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Native Forest and Woodland Management Guidelines for Nebraska's Wildlife Management Areas

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Chapter 1 - Introduction

This document is one in a four part series produced by the Nebraska Game and Parks Commission to provide direction to managers of Wildlife Management Areas (WMAs) in Nebraska. Other documents in the series cover management of grasslands, wetlands, and early successional habitats.

Prior to Euroamerican settlement wildfires, drought and competition with prairie grasses limited the presettlement distribution of trees in Nebraska to well-watered and somewhat fire protected river valleys and rocky escarpments. At that time, wooded habitats covered about 2 percent of the Nebraska landscape. Though limited in areal, these communities were diverse and supported important components of Nebraska's biodiversity. Since settlement Nebraska's forests and woodlands have suffered serious decline. Fore example, nearly all of the riparian woodlands along the now channelized stretch of the Missouri River have been lost to development. Remnant wooded habitats are threatened by logging, invasive plants, overgrazing, catastrophic wildfires (coniferous woodlands only) and fragmentation from development. Only through sound management can the native forests and woodlands on our WMAs be conserved.

This document is directed towards management that maintains and enhances the ecological quality and biodiversity of native woodlands on WMAs. Though plant community based, the management objectives promoted within this document will provide benefits for wildlife, including game species.

The specific objectives of this document are as follows:

1) Develop a philosophy of forest and woodland management to be used by WMA managers.
2) Provide background of information on the need for and benefits of sound woodland management.
3) Provide information that will help WMA managers identify forest and woodland types and their quality.
4) Provide information on woodland management techniques.
5) Provide minimum management requirements and management options for forest and woodland types on WMAs.

Forest and Woodland Definition

Woodlands are plant communities with a tree layer >5 m tall with 10 to 60 percent canopy cover. The tree cover is often discontinuous and clumped. The lower canopy branches are widely spreading, visibly longer than those of forest trees, and may originate halfway up the stem. Nearly always only one layer of woody plants is prominent in woodlands. Woodlands often have groundlayer dominated by prairie grasses and plants adapted to semi-shaded conditions. Stands with 10 to 25 percent tree canopy cover are often referred to as savannahs. In this document such stands are included in the woodland category. Herbaceous plant communities with less than < 10 percent tree cover are classified as grasslands.

Forests are dominated by trees > 5 m tall with > 60 percent cover. The canopy of most forest trees are not widely spreading and are confined to the upper third of the stem. At least, two layers of woody plants are nearly always prominent in forests including a layer of tall shrubs. Forests have a groundlayer dominated by shade-tolerant plants.

Technically forest and woodland are two distinct community types as defined above. However, for the sake of brevity the term "woodland' or "wooded habitats" will sometimes be used in this document as a general term to include both forest and woodland communities. This guide deals only with native woodlands and forests. Planted woodlots and shelter belts are not covered by this guide.

Forest and Woodland Types

Nebraska's forests and woodlands can be classified as three broadly recognized types: 1) upland deciduous forests and woodlands, 2) riparian deciduous forests and woodlands, and 3) coniferous forests and woodlands. This document contains chapters discussing the ecological characteristics and management needs of each type. For purpose of management planning on WMAs, these three types have been further divided into six systems: 1) upland deciduous forests, 2) upland deciduous woodlands, 3) eastern riparian forests/woodlands, 4) western riparian forests/woodlands, 5) coniferous forests, and 6) coniferous woodlands. System descriptions, quality rankings and management guidelines are provided in Chapter 6.

Upland Deciduous Forests and Woodlands

In Nebraska, upland deciduous forests and woodlands generally occupy high stream terraces, bluffs and ravines in the eastern portion of the state and are most abundant within the mesic valleys of the Missouri River and the lower reaches of its tributaries including those of the Elkhorn, Nemahas, Niobrara, and Platte rivers. More fire- and drought-tolerant bur oak-dominated woodlands extend westward into central Nebraska along stream valleys.

Upland deciduous forests generally occur on mesic bottoms and lower and mid slopes, but often extend upslope on north- and east-facing slopes. Deciduous forests often merge with bur oak woodland or tallgrass prairie on drier upper slopes. Dominant canopy trees in Nebraska's upland deciduous forests include red oak, black oak, bur oak, bitternut hickory, shagbark hickory, black walnut, hackberry, green ash, and basswood. Dominant understory trees include redbud, ironwood, elms, red mulberry, hackberry, and green ash

A multi-layered tree structure, diverse tree species, and shaded, mesic conditions are important habitat features of Nebraska's deciduous forests. Many native plant species are adapted to this habitat and some of the rarer ones include the yellow lady's-slipper orchid, coral-root orchids, and ginseng. Many animal species also dependent on this habitat and rarer ones include the cerulean warbler (tall, uneven canopy with gaps) and southern flying squirrel (large mast producing trees).

Many of the south-facing, west-facing, and upper slopes in eastern Nebraska stream valleys support oak woodland and savannah. These woodlands often merge with forests on lower slopes and frequently merge with tallgrass prairie on upper slopes. Bur oak is the dominant tree species in these woodlands, though chinkapin oak, bitternut hickory, honey locust, hackberry, green ash, and eastern red cedar can also be prominent.

A single tree layer of few species and semi-shaded conditions are important habitat features of deciduous woodlands. Rarer plant species dependent on this habitat in Nebraska include pale Indian-plantain, mullein foxglove, frostweed, and narrow-leaf

pinweed. Rarer animal species dependent on this habitat include the southern flying squirrel and red-headed woodpecker.

Cessation of wildfires since Euroamerican settlement has caused many oak-dominated woodlands and savannah to succeed to forest types. These stands are now dominated by relatively young trees and have a poorly developed herbaceous groundlayer.

Riparian Forests and Woodlands

Riparian deciduous forests and woodlands occur on the floodplains and low terraces of rivers and their larger tributaries throughout the state, though, prior to Euroamerican settlement they were most abundant in the valleys of the Missouri River valley and the lower reaches of its primary tributaries including the Elkhorn, Nemahas, Niobrara, and Platte rivers. These communities were often dependent on flooding for their establishment and stream hydrology, sedimentation, and erosion played key roles in their development and succession.

Riparian forests and woodlands often occur interspersed with other plant community types including wet meadows, marshes, shrublands, and sandbars. Cottonwoods are often the dominant canopy tree in riparian forests and woodlands, especially in younger woodlands and on frequently flooded sites. Peachleaf willow, box-elder, hackberry, green ash, honey-locust, and American elm can also be prominent in the canopy, but more often as subcanopy trees, especially on sites where the flood frequency and duration are less. Wet swales in floodplain forests in eastern Nebraska often support silver maple

Relatively few at-risk plant species occur in riparian woodlands and forests. A few that do occur in this habitat include green dragon, hop sedge, and eastern star sedge. At-risk animal species dependent on riparian woodlands include Bells; vireo, bald eagle, and timber rattlesnake.

Coniferous Forests and Woodlands

Coniferous forests and woodlands occur in the Pine Ridge, Wildcat Hills, and other smaller rocky escarpments in western Nebraska and extended eastward along the Niobrara River valley to central Nebraska. Historically, these steep, rocky escarpments were somewhat fire-protected allowing the pines to survive there. Ponderosa pine is the most common tree in these woodlands, though Rocky Mountain juniper and eastern red cedar sometimes occur as subdominants. Limber pine occurs in one small area of Kimball County. In some coniferous forests deciduous trees, especially green ash, American elm, and boxelder, occur as scattered individuals.

Nebraska's coniferous forests generally occur in mesic canyon bottoms and on lower east- and north-facing slopes. Prior to settlement, forest stands were most prominent in the Pine Ridge and occurred to a limited extent in the Wildcat Hills and central Niobrara River valley. Coniferous forests often merge with pine woodlands or mixedgrass prairies on drier mid and upper slopes. In forest stands, a single canopy layer of pines is often present, though other trees may form a subcanopy. A tall shrub layer is often present and is usually dominated by chokecherry. The groundlayer is dominated by shade-tolerant species and can be sparse where the tree canopy is dense. Relatively few native plant species are dependent on pine forests in Nebraska, though some of the rarer

species include spotted coral-root and rattlesnake-plantain orchid. Rare animal species dependent on this habitat include the western tanager and blue-gray gnatcatcher.

Prior to settlement, many south-facing and west-facing slopes, upper slopes and ridgetops of the western escarpments supported pine woodland and savannah. The woodlands sometimes merged with pine forests on lower slopes and usually merged with mixedgrass prairie on upper slopes. Small to large patches of mixedgrass prairie and rock outcrops were intermixed among the coniferous woodlands.

A single tree layer of ponderosa pine, sometimes with a subcanopy of cedars, is characteristic of pine woodlands. These woodlands were semi-shaded to open. More open stands had a groundlayer dominated by mixedgrass prairie species, while denser stands also contained woodlands species in the groundlayer. Rarer plant species dependent on pine woodlands include white-scaled sedge and pinedrops. Rarer animal species dependent on this habitat include pinyon jay and Lewis's woodpecker.

Cessation of wildfires since Euroamerican settlement has caused many pine woodlands and savannah to be heavily invaded by young pines. These stands often have a sparse herbaceous groundlayer lacking species diversity.

Threats to Nebraska's Native Forests and Woodlands

Many of Nebraska's native forests have been lost to agricultural and other development. For example, most of the native riparian woodlands in southeastern Nebraska have be cleared and converted to cropland. However, wooded habitats in many parts of the state have expanded since settlement. For example, pine forests and woodlands in the western Nebraska are likely more extensive due to fire suppression than prior to settlement. Today, however, high quality woodlands are rare. Most of Nebraska's native woodlands were heavily logged following settlement and many were heavily grazed. The natural hydrology of most riparian woodlands has been altered since settlement. Most of Nebraska's remnant native forests and woodlands are in fair to poor ecological condition, though some high quality sites remain.

The small size, isolated nature of many native wooded habitats and loss of natural processes has resulted in increased edge effects, invasion of non-native plants, and loss of species diversity. A primary objective on WMAs is to mitigate threats and stresses to remnant native woodlands so that their ecological quality and habitat values can be maintained and enhanced. The primary existing threats and stresses to Nebraska's native forests and woodlands are listed below:

1) Commercial logging – Logging occurs in woodlands in areas, most prominently in pine woodlands in the Pine Ridge, but also occasionally in other woodland types. Logging often destroys the natural stand structure of woodlands, causes soils erosion, disturbs the groundlayer vegetation, and sets the stage for exotic species invasion. Commercial logging can cause long-lived decreases in herbaceous layer cover and diversity in deciduous forest (Duffy and Meier 1992). Other studies have found that forest understories to recover rather quickly from logging (Gilliam 2002).
2) Cattle grazing – Cattle grazing can be detrimental in many deciduous woodlands and forests causing soil erosion, soil compaction, reduced reproduction of desirable trees, damage to tree roots making them susceptible to insects and disease, and

reduced density and diversity of ground layer plants. In open woodland communities with native a graminoid groundlayer proper grazing can have beneficial affects.

3) Excess deer browsing - Excess deer browsing is detrimental in many Nebraska deciduous woodlands resulting in reduced density and diversity of ground layer vegetation, limit tree reproduction and spread of invasive species (e.g. garlic mustard). Excessive deer browsing weakens native vegetation giving a competitive advantage to exotic species. Deer can also be agents of seed dispersal for exotic plants.
4) Lack of fire – Suppression of wildfires has resulted in an abundance of young trees in many coniferous and deciduous woodlands and the conversion of many grasslands to young forests. In addition, lack of fire in once-open woodlands has resulted in denser canopies, establishment of a dense mid-story, an increased shrub layer, reduced sunlight reaching the groundlayer, and litter buildup. In deciduous habitats, these conditions generally favor weedy shrubs, such a rough dogwood and prickly ash, and lead to an increase in shade-tolerant tree species, such as hackberry and elms. Seedlings of shade-intolerant tree species, such as oaks, rarely establish under such conditions and without the return of fire, and possibly thinning, these species may eventually be lost from our woodlands. Many shade-intolerant groundlayer plants have also declined in abundance in both coniferous and deciduous woodlands due to fire suppression. Long-term fire suppression can cause soil erosion and loss of the seed bank.
5) Fragmentation - Many of Nebraska's native forests and woodlands have been logged or cleared and converted to cropland or development leading to fragmentation and increased edge effects. Small forest patch size can affect the nesting success of size-dependent bird species and can lead to increased nest predation and parasitism. Small patch size can lead to microclimate changes within forests, such as increased temperatures due to warm summer winds entering the forests, leading to changes in plant species composition. Isolated woodlands have a greater chance of species loss through genetic inbreeding and stochastic events.
6) Invasive species – Invasive species, including trees, shrubs and herbaceous plants, compete with and displace native vegetation and degrade wildlife habitat. In addition, control of exotic species, such as tree thinning or herbicide spraying, can damage native vegetation.
7) 7) Intense recreational use - Intense use from all terrain vehicles (ATVs) and horseback riding can cause soil erosion and disturb groundlayer vegetation in woodlands.
8) Altered natural hydrology - In riparian woodlands alteration of a floodplains natural hydrology, primarily change in the natural flood regime and reduced groundwater levels, can disrupt natural tree regeneration, alter the native plant composition and promote exotic plant invasion.

