Previous View

Chapter 52

Central Hardwood Cover Type

WISCONSIN
DEPT. OF NATURAL RESOURCES

Last Full Revision: 1/16/2009
Note- this chapter has not been fully revised since the restructuring of the Wisconsin Silviculture Guide, therefore some subject areas may be missing in the current version of this chapter.

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1 TYPE DESCRIPTION

1.1 Stand Composition and Associated Species

Stand Composition
The central hardwood cover type consists of variable associations of upland hardwood species, predominantly oaks (*Quercus spp*.), shagbark hickory (*Carya ovata*), bitternut hickory (*Carya cordiformis*), elms (*Ulmus spp*.), black cherry (*Prunus serotina*), red maple (*Acer rubrum*), white ash (*Fraxinus americana*), green ash (*Fraxinus pensylvanica*), basswood (*Tilia americana*), hackberry (*Celtis occidentalis*), and sugar maple (*Acer saccharum*). This association does not satisfy the defining criteria for:

Oak (Chapter 41) – at least 50% of the basal area is oak
Red maple (Chapter 51) – at least 50% of the basal area is red maple
Northern Hardwood (Chapter 40) – at least 50% of the basal area is any combination of sugar maple, beech, basswood, white ash, yellow birch.

Tree size, age, and condition in addition to stand composition, reflect physical site factors, natural history, and human impacts (e.g. fire, grazing, harvesting, and clearing for agriculture). The present composition of many stands depends more upon the past history of the stand than on site quality. Poor harvesting practices (e.g. high grading, diameter limit cutting, and commercial clear cutting) and grazing have resulted in many low density, low quality stands with high density shrub layers.

Associated Species
Aspen (*Populus grandidentata, P. tremuloides*), black walnut (*Juglans nigra*), butternut (*J. cinerea*), honey locust (*Gleditsia triacanthos*), black locust (*Robinia pseudoacacia*), box elder (*Acer negundo*), white birch (*Betula papyrifera*), ironwood (*Ostrya virginana*), white pine (*Pinus strobis*).

1.2 Silvical Characteristics[1]

Shagbark Hickory
Shagbark hickory represents 10% of the total net growing-stock volume within Ecological Province 222 which encompasses most of southern Wisconsin (Vissage *et al.* 2005). Although shagbark hickory grows best in humid climates, it is adapted to a wide range of climatic conditions and occupies a variety of sites.

Shagbark hickory is a medium-sized slow growing tree that ranges in height from 70 to 80 feet. Shagbark hickory is a long lived, mid to late successional species classed as intermediate in shade tolerance. Saplings and small reproduction can persist for many years under a dense canopy overstory and respond rapidly when released.

Shagbark hickory reaches seed bearing age at 40 years, and produces abundant seed crops every 1 to 3 years. The heavy seeds are dispersed from September through December, primarily by gravity and small mammals. The seed is encapsulated within a husk that becomes

[1] Burns, R.M., and B.H. Honkala (tech. coords.). 1990. Silvics of North America: 2. Hardwoods Agric. Hndbk 654. USDA For. Serv., Wash. D.C.

dry at maturity and splits freely into four valves along grooved sutures. Germination of fresh seed ranges between 50 - 75%. Once established, hickory seedlings typically develop a large deep taproot that can extend down 2 feet or more. Successful germination of seed requires cold stratification either naturally through over-wintering within forest litter or artificially for a period of 90 - 120 days. Shagbark is rated as windfirm on most sites.

Shagbark hickories less than 8 inches in diameter can produce vigorous stump sprouts. However, as stump diameters increase in size, stump sprouting declines, and the proportion of root suckers increases. Young sprouts generally compete well in newly regenerated stands, but after 10 to 20 years, the rate of sprout growth declines and shagbark hickory may be outcompeted by faster growing associates.

Although they do develop clear straight boles, shagbark hickories also have a propensity to fork at one-half to two-thirds the height of the tree. Due to its relatively slow growth, shagbark hickory can be at a distinct disadvantage under even-aged management systems where rotation lengths are less than 100 years. Growing more slowly than oaks and other associated species, shagbark hickories can be found in subdominant crown positions by mid-rotation thus making them likely candidates for removal during periodic thinnings. Since shagbark hickory is considered a long-lived tree that can withstand shading and crowding and responds well to release, it appears to be well suited (along with white oak) for longer rotations up to 200 years or more.

Shagbark hickory is an excellent source of food for wildlife.

<u>Bitternut Hickory</u>
Bitternut hickory represents 4% of the total net growing-stock volume within Ecological Province 222 which encompasses most of southern Wisconsin (Vissage *et al.* 2005). Bitternut hickory grows on a wide range of sites from dry, gravelly uplands to moist flats. In Wisconsin, it grows well on mesic, nutrient rich sites.

Bitternut hickory produces good seed crops every 3 to 5 years, with optimum seed production occurring between 50 and 125 years of age. Seed dissemination is almost exclusively by gravity, and seed viability is estimated to range between 70% and 85%. Establishment of bitternut hickory trees from seedlings can be difficult primarily due to seed predators (e.g. squirrels, chipmunks, rabbits and wild turkey). Seeds remaining on the ground for more than 1 year seldom germinate. Germination time is usually 90 to 120 days. In addition, hickory seed requires a period of cold stratification for approximately 30 to 150 days in temperatures that range between 33 to 40 degrees.

Bitternut hickory is considered to be intermediate in shade tolerance. Seedling survival is poor under low light conditions which occur underneath dense forest canopies. Once established, bitternut hickory quickly develops a dense root system with a large taproot. Within the first year of growth, a seedling's taproot reaches to a depth of 12-36 inches, and by the second year it can reach to a depth of 48 inches.

Bitternut hickory sprouts from roots and stumps. Saplings and pole-sized trees produce sprouts from the root collar whereas sawtimber-sized trees produce only root suckers. The copious production of sprouts allows bitternut to withstand damage from a variety of sources such as intensive browsing, breakage, drought and fire. Repeated top dieback and eventual re-sprouting allow each new shoot to become larger in size and develop a stronger root system. This process allows hickory reproduction to gradually increase under moderately dense canopies, especially on drier sites that limit the establishment of more tolerant species. In areas where advanced regeneration of bitternut hickory is adequate, overstory removal results in a fast-growing stand of saplings.

Bitternut hickory typically reaches a height of approximately 100 feet with a maximum life span of about 200 years, making it the shortest lived of all the hickories. When grown in partial light to full sunlight, bitternut hickory rarely experiences significant epicormic branching, and is considered a good self-pruner. In comparison with other true hickories, bitternut hickory is not equal in its wood grain strength, hardness and toughness.

Bitternut hickory is considered a valuable food source for wildlife.

Black Cherry

Black cherry represents 8% of the total net growing-stock volume within Ecological Province 222 which encompasses most of southern Wisconsin (Vissage *et al.* 2005). Although black cherry has a large natural range, its best growth and reproduction occurs on well drained, mesic sites.

Black cherry is a fast growing, shade intolerant tree that can quickly outgrow and overtop any tolerant competitors in stands when initiated simultaneously. In partial shade the reverse is true and height growth of black cherry is considerably less than that of its shade tolerant associates.

Black cherry produces seed most years with abundant crops every 1 to 5 years. Seeds are dispersed primarily by gravity, birds and mammals. The majority of seed falls to the ground in the vicinity of the parent tree. Consequently the number of seedlings is directly proportional to the number and distribution of seed trees in the overstory; birds and mammals are successful in distributing seeds to stands where seed-producing cherry trees are lacking. Black cherry seeds require a period of cold stratification, and utilize a delayed germination process whereby seeds from one crop can germinate over a period of three years. This process allows black cherry to bank large amounts of seed in the forest floor. Mineral soil is not a requisite for successful germination of black cherry. Few seeds germinate in areas lacking organic horizons or compacted by logging machinery. Germination occurs best on undisturbed humus or leaf litter and beneath a canopy that represents 60% canopy coverage or more. In addition to natural seeding, black cherry can regenerate itself vegetatively through stump sprouts.

Below 60% canopy cover, germination decreases and is poorest in full sunlight. However, newly germinated seedlings under these conditions grow rapidly and can reach heights of 2 to 4 inches within 30 days. In contrast, black cherry seedlings established under dense shade can survive 3 to 4 years, but few will grow to be more than 5 or 6 inches tall or survive more than 5 years. Seedlings that die are soon replaced because of the abundance of buried seed. When seedlings are released, growth is rapid and quickly fills an existing gap, overtopping any shade tolerant associates present. Black cherry has a shallow and spreading root system (within 24 inches of the soil surface) making it highly susceptible to wind damage.

Black cherry can attain heights ranging from 60 to 125 feet, with a maximum life span of 150 to 200 years depending on site. On well drained mesic sites, black cherry saplings and poletimber are outcompeted by more shade tolerant species when under a dense canopy cover. In contrast, sites that are either dry-mesic or dry, and generally dominated by oaks and pine, tend to provide more favorable light conditions for black cherry seedlings and sapling. However, on these sites, black cherry has measurable limitations in growth, size, and quality.

American Elm

Collectively the elm species (American and slippery elm) represent 11% of the total net growing-stock volume within Ecological Province 222 which encompasses most of southern Wisconsin (Vissage *et al.* 2005). American elm commonly occurs on poorly drained flats and bottomlands sites, but grows best on rich, well-drained loams. Within the Lake States and Central States, it is common on the plains, moraine hills, bottomlands and swamp margins. It seldom grows in pure stands and is usually found in mixture with other species. American elm is considered a soil-improving species due to a relatively high content of potassium and calcium in its rapidly decomposing leaf litter.

American elm is a prolific spring seed producer, sometimes beginning as early as age 15; however abundant crops seldom occur before age 40. Seeds are light and disseminated primarily by wind and water with the majority of seed falling within 300 feet of the parent tree. Within river-bottom stands seeds may be carried for miles. Seed crop reduction may occur due to predation by many species (e.g. mice, squirrels, opossum, ruffed grouse). Elm seeds germinate in the spring and usually within 6 to 12 days of seed drop. Mineral soil is the best substrate for germination of elm seeds, but alternate seed beds include moss, moist litter, and decayed stumps and logs.

American elm is classified as intermediate in shade tolerance; responding well to release even at advanced ages. First and second year seedlings grow best in about 60% canopy cover. After two years, elm seedlings perform best in full sunlight. Although elm is considered intermediately tolerant when exposed to dormant season flooding, mortality will result in seedlings and saplings when prolonged flooding occurs into the growing season. In addition to natural seeding, small American elms are capable of producing vigorous stump sprouts. Where seeds are available, American elm is a prominent early invader of abandoned fields.

American elm is a fast growing, large-sized tree attaining heights ranging from 80 to 125 feet, and a lifespan of 175 to 200 years, with some older than 300. Its' shallow wide-spreading roots penetrate to depths of 3 - 4 feet on wet, heavy soils, and 5 - 10 feet on drier, medium textured soils. On bottomland sites, the growth rate of elm is considered moderate.

Dutch elm disease arrived in the United States from Europe in 1930. The disease and removal efforts to reduce the disease have since limited elm commercially across much of its landscape. The disease is caused by the fungus *Ceratocystis ulmi*. Spores of this fungus are carried by the American (*Hylurgopinus rufipes*) and European bark beetles (*Scolytus multistria*) from diseased trees to healthy trees. Once a tree is infected, spores of the fungus plug the xylem and a toxin is produced killing the tree.

Slippery Elm
Slippery elm, also called red elm, shares many of the same silvical characteristics as that of American elm; therefore only their primary differences will be described in detail below.

The seeds of slippery elm are larger than those of American elm and produced most years with good crops occurring every 2 to 4 years. Seeds are primarily dispersed by both gravity and wind, and once established elm seedlings are often susceptible to damping off. Slippery elm seedlings can become established in a variety of conditions including grasses and herbaceous plants but is best suited on mineral soil. Slippery elm is classified as a shade-tolerant species, however under fully-stocked stands, reproduction is unpredictable and erratic.

Like American elm, slippery elm produces vigorous sprouts from both the stump and root crown. During its seedling stage it produces sprouts from rhizomes that sometimes form reproduction less than 2 feet tall and in patches 30 feet or more in diameter. Slippery elm can also reproduce by layering.

Slippery elm is fast growing, medium-sized tree reaching heights of 60 to 70 feet on average sites, and 135 feet on the best sites with a maximum lifespan of 200 to 300 years. It grows best on moist, rich soils of lower slopes, stream banks, river terraces, and bottomland, but it can often be found on much drier sites, especially those of limestone substrate.

Like American elm, slippery elm is subject to infection from Dutch elm disease. In contrast, the wood of slippery elm is considered inferior to that of American elm.

Hackberry
In Wisconsin, hackberry is a minor species, representing less than 1% of both the total wood volume and hardwood volume (Vissage *et al.* 2005).

Hackberry is considered intermediate to tolerant of shade, and survival of hackberry seedlings varies significantly under various light conditions and on various sites. Trees suppressed for extended periods of time often become poorly formed.

Hackberry is found in a wide variety of forest types ranging from early-successional to subclimax. It can be propagated by stem cuttings and layering. Sprouts develop from stumps of small trees but rarely from large ones.

Hackberry produces abundant seed crops most years with light seeded crops occurring on intervening years. The seed (a spherical drupe) ripens in September and October and is principally disseminated by birds and small mammals.

Hackberry is a small to medium sized tree ranging in height from 50 to 80 feet, with a maximum life span of 150 to 200 years. It is deep-rooted, reaching depths of 10-20 feet on most sites. It commonly occurs on moist bottomland soils but will grow rapidly in a variety of soil types from moist, fertile valley soils to hot, dry, rocky locations such as limestone or sandstone ridges in full sun. Hackberry is classified as moderately tolerant of flooding, but growth is poor on sites which have high water tables.

Table 52.1. Summary of selected silvical characteristics.

Species	Shagbark Hickory	Bitternut Hickory	Black Cherry	American Elm	Slippery Elm	Hackberry
Flowers	April-May Monoecious wind pollinated	April-May Monoecious wind pollinated	May-June Monoecious, Perfect	April-May Perfect flower	April-May Inconspicuous perfect flowers	May-June population both polygamous and monoecious
Fruit Ripens	Sept.-Oct.	Sept.-Oct.	Aug.-Sept.	May-June	April-June	Sept.-Oct.
# seeds/lb.	100/lb.	125-185/lb.	3,100 - 8,100/lb.	70,900/lb.	35,000 - 54,000/lb	1,600/lb.
Seed Dispersal	Sept.-Jan. Principally gravity rodents extend seeding range	Sept.-Dec. Principally gravity rodents extend seeding range	Autumn. Principally gravity also dispersed by birds and mammals.	May-June, wind dispersed up to .25 miles, waterborne farther.	April to June Principally gravity, wind, and water	Autumn. Principally gravity also dispersed by birds, mammals, and water.
Good Seed Years	Every 1-3 years	Every 3-5 years	Every 1-5 years	Most years unless flower/ fruit frozen.	Every 2-4 years	Most years unless flower/ fruit frozen.
Seeding, yrs (begins/optimal/ declines)	40/60/200	30/50/175	10/25/100	15/40/125	15/40/150	15/30/70
Seed Viability	Prolific seeder. High viability, 50-75%.	Prolific seeder. High viability, 70-85%. Seldom viable >one year in seed bank	Prolific seeder. High viability, avg. 80%. Can remain viable on forest floor >5 years.	Very prolific seeder. High viability, 63% average.Viable on forest floor up to 1 year.	Prolific seeder. With a low viability, 23% average. Stored seed can exhibit lower germination rates.	Prolific seeder. High viability, avg. 47%. Viable on forest floor up to 2 years.
Germination	Spring with pronounced dormancy, requires cold stratification; hypogeal.	Spring with pronounced dormancy, requires cold stratification; hypogeal.	Spring with pronounced dormancy, requires cold stratification; hypogeal.	Spring with no dormancy. Usually within 6-12 days of seed drop, increases in light; epigeal	Spring. Occasionally shows dormancy. Germination soon after sowing in cold conditions: epigeal.	Spring; epigeal

Seedbed Requirements	Moist leaf litter, humus, or mineral soil.	Moist leaf litter, humus, or mineral soil; tolerates moister seedbed than shagbark, less susceptible to frost	Variable. Mineral soil not required. Burial of seed (1-2") and moist seedbed are beneficial.	Variable. Moist litter, moss, and decayed logs & stumps but best on mineral soil.	Variable, but mineral soil seedbeds are best.	Variable. Moist leaf litter, humus, or mineral soil.
Vegetative Reproduction	Sprouts readily up to 10" stump dia. As stump diameters increase, stump sprouting declines and proportion of root suckers increases	Sprouts very readily from stump, root collar and roots. As stump diameters increase, stump sprouting declines and proportion of root suckers increases	Sprouts readily and rapidly in all sizes, especially in full sun. Root collar sprouts are an important and highly desirable.	Small trees produce vigorous stump sprouts.	Sprouts readily from stump and root collar.	Small stumps sprout readily, as stump diameter increases, stump sprouting declines
Seedling development	Produces a long taproot and very little top growth during early development.	Produces long taproot. Top dieback and resprouting occur frequently, successive shoots progressively larger.	Only produces taproot as seedling. High light levels improve seedling survival and height growth.	Depth of rooting varies with soil texture and soil moisture, grow best in full sunlight.	Root system shallow but wide spreading. Juvenile growth is rapid in the open or under light shade.	Deep rooted but taproot rarely develops. Seedlings less flood tolerant than saplings, mature trees.
Shade Tolerance	Intermediate. Saplings/seedlings can survive under dense canopy then recover rapidly when released.	Intermediate, can persist under low light condition on dry-mesic to mesic sites.	Intolerant of both shade and competition	Intermediate, responds well to release	Tolerant, reproduction is erratic under fully stocked stands.	Intermediate – tolerant, successional position is difficult to determine.
Maximum Longevity	Approx. 300 years	Approx. 200 years	Approx. 150-200 years	Approx. 175-300 years	Approx. 200 years	Approx. 100-150 years

Note: For information on central hardwood associate species not listed in this summary, refer to the appropriate cover chapter within this handbook.

