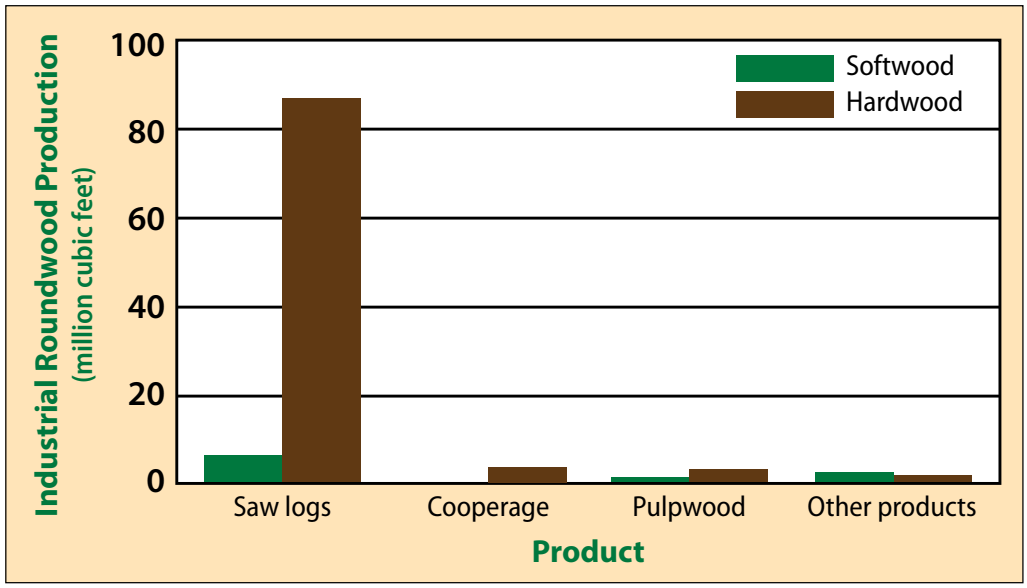
Figure 8.2. *Railroad ties are a common product produced from saw logs in Missouri.*
Figure 8.3. *Pallets made from low-quality, small-diameter saw logs*
Figure 8.4. *White oak barrels produced from stave logs*
Figure 8.5. *High-quality pine poles*
Figure 8.6. *Small-diameter material can be used for paper pulp, pallets, and other low-value forest products.*

single timber sale yield more than a few stave-quality logs. Their value makes it worthwhile for most loggers and sawmills to sort out these logs until they have a truckload ready to be delivered to a cooperage facility.

Pulp is wood fiber used to create paper products. These are pieces of harvested wood that are too small or defective for even the lowest quality product. Unless a logger has an economical way to consolidate and transport pulpwood, it may never leave the woods. Unfortunately, these defective trees may not even be cut down even though doing so would serve to improve the long-term health and quality of the stand. Viable pulpwood markets can enhance the forest manager's ability to conduct the necessary management work in a more cost-effective manner.

Posts are typically small pine but can be oak or cedar. Posts are typically treated with a wood preservative to extend their useful life.

Sawtimber shortleaf pine can produce construction-grade lumber. Missouri shortleaf pine is desirable due to both its slower growth and greater strength compared to other southern yellow pines. Unfortunately, Missouri markets that capitalize on this resource are limited. The highest quality shortleaf pine can be used for utility poles. Pole-quality pine represents a small percentage of trees. Their high value makes marketing pole-quality pine a good financial decision. Pine shavings are another growing market for shortleaf pine. Shavings are utilized for animal bedding material for livestock and poultry.



INFORMATION COURTESY OF USDA FOREST SERVICE

Figure 8.7. *Industrial roundwood production by product type, hardwoods, and softwoods*

Woody Biomass

Dramatic increases in petroleum prices have resulted in greater emphasis on the need to develop alternative energy sources, including woody biomass. Woody biomass can be utilized to create many different products such as firewood, charcoal, and various biofuels. For more information on how to properly harvest woody biomass, refer to the *Missouri Woody Biomass Harvesting Best Management Practices Manual*.

Carbon Sequestration and Biomass

When trees grow, they accumulate and store carbon. When they die and decompose, they gradually release carbon. When trees are used for products, carbon remains stored in the wood and paper products until they decompose and release carbon back to the atmosphere. For paper this may be a few months or a few years. For wood products it may not be for decades or even centuries.

Although there are instances around the country where landowners have sold the carbon sequestered by their forest, a dependable and price-attractive market for carbon sequestration has yet to develop. At some point in the future, a viable market for this ecological service may yet emerge. Regardless, landowners and managers can benefit from a better understanding of the role that forests play both as a carbon sink and as an energy source that is more carbon-emitting neutral than nonrenewable fuels.

Landowners selling the carbon sequestered by their forests enter into a contract with the purchaser that guarantees a volume of carbon to be stored over a specified period of time. This stored carbon serves to offset a carbon emission elsewhere, by a coal-fired power plant perhaps, thus mitigating that emission's impact on the global balance of greenhouse gases. Formulas are applied that estimate carbon storage based on the composition, age, condition, and extent of the forested acreage.

When a forest is sustainably managed to produce woody biomass, there is eventually an off-setting effect between the carbon that is accumulated in the growing forest and the carbon that is emitted when the wood is used for energy. Comparatively, nonrenewable fuels such as petroleum products emit carbon when consumed with no counter-balancing absorption of carbon from the atmosphere. Although studies suggest that the use of woody biomass is not perfectly carbon neutral, as an alternative energy source it can have a positive impact on greenhouse gas accumulation when efficiently used in place of nonrenewables.