Chapter 2 – Philosophy and Principals of Forest and Woodland Management on WMAs

Management Philosophy

Management philosophy can be as important to sound forest and woodland management as choosing the proper management technique. The management philosophy for native wooded habitats on WMAs should include the following considerations:

1) Forest and woodland management is a long-term process - Woodland management is a long-term process, though some management objectives, such as reducing surface fuels, can be accomplished in a relatively short time. Some management objectives, such as reducing tree densities and enhancing groundlayer vegetation, may take longer time frames. For example, one burn may not be effective in accomplishing these objectives, it may take several burns. Choose management strategies that accomplish both short-term and long-term objectives.
2) Set objectives for each woodland - Management progress and effectiveness can only be measured if objectives have been set. These should be quantifiable and timed-based, such as reduce surface litter by 50 percent in three years or raise the woodland quality from Grade C to Grade B in 5 years.
3) Use adaptive management – Adaptive management is simply the process of setting objectives, taking action, measuring progress, then adjusting objectives and strategies. Once management plans are implemented they need to be regularly evaluated over a period of years to see if objectives are being met. Frequently altering management plans in response to short-term goals or perceived problems is not adaptive management.
4) Use prescribed fire as the tool of choice – Fire was a natural component of all Nebraska forests and woodlands. Prescribed fire should be used as the first tool of choice to thin tree densities, reduce fuel loads, to enhance groundlayer vegetation and to achieve other objectives. Prescribed fire is less costly than tree thinning, causes less soil disturbance and leaves fewer fuels on the ground. In certain situations, tree thinning may be necessary, for example, thinning eastern red cedars from oak woodlands prior to prescribed fire to prevent scorching of oaks or thinning small pines prior to burning to prevent crowning.
5) Be flexible and use diverse management if needed – To meet management objectives, managers must sometimes use a variety of management practices and be willing to change the timing, frequency and intensity of practices. Diverse management and timing of management can promote both species diversity and structural diversity. Though prescribed fire is the key management tool for Nebraska woodlands, other management tools, such as planned grazing, tree thinning and herbicide use, may have practical rolls in certain woodland management situations.
6) Knowledge of woodland plants – A knowledge a woodland plants is vital to sound management. Native woodland plants, and well exotics, are indicators of woodland condition and management needs. Changes in condition, both good and bad, will be reflected in a woodland's plant species composition. Also, many woodland

plants are especially beneficial to wildlife, for example, providing good browse or nesting habitat. At-risk plant species may also be management priorities and managers must be able to identify these in the field.

7) Make woodland management a priority - Work loads are also high for WMA managers and to accomplish objectives woodland management will need to be made a priority task. Much time and effort can be put into management planning, but if time is not allocated to on-the-ground woodland management this effort will be in vain. Annual review of all management plans will ensure plans are being adequately followed. Protecting and enhancing high quality natural areas on WMAs is a directive of the Nebraska Natural Legacy Plan and management funds need to be directed to management of the our highest quality woodlands. Managers should prioritize management on the highest quality forests and woodlands.
8) Knowledge of woodland management techniques - Expertise in woodland management techniques is essential to accomplish sound ecological results. Unfortunately, many land managers are unfamiliar with woodland management practices. For example, many managers have little experience in burning coniferous woodlands. Providing staff training or access to individuals with high levels of knowledge in woodland management, or hiring knowledgeable individuals will be necessary.

Guiding Ecological Principals

Guiding principals are general rules agreed upon by WMA managers to guide management of native forests and woodlands on WMAs. Individual guiding principals may not apply to all management situations. For example, it is not feasible to emphasis large-scale management in a small woodland. Mangers are to follow these guidelines where applicable during woodland management.

1) Manage for native plant and animal species diversity – A diversity of native plants provides habitat and food for a greater variety of wildlife species. Diverse woodlands are also more resilient to invasive species and other disturbances. Reducing exotic species and providing variability in the timing and intensity of management within a management unit generally allows for the greatest plant diversity. Avoid uniform management at the same time each year as this can lead to the dominance of specific plant species. Lack of management is likely a cause for loss of species diversity in many WMAs.
2) Restore natural disturbance regimes (fire, grazing, flooding) – Native plants and wildlife are best adapted to natural disturbance regimes. Managers will promote the greatest plant and animal diversity if natural disturbance regimes are restored. Fire was an important disturbance in nearly all of Nebraska's native forests and woodlands. Occasional large ungulate grazing occurred in more open woodlands with a graminoid groundlayer. Riparian woodland establishment and succession was closely tied to flooding and factors of stream hydrology. In many situations it may be difficult to restore a natural flooding regime and hydrology to riparian woodlands.

3) Recreate natural community mosaics while limiting fragmentation – Many coniferous and deciduous wooded habitats in Nebraska naturally occurred as mosaics of forest, woodland and prairie. Maintaining this natural mosaic of communities will provide the greatest diversity of habitats for native plants and wildlife. Managers must take precautions to avoid over fragmentation of wooded habitat during management as many woodland wildlife species, including many bird species, are patch-sized dependent. In Missouri, it is recommended that old-growth deciduous forests should be at least 15 contiguous acres in size with a minimum width of 200 feet to meet the needs of most old growth forest interior species (Missouri Department of Conservation and US Forest Service 1986). Woodland and forest management requires a balance between maintaining habitat mosaics and edge and maintaining sufficient habitat patches for patch-size dependent species.
4) Manage for old-growth stand characteristics – Managers should strive to restore old growth stand characteristics to woodlands and forests (these are described for deciduous woodlands in Chapter 3 and for coniferous woodlands in Chapter 5). In general, old growth woodlands provide habitat for a greater diversity of species and are required by many specialist species.
5) Restore natural communities – At times converted habitats can be restored to native plant communities and provide ecological benefits. For example, buffering small, high-quality woodlands with native tree plantings can provide buffers and prevent edge effects. Planted woodlands can also serve as corridors between blocks of native woodlands. Restore or allow nonnative areas (e.g. crop fields or old fields) within native woodlands and forests to succeed to wooded habitats or plant these to native woodlands or grasslands.
6) Emphasis large-scale management – Where possible provide for large scale-management, especially with regard to prescribed fire. Large- scale management is more efficient, cost-effective and allows more management to be accomplished than small-scale management.
7) Control invasive species – Manage woodlands to have as few exotic species as possible. Use ecological sensitive methods of control.
8) Manage for at-risk species where present – Where present on WMAs at-risk species should receive management consideration. Their habitat can often be improved by managing at the plant community level.
9) At times, manage for specific wildlife habitats - In situations, it may be desired to improve native woodlands as habitat for specific wildlife species. In many cases habitat for most wildlife species can be improved through community level management.
10) Reduce the threat of catastrophic wildfires (coniferous ecosystems only) - Catastrophic wildfires are becoming more frequent in Nebraska's coniferous woodlands has fuels accumulate. Climate change is predicted to provide conditions under which catastrophic wildfires become even more frequent. Catastrophic wildfires threaten human lives and property, and can also destroy pine forests and woodlands. Restoring natural community mosaics and reducing fuel levels through prescribed burning and thinning can reduce the threat of catastrophic wildfires.

Quality Grades

A first step in wooded habitat management on WMAs is to map all native forests and woodlands and assign them condition grades. The condition grades will facilitate management decisions and planning (see below). Native woodland condition is based on several characteristics including tree composition and age, native groundlayer plant diversity and abundance, abundance of invasive species, and in riparian systems the intactness of the natural hydrology. Detailed criteria for ranking each Nebraska woodland and forest type is provided in Chapter 6. Condition grades range from A through D, with Grade A woodlands and forests being in the best ecological condition, and Grade D communities being the most highly disturbed.

Levels of Improvement

In situations it is possible to improve a woodland's or forest's condition grade through long-term management. In most cases, however, in the foreseeable future, it is unlikely a woodland's condition can be improved more than one condition rank as components of it is plant diversity and structure may have been lost or highly modified. For example, it may be possible to convert a Grade C woodland to a Grade B woodland, but likely not to a Grade A woodland. Management objectives for all woodlands should include improving the condition grade. Some Grade D woodlands may be so degraded, for example, invaded by exotics and lacking native plants that it is not possible to improve their condition. For Grade A woodlands the goal should be to maintain the site's present condition.

Chapter 3 - Upland Deciduous Forest and Woodland Ecology

Need for Management

Nebraska's presettlement forests and woodlands experienced and were well-adapted to disturbance. All of Nebraska's upland deciduous woodlands experienced fire. Some wooded habitats, however, occurred in areas, such as moist bottoms and low slopes, which burned with less frequency and intensity than surrounding grasslands.

Open woodlands with grass-dominated groundlayers were likely grazed by bison and other large undulates. Dense canopied forest lacking a grass-dominated groundlayer likely received less grazing pressure than the open woodlands. However, in the central Niobrara River valley, during early spring and late fall, bison are attracted to native cool-season graminoids growing in dense-canopied deciduous forests.

Nebraska's upland deciduous wooded habitats are most often associated with river valleys and breaks occurring as a mosaic of forest, woodland and prairie. Moisture conditions and fire, and to a lesser extent grazing, defined formation of the mosaic. These woodland/grassland mosaics provided a more diverse vegetation structure and diversity than the individual community types alone. The variety and interspersion of habitat may have increased wildlife diversity. With settlement and the cessation of wildfires tree cover and densities have increased dramatically in Nebraska deciduous woodlands. Most of the once open oak and hickory-dominated woodlands have succeeded to dense stands with an abundance of shade-tolerant, fire-sensitive species, such as elms and hackberry. Furthermore, the fire-adapted oaks are not regenerating

under the now dense canopies. The adjacent prairies are also being invaded by fire-sensitive trees.

Cessation of wildfire and expanded tree growth has simplified the presettlement the forest, woodland, and prairie mosaic to a mainly young forest and prairie system with loss of vital intermediate open woodlands. The shift has also resulted in a decline of open woodland- and edge-dependent species, such as northern bobwhite and purple milkweed. This change in woodland structure and composition has likely led an overall loss of both native plant and animal diversity.

The loss of oaks in particular may have severe consequences for wildlife as acorns make up a substantial portion of the diet of many species including turkeys, white-tailed deer, white-footed mice, squirrels, northern bobwhite, woodpeckers, and tufted titmouse among others (Sullivan 1995). Many cavity nesting species are also dependent on oaks. Packard (1993) stated that many animals dependent on oak savannah and open woodlands, including the Cooper's hawk and silvery blue butterfly, are declining due to fire suppression.

Fire in Upland Deciduous Forests and Woodlands

As mentioned, fire was historically an important disturbance in Nebraska's upland deciduous forests and woodlands. Presettlement fire frequency in deciduous woodlands likely varied with climate and Native American population densities with more frequent fires as human populations increased. The fire frequency in Missouri woodlands increased between 1850 and 1890 and Euroamerican settlement (Guyette et al. (2002). After 1890, land use changes, such as agriculture, and road development, and active fire control greatly reduced fire frequency in Missouri woodlands. The same trend likely holds true for Nebraska's deciduous woodlands.

Prescribed fire, often in combination with silviculture practices, has been advocated to restore natural fire regimes, structure, and species composition to oak-dominated woodlands and savannahs (Artman and others 2005). Most prescribed fires in deciduous woodlands are conducted in early spring before leaf out and in fall after leaf fall. Single low intensity fires have been found to cause little direct mortality to overstory trees (Brose and Van Lear 1999), however repeated fires may cause more mortality in large trees (Huddle and Pallardy 1996). Hartman and Heumann (2004) observed in the Missouri Ozarks that many of the large trees that died from prescribed fire were the results of fire entering existing wounds, such as cavities and hollow trees. Drought can influence the severity and frequency of fire in deciduous woodlands by reducing fuel moister levels resulting in more severe fires. In addition, drought stressed trees are more susceptible to pathogens after fire wounding and sprout less vigorously after top-killed.

Intense fires, such as those with abundant eastern red cedar in the undertory, can top-kill mature oaks. Also, trees on exposed slopes and at the heads of draws and ridges where fire intensity are the greatest are more prone to be killed. Younger top-killed oaks generally resprout, however larger oaks generally do not resprout when top-killed.

Repeated fires, for several consecutive years, are likely necessary to significantly reduce the density of shade-tolerant shrubs and young trees in deciduous woodlands. Species such as rough dogwood resprout after fire and several years of fire are needed to eventually weaken and kill plants.

On the forest floor, prescribed fire generally increases herbaceous plant cover (Hutchinson and Sutherland 2000 and Hartman and Heumann 2004). In the Ozarks, the biggest increases in herbaceous coverage were by legumes, grasses, and sedges. Fire also increased flowering and seed production in grasses, sedges and forbs. In an Iowa study, prescribed fire in oak woodlands resulted in an increase in flowering of forbs and reduced weedy woody species, such a prickly ash and black locust. Low intensity, spring fires often result in modest release of herbaceous plants. Apfelbaum and Haney (1987) found that intense fall burns provided the greatest release of ground layer vegetation and oak seedling regeneration.

Short-term studies in deciduous forests have shown prescribed fires to either improve the competitive status of oaks or have a neutral effect (Artman and others 2005.). These authors also state that the combination of prescribed fire and overstory thinning have shown both positive and negative effects on oaks. A key factor for oak regeneration is that the fire-free interval must eventually be long enough for oak seedlings to develop a degree of fire resistance. Vankat (1979) stated that bur oak sprouts not burned for 12 to 15 years grow large enough to survive most fires. Oak regeneration is often dependent on fire to reduce leaf litter that impedes acorn germination, thin competitive groundcover and understory species, stimulate clonal sprouting, and inhibit the activity of acorn predators and tree pathogen and pests (Courteau and others 2006). Stan and others (2006) found in woodlands with a well established understory low to moderate intensity burns at infrequent intervals are ineffective at removing competition and stimulating oak regeneration. A study in northwestern Ohio, found that five successive annual burns following understory thinning stimulated oak regeneration (Sekura and others 2005). Intense, frequent burns will likely be necessary in the early stages of restoring Nebraska's deciduous woodlands, but later in the process, longer fire return intervals may be necessary to allow oak seedlings to mature. It is hypothesized that large oaks in an old-growth forest in southeastern Ohio established following one or more large-scale disturbances, either fire or windstorm.

Most research regarding the impacts of deciduous woodland fires on wildlife deal with birds. Artman and others (2005) provide of summary of these research results from which the following information was derived. In Indiana, low intensity surface fires in forests resulted in reduced populations of several ground or low shrub nesting species including ovenbirds and northern cardinal. Populations of eastern wood-pewee and American robin increased in response to fire in southern Ohio as the burning may have improved their foraging habitat by creating a more open understory. The authors also stated that burning may increase food accessibility for ground foraging birds, including wood thrushes, ovenbirds, northern bobwhite and turkeys, by removing litter, brush and dense vegetation. Populations of mid-canopy and canopy nesting birds, including the Cerulean warbler (a Nebraska Tier 1 species), were unaffected by low intensity fires in southern Ohio.