2 MANAGEMENT GOALS, LANDOWNER OBJECTIVES

Management objectives should be identified in accordance with landowner goals within a sustainable forest management framework, which gives consideration to a variety of goals and objectives within the local and regional landscape. The silvicultural systems described herein are designed to promote the optimum quality and quantity of central hardwood sawtimber. High quality sawlog and veneer production is the objective for most sites of average to better quality. These silvicultural systems may be modified to satisfy other management objectives, but vigor, growth and stem quality could potentially be reduced. The habitat type is the preferred indicator of site potential. Other indicators of site potential include site index, slope, slope position, aspect, and soil characteristics.

Prior to development and implementation of silvicultural prescriptions, landowner goals need to be clearly defined and articulated, management units (stands) must be accurately assessed, and landowner stand management objectives should be detailed. In-depth and accurate stand assessment will facilitate discussion of management options and objectives in relation to realistic and sustainable management goals.

3 LANDSCAPE, SITE, AND STAND MANAGEMENT CONSIDERATIONS

3.1 Landscape Considerations

Central hardwood forests occur south of the Tension Zone in Wisconsin, occupying areas that were formerly oak forest or savanna and which are now undergoing succession to maple-dominated forest. Past management has altered species composition and affected timber quality in these forests. Landscape considerations for managing central hardwoods are intended to mitigate some of the anticipated negative effects of the transition of oak forests to central hardwoods, including considerations for forest composition and structure, and the cumulative effects of management practices.

3.1.1 Historical Context

Historically, central hardwood forests as we currently define them appear to have been of very limited extent in Wisconsin (Finley 1976). When Euro-American settlement began in the 1830's, the areas that are now central hardwoods were dominated by oak forest and savanna. Land clearing for agriculture led to the loss of many oak-dominated forests. Oaks and other hardwoods were used for fences, building materials, and fuels, and many were piled and burned to clear the land. As marginal agricultural areas reverted to forest, the combined effects of burning and pasturing created ideal conditions for the re-establishment of oak forests. As oaks re-grew, fire suppression allowed the new forests to achieve a greater density than was typical of the savannas and forests that existed prior to Euro-American settlement.

Figure 52.1. Central hardwood range (USA) (Clark and Hutchinson 1989).

During the past several decades, FIA data have indicated a steady decline in the oak component of mesic forests in southern Wisconsin. Lack of fire, competition from native and non-native species, as well as herbivory by white-tailed deer, has impacted oak regeneration and caused a gradual shift to shade-tolerant species characteristic of later-successional central hardwood forests, including red and sugar maple, basswood, hickories, elms, green and white ash, black cherry, and ironwood. The selective removal of commercially valuable red and white oaks has contributed to the loss of an oak component (see Oak Cover Type chapter). In locations where sugar maple seed sources are present, central hardwoods appear to be succeeding to northern hardwoods, and this trend is expected to continue. Improper forest management practices have genetically and structurally degraded many central hardwood stands, often resulting in low-density stands with thick understory shrub layers, and low economic value.

FIA data indicate that central hardwoods increased between 1996 and 2005 in poletimber and sawtimber size classes, but not in seedling/sapling classes (Figure 52.2). Overall acreage occupied remained about the same. This analysis used FIA plots that closely matched WDNR's criteria for the central hardwood cover type within Province 222 excluding the Central Sand Plains.

Figure 52.2 shows trends in central hardwoods as well as "non-central hardwoods", which generally represent northern hardwoods, red maple, and oak cover types on dry-mesic to mesic sites in southern Wisconsin, excluding the Central Sand Plains.

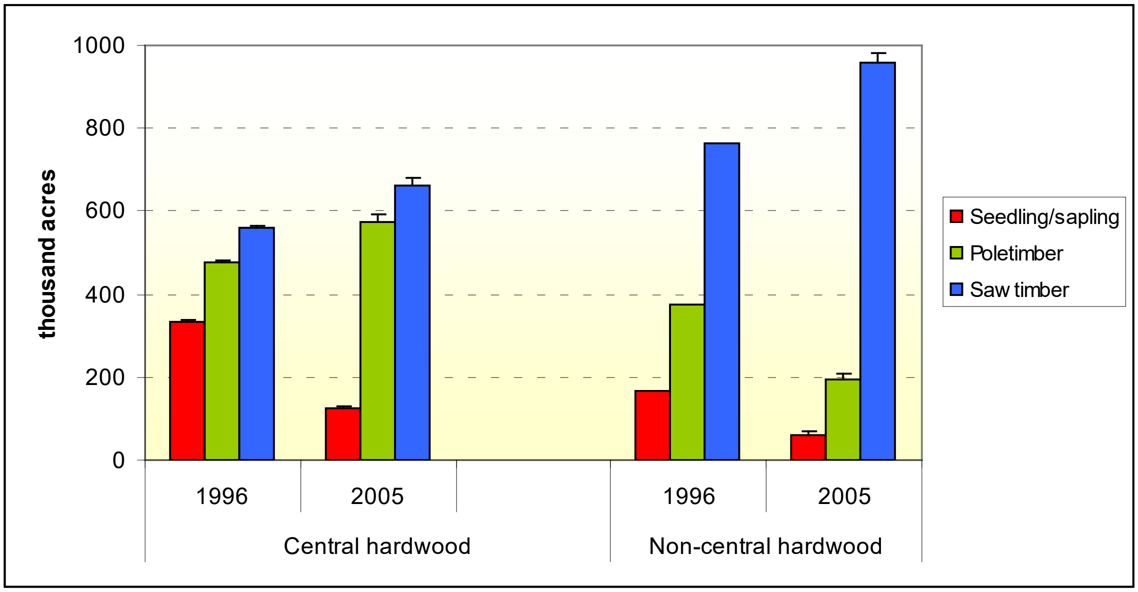

Figure 52.2. Acreage trends by stand-size class in central hardwoods and non-central hardwoods in Province 222, excluding the Central Sand Plains (FIA data, 1996-2005).

3.1.4 Landscape Composition

Central hardwoods are a forest type that until recently was uncommon in Wisconsin, and we have very little information on how its increasing dominance will affect wildlife, understory plant species, and other ecosystem properties. Central hardwoods are gradually replacing oak-dominated forests on mesic and dry-mesic sites, and the decrease of oak, a valuable wildlife species, is of concern. Many structural characteristics of oak species are not duplicated in the central hardwoods. Also, leaf litter from central hardwood stands is a poor carrier of fire, and the loss of fire disturbance will lead to further changes in soil and microbial properties. We anticipate that the increase in Central Hardwoods will have net negative effects on wildlife and ecosystem components that have been associated with oak forests during the past century. Generally, when an environment changes, some wildlife species lose their habitat while others benefit. In this case we do not know which species might benefit, because central hardwoods were not previously common. We do not know of any species that prefer central hardwoods to oak forest.

3.1.5 Landscape Structure

The central hardwood forests of southern Wisconsin are primarily distributed as small, isolated patches, or as linear features with little interior forest, with a few exceptions. Forests are mostly separated by agricultural and suburban areas, which differ starkly in habitat quality, making it difficult for certain wildlife and plant species to move from one forest patch to another. This landscape is characterized by a high level of "permanent fragmentation" – a term that refers to the long-term conversion of native habitat to urban, residential or agricultural uses.

Fragmentation and edge effects are particularly prominent in the central hardwood forest type. Southern Wisconsin's rich prairie soils were developed for agriculture early in the process of

Euromerican settlement, and rural areas have been further impacted in recent decades by extensive residential development. Consequently, there are few remaining large blocks of forested land. The average size of private non-industrial forest land parcels declined from 36 to 30 acres between 1984 and 1997 in southern Wisconsin. By comparison, in northern Wisconsin parcel size declined only slightly, from 44 to 43 acres, during the same time period (Roberts *et al*. 1986, Leatherberry 1997).

The fragmented patch structure of central hardwood forests leads to excessive amounts of edge habitat, which is beneficial to some species, but is associated with declines in populations of neotropical migratory songbirds (NTMB's). Edge effects on other wildlife species are not as well documented. NTMB's are considered "indicators of ecosystem health" (Robbins 1995). During the 1980's, research studies identified increases in predation and nest parasitism along forest edges (Brittingham and Temple 1983, Wilcove 1985). These effects are more harmful to songbirds in areas where agricultural and urban land uses predominate (Small and Hunter 1988). The less-fragmented forests of northern Wisconsin are "centers of abundance" for breeding populations of some species of NTMBs (Howe et al. 1995), and may be population "sources" (net productivity is positive and population increases). Parts of southern Wisconsin may be 'sinks' (excess population from source areas occupies inferior habitat where net productivity is negative, but populations persist over time because of proximity to the source area). In this fragmented landscape, cowbird parasitism is of large concern for NTMB's, as is nest predation from small mammals, crows, jays, raccoons, skunks, opossums, coyotes, foxes, domestic pets, and feral cats and dogs.

Some species are "area-sensitive", requiring large patches of relatively contiguous forest cover. Mossman and Hoffman (1989) summarized a number of breeding bird surveys, noting that isolated forest patches of 40 to 80 acres in size were dominated by generalist species, while interior forest specialists such as Cerulean Warbler and Acadian Flycatcher occurred in patches of 100 acres or larger. Among the interior forest species, the Worm-eating Warbler, Kentucky Warbler, and Hooded Warbler only bred consistently in forest patches larger than 500 acres. As larger forest patches become increasingly scarce in southern Wisconsin, smaller patches of mature central hardwoods, especially those with an oak component, may be important if they are located near large, forested tracts, especially if there is potential for restoring connectivity or increasing patch size in the future. These smaller tracts may also be important as migratory stopovers, and as habitat for amphibians.

3.1.6 Cumulative Effects

The cumulative effects of stand-level characteristics can alter the function of a landscape. Declines in components of oak, large old trees, dead woody material, or supercanopy stand structure are a consequence of natural as well as human-induced disturbance. Historically, disturbances would have impacted only a portion of the landscape at each event, so that most of the area was largely undisturbed. In today's environment, disturbance has accelerated and become more pervasive, and is now a constant influence throughout the landscape. These changes affect wildlife habitat and ecosystem function.

Oak has been shown to be a species utilized by many species of wildlife, for mast as well as foraging sites and shelter (Rodewald 2003, Mossman and Hoffman 1989). Maintaining an oak component in central hardwood stands may be necessary to continue to provide for viable populations of some species that utilize southern Wisconsin forests. Often, a component of oak can be regenerated or planted within a central hardwood stands, if competition and herbivory can be controlled. Given the diminishing oak component on mesic and dry-mesic sites in southern Wisconsin, some older central hardwood forests that contain mature oaks could be deferred or managed on extended rotation. The longer that forests with a significant oak component can be retained, the better the chance of maintaining wildlife habitat while developing oak regeneration techniques that will be more successful in the future.

Within-stand structure of the central hardwood forest is often characterized by low density, relatively short stature, and small diameter trees. Understories, particularly in southeast and south central Wisconsin, are frequently choked with non-native or undesirable brush species. Management of these degraded stands should encourage development of a taller canopy including supercanopy trees, larger diameter trees, and dead woody material.

3.1.7 Summary of Landscape Considerations

When deciding whether to regenerate a central hardwood stand or convert another forest type to central hardwoods, assuming the habitat type is suitable, consider the following factors:

- Consider landscape composition and structure, including species composition; successional and developmental stage; age structure; stand/patch size; type, intensity, and pattern of fragmentation; habitat diversity; NTMB populations and habitat needs; and common/uncommon management techniques.
- Maintain or increase the representation of oak species wherever possible.
- Promote diversity of species within a stand.
- Increase structural diversity within stands (i.e. supercanopy trees, large trees, large cavity trees, large snags, large downed woody debris, and variable gap and patch sizes).
- Encourage connectivity of forest patches where it is possible to coalesce adjacent central hardwood or oak stands, to create larger blocks of forest over time.
- Increase the representation of older trees and stands.
- Apply a variety of management techniques, including old-growth reserves, managed old forests, extended rotations, uneven-aged management, even-aged management, and the maintenance of reserve trees.
- Control deer and limit herbivory.
- Limit the area devoted to infrastructure (e.g. roads and landings).

3.2 Site and Stand Considerations

3.2.2 Site Quality

3.2.2.1 Range of Habitat Types

The central hardwood forest region is one of the largest hardwood forest areas in the nation (Figure 52.1). Four distinct tree associations defined within this type are oak-hickory, oak-pine, mixed hardwoods, and elm-ash-cottonwood. In Wisconsin, the central hardwood type is located within Province 222 which lies south of the Tension Zone (Figure 52.4). All Ecological Landscape units within this Province except the Central Sand Plains contain a significant component of the central hardwood type.

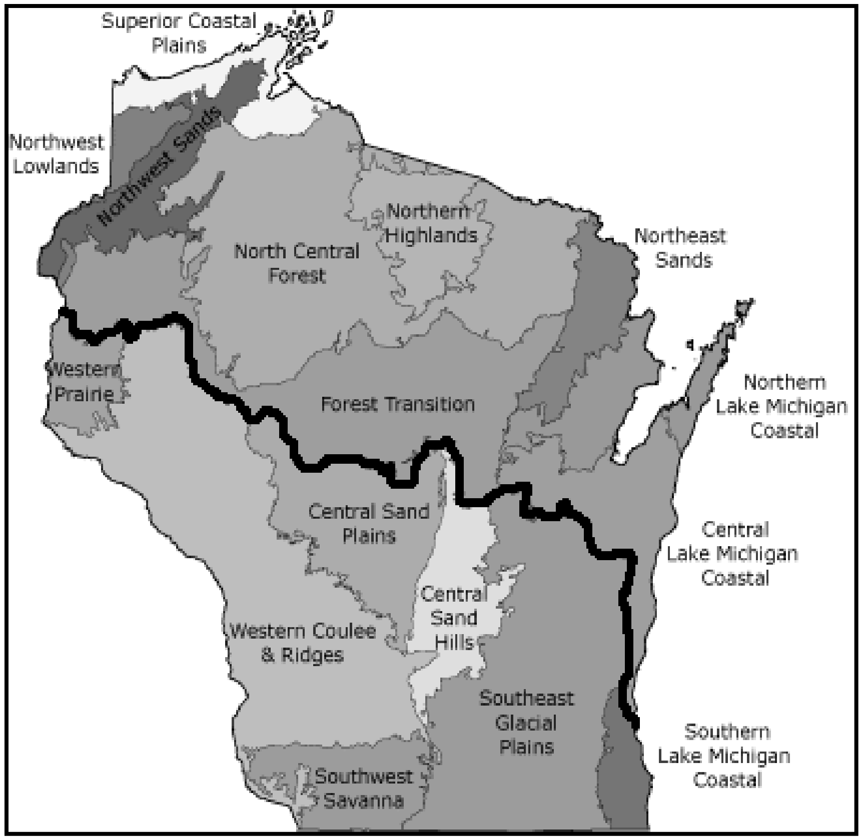

Figure 52.3. Central hardwood cover type area of application (WI). CH occurs south of the dark line which represents the approximate location of the tension zone and separates province 222 in the south from 212 in northern WI.

Compositional variation occurs within the central hardwood type across ecological units (Table 52.2). These variations are normally associated with a significant oak canopy component (Figure 52.5).

The central hardwood association is a mid-successional community type characterized by a variety of tree species occurring in a variety of combinations. Oaks are the most common overstory dominants. Successional directions tend toward northern hardwoods dominated by sugar maple with basswood, white ash, and ironwood. Northern hardwoods are most prominent on mesic sites. In areas where northern hardwood seed sources have not become well established (e.g. habitat type phases), and on sites that are marginal for the vigorous growth of sugar maple (e.g. dry-mesic), species that may increasingly dominate central hardwood stands include red maple, elms, shagbark hickory, and ironwood. In some stands, aggressive shrub and herb layers may out-compete tree seedlings; intensive management techniques may be required to control competition and establish regeneration.

Table 52.2. Variation in abundance and composition of the central hardwood cover type by ecological regions in Southern Wisconsin (Province 222 except the Central Sand Plains). The Western Coulee and Ridges Unit is divided into north and south subunits based on FIA interpretation. That division extends east/west across the unit near La Crosse.

Ecological Landscape Unit (ELU)	Central Hardwood Acres Within ELU	Compositional Variation Within Central Hardwood Type (% of acreage)		
Western Prairie	12,370	77% Elm-oak	23% Hickory-oak	0% Cherry-oak
Western Coulee and Ridges-North	115,616	31% Elm-oak	41% Hickory-oak	29% Cherry-oak
Western Coulee and Ridges-South	361,864	36% Elm-oak	50% Hickory-oak	14% Cherry-oak
Central Sand Hills	28,889	36% Elm-oak	10% Hickory-oak	53% Cherry-oak
Southwest Savanna	65,543	69% Elm-oak	13% Hickory-oak	18% Cherry-oak
Southeast Glacial Plains	97,994	49% Elm-oak	27% Hickory-oak	24% Cherry-oak
Southern Lake Michigan Coastal	9,128	0% Elm-oak	65% Hickory-oak	35% Cherry-oak

The two habitat type group phases are characterized by the lack or poor representation of northern hardwoods and red maple. Following oak, central hardwood is the next most common cover type. Hickories, elms, and black cherry often are comparatively abundant on these sites. In contrast these three species tend to be poorly represented and less productive on the poorer dry-mesic sites. They also tend to be less abundant on mesic sites, where they are out-competed by vigorous northern hardwoods.