Encouraging Landowners to Produce Forest Products

The 359,000 private forest owners in Missouri own forest land for a great variety of reasons. The vast majority of these (95 percent) are family forest owners who rank timber production as a relatively low priority. The forest management practices that interest these owners may be those designed to improve wildlife habitat, increase herbaceous vegetation diversity, improve aesthetics, provide firewood, or provide recreation opportunities rather than grow marketable timber. Timber sales can provide a source of income to help implement silvicultural treatments designed to meet non-timber objectives. Timber sales are the primary source of income from Missouri forests. Commercial forest harvest operations may be the most economical means of altering forest structure and composition, which may be necessary for achieving other goals such as habitat restoration, hazardous fuel reduction, or invasive species mitigation. Landowners can benefit from working with foresters to combine timber sales with treatments to meet other conservation objectives and thereby reduce or eliminate out-of-pocket costs associated with non-timber management objectives.

Encouraging Trust Among Landowners, Foresters, and Industry

Another issue that significantly influences the process of buying and selling timber is trust or the lack thereof between landowners, foresters, and industry. Reassuring all partners of the integrity of a transaction is essential to improving the viability of the forest products industry. A timber harvesting contract with a forester serving as a sale administrator can help to ensure that all parties are protected. An example of a timber harvesting contract is located in Appendix D.

When to Harvest

Timber harvesting can be used to accomplish numerous landowner objectives: generating revenue, improving individual tree growth, improving conditions for regeneration, and maintaining or enhancing habitat for wildlife. Without a forest management plan (see Chapter 10), it can be difficult to know the best time to conduct a timber sale. An important first step in knowing when to harvest is the development of a forest management plan that identifies landowner objectives and articulates the harvest methods and timing of activities to achieve these goals.

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Figure 8.9. *Foresters, loggers, and landowners should work together to ensure that Missouri's forest resource is managed well.*

Timber resources experience financial ingrowth, or increasing product value, as a tree's diameter increases over the course of its life. An example of financial ingrowth is when a tree grows from a pulpwood size class into a sawtimber class. (Figure 8.10)

Harvesting too early can yield substantially lower revenue to the landowner. A properly conducted thinning, however, may produce short-term income while allowing the stand to grow into the next size class sooner. Based on the concept of financial ingrowth, a landowner should delay final harvest

Figure 8.8. *The timber harvesting process: (a.) marking the trees to be removed, (b.)directionally felling tree, (c.) tree falling without causing residual damage, (d.) topping the tree, (e.) skidding tree to landing, (f.) cutting the tree to correct length at the landing, (g.) sorting and loading logs on truck, (h.) hauling logs out on truck to the mill.*

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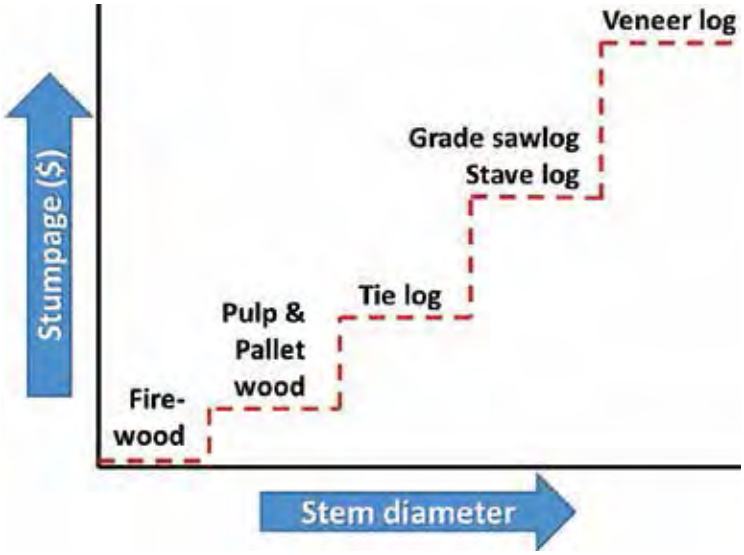
until the estimated revenue of a timber sale is maximized. Delaying a timber harvest is not totally without risk. The likelihood that a natural disturbance will damage or kill a tree increases the longer it is left to grow. The decision on when to harvest should be based on a forest inventory. An inventory can reveal whether the landowner should delay harvesting until financial ingrowth leads to an increase in timber sale revenue.

Maximizing Utilization and Product Values

The types and availability of wood product markets is highly variable throughout Missouri. For example, in portions of the Missouri Ozarks, markets are available for pulpwood, pallet lumber, and tie logs, as well as stave logs and veneer. In this area, there is potential for marketing products of a variety of sizes and levels of quality. Markets in northern Missouri limit utilization of timber resources due to a lack of small-diameter wood markets. Landowners, foresters, and loggers should work together to ensure that products removed during harvest operations reflect the highest and best use of each tree removed. This will help maximize the profit for both the landowner and the logger and can help create a more visually appealing timber sale that has less forest residues. This reduction in forest residue will also help reduce hazardous fire fuel loadings. It is also socially responsible to use the forest resource wisely. Although trees are a renewable resource, it may take decades for a stand to mature enough to provide higher-valued products. If low-value product markets are not available in your area, consider using firewood cutters to meet these objectives. Refer to Chapter 15 for guidelines on how to maximize product utilization during harvesting operations.



MATTHEW OLSON

Figure 8.10. *Timber resources experience financial ingrowth, which is the jump in product value associated with increasing tree size. This phenomenon can create a financial incentive for landowners to delay harvesting until the ingrowth of their timber to a higher-valued product class has occurred.*

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Figure 8.11. *This logger has sorted low-value pallet and pulp logs (on left) from higher-valued saw logs to ensure that he maximizes his profits and uses the forest resource wisely.*

References to Other Chapters

- For best management practices for using harvested material and implementing a timber sale see Chapter 15.

Additional Resources

Forest Management for Missouri Landowners, revised edition. Missouri Department of Conservation. 2007. Available at ***mdc.mo.gov/node/5574***.