In Minnesota, where prescribed fire was applied to restore savannahs open-country and disturbance tolerant species including red-headed woodpeckers, eastern bluebirds, and brown thrashers increased in abundance. Open woodlands and early successional habitats in deciduous forests tend to exhibit earlier bud break and flowering

and presumably have greater arthropod abundance than closed canopy forests, which are weeks later in phenology and may provide better foraging for migrating birds

Prescribed fires in deciduous woodlands and forests can be conducted from mid-fall after leaf drop through winter if dry conditions prevail. Spring fires can be conducted as soon as the ground dries and preferably before wildflowers break dormancy in early April. Fall burns are most effective after the drop of oak leaves in late October or early November. As mentioned, consecutive annual burns may be most effective. Once management objectives are met, for example oaks start to regenerate, exotic plants decline or native plants increase burning can be done less frequently. Deciduous woodland and forest burns are generally patchy and therefore, there is little fear of burning large areas or burning in consecutive years will harm insect populations or other fire sensitive wildlife.

In wooded habitats, once trees leaf out heat from prescribed fires can be trapped under the tree canopy causing considerable damage to trees including old individuals (Hartman 2005). On steep sites with little herbaceous ground cover there is sometimes concern that fall burns will expose the site to winter soil erosion. Generally this should not be a concern in Nebraska, however, if fall burns are conducted during leaf drop the residual leaves will provide some erosion control over winter until the herbaceous layer can respond. Fall fires after leaf fall provide hotter more continuous fires than early fall or spring fires. Summer fires can be more effective controlling invasive woody species, however to be successful, woody canopy cover needs to be less than 50 percent otherwise fuel moisture will generally be too high to burn. Sufficient plant litter must also be present to carry such a fire.

Removing unwanted trees larger than 4 to 5 inches diameter breast height (dbh), such as hackberries or elms, with fire requires a fire intensity likely to damage the residual stand and such a fire may be difficult to control (Hartman 2005). If killing such larger trees is an objective, mechanical harvest, felling, or deadening can be used before burning. In situations a delay of a few years between initial and follow-up burns may be required to allow herbaceous layer to develop and better carry fire. When dependent on oak leaf litter to carry the fire this will not be the case. The possibility exist that exotic plants will spread into recently cut or burned areas and managers should consider exotic control when developing management plans.

Silviculture in Upland Deciduous Forests and Woodlands

Mature, high-quality deciduous forests and woodlands in Nebraska are becoming increasing rare and should not be commercially logged. Harvesting mature trees causes long-term damage to woodland structure. The use of logging equipment often spreads the seeds of invasive plants such as garlic mustard. Also the ground disturbance of logging can promote weedy plants and damage native vegetation. If logging does occur machinery should be thoroughly cleaned before entering an area.

If shade-tolerant and invasive trees, such as hackberry or eastern red cedar, are dense and of such size that fire alone will not kill them, cutting or thinning will likely be necessary. Machinery may be used, but it should be done at a time of year, preferably winter, when there will be the least damage to soils. In in-accessible or on steep slopes hand cutting may be necessary. Stumps of cut trees should be treated with an appropriate herbicide to prevent resprouting. Another method of controlling unwanted

trees is to apply herbicide to the cambium without felling. Often referred to as "hack and squirt" the bark of standing trees is cut or slashed with an ax and herbicide applied to the cut. These trees can be left standing. Dead trees will fall within a few years.

In stands with a dense cedar understory, fires can burn cedar crowns killing desirable deciduous trees. Where dense, cedars may need to be cut and placed a needed distance from desirable trees. Where cut and dried cedars burned adjacent to large oaks on a burn at Rock Glen WMA in Jefferson County many larger oaks were killed. The majority of these large oaks did not resprout, however many smaller oaks resprouted providing the first oak regeneration on the site in decades.

Grazing in Upland Deciduous Forests and Woodlands

In presettlement savannahs and open woodlands with grass or sedge-dominated groundlayers at least occasional bison and other large ungulate grazing likely occurred. Similar to surrounding grassland types, planned grazing can be used in such habitats to reduce litter levels, control some exotic plants, promote native plant diversity and provide structure suitable for wildlife. However, cattle tend to concentrate in shaded areas and cattle grazing can cause extensive damage to deciduous woodlands and forests. Deciduous forests and denser woodlands should not be grazed. Open woodlands with a grass or sedge-dominated groundlayer can be grazed with caution using methods acceptable for surrounding grassland types.

Old Growth Deciduous Woodland Characteristics

Most of Nebraska's upland deciduous forests and woodlands have been logged in the past removing many of the larger trees. In addition, fire suppression since settlement has promoted an increase in young trees. These factors have lead to a dominance of younger trees in our deciduous forests and woodlands. A more desired ecological condition for woodlands and forests under conservation ownership or management is old-growth structure. Old-growth forests and woodlands are superior habitat for native plants and wildlife than young stands. They are heterogeneous, have living and dead trees, snags, cavities and downed logs for wildlife. Old growth woodlands have greater plant and wildlife diversity and provide habitat for more specialist species than young forests.

The Missouri Department of Conservation and US Forest Service (1986) have defined old-growth conditions for Missouri's deciduous forests. In Missouri approximately 100 to 250 years are required to reach old-growth status in deciduous forests depending on the longevity of selected tree species. Old growth stands have dominant trees with an average dbh of at least 14 inches. Some wildlife species require trees with a dbh of at least 20 inches. Many old-growth characteristics only begin to appear when stands reach 100 years of age. The authors also list seven additional characteristics that old-growth forests may exhibit:

1) a wide range in tree height and age
2) a diverse dominant tree species composition
3) a multi-layered canopy
4) various degrees of understory density ranging from open to dense
5) various degrees of herbaceous ground cover
6) increased percentage of shade-tolerant trees
7) large logs in streams and drainages

The authors further state that for wildlife, woodlands and forests should contain dead trees (snags) at least 6 inches dbh which are at least ten feet tall. Some wildlife species require snags at least 20 inches dbh. Furthermore, some species require old snags (soft snags) while others require recent snags (hard snags).

Plant species composition in old growth woodlands and forests should include both shade-tolerant and shade-intolerant species. The vertical stratification of the canopy will mainly determine the bird community present. Some forest interior species, such as the cerulean warbler and ovenbird, require closed canopies with an open understory. Some species, such as the wood thrush and red-eyed vireo, prefer multi-layered stands.

Chapter 4 Riparian Forest and Woodland Ecology

Need for Management

Similar to Nebraska's upland deciduous woodlands, riparian woodlands in Nebraska were also subject to the natural disturbances of fire and large ungulate grazing. The frequency and intensity of fires likely varied with location and site hydrology. Wet forests and woodlands likely burned less frequently than drier sites and those with a oak canopy or lush groundlayer likely burned more frequently. More open riparian woodlands or those with a sedge or grass groundlayer likely experienced occasional large ungulate grazing, especially those woodlands in central or western Nebraska where bison densities were greater. Fire and grazing should be incorporated into riparian forest and woodland management where appropriate.

Flooding was the major presettlement disturbance factor in Nebraska's riparian forests and woodlands (see discussion that follows) and greatly affected plant community composition and structure. Unfortunately, WMA managers have little control over stream hydrology.

Flooding in Riparian Forests and Woodlands

Flooding was a major disturbance in Nebraska's presettlement riparian forests and woodlands. Direct interaction between streams and the riparian woodlands occur through over-bank flooding, bank cutting, and sedimentation. For example, overbank flooding can directly lead to tree fall or indirectly to windthrow by increasing soil saturation (Michigan Natural Features Inventory), high flows and sediment deposition provide appropriate germination conditions for cottonwood seedlings, and seasonal inundation can lead to a substantial reduction in tree seedlings and shrub layer in floodplain forests. Through input of organic matter floodplain forests provide streams with nutrients for aquatic life.

Riparian woodland development and succession are also highly tied to stream hydrology and morphology. Point bars on streams and rivers are often colonized by pioneer riparian trees species, mainly cottonwood and willows. Bare, saturated soils and high light levels favor seedling establishment and growth of these shade-intolerant and flooding-tolerant species.

Succession is a very active process in Nebraska's floodplain woodlands, especially in eastern Nebraska. Cottonwoods and willow seedlings establish on recently flooded areas of the floodplain. Their establishment often occurs at irregular intervals in association with large floods (Rood and Mahoney 1990). If not scoured by

subsequent high flows, these seedlings will eventually develop into cottonwood stands. In stands only occasionally flooded, other trees species that can tolerate only limited flooding, often green ash and American elm, eventually form a subcanopy below the cottonwoods. Cottonwoods are relatively short-lived species and in Nebraska most cottonwoods probably do not live much beyond 100 years. In older stands, ash, elm and other trees eventually displace cottonwoods as they die. Historically, stream channel migration and severe floods eroded many stands and there was a continual process of forest establishment and destruction.

In recent decades reduced stream flows and flooding and stream channelization and downcutting has greatly altered the natural hydrology of many Nebraska streams and altered riparian woodland development and succession. For example, damming along the South Platte and North Platte rivers and their tributaries has lead to a decrease in scouring floods and an increase in cottonwood woodlands along the Platte River in Nebraska. Damming of the upper Missouri River has resulted in reduced downstream flooding and has allowed extensive conversion of floodplain woodlands to cropland (Johnson 1998).

There are now few large flood events on Nebraska streams that create new cottonwoods stands and most established cottonwood stands will eventually succeed to other forests types. Unfortunately, two of Nebraska's most prominent late successional riparian tree species, American elm and green ash, are highly susceptible to exotic pest. Since the Dutch elm disease outbreak in the 1960s, American elm is now regulated to small subcanopy tree in Nebraska's riparian woodlands, with nearly all individuals over six inches in diameter having been killed. Green ash is threatened by the emerald ash borer which is expected to reach Nebraska from the east in coming years. As cottonwoods die out in Nebraska's riparian woodlands in coming decades in many stands they will likely be replaced by exotic or invasive species, such as eastern red cedar, Russian olive, salt cedar, white mulberry, and Siberian elm. Some stands may succeed to native species, primarily hackberry.

Effective conservation and management of riparian woodlands requires an ecosystem-based approach because of their complex longitudinal, lateral and vertical dimensions (Michigan Natural Features Inventory). Because hydrology is the primary driver in floodplain woodlands, the natural spatial and temporal patterns of stream flow rates, water levels, and run-off patterns must be maintained or reestablished for ideal restoration. Restoration of channel morphology may also be needed in areas where stream channelization, channel construction and dams have altered water flow and geomorphology. Most of these factors are likely beyond the control of individual WMA managers and provides a dilemma for riparian woodland management.

Further complicating management, riparian woodlands are also highly susceptible to invasion by exotic plants due to their high ratio of edge, sedimentation from flooding which provides a seed bed for many exotics, transport of seed by floodwaters, high nutrient levels, and high deer populations. Deer are vectors for seed transport and excessive browsing can stress native vegetation making woodlands susceptible to invasive species. Preemptive measures to minimize the impacts of exotic plants in floodplain woodlands include maintaining mature stands, minimizing and eliminating trails and roads through floodplains, buffering riparian areas with native vegetation, and limiting deer populations (Michigan Natural Features Inventory).

Fire in Riparian Forests and Woodlands

As with upland deciduous woodlands, prior to settlement fire appears to have been an important disturbance in Nebraska's riparian woodlands. Where plains cottonwoods occur in riparian systems in the western portions of the northern Great Plains, Sieg (1997) estimated the fire return interval to be 20 to 30 years. In more mesic eastern portions of the northern Great Plains where cottonwoods occurs the fire return interval was estimated at 1 to 5 years. These fires generally occurred in late in the growing season when the groundlayer vegetation was cured.

Intense fires can top-kill mature cottonwoods, especially if trees are damaged and fire enters the truck. Cottonwoods thick bark usually protects them from lower intensity fires. If dense cedars occur in the cottonwood understory flames and heat from burning cedars can kill mature cottonwoods. Cottonwoods less than 20 years old often resprout after fire especially if growing in areas with a high water table. Mature cottonwoods are weak sprouters and sprouts rarely survive (Gom and Rood 1999).

Willows, including sandbar willow and peachleaf willow, are usually top-killed by more intense fires (Uchytil 1989). Most top-killed willows, however, resprout following fire. Severe fire that consumes organic layers and exposes roots will kill most willows. Mid and late successional riparian species, such as American elm, silver maple, and boxelder, are easily damaged or top-killed by fire, particularly when young. These species often resprout when top-killed. In stands where mature cottonwoods are dying out and will be replaced by late successional species, care should be taken during fires not to severely damage replacement trees. In riparian woodlands, fire alone is not effective in controlling many invasive deciduous trees, such as Russian olive, salt cedar and white mulberry, as they also vigorously resprout if top-killed.

Prior to settlement, fire may not have played as critical a role in shaping Nebraska's riparian woodlands as it did the upland, oak-dominated woodlands. Fire, though, can have positive impacts on riparian woodlands. It can be effective reducing controlling invasive eastern red cedars and some deciduous trees species, reducing litter and downed woody material, stimulating native groundlayer plants, and reducing the abundance of some invasive herbaceous plants. In more open riparian woodlands with a grass-dominate groundlayer, fire may have many of the same benefits as grassland fires.

Silviculture in Riparian Woodlands and Forests

In many areas of Nebraska high-quality, mature and old-growth riparian woodlands and forests are rare and of limited extent and should not be commercially logged. Logging in riparian woodlands can result in many of the same problems as logging in upland deciduous woodlands. Tree thinning may be needed in riparian woodlands to reduce tree densities of native as well as invasive tree and shrub species. The discussion of logging and tree thinning in upland deciduous forests and woodlands (above) generally applies to and can be referenced for riparian wooded habitats.

Grazing in Riparian Forests and Woodlands

In presettlement open woodlands with grass or sedge- dominated groundlayers occasional bison and other large ungulate grazing likely occurred. Similar to surrounding grassland types, planned grazing can be used in such habitats to reduce litter levels, control some exotic plants, promote native plant diversity and provide a vegetation structure suitable for wildlife. However, cattle tend to concentrate in shaded areas and

cattle grazing can cause damage to deciduous woodlands and forests (see discussion above for upland deciduous forests and woodlands). Deciduous riparian forests and dense woodlands should not be grazed and open grassy woodlands should be grazed with caution using methods acceptable for surrounding grassland types.

