Chapter 31

White Pine Cover Type

Last Full Revision: 9/11/2002
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

More than 50 percent of the basal area in pine with **white pine** (*Pinus strobus*) predominant.

Associated Species

White pine can be found growing in associations with most major tree species native to Wisconsin. It is a common to occasional associate in most of the major forest cover types.

Within the white pine forest type, the most common associates currently are: red pine (*Pinus resinosa*), jack pine (*Pinus banksiana*), aspen (*Populus* spp.), white birch (*Betula papyrifera*), red maple (*Acer rubrum*), red oak (*Quercus rubra*), northern pin oak (*Quercus ellipsoidalis*), black oak (*Quercus velutina*), white oak (*Quercus alba*), balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), and eastern hemlock (*Tsuga canadensis*).

1.2 Silvical Characteristics

Table 31.1. Summary of selected silvical characteristics.

White pine (*Pinus strobus*)	
Pollination	May to June
Cones Mature	By late August
Seed Dispersal	Occurs within the month following cone maturity. Seed will travel 200 feet within stand, 700 feet in open areas. With an average of 27,000 seeds per pound, a 90-year old stand can produce 87 pounds of seed per acre. Dominant trees produce more seed than co-dominant trees.
Good Seed Years	Every 3 to 5 years with less seed produced in most intervening years. Crop losses to white pine cone beetle, coneborers, and squirrels can be significant. It is important to monitor cone crops throughout the summer prior to implementing site preparation operations in the fall. What appears to be a bumper cone crop in the spring can be virtually eliminated by these cone pests by mid-July.
Germination	Dormancy broken by exposure to moisture at 40-50 degrees Fahrenheit for 30 to 60 days. Seedlings develop best in 30 to 60 percent full sunlight. Moist mineral soil is the preferred seedbed. Dry mineral soil, pine litter, lichen, and grasses are unsuitable seedbeds.
Seed Viability	The number of good seeds per cone varies from 0 to 73. However, germinative capacity is high (93 to 100 percent) in tests on cold stratified seeds. The recommended cold stratification period is 60 days at 33-41 degrees Fahrenheit for both fresh and stored seed (Krugman and Jenkinson, 1974).
Seedling	Light intensity is critical for survival and growth of seedlings. At

Development	least 20 percent of full sunlight is required. Growth at a given light intensity is better in the absence of root competition.
Growth	Early growth is slow; open grown trees are 5 inches in height at age 3, 12 inches at age 5, and 4.5 feet after 8 to 10 years. Between 10 and 20 years, growth in open-grown trees can be as much as 4.5 feet per year, but average growth is only 16 inches per year. Dominant trees ordinarily grow at a rate of 5 to 10 rings per inch, with diameter increasing one inch every 5-6 years in fully stocked stands on average sites. White pine yields will vary depending on site conditions and stocking density. Sawtimber averages 300 - 800 board feet per acre per year, with yields on the best sites as high as 1,200 - 1,600 board feet per acre per year (Lancaster and Leak 1978). White pine yields exceed by far all native species found in the Lake States with studies showing 100-year old stands with in excess of 80,000 board feet per acre of growing stock (Leak *et. al*. 1970). White pine is a long-lived species. Individual trees often reach 200+ years. Maximum age can exceed 450 years. Recent observations by Menominee Tribal Enterprises (MTE) indicate that stands decline rapidly after age 200 even on a very rich site. However, fully stocked stands of 160-year old white pine are common.
Shade Tolerance	Intermediate. White pines less than 30 years old, with one-third of height in live crown, will respond well to release from suppression.

2 MANAGEMENT GOALS, LANDOWNER OBJECTIVES

Landowner goals and ecological potentials determine management alternatives and objectives. An ecosystem management framework gives consideration to a variety of goals and opportunities within the local and regional landscape. The silvicultural system described below is designed to promote the optimum vigor of white pine, with white pine sawlogs as the management objective. This system can be adapted to satisfy other management objectives, but white pine vigor and sawlog quality and quantity could be reduced. The habitat type is the preferred indicator of site potential.

3 LANDSCAPE, SITE, AND STAND MANAGEMENT CONSIDERATIONS

3.2 Site and Stand Considerations

3.2.1 Soils

White pine will grow on almost all soils within its range. It is often found on excessively drained sands. Although the relative growth potential is only moderate, it is one of the most productive

and competitive species capable of growing on these droughty sites. Loamy sands and sandy loams (somewhat excessively to somewhat poorly drained) present the best opportunities for white pine management. Growth potentials are very good, and competition by mesic hardwoods is limited. White pine is very productive on well drained to somewhat poorly drained loams and silts, however hardwood competition on these sites makes regeneration difficult.

3.2.2 Site Quality

3.2.2.1 Range of Habitat Types

White pine, as a cover type and an associated species, was a more common component of northern and central Wisconsin forested landscapes in the pre-European settlement era than at present. Natural disturbance regimes, which created conditions conducive to white pine, have been severely altered. The historical cutover and fires that followed significantly reduced white pine occurrence. This resulted in a limited seed source, which has further restricted re-establishment. White pine was, and could become, a more important component on some habitat types than is suggested by current occurrence.

In northern Wisconsin, white pine currently is:

- A minor associate and minor cover type, exhibits moderate to good growth potential, and is competitive on the very dry to dry (VD-D) habitat type group. Occurrence and growth potentials improve as available moisture and nutrients increase (*Pinus-Acer* series). Management opportunities are good.
- A common associate and minor cover type, exhibits very good growth potential, and is competitive on the dry to dry-mesic (D-DM) habitat type group. Management opportunities are excellent.
- A minor associate and minor cover type, exhibits very good growth potential, and is somewhat competitive on the dry-mesic (DM) habitat type group. Management opportunities are good.
- A minor associate and rare cover type, exhibits excellent growth potential, but generally is not competitive on the mesic (M) habitat type group. Competition intensity from mesic hardwoods increases from moderate to severe as soil moisture and nutrients improve.
- A minor associate and rare cover type, exhibits very good growth potential, but generally is not competitive on nutrient medium to rich sites (loamy and silty soils) within the mesic to wet-mesic (M-WM) habitat type group.
- A common associate and minor cover type, exhibits very good growth potential, and is somewhat competitive on nutrient poor to medium sites (sandy and loamy soils) within the mesic to wet-mesic (M-WM) habitat type group. Example habitat types are ArAbVC and TMC. Management opportunities are good to excellent.

In central and southern Wisconsin, white pine currently is:

- A common associate and minor cover type, exhibits good to very good growth potential, and is competitive on the dry (D) habitat type group. Management opportunities are excellent.

- A minor associate and minor cover type, exhibits very good growth potential, and is somewhat competitive on the dry-mesic (DM) habitat type group. Management opportunities are good.

Most of the other upland habitat type groups in central and southern Wisconsin can provide very good to excellent growth potentials for white pine, but competition is severe and/or white pine occurrence is rare.