Missouri Woody Biomass Harvesting Best Management Practices Manual. Missouri Department of Conservation. 2009. Available at ***mdc.mo.gov/node/9806***.

Call Before You Cut program: ***callb4ucut.com***

CHAPTER 9
Forest Health


JIM RATHERT

Topics Covered

- Threats to the Health of Missouri's Forests
- Integrated Pest Management
- Native Forest Health Threats
  - Red Oak Decline
  - Oak Wilt
- Nonnative (Exotic) Forest Health Threats
  - Bush Honeysuckle
  - Garlic Mustard
  - Emerald Ash Borer
  - Asian Longhorned Beetle
  - Gypsy Moth
  - Thousand Cankers Disease of Black Walnut
  - Feral Hogs
- Other Forest Health Threats
  - Extreme Weather Events and Climate Change
  - Large Animal Impacts

Thousands of species of bacteria, fungi, and insects occur naturally in a forest and have developed along with trees, other plants, vertebrates, and other organisms as essential components of healthy ecosystems. Natural and human-caused disturbances occasionally cause changes in the interactions of these many elements, leading to declines in forest health. Disturbances can be caused by changing weather patterns, weather events (e.g., tornadoes), human actions directly affecting the forest, human-assisted introduction of invasive species, and many other events.

Threats to the Health of Missouri's Forests

One good example of human actions directly affecting the forest is oak decline. At the turn of the 20th century, the forests of the Missouri Ozarks were exploitatively harvested for timber with no regard for forest regeneration. This harvesting stimulated an abundance of oak seedlings and two to three sprouts occurred on almost every black and scarlet oak stump, resulting in too many trees growing on too little land. To make matters worse, many of these sites had historically been dominated by pine and had soil that was rocky, infertile, and susceptible to drought. This was further complicated by the fact that the normal life expectancy of these tree species is only 70–90 years. When the severe droughts of 1980 and 2000 took place, a major component of Missouri's forests came under significant stress. Various insects and pathogenic fungi whose normal role in the forest is to attack and decompose weak and dying trees had an overabundant food supply, and their populations exploded, leading to even more decline. The cycle was broken when the most vulnerable black and scarlet oaks died, weather conditions moderated, and insect and fungal populations declined. Oak decline is expected to be a continuing problem in the future as trees increase in age and additional drought and other stress events occur.

At times humans have knowingly introduced "exotic" or "nonnative" plants and animals for a specific use, as in the case of autumn-olive for erosion control or Serecia lespedeza for livestock feed. In other instances, introduction has occurred accidentally via incoming international cargo, as in the case of chestnut blight, Dutch elm disease, or the emerald ash borer. In these or similar instances, when an organism is taken out of its original environment and placed in another the ecological balance shifts. Other species that help keep the introduced organism in check may not be a part of the new environment. In the case of an introduced insect or disease, the host plant species has not coevolved with the introduced species and has few natural defenses to resist the attack. These "invasive" species are then able to modify native ecosystems, resulting in adverse economic and ecological impacts.

One of the most difficult aspects of managing a harmful pest species is that it is usually widespread before it is detected. And it usually takes multiple detections before public awareness reaches the point where action is taken to combat the threat. The Nature Conservancy developed the following graph (Figure 9.1) to depict how one forest health threat, an invasive plant, increases over time and the relative potential for controlling it. Insects and disease-causing pathogens follow the same pattern.

A note of caution is appropriate here regarding the concept of "eradication" of an invasive species. The chances for eradication or containment (control) of a pest or an invasive

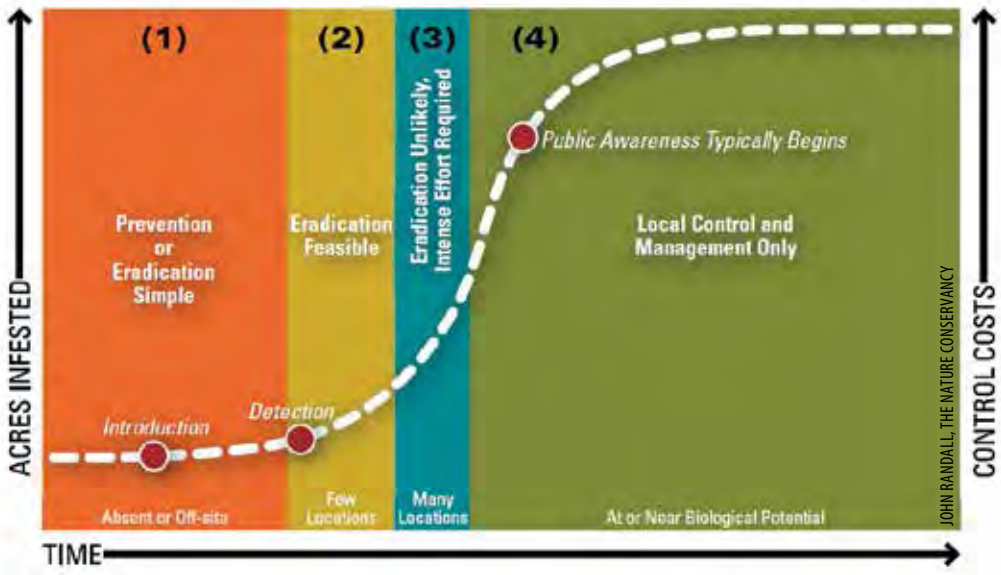

Figure 9.1. *Invasive plant increase over time and control potential. The process of invasion is characterized in four phases. The first phase (1) is the introduction phase, where prevention or eradication is simple. Typically an introduced species must survive at low population densities before it becomes invasive in a new location; some species are present for many years before they exhibit invasive characteristics. The second phase (2) has a few populations, and eradication is still feasible. If an invasive species is detected early, when it is found in a few locations before the population has entered the exponential growth phase, it may be possible to eradicate it. The third phase (3) has many more populations, and eradication is unlikely and requires intense effort. The fourth phase (4) is where the population is at or near its biological potential, and local control and management is the only option. The goal is to keep a species in phases 1 through 3 and have the public awareness point on the curve drop.*