Other Thoughts on Riparian Forest and Woodland Management

Many of Nebraska's riparian forests and woodlands have received recent disturbance from logging, overgrazing, or modified steam hydrology that has altered their natural successional patterns and tree canopy structure and composition. Cottonwood trees, the dominant tree in most Nebraska riparian woodlands, are rather short-lived and dependent on stream dynamics for stand replacement. Under ideal conditions in systems that have maintained a natural stream hydrology, stands of young, middle-aged and old cottonwoods are present. Most cottonwood-dominated woodlands in Nebraska are now dominated by older trees with few young cottonwoods as replacement trees. If stream hydrology is not restored, in most areas of the state it can be assumed that these woodlands will eventually succeed to dominance by later successional species, most likely hackberry, elm, boxelder, green ash, or exotic species. Managers should be aware of this succesional trend when designing management goals.

Presently, cottonwood-dominated riparian woodlands are management quite differently in areas of the state dependent on management objectives. For example, in the central Platte River valley, where prior to settlement were few riparian woodlands existed, both young and old cottonwood stands are cleared on some conservation lands to maintain open riverine habitat for waterbirds. For these managers, the open sandbars and wet meadows the cottonwoods have invaded in recent decades conservation priorities. In the Missouri River valley, cottonwood stands are now rare and few conservationists would consider clearing these stands. Managers will be ultimately responsible for establishing management decisions for lower grade riparian. However, high-quality riparian woodlands should not be cleared. For example, in the Loup River system, streamside cottonwood-diamond willow woodlands, though dominated by small trees, often contain a pristine groundlayer with several rare orchid species. Such woodlands should not be cut or cleared to improve waterbird habitat

In stream valleys where riparian woodlands are desired, older stands can be management for the old growth characteristics listed above for upland deciduous forests. A few, of the upland deciduous woodland old-growth characteristics do not pertain to riparian woodlands. For example, "a wide range in tree heights and ages" and "a diverse dominant tree species composition" are not natural characteristics of many riparian woodlands. Riparian woodlands often consists of even-aged stands of one or few tree species

Re-establishing the natural flood regime would likely be necessary for cottonwood regeneration in riparian woodlands and this is beyond the control of WMA managers. In some areas, for example, the lower Missouri River floodplain, cottonwoods still establish after flood events. Where cottonwoods do establish, manage may allow them to develop into replacement stands.

Chapter 5 - Coniferous Forest and Woodland Ecology

Need for Management

Nebraska's coniferous forests and woodlands are well-adapted to disturbance. The primary presettlement disturbances that shaped these communities were fire, large ungulate grazing and browsing, and drought. Other disturbances likely included insects, various pathogens, and wind-throw. Insect and pathogen outbreaks likely occurred in periodic episodes. Presettlement fires were primarily low intensity surface fires. Drought may have altered the fire frequency or intensity or stressed pines making them more vulnerable to fire or pests. Large ungulate grazing impacted groundlayer vegetation and fuel loads. In addition, rubbing by bison can kill young pines and cedars and occasionally older trees.

Nebraska's pine forests and woodlands most frequently occur on rocky escarpments and steep valley slopes. Unlike the Black Hills and other western mountains where extensive pine stands occur, in Nebraska coniferous stands are relatively small and part of community mosaic of pine forest and woodland, mixedgrass prairie, shrublands and rock outcrops. Soil moisture, fire and to a lesser extent grazing formed the mosaic pattern pattern. The community mosaic had a more diverse vegetation structure and diversity than the individual plant communities alone, and this variety likely increased native plant and wildlife diversity.

With settlement came the control of wildfires and a subsequent increase in pine and cedar densities on western escarpments. Many once-open pine woodlands succeeded to young pine forests and pines expanded into adjacent grasslands. In addition, logging removed many of the larger, old pines further shifting the age structure of stands. "Dog hair" pine stands are now common and ground litter, consisting mainly of fallen needles, is now abundant under pines. Open pine woodlands have been lost as well as the old-growth stand characteristic. Native plant diversity and abundance in pine stands has declined, plant community structure has been simplified as well as wildlife habitat diversity. Mangers should attempt to restore and enhance the natural mosaics in which our pine forests and woodlands occurred and return old growth characteristics to Nebraska' pine stands.

Fire in Coniferous Forests and Woodlands

As previously mentioned fire was an important disturbance in Nebraska's presettlement ponderosa pine ecosystems. In low elevation ponderosa pine woodlands on the Colorado Front range the presettlement fire return interval ranged from 3 to 20 years (Brown et al. 1999). The presettlement fire return interval was 10 to 12 years for pine savanna sites in the south-central Black Hills (Brown and Sieg 1999). For the pine savannahs (open woodlands) of north-central Nebraska along the Niobrara River, Bragg (1985) reported a mean fire frequency of 3.5 years between 1851 and 1900. Most historic fire scares recorded on pine trees at Wind Cave National Park in the southern Black Hills occurred late in the growing season or as dormant season scars between the rings (Brown and Sieg 1999). At Wind Cave presettlement fire was twice as common in ponderosa pine savanna as in interior pine forests stands at Jewel Cave National Monument in the central Black Hills (Brown and Sieg 1999).

Frequent, low intensity fires gave the presettlement ponderosa pine woodlands of the western United States a park-like appearance. On the Colorado Front Range, research has revealed that historic stands were open in nature and more than 90 percent of the landscape had crown closures of 30 percent or less and openings (areas with crown closure of 10 percent or less) of more than 40 acres were common (Dennis and Sturtevant 2007).

Since settlement, the fire frequency in most ponderosa pine ecosystems has been greatly altered due to suppression efforts, fragmentation of native habitats and livestock grazing. Less frequent fires have lead to increased pine densities, a higher proportion of young trees and saplings, elevated fuel loads, increased litter, reduced nutrient cycling, shift in plant species composition with a general loss of plant diversity, loss of groundlayer production, smaller canopy gaps, altered wildlife habitats, and a great threat of catastrophic wildfire. In addition, the subsequent canopy closure in pine ecosystems has resulted in reduced flows in local streams (Covington and others 1994).

Loss of understory vegetation is a critical concern as it contributes the greatest to plant biodiversity in ponderosa pine woodlands, regulates many processes (e.g. conifer regeneration, soil retention, and nutrient recycling) and provides critical habitat for wildlife (Kerns and others 2006). In many of Nebraska's pine woodlands a once diverse groundlayer has been replaced by thick mat of pine needles that supports only a sparse herbaceous layer often dominated by Kentucky bluegrass. Such areas have little value for wildlife. In the Black Hills, Wienk and others (2004) found few viable seeds of late successional native plants in the soil seed bank in dense ponderosa pine stands.

There is also evidence from the Black Hills that ponderosa pines have spread extensively into former grasslands since settlement of the region (Fisher and others 1987). These new woodlands are dominated mainly by small trees, with few patches of larger old-growth trees. The recent spread of pines into former mixedgrass prairies has also occurred on western Nebraska escarpments. Logging since settlement has removed many of the larger trees from our pine woodlands and so most stands are now dominated by younger trees. There is evidence that the loss of variability in tree size and the present homogeneity of ponderosa pine stands have lead to an increase in pine damaging insect outbreaks, such as outbreaks of the mountain pine beetle (Brown and others. 2001)

Recent catastrophic crown fires, such as the 2007 Valentine and Chadron fires, were fueled by dense pine canopies and excessive surface fuels and resulted in the loss of large areas of pine canopy and property damage. Future warming of our climate will likely make such fires a more common.

Prescribed fire is recognized as the best tool available for restoration and management of ponderosa pine ecosystems (Arno and others 1995 and Covington and others 1997). The health of ponderosa pine woodlands historically was dependent on fire to thin tree densities and reduce surface fuel loads and make stands less susceptible to stand replacing crown fires. In an effort to restore structure and function to pine woodlands, managers in the western United States have successfully introduced thinning and prescribed fire to create more productive and resilient stands (Sabo and others 2009). Variability in both timing and amount of area burned during different years promotes landscape heterogeneity.

Lower intensity fires in ponderosa pine systems can maintain open stands through increased seedling and sapling mortality and occasional small crown fires in the canopy.

Prescribed fire can also restore ecosystem functions such as nutrient recycling, restore plant diversity and landscape patterns, and reduce tree encroachment into grasslands. Fire-killed trees are an important habitat for wildlife, such as cavity nesting birds, and the openings they leave in the canopy provide sites for tree regeneration and groundlayer plant growth. Return of the natural fire interval, a more natural mosaic of plant communities, and old-growth characteristics can improve habitat for targeted at-risk species, such as quacking aspen (Howard 1996), pygmy nuthatch (Cameron and Dobbs 2006, Hejl 1994), common poorwill (Hall et al. 1997, Nicholoff 2003), mountain bluebird (Hejl 1994, Holt and Martin 1997), pinyon jay (Ulev 2006, Wiggens 2005) fringed myotis (South Dakota Bat Working Group 2004, Creighton and Bottoroff), and bighorn sheep (Krausman et al. 1999). Tawny crescent butterfly, a Nebraska at-risk species, habitat can also be improved through use of prescribed fire by keeping grassy ridge tops with pine woodlands open and stimulating larvae food plants (big bluestem and little bluestem) and nectar sources (asters) (Marrone 1992).

For prescribed fire in pine ecosystems, spring weather and fuel conditions generally allow fuel consumption and fire behavior to be more easily controlled, but may not be preferable from an ecological standpoint (Kerns and others 2006). In the Blue Mountains of Oregon, Kerns found spring fires may help control exotics such as Kentucky bluegrass and annual bromes, but may also kill seeds of native perennial plants. They also found that fall fires were generally more intense and resulted in thinner soil O horizons, less coarse woody debris, less tree basal area, and greater rock and bare soil cover. In the Blue Mountains, initial fall fires burned hotter than spring burns or second fall fires (Fire Science Brief 2008). These researchers concluded the decision of when to burn may be guided by the overriding need to reduce fuels and prevent catastrophic wildfires. In other words burn when conditions allow.

In the northern Black Hills Wienk and others (2004) found that prescribed burning (surface fires) reduced the litter layer by about 30% in a patchy pattern. In these dense stands they found significant mortality of ponderosa pine resulted from prescribed burning, with higher mortality on partial-cut plots than uncut plots. They recommended using backfires or a strip head fire technique with strips < 5 m to control fire intensity. They also found that smooth sumac, currants, red raspberry, chokecherry, Saskatoon serviceberry, and Oregon grape, all important wildlife plants, colonized burned sites by the second year after burning.

Several studies have documented invasive species spread after fire in ponderosa pine stands, especially those that burn under severe conditions. (Kerns and others 2006, Saboe and others 2009). The most problematic species to invade in Nebraska pine stands after fire are smooth brome, annual bromes, intermediate wheatgrass, and thistles. Severe disturbance, such as pile burning or stand-replacing wildfires, can create more favorable condition for invasive species. In the Blue Mountains of Oregon, fall fires increased cover of annual and biennial exotics more than spring fires due to fire severity and overstory gaps (Kerns and others 2006). In northern Arizona the combination of mechanical thinning and prescribed fire resulted in higher cheatgrass abundance compared to only burned or cut plots (McGlone and others 2009). There is, however, evidence that pine forests treated with prescribed fires are less susceptible to exotic invasion than those burned in wildfires (Sabo and others 2009). Wildfires though, can also have a positive effective on groundlayer vegetation depending on intensity and

timing. A wildfire in 2006 in the Wildcat Hills improved groundlayer plant composition (Steinauer 2007).

Dennis and Sturtevant (2007) stated that for the Colorado Front Range prescribed fire can be effective in reducing wildfire severity in ponderosa pine woodlands for up to 10 years. They also state, that if the goal is to reduce fire danger, treatments that leave heavy fuels behind in the form of slash or living trees are ineffective. Only treatments that allow for the possibility of future low-severity fires to manage fuels represent the only viable long-term solution to the problem of unnatural fire intensity. Maintenance burns likely will be needed within 3 to 10 years after the initial prescribed burn to reintroduce a periodic fire regime to sites.

Silviculture in Coniferous Forests and Woodlands

Most ponderosa pine ecosystems in Nebraska now have unnaturally high tree densities and fuels loads. In some circumstances, mechanical tree thinning may be a necessary management tool. Thinning can be used to reduce fuel loads or create fire breaks prior to prescribed burning and as a partial surrogate for prescribed fire where burning is not feasible due to safety concerns. Thinning in pine ecosystems has several disadvantages: 1) it is extremely costly, 2) thinned materials left of the ground can make subsequent prescribed fires burn extremely hot, and 3) disturbance from thinning can lead to exotic plant invasion and soil erosion. Well planned and executed prescribed fires may eliminate the need for tree thinning on many WMAs.

Schwilk and others (2009) state that thinning can be an effective pre-treatment to prescribed fire to create conditions that allow subsequent prescribed fires to achieve desired management outcomes. Removing excess trees and ladder fuels can reduce the likelihood that ground fires will become crown fires. Thinning can also reduce the connectivity of tree crowns, which make it more difficult for crown fires to spread through the canopy. It is, however, unlikely that mechanical thinning can fully replace the ecological role of fire in pine ecosystems, as thinning has no impact on surface litter. Thinning alone reduces fire danger only temporarily and provides few other benefits.

Studies have shown that light thinning or low severity prescribed fire in ponderosa pine stands have little impact on plant community production or composition (Sabo and others 2009). In northern Arizona, these authors found that in low basal area stands, tree distribution had a greater influence on groundlayer standing crop than tree density. Sabo recommends that if the goal is to restore open ponderosa pine forests with predominantly native plant understory managers should consider thinning to basal areas <10 m^2/ha and clumping trees to enhance canopy openings. They also recommend that due to low native herbaceous plant cover in dense pine stands to consider delaying prescribed burning in stands until understory vegetation is well-established to avoid invasion by exotic plants.