In general, on most upland habitat type groups, white pine offers the highest potential productivity (volume growth) compared to other naturally occurring native tree species.

Within forested lowlands (wet-mesic to wet), white pine occurs as a minor associate and a rare cover type.

Terms used above to describe frequency of occurrence:
- common: >10%
- minor: 1-10%
- rare: <1%

3.2.3 Forest Health

Major pests include white pine blister rust (*Cronartium ribicola*) and white pine tip weevil (*Pissodes strobi* Peck). Due to past concerns with these pests, additional discussion has been included below. See additional information in the Pest Management Guidelines section at the end of the chapter.

3.2.3.1 White Pine Blister Rust

The incidence of white pine blister rust varies between stands, and risk factors relating to the diseases are poorly understood. Generally, tree losses attributable to blister rust appear to be manageable on most sites. While individual trees will succumb to blister rust, survivors most often fully stock the stands at rotation. Pruning of the lower branches appears to help reduce the risk of infection. Early sanitation pruning of infected limbs prior to entry into the main stem can reduce losses. This can be accomplished by annually surveying stands in the summer to identify flagging branches. Those branches containing blister rust cankers should be immediately pruned to restrict the translocation of the disease into the main stem, which often results in mortality. White pine should not be planted in areas of heavy blister rust incidence without consulting a forest pathologist and plans for future pathological pruning. Areas where cool moist air collects appear to be more conducive to blister rust infection. Expect highest disease incidence on, or avoid, sites that have **both** of these high risk factors: 1) *Ribes spp.* (gooseberries) on or in close proximity to the site, **and** 2) site conditions that enhance lasting dew formation during cool windless nights [such as a) kettle holes or depressions, b) northerly aspect, c) small openings (diameter less than the height of surrounding trees), particularly at the bases of slopes and in low areas, d) ridge tops and shoulders in close proximity to any body of water or lowlands, and e) on the Bayfield Peninsula, sites on aspects which face Lake Superior].

3.2.3.2 White Pine Tip Weevil

The white pine tip weevil can cause stem deformity. Eggs are deposited in the terminal leaders, and larvae feeding under the bark girdle the leader and kill it. Lateral branches then compete to replace the dead leader and cause crook, forking, and sweep. Repeated hits by the weevil can cause the tree to lose its commercial value for sawtimber. The insect prefers to utilize white pine that have larger terminal leader diameters (0.2 inches), and a warm and dry environment seems to increase weevil activity. Therefore, open- grown pine tend to be injured by the weevil more frequently than understory pine. A study conducted on the Black River State Forest (Katovich, 1992) indicated increased tip weevil hits in open-grown -vs.- pine grown under a canopy. Recommendations were made to grow white pine in the understory under a 40 - 50 percent crown closure to prevent tip weevil injury.

Studies conducted by Menominee Tribal Enterprises (MTE) indicated both radial and height growth rates suffered substantially under more than twenty percent crown closure (Pubanz, 1995). Trees grown in the open had better color, denser foliage, better crown position, and greater height and radial growth. It does appear that stands which were poorly stocked (total stems of all species) may run the risk of not being well stocked in white pine crop trees in the sawtimber size classes. Stocking is important in that the adjacent trees serve as trainers (to correct stem form and keep branches small) and provide more choices for removal in intermediate thinnings. The recommendation is to grow pine unsuppressed to promote optimum vigor while maintaining high stem densities (700+ trees per acre) until crowns close.

Additional studies conducted by MTE (Pubanz, 1995) looked at the effects of tip weevil injury on well stocked, open grown white pine plantations across the northern two-thirds of Wisconsin. This study found that well stocked plantations had adequate numbers of crop trees 77 percent of the time even though these trees were attacked by the tip weevil an average of over 2 times in the first log position. The mere presence of tip weevil attack did not preclude crop tree development. Pine grown in an unsuppressed condition are substantially more vigorous. More vigorous pine have the ability to correct stem deformity associated with weevil injury. In this study, over 88 percent of the crop trees had identifiable tip weevil injury.

Stem analysis in 150-year old codominant pine indicated that these trees, which had developed in full sunlight, had been attacked by the weevil at a rate similar to that observed throughout northern Wisconsin. They had also outgrown virtually all of the stem offset and exhibited crop tree form. The sample trees in this study represented those removed in the seeding cut of a pine shelterwood. The residual trees were dominant, well-formed trees that should have been the most attractive to the tip weevil, yet these trees were generally of better quality than the sample trees. Volume losses attributable to weevil attack were insignificant and lower than losses due to felling breakage.

White Pine Pest Management Guidelines are included at the end of this chapter.

3.2.4 Wildlife

White pine is an important tree for a number of wildlife species. Total numbers of wildlife species tend to be higher in mixed white pine types (e.g. pine-oak, pine-aspen) than in pure dense stands of old field or pine plantation. Numbers of species are high in regenerating stands, then drop off in pole stands due to the decline of the herb and shrub layers which are important for many songbirds, voles, and long-tailed weasels. Numbers of species then rise in mature and overmature stands, mainly due to the increasing number of tree bole users.

Retaining wildlife trees in thinnings results in habitats with potential species numbers similar to those in the later stages of stand development. Timber thinning without reserved wildlife trees eliminates high exposed perches, medium and large diameter cavity trees, and larger crowned mast-producing individuals, and also reduces deciduous/coniferous overstory inclusions; these features are important to many wildlife species. The presence of large white pine in the supracanopy of many stands provides favorable nesting and perching sites for various hawks. Great blue herons, osprey, and bald eagles can also use the supracanopy features where white pine occurs near water bodies and other wetlands. Other wildlife attributes of white pine include the use of large individual trees by black bear cubs for escape cover, and the use of white pine stands by white-tailed deer in winter as thermal cover. Standing dead and fallen pine provide many benefits. White pine can achieve large size and deteriorates slowly so it provides very good coarse woody debris.

4 STAND MANAGEMENT DECISION SUPPORT

4.2 Key/ Checklist for Evaluating Cover Type Stand Management Options

Key to recommendations (NOTE – the following silvicultural system assumes that the management objective is to manage for optimum quantity and quality of white pine sawlogs).

Table 31.2. Management options based on stand conditions.

1. Stand approaching or past rotation age	Go to 4.
1. Stand not yet at rotation age	Go to 2.
2. Understocked stands	Evaluate stand condition. If adequate numbers of crop trees are present, schedule thinnings according to the appropriate even-aged stocking guides based on species mix and stand conditions. Identify and prune crop trees leaving one-half to one-third live crown. If adequate numbers of crop trees are not present, regenerate the stand. Go to 4.
2. Fully stocked stands	Utilize appropriate stocking guides to schedule thinnings. Prune crop trees after first thinning.