species are greatest immediately after their introduction. However, due to a lack of adequate detection technology and lack of public awareness of the problem, detection of many invasive species occurs after the pest is well established over a broad area. As a result, eradication is not possible in most cases. Even if eradication is feasible, it is often very expensive. For example, local, state, and federal agencies spent millions of dollars trying to eradicate the emerald ash borer in what was perceived then as isolated infestations outside the initial introduction area of southeast Michigan. In all instances the eradication efforts failed. The emerald ash borer had spread to larger areas than could be easily detected. Slowing the spread of a newly established pest is typically the primary objective of invasive species management. As such, early detection and rapid response are both key to managing the threat of invasive species.

Integrated Pest Management

Given the unpredictability of pest invasions and their impacts, the most effective preventative measure is to manage forests to be resilient to a wide range of disturbances.

The best strategy for maintaining this resiliency and managing a pest if action is warranted is through integrated pest management (IPM). IPM is a concept that recognizes ecological, social, and economic values in resource planning and management. IPM in a forest ecosystem is the process of managing a forest with all available tools so that potentially destructive organisms are maintained at a level that is below an economic or damage threshold.

Each invasive plant, insect, or disease-causing organism will have a life cycle that makes it unique. IPM requires an understanding of the forest pest life cycle or method of infection, reproduction, and spread. Interrupting the life cycle is key to managing these species. There is no one source of information on all forest pests, yet technical information on the biology and management of the most destructive species is available through a variety of resources.

The following IPM practices can help minimize pest damage:

- Establish or maintain a diverse mixture of tree species, along with a mixture of ages and sizes of trees.
- Match tree species to the sites where they grow best.
- Use only native planting stock:
  - Avoid planting nonnative trees for most field applications, such as wind breaks, soil stabilization and erosion control, fiber production, and wildlife habitat.
- Maintain individual tree vigor by regularly thinning the forest:
  - Remove low vigor trees, infested trees, and those that are especially susceptible to local pest problems.
- Leave snags for cavity-nesting birds.
- Avoid pruning or thinning during the growing season.
- Avoid wounding trees when operating heavy equipment or logging.
- Periodically monitor the forest to identify pests before they cause too much damage:
  - Monitoring can be integrated with other forest activities.
  - Monitoring may be targeted to specific areas:
    - Where introductions of invasive species are likely, such as access points and travel corridors (along roadways or near parking lots for feral hogs)
    - With high ecological value, where impacts are likely to be significant
    - That are vulnerable habitats or recently disturbed areas
- Minimize disturbance if invasive species are known to be present on-site; if openings in forest canopy and/or ground cover could allow invasive plants to gain a foothold; or if wounding, creation of slash and stumps, and increased stress on trees could allow invasive wood borers or pathogens to build up.
- Avoid transporting insects and diseases:
  - Do not move firewood.
  - Examine recreational vehicles.
  - Brush debris off of equipment before leaving the site.
  - Be aware of quarantines.
- Maintain awareness of conditions that may result in opportunities for invasive plant or animal establishment (i.e., proximity to disturbance, pockets of source species, etc.).
- Salvage damaged trees after a weather event (e.g., ice/wind storm or flood) to reduce the opportunity for introduction of invasive species.
- Before taking action to manage the pest, consider:
  - All available control methods
  - Any local, state, and federal regulations that apply
  - The benefits and risks of each available treatment method or combination of methods
  - Whether there are any threatened or endangered species in the area to be treated

- Choose the methods that are effective yet will cause the least harm to you, others, and the environment.
- Correctly carry out the control practices and keep accurate records.

Native Forest Health Threats

This is a list of some examples of forest health threats in Missouri. For more information about other forest health threats, refer to the additional resources at the end of the chapter.

Red Oak Decline

There is no single cause responsible for oak decline. Periodic episodes of decline and death of oaks occur over widespread areas and are caused by a complex interaction of environmental stresses and pests. Scarlet oak, black oak, and northern red oak are the species primarily affected.

First, red and black oak trees are predisposed to decline because of their age (many live only 70–90 years), where they grow (shallow rocky soils, often on ridge tops and upper slopes which were originally dominated by pine), and historical land use (excessive harvesting, burning, and grazing in early 1900s). Declines are then triggered by inciting factors such as short-term drought, repeated insect defoliation, and late-season frosts. Contributing factors such as Armillaria root rot, Hypoxylon canker, red oak borer, two-lined chestnut borer, and leaf-eating insects combine with the previously mentioned factors to cause greater stress and damage to the oaks.

SUSAN FARRINGTON

Figure 9.2. *Declining red oak*

Identification

The first symptoms often include progressive dieback in the upper crown of the tree. Dieback symptoms can result from the effects of stress alone. Indeed, stress, if sufficiently severe or prolonged, can result in tree mortality. However, the continued decline and death of stressed oaks usually results from lethal attacks by Armillaria root rot, Hypoxylon canker, two-lined chestnut borers, and other insects. Final symptoms of oak decline primarily reflect the root-killing and stem-girdling effects of these organisms. In attacked trees, leaves sometimes fail to develop in the spring or wilt shortly after budbreak; sometimes they wilt or brown suddenly in the latter part of the growing season.