If thinning occurs on WMAs it should be limited to younger trees and designed to protect older pines. The city of Boulder, Colorado has proposed silviculture prescriptions that make use of multi-aged methods designed to maintain ponderosa pine regeneration in stands (Brown and others 2001). They put a cap on cutting all trees larger than 30 cm dbh to promote the development of old-growth characteristics.

Fewer young pines will lower the competitive pressure on old trees and protect them from fire. Dennis and Sturtevant (2007) recommend for the Colorado Front Range

thinning trees to 25 to 50 or more trees per acre which is the estimated presettlement density for the area. They state "trees left after thinning operations should be grouped and clumped in a fashion that more closely resembles pre-1870 stand structures. Even spacing is not desirable. Density should vary throughout forest stands from open pockets with no or few trees to dense pockets of trees with the equivalent of up to 150 trees per acres. Within forest stands or project areas, strive for and, over time, develop irregular stand structure and spatial arrangements. Historical stand structure appears to have been comprised of even-aged groups of trees that varied widely in size and shape. Often two, three, and sometimes more age and size groups were represented in a stand."

They further state "Ponderosa pines frequently grow in clumps, often with interlocking crowns, which provide habitat for species that utilize tree trunks and crowns. The size, density, number and location of such clumps profoundly affect both wildlife habitat and the future risk of crown fires. Finding a balance between wildlife habitat considerations, individual tree health, and future fire risk is a vital part of planning restoration treatments." Another goal of thinning and management in general should be to reduce the heavy fuel load of dead woody debris, saplings, and small trees (eastern red cedar and young pines).

Once thinning is complete, slash will need to be removed or treated as if not treated it can create a greater fire hazard than present prior to the thinning. There are several methods of slash treatment. Hand piling is the manual piling of slash to be later burned. Hand piles are generally small, up to six feet high and 6 to 8 feet in diameter and are often located in openings to minimize scorching and mortality of nearby trees when burned. Hand piling is labor intensive and costly. Machine piling is done with bulldozers or skidders and is often used on flatter terrain, stable soils, and in more open areas. Machine piles can be 12 feet high and cover large areas. Lop and scatter slash treatment is used in areas where the fuel load is less. In this method thinned trees are limbed and cut to lay within 12 to 24 inches off the ground and dispersed to prevent fuel concentrations. The scattered fuels are then consumed during prescribed fires. Mastication or chipping uses "hydro-mow" equipment with rotating blades to shred live trees into large wood chips that are dispersed across the topsoil. This method can be relatively expensive and chips may decompose slowly in areas.

A recent study by Owen and others (2009) compared the impacts to soils and vegetation of slash pile burning to mastication of trees in a pinyon – juniper woodland in southwestern Colorado. They found pile burning degraded soil properties, had a different AMF (arbuscular mycorrhizal fungi) composition compared to untreated or mastication plots, had dramatically lower plant cover in all life forms than untreated or mastication plots, and had the highest percentage of exotic plant species. Though they state more study is needed, they conclude that mastication may somewhat improve soil structure and result in less soil disturbance than burning slash piles. Cheatgrass cover increased in mastication plots likely in response to the mulching effect of the woodchips resulting in higher soil moisture. In a study of mastication in a ponderosa pine forest in Colorado Miller and Seastedt (2009) found woodchips reduced understory plant richness, diversity and cover and increased exotic species.

Owen and others (2009) concluded that tree thinning treatments should be undertaken conservatively and only when it can be reasonably argued that ecosystems are at risk of extreme perturbation due to stand replacing fires. They further recommend that mastication be limited to high priority areas, limiting the amount of disturbance by

treating areas only when there is snow on the ground, monitoring exotic plants, restoring disturbed areas of erosion and promoting native plant diversity.

Exotic grasses and forbs are common adjacent to logging roads in the Pine Ridge. The roads either provide the disturbance necessary for exotics to establish or vehicles traveling the roads bring in exotic seeds. Exotic grasses are often seeded along roads after logging operations. In forested ecosystems, increases in exotic herbaceous vegetation has been more associated with combined mechanical plus burning treatments presumably because the combined treatments resulted in higher resources for growth and the highest amount of soil disturbance compared to either treatment alone (Schwilk and others 2009). Sabo and others (2009) found that exotic invasive grasses were more prominent in stands that had burned in intense wildfires compared to treated (thinned or thinned and burned) stands.

The following precautions can be taken to limit disturbance caused by mechanical thinning: 1) conduct thinning in winter when soils are frozen, 2) use horses or tractors which cause less soil compaction and damage than other mechanical equipment, 3) wash all equipment during all phases of the operation to avoid transport of invasive plant seeds. Do not use heavy equipment or build roads during thinning operations in higher quality woodlands and grasslands to avoid damage to native vegetation and soils and to prevent exotic species invasion. Covington and others (1997) stated that while treatment methods cause some disturbance and can increase exotics, the impacts of catastrophic wildfires can be more damaging.

Snags left during thinning operations in ponderosa pine stands can provide valuable habitat for cavity nesting birds, and other snag-dependent species, such as pygmy nuthatch (Ghalambor and Dobbs 2006) and fringed myotis (Waldien and others 2000). Where thinning occurs in pine systems it is recommended to leave at least 3 snags per acre of trees with greater than 9 to 10 inch dbh and >25 feet tall and with at least one snag greater 14 to 20 inches dbh. Creating clumps of snags may be desirable.

Grazing in Coniferous Forests and Woodlands

Prior to settlement open woodlands with a grass-dominated groundlayer likely were the predominant pine type in Nebraska. Stands on more level to rolling topography where likely grazed by bison and other ungulates more so than stands on steep slopes or ridge tops. Today, well planned grazing in the pine woodlands can be used to reduce thatch, help control exotic plants, promote plant diversity, and provide grazing lawns for large ungulates. Managers should use grazing methods recommended for surrounding grassland types. Care must be taken as cattle tend to concentrate in shaded habitats. Dense pine forests have a groundlayer dominated by shade-tolerant forest species less adapted to grazing than the grasses of open stands. Fire alone will likely suffice to reduce litter and promote plant diversity in forests stands.

There is evidence that overgrazing by livestock has played a role in increasing pine densities since settlement. Heavy livestock grazing can change the competitive relationship between grasses and woody plants, by placing pressure on the palatable grasses and favoring the unpalatable woody species (Brown and others 2001). This is an added reason for implementing proper grazing methods and stocking densities in pine ecosystems.

Cattle generally avoid grazing on steep slopes and high ridges where pine stands often are found. In addition, forage production is limited under the pines and on rock outcrops commonly found in these areas. Managers must take these factors of reduced forage production and grazing potential on the pine escarpments into consideration when determining cattle stocking rates to avoid overgrazing.

On WMAs in the Nebraska Panhandle dominated by pine woodlands, grazing levels should be low to moderate, and grazing need not occur every year, if the sites are being burned at recommended frequencies. Therefore, multi-year grazing systems may not be ideal for pine-dominated WMAs. However, occasional grazing is needed to reduce thatch accumulation, stress exotic plants and maintain healthy plant and wildlife diversity.

Old Growth Coniferous Woodland Characteristics

Most of Nebraska's coniferous forests and woodlands have been logged in the past, removing many larger trees. In addition, fire suppression since settlement has allowed an increase in young pines and cedars. These factors have skewed the pine woodland structure to a dominance of dense, young trees. A more desired ecological condition for pine habitats under conservation ownership and management is old-growth status. Old-growth habitats are heterogeneous, have living and dead trees, snags, cavities and downed logs for wildlife. Old growth stands also have greater plant and wildlife diversity and more specialist species than young stands.

Eyre (1980) defined the following characteristics for quality old growth ponderosa pine stands in the Black Hills:

1) a combination of 10 or more trees per acre in the canopy with a minimum dbh of 16 inches and an age of 160 years.
2) variation in tree diameter.
3) decadence in the form of broken or deformed tops or bole and rood decay.
4) at least two dead standing trees with a minimum dbh of 10 inches per acre.
5) presence of dead down trees.
6) multiple canopy layers need not be present.

The old growth status goal applies for both dense forest stands with an understory of shade-tolerant species and open woodland stands with shade-intolerant species

Other Thoughts on Coniferous Forest and Woodland Management

A desired condition and goal of managing pine ecosystems on WMAs is to restore the natural community mosaic to more closely resembling historic conditions. Prior to settlement, areas of Nebraska's Pine Ridge was likely a mosaic of dense pine forest on lower north and east-facing slopes and bottoms with a shade-tolerant groundlayer. South and west-facing slopes, upper slopes and ridge tops were open pine woodlands, savannah or prairie. This system had more variable tree densities than at present.

Restoring pine ecosystems on WMAs efforts should not focus solely on restoring forest structure. Restoring natural processes, primarily fire, to the ecosystem should also be a goal. Only with prescribed fire can we restore healthy pine ecosystems and provide a long-term solution to problem of excess fuels and catastrophic wildfires. Once a more natural forest structure and fuel levels are achieved periodic low intensity prescribed fire

can be used as an inexpensive method to maintain healthy pine ecosystem with resilience to future disturbance without the need for thinning.

It is recommended that prescribed fire be the primary tool used to thin trees, reduce fuel loads and restore structure, function and diversity to pine ecosystems on WMAs. Mechanical or hand tree thinning should be secondary options used in situations where prescribed fire is not possible. Initial prescribed fires should occur under "cool conditions" most likely in winter and spring when fuels are not overly dry. Once fuels and tree densities are reduced, prescribed fires can be conducted under hotter conditions. In the recovery phase is may take frequent fires to reduce tree densities and fuels to acceptable levels. It is critical that pine ecosystems be burned under careful prescriptions and by well trained staff. It may be necessary for the NGPC to hire or contract individuals with extensive knowledge of fire in pine ecosystems to write prescriptions for and conduct initial prescribed fires.

Chapter 6 – System Descriptions, Quality Rankings and Management Guidelines

Upland Deciduous Forest System

Range

Eastern deciduous forests occur on the bluffs and high terraces of the Missouri River and its tributaries in eastern Nebraska.

Communities Included

The following natural communities described by Steinauer and Rolfsmeier 2010 are included in the Eastern Deciduous Forest System:

Oak-Hickory-Ironwood Forest
Bur Oak- Basswood-Ironwood Forest
Red Oak- Basswood- Ironwood Forest
Dry-Mesic Bur Oak Forest and Woodland
Mesic Bur Oak Forest and Woodland
Paper Birch Springbranch Canyon Forest
Basswood – Ironwood Springbranch Canyon Forest

Dominant Species

Bur oak (Quercus macrocarpa), chinkapin oak (Q. muehlenbergia), red oak (Q. rubra), black oak (Q. velutina), shagbark hickory (Carya ovata), basswood (Tilia Americana), elms (Ulmus spp.), green ash (Fraxinus pennsylvanica), hackberry (Celtis occidentalis), ironwood (Ostrya virginiana), paper birch (Betula papyrifera), black walnut (Juglans nigra)

Primary Invasive Species

Garlic mustard (Alliaria petiolata), dame's rocket (Hesperis matronalis), ground ivy (Glechoma hederacea), Amur honeysuckle (Lonicera maackii), Tatarian honeysuckle (L.

tatarica and hybrids), buckthorns (Rhamnus spp.), Japanese barberry (Berberis thunbergii), autumn-olive (Elaeagnus umbellata), Osage orange (Maclura pomifera), tree-of-heaven (Ailanthus altissima), Siberian elm (Ulmus pumila)

System Quality Grades

Grade A Upland Deciduous Forests – Grade A forests are rare. Grade A forests have an overstory dominated by mid-aged (50-90 years), mature (90-120 years), and old-growth (120 years +) trees, which maintain a stable canopy coverage. These woodlands may have had light cutting in the distant past. These stands may be nearly even-aged or all-aged. Grade A forests have had very little disturbance from grazing. Conservative forest species are conspicuous throughout and dominate the groundlayer including sedges, Dutchman's breeches (Dicentra cucullaria), Jack-in-the-pulpit (Arisaema triphyllum), white trout-lily (Erythronium albidum), bloodroot (Sanguinaria canadensis), aniseroot (Osmorhiza longistylis), May apple (Podophyllum peltatum), showy orchis (Galearis spectabilis), blue wood phlox (Phlox divaricata), lowland baldder fern (Cystopteris protrusa), Soloman's-seal (Polygonatum biflorum), large-flower tickclover ((Desmodium glutinosum), wild leek (Allium tricoccum), and violets (Viola spp.). Exotic plant species including invasive trees species are restricted to small isolated patches. Examples include portions of The Nature Conservancy's Rulo Bluffs Preserve and the Fontenelle Nature Association's Andrews Tract located north of Omaha.

Grade B Upland Deciduous Forests – Grade B forests are still relatively common in areas of the Missouri River bluffs. Grade B forests have an overstory dominated by mature and/or old growth trees that have had limited disturbance from cutting. Grade B stands also include mid-aged stands (50-90 years) that are second growth, but otherwise have received little recent disturbance. These stands may have rather significant gaps in their age class structure resulting from past grazing or cutting. Conservative groundlayer plants are still common in Grade B stands, though their diversity and abundance is less than in Grade A forests. More disturbance-tolerant native species, such as white snakeroot (Ageratina altissima), hairy wildrye (Elymus villosus), nodding fescue (Festuca subverticillata), Virginia creeper (Parthenocissus quinquefolia), Canada sanicle (Sanicula canadensis), Virginia waterleaf (Hydrophyllum virginianum), wood nettle (Laportea canadensis), stinging nettle (Urtica dioica), goldenrods (Solidago spp.), and moonseed (Menispermum canadense) can be common. Exotic plant species are more common than in Grade A forests, though they are not widespread or dominant. Examples include most forests on the Winnebago and Omaha Indian Reservations in northeast Nebraska, Ponca State Park, and Indian Cave State Park.