See Chapter 12 – Forest Habitat Type Classification System for information summarizing the system and the habitat type groups. Information about specific habitat types associated with central hardwoods can be found in: *A Guide to Forest Communities and Habitat Types of Central and Southern Wisconsin* (Kotar & Burger 1996). The central hardwood cover type commonly occurs on the following habitat type groups (site types):

- dry-mesic
- dry-mesic to mesic
- dry-mesic to mesic (phase)
- mesic (phase)
- mesic

Previous View

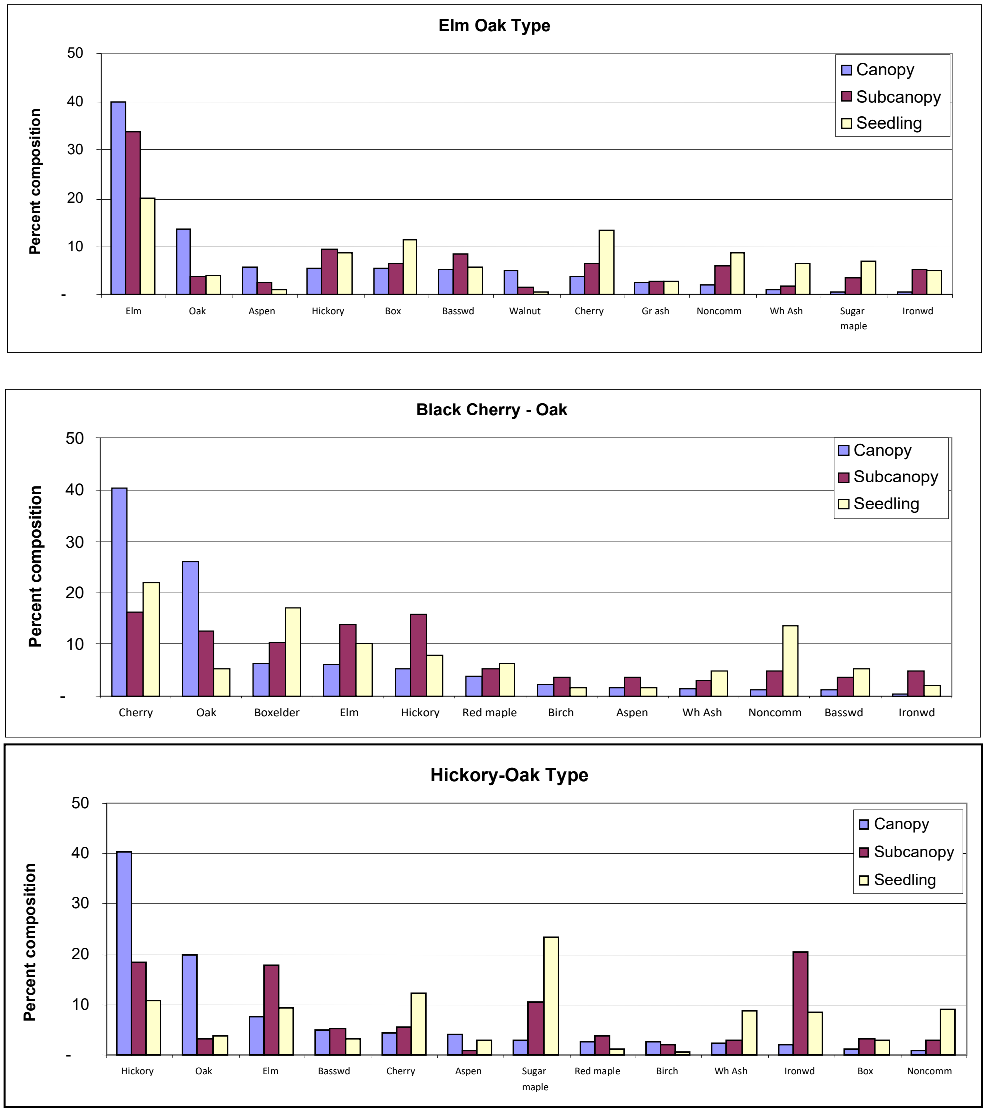

Figure 52.4. Compositional variations within the central hardwood cover type in Southern Wisconsin. The three bar charts demonstrate compositional differences among the three major subgroups of the type.

Table 52.3. Occurrence of central hardwood compositional variations in regards to habitat type, aspect and position on slope. Text bolding within the table characterize a general tendency of occurrence of the central hardwood variations.

Central Hardwood Type Variations	Percent of Acres by Habitat Type	Percent of Acres by Aspect	Percent of Acres by Position on Slope
Hickory-Oak	**38% DM-M** **36% M** 22%DM	35% N/NE/NW **58% S/SE/SW** 2% Flat	5% Flat 13% Lower **50% Mid** **31% Upper**
Cherry-Oak	**42% DM** **35%DM-M** 20% M	**71% N/NE/NW** 28% S/SE/SW	6% Flat 19% Lower **46% Mid** **29% Upper**
Elm-Oak	**34% DM-M** **33% M** 15%DM	**30% N/NE/NW** **38% SE/SW** 3% Flat	9% Flat **24% Lower** **49% Mid** 18% Upper

Chapters 40 (Northern Hardwood), 41 (Oak), 45 (Black Walnut), and 51 (Red Maple) provide specific information about variability in the occurrence and relative growth potential across habitat types of these important components of the central hardwood cover type. This information can provide a base for evaluating growth potentials, successional potentials, and potential impacts of alternative silvicultural practices in central hardwoods.

3.2.5 Wildlife

The variety of plant species and structural attributes found in the central hardwood cover type create a wide spectrum of food and cover for wildlife species. As in other forest cover types, one species' niche may appear and then disappear rather quickly while another species' preferred niche is still developing.

In the central hardwood cover type some developmental stages have a higher value for a larger variety of species than others. Early regeneration (stand initiation and early stem exclusion) stages offer exceptional cover, abundant forage, and soft mast from shrubs while the transitional and multi-aged developmental stages offer a good selection of hard and soft mast and also provide cavities and snags that are used by wildlife species that den, cavity nesters, and birds that forage by probing and searching tree trunks. A tree that may be problematic when overabundant in transitional and multi-aged stands but is also a valuable wildlife food source is ironwood. In areas that lack aspen, ironwood buds and male catkins and are often the primary ruffed grouse winter food.

Even-aged, pole-size stands of central hardwoods provide habitat for relatively few wildlife species. While these young stands produce little or no mast, their closed canopies result in a sparse understory. As a central hardwood stand matures from the sapling stage to the pole timber stage, it will likely go through an extended period of poor forage and low mast production. Consequently, a principal wildlife concern is to mitigate this condition in stands. A management practice that can lessen this condition is the designation of reserve trees and patches. Reserve trees and patches may be retained to develop into large, old trees and to complete their natural lifespan. In doing so, these trees may satisfy cavity and mast tree recommendations and later become large snags and coarse woody debris

Another technique used to improve habitat in dense, even-aged early successional central hardwood stands is the creation of living brush piles. Living brush piles are established to improve or maintain cover and forage in depauperate stands. Trees 2 to 6 inch in diameter can be cut part way through and pushed over, leaving as much bark uncut as possible. Falling 5 or 6 of these onto each other creates an area of dense cover that will last several years. A more aggressive approach would be to cut more trees in this manner, creating a larger tangle. On larger piles, the trees are not be shaded out as quickly and survive longer. The resulting dense cover protects nesting and foraging birds from predation while promoting soft mast production. Grapevines, while problematic when overabundant, are an excellent source of late season soft mast and contribute substantial cover value. When possible, incorporate them into living brush piles and at least selectively leave other grapevines where the threat of killing or deforming neighboring trees is minimal.

3.2.6 Endangered, Threatened and Special Concern (ETS) Species

Rare species are continuously under threat due to shrinking habitat. These species are usually rare because they rely on small niches, rare seral stages, or use specific microhabitats, although some rare species occupy a large home range. They are often best addressed during the early planning stages of timber management. Consideration of various landscape elements can alleviate many potentially negative effects of management activities. Numerous species can be accommodated in central hardwoods by identifying and protecting special habitats such as cliffs, caves, rockslides, thermal features, prairie/savanna openings, and vernal features, as well as managing for patches of late-developmental forest, often lacking in the local landscape. Managing for a single species may be necessary in some cases; however, considering a broad set of ecological characteristics can enrich the overall forest for many rare species and improve their chances for survival.

<u>Structural Retention at the Time of Regeneration Harvest</u>
Retaining structure from the original central hardwood stand such as large decadent trees, snags, and logs can enhance structural complexity. Structural retention is modeled on the biological legacies that remained after natural forest disturbances. Even under the most intense fires many individual trees and groves would survive. Consider reserving scattered decadent trees and snags in even-aged silvicultural systems (see Chapter 24).

Little data exists on how much structure to retain. Some of the decisions would require more analysis and consideration of species-specific requirements. In general, retention of old trees can provide benefits such as cavities both present and future, distinctive architecture with large branches that are used as movement corridors or the foundation for large nests, and diverse habitats for insects and spiders, which provides the prey base for vertebrates and maintenance of diverse fine root and fungi systems in the soil.

Remnant patches of late developmental forest and maintenance of long-rotation forest with high canopy closure can greatly affect the persistence of species like cerulean warbler (*Dendroica cerulea*). Planning for species, such as cerulean warbler, requires looking into the species life history to develop a management strategy. This species prefers old mixed hardwood forest, especially with large oaks, that occurs in large patches (>250 acres) with at least 70% crown closure; therefore, a forest management plan may need to consider forest size, age, and crown closure.

<u>Identify Special Habitats</u>
Many rare species are limited in their distribution to small or microhabitats within larger blocks of forest. Habitats such as cliffs, vernal or ephemeral pools, seeps or springs, rock outcrops, or prairie/savanna remnants may harbor rare species. Even if no records of rare species exist, management of these areas can provide habitat for existing or future rare species populations. Often special habitats can be protected while achieving other goals such as retention of biological legacies (see Chapter 24 for more information).

Cliffs may require two different approaches, depending on their physical characteristics and the species present. The first is retention of shading on the cliff face and searching for sources of seepage flow. If the species of concern has shading and moisture requirements, a modification of harvest near the feature is recommended. If the species requires more open conditions, then removal of shade, especially by removing trees from the base of the cliff could great improve the conditions for these species.

Vernal features can have a similar approach. For those species found in areas rarely affected by disturbance (both past and present) retention of shade on pools can be very beneficial. For those species found in vernal areas affected regularly by fire, such as northwest barrens or former prairie areas, consideration should include greatly reducing shade.

Riparian Habitats: The well-known and widely used Best Management Practices for Water Quality has greatly improved our knowledge and appreciation of riparian areas. However, additional considerations may be needed for some rare species. Wider corridors may be necessary for species whose optimum habitat is riparian features. A good rule is to look at the stream order. For species using small streams (1 or 2) riparian areas the existing BMP's are most likely adequate. Mid-order Streams (3 and 4) may require looking at topographic relief to assess the extent of the floodplain. These streams can have very narrow riparian or broad meanders. Large high order streams have extremely complex disturbance regimes which may necessitate gathering information on flood pulses, wind events and fire intervals to address the effects on rare species populations.

Biological Hotspots: Bird rookeries, bat hibernacula, herp hibernacula, migratory bird concentration areas, and cave/sinkhole systems can harbor many rare species. These hotspots can be permanent, as with caves, or ephemeral as in the case of bird rookeries. Different strategies may apply. When these hotspots are encountered, seek consultation and advice from wildlife or endangered resources specialists.

Artificial Habitats: In some instances, a critical habitat requirement for a species is missing or is much reduced on the landscape. For some species, competition for the few spaces remaining prevents them from being successful. An example is the Eastern Bluebird (*Sialia sialis*), which most often loses competition battles with other larger more aggressive birds; therefore, erecting and monitoring nest boxes with dimensions that exclude competition can increase the chances of survival for this species.

Risk Spreading: Many aspects of endangered and threatened species management are not well known. Applying the best available information for species life history or ecological disturbance patterns can help address habitat needs. However, in cases of uncertainty, it will be important to employ more than a single method. To improve our knowledge and guide future management, the best approach would involve monitoring and documentation of the various management techniques in use by foresters throughout the state while making every effort to protect existing known species populations.

Table 52.4. Rare species associated with central hardwood stands, their general habitat preferences, and sample management considerations that for which they may benefit. These are meant as broad considerations for planning purposes, rather than avoidance measures, and neither the species, habitat information, nor the management considerations are meant to be exhaustive.

Species	Habitat	Mgmt Considerations
Plant Species		
Bluestem goldenrod- *Solidago caesia* – E	Central Hardwood forest and rich maple forest in southeast Wisconsin	Extended rotation or old-growth management.
Three birds orchid – *Triphora trianthophora* -SC	Rich oak and central hardwood forests.	Extended rotation or old-growth management
Prairie trillium – *Trillium recurvatum* – SC	Rich oak and central hardwoods in the southern two tiers of counties	Extended rotation or old-growth management.
Hairy-jointed meadow parsnip – *Thaspium barbinode – E*	Oak woodlands near loess capped crests or in ravines.	Manage near minimum stocking levels or convert to oak savanna native community management and prescribed fire.
Heart-leaved skullcap – *Scutellaria ovata – SC*	Scattered locations in central hardwoods.	Responds well to group selection and prescribed fire. Avoid clear cuts, shelterwood harvests and landings on populations.
October ladies-tresses – *Spiranthes ovalis – SC*	Found in oak and central hardwood forests.	Extended rotation or old-growth management.
Hooker orchid – *Platanthera hookeri* – SC	Found primarily in pine stands but also in central hardwood stands contain scattered white pine in the Driftless Area.	Management should consider retaining the white pine in mixed forests.
Large roundleaf orchid – *Platanthera orbiculata* – SC	Found primarily in pine stands but also in central hardwood stands contain scattered white pine in the Driftless Area.	Management should consider retaining the white pine in mixed forests.
Upland boneset – *Eupatorium sessilifolium* – SC	Rich oak woodlands	Manage near minimum stocking levels or convert to oak savanna native community management and prescribed fire
Hoary tick-trefoil – *Desmodium canescens* – SC	Rich oak woodlands	Manage near minimum stocking levels or convert to oak savanna native community management and prescribed fire
Mullein foxglove – *Dasistoma macrophylla* – SC	Found in rich oak and hardwood forest mostly southwest.	Extended rotation or old-growth management, esp. near shaded rocks.
Rocky Mountain sedge – *Carex backii – SC*	A species of grass found mostly on sandy soils and rocks.	Open bedrock management.
Yellow-billed cuckoo - *Coccyzus americanus* – SC	Prefers floodplains and mature hardwoods	Riparian BMP's and extended rotation.
Cerulean warbler - *Dendroica cerulea* – T	Mature to old oak and central hardwoods and floodplains	Extended rotation and landscape planning
Animal Species		
Great blue heron - Ardea herodias – SC	Forages along nearly every watercourse. Nests in rookeries, often in woodlots far from water.	Rookery management

Species	Habitat	Mgmt Considerations
Worm-eating warbler - Helmitheros vermivorus – T	Prefers wooded slopes within mature to old blocks of hardwoods	Extended rotation and landscape planning
Red-shouldered hawk - Buteo lineatus – T	Floodplain forest and mature to old-growth hardwoods are preferred habitats	Riparian BMP's and extended rotation.
Acadian flycatcher – Epidonax virescens – T	Moist mature hardwoods in southern Wisconsin	Extended rotation and landscape planning
Kentucky warbler – Oporonis formosus – T	Large blocks of mature hardwood forest usually near streams or in ravines	Extended rotation and landscape planning
Louisiana waterthrush - Seirus motacilia – SC	Large blocks of mature hardwood forest usually near streams or in ravines	Riparian BMP's on small streams and extended rotation.
Hooded warbler – Wilsonia citrine- T	Brushy gaps in large blocks of oak and hardwoods forest	Group selection management and Landscape planning
Timber rattlesnake – Crotalus horridus – SC	Steep rocky prairies and adjacent oak woodlands	Manage near minimum stocking levels and prescribed fire
Black rat snake - Elaphe obsoleta – SC	Large blocks of mature forest in southwest Wisconsin	Extended rotation
Hickory hairstreak – Satryium caryaevorum- SC	Host plant is hickory	Retention of hickory
Cherrystone drop – Hendersonia occulta – T	Moist cliffs or under woody debris on moist slopes in central hardwoods	Extended rotation and keep shade in the cliffs

Other rare species may occur in central hardwoods considered for harvest. Many of these species will be found in specialized habitats such as rock outcrops, cliffs, ephemeral ponds, and seeps. If a rare species is known to be present, including Element Occurrences documented in the NHI database, refer to department screening guidance for avoidance, and contact the appropriate staff, as needed. Information on NHI Working List species and their habitats can be found through the Bureau of Endangered Resources Web pages (dnr.wi.gov/org/land/er/).

3.2.8 Operational Considerations and Maintaining Soil Productivity

The central hardwoods cover type presents some unique operational considerations for implementing silvicultural prescriptions while maintaining soil productivity and stand quality. Poor skidding technique and timing can reduce both residual stem quality and soil productivity. Harvesting during spring when trees are actively growing can result in increased defects on residual stems as the bark is more easily damaged at this time of year. Silvicultural practices need to be properly implemented.