	Go to 3 for additional information.
3. Distinct rows	Do the first thinning at the earliest opportunity (normally about age 20-25 years). Apply mechanical selection of rows if possible. The basic mechanical method to apply for the initial thinning is every other row removal. In stands where thinning has been delayed (30+ years old) or diameter or tree quality variation is high, mechanically thin every third row and selectively thin (follow standard order of removal) the remaining rows to reduce stocking to not less than the "B" level from the stocking guides. Stands where thinning has been delayed will appear spindly and have a live crown ration of twenty-five percent or less of the tree's height. These plantations pose significant risk to wind and snow damage after thinning if thinned too heavily in the initial thinning. Reschedule next thinning in five years. Subsequent selection thinnings should occur at eight to ten-year intervals and follow the guidelines below for “3. Indistinct rows.”
3. Indistinct rows	Mark out skid trails for access and mark between trails to obtain not less than "B level" stocking from the stocking guides described in Figure 31.2. Thinning should favor the retention of crop trees following the standard order of removal. Subsequent thinnings should occur at eight to ten year intervals and stocking should be reduced to not less than "B level" stocking from the stocking guides. Thinning should be from below and follow the standard order of removal. **Never remove more than fifty percent of the stocking in any one thinning operation to reduce the risk of wind or snow damage.** **STANDARD ORDER OF REMOVAL FOR SELECTION THINNING IN WHITE PINE** **1. HIGH RISK TREES** **2. RELEASE CROP TREES** **3. CULL TREES** **4. LOW VIGOR** **5. UNWANTED SPECIES (REMOVE SEED SOURCE)** **6. IMPROVE SPACING** Continue periodic thinnings until the stand

	approaches rotation age. Then go to 4.
4. Adequate seed source present. Conduct natural regeneration harvest. The following assumes that the objective for regeneration is white pine and its associated species, that the stand has adequate seed source, and is approaching rotation. The recommended steps for using the shelterwood and seedtree systems are as follows:	a. Evaluate the existing reproduction. If inadequate numbers of desired species are present, go to step b. If adequate reproduction is already present, release the understory by reducing overstory to no more than twenty percent crown closure. b. Conduct the regeneration harvest. For a shelterwood, reduce overstory to 50 percent crown closure. For a seed tree, harvest all trees not desired as seed trees. All regeneration harvests should be from below and all unnecessary competing stems should be cut. The trees exhibiting the best vigor, form, and crowns should be retained as seed trees. A minimum of 4 well distributed seed trees per acre is required for adequate seed dispersal. Marking these harvests as "leave tree" is often the most effective. This cut can be made irrespective of seed crop. c. Allow the site to develop for two years or more. This allows slash to break down, stump sprouts to form, and the seedbank to germinate. d. After two years monitor white pine seed crop. Site preparation should be tied to a year with a good seed crop for white pine. The seed crop can be evaluated in the spring but its adequacy must be monitored throughout the summer to assure that it is not lost to insects. If the seed crop is adequate, begin site preparation in the late summer. e. Control the understory competition using chemical or mechanical means or fire. f. Scarify the area to create a favorable seedbed of exposed mineral soil. Expose a minimum of fifty percent of the area.
4. Inadequate seed source present. Conduct artificial regeneration.	Evaluate site potential. If white pine is suited to the site and the objective of management, conduct site preparation in the summer/fall of the year prior to planting to control competition. In the spring of the following year, plant 900 or more white pine seedlings per acre.

Management Recommendations

- To optimize vigor, white pine should be grown in full sunlight in a fully stocked condition. Underplanting is generally discouraged, and more than twenty percent overstory significantly reduces pine development. In natural regeneration systems, once pine seedlings are established on the site (within 3 - 5 years), retain no more than twenty percent crown closure over the pine to promote vigor. Maintain stands at 700 or more total stems per acre until crown closure and lower branch mortality occurs. High stem density will promote correcting of tip weevil damage and ensure adequate numbers of crop trees in sawtimber at rotation. All stems need not be white pine.
- White pine is capable of producing veneer and grade lumber. Pruning is essential in the management of white pine for quality sawtimber products as white pine does not self-prune well. Pruning offers the benefits of increasing sawlog grade (substantially increasing value), reducing infection courts for blister rust, removing blister rust infected branches, and helping to confine the spread of red rot within the tree. A recent study (Pubanz, 1995) found that pruning pole sized white pine plantations could increase the number of crop trees by 33 percent by removing competing leaders resulting from terminal damage. These competing leaders often developed into forks and/or branches too large to heal over properly. Poorly formed or diseased trees, including those resulting from tip weevil damage, should be removed in intermediate thinnings consistent with recommended stocking levels.
- Open-grown white pine stands irreparably deformed by tip weevil should be treated as any other stand understocked with crop trees. Based on site quality, an evaluation should be made whether white pine is consistent with management objectives for the site. If so, regenerate the stand to white pine using natural or artificial regeneration methods described below. It is important to completely evaluate crop tree stocking prior to considering any stand a failure and harvesting it prior to its rotation age. Keep in mind that weeviled pine often will correct, if vigor and stocking are maintained. All stems do not need to be crop tree quality, as most stems will be removed in intermediate thinnings.
- Pine stands on most habitat types will eventually convert to hardwood species unless competition is controlled and regeneration requirements for white pine are met.
- White pine regenerates best on exposed mineral soil with minimum understory competition. Delay site preparation efforts in natural regeneration systems until after the stand has had an opportunity to respond to cutting, i.e. stump sprouts and seed banks flush. This will provide for better control of competition. Natural regeneration should be started at least 10 years prior to rotation of the stand. Maintaining overstory with the intent of reducing competition is ineffective as the shade tolerant competition develops more aggressively in low light conditions than does the white pine. Allowing established white pine seedlings adequate light appears to be the best way to allow them to gain dominance over competing hardwoods. The overstory should be reduced to no greater than twenty percent crown closure as soon as the pine seedlings are established and entering the period of rapid growth, usually in 3-5 years.
- Where white pine is a desirable associate in mixed stands, several scenarios may help encourage white pine composition. In stands which have existing pine reproduction, release will allow the pine to develop within the stand. Where advanced reproduction is

not present but a seed source exists, patch clearcutting near the seed source may result in the establishment of a pine component, especially if measures are taken to scarify the site or control competition through logging or other means. Timing such operations to a good pine seed year should increase their effectiveness. Foresters should watch for opportunities to take advantage of local situations to enhance the representation of white pine.

5 SILVICULTURAL SYSTEMS

5.1 Seedling / Sapling Stands

Maintain pine in an unsuppressed condition. Understory pine should be released at the earliest opportunity. Stand should be maintained at 700 stems per acre or greater until the canopy closes. Utilize stump sprouts and root suckers of other tree species to augment pine stocking. If desired, conduct crown release on 150 crop trees per acre at about age 15 by cutting all trees touching or overtopping crop tree crowns.