A characteristic of oak decline is that it may develop suddenly on many trees in the area affected by the initiating stress factor. Within the affected areas, however, decline and mortality occur in patterns, which may reflect the intensity and severity of the stress, the distribution of the hosts, the aggressiveness of Armillaria root rot, and the abundance of two-lined chestnut borers, coupled with site features such as poor or excessive soil drainage and frost pockets. Oak decline may become more apparent 2–5 years after the initiating stress factors occur.

Prevention

Oak decline is initiated by tree stress, which can disappear before effects are manifested. Practices to promote good tree health such as thinning to reduce stand density, regenerating stands as trees mature and maintaining tree diversity appropriate to the site can reduce the potential impacts of damage by oak decline.

Management

While it may be possible to improve the health and vigor of some declining trees, many of them are past the point of no return. The resulting spike in mortality and decline has and will continue to have a significant impact on the forest products industry.

Missouri's maturing red oaks need to be harvested in a short period of time to help reduce the threat of widespread oak decline. However there will always be some trees that do not get harvested before they die; these trees will still serve other useful purposes such as wildlife habitat.

Additional Information

USFS Oak Decline Forest Insect and Disease Leaflet: ***na.fs.fed.us/spfo/pubs/fidls/oakdecline/oakdecline.htm***

Managing Oak Decline. pub by University of Tennessee (at University of Kentucky): ***uky.edu/Ag/Forestry/extension/pub/pdf/for99.pdf***

Oak Wilt

Oak wilt is an aggressive disease that affects many species of oak (*Quercus* spp.). It is one of the most serious tree diseases in the Eastern United States, killing thousands of oaks each year in forests, woodlots, and home landscapes

Identification

Symptoms of oak wilt can look similar to other tree health issues, such as oak decline. Consider contacting a forester for assistance with identification or contact a plant diagnostic lab (***npdn.org***) for information on sample testing to confirm oak wilt.

Red Oak Group: The first symptom of oak wilt in red oaks is usually browning and wilting of leaves in the crown in early summer. Wilted leaves show olive drab or light tan to bronze tissue starting at the margins and progressing toward the leaf base. Brown or black streaking may be seen under the bark of wilted branches. Rapid defoliation and death of red oaks can occur within two to six weeks of initial infection.

White Oak Group: White oaks often exhibit scattered patches of wilt and leaf drop in the crown. Brown or black streaking may be seen under the bark of wilted branches. White oaks may take years to die from the infection.

Prevention

In areas where oak wilt occurs, avoid pruning or damaging oaks from mid-March through June. Use tree paint on wounds or storm-damaged areas during the spring infection period. Don't move untreated wood from infected trees to areas where oak wilt is not present.

Management

Overland Spread: In areas where oak wilt occurs, if healthy trees are wounded during the high risk period of mid-March through June, the wounds should be treated with a tree-wound paint to prevent sap-feeding beetles from feeding on them. Trees that have died from oak wilt can harbor mats of the oak wilt fungus. If this wood is moved, the fungal mats are moved and the disease may spread into unaffected areas. Small trees are less likely to produce fungal mats.

Trees that have died from oak wilt and have bark that is tightly attached to the wood could harbor fungal mats. This wood must receive special treatment before moving. In Missouri, trees are most likely to produce fungal mats the spring following tree death. Fungal mat production is unlikely beyond the year after tree death. In that case, no special treatment is necessary and movement of the wood is no longer a concern.

Underground Spread: This method of spread is less significant in Missouri than in some states. Disrupting root grafts can stop the underground spread of the fungus. Options include physically severing roots with a vibratory plow, cable plow, or trencher. Not all sites are suitable for this option; steep slopes prohibit the use of root barrier equipment, and sites with large rocks inhibit barrier placement. Locating barriers correctly is crucial to success. Guidance on barrier placement is available in *Oak Wilt Management: What Are the Options?* (University of Wisconsin–Extension Bulletin G3590) or consult an oak wilt management specialist.

STEVEN KATOVICH, USDA FOREST SERVICE, BUGWOOD.ORG

Figure 9.3. *Oak wilt*

Firewood: Two methods of wood treatment are effective in preventing overland spread via firewood:

1. Debarking the wood (removing the bark from the wood) will prevent the fungal mats from forming. Debarking must be conducted before fungal mats form; thus, it should occur in the late summer, fall, or winter following tree death.

2. Cutting, splitting, stacking, and covering the wood with 4 mil or thicker plastic will prevent overland spread. All sharp edges or stubs should be cut to eliminate the possibility of puncturing the plastic. The entire pile must be sealed all around. Seal the bottom by covering it with dirt, stones, or other heavy objects. If the wood is not burned over the winter following tree death, leave the tarp on through the next growing season (until October 1) or until the bark is loose. Once the bark is loose, the wood is no longer infectious.

Additional Information

O'Brien, J.G.; Mielke, M.E.; Starkey, D.; Juzwik, J. 2011. *How to Identify, Prevent, and Treat Oak Wilt*. Newtown Square, PA: USDA Forest Service, Northeastern Area State and Private Forestry. NA-FR-01-11. 38 p. Available at: ***na.fs.fed.us/pubs/howtos/ht_oakwilt/identify_prevent_and_control_oak_wilt_print.pdf***.

Nonnative (Exotic) Forest Health Threats

Bush Honeysuckle

Amur and Bella honeysuckle are exotic shrubs that thrive in shaded forest understory. They form a thick understory that limits sunlight to native plants and inhibits forest regeneration. They may produce a chemical that inhibits native plant growth. The fruit is not as nutritious for wildlife as the native plants it replaces.

Identification

Bush honeysuckles are easily separated from native honeysuckles by their stout, erect shrub growth. All native species are vine-like in nature.

Leaves are opposite, elliptical, and have a green surface with a pale green, slightly fuzzy underside. The leaves emerge early in spring and remain late in the fall.