Central hardwoods occur on loamy soils where vehicle traffic can cause detrimental soil compaction. Soil compaction and rutting have been shown to decrease forest productivity in aspen stands and probably have the same consequences in central hardwoods. While soil compaction cannot be avoided entirely during a harvest, it should be minimized. Utilize a system of pre-planned skidding routes and landing areas designed to meet the needs of the harvest while impacting as little of the stand area as possible. As a general rule, less than 15 percent of a harvest area should be devoted to haul roads, skid trails, and landings (WDNR 2003). Soils are most susceptible to compaction and rutting when they are saturated, so harvesting when the soil is frozen or dry can reduce compaction. Increasing the interval for re-entry into stands may partially mitigate and reduce the amount of compaction and rutting.

Many central hardwood stands are located in southwest Wisconsin's "Driftless Area", which is characterized by steep, easily eroded hillsides and shallow bedrock. In these areas, soil compaction, displacement, and erosion are a particular concern. Roads should be designed with a consideration for slopes, and operations during periods of rainfall should be carefully monitored to ensure that compaction, rutting, and erosion do not exceed guidelines. See "Wisconsin Forest Management Guidelines" (WDNR 2003).

The cumulative effects of infrastructure development and soil compaction in forests have been studied in other parts of the country and found to be correlated with changes in hydrologic regimes, surface drainage patterns and soil moisture. The negative ecological effects of soil compaction and rutting and of forest roads are well known at fine scales but the issues have not been studied in an integrated fashion on larger landscapes in our area. Roads and utility corridor have been implicated in the spread of non-native invasive plants. They also act as barriers to the movement of some species, create fragmentation and edge and can attract human disturbances.

Central hardwood stands sometimes contain small, seasonally flooded ponds called "vernal pools". Vernal pools are in confined basins, lack established fish populations, and dry up annually or every few years. Their size depends on landscape characteristics, but most are smaller than a quarter acre (Colburn 2004). They support tree species, other flora, and fauna that are typically not found in the remainder of a stand of central hardwoods and are especially important for the production of amphibians. Harvesting should avoid felling trees into or skidding through vernal pools. These areas, along with a suitable buffer, should be delineated in some manner prior to beginning harvesting. Vernal pools may not always be readily apparent due to the lack of standing water at dry times of the year, or when they are under snow cover.

4 STAND MANAGEMENT DECISION SUPPORT

4.1 Stand Inventory

Central hardwood stand assessment should include quantifying variables such as:

- present species composition
    - canopy, shrub, and ground layer
    - sources of regeneration
    - potential growth and competition
    - invasive and/or exotic species

- stand structure
    - size class distribution and density
    - age class distribution

- stand and tree quality (present and potential crop trees)
- site quality
- stand and site variability.

4.2 Key/ Checklist for Evaluating Cover Type Stand Management Options

Note: The following recommendations assume the management objective is to maximize quality and quantity of central hardwood sawlogs and the site has the potential for fair to excellent central hardwood growth as identified by habitat type(s) and/or site index.

Poletimber and Sawtimber Stands

1. Management objective best achieved by even-aged management	2
1. Management objective best achieved by continuous forest cover, uneven-aged management	7
2. Stand quality and stocking levels sufficient for continued management (meets one of the following): >40 crop trees per acre >40% stand relative density or C-line stocking	3
2. Stand quality and stocking levels insufficient for continued management (meets one of the following): <40 crop trees per acre <40% stand relative density or C-line stocking	6
3. Stand relative density > B-line or 60%	4
3. Stand relative density < B-line or 60%	Apply crop tree release if needed. Cut only the trees in direct competition with the crop trees, all non-competing trees remain in the stand. Otherwise, do nothing, let stand develop; periodically monitor stocking and crop tree development.

4. <75% of desired rotation age	When stand relative density is 80-100%, apply a commercial intermediate treatment and thin to B-line or 60-70%. Never remove more than 1/3 of stand relative density. Thinning should follow appropriate central hardwood stocking guides and the recommended order of removal. Wait 10-15 years. Thinning interval will vary based on intensity of previous thinnings, site quality, species present, and landowner objectives.
4. >75% of desired rotation age	5
5. Within 75-100% of desired rotation age	Let grow until rotation age as thinning is generally not recommended. Thinning will only remove a few trees per acre and relatively few remaining trees will benefit directly.
5. Attained rotation age	6
6. Stocking of desired advance regeneration established adequate for stand objective	Apply overstory removal regeneration method.
6. Stocking of desired advance regeneration established inadequate for stand objective	Apply shelterwood regeneration method.
7. Stand currently even-aged	8
7. Stand currently uneven-aged	Apply group and patch selection regeneration method with area regulation. Rotate groups or patches as they attain rotation age. Apply intermediate treatments to majority of stand not at rotation.
8. Stand quality and stocking levels sufficient for continued management (meets one of the following):	Apply group and patch selection regeneration method with area regulation. Rotate groups or patches that are:

>40 crop trees per acre >40% stand relative density or C-line stocking	poorest quality understocked stocked with desirable advance regeneration.
8. Stand quality and stocking levels insufficient for continued management (meets one of the following): <40 crop trees per acre <40% stand relative density or C-line stocking	Apply even-aged regeneration method and work toward uneven-aged management with new stand.

5 SILVICULTURAL SYSTEMS

As defined in Chapter 21, Natural Regeneration, a silvicultural system is a planned program of vegetation treatment during the entire life of a stand. All silvicultural systems include three basic components: intermediate treatments (tending), harvesting, and regeneration. With central hardwoods, silvicultural systems can be adapted to meet multiple land management considerations. Regeneration of central hardwoods can be accomplished with either even-aged or uneven-aged regeneration methods though even-aged silvicultural systems are most commonly recommended.

For land managers with the goal of maintaining shade intolerant to mid-tolerant species, even-aged management is the preferred method. The even-aged regeneration methods generally accepted and supported by literature are:

- Overstory removal
- Shelterwood

Where maintenance of mid-tolerant central hardwood species is a goal, uneven-aged management may be suitable. The uneven-aged regeneration method generally accepted and supported by literature is:

- Group or patch selection

5.1 Seedling / Sapling Stands

Although little research has been done on the silviculture of central hardwood stands dominated by non-oak species, principles of sound management can be gleaned from similar oak dominated stands. The first 10-15 years of stand development are a dynamic period. During this "brushy" stage, there may be as many as 10,000 stems per acre, in a wide variety of species. Management at this stage should focus on improving stand composition (Smith & Lamson 1983). When desired species are present in sufficient numbers, their growth is often slow and mortality high due to intense competition from herbaceous vegetation and less preferred species. Early, intensive release can be used to improve stand species composition and growth by reducing competition (Della-Bianca 1969). Individual release of selected stems can facilitate adequate stocking of preferred species as the stand matures. Select 50 – 100 trees per acre, approximately 20 – 30 feet apart, and remove all trees whose crown touches the crown of the selected tree. This should occur when a stand is 5-20 years old or when tree height averages 25 feet. Apply the release cut before selected crop trees fall below the codominant size class.

In many situations, existing seedling/sapling stands do not contain sufficient numbers or adequate size of preferred species. One option is to consider altering stand objectives to accept a less desirable species composition. Changing markets (e.g. aspen, red maple) and landscape species dynamics (e.g. emerald ash borer) often alter our understanding of how desirable species are defined. Another option is to interplant the stand with desirable species. Interplanting is often used to establish or increase the number of desirable species within degraded stands. This approach may also be used to introduce genetically superior hardwoods (Clatterbuck 2006). Mechanical or chemical competition control will improve the long-term survival and viability of planted trees.

A serious threat to forest regeneration throughout Wisconsin is locally high populations of white-tailed deer. It is important for foresters prescribing intermediate treatments in these stands to anticipate and plan for this additional constraint on seedlings and saplings. In areas of extremely high deer populations, regeneration should be protected against browsing (Marquis *et al.* 1992).

5.2 Intermediate Treatments

For most central hardwood management objectives, the development of individual tree quality is a principal concern. Tree quality depends on stand history, species composition, stand density, site quality, tree age, and damage due to factors such as grazing, insects, disease, ice, wind, and poor harvesting techniques (e.g. logging damage, high grading, diameter limit cutting, and commercial clear cutting). It may be necessary to enhance stand development with non-commercial intermediate treatments or timber stand improvement practices (TSI). To reduce the risk of resprouting, it may be necessary to treat many undesirable species with an appropriate herbicide according to label rates. For details on these methods refer to Chapter 23, Intermediate Treatments.

Within the central hardwood cover type, TSI is often a combination of some or all of the following practices:

5.2.1 Weeding

This practice eliminates or suppresses undesirable plants (trees, shrubs, vines, and herbaceous vegetation) within a stand. Most often these plants are aggressive shrubs and herbaceous species that retard advance regeneration or prevent the establishment of desirable regeneration. Intensive management techniques may be required to control competition and establish regeneration. Within the central hardwood cover type, undesirable plants which are commonly weeded include:

Native Species:

a. Ironwood (*Ostrya virginiana*): Ironwood is a tolerant, slow-growing small to medium-size tree that often forms a subcanopy which can suppress the recruitment and development of desirable tree species. High populations of ironwood are often associated with a history of livestock grazing.
b. Grapevine (*Vitis spp.*): Grapevines often grow through and over the tops of trees, and can kill or deform them. Note lianas or perennial vines that develop rootlets (hairs) which fasten to tree trunks are not grape and do not need to be removed because they do not grow over the top of tree leaves and branches.
c. Prickly ash (*Zanthoxylum americanum*): Prickly ash is a native shrub of deciduous woods that grows to 10-15 ft. It is common at the woods edge or in the interior when land has a history of disturbance such as grazing. It spreads by suckers from shallow roots, a very large patch may be a single plant or clone.

Invasive / Exotic Species:

a. Garlic mustard (*Alliaria petiolata*): A shade tolerant rapidly spreading biennial herb capable of establishment on a wide range of forest habitats except acidic soils. First year plants (rosettes) are 2-4-inches tall with round, scalloped leaves. Second year plants are 12-48-inches tall with 2-4 stems and white flowers in May. Crushed leaves have an onion/garlic odor. A single plant can produce hundreds of seeds in 1-3-inch capsules that easily disseminate in late summer/fall by wildlife, streams, people and equipment.
b. Common buckthorn (*Rhamnus cathartica*), Glossy buckthorn *(Rhamnus frangula)*: Shade tolerant shrubs that can reach 20-25 feet in height and 12-inches diameter. Both species grow rapidly and resprout vigorously after cutting. Prolific black, pea-size fruits are eaten and dispersed widely by birds.
c. Bush honeysuckles (*Lonicera tatarica, L. morrowii, L. x bella*): Shade tolerant shrubs 3-10 feet in height, shaggy bark, begin leaf development 1-2 weeks before native shrubs and hold leaves later into fall than native species. Occupies broad range of habitats and favors disturbed sites. Small red to orange fruits are dispersed widely by birds. Young shrubs are shallow rooted and easily pulled.
d. Japanese barberry *(Berberis thunbergii):* Shade tolerant compact, spiny shrub, 2-3 feet in height. Prefers well-drained soils. Survives well under oak/central hardwood canopy. Branches root freely when they touch the ground. Bright red fruit is dispersed widely by birds.
e. Multiflora rose *(Rosa multiflora):* Often established in pastures and pastured woodlands this shrub will persist and spread in woodlands after cattle are excluded. Mature shrubs are dense and can obtain 15-feet in height and an 8-feet spread with arching canes and stiff curved thorns. Branches are capable of rooting when they touch the ground. Red, ¼-inch fruits persist in winter which are readily eaten and spread by birds. A mature shrub can produce 500,000 seeds per year.

When abundant, invasive plants alter forest composition and structure, and can ultimately affect successional patterns and future forest conditions over large landscapes (WDNR 1997). A website useful for additional identification, information and methods of control of invasive species is:

http://www.ipaw.org/

5.2.2 Liberation

This practice releases a young crop of desirable seedlings and/or saplings by removing less desirable, older, overtopping trees. With central hardwoods, this often entails the removal of poor-quality trees to favor the advancement and quality of young, vigorous and potentially valuable trees. Retention of some wildlife trees may be desirable for non-timber goals.

5.2.3 Cleaning

This practice releases desirable seedlings and saplings from undesirable tree species in the same age class. It is used to control a stand's species composition and to improve growth and quality of crop trees.

5.2.4 Non-Commercial Thinning and Improvement

Crown thinning in non-commercial poletimber stands favor crop trees by removing adjacent crown competitors. This allows crop trees to develop full, vigorous crowns necessary for improving growth and quality. This is often referred to as "crop tree release."

5.2.5 Commercial Thinning and Improvement

Intermediate thinning is used in central hardwood stands to control stand density and structure. Unlike uneven-aged selection harvesting, reproduction is not a management concern. The primary objectives of intermediate thinnings in central hardwood stands are:

1. To increase the rate of growth of residual trees
2. To concentrate growth on the most desirable trees
3. To improve species composition
4. To salvage losses that would occur as a result of competition and suppression.
5. To generate income during the stand rotation
6. To enhance forest and tree health

To determine how much to remove and retain with an intermediate thinning, stocking charts have been developed for many forest types (Figure 52.7 and Figure 52.8). These charts identify a stand's relative density when stand basal area and the number of trees per acre are known (see Chapter 23 – Intermediate Treatments). Relative density is a measure of tree crowding that accounts for both the size of the tree and the amount of space typically occupied by a tree of that size and species, so it is an especially useful measure in mixed species stands (Stout & Nyland 1986). A relative density of 100 percent implies that the growing space is fully occupied and trees must either slow their growth to survive and some trees will be crowded out and die. On most stocking charts, 100% relative density is represented as the A-line. If relative density is between 60% and 100%, trees can fully occupy the growing site. The optimum relative density to retain after a thinning is a compromise between an individual tree's rate of growth, quality, and the number of trees needed to fully utilize available growing space (Gingrich 1967). The lower limit of stocking necessary to reach 60% (B-line) stocking in ten years on average sites is centrally represented as the C-line and corresponds roughly to 40-

50% relative density. Typically, thinnings are implemented at 80-100% stocking (usually economically operable), and density is reduced to 60-70% stocking to optimize sawtimber growth and quality.

To use stocking charts as a guide for thinning, the current stand relative density, the desired stand residual density, stand (quadratic) mean diameter, and the probable (quadratic) mean diameter of the residual stand must be estimated (Roach 1977). This allows the conversion of stand relative density to basal area. This is important, since inventory procedures and marking controls are applied using basal area (Marquis *et al.* 1992).

Since central hardwood stands can differ widely in species composition, estimates of relative density based on stocking charts may be inaccurate and should be used with caution (Stout & Nyland 1986).

Relative stand density (stocking), may be more accurately calculated directly from stand data using a species-specific tree-area ratio than with stocking charts (Table 52.11). If the relative density of a stand is calculated this way, a ratio can be developed for determining the desired residual basal area.

> *Example*: A central hardwood stand is inventoried with the aid of software that calculates relative density. Per this calculation the stand basal area is 124 sq. ft. and the relative density is 90%. The target residual relative density for this stand is 60% after an intermediate thinning. To estimate the residual basal area when marking the stand, a ratio is developed:
>
> Current RD/Current BA = Residual RD/Residual BA
> 90/124 = 60/X
> X=82.6
>
> For ease of use in the field and assuming a slight increase in mean diameter (quadratic) with thinning from below, 85 sq ft. would be a useful guide for 60% relative density in this stand.

5.2.6 Tree Selection for Thinning and Improvement Cutting

When thinning central hardwood stands, determine which crop trees to favor by first identifying desirable crop tree characteristics. The following characteristics are identified for selecting the ideal timber crop tree (see Chapter 24 – Marking Guidelines):

- Low risk of mortality or failure (expected longevity of 20+ years)
- Good crown vigor
    - Dominant or codominant trees
    - Full concentric crown with good silhouette and healthy leaves
- Good timber quality
    - 16’ butt-log potential of tree grade 1 or 2
    - No indicators of high probability of degrade due to defect on trunk (see FHP defects table at end of this chapter)
- Desirable species
    - Valuable commercial species

- Species well adapted to the site

Trees may also be selected for retention to achieve other objectives such as aesthetics or wildlife management (see Chapter 24 – Marking Guidelines).

When thinning central hardwood stands, determine which trees to cut by following the recommended order of removal (also see chapters 23 and 24):

1. High risk of mortality or failure – cut high risk trees that are likely to die between cutting cycles, unless retained for wildlife
2. Release crop trees – cut poorer quality competitors to provide crown growing space around crop trees to promote growth and quality development
3. Low crown vigor – cut low vigor trees, based on crown class, size and condition
4. Poor stem form and quality - cut based on usable log length and potential degrade due to defect
5. Less desirable species (determined by landowner objectives, site, and silvics)
6. Improve spacing

Intermediate thinning should control both stand density and structure to maximize both stand growth and quality. As a rule of thumb when thinning central hardwoods, approximately 75% of the cut relative stand density should be removed from below the average stand diameter (low thinning) and 25% from above (crown thinning) (Nowak & Marquis 1997). This avoids many of the pitfalls of diameter limit harvesting and high grading.

As a general guideline, thinning is most effective as a management tool in young stands but can be implemented in stands up to 75% of the desired stand rotation age. Thinning young stands offers the best opportunity to influence stand species composition and increases the growth rate of residual trees. Past 75% of the rotation age, thinning large trees will remove and benefit relatively few trees per acre while often encouraging a brushy understory that may interfere with desirable regeneration at stand rotation. Thinning later than 75% of a stand's rotation age may even remove the periodic growth of the stand and defeat the purpose of thinning (Marquis *et al.* 1992).