5.2 Intermediate Treatments

5.2.1 Thinning

Stands are overstocked when stocking exceeds "A" level on the stocking guides or it is determined that radial growth is slowing down. Overstocked stands should be thinned from below to not less than "B" level stocking on the stocking guides in trees making up the overstory canopy. Thinnings should be conducted at roughly seven- to ten-year intervals and never remove more than fifty percent of the stand stocking.

White pine appears to exhibit a higher degree of genetic diversity in relation to growth characteristics than red pine. Selection thinnings will allow the forester to retain the best stems in the stand consistent with recommended stocking levels. Row thinning should be restricted to providing access to the stand for equipment. Where mechanical thinning may yield questionable results, a small sample area can be marked using mechanical thinning criteria and the residual basal area checked to predetermine the resulting residual density level. Field studies conducted at the Wild Rose Demonstration Forest indicate that white pine development was best in stands thinned every other row at age 20 with a subsequent selection thinning done in a timely manner and stocking reduced to prescribed levels using the stocking guides. This study also indicates that stands in which initial thinnings are delayed should be thinned every third row initially to prevent substantial potential loss to snowload and/or windthrow.

5.3 Natural Regeneration Methods

5.3.1 Even-Age Regeneration Methods

Even-age management will be applied with periodic thinnings based on basal area control. Pruning is recommended. White pine can be naturally regenerated using the seed tree and/or shelterwood regeneration methods. The primary purpose of the seed tree/shelterwood overstory is to provide an abundant source of seed rather than modifying understory environmental conditions. Where natural regeneration is not feasible, artificial regeneration

may provide an alternative. Site preparation and competition control are important considerations for regeneration and establishment.

5.5 Rotation Lengths and Cutting Cycles

Ideally, the rotation length range would be defined by the maximization of mean annual increment (MAI) at the lower end and the average stand life expectancy at the upper end. But very little objective data exists identifying these endpoints in general, and even less by site type. The numbers provided are based on general data, empirical evidence, and the best estimations of the authors. Within each habitat type group, a range of conditions do exist, therefore the lower end should represent maximum MAI on the poorer sites and the upper end should represent the average stand life expectancy on the better sites. Individual trees and stands may live longer or decline earlier than these rotation length guidelines indicate. In application, foresters will need to regularly review stands in the field and exercise professional judgment concerning growth and mortality.

Table 31.3. Rotation length recommendations for cover type.

HABITAT TYPE GROUP	ROTATION LENGTH (YRS)
N. Very Dry to Dry	80-160
N. Dry to Dry-mesic	110-180
N. Dry-mesic	120-180
N. Mesic	140-200
N. Mesic to Wet-mesic	120-180
N. Wet-mesic to Wet	
S. Dry	80-160
S. Dry-mesic	110-180
S. Dry-mesic to Mesic	140-200
S. Dry-mesic to Mesic (Phase)	140-200
S. Mesic	140-200
S. Mesic (Phase)	140-200
S. Mesic to Wet-mesic	120-180
S. Wet-mesic to Wet	

8 APPENDICES

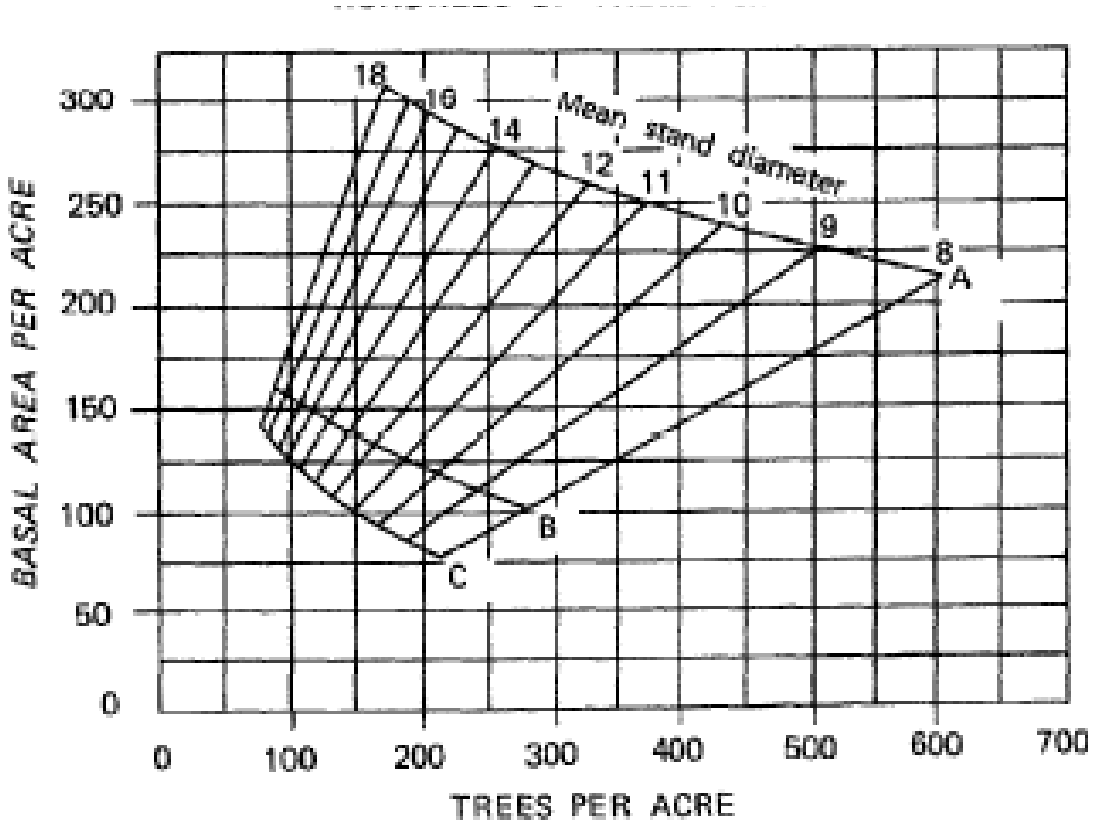


Figure 31.1a. Stocking chart for white pine, average diameter 8-18 inches (Philbrook et al. 1973, Lancaster and Leak 1978).