In the spring, flowers are fragrant, paired, tubular, and 1 inch long with narrow petals. They may be white or pink but become yellowish as the plant matures.

The fruit matures in September to October. Red berries are produced in pairs near the origin of the leaves.

Prevention

Do not plant nonnative honeysuckles. Use native plants in landscaping. For suggestions of native substitutes visit the Grow Native website at ***grownative.org***.

Educate and coordinate with your neighbors to prevent spread as the seeds are primarily carried by birds and small mammals.

Management

Hand pulling can be used when the plant is small and the soil is moist. Don't use this method in sensitive areas because it disturbs the soil and aids in the spread of other invasive species.

The cut-stump method involves cutting the bush off at the stump and applying a 20 percent glyphosate solution to completely cover the cut area.

The foliar spray method involves spraying the leaves with a 2 percent solution of glyphosate and water plus a nonionic surfactant. Use this method in early spring or late fall when leaves of native plants are not present.

The basal-bark method consists of spraying a mix of 25 percent triclopyr and 75 percent horticultural or crop oil to the bush's stems. Thoroughly wet the bottom 12–15 inches of the plant.

Fire can be used when done safely and as part of a plan. Burn every spring, or every other spring, for several years in order to control re-sprouting.

Additional Information

Missouri Department of Conservation, Identification and Control: ***mdc.mo.gov/8243***

Plant Conservation Alliance Bush honeysuckle page: ***nps.gov/plants/alien/fact/loni1.htm***

Garlic Mustard

Garlic mustard is extremely invasive due to its prolific seed production. It out-competes native vegetation by spreading quickly and producing a chemical that inhibits other plants. The plant is unpalatable to wildlife.

Identification

First year: A rosette of green, roundish leaves about 4 inches off the ground that stay green throughout the winter.

Second year: A 2–3.5 foot tall flowering stem that has a distinctive "S" crook at the base. The leaves are alternate and triangular with the largest near the base. They have large teeth around the margins and are 2–3 inches wide.

Flowers begin to form in April, are clustered near the top of the stem, and have four white petals.

Fruit is a narrow, linear 1–2.5 inch green pod, produced from early summer through early fall.

Dead garlic mustard appears as long, slender seed stalks, with the seed pod turned upward

Prevention

Minimize disturbance of soil. Clean vehicles and equipment before moving from a known infestation site.

JIM RATHERT

Figure 9.4. *Bush honeysuckle*

MDC FILE

Figure 9.5. *Garlic mustard*

Management

New infestations and small populations: Hand pulling is effective if done before seed dispersal.

Other methods: Cut the plant just above the ground after the flower stalks have elongated but before the flowers have opened. Bag plants and deposit in a landfill (compost piles do not produce enough heat to kill the seed).

Chemical control: A foliar spray of 2 percent glyphosate can be applied to individual plants in the fall or early spring when native plants are dormant. Or, when non-target vegetation is dormant, apply 2,4-D or 2,4-D plus dicamba.

Control with prescribed fire: Annual burns in spring or fall could help control or reduce medium-to-large infestations. However, the effectiveness of fire differs based on site characteristics and burning conditions. Mistimed burns could actually encourage germination of seed.

No matter the method, control must be continued annually until the seed bank is exhausted. Seeds can remain viable in the soil for five or more years.

Additional Information

Missouri Department of Conservation: ***mdc.mo.gov/node/4946***

Emerald Ash Borer

Emerald ash borer (EAB) is a wood-boring insect that attacks all types of ash trees. It is a threat to native forests as well as urban trees. It has killed many millions of ash trees in Michigan, where the infestation was first discovered, and across the northeastern United States and eastern Canada. Ash makes up 3 percent of Missouri's forests but a much higher percentage in riparian and bottomland forests. The emerald ash borer has been detected in several locations in Missouri and has a statewide quarantine.

Identification

Look for signs of stressed ash trees: Canopy dieback beginning at the top of the tree and progressing until the tree is bare; new sprouts on the roots, lower trunk, or lower branches (known as epicormic sprouting); and vertical splits in the bark about 3–5 inches long.

Increased woodpecker activity may indicate the presence of EAB.

S-shaped galleries under the bark indicate larval feeding. Adults emerge from D-shaped exit holes one-eighth inch in diameter.

The adult EAB is bright, metallic green, and is a half inch long with a flattened back.

There are several native borers that feed on both healthy and stressed ash trees. Become familiar with EAB look-alikes (***emeraldashborer.info/identifyeab.cfm***).

If you find EAB, contact your local MDC forester or e-mail: ***forest.health@mdc.mo.gov***.

Prevention

Do not move ash material (firewood, nursery stock, logs) onto property. Buy only local firewood and burn it all.

Use appropriate forest management strategies to reduce your risk: Consult a forester, inventory the trees on your property to identify your ash resource, and develop a plan of action.

Management

Until EAB is found in the local area, continue current management practices. Practice sustainable forestry.

When selecting ash trees to remove, first select those that have low vigor and quality. You should maintain dominant and co-dominant ash trees with good health and form.

Know the risks of moving logs and firewood from and to your land. Become familiar with state quarantines and the associated regulations.

Landowners in quarantined areas should consult with a forester to determine whether their management practices should change due to a known EAB infestation.

Insecticide treatments are only recommended for high-value trees in areas with known infestations. Be aware that these treatments may provide only limited control.

Additional Information

Missouri Department of Conservation: ***mdc.mo.gov/node/5326***

University of Missouri: ***eab.missouri.edu***

U.S. Forest Service Pest Alert: ***na.fs.fed.us/spfo/pubs/pest_al/eab/eab.pdf***

National EAB website: ***emeraldashborer.info***

NOPPADOL PAOTHONG

Figure 9.6. *(a.) Emerald ash borer, (b.) D-shaped borer hole, (c.) Damage under bark*

Asian Longhorned Beetle

The Asian Longhorned Beetle (ALB) is a wood-boring insect that attacks a wide variety of hardwood trees. It will attack live, healthy trees. The first infestation was discovered in Brooklyn, New York, in 1996 after it arrived in wood crates and shipping material from China. ALB could have damaging impacts to forest ecosystems because of its wide host range, which includes maple, willow, birch, poplar, and elm.