In central hardwood stands that have been grazed, high graded, or contain a wide variety of stand conditions, prescriptions for first thinnings will tend to be imprecise and will combine thinning and improvement cutting (Roach & Gingrich 1968). Free thinning is the removal of trees to control stand spacing (density) and favor desired crop trees, using a combination of thinning criteria without strict regard to crown position. In central hardwood application, this method is likely a combination of low and high thinning with improvement cutting while applying the order of removal. Often, free thinning is conducted in previously untreated natural stands in preparation for a more systematic future thinning method.

5.3 Natural Regeneration Methods

5.3.1 Even-Age Regeneration Methods

5.3.1.1 Shelterwood

This even-aged management system is appropriate for the establishment and advancement of most central hardwood species. It involves two or three cutting treatments that can be extended over a 5 to 20 year period and includes:

1. **Preparatory cutting** designed to remove poor quality trees, leave good phenotypes, and increase vigor and seed production among the residuals. This treatment often is not applied, especially in well managed stands that have been thinned previously.
2. **Seeding cut** to open the stand sufficiently to encourage the development of regeneration.
3. **Overstory removal** is conducted after regeneration is established to release the new stand to grow vigorously. Retention of some reserve trees (5-15% canopy cover) is recommended to achieve sustainable forest management benefits (see Chapter 21).

Regeneration is usually accomplished using a two-step shelterwood (seed cutting and removal cutting) implemented over a 5 to 10 year period. Initial harvesting will provide for proper crown closure and tree spacing depending on the preferred regeneration species composition. Leave a high uniform crown cover of 40-60% in the residual shelterwood overstory. Consider timing of the shelterwood cut and site preparation operations relative to the production of good seed crops. Site preparation is generally recommended when hickories, walnut and oaks are the preferred species to be regenerated and when there is an unacceptable presence of undesirable species such as ironwood, prickly ash and non-native invasive species. Site preparation can be accomplished via mechanical or chemical methods, prescribed burning or a combination of these techniques (see Chapters 21 & 22). Complete the final removal of the shelterwood overstory once acceptable advanced regeneration has been achieved. Acceptable regeneration can generally be defined as a minimum of 1,000 well distributed desirable seedlings per acre (Loftis 1998) that are at least 2-feet tall. During the removal cutting, care should be taken to preserve as much of the desirable advance regeneration as possible. Release may be needed in 1-10 years.

5.3.1.2 Overstory Removal

This even-aged regeneration method removes all trees in one cut to fully release sufficient numbers of desirable, advanced regeneration. Acceptable regeneration can generally be defined as a minimum of 1,000 well distributed desirable seedlings per acre that are 2’ – 4’ tall. Retention of some reserve trees (5-15% canopy cover) is recommended to achieve sustainable forest management benefits (see Chapters 21 & 24). When considering overstory removal, contemplate methods to protect advance regeneration. Ideally, overstory removal operations should be conducted during the winter or fall to limit damage to the regeneration. Overstory removal is conducted typically when the canopy is mature (at rotation age/size), or has such poor quality that management for sawlog production is not a viable option. Release may be needed in 1-10 years.

5.3.1.3 Clearcut[2]

Clearcutting involves the felling of all trees in a stand in one operation for harvest and for regeneration of a new stand; regeneration from seed is established during or following stand removal. To some degree, this system mimics natural disturbances such as windstorms, fire, and insect and disease outbreaks which promote regeneration of fast growing, shade intolerant species that exploit these conditions. Risks to success of new stand establishment include seed sources and annual productivity, variability in the type and amount of regeneration, the potential proliferation of unwanted competing vegetation, and the potential impact of deer browsing. Clearcutting can result in stand conversion to another forest type. It is important to assess the potential for such competitive interactions before clearcutting. A clearcut needs to be least 1-2 acres in size to create the characteristics of a clearcut (Sander 1992, Dale *et al.* 1994), and at least 2 acres to conform to DNR protocols. To favor tree regeneration, soil compaction needs to be minimized during logging by confining equipment to skid trails and landings. Additional release of regeneration may be needed within the initial 10 years of establishment. Intermediate thinnings would be conducted as described in the Commercial Intermediate Treatments section of this chapter.

5.3.2 Uneven-Age Regeneration Methods

5.3.2.1 Group and Patch Selection

This method is appropriate for promoting an uneven-aged forest structure in the central hardwood type. A goal of group and patch selection is to produce a balanced uneven-aged stand by creating cohorts of regeneration. Spatial distribution and size of groups and patches may be systematic or irregular and dictated by the presence of desirable and adequate regeneration, the silvical characteristics of the species to be regenerated, and small variations in stand conditions such as vigor, health and size of individual and small groups of trees. Retention of scattered groups of reserve trees is recommended to achieve sustainable forest management benefits (see Chapters 21 & 24).

Group and patch selection should be viewed as a relatively intense stand management practice with several different cultural practices applied at the same time in different parts of the stand. Groups of trees are selectively removed on 5-15% of the area per entry to create “small openings “(Smith 1986). Group selection openings range from 0.1 to 0.5 acres while patches range from 0.5 to 2 acres. Smaller openings often encourage increased representation of tolerant to mid-tolerant species, whereas larger openings can facilitate increased representation of intolerant to mid-tolerant species. For shade intolerant and mid-tolerant species regeneration and development, an opening should be 150-feet in diameter or more (at least 0.5 acres).; a general rule of thumb is to make opening diameters twice the total height of mature codominant trees expected for the forest type (Miller *et al.* 1995). Within the openings, all undesirable trees of one-inch and greater stem diameter are cut. Herbicide control of unwanted competition may be utilized as seed bed site preparation. Release may be needed in 1-10 years. Beyond openings within the stand, thinning and crop tree release within different aged groups occurs following a standard order of removal. As stands undergo

[2] Management practice that may have potential for application in managing central hardwoods but has not been widely utilized and tested.

multiple entries with group and patch selection, tracking locations of group and patch openings in the field becomes difficult. Placement of new groups and patches without overlapping prior openings becomes increasingly difficult over time and failure to do so effectively decreases the rotation length and/or reduces harvest volume by removing groups and patches earlier than prescribed (Shifley *et al.* 2006).

5.5 Rotation Lengths and Cutting Cycles

In even-aged silvicultural systems the rotation is defined as the period between regeneration establishment and final cutting. The length of rotation may be based on many criteria including culmination of mean annual increment, mean size, age, attainment of particular minimum physical or value growth rate, and biological condition. Ideally, the lower end of the rotation length range would be defined by the age at which maximization of mean annual increment (MAI) growth occurs. The upper end of the rotation length range would be defined by the average stand life expectancy. However, very little objective data exists identifying these endpoints in general and even less by site type.

Central hardwoods are usually managed to produce sawtimber on sites where relative potential productivity is good to excellent (red oak SI>60). The recommended even-aged rotation to balance high quality development and high growth rates (vigor) is species specific. Table 52.9 and chapters 40 (Northern Hardwood), 41 (Oak) and 51 (Red Maple) provide rotation age guidelines for central hardwood associates.

Table 52.5. Recommended and extended rotations for selected central hardwood species.

Species	Recommended Rotation	Extended Rotations
Ash, green	70-110	-
Cherry, black	70-110	120-150
Elm, American	80-120	-
Elm, slippery	80-110	-
Hackberry	70-100	110-130
Hickory, bitternut	70-110	120-150
Hickory, shagbark	80-120	140-200

For some species, rotations up to 200 years can be considered (on excellent sites), but volume growth rates will decline and economic risk will increase. On poorer sites, recommended rotation ages may be on the lower end of the range because of reduced quality and slower growth rates. Actual rotation ages may vary based on stand conditions and landowner objectives. In application, foresters will need to regularly review stands in the field and exercise professional judgment concerning quality, vigor, mortality, and merchantability. The numbers provided are based on general data and the best estimations of the authors and other contributors.

5.5.1 Uneven-Aged Management

Group and patch selection rotates groups or patches of trees rather than stands of trees. Group or patch rotations depend on the same criteria used to determine an even-aged rotation. Groups range in size from 0.1 to 0.5 acres whereas patches range in size from 0.5 to 2.0 acres. In either version of uneven-aged management, groups or patches should be established on approximately 5% - 15% of the stand area at each entry. Groups and patches will require both site preparation and follow up treatment.

In stands managed under uneven-aged management, the cutting cycle re-entry interval generally ranges from 10 to 20 years based on landowner objectives, site quality, and growth. Shorter cutting cycles can maintain higher tree growth rates but operability (costs and benefits) must be considered. Shorter, more frequent re-entries may increase the potential for degrading stand quality through stem damage and soil compaction. Conversely, shorter cutting cycles will allow for capture of more high risk and low vigor trees succumbing to mortality. Longer cutting cycles can maximize tree quality and reduce negative impacts, such as damage to residual trees, soil compaction, aesthetic impacts (e.g. reduced slash), and ecological impacts (e.g. habitat disruption).

5.5.2 Extended Rotation

Management goals for extended rotations attempt to balance economic, social, and ecological management goals. While timber production is still an important value, increased emphasis is placed on other values, such as aesthetics, wildlife habitat, and biodiversity. In central hardwoods, extended rotations are compatible with even-aged or uneven-aged management. Additional ecological management techniques will be applied, such as the retention of reserve trees and management of coarse woody debris (e.g. large snags and downed rotting logs).

5.6 Other Silvicultural Considerations

5.6.1 Managing “Degraded” Stands

Many central hardwood stands throughout southern and central Wisconsin are “degraded”. These stands, many of which started as oak dominated stands, have been reduced in quality due to a number of factors including:

- woodland grazing
- poor harvesting techniques
  - residual logging damage
  - diameter limit cutting
  - incomplete clear-cuts
  - high-grading
- intense fire
- abiotic agents
  - wind
  - ice storms
- biotic agents
  - insects
  - disease

Many of these stands have an abundance of poor quality stems, poor species composition, poor quality larger diameter stems overtopping a younger stand (poles, saplings, or seedlings), or a combination of these conditions.

To assess the management potential of each degraded stand, a thorough stand assessment is required to determine:

- site quality (site index, habitat type, soil, topographic position)
- species composition
  - canopy, understory, and ground layer
  - sources of regeneration
  - potential growth and competition
  - invasive and/or exotic species

- stand structure (size and density)
- stand and tree health and vigor
- stand and tree quality - number or percentage of acceptable growing stock (AGS) trees and potential crop trees.
- variability across the stand.

Poletimber and sawtimber stands with less than 40 crop trees per acre or less than 40% stand relative density are generally considered degraded and should be regenerated (Clatterbuck 2006). Acceptable growing stock is defined as trees capable of producing sawtimber products. If stand quality and stocking levels are sufficient for management, the stand should be thinned to improve residual stand quality. If stand quality and stocking levels are insufficient for management, the stand should be regenerated using an even-aged regeneration technique.

The adequacy of advance regeneration will help determine which even-aged regeneration technique is applicable. For stands with adequate desirable regeneration (>1000 well distributed seedlings / acre, >2' tall), an overstory removal harvest is appropriate. This may be done in one or more harvests depending upon the volume to be harvested, the silvical needs of the advance reproduction, and other management goals.

For stands with inadequate desirable regeneration (<1000 well distributed seedlings / acre, >2' tall), a shelterwood harvest and/or supplemental seedling planting is appropriate. Site and species selection criteria for supplemental seedling planting should follow the guidelines established in chapter 22*, artificial regeneration*. A high percentage of degraded central hardwood stands will also have dense shrub layers that limit light availability and inhibit regeneration. This layer often should be controlled or killed as part of site preparation for supplemental planting.

APPENDICES

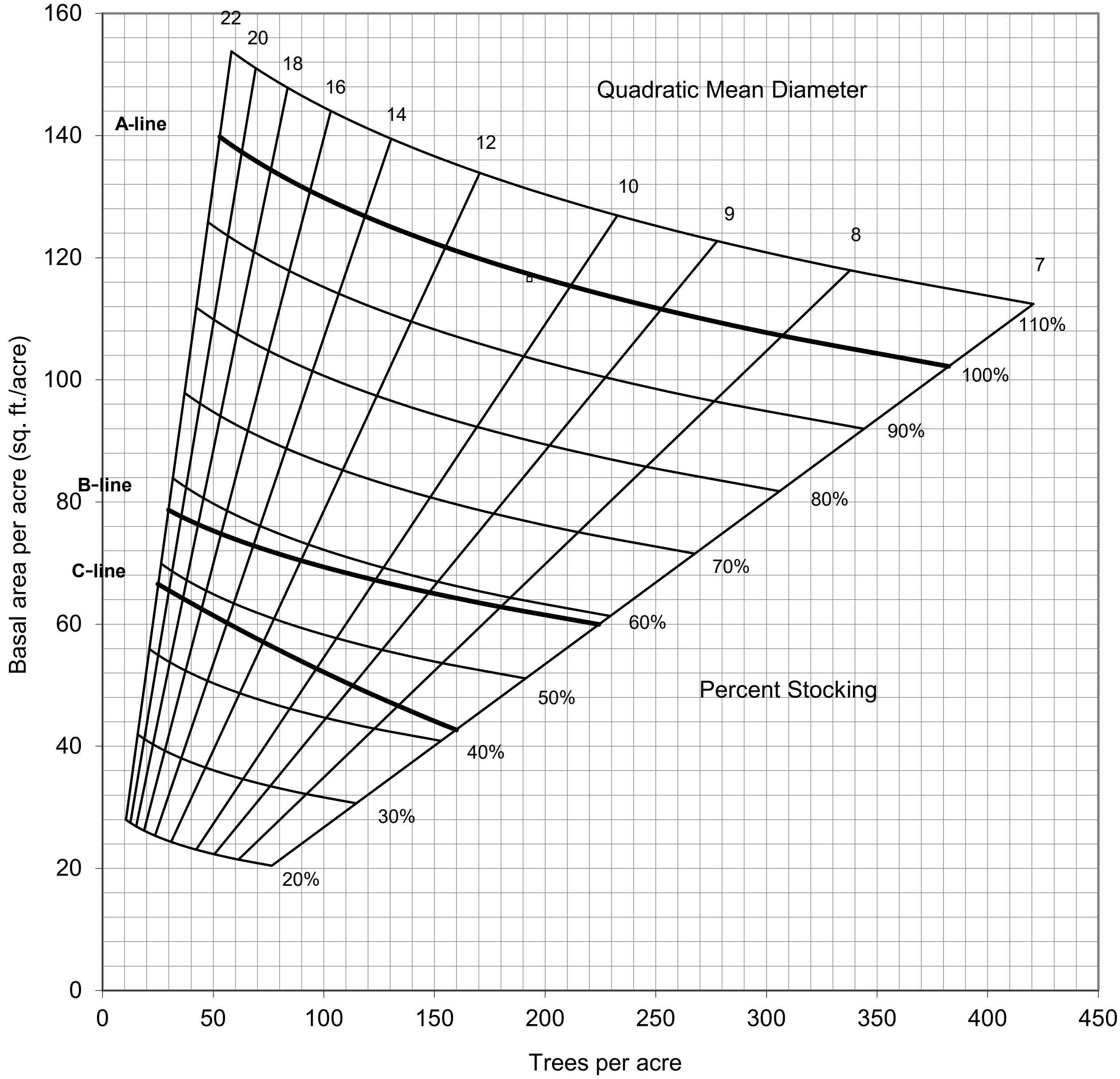

Figure 52.5. Upland central hardwood stocking guide, average diameter 7-22 in (Larsen 2002).

The Upland Central Hardwood Stocking Guide displays the relationship between basal area, number of trees, and mean stand diameter and provides a statistical approach to guide stand density management (see Chapter 23).

- To utilize the stocking guide, statistically accurate estimates of at least two stand variables must be obtained, including basal area per acre, number of trees per acre, and/or mean stand diameter. For the applicable central hardwood stocking guides, these variables are measured only for canopy trees.

- The area between the A-line and B-line indicates the range of stocking where optimum stand growth and volume yield can be maintained.
  - The A-line represents maximum stocking. Maintaining stocking levels near (but below) the A-line will produce comparatively more trees, but of smaller diameter.
  - The B-line represents minimum stocking. Maintaining stocking levels near (but above) the B-line will produce larger diameter trees faster, but comparatively fewer trees.
  - The C-line shows the limit of stocking necessary to reach the B-line level in 10 years on average sites.

- When designing and implementing a thinning regime for a stand, do not reduce stand density to below the B-line or allow it to surpass the A-line.
- Thinning can occur at any time as long as stand density is maintained between the A-line and B-line. The A-line is not a thinning "trigger." When to thin depends on management objectives, stand conditions, and feasibility.

Typically, thinning is implemented when average stand stocking is halfway or more between the B-line and A-line. Stocking is reduced to slightly above the B-line. Crop tree concepts are applied to retain and focus growth on desirable trees, and order of removal concepts are applied to select which trees will be cut to achieve stand management objectives.

In overstocked stands, thin lightly and frequently, with increasing intensity, for the first several thinnings, to safely develop tree crown vigor and stem strength, and until target residual densities (near the B-line) are achieved. A general rule of thumb is do not remove >33% of the basal area in any one thinning operation.

Since central hardwood stands can differ widely in species composition, estimates of relative density based on stocking charts may be inaccurate and should be used with caution (Stout & Nyland 1986).