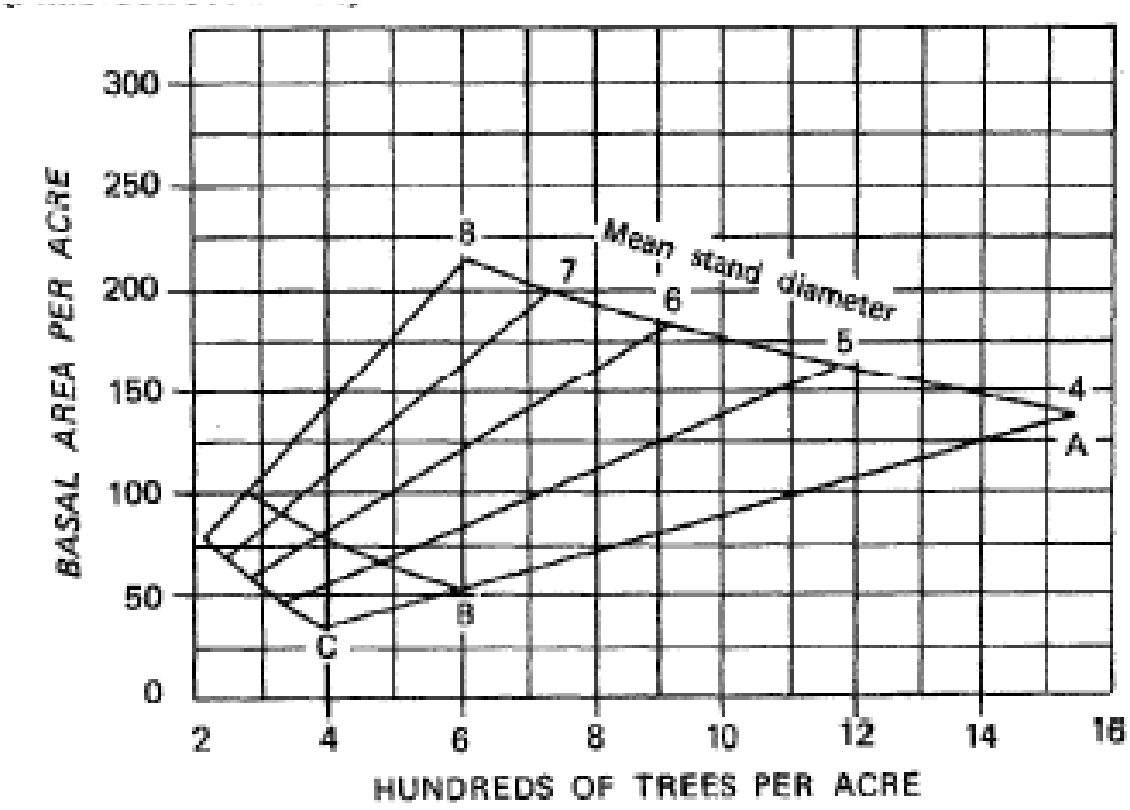


Figure 31.2b. Stocking chart for white pine, average diameter 4-8 inches (Philbrook et al. 1973, Lancaster and Leak 1978).

Stocking chart for white pine, displaying the relationship between basal area, number of trees, and mean stand diameter. The area between the A-line and B-line indicates the range of stocking where trees can fully occupy and utilize the site (fully stocked stand). The C-line shows the limit of stocking necessary to reach the B-line level in 10 years on average sites.

The stocking chart provides a statistical approach to guide stand density management (see Chapter 23).

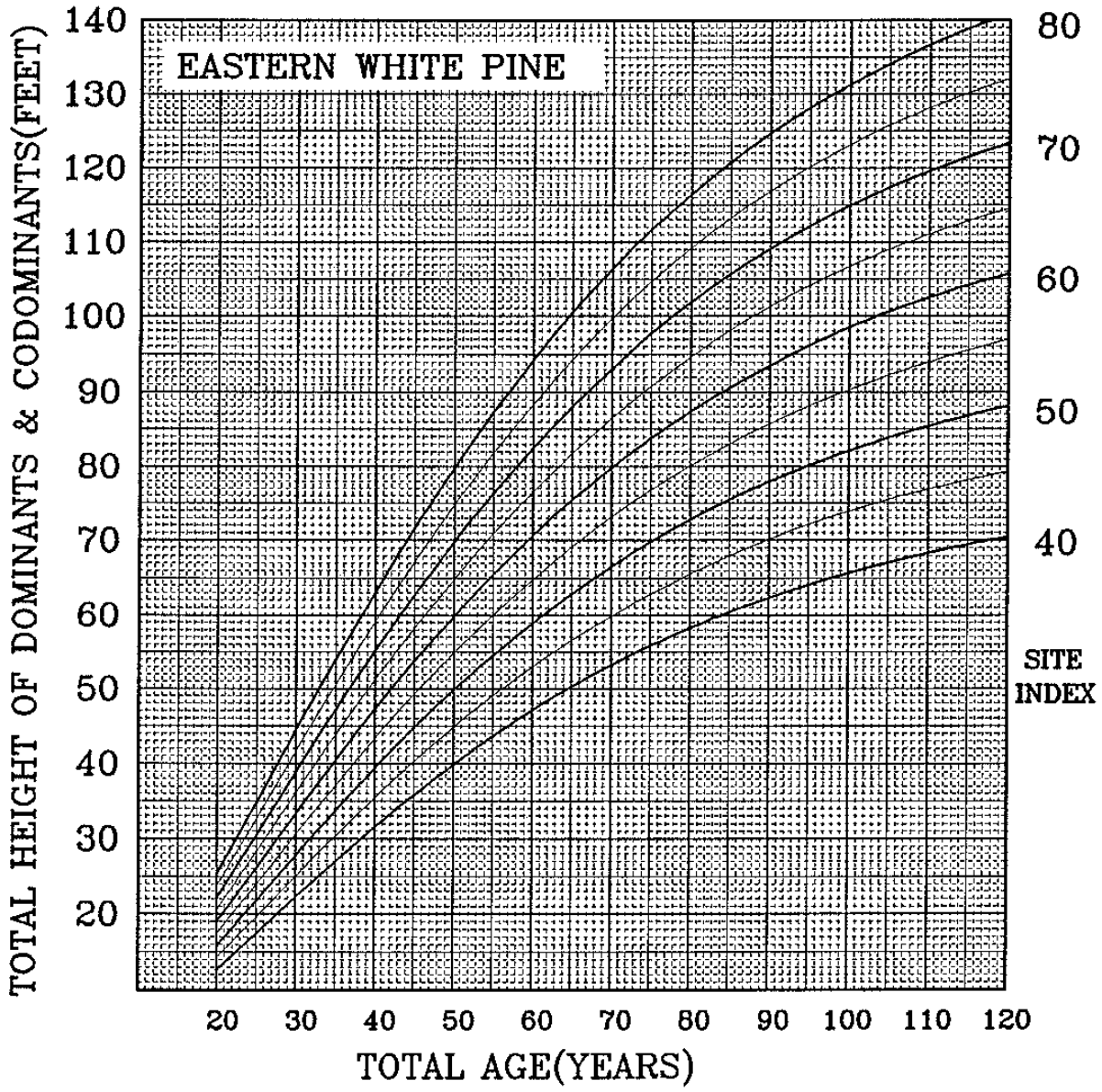
- To utilize the stocking guide, statistically accurate estimates of at least two stand variables must be obtained, including basal area per acre, number of trees per acre, and/or mean stand diameter. For the white pine stocking guide, these variables are measured only for canopy trees.
- The area between 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.
- 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. For white pine, it is

suggested that 80% of A-line stocking is actually the upper limit for practical management.