Note: ALB is a potential threat. As of May 2014, established populations have not been found in Missouri.

Early Detection/Identification

The adults are shiny black with irregular white spots and are from three-quarters of an inch to an inch and a half in length, with antennae that are 1–2 times their body length. The antennae have alternating black and white bands.

Adults emerge from round exit holes three-eighths of an inch in diameter or larger.

Adult females chew bowl-shaped holes in the bark to deposit eggs. These egg niches are roughly the size of a dime and often are orange in color.

Larvae can be up to 2.4 inches long, fleshy, off-white in color, with many segmented body parts and brown mouth parts.

Infested trees may have "frass" or sawdust on the upper sides of branches or at the base of the tree.

There are native borers that can look similar to ALB, especially the cottonwood borer. Become familiar with look-alikes (***na.fs.fed.us/fhp/alb/ident_reporting/identifying.shtm***).

If you find Asian Longhorned Beetle, contact your local Missouri Department of Conservation forester or e-mail: ***forest.health@mdc.mo.gov***.

Prevention

While most of the infestations to date have been from wood crates and pallets entering the United States, the movement of wood (firewood, nursery stock, logs) is still a potential spread method. Don't move firewood. Buy only local firewood and burn it all.

Use appropriate forest management strategies to reduce your risk: maintain a healthy forest.

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Figure 9.7. *Asian longhorned beetle*

Control and Management

Until Asian Longhorned Beetle is found in the local area, continue current management practices. Practice sustainable forestry.

Because the majority of the beetle's life is spent inside the tree, pesticides are rarely effective.

The best method of control is cutting, then chipping or burning of infested trees.

If an ALB infestation is discovered, expect that a quarantine will be issued. Become familiar with the quarantine and associated regulations.

Additional Information

Missouri Department of Conservation: ***mdc.mo.gov/node/6134***
USDA: ***beetlebusters.info***
U.S. Forest Service Pest Alert: ***na.fs.fed.us/pubs/palerts/alb/alb_pa.pdf***

Gypsy Moth

Gypsy moth is a highly destructive, leaf-eating insect. It feeds on a wide variety of hardwood trees, but oak is one of its preferred hosts. When populations are high, the caterpillars can defoliate entire neighborhoods or forests of leaves. Repeated defoliations can stress trees, causing widespread mortality.

Note: Gypsy moth is a potential threat. As of May 2014, established populations have not been found in Missouri.

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Figure 9.8. *Gypsy moth larva (top) and Gypsy moth adults*

Identification

Look for tan-colored egg masses the size of a quarter or larger, and covered with tiny, fuzzy hair. Egg masses can be found on tree trunks and the underside of branches, as well as buildings, firewood, vehicles, boats, play sets, and other outdoor objects.

Caterpillars, or larvae, change appearance as they grow. Young caterpillars are black or brown and are about one-quarter inch in length. Mature caterpillars are as long as 2.5 inches and have pairs of blue and red dots along their back.

Adults are seen in midsummer. Males are gray-brown and can fly; females are white and cannot fly.

Egg masses are 1–2 inches in diameter, flattened, velvety brown masses.

Prevention

Inspect vehicles, trailers, and belongings for egg masses, larvae, and adult moths after visiting an infested state.

Use appropriate forest management strategies to improve forest health and tree vigor, so trees are more likely to survive if defoliation occurs.

Management

Early detection is the key to combating this pest. Should you find a suspect insect, collect a sample by trapping the insect in a zippered plastic bag. Place the bag in the freezer for several days to kill the insect. Contact your local MDC forester.

Management of gypsy moth requires an integrated approach that depends on the size of the infestation and the type of site where it is found (landscape vs. forested environment). Strategies may include the use of insecticides, mechanical control, and/or biological control organisms.

Additional Information

Missouri Department of Conservation: ***mdc.mo.gov/node/6146***

U.S. Forest Service leaflet: ***na.fs.fed.us/spfo/pubs/fidls/gypsymoth/gypsy.htm***

Missouri Department of Agriculture: ***mda.mo.gov/plants/pests/gypsymoth.php***

DIANE WARWICK, TN DIVISION OF FORESTRY

WHITNEY CRANSHAW, COLORADO STATE UNIVERSITY

Figure 9.9. *(a.) Black walnut trees with TCD symptoms, (b.) TCD canker with walnut twig beetle in gallery*

Thousand Cankers Disease of Black Walnut

Thousand cankers disease of walnut (TCD) is a recently recognized insect/disease complex affecting eastern black walnut, butternut, and other walnut species. Black walnut appears to be the most susceptible species, with eventual tree mortality. The disease is the result of the activity of the walnut twig beetle, which transports spores of a canker-producing fungus, *Geosmithia morbida*. As cankers expand and coalesce, the tree becomes unable to store and move nutrients, causing tree decline and mortality after several years.

As of May 2014, TCD has been found in five eastern states (North Carolina, Ohio, Pennsylvania, Tennessee, and Virginia) within the native range of black walnut, as well as nine western states (Arizona, California, Colorado, Idaho, Oregon, New Mexico, Nevada, Utah, and Washington). Evidence suggests the disease has been present in these locations for several years prior to detection, with the potential for the disease to have been transported to other locations on TCD-infected walnut materials. Walnut is the most valuable timber species in Missouri, and the economic impact to the state from a loss of walnut is estimated at $851 million dollars over 20 years.