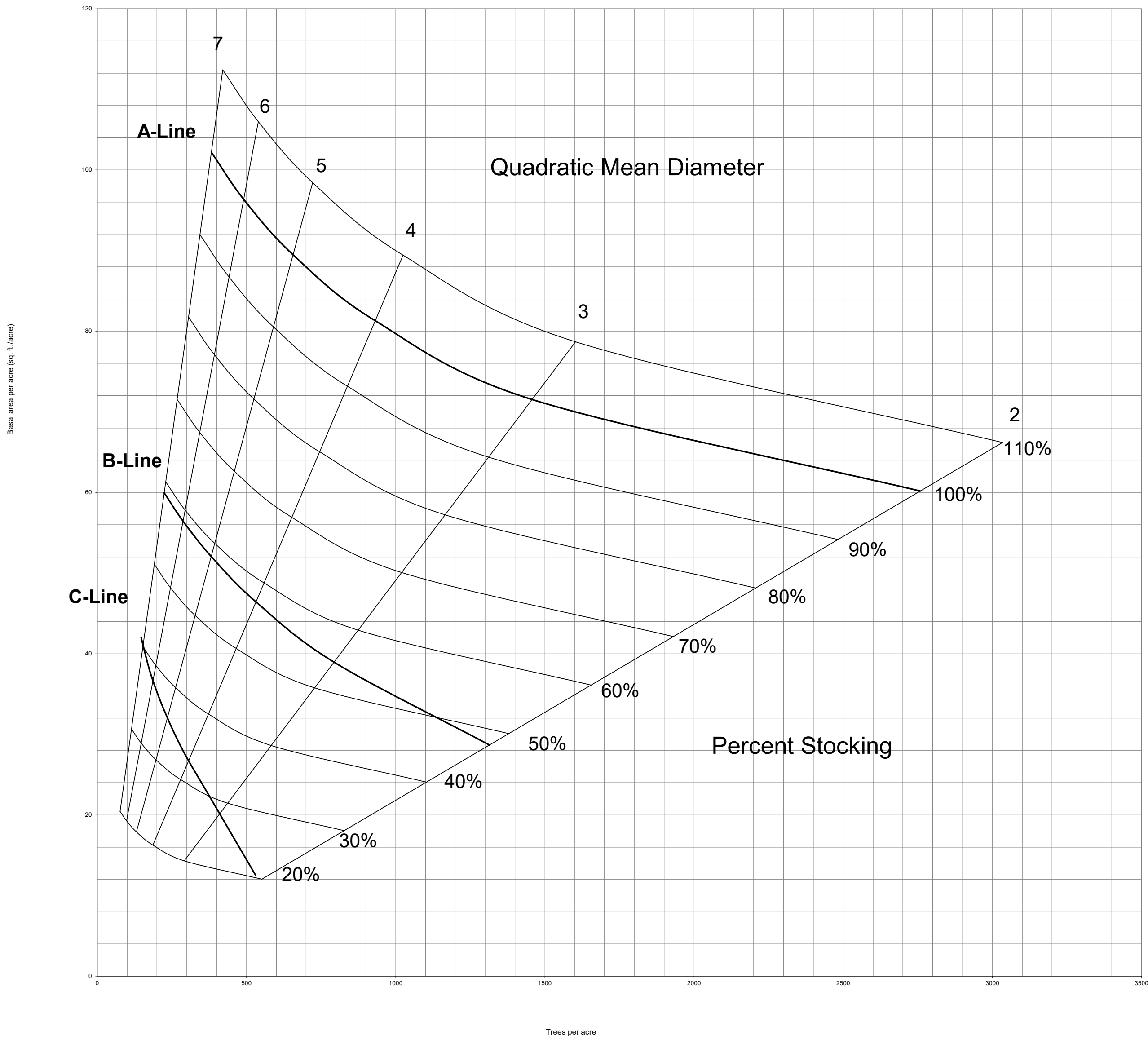

Figure 52.6. Upland central hardwood stocking guide, average diameter 2-7 in (Larsen 2002).

Table 52.6. Tree area ratio coefficients for Wisconsin tree species (NED-2).

Species	WDNR Species Code	K_1	K_2	K_3
Ash, Black	AB	-0.01797900	0.02142500	0.00171100
Ash, Green	AG	0.03258900	0.00743860	0.00383380
Ash, White	AW	0.02793700	0.01545200	0.00087100
Aspen	A, AQ, AY	0.00418710	0.01255100	0.00237960
Basswood, American	BA	-0.00815040	0.00081670	0.00280480
Beech	BE	0.00770410	0.00626130	0.00384800
Birch, River	BR	-0.01797900	0.02142500	0.00171100
Birch, Yellow	BY	0.00770410	0.00626130	0.00384800
Black Walnut	W	0.03087800	0.01805800	0.00423210
Box Elder	BS	-0.01797900	0.02142500	0.00171100
Butternut	WC	0.03087800	0.01805800	0.00423210
Cedar, White	C	-0.00240550	0.00494220	0.00226670
Cherry, Black	CH	0.02793700	0.01545200	0.00087100
Cottonwood	CW	0.03258900	0.00743860	0.00383380
Elm, American	EA	0.03258900	0.00743860	0.00383380
Elm, Slippery	ES	-0.01797900	0.02142500	0.00171100
Fir, Balsam	FB	-0.01970100	0.02164000	0.00031039
Hackberry	HB	-0.01797900	0.02142500	0.00171100
Hemlock	H	-0.01152800	-0.00085458	0.00264390
Hickory, Bitternut	HI	0.00280200	0.01188100	0.00354600
Hickory, Shagbark	HS	0.00280200	0.01188100	0.00354600
Locust, Black	LB	-0.01797900	0.02142500	0.00171100
Locust, Honey	LH	-0.01797900	0.02142500	0.00171100
Maple, Red	MR	-0.01797900	0.02142500	0.00171100
Maple, Silver	MS	-0.01797900	0.02142500	0.00171100
Maple, Sugar & Black	MH, MB	0.00770410	0.00626130	0.00384800
Miscellaneous Hardwoods	MX	-0.01797900	0.02142500	0.00171100
Oak, Northern Red	OR	-0.00534020	0.00737650	0.00432100
Oak, not Northern Red Oak	OW, OS, OM, OB, OO	0.00280200	0.01188100	0.00354600
Pine, Jack	PJ	-0.07219700	0.03416300	0.00102220
Pine, Red	PR	-0.02541800	0.01475300	0.00162290
Pine, White	PW	0.02798000	0.00783220	0.00174670
Spruce	SW, SB, SN	-0.01970100	0.02164000	0.00031039

Tree Area Ratios

Relative stand density (stocking), may be more accurately calculated directly from stand data using a species-specific tree-area ratio than with stocking guides. Stocking based on a tree-area ratio is determined by calculating the area occupied by individual trees within a stand based on species and diameter (Chisman & Schumacher 1940). When summed across the stand, this ratio reflects relative stand density.

$$(K_1 + (K_2 \times \text{dbh}) + (K_3 \times \text{dbh}^2)) \times \text{stems per unit area} = \text{Relative Density}$$

In this equation K_1, K_2, and K_3 depend on the individual tree species coefficients (see above).

Estimates derived from the tree area ratios will be nearly identical to estimates from a stocking chart when the stand species composition is appropriate to the chart (Stout *et al.* 1987). If the stand composition is not appropriate to the chart, the latter technique will be more accurate. The main advantage of this technique is its flexibility for use in stands with a variety of cover types and species compositions. This technique is greatly simplified when using spreadsheets or computer programs that summarize and calculate stand data.

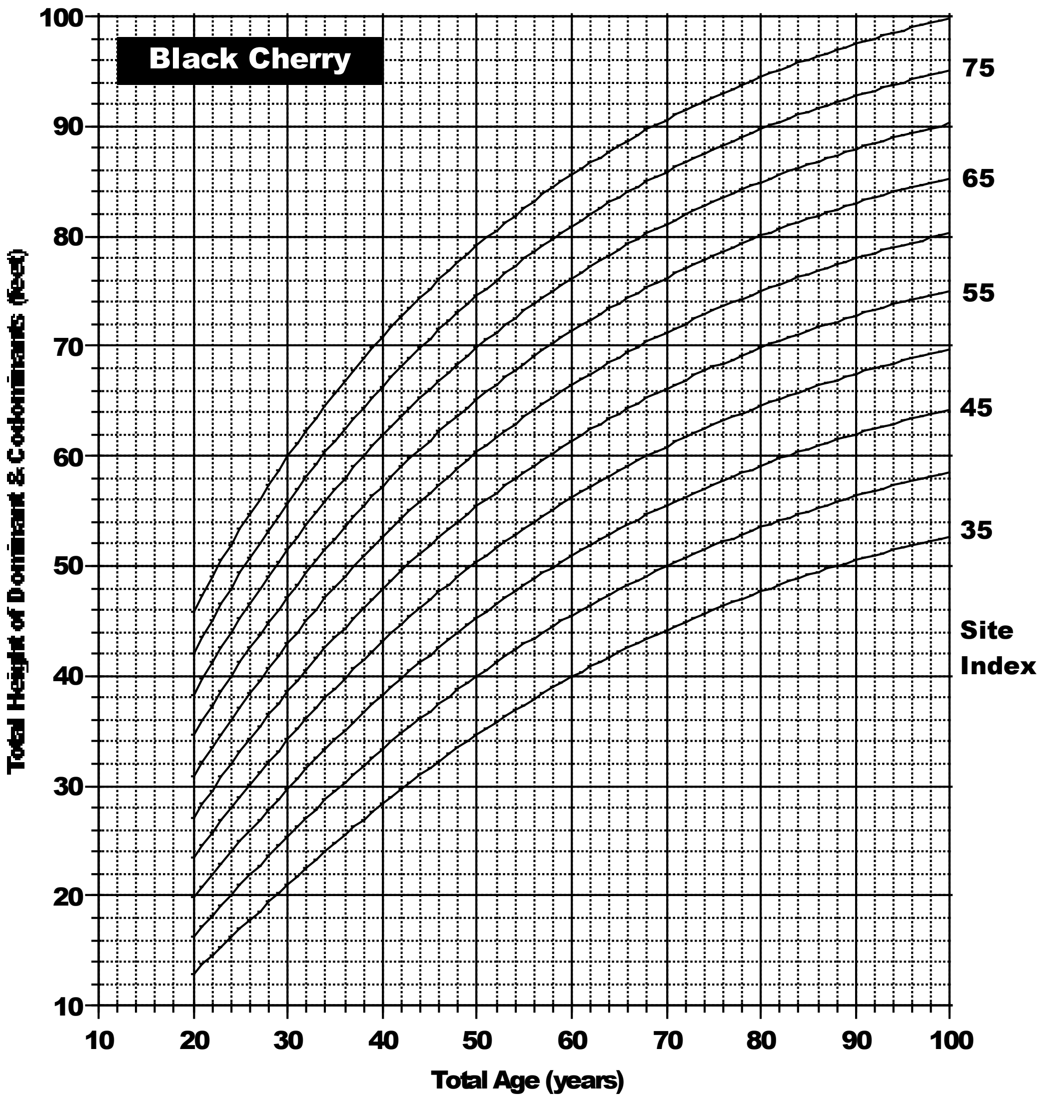

Figure 52.7. Site index curve for black cherry in northern Wisconsin and upper Michigan (Carmean et al. 1987).

Black cherry (Carmean 1978)

- Northern Wisconsin and Upper Michigan
- 42 plots having 126 dominant and codominant trees
- Stem analysis, nonlinear regression, polymorphic
- Add 4 years to dbh. age to obtain total age (BH=0.0)

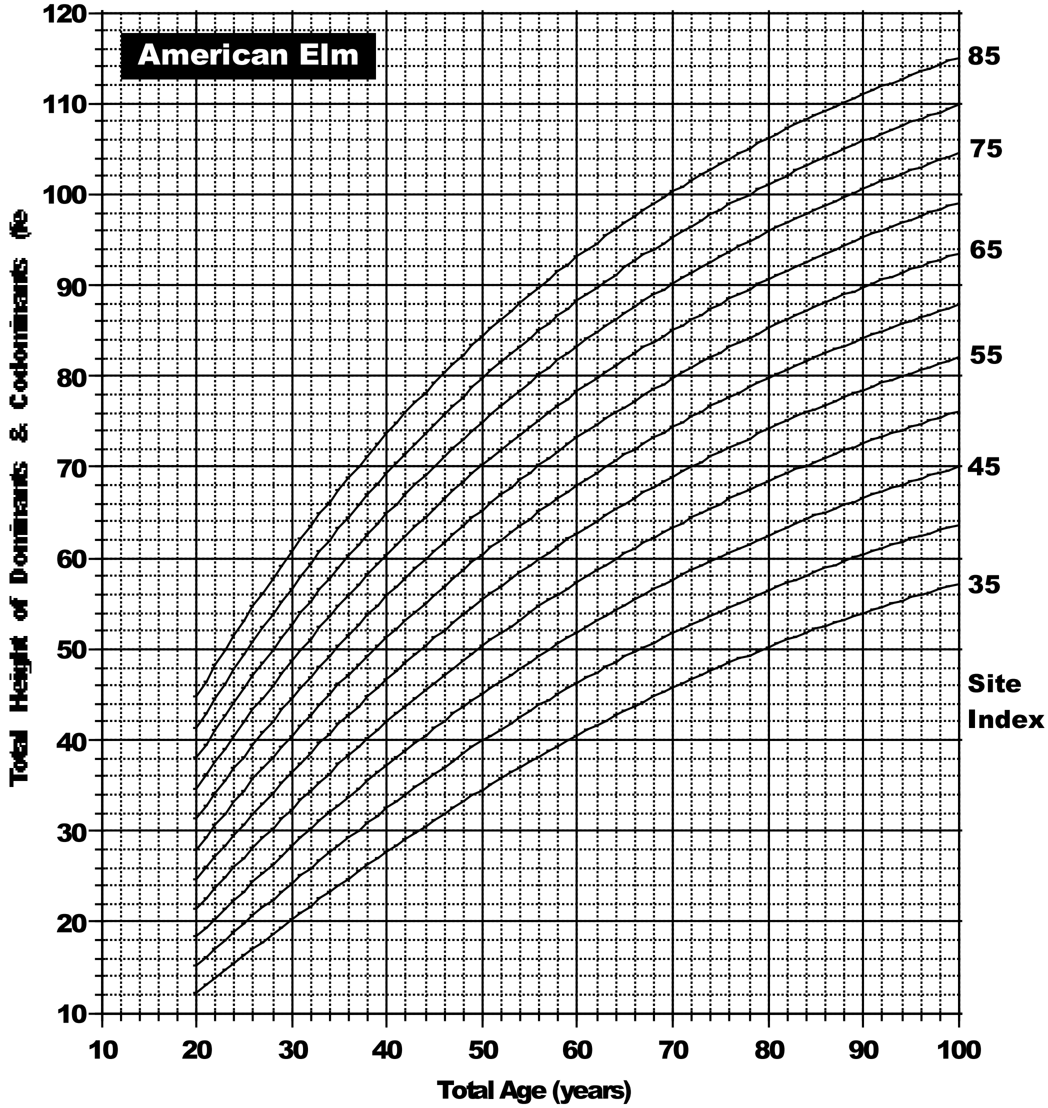

Figure 52.8. Site index for American elm in northern Wisconsin and upper Michigan (Carmean et al. 1989).

American elm (Carmean 1978)

- Northern Wisconsin and Upper Michigan
- 109 plots having 416 dominant and codominant trees
- Stem analysis, nonlinear regression, polymorphic
- Add 4 years to dbh. age to obtain total age (BH=0.0)

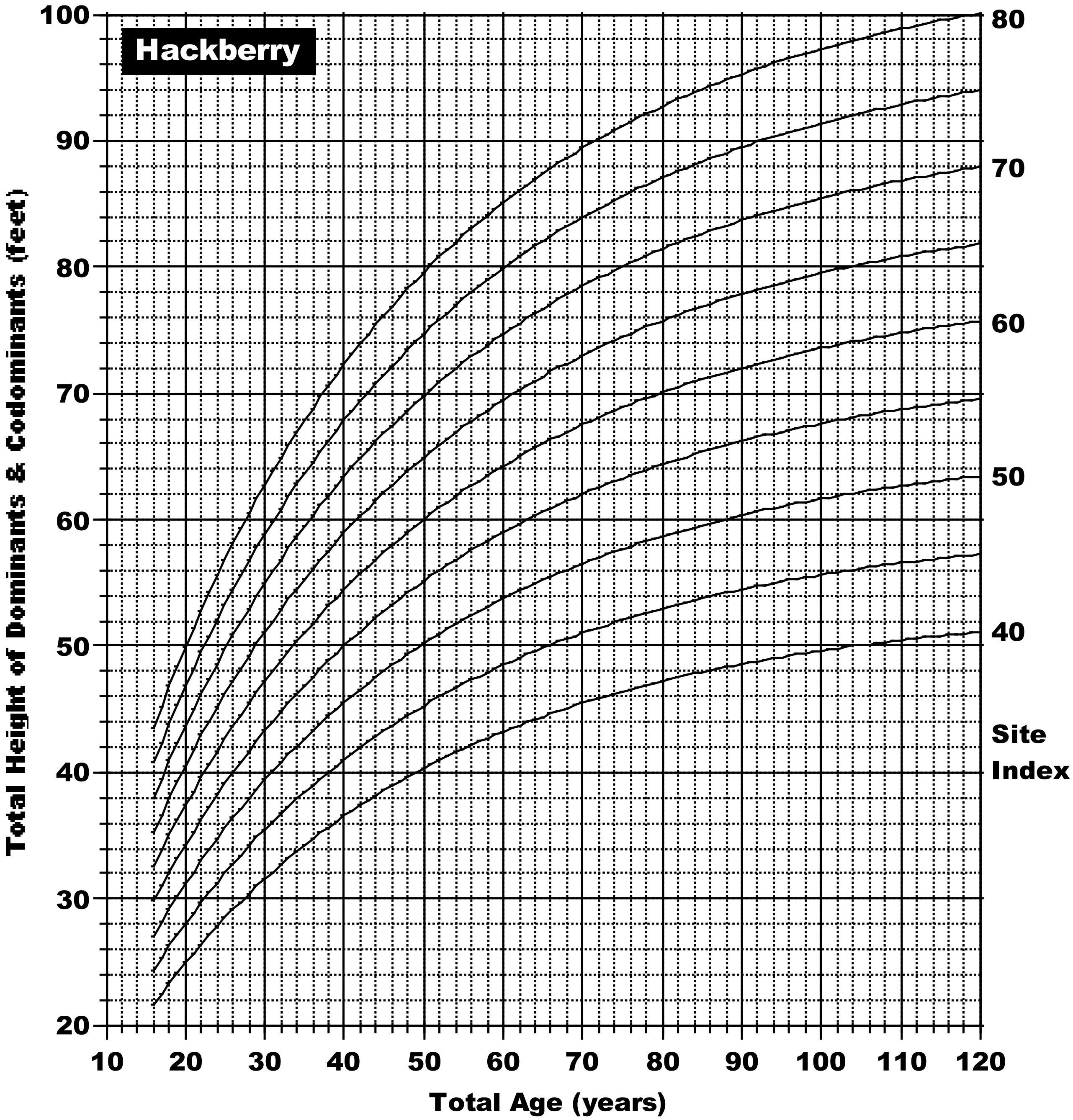

Figure 52.9. Site index for hackberry (Carmean et al. 1989).