- 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 >50% of the basal area in any one thinning operation.



-Eastern white pine (Gevorkiantz 1957f, derived from Gevorkiantz and Zon 1930)
Northern Wisconsin
92 plots, number of dominant and codominant trees not given
Total height and total age, anamorphic, equation not given
Convert d.b.h. age to total age by adding years according to site index (BH = 0.0):

SI:	40	50	60	70	80
Years:	12	12	10	8	6

	b_1	b_2	b_3	b_4	b_5	R^2	SE	Maximum difference
H	1.9660	1.0000	-0.0240	1.8942	0.0000	0.99	0.66	1.7
SI	0.5086	1.0000	-0.0240	-1.8942	0.0000	0.99	0.66	1.7

Figure 31.3. Site index curves for white pine in northern Wisconsin (Carmean et al., 1989).

8.1 Forest Health Guidelines - Forest Health Protection (FHP)

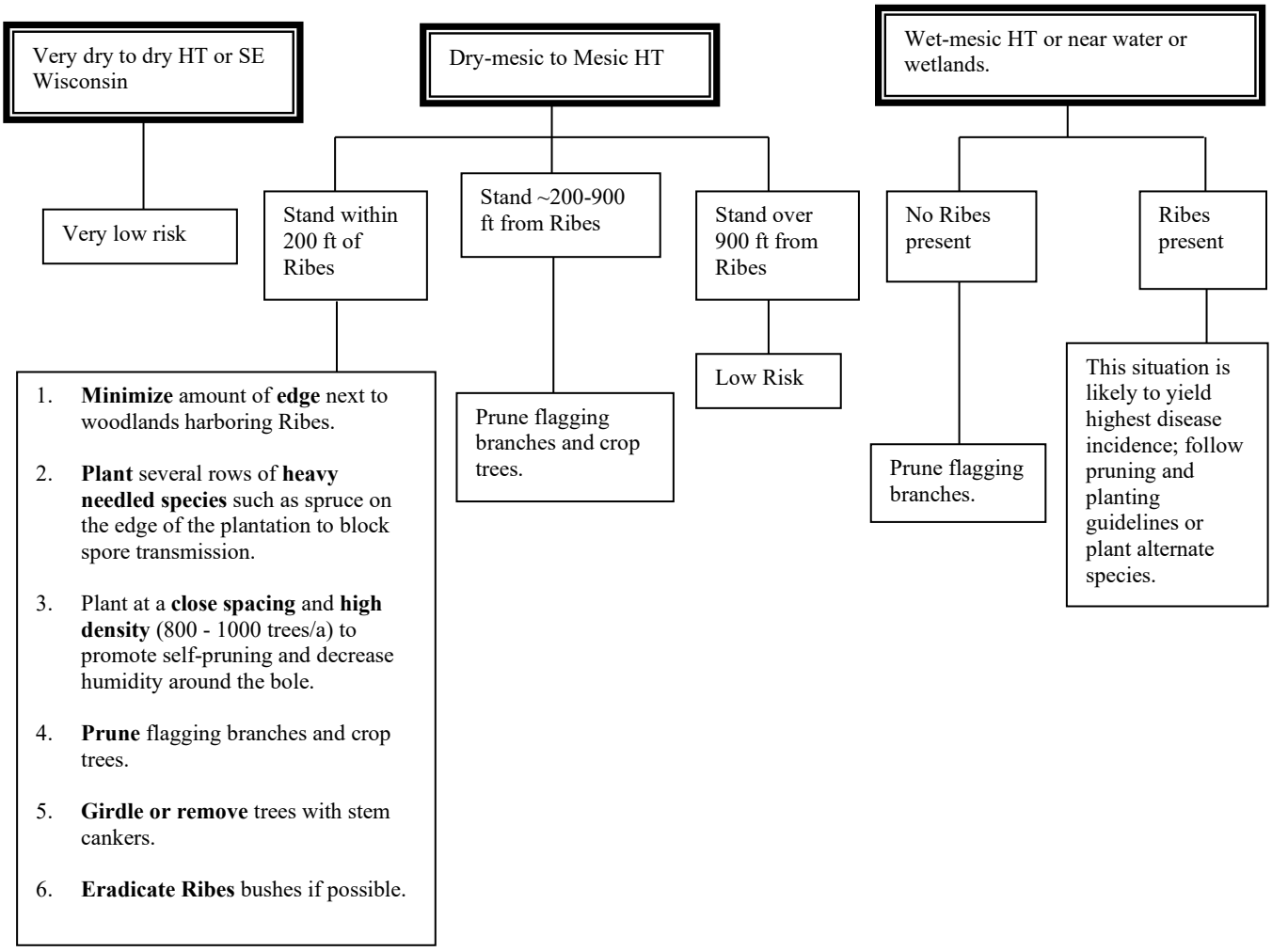
PEST MANAGEMENT GUIDELINES FOR WHITE PINE - WI DNR FOREST HEALTH PROTECTION

Disturbance Agent and Expected Mortality or Damage	Options for Minimizing Mortality or Preventing Disease	References
White Pine Blister Rust – *Cronartium ribicola* 1. Infected seedlings usually die. 2. Infected saplings and poles may have one or several cankers on branches and the main stem, within 10-15 feet of the ground. Branch cankers cause branch mortality. Stem cankers cause treetop or whole tree mortality. 3. Sawlog-sized trees will occasionally be infected. Branch and stem cankers will be located high in the crown. Cankers will cause branch and treetop mortality. 4. Disease incidence and tree mortality are highest in areas where 100% relative humidity and a temperature of <68°F is maintained for a minimum of 48 hours in late summer and fall. 5. Several factors influence disease incidence. Localized areas of high disease incidence (>25% of trees infected) can be observed in areas generally considered to be at low risk, and low disease incidence (<5%) can also be common in high risk areas. Thus, generalized statements regarding high and low risk zones within the state are not useful for local management decisions. Each site should be evaluated based on several factors (see management options). 6. Recent surveys (1998–'01) have shown proximity to the alternate host, *Ribes* spp., is still an important factor to consider, yet long range transport of the spore that infects white pine complicates Ribes eradication recommendations.	**Expect highest disease incidence on sites with both:** **1. Ribes spp. on or in close proximity to the site, and** **2. Site conditions that enhance lasting dew formation during cool windless nights:** • kettle holes or depressions, • sites with a northerly aspect, • small openings (diameter less than the height of surrounding trees), particularly at the bases of slopes and in low areas, • ridge tops or shoulders in close proximity to any body of water or close proximity to any lowlands, • on the Bayfield Peninsula, sites on aspects which face Lake Superior. **Management Options - Also see flow chart** **1. Established understory white pine regeneration.** • Recent (1998-'01) surveys have supported the known benefits of a hardwood overstory: interception of rust spores and prevention of dew formation on white pine needles. A 40-50% crown closure will reduce infection when trees are young. • To promote growth and vigor of white pine, no more than 20% overstory crown closure should be maintained. Substantial growth and vigor losses occur at higher crown densities. Stands which are well stocked (>700 trees/a) and free to grow (<20% crown closure) will exhibit higher vigor, faster growth, and earlier self-pruning of the lower branches. Losses due to blister rust normally are manageable. **Release pine from hardwood overstory at the earliest opportunity.** Prune all crop trees. **2. Established white pine plantations.** Selectively remove trees with stem cankers. Prune all crop trees. **3. New white pine plantations.** Habitat type and proximity to Ribes significantly influence disease incidence. **See flow chart for specific recommendations related to site. Also, follow these general guidelines:** • avoid planting in small openings (diameter less than the height of surrounding trees), • plant seedlings at a high density (800 - 1000 trees/a), • follow the pruning guidelines when trees reach 5-7 years of age, • keep grass cut when the trees are young (to reduce the humidity in the lower crown). **4. Pruning Guidelines.** Begin pruning lower branches when trees are approximately 5-years-old. Pruned branches can be left on site. Attempt to maintain 2/3 of the tree's height in live branches. At no time should branches be pruned from more than ½ the height of the tree. Continue pruning until a minimum of 9' of the main stem is clear of branches. Pruning to 17' is ideal. Aim to	1. How To Manage Eastern White Pine to Minimize Damage from Blister Rust and White Pine Weevil. S. Katovich et. al. 1993. USDA Forest Service. NA-FR-01-93. 2. How To Identify White Pine blister rust and Remove Cankers. T. Nicholls et al. 1977. USDA Forest Service NC For. Exp. Sta. Paper. 3. Incidence of White Pine Blister Rust in a High-Hazard Region of Wisconsin. S. Dahir et al. 2001. No. JAF, 18:3 pp 81-86.