Grade C Upland Deciduous Forests – Grade C forests are common. Grade C forests can have an overstory dominated by mid-aged, mature, and/or old growth trees which have experienced rather recent heavy disturbance from cutting. Also included here are forests dominated by young (20-50 years) second growth trees that have been relatively undisturbed since cutting. Grade C forests may have very significant gaps in the age class structure of the overstory resulting from past grazing and/or cutting. Conservative native forb diversity and abundance is limited compared to Grade A and B stands. More disturbance tolerant native plants are usually dominant, including white snakeroot,

nettles, goldenrods, and annual bedstraw (Galium aparine). Invasive tree species, such as eastern red cedar, Osage orange, Siberian elm, and honey locust, may be prominent. Native shrubs, such as pricky ash (Zanthoxylum americanum), coralberry (Symphoricarpos orbiculatus), woldberry (S. occidentalis), raspberry (Rubus ocidentalis), green briar (Smilax hispida), and roughleaf dogwood (Cornus drummondii), are frequently common. Invasive herbaceous species, such as garlic mustard and ground ivy may be common to abundant. Examples include large areas of Fontenelle Forest Nature Center located near Bellevue.

Grade D Upland Deciduous Forests – Grade D forest are less common that Grade C forests, though not uncommon. Grade D forests are dominated by various age classes of trees. They have often experienced severe disturbance for grazing or cutting. The ground layer is dominated by weedy native plants or exotic species. Conservative forbs are absent. Invasive trees are often prominent to dominant including Siberian elm, Osage orange, and eastern red cedar.

Management Objectives and Guidelines for Various Grade Upland Deciduous Forests

Grade A and B Upland Deciduous Forests
Management Objective: Maintain and enhance Grade A site quality, enhance Grade B sites to Grade A quality.

Minimum Management:

1) Conduct prescribed burns every 3 to 4 years. Once litter, groundlayer vegetation and small tree densities are at desired levels the fire return interval can be extended to 6 to 8 years to allow saplings of oaks and other tree species to reach a size where they are not prone to top-killing from fire.
2) Annually survey for and spot spray or otherwise control all garlic mustard, nonnative buckthorns, Amur and Tatarian honeysuckle, tree-of-heaven and other invasive herbaceous species.
3) Control all invasive tree species not controlled by prescribed fire.
4) Maintain deer populations as low to moderate densities.

Management Options

1) Annual burns can be conducted if necessary to meet management objectives, such as controlling exotic species or stimulating oak regeneration.

Grade C Upland Deciduous Forests
Management Objective: Enhance site quality to Grade B condition.

Minimum Management:

1) Conduct early spring or fall prescribed burns every 5 to 6 years. Once litter, groundlayer vegetation and small tree densities are at desired levels the fire return interval can be extended to 6 to 8 years to allow the saplings of oaks and other tree species to reach a size where they are not prone to top-killing from fires.

2) Annually survey for and spot spray or otherwise control all garlic mustard, exotic buckthorns, Amur and Tatarian honeysuckle, tree-of-heaven, and autumn-olive populations.

Management Options

1) Annual burns can be conducted if necessary to meet management objectives, such as controlling exotic species or stimulating oak regeneration.

Grade D Upland Deciduous Forests

Management Objective: Improve wildlife habitat and provide buffers for and corridors between other native plant communities. Where native plant species remain, manage for these species as wildlife habitat.

Minimum Management:

1) Annually survey for and spot spray or otherwise control all garlic mustard, exotic buckthorns, Amur and Tatarian honeysuckle, autumn-olive, and tree-of-heaven populations.

Management Options:

1) Conduct prescribed burns to promote wildlife habitat and control invasive species.

Upland Deciduous Woodland System

Range

Upland deciduous woodlands occur mainly in the east half of the state in on river and stream bluffs and high terraces and ravines. They extend westward along the Niobrara River and occur in a few scattered localities in the west half of the state.

Communities Included

The following natural communities described by Steinauer and Rolfsmeier 2010 are included in the Upland Deciduous Woodland System:

Sandstone Upland Bur Oak Woodland
Dry Upland Bur Oak Woodland

Dominant Species

Trees - primarily bur oak (Quercus macrocarpa), but also to a lesser extent green ash (Fraxinus pennsylvanica), elms (Ulmus spp.), and eastern red cedar
Shrubs - Roughleaf dogwood, wild plum (Prunus Americana), chokecherry (Prunus virginiana), and smooth sumac (Rhus glabra)

Primary Invasive Species

Trees - eastern red cedar, Siberian elm (Ulmus pumila), honey locust (Gleditsia triacanthos), Osage orange (Maclura pomifera)

Shrubs - Japanese barberry (Berberis thunbergii), Amur honeysuckle (Lonicera maackii), Tatarian honeysuckle (L. tatarica and hybrids)
Herbs - garlic mustard (Alliaria petiolata), dame's rocket (Hesperis matronalis), buckthorns (Rhamnus spp.), smooth brome, Kentucky bluegrass

System Quality Grades

Grade A Upland Deciduous Woodlands – Grade A woodlands are rare. Grade A woodlands have an overstory dominated by mid-aged (50-90 years), mature (90-120 years), and/or old-growth (120 years +) trees. These woodlands may have had light cutting in the distant past and little or no disturbance from past grazing. They may be even-aged or all-aged. Bur oaks are the dominant overstory tree with ash, elm, hackberry, honey locust and/or eastern red cedar making up only a small portion of the canopy, subcanopy, and saplings. Oak regeneration should be present, though it may be limited. Exotic plant species, such as smooth brome, Kentucky bluegrass, and garlic mustard are restricted to small isolated patches. Conservative woodland species are conspicuous throughout and dominate the groundlayer with prairie grasses, sedges and forbs in more open areas and Dutchman's breeches (Dicentra cucullaria), Jack-in-the-pulpit (Arisaema triphyllum), white trout-lily (Erythronium albidum), aniseroot (Osmorhiza longistylis), sweet scented bedstraw (Galium triflorum) blue wood phlox (Phlox divaricata), Virginian creeper (Parthenocissus quinquefolia), false Soloman's-seal (Maianthemum stellatum), large-flower tickclover ((Desmodium glutinosum), and violets (Viola spp.) in more shaded areas.

Grade B Upland Deciduous Woodlands – Grade B woodlands are uncommon. Grade B woodlands have an overstory dominated by mid-aged, mature and/or old-growth trees in stands that have experienced moderate past disturbance from grazing or cutting. Grade B woodlands include mid-aged stands (50-90 years) that are second growth, but otherwise have received little recent disturbance. These stands may significant gaps in their age class structure resulting from past grazing or cutting. Bur oaks are the dominante canopy tree, though ash, elm, hackberry, honey locust and/or eastern red cedar may be present in the canopy and comprise a significant percent of the saplings. Invasive exotic trees, such as Siberian elm, Osage orange, and white mulberry are limited. Exotic cool-season grasses and other invasive herbaceous plants are more abundant than in Grade A woodlands though they are not widespread or dominant. Weedy native plants including such as white snakeroot, whitegrass (Leersia virginica), and hairy wild-rye (Elymus villosus) may be locally common. Conservative groundlayer plants are still abundant in Grade B woodlands, though their abundance and diversity is less than in Grade A woodlands. Examples of Grade B woodlands occur at Oak Valley WMA and Rock Glen WMA.

Grade C Upland Deciduous Woodlands – Grade C woodlands are common, probably comprising the majority of oak woodlands on WMAs. Grade C woodlands may have an overstory dominated by mid-aged, mature, and/or old-growth trees which have experience rather heavy disturbance from grazing and past cutting. Also included here are woodlands dominated by young (20-50 years) second growth trees that have been relatively undisturbed since cutting. Grade C woodlands may have very significant gaps

in the age class structure of the overstory resulting from past grazing and/or cutting. Bur oaks are often only co-dominant in the canopy with ash, elm, hackberry, honey locust and/or eastern red cedar. The latter species often comrpise the majority of the saplings. The exotic trees Osage orange, Siberian elm, and white mulberry may also be prominent. More disturbance tolerant native plants usually dominate the groundlayer, including white snakeroot, nettles, goldenrods, and annual bedstraw (Galium aparine). Native shrubs, such as pricky ash (Zanthoxylum americanum), coralberry (Symphoricarpos orbiculatus), woldberry (S. occidentalis), raspberry (Rubus ocidentalis), green briar (Smilax hispida) and roughleaf dogwood (Cornus drummondii) are often common to abundant. Exotic cool-season grasses and other exotic herbaceous plants may be common to co-dominant in the groundlayer. Conservative native forb diversity and abundance is limited compared to Grade A and B sites. An example of a Grade C deciduous woodland occurs on Prairie Plains Resource Institute's Olson Nature Preserve.

Grade D Upland Deciduous Woodlands – Grade D woodlands are common, though probably less so on WMAs than Grade C woodlands. Grade D woodlands are dominated by various age classes of trees. They have often experienced severe disturbance from grazing or cutting. Oaks may occur only as scattered trees with weedy native or exotic trees as dominants. The ground layer is dominated by weedy native plants or exotic species. Conservative native species only occur as scattered individuals.

Management Objectives and Guidelines for Various Grade Upland Deciduous Woodlands

Grade A and B Upland Deciduous Woodlands
Management Objective: Maintain and enhance Grade A site quality, enhance Grade B sites to Grade A quality.

Minimum Management:

1) Conduct prescribed burns every 3 or 4 years. Once litter, groundlayer vegetation and small tree densities are at desired levels the fire return interval can be extended to 6 to 8 years to allow oak saplings to reach a size where they are not prone to top-killing from fires.
2) Annually survey for and spot spray or otherwise control all garlic mustard, exotic buckthorns, autumn olive, Amur and Tatarian honeysuckle, smooth brome, and other invasive plant populations.
3) Control all invasive tree species not controlled by prescribed fire.
4) Maintain deer populations as low to moderate population densities.

Management Options

1) Annual prescribed burns can be conducted if necessary to meet management objectives, such as controlling exotic species or stimulating oak regeneration.
2) Woodlands with a native prairie groundlayer can be grazed at light to moderate intensity using methods described for Grade A and Grade B tallgrass or mixedgrass prairies depending on region. If these woodlands

occur in conjunction with higher quality deciduous forests and cattle cannot be excluded from the forests, the woodlands should not be grazed.

Grade C Upland Deciduous Woodlands

Management Objective: Enhance site quality to Grade B condition.

Minimum Management:

1) Conduct prescribed burns every 3 to 4 years. Once litter, groundlayer vegetation and small tree densities are at desired levels the fire return interval can be extended to 6 to 8 years to allow oak samplings to reach a size where they are not prone to top-killing from fires.
2) Annually survey for and spot spray or otherwise control all garlic mustard, exotic buckthorns, autumn olive, and Amur and Tatarian honeysuckle.

Management Options

1) Annual prescribed burns can be conducted if necessary annually to meet management objectives.
2) Woodlands with a native prairie groundlayer can be grazed at light to moderate intensity using methods appropriate for surrounding grassland types. If these woodlands occur in conjunction with higher quality deciduous forests and cattle cannot be excluded from the forests, the woodlands should not be grazed.

Grade D Upland Deciduous Woodlands

Management Objective: Improve wildlife habitat and provide buffers for and corridors between other native plant communities. Where native plant species remain, manage for these species as wildlife habitat.

Minimum management:

1) Annually survey for and spot spray or otherwise control all garlic mustard, exotic buckthorns, autumn olive, and Amur and Tatarian honeysuckle populations.

Management Options:

1) Conduct prescribed burns when desired to promote wildlife habitat and control invasive trees.
2) If they woodlands have a grass understory they can be managed with grazing systems recommended for the surrounding grassland types. If the woodlands occur in conjunction with higher quality deciduous forest and cattle cannot be excluded from the forests, the woodlands should not be grazed.

Eastern Riparian Forest/Woodland System

Range
Eastern Riparian Forests/Woodlands occur in on stream and river floodplains and low terraces in the eastern third of the state.

Communities Included
The following natural communities described by Steinauer and Rolfsmeier 2010 are included in the Eastern Riparian Woodland system:

Eastern Riparian Forest
Eastern Cottonwood – Dogwood Riparian Woodland
Cottonwood – Diamond Willow Woodland

Dominant Species
Trees - Primarily plains cottonwood (Populus deltoides), but also peachleaf willow (Salix amygdaloides), diamond willow (S. famelica), silver maple (Acer saccharinum), box-elder (Acer negundo), hackberry (Celtis occidentalis), green ash (Fraxinus pennsylvanica), American elm (Ulmus Americana), honey-locust (Gleditisia triacanthos).
Shrubs – roughleaf dogwood (Cronus drummondii), Missouri gooseberry (Ribes missouriense), coralberry (Symphoricarpos orbiculatus)
Herbs – white snakerood (Ageratina altissima), sedges (Carex spp.), Virginia wild-rye (Elymus virginicus), nodding fescue (Festuca subverticillata), common scouring rush (Equisetum hymale), Virginia creeper (Parthenocissus quinquefolia), stinging nettle (Urtica dioica)

Primary Invasive Species
Trees - eastern red cedar, Siberian elm, Russian olive (Elaeagnus angustifolia), white mulberry
Shrubs - Japanese barberry, Amur honeysuckle, Tatarian honeysuckle (L. tatarica and hybrids), multiflora rose (Rosa multiflora), Oriental bittersweet (Celastrus orbiculatus), autumn olive, exotic buckthorns (Rhamnus spp.)
Herbs - garlic mustard, ground-ivy (Glechoma hederacea), dame's rocket, moneywort ((Lysimachia nummularia), reed canary grass (Phalaris arundinacea), smooth brome, Kentucky bluegrass.

System Quality Grades

Grade A Eastern Riparian Forests/Woodlands – Grade A eastern riparian forests/woodlands are rare. They may have an overstory dominated by young (20-50 years) to old-growth (120 years +) trees. These woodlands may have had light cutting in the distant past, but little or no disturbance from past grazing. Riparian woodlands often have even-aged canopy, though some stands may be all-aged. Cottonwoods are generally the dominant overstory tree though ash, silver maple, hackberry, willows and other trees may be dominant. Shrubs may be prominent including dogwoods and coralberry. Invasive tree species, such as Siberian elm, white mulberry, Russian olive, and eastern

red cedar, and invasive shrubs and herbs are restricted to small isolated patches. Conservative woodland species are conspicuous throughout and dominate the groundlayer including sedges, Virginia creeper (Parthenocissus quinquefolia), sanicles (Sanicula spp.), hog-peanut (Amphicarpaea bracteata), aniseroot (Osmorhiza longistylis), sweet scented bedstraw (Galium triflorum), willowleaf aster (Symphyotrichum praealtum), nodding fescue, poison ivy, scoring rushes (Equisetum spp.), false Soloman's-seal (Maianthemum stellatum), and violets (Viola spp.). The hydrology and flood regimes of the sites has not been altered, or only slightly altered, by dikes, ditches, drains, or reduced groundwater levels resulting from pumping, channelization or reduced instream flows in adjacent streams. An example of a Grade A riparian woodland occurs at Yellowbanks WMA.