Hackberry (Lynch, KD and Geyer, WA) Kansas

- General equation based on 130 dominant and codominant trees, number of plots not given

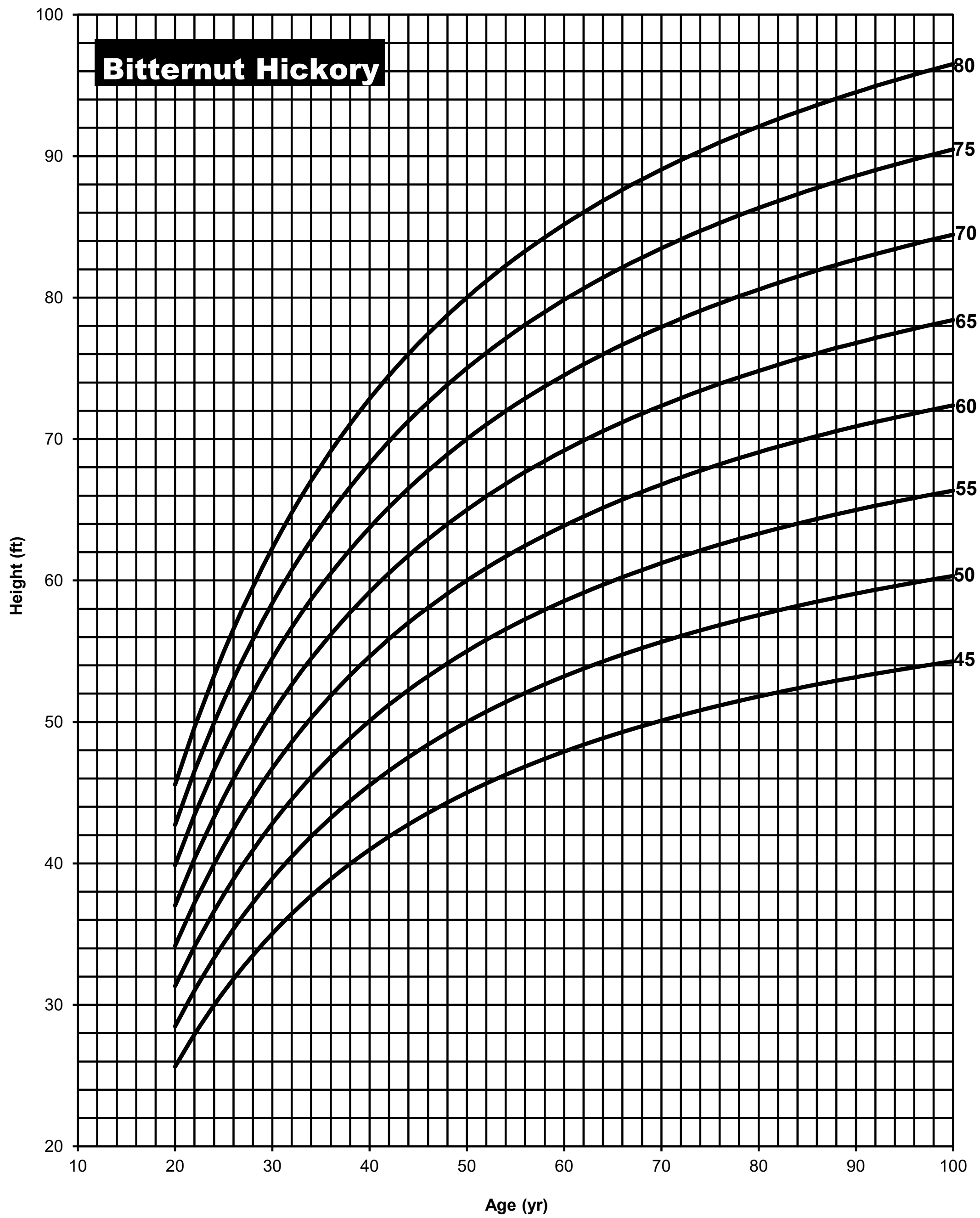

Figure 52.10. Site index for bitternut hickory in Wisconsin.

Bitternut hickory

- Chart based on 264 trees from 1983, 1996, 2003 FIA Site Tree Data
- Total height and age, anamorphic
- Convert dbh age to total age by adding 4 years
- Created by Brad Hutnik and Rick Livingston

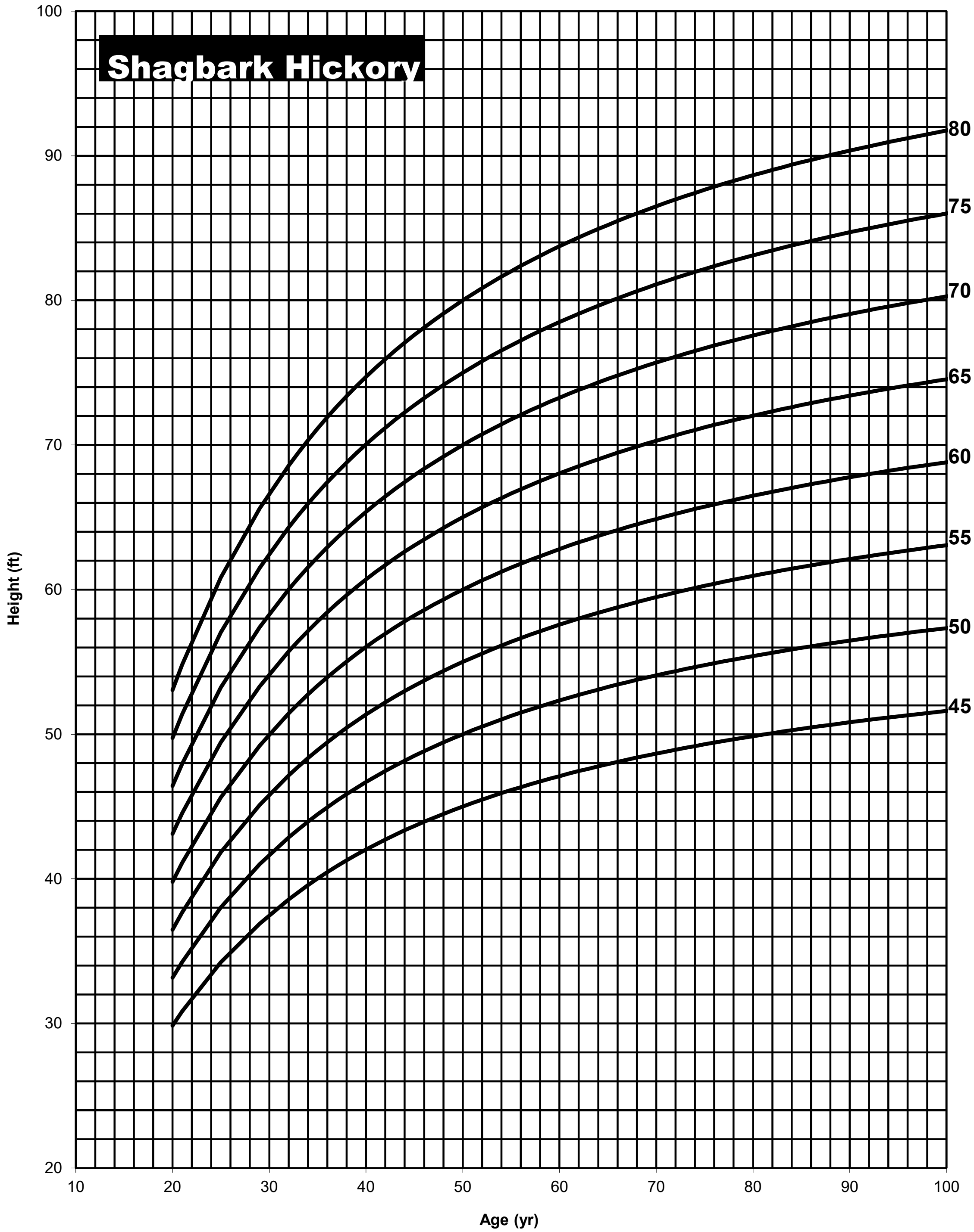

Figure 52.11. Site index for shagbark hickory in Wisconsin.

Shagbark hickory

- Chart based on 318 trees from 1983, 1996, 2003 FIA Site Tree Data
- Total height and age, anamorphic
- Convert dbh age to total age by adding 4 years
- Created by Brad Hutnik and Rick Livingston

7.1 Forest Health Guidelines - Forest Health Protection (FHP)

Species included in this table are butternut, cherry, elm, hackberry, and hickory.
For other species found in central hardwoods, please refer to appropriate chapters.

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
DEFOLIATING INSECTS			
Cherry scallop shell moth - *Hydria prunivorata* Larvae tie margins of the leaves and form an elongated tube-like nest. Feeding occurs on the upper tissues of the leaves inside the nest. Severe defoliation may be seen.	Cherry	Maintain stand vigor through proper forest management	Pest Alert: Cherry Scallop Shell Moth. USDA Forest Service. NA-PR-01-96 https://www.forestpests.org/acrobat/cherry_scallop_shell_moth.pdf
Eastern tent caterpillar – *Malacosoma americanum* Defoliation in spring by larvae. Larvae construct a silken tent on a fork of branches.	Many hardwood species. Cherry is one of the preferred hosts	Maintain stand vigor through proper forest management Insecticides may be applied to control this pest in urban setting	Eastern tent caterpillar. 1999. UW Extension A2933.
Elm flea beetle - *Altica ulmi* Elm leaf beetle – Xanthogaleruca luteola Grub-like larvae skeletonize the undersides of the leaves, leaving the veins and upper leaf surface. Infested leaves later turn brown, dry and may fall off.	Elm	Maintain stand vigor through proper forest management Insecticides may be applied to control this pest in urban setting	Elm Leaf Beetle. Ohio State University Extension Factsheet. HYG-2036-94.
Elm leafminer – *Fenusa ulmi* Larvae mine leaves and cause blister-like blotches on leaves. Mined areas are initially white, and then later turn brown. Adult is a sawfly.	Elm	Maintain stand vigor through proper forest management	Insects of Eastern Hardwood Trees. 1997. Natural Resources Canada
Elm sawfly – *Cimbex americana*	Elm and other hardwood species	Maintain stand vigor through proper forest management	Insects of Eastern Hardwood Trees. 1997. Natural Resources Canada

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
Defoliation in summer to early fall by larvae. Largest species of sawfly in North America.			
Elm spanworm – *Ennomos subsignarius* Defoliation in late spring by larvae.	Elm, Hickory and other hardwood species	Maintain stand vigor through proper forest management	Insects of Eastern Hardwood Trees. 1997. Natural Resources Canada
Fall webworm – *Hyphantria cunea* Defoliation in mid- to late summer by larvae. Larvae construct a silken web, covering the ends of branches, and feed within the web. Webs as large as a few feet across may be formed.	Many hardwood species	Control is usually not necessary as defoliation occurs toward the end of growing season. Maintain stand vigor through proper forest management	Fall webworm. 2004. UW Extension Garden Facts XHT1066. https://hort.extension.wisc.edu/files/2014/11/Webworms.pdf
Lace bugs – *Corythucha* spp. Lace bugs feed on the undersides of leaves by inserting their needle-like sucking mouthparts and extracting sap. Infested leaves have white or yellow spots. Heavily infested leaves may turn yellow or brown in summer.	Many hardwood species, including butternut, cherry, elm, and hackberries	Control is usually not necessary as the damage does not affect the health of the trees significantly Maintain stand vigor through proper forest management	Lace bugs on deciduous trees and shrubs. 2002. Univ. of Minnesota. Yard & Garden Brief.
Ugly nest caterpillar – *Archips cerasivorana* Defoliation by larvae in late spring to summer. Larvae tie leaves with silk and construct a dense web filled with excrement and bits of leaves.	Cherry and other hardwood species	Maintain stand vigor through proper forest management Chemical control is usually not necessary as the damage does not affect the health of the trees significantly.	Insects of Eastern Hardwood Trees. 1997. Natural Resources Canada

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
FOLIAGE DISEASES			
Anthracnose – Multiple Anthracnose causing fungi (see reference) Irregular dead blotches on foliage. Growth loss.	Many hardwood species including elm and hickory	Maintain stand vigor through proper forest management Direct control is impractical and usually unnecessary. Silvicultural measures to encourage air circulation may reduce infection.	Anthracnose Diseases of Eastern Hardwoods. 1985. Forest Insect & Disease Leaflet 133 https://www.fs.usda.gov/foresthealth/docs/fidls/FIDL-133-AnthracnoseHardwoods.pdf
GALL MAKING INSECTS			
Elm cockscombgall aphid – *Colopha ulmicola* The insect causes a gall that resembles a comb on leaves. Galls are irregularly toothed, reddish brown, and later turn brown and hard. Woolly elm aphid - *Erisoma americanum* The insect is covered with white waxy threads. Infested leaves are twisted and curled.	Elm	Maintain stand vigor through proper forest management Chemical control is not necessary as the damage does not affect the health of the trees significantly.	Insects of Eastern Hardwood Trees. 1997. Natural Resources Canada
Hackberry nipple gall - Pachypsylla celtidismamma Round nipple-like galls on leaves are caused by psyllids or jumping plant lice.	Hackberry	Maintain stand vigor through proper forest management Chemical control is not necessary as the damage does not affect the health of the trees significantly.	Deciduous Tree Galls. 2000. UW Extension Garden Facts. X1064. https://hort.extension.wisc.edu/files/2014/11/Deciduous-Tree-Galls.pdf Insect and Mite Galls. 2005. Univ. Minn. Ext. DG1009 http://cues.cfans.umn.edu/old/extpubs/1009galls/DG1009.html

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
Phylloxera galls - Phyllloxera spp. Galls are caused by aphid-like insects called phylloxera. Gall growths vary in size and shape. Hickory pouch gall The insects cause pouch-like growths on the twigs and leaves.	Hickory	Maintain stand vigor through proper forest management Chemical control is not necessary as the damage does not affect the health of the trees significantly.	Deciduous Tree Galls. 2000. UW Extension Garden Facts. X1064. Insect and Mite Galls. 2005. Univ. Minn. Ext. DG1009
GALL DISEASES			
Black knot - Apiosporina morbosa The fungus causes black, corky swelling, primarily on twigs and branches, but also on main stems. Severe infections girdle branches and trunks and cause branch dieback and could lead to tree mortality.	Cherry and other Prunus spp.	Trees with galls on main stem have a high probability of degrade in value during the next cutting cycle and may be selected against during the normal thinning practice1. Pruning of branches at least six to eight inches below each swelling is effective to control this disease in urban situations.	Black Knot. 2000. UW Extension Garden Facts. X1056. https://hort.extension.wisc.edu/files/2014/11/Black-Knot.pdf
Phomopsis gall - Phomopsis spp. The fungus causes round tumor-like growths on twigs, branches, and trunks. Galls occur singly or in clusters. Severe infections girdle branches and trunks and cause branch dieback and could lead to tree mortality.	Hickory	Trees with galls on main stem have a high probability of degrade during the next cutting cycle and may be selected against during the normal thinning practice1.	Phomopsis Canker & Gall. 2000. Univ. Minn. Ext. Yard & Garden Brief.
SCALE INSECTS			

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
Lecanium scale – Parthenolecanium spp. This insect sucks plant juice, causing twig and branch dieback, and growth loss.	Many hardwood species	Maintain stand vigor through proper forest management Chemical control is impractical, and usually unnecessary.	Scale Insects of Trees and Shrubs. 1999. Univ. Minn. Ext. FO-01019.
CANKERS			
Butternut canker - Sirococcus clavigignenti-juglandacearum The fungus causes perennial cankers on twigs, branches, stems and exposed roots. Multiple stem cankers eventually girdle and kill infected trees. A statewide survey conducted in Wisconsin in 1992 found that 27% of the surveyed trees were dead and 91% of live trees were cankered.	Butternut	Tree Retention Guidelines (the 70-20-50 Rule) Retain all trees with more than 70% live crown and less than 20% of the combined circumference of the bole and root flares affected by cankers. Retain all trees with at least 50% live crown and no cankers on the bole or root flares. Harvest dead or declining trees based on landowner objectives	How to Identify Butternut Canker and Manage Butternut Trees. 1996. USDA FS Butternut-Strategies for Managing a Threatened Tree. 1994. USDA FS General Technical Report NC-165.
Nectria canker – Nectria cinnabarina Trunk deformity and growth loss (all ages). Although it rarely causes mortality, a tree may break off at the point of canker.	Many hardwood species	Silvicultural control measures are based on percent of infected trees in stand (see reference). Most infections occur when trees are 12-20 years old. Conduct improvement cut after age 20. A canker that affects >50% of the stem's circumference or >40% of the stem's cross	How to Identify and Control Nectria Canker of Hardwoods. R. Anderson. 1978. USDA FS