	prune 100-200 trees per acre in natural stands and 350 per acre in pure white pine plantations.	

Recommendations for White Pine Blister Rust Management based on Habitat Type (HT)

WI DNR Forest Health Protection



Disturbance Agent and Expected Mortality or Damage	Options for Minimizing Mortality or Preventing Disease	References
Ozone and Sulfur Dioxide as Air Pollutants Individual trees that are genetically susceptible will show chlorosis and necrosis of the tips of current year's needles in July and August. Highly susceptible trees will be stunted and chlorotic. These trees are referred to as chlorotic dwarfs. Susceptible trees are usually scattered throughout plantations or natural stands. Mortality is rare.	Highly susceptible trees will not "grow out" of symptoms and are likely to always be stunted. Stunted trees can be removed yet this is not necessary.	Wisconsin Woodlands: Identifying and Managing Pine Pests in Wisconsin. H. Goulding et al. 1988. U. of WI Ext. G3428. Regional Effects of Sulfur Dioxide and Ozone on Eastern White Pine in Eastern WI. C. Rezabek et al. 1989. Plant Disease Vo. 73. No. 1
White Pine Root Decline – *Verticicladiella procera* Causes a resinous, girdling canker at the root collar and on the main roots. Infected trees turn yellow and die. All ages may be affected. In Wisconsin, this pathogen appears to be most active on white pine stressed by standing water in heavy, clay soils.	Do not plant white pine on heavy clayey sites where drainage is impeded and water stands for more than 24 hours following a rain.	How To Identify and Control White Pine Root Decline. R. Anderson et al. 1979. USDA Forest Service SA-FR/P6
White Pine Root Disease – *Armillaria spp.* The fungus, Armillaria, decays dead and dying hardwood or conifer roots and stumps. It can also infect seemingly healthy white pine roots and root collars. It can cause decline and mortality of trees of all sizes. It is often found in association with other disturbance agents such as bark beetles and poor soil drainage. It can also be a problem on very droughty sites. New plantings of white pine on sites that harbor stumps and roots of hardwoods or conifers are likely to suffer some mortality of seedlings (10-30% mortality over 15 years has been observed.)	Expect some losses if planting on sites where hardwood and/or coniferous stumps and roots are decaying. Delay planting until 5-7 years after cutting a stand. This will avoid the peak productive time for Armillaria.	Armillaria Root Disease. C. Shaw III et al. 1991. USDA Forest Service Ag. Handbook No. 691.
Annosum Root Rot – *Heterobasidion annosum* Annosum root rot is a very important disease of conifers, only recently observed in Wisconsin. This fungus decays the roots of white pine and moves both overland, through basidiospores and underground through root contact. Overland infection usually occurs through freshly cut stumps. *H. annosum* causes mortality of infected trees. Its underground movement generally produces an ever-widening circle of dead trees.	As of 10/1/01, *H. annosum* had been observed in red pine plantations in Adams, Iowa, Richland and Sauk counties. Scattered white pines within the Iowa County stand have been killed by *H. annosum*. This disease is likely to be present in other areas of the state, yet surveys have not located additional infection centers. 1. To be highly cautious, treat stumps of white and red pine during thinnings with a registered product such as SPORAX. Cut stumps must be treated within 24 hours of felling. SPORAX creates an unfavorable environment for colonization of stumps by *H. annosum*. 2. If *H. annosum* is already established in a stand, consider converting or regenerating to less susceptible species such as hardwoods.	1. Protect Pine Forest Productivity by Preventing Annosum Root Rot. G. Stanosz. 1997. Dept. of Plant Pathology, UW – Madison. 2. Annosus Root Rot in Eastern Conifers. K. Robbins. 1984. USDA Forest Service I&D Leaflet 76.

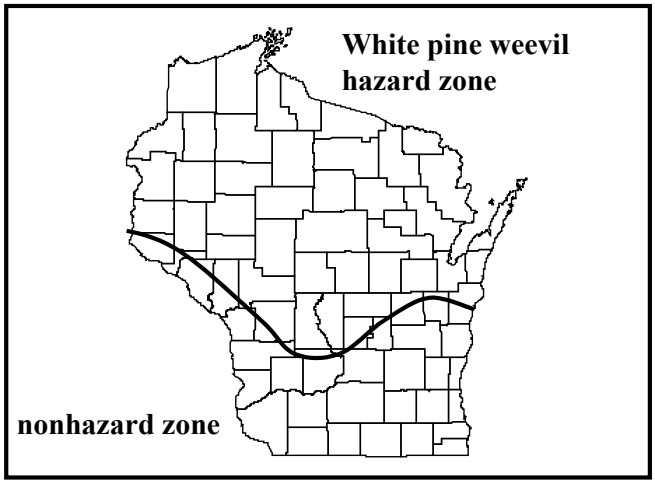
PEST MANAGEMENT GUIDELINES FOR WHITE PINE – WISCONSIN DNR FOREST HEALTH PROTECTION