Grade B Eastern Riparian Woodlands/Forests – Grade B eastern riparian forests/woodlands are uncommon. Grade B woodlands have an overstory dominated by young to old-growth trees. Stands may have experienced limited past disturbance from grazing or cutting. Cottonwoods are often the dominate canopy tree, though other native tree species may be dominant. Invasive trees are limited in abundance. Exotic shrubs and herbaceous plants are more abundant than in Grade A woodlands though they are not widespread or dominant. Weedy native plants including white snakeroot, whitegrass, and nettles may be locally common. Conservative groundlayer plants are still abundant in Grade B woodlands, though their abundance and diversity is less than in Grade A woodlands. The hydrology and flood regime of Grade B sites is often somewhat to moderately altered by dikes, ditches, drains, or reduced groundwater levels resulting from pumping, channelization or reduced instream flows in adjacent streams. Examples of Grade B eastern riparian woodlands occur at Margrave WMA and Two Rivers SRA.

Grade C Eastern Riparian Forests/Woodlands – Grade C woodlands are common, these probably making up the majority of riparian woodlands on WMAs. Grade C woodlands can have an overstory dominated by young to old-growth trees. These stands have often experienced rather heavy disturbance from grazing, past cutting, or siltation. Cottonwoods are often the dominant overstory tree, though other native trees may be dominant. Invasive trees and shrubs may be prominent. Exotic herbaceous species, such as reed canary grass, smooth brome and garlic mustard may be prominent to co-dominant in the groundlayer. Disturbance tolerant native plants are usually co-dominant or dominant in the groundlayer, including white snakeroot, nettles, whitegrass, Wood's rose (Rosa woodsii), and annual bedstraw (Galium aparine). Conservative native plant diversity and abundance is limited compared to Grade A and B sites. The natural hydrology and flood regime of these sites has often been significantly altered. Examples of Grade C riparian woodlands occur on Dry Creek WMA and Rose Creek WMA.

Grade D Eastern Riparian Forests/Woodlands – Grade D eastern riparian forests/woodlands are fairly common, though possibly less so on WMAs than Grade C riparian woodlands. Grade D woodlands can be dominated by young to old-growth trees. They have often experienced severe disturbance from grazing, cutting, or sedimentation. Native trees may dominate the sites, though exotic trees and shrubs may be prominent to dominant. Though weedy native plants may be prominent, the groundlayer is usually

dominated by exotic species, especially reed canary grass or smooth brome and possibly garlic mustard. Conservative native species only occur as scattered individuals if at all. The hydrology of these woodlands has often been so disrupted that the sites may no longer resemble wetlands.

Management Objectives and Guidelines for Various Grade Eastern Riparian Deciduous Forests/Woodlands

Grade A and B Eastern Riparian Forests/Woodlands
Management Objective: Maintain and enhance Grade A site quality, enhance Grade B sites to Grade A quality. This includes maintaining or enhancing the site's natural hydrology.

Minimum Management:

1) Conduct prescribed burns every 5 years.
2) Annually survey for and spot spray or otherwise control all exotic honeysuckle, exotic buckthorn, reed canary grass, smooth brome, garlic mustard, smooth brome and other invasive species populations.
3) Control all invasive tree and shrub species not controlled through prescribed fire.
4) Maintain deer populations as low to moderate population densities.
5) Restore the sites natural hydrology where possible through plugging of ditches removing of dikes, etc.

Management Options

1) Annual prescribed burns can be conducted if necessary to meet management objectives, such as controlling exotic species or reducing tree densities.

Grade C Eastern Riparian Forests/Woodlands
Management Objective: Enhance the forest quality to Grade B. This includes enhancing the site's natural hydrology.

Minimum Management:

1) Conduct prescribed burns every 5 to 7 years.
2) Annually survey for and spot spray all garlic mustard populations.
3) Cut and stump spray all Russian olive, autumn olive, exotic buckthorn, exotic honeysuckle and other highly invasive tree and shrub species.

Management Options

1) Annual prescribed burns can be conducted if necessary to meet management objectives, such as controlling exotic species or reducing tree densities.
2) Restore the sites natural hydrology where possible through plugging of ditches, removing of dikes, etc. where possible.

Grade D Eastern Riparian Forests/Woodlands

Management Objective: Improve wildlife habitat and provide buffers for and corridors between other native plant communities. Where native plant species remain, manage for these species as wildlife habitat.

Minimum management:

1) Annually survey for and spot spray or otherwise control all garlic mustard.
2) Cut and stump spray all Russian olive, autumn olive, exotic honeysuckles, exotic buckthorns and other highly invasive woody species.

Management Options:

1) Conduct prescribed burns when desired to promote wildlife habitat and control invasive trees.
2) Restore the sites natural hydrology if possible.

Western Riparian Woodland System

Range

Western riparian woodlands occur on stream and river floodplains and low terraces in the western two-thirds of the state.

Communities Included

The following natural communities described by Steinauer and Rolfsmeier 2010 are included in the Western Riparian Woodland system:

Cottonwood-Peachleaf Willow Riparian Woodland
Cottonwood Riparian Woodland
Cottonwood – Diamond Willow Woodland
Peachleaf Willow Woodland

Dominant Species

Trees - primarily plains cottonwood (Populus deltoides) and peachleaf willow (Salix amygdaloides), but also box-elder (Acer negundo), green ash (Fraxinus pennsylvanica), American elm (Ulmus americana)
Shrubs – roughleaf dogwood (Cronus drummondii), chokecherry (Prunus virginiana), wild plum (P. Americana), sandbar willow (S. interior), buffaloberry (Shepherdia argentea), and wolfberry (Symphoricarpos ooccidentalis)
Herbs – white snakerood, sedges (Carex spp.), western wheatgrass (Elymus smitthii), switchgrass (Panicum virgatum), little bluestem (Schizachrium scoparium), green needlegrass (Nassela viridula), prairie cordgrass (Spartina pectinata), eastern poison ivy (Toxicodendron radicans), scouring rushes (Equisetum spp.), Virginia creeper, wild licorice (Glycyrrhiza lepidota)

Primary Invasive Species

Trees- Eastern red cedar, Siberian elm (Ulmus pumila), Russian olive (Elaeagnus angustifolia), white mulberry (Morus alba)

Shrubs - common buckthorn (Rhamnus cathartica), salt-cedar (Tamarix chinensis) Herbs - garlic mustard (Alliaria petiolata), ground-ivy (Glechoma hederacea), leafy spurge (Euphorbia esula), Canada thistle (Cirsium arvense), musk thistle (Carduus nutans), cheatgrass (Bromus spp.), redtop (Agrostis gigantean), Kentucky bluegrass (Poa pratensis), reed canary grass (Phalaris arundinacea), Garrison creeping foxtail (Alopecurus arundinaceus), smooth brome (Bromus inermis), and intermediate wheatgrass (Elymus hispidus)

Quality Grades

Grade A Western Riparian Woodlands – Grade A western riparian woodlands are rare. They may have an overstory dominated by young (20-50 years) to old-growth (120 years +) trees. These woodlands may have had light cutting in the distant past and little or no disturbance from past grazing. Cottonwoods are generally the dominant overstory tree though peachleaf willow, green ash, American elm, and boxelder may also be dominants. Native shrubs may also be prominent. Invasive trees and shrubs, such as Russian olive, are restricted to isolated individuals or patches. Invasive herbaceous plants species are restricted to small isolated patches. Conservative native grasses and sedges dominate the groundlayer, along with some forbs, including wholly sedge (Carex pellita), Emory's sedge (C. emoryi), Canada wild-rye (Elymus canadensis), prairie cordgrass, green needlegrass, Virginia creeper (Parthenocissus quinquefolia), Canada sanicle (Sanicula canadensis), hog-peanut (Amphicarpaea bracteata), sweet scented bedstraw (Galium triflorum), scoring rushes (Equisetum spp.), and false Soloman's-seal (Maianthemum stellatum). The hydrology and flood regimes of these sites has not been altered, or only slightly altered, by dikes, ditches, drains, or reduced groundwater levels resulting from pumping, channelization, or reduced instream flows in adjacent streams.

Grade B Western Riparian Woodlands – Grade B western riparian woodlands are uncommon. Grade B woodlands have an overstory dominated by young to old-growth trees. Cottonwoods are generally the dominant overstory tree, though peachleaf willow, green ash, American elm, and boxelder may be dominants. Native shrubs may also be prominent. Stands may have experienced moderate past disturbance from grazing, cutting, or sedimentation. Invasive exotic trees, such as Russian olive, are limited in abundance. Invasive herbaceous plants, especially exotic cool-season grasses, may be more abundant than in Grade A woodlands though they are not widespread or dominant. Weedy native plants including white snakeroot (Ageratina altissima), western ragweed (Ambrosia psilostycha), sand dropseed (Sprobolus cryptandrus), and western wheatgrass may be locally common. Conservative native grasses sedges, and forbs are abundant in Grade B woodlands, though their abundance and diversity is less than in Grade A woodlands. The hydrology and flood regime of Grade B sites is often somewhat to moderately altered by dikes, ditches, drains, or reduced groundwater levels resulting from pumping, channelization, or reduced instream flows in adjacent streams. An example of Grade B western riparian woodland occurs on Soldier Creek Research Natural Area.

Grade C Western Riparian Woodlands – Grade C western riparian woodlands are common, probably making up the majority of riparian woodlands on WMAs. Grade C

woodlands can have an overstory dominated by young to old-growth trees. Cottonwoods are often the dominant overstory tree, though peachleaf willow, green ash, American elm, and boxelder may also be dominant. Invasive trees and shrubs, such as Russian olive, may be prominent. These stands have often experienced rather heavy disturbance from grazing, past cutting, or sedimentation. Disturbance tolerant native plants are usually dominant in the groundlayer, including white snakeroot, western ragweed, sand dropseed and western wheatgrass. Exotic herbaceous species, such as reed canary grass, smooth brome, Kentucky bluegrass, and thistles, may be prominent to co-dominant in the groundlayer. Conservative native plant diversity and abundance is limited compared to Grade A and B sites. The natural hydrology and flood regime of these sites has often been significantly altered. An example of a Grade C western riparian woodland occurs on Dry Creek WMA.

Grade D Western Riparian Woodlands – Grade D western riparian woodlands are fairly common, though possibly less so on WMAs than Grade C riparian woodlands. Grade D woodlands can be dominated by young to old-growth trees. They have often experienced severe disturbance from grazing, cutting, or sedimentation. Native trees including cottonwoods, peachleaf willow, green ash, American elm, and boxelder may dominate the sites, though exotic trees and shrubs may be prominent to dominant. Though weedy native plants may be prominent, the groundlayer is usually dominated by exotic species, commonly reed canary grass, smooth brome, Kentucky bluegrass, or thistles. Conservative native species only occur as scattered individuals, if at all. The hydrology of the woodlands have often been so disrupted that the sites no longer resemble wetlands. An example of a Grade D western riparian woodlands occurs on Platte WMA.

Management Objectives and Guidelines for Various Grade Western Riparian Woodlands

Grade A and B Western Riparian Woodlands
Management Objective: Maintain and enhance Grade A site quality, enhance Grade B sites to Grade A quality. This includes maintaining or enhancing the site's natural hydrology.

Minimum Management:

1) Conduct prescribed burns every 5 to 7 years.
2) Annually survey for and spot spray or otherwise control all smooth brome, reed canary grass, garlic mustard, and other invasive herbaceous plants.
3) Control all invasive tree and shrub species, including Russian olive, salt-cedar, eastern red cedar, and common buckthorn, not controlled by prescribed fire.
4) Maintain deer populations as low to moderate population densities.
5) Restore the sites natural hydrology where possible through plugging of ditches, removing of dikes, etc.

Management Options

1) Annual prescribed burns can be conducted if necessary to meet management objectives, such as controlling exotic species or reducing trees densities.
2) Open woodlands with grasses dominate groundlayer can be occasionally grazed using methods approved for Grade A and Grade B wet meadows.

Grade C Western Riparian Woodlands

Management Objective: Enhance the forest quality to Grade B condition. This includes enhancing the site's natural hydrology.

Minimum Management:

1) Conduct prescribed burns every 5 to 6 years.
2) Annually survey for and control garlic mustard, and all noxious weeds.
3) Control all Russian olive, salt-cedar, and exotic buckthorns.

Management Options

1) Annual prescribed burns can be conducted if necessary to meet management objectives, such as controlling exotic species or reducing trees densities.
2) Open woodlands with grasses dominate groundlayer can be occasionally grazed using methods approved for Grade C wet meadows.
3) Restore the sites natural hydrology where possible through plugging of ditches, removing dikes, etc.

Grade D Western Riparian Woodlands

Management Objective: Improve wildlife habitat and provide buffers for and corridors between other native plant communities. Where native plant species remain, manage for these species as wildlife habitat.

Minimum Management:

1) Annually survey for and control garlic mustard, exotic buckthorns, Russian olive, salt-cedar and all noxious weeds.

Management Options:

1) Conduct prescribed burns when desired to promote wildlife habitat and control invasive trees.
2) Open woodlands with a grass dominated groundlayer occasionally can be grazed using methods approved for Grade C wet meadows.
3) Restore the sites natural hydrology if possible.

Coniferous Forest System

Range

Coniferous forests occur commonly in the Pine Ridge, locally in the Niobrara River valley in Brown and Cherry counties and the Wildcat Hills of Banner and Scotts Bluff counties.