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
		section has a high risk of failure during the next cutting cycle. 1	
WOOD BORERS			
Hickory bark beetle – Scolytus quadrispinosus Larval mining radiates from egg galleries, creating etching that resembles a centipede. Foliage of infested trees turns yellow and later brown. Larval tunneling girdles branches and stems, causing branch dieback and mortality.	Hickory is the primary host. Butternut is listed as a host; however infestations have not been reported in Wisconsin yet.	Maintain stand vigor through proper forest management. Destroy trees harboring overwintering larvae during winter and spring.	Hickory Bark Beetle:Biology and Control. 1964. WI Conservation Dept. Forest Pest Leaflet No.6 Guide to insect borers of North American broadleaf trees and shrubs. 1995. USDA Forest Service. p504-506
Hickory borer – Goes pulcher Larvae are round-headed wood borers. Larval feeding causes serious damage to young trees. Attacks in large trees are usually restricted to branches and upper stem.	Hickory	Maintain stand vigor through proper forest management. Destroy trees harboring overwintering larvae during winter and spring.	Guide to insect borers of North American broadleaf trees and shrubs. 1995. USDA Forest Service. p308-311
Peach bark beetle – Phloeotribus liminaris First confirmed case of infestation in Wisconsin was found on a mature black cherry stand in 2000. The insect is known to attack individual trees repeatedly until the trees die.	Black cherry	Caution is urged when making partial cuts in black cherry. Utilization of the logging slash as much as possible would be a wise practice until more information about this insect becomes available.	Black Cherry Pest Alert! Peach Bark Beetle. 2001. WI DNR FHP.
ROOT DISEASE			

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
Armillaria root disease (shoestring root rot) – Armillaria spp. Stringy white rot. Dieback and mortality, especially during drought years or following 2 or more years of defoliation (all ages).	Many tree and shrub species	Maintain stand in healthy condition. Harvest declining trees before mortality and decay take place.	Armillaria Root Disease. R. Williams, et al. 1986 USDA Forest Service, Forest Insect and Disease Leaflet 78
WILT DISEASE			
Dutch elm disease – Ophiostoma ulmi/O. novo-ulmi Infection by the fungus results in clogging of the vascular system of a tree. Foliage of the infected tree becomes wilted, turns yellow and later brown. First, wilting symptoms appear at the end of an individual branch (flagging), and then progress to the entire crown. Infected tree eventually dies.	Elm	Remove and destroy infected trees. If infected wood is stored as firewood it needs to be debarked or covered with thick plastic tarp during growing season. Disruption of root grafts prevents the movement of the fungus from diseased to nearby healthy elms. Fungicides can be applied to protect individual valuable trees in urban setting.	How to Identify and Manage Dutch Elm Disease. 1998. USDA Forest Service. NA-PR-07-98.
MORTALITY			
Hickory mortality Dieback and mortality on hickory have been observed in central and southern Wisconsin. Recent research found that the mortality is associated with the hickory bark beetle and two fungal species of the genus Ceratocystis (C. carya and C. smalleyi). The fungus has been isolated from sunken bark cankers and discolored	Hickory	Since this problem is currently under investigation, no known control is available, though practices to reduce hickory bark beetle attacks may be considered (see hickory bark beetle under wood borers).	Pest Alert: Hickory Mortality. 1994. USDA Forest Service. NA-FR-02-94.

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
wood associated with beetle attacks. At this point, little is known about the relative role of the fungus and its distribution in Wisconsin.			
ANIMAL DAMAGE			
Sapsuckers (Sphyrapicus varius) Value loss through wood decay and discoloration. Occasional tree mortality.	Central Hardwood	Leave attacked tree in place. It will concentrate most of the attacks on one tree.	How to Identify Sapsucker Injury to Trees. M. Ostry. 1976. USDA FS. NSEFES.
Voles/mice (Microtus spp.) Mortality of reproduction through stem girdling in grassy plantations.	Central Hardwood	Control grass first five years	Animal Damage to Hardwood Regeneration and Its Prevention in Southern Ontario. F.W. Von Althen. 1983. Information Report 0-X-351.
Rabbits/hares (Sylvilagus spp./Lepus americanus) Mortality of reproduction through stem girdling.	Central Hardwood	Control usually unnecessary	Animal Damage to Hardwood Regeneration and Its Prevention in Southern Ontario. F.W. Von Althen. 1983. Information Report 0-X-351
Squirrels (Sciurus spp., Tamiasciurus hudsonicus, Glaucomys spp.) Gnawing on bark of maple saplings occasionally causes tree mortality. Squirrels also tend to feed on the edges of fungal cankers.	Central Hardwood	Control usually unnecessary	Animal Damage to Hardwood Regeneration and Its Prevention in Southern Ontario. F.W. Von Althen. 1983. Information Report 0-X-351

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
White-tailed deer (Odocoileus virginianus) Browsing can cause mortality, deformity, or reduced growth rates of seedlings. Preferential browsing can alter forest composition. Antler polishing can shred bark and can cause deformity or mortality of small trees.	Forests, including Central Hardwood	Population management by hunting Fencing (exclusion) Tree shelters, bud caps, and repellents	Controlling Deer Damage in Wisconsin. S. Craven et al. 2001. UW Extension G3083. Animal Damage Management Handbook. 1994. USDA FS PNW-GTR-332.
Livestock Potential impacts include soil compaction, root and stem wounding, reduced tree vigor and sap production, mortality and deformity of seedlings, and altered forest composition. Damage can be severe when soil is saturated or grazing is heavy (large populations or extended time periods).	Forests, including Central Hardwood	Eliminate or limit livestock from forests.	Sugarbush Management: A Guide to Maintaining Tree Health. 1990. D. Houston et al. USDA FS GTR-NE-129. Wisconsin Forest Management Guidelines. 2003. WDNR PUB-FR-226.
European earthworms (Lumbricus, Dendrobaena, Octolasion, and Aporreclodea spp.) Declines in native understory plant species and tree seedlings follow the invasion of non-native earthworms. They rapidly decompose the leaf litter that makes up the duff layer, leaving a bare soil surface inhospitable to tree seedlings and other plants that germinate in the duff or require it for protection. Partial recovery occurs after the invading front has passed and the earthworms become naturalized.	Forests and open lands, including Central Hardwood.	Prevent new earthworm introductions. Don't transplant plants and trees into areas where earthworms are not present. Dispose of extra fishing bait in the trash. Experts recommend limiting deer populations in areas with new invasions to avoid stacking stresses on flora.	

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
ABIOTIC and MECHANICAL DAMAGE			
Storm damage Limb and trunk breakage. Decay and discoloration through wounds.	Central Hardwood	See FHP Signs of Defect table for specific recommendations related to impact.	Caring for ice-damaged woodlots and plantations. 1999. Ontario Extension Notes
Cold injury Cold injury occurs when the winter temperature falls to approximately -35° F or colder. Species' sensitivity varies. Injury is typically manifested by patches of dead (brown and black) cambium. In spring, affected trees will have reduced bud break and may have epicormic sprouts.	Central Hardwood	Monitor for dieback in upper and outer crown. If more than 50% of the crown dies, expect decline to continue to mortality.	
Late spring frost damage This phenomenon is unpredictable and occurs when temperatures dip below freezing during bud expansion, break and when foliage is just emerging. Foliage turns black and wilts. Twig dieback can occur. New lateral buds can break within 4 weeks after damage.	Central Hardwood	In frost pockets, expect injury to new expanding growth during years with late spring frost. Monitor for dieback in upper and outer crown. If more than 50% of crown dies, expect decline to continue to mortality.	
Drought Symptoms of drought include premature defoliation, thin crowns, subnormal leaf size and in severe cases, wilting foliage. If drought persists for more than one year, dieback of the upper and outer crown may occur.	Central Hardwood	Monitor for dieback in upper and outer crown. If more than 50% of crown dies, expect decline to continue to mortality. Hardwoods take longer to recover from drought than	

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
		conifers. Improvement in crown may not be noticeable for a year after normal precipitation returns.	
Logging damage Wounds. Limb and trunk breakage. Decay and discoloration through wounds.	Central Hardwood	Careful felling and skidding, directional felling techniques, careful harvest plan layout. Limit harvest activities to times when soil is frozen or dry enough as to minimize soil compaction. See FHP Signs of Defect table for specific recommendations related to impact.	
INVASIVE PLANT SPECIES			
Black-bindweed, False buckwheat - Polygonum convolvulus Black-bindweed can outcompete and displace other flora.	Forests, including Central Hardwood.	Little is known about control in forests. Herbicide or hand-pulling may be used where control is needed.	
Field bindweed - Convulvulus arvensis A Wisconsin state-listed “noxious weed” that can outcompete and displace other flora.	Forests, including Central Hardwood.	Little is known about control in forests. Herbicide or hand-pulling on a regular basis (perhaps only once per year), may be used where control is needed.	

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
Garlic mustard - Alliaria petiolata A major invasive plant that outcompetes herbaceous flora and tree seedlings. There is some evidence of allelopathy to beneficial mycorrhizae. Small seeds spread easily on equipment and clothing.	Forests, including Central Hardwood. One of the few invasive understory plants to thrive in full shade.	Use preventative measures; clean equipment and clothing before entering the forest. Monitor to ensure early detection. Small infestations can be eradicated by hand pulling, or by repeatedly cutting the flower stalk close to the soil surface before flowering begins. Spray with glyphosate in spring or fall to kill basal rosette; avoid non-target species.	
Japanese knotweed - Polygonum cuspidatum Outcompetes and displaces other flora. Early emergence, height, and density allow it to shade out other vegetation and limit tree regeneration. Not yet widespread in Wisconsin. Difficult to eradicate once established.	Central Hardwood forests, riparian forests, open lands with mesic or wet-mesic conditions.	Repeated cutting (3x per growing season) provides control but may not eradicate a stand. The herbicide glyphosate can be effective, especially applied in fall. Continued monitoring and follow-up are needed after treatment.	
Japanese barberry - Berberis thunbergii Has potential to limit forest regeneration as it becomes more abundant. With a concerted effort, potential remains to suppress this species. It can outcompete and displace other flora. Its thorns make it	Forests and semi-open areas, including Central Hardwood.	Mechanical removal in early spring is recommended for small infestations. Wear thick gloves. Glyphosate or triclopyr herbicides can be effective.	

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
difficult to work or recreate in an infested area.	Tolerates full shade.	Avoid impacts to non-target vegetation.	
Common buckthorn and smooth (glossy) buckthorn (Rhamnus cathartica and R. frangula) Tall shrubs form dense thickets that outcompete and displace other flora. There is some evidence that they are also allelopathic. Seeds are spread by birds, and in mud on equipment.	Forests, including Central Hardwood, and open lands. Smooth buckthorn is more restricted to wet and wet-mesic areas.	Monitor to ensure early detection. Clean equipment before entering the forest. Small plants can be eradicated by hand pulling. Large shrubs can be mechanically removed, cut and stump-treated, or controlled with a basal bark application. Foliar sprays should be restricted to fall months when buckthorn is still actively growing but other species are dormant, to avoid impacts to non-target vegetation. Trichlopyr may be more selective than glyphosate. In areas with high water tables, use herbicides labeled for use over water. Continued monitoring and follow-up are needed after treatment.	

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
Bush honeysuckles (Lonicera spp.) Forms dense shrub thickets that outcompete and displace other flora. Seeds are spread by birds, and in mud on equipment.	Forests, including Central Hardwood, and open lands.	Monitor to ensure early detection. Clean equipment before entering the forest. Small plants can be eradicated by hand pulling. Large shrubs can be mechanically removed or cut and stem-treated. Foliar spray using glyphosate in spring, prior to emergence of native plants. In areas with high water tables, use herbicides labeled for use over water.	
Norway maple - Acer platanoides A tree species that can outcompete and displace other flora, including sugar maple seedlings. The sap is not suitable for maple syrup. Identification is difficult, as morphology is ambiguous with sugar maple. Flattened seed cavity is distinctive. Norway maples may or may not have milky sap.	Central Hardwood and other upland forests. Tolerates shade. Prolific stump sprout reproduction and viable seeds.	Pull seedlings. Cut stump and treat with glyphosate or basal bark spray stem with triclopyr.	https://www.dnr.state.mn.us/invasives/terrestrialplants/woody/norwaymaple.html

Disturbance Agent and Expected Loss or Damage	Host	Prevention, Options to Minimize Losses and Control Alternatives	References*
Amur maple - Acer ginnala A tall shrub or small tree that can outcompete and displace other flora. Foliage turns bright red in fall.	Central Hardwood and other upland forests. Tolerates shade. Prolific stump sprout reproduction and viable seeds.	Mechanical removal of small infestations Cut stump and treat with glyphosate or basal bark spray stem with triclopyr.	https://www.dnr.state.mn.us/invasives/terrestrialplants/woody/amurmaple.html

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Signs of defect, and evaluation of potential impacts on risk, vigor and value
For the complete defect table of northern hardwood species, please refer to Chapter 40, Northern Hardwood Cover Type.

DEFECT	High Probability of Mortality or Failure (high risk)	High Probability[1] of Degrade due to Defect
Canker Localized area of dead bark and cambium; wood behind canker may or may not be decayed. Commonly caused by fungi. Fungal cankers are a source of spores that may infect healthy trees.	Canker affects >50% of the stem's circumference or >40% of the stem's cross section. Horizontal crack on a canker face. >20% of combined circumference of the stem and root collar are affected by butternut canker.	Decay associated with large canker (affects >50% of stem's circumference). Fruit body visible in the canker's face. Extent of decay and discoloration will vary depending on organisms involved.
Wounds Any injury to tree that exposes the cambium or wood beneath cambium.		1 or more wounds ≥50 in^2 or ≥30% of tree's circumference. >2 large (>5") branches broken close to the stem. Codominant ripped from stem. Fire scars affecting ≥ 20% of tree's circumference
Decay Wood that is missing or structurally compromised. Canker rot fungi are not compartmentalized and will cause significant decay.	Decay in main stem results in <1" of sound wood for every 6" in diameter; must have 2"of sound wood for every 6" dbh if there is also a cavity present. Decay or cavity affects >40% of the stem's cross-section. Tree infected with a canker-rot fungus	Tree infected with a canker-rot fungus including but not limited to: Cerrena unicolor (maple & oak) Phellinus everhartii (oak) Inonotus hispidus (oak) Spongipellis pachyodon (Irpex mollis) (oak)
Cracks (open, can see into the tree at least an inch) A split through the bark, extending into the wood. Wood fibers are not fused. Cracked stems or branches cause wood to act as 2 separate	Crack goes completely through a stem or is open for >4-6' (length). Two open cracks occur on the same stem segment. The stem has an open crack in contact with another defect such as decay, a canker, or weak union.	>1 face with open crack or seam or any spiral crack. Open cracks are more likely to be associated with decay and discoloration.

DEFECT	High Probability of Mortality or Failure (high risk)	High Probability[1] of Degrade due to Defect
beams, weakening mechanical support.		
Galls Abnormal growths on stems and branches. Galls are typically sound but may cause degrade in a localized area around the gall.		Galls on main stem Black knot of cherry (cherry) Phomopsis galls (hickory&oak) Unknown growth (aspen&cherry)
Weak union Union with ingrown bark between stems; wood fibers are not fused. Weak unions are characterized by an acute angle between stems.	Stump sprouts joined above ground in V-shaped union and associated with a crack, showing failure has already begun.	Large (>8" diameter stems) tight union that is either cracked or decayed or associated with another defect. Could result in failure; stain and decay will vary.
Structural compromise Unusual form typically initiated by storm damage.	Leaning tree with recent root lifting. Leaning tree with a horizontal crack, long vertical crack, or buckling wood on the underside of the tree. New leader formed in response to a dead or broken top. Risk increases as top gets larger and stem decays at break point.	
Root defects Loss of structural support due to root rot, wounding, severing or any other factors that cause root mortality.	More than 33% of roots severed, decayed or otherwise compromised. Stump sprouts with a tight union where root structure is not sufficient to support stems.	>3 root wounds within 4' of the main stem; each wound encompasses >30% of root diameter.
Crown density/dieback/ leaf condition Crown symptoms are often showing a response to poor root health, stress such as defoliation or	50% of the crown dead, unless loss of crown is due to stem breakage. 75% of leaves subnormal in size or abnormal in color. (excluding iron chlorosis.) Signs of cambium miners	Multiple large (>5" diameter) dead branches, dead top or codominant (>10" diameter).

DEFECT	High Probability of Mortality or Failure (high risk)	High Probability[1] of Degrade due to Defect
drought or infestation by cambium-mining beetles.		

[1] There is a high probability that the defect will cause a significant reduction in value over a 15-year period; rate of decay/stain development varies by species. Defect may be limited to localized area.

NOTE:

Fire scars are common entries for decay fungi in central hardwood species. Ten years after fire injury, decay may extend .5 – 1 foot above the top of the fire scar. Avg. rate of decay development = 1.25'/ decade. Fire scar wound size may be calculated:

Wound height: multiply bark scorch height x 0.9

Wound width: multiply bark scorch width at 1' above ground x 0.6

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