HAZARD	LOSS OR DAMAGE	PREVENTION, MINIMIZING LOSSES, AND CONTROL ALTERNATIVES- The following alternatives assume that the management objective is optimum quantity and quality of sawlogs.	REFERENCES
White Pine Weevil	Destruction of current year and previous year's terminal growth allows lateral branch to assume terminal dominance resulting in deformity of main stem of sapling to pole-sized trees. IN HAZARD ZONE : (see map) Five to 30 percent of open growing white pines are likely to be attacked annually.	In existing infestations, local population and damage can be reduced by removing and destroying infested terminals before new adults emerge in mid July. IN HAZARD ZONE : (see map) In plantations and open grown seedling/sapling stands: In open areas, plant 900 - 1,000 trees per acre in mixed or pure plantations and maintain at least 700 trees per acre until canopy closes. Alternatives: Accept stem deformity and remove damaged stems during thinning. Accept stem deformity up to limit (until 200-300 acceptable crop trees per acre remain) and apply corrective pruning or insecticidal application to prevent attack by adult beetles. If less than 150 acceptable crop trees per acre remain, consider different objective. In Understory Situations:	White Pine Weevil. A. Hamid, et al. 1995. USDA Forest Service, Forest Insect & Disease Leaflet 21. How to Manage Eastern White Pine to Minimize Damage from Blister Rust and White Pine Weevil. 1993. S. Katovich, et al. USDA-Forest Service, NA-FR-01-93. Wisconsin Woodlands: Identifying and Managing Pine Pests in Wisconsin. H. Goulding, et al. 1988. Univ. Wis. Ext. G3428. The White Pine Weevil and Eastern White Pine in Wisconsin. 1995. D.M. Pubanz. Menominee Tribal Enterprises Research Report. Evaluating and Scheduling White Pine Weevil Control in the Northeast. R. Marty. 1964. USDA Forest Service, NEFES Res. Pap. 19. Effects of the White Pine Weevil in Well-Stocked Eastern White Pine Stands in Wisconsin. 1999. Pubanz, D. M., R. L. Williams, D. L. Congas,

	OUTSIDE HAZARD ZONE Little or no white pine weevil problem. Annual attacks not expected to exceed 5% of terminals in open growing white pine stands.	Reduce hardwood overstory to no more than 20 percent crown cover. OUTSIDE HAZARD ZONE No prevention or control required.	and M. Pecore. Northern Journal of Applied Forestry 16(4), pp185-190.
Spongy Moth (formerly known as gypsy moth)	Defoliation of reproduction under oak, aspen or birch overstory during outbreaks may cause up to 10% mortality. If defoliation occurs during drought, mortality could be greater. Solid stands of white pine are defoliated only along the edges.	Alternatives: If reproduction is sufficient, accept loss of up to 10%. If 10% loss of reproduction is not acceptable, remove overstory.	Gypsy Moth Silvicultural Guidelines for Wisconsin. C. Brooks and D. Hall. 1997. WDNR PUB-FR-123 97. Silvicultural Guidelines for Forest Stands Threatened by the Gypsy Moth. K. W. Gottschalk. 1993. U. S. Forest Service Gen. Tech Rep. NE-171. Gypsy moth: forest Influence. R. W. Campbell. 1979. USDA-Forest Service. Ag. Info. Bull. No. 423. Wisconsin Woodlands: Identifying and Managing Pine Pests in Wisconsin. H. Goulding, et al. 1988. Univ. Wis. Ext. G3428
Introduced Pine Sawfly	Summer defoliation, growth loss and mortality of sapling-sawlog trees usually in open grown situations.	Promote early crown closure; accept some growth loss and/or tree mortality or spray with insecticide.	Wisconsin Woodlands: Identifying and Managing Pine Pests in Wisconsin. H. Goulding, et al. 1988. Univ. Wis. Ext. G3428
White Pine Sawfly	Summer defoliation, growth loss and mortality of saplings in southern 1/3 of state.	Promote early crown closure; accept some growth loss and/or tree mortality or spray with insecticide.	Wisconsin Woodlands: Identifying and Managing Pine Pests in Wisconsin. H. Goulding, et al. 1988. Univ. Wis. Ext. G3428
Pine Spittlebug	Sapsucking may cause flagging and mortality of saplings. Seldom serious.	Direct control seldom necessary. Apply insecticide, if necessary.	A Guide to Insect Injury of Conifers in the Lake States. L.F. Wilson. 1976.

			USDA Forest Service, Agr. Handbook 501.
White Pine Aphid	Sapsucking and sooty mold may cause flagging and mortality of saplings in localized pockets during extended dry weather. Local ant populations may protect aphids from natural enemies and lead to further aphid population increase.	Direct control is seldom necessary. If high populations occur, direct insecticide application on aphid and ant mounds may be necessary.	A Guide to Insect Injury of Conifers in the Lake States. L.F. Wilson. 1976. USDA Forest Service, Agr. Handbook 501.
Mound Ants	Ants cause fatal canker at base of saplings that shade mounds. Ants protect white pine aphids from natural enemies but also protect trees by eating many sawfly larvae.	ALTERNATIVES: Accept loss of a few saplings. If numbers of mounds become excessive, treat some or all mounds with insecticide.	A Guide to Insect Injury of Conifers in the Lake States. L.F. Wilson. 1976. USDA Forest Service, Agr. Handbook 501.
Pales weevil	Populations build up in fresh cut conifer stumps. Adult weevils emerge in late summer. Bark feeding by adults causes twig and seedling mortality.	Avoid planting in areas with fresh pine stumps or treat seedlings with insecticide.	Wisconsin Woodlands: Identifying and Managing Pine Pests in Wisconsin. H. Goulding, et al. 1988. Univ. Wis. Ext. G3428
Pine Engraver Beetle (bark beetles)	Tunneling in inner bark of weakened trees may cause mortality in pole and sawlog sized trees. Seldom serious, in white pine.	Treatment seldom necessary.	Wisconsin Woodlands: Identifying and Managing Pine Pests in Wisconsin. H. Goulding, et al. 1988. Univ. Wis. Ext. G3428
White tail deer	Browsing kills and causes deformity of seedlings and saplings.	Alternatives: Deer population control by intensive hunting Remove heavily damaged stems during thinning Repellents (variable success) Bud caps Shelters Fencing	Deer. Scott Craven. 1983. IN: Prevention and Control of Wildlife Damage. Univ. Neb. Ext. Publ.

Meadow Vole (meadow mouse)	Gnawing on bark causes mortality of seedlings and saplings.	Control grass and heavy weed growth in plantations during first five years.	Meadow Mouse Control. Scott Craven. 1983. Univ. Wisc. Ext. Leaflet A2148.


White pine weevil
hazard zone
nonhazard zone

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