Communities Included:

The following natural communities described by Steinauer and Rolfsmeier 2010 are included in the Coniferous Forest system:

Ponderosa Pine Forest
Green Ash – Elm – Hackberry Canyon Bottom Woodland (This deciduous community often occurs in close association with coniferous forests in the Pine Ridge and to a lesser extent the Wildcat Hills. It is dominated by green ash, American elm, boxelder, and hackberry and occurs in ravine and canyon bottoms bordered by coniferous forests. These stands should be managed with the same techniques employed on the surrounding coniferous forests).

Dominant Species
Tree canopy - ponderosa pine (Pinus ponderosa)
Tree subcanopy - green ash (Fraxinus pennsylvanica)
Shrubs - saskatoon serviceberry (Amelanchier alnifolia), chokecherry (Prunus virginiana), Oregon grape (Berberis repens), dwarf juniper (Juniperus communis), skunkbush sumac (Rhus aromatica), wolfberry (Symphoricarpos occidentalis), western poison ivy (Toxicodendron radicans)
Herbs - spreading dogbane (Apocynum androsaemifolium), common wood sedge (Carex blanda), sun sedge (C. heliophila), Rocky Mountain sedge (C. saximontana), brittle bladder fern (Cystopteris fragilis), wild-ryes (Elymus spp.), starry false Solomon'seal (Miianthemum stellatum), littleseed ricegrass (Piptatherum micranthum), smooth blue aster (Symphyotrichum laeve)

Primary Invasive Plants
Trees- eastern red cedar (Juniperus virginiana)
Herbs - Kentucky bluegrass (Poa pratensis), intermediate wheatgrass (Elymus hispidus), smooth brome (Bromus inermis)

Quality Grades
Grade A Coniferous Forests – Grade A coniferous forests are rare. Grade A forests often have an all-aged overstory (minor gaps may occur) with a prominence of mature (90-120 years) and old-growth (120 years +) trees. These forests may have had light cutting in the distant past and little disturbance from grazing. Pine densities are at fairly natural levels. The shrub layers may be dense, with eastern red cedar occurring only as widely scattered individuals. There is not excessive ground litter. Conservative forest plants are conspicuous throughout and dominate the groundlayer including sedges (Carex spp), spreading dogbane, brittle bladder fern, wild-ryes, starry false Solomon'seal, littleseed ricegrass, smooth blue aster, harebell (Campanula rotundifolia), prairie alumroot (Heuchera richardsonii), columbine (Aquilegia canadensis), northern bedstraw (Galium boreale), spotted coral-root (Corallorhiza maculata), and nodding onion (Allium cernuum). Exotic herbaceous species are restricted to small isolated patches. Examples of Grade A coniferous forests occur on the Pine Ridge NRA.

Grade B Coniferous Forests – Grade B coniferous forests are somewhat common in the Pine Ridge. Grade B forests have an overstory dominated by mature and/or old-growth

trees that have had limited past disturbance from grazing or cutting. Grade B occurrences also include mid-aged stands (50-90 years) that are second growth, but otherwise have received little recent disturbance. These stands may have rather significant gaps in their age class structure resulting from past grazing or cutting. Pine densities may be somewhat unnaturally high in Grade B occurrences. The shrub layers may be dense, though eastern red cedar has low to moderate abundance. Ground litter may be somewhat high. Conservative groundlayer plants are common, though their diversity and abundance is less than in Grade A forests. Exotic herbaceous plants are more common than in Grade A forests, though they are not widespread or dominant. Examples of Grade B coniferous forests occur at Chadron State Park and Gilbert Baker WMA.

Grade C Coniferous Forests – Grade C coniferous forest are common in the Pine Ridge. Grade C woodlands can have an overstory dominated by mid-aged (50-90 years) trees, possibly with a few mature and old-growth trees. These stands often have experience heavy disturbance from past grazing and cutting. Also included here are forests dominated by young (20-50 years) second growth trees that have been relatively undisturbed since cutting. Pine densities can be fairly high, especially young trees. Eastern red cedars may be prominent. Occasional logging roads may be present. Ground litter accumulation is often dense and may limit herbaceous vegetation. Conservative native forb diversity and abundance is limited compared to Grade A and B sites. Exotic herbaceous species, especially Kentucky bluegrass, may be prominent to co-dominant. Examples of Grade C coniferous forests occur on Metcalf WMA and Soldier Creek RNA.

Grade D Coniferous Forests – Grade D coniferous forests may be less common than Grade C forests. Grade D forests are generally dominated by young trees. These stands have often experienced recent severe disturbance from grazing or cutting. Logging roads may be common. Eastern red cedars may be prominent to co-dominant in the subcanopy and shrub layers. Ground litter accumulation is often excessive, severely limiting growth of herbaceous species. The ground layer is dominated by weedy native plants or exotic species.

Management Objectives and Guidelines for Various Grades of Coniferous Forests

Grade A and B Coniferous Forests
Management Objective: Maintain and enhance Grade A site quality, enhance Grade B sites to Grade A quality

Minimum Management:

1) Conduct prescribed burns at least once every 5 years. Once ground litter, groundlayer vegetation, small tree densities, and ladder fuels are at desired levels the fire return interval can be extended to 8 to 10 years.
2) Where needed hand thin excess younger pines and all eastern red cedar. Some mechanical thinning may be used with extreme caution.
3) Annually survey for and spot spray or otherwise control all noxious weeds and other invasive plant infestations.
4) Maintain deer populations as low to moderate population densities.

Management Options:

1) Initially prescribed fires can be conducted more frequently than every 5 years to meet management objectives.
2) Coniferous forests often occur as patches within a mosaic of coniferous woodland and prairie therefore, it may be necessary to include them within grazing units. Grazing of Grade B forests is acceptable as long as appropriate grazing methods for the surrounding grassland types are used.

Grade C Coniferous Forests

Management Objective: Enhance the forest quality to Grade B condition.

Minimum Management:

1) Conduct prescribed at least once every 5 years. Once ground litter, groundlayer vegetation, small tree densities, and ladder fuels are at desired levels the fire return interval can be reduced to a minimum of once every 10 years.
2) Mechanically thin excess trees (young pines and eastern red cedars) using ecologically sensitive methods while minimizing road and trail development.
3) Annually survey for and spot spray or otherwise control all noxious weeds.

Management Options

1) Initially prescribed fires can be initially conducted more frequently than once every 5 years to meet management objectives.
2) Coniferous forests often occur as patches within a mosaic of coniferous woodland and prairie therefore, it may be necessary to include them within grazing units. Grazing of Grade C forests is acceptable as long as appropriate grazing methods for the surrounding grassland types are used.

Grade D Coniferous Forests

Management Objective: Manage as wildlife habitat and as buffers for and corridors between higher quality native habitats and reduce fuel loading to prevent catastrophic wildfires.

Minimum management:

1) Conduct prescribed at least once every 10 years. Once ground litter, groundlayer vegetation, small tree densities, and ladder fuels are at desired levels the fire return interval can be extended to a minimum of once every 15 years.
2) Annually survey for and spot spray or otherwise control all noxious weeds.
3) Management Options
4) Grazing of these forests is acceptable as long as appropriate grazing methods for the surrounding grassland types are used.

Coniferous Woodland System

Range
Coniferous woodlands occur in the Pine Ridge, along the Niobrara River valley in Cherry, Brown and Keya Paha counties, the Wildcat Hills in Banner and Scotts Bluff counties, and to a limited extend on escarpments in Cheyenne, Kimball, and Morrill counties.

Communities Included
The following natural communities described by Steinauer and Rolfsmeier 2010 are included in the Coniferous Woodland System:

Dry-Mesic Ponderosa Pine Woodland
Dry Ponderosa Pine Open Woodland and Savanna
Pine-Juniper Scarp Woodland

Dominant Species
Tree canopy - ponderosa pine (Pinus ponderosa)
Tree subcanopy - Rocky Mountain juniper (Juniperus scopulorum)
Shrubs - chokecherry (Prunus virginiana), skunkbush sumac (Rhus aromatica), Arkansas rose (Rosa arkansana), wolfberry (Symphoricarpos occidentalis)
Herbs - big bluestem (Andropogon gerardii), little bluestem (Schizachrium scoparium), side-oats grama (Bouteloua curtipendula), blue grama (B. gracilis), prairie sandreed (Calamovilfa longifolia), western wheatgrass (Elymus smithii), slender wheatgrass (Elymus trachycaulis), needle-and-thread (Hesperostipa comata), threadleaf sedge (Carex filifolia), sun sedge (C. heliophila), Rocky Mountain sedge (Carex saximontana), white sage (Artemesia ludoviciana), rough heath aster (Symphyotrichum falcatum), golden pea (Thermopsis rhombifolia), yucca (Yucca glauca)

Primary Invasive Plants
Trees- eastern red cedar (Juniperus virginiana)
Herbs - Kentucky bluegrass (Poa pratensis), intermediate wheatgrass (Elymus hispidus), smooth brome (Bromus inermis)

Quality Grades
Grade A Coniferous Woodlands – Grade A coniferous woodlands are rare. Grade A woodlands are dominated by mature (90-120 years) and old-growth (120 years +) trees. These woodlands may have had light cutting in the distant past and little disturbance from grazing. Pine densities are at fairly natural levels. Eastern red cedars occur only as widely scattered individuals. There is not excessive ground litter. Conservative grassland species are conspicuous throughout and dominate the groundlayer including: native warm-season grasses, native cool-season grasses, sedges (Carex spp.), white prairie clover (Dalea candidum), golden pea, dotted gayfeather (Liatris punctata), Montana lily (Leucocrinum montanum), false Soloman's seal (Maianthumum stellatum), northern pussytoes (Antennaria howellii), pasque flower (Anemone patens), purple

coneflower (Echinacea angustifolia), Arkansas rose, Indian breadroot (Pediomelum esculentum), silver-leaf scurf-pea (P. argophyllum), and penstemons (Penstemon spp.). Exotic herbaceous species are restricted, the exception being Kentucky bluegrass and annual bromes which may be scattered throughout the woodland.

Grade B Coniferous Woodlands – Grade B pine woodlands are fairly common. Grade B coniferous woodlands are dominated by mature and/or old-growth trees, these stands have received only light disturbance from recent cutting or grazing. Grade B occurrences also include mid-aged stands (50-90 years) that are second growth and have received little recent disturbance. Eastern red cedars have low to moderate abundance. Ground litter accumulation may be somewhat high. Conservative groundlayer plants are still common, though their diversity and abundance is less than in Grade A woodlands. Exotic herbaceous plants, including annual bromes and Kentucky bluegrass, are more common than in Grade A woodlands, though they are not widespread or dominant. Examples of Grade B coniferous woodlands occur on the Peterson WMA.

Grade C Coniferous Woodlands – Grade C coniferous woodlands are common. Grade C woodlands have an overstory usually dominated by mid-aged trees with some older trees. These stands have often experienced rather heavy disturbance from past grazing and cutting. Also included here are woodlands dominated by young (20-50 years) second growth trees that have been relatively undisturbed since cutting. Eastern red cedars and pine saplings and pole-sized trees may be prominent. Occasional logging roads may be present. In areas, ground litter accumulation is often dense and may limit groundlayer vegetation. Native grasses and sedges still dominate, though exotic cool-season grasses can be prominent to co-dominant. Conservative native forb diversity and abundance is limited compared to Grade A and B sites. Examples of Grade C coniferous woodlands occur on the Platte River Basin Environment's Carter Canyon Ranch.

Grade D Coniferous Woodlands – Grade D coniferous woodlands are probably less common than Grade C woodlands. Grade D woodlands are generally dominated by young trees, though older trees may be present. These stands have experienced severe disturbance from grazing or cutting. Logging roads may be abundant. Eastern red cedars may be prominent to co-dominant in the subcanopy and shrub layer. Ground litter accumulation is often excessive, severely limiting growth of herbaceous species. The ground layer is dominated by weedy native plants or exotic cool-season grasses. Conservative native grasses may still occur as scattered individuals. Conservative native forbs occur only as widely scattered individuals, if at all.

Management Objectives and Guidelines for Various Grade Coniferous Woodlands

Grade A and B Coniferous Woodlands
Management Objective: Maintain and enhance Grade A site quality, enhance Grade B sites to Grade A condition.

Minimum Management:

1) Conduct prescribed burns at least once every 3 or 4 years. Once ground litter, herbaceous vegetation, tree densities, and ladder fuels are at desired levels the fire return interval can be extended to once every 6 to 7 years.
2) Where not controlled by prescribed fire hand thin excess younger pines and all eastern red cedar. Mechanical thinning can be used with caution in areas where it will not cause soil disturbance, such as level slopes.
3) Graze woodlands once in every 3 years using short-duration, moderate to high intensity grazing at various times of the year.
4) Annually survey for and spot spray or otherwise control all noxious weeds and other invasive plant infestations.

Management Options

1) Annual prescribed burns can be conducted if necessary to meet management objectives, such as controlling exotic species or reducing trees densities.

Grade C Woodlands

Management Objective: Enhance the woodland quality to Grade B condition.

Minimum Management:

1) Conduct prescribed burns at least once every 5 years. Once ground litter, herbaceous vegetation, small tree densities, and ladder fuels are at desired levels the fire return interval can be extended to a minimum of once every 6 to 7 years.
2) Graze woodlands once in every 3 years using short-duration, moderate to high intensity grazing at various times of the year.
3) Annually survey for and spot spray or otherwise control all noxious weeds.

Management Options

1) Annual prescribed burns can be conducted if necessary to meet management objectives, such as controlling exotic species or reducing trees densities.
2) Mechanical tree thinning may be used in areas where prescribed fire is absolutely not practical. This should be done in an ecological sensitive manner.

Grade D Coniferous Woodlands

Management Objective: Manage as wildlife habitat and as buffers for and corridors between higher quality native habitats, reduce fuel loading to prevent catastrophic wildfires.

Minimum management:

1) Conduct prescribed at least once every 10 years. Once ground litter, groundlayer vegetation, small tree densities, and ladder fuels are at desired levels the fire return interval can be extended to a minimum of once every 15 years.
2) Annually survey for and spot spray or otherwise control all noxious weeds.

Management Options

1) These sites can be grazed once every 3 to 5 years using short-duration grazing or as part of grazing system appropriate for surrounding grassland types.

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