Note: TCD is a potential threat. As of May 2014, established populations have not been found in Missouri.

Identification

In midsummer yellowing, wilting, and browning of foliage can be seen high in the crown. Leaves that wilt in midsummer often remain attached to twigs. Limbs die back, usually from the top downward.

New sprouts may grow from roots or trunk, leading to a "bushy" appearance below dead branches.

Removing outer bark from dying limbs exposes shallow dark brown cankers underneath. Tiny insect tunnels may also be present. Cutting too deeply removes cankers. TCD cankers occur only in the thin phloem layer immediately under bark in branches greater than one inch in diameter.

Signs of walnut twig beetles: The beetles are tiny, about the size of the letter "i" in the word "liberty" on a dime. It may be easier to find cankers and beetle tunnels under the bark than to find the beetles themselves.

Prevention

Don't bring walnut trees or untreated walnut wood into Missouri. While the rate of natural spread of this disease is expected to be slow, TCD spreads quickly when walnut wood containing the walnut twig beetles is moved to new locations.

Be aware of state quarantines. The current Missouri quarantine can be found at ***mda.mo.gov/plants/pests/TCDEmergencyRule.pdf***.

All walnut plants and plant parts as well as all hardwood firewood from TCD-infected states are now prohibited from entering Missouri. This includes nursery stock, budwood, scionwood, green lumber, and other material living, dead, cut, or fallen, including stumps, roots, branches, and composted and uncomposted chips. Exceptions are nuts, nutmeats, hulls, and processed lumber (100 percent bark-free, kiln-dried with squared edges).

Don't move firewood. Buy only local wood and burn it all.

Avoid stressing trees. Trees that are on suitable sites and are growing vigorously may resist some of the effects of TCD.

Management

Currently, no effective methods have been identified to control TCD successfully once it is established. The priority in Missouri is to delay the establishment of TCD and slow the spread of TCD in any areas where it is detected.

If you believe your walnut tree is infested with TCD, take photographs of the entire tree, close-ups of the leaves, and photos of any other symptoms. Contact your local MDC forester or e-mail ***forest.health@mdc.mo.gov***.

Additional Information

Missouri Department of Conservation: ***mdc.mo.gov/thousand-cankers***

A collaborative website between the Northeastern Area State and Private Forestry, the USDA Forest Service Northern Research Station, the Purdue University Department of Forestry and Natural Resources, the Hardwood Tree Improvement and Regeneration Center, the American Walnut Manufacturers Association, and the Walnut Council: ***thousandcankers.com***

U.S. Forest Service TCD Pest Alert: ***na.fs.fed.us/pubs/palerts/cankers_disease/thousand_cankers_disease_screen_res.pdf***

Feral Hogs

Feral or wild hogs are any swine that have escaped or have been released into the wild. Because of their feeding habits and their potential to spread disease, they cause significant damage to landscape, agriculture, and forestry lands as well as to native wildlife. Feral hogs compete directly with native wildlife for food.

Identification

Feral hogs can include an assortment of hybrids of domestic breeds as well as Russian and European wild boars. Any hog roaming freely on public or private land that is not conspicuously identified is considered feral.

They can be 3 feet in height and 5 feet in length, weighing up to 400 pounds. However, average size for a sow is 110 pounds and 130 pounds for boars.

Tracks are similar to deer but are more rounded.

Feral hogs can plow the soil to depths of 2–8 inches. The ground looks as if it has been plowed, and hogs can cover many acres in one evening.

Prevention

Report feral hog releases, sightings, or kills to your local conservation agent, the nearest MDC regional office, the state veterinarian's office (573–751–3377), or USDA Wildlife Services (573–449–3033).

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Figure 9.10. *Feral hog*

Management

Hunters afield for other game are encouraged to shoot feral hogs on sight.

Feral hogs may be killed in any number throughout the year. Special restrictions apply during the spring turkey and fall firearms deer and turkey seasons.

Resident landowners and lessees on land on which they reside may kill feral hogs without a permit.

Trapping can be done using corral-type traps. Assistance with trapping can be obtained from MDC.

Additional Information

Missouri Department of Conservation, Feral Hog Control: ***mdc.mo.gov/node/17158***

University of Missouri Extension: ***extension.missouri.edu/p/G9457***

Other Forest Health Threats

Extreme Weather Events and Climate Change

Weather can also have a significant impact on forest health. With advancing changes in global climate, variability in climatic conditions and frequency of extreme weather events are predicted to increase. Floods, droughts, wind events (i.e., tornadoes), late frosts and freezes, and ice storms impact tree health directly and indirectly. Direct impacts include tree mortality and damage, but increasing the stress on trees and forests can cause indirect impacts such as increased vulnerability to insects and diseases and changes in the structure of forests and the sites they grow on.

Large Animal Impacts

Large animals, both native and nonnative, can impact tree and forest health. Overgrazing by domestic livestock or high populations of white-tailed deer can be destructive to forests. They can compact forest soils and reduce herbaceous vegetation that wildlife rely on.

References to Other Chapters

- For best management practices to help slow the spread of invasive species during management activities see Chapters 12, 13, 14, 15, 16, 17, and 18.

Additional Resources

Missouri Department of Conservation. 1997. *Missouri Vegetation Management Manual*. Jefferson City, MO. 177 p. Available at: ***mdc.mo.gov/sites/default/files/resources/2010/05/5398_3326.pdf***. (contains links to *Missouri Vegetation Management Manual*)

nps.gov/plants/alien/ — Go to "Entire List of Completed Fact Sheets" and pick species that are presented in alphabetical order by Latin name. Clear, concise documents with photos, U.S. range maps, and control recommendations.

Bugwood.org — The University of Georgia Center for Invasive Species and Ecosystem Health. Extensive resource on forest insects and related topics.