



Field Manual for Managing Eastern White Pine Health in New England

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INFORMATION ABOUT THIS GUIDE

This manual provides basic information for identifying and evaluating important health problems of eastern white pine in New England. The health problems include:

- White pine weevil
- White pine blister rust
- *Caliciopsis* canker
- White pine bast scale
- White pine needle damage
- Red rot or Red-ring rot

In addition to providing descriptions of symptoms, signs, and risk factors, recommendations for white pine silviculture are described for managing stands for low densities and crop trees.

How to use this manual:

To find out which health problem you have:

- Match the symptoms of tree damage with the pictures showing needle discoloration (page 2), stem cankers and resin (page 3), and damage (page 4)
- Look for and identify the signs of stress agents associated with the health problems (page 5)
- Then, read further details of each health problem (pages 7-10) to find if one or more of the health problems match what you have on the tree

To understand how to respond to the health problems:

- Identify the risk factors associated with the health problems (page 6)
- Read the options for reducing risks that can be implemented at various stages of stand management (pages 10-14)

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Figure 1. Needle Discoloration

<p>White Pine Weevil</p>	<p>White Pine Blister Rust</p>	<p>Pine Bast Scale/Calliclipsis Canker</p>	<p>White Pine Needle Damage</p>
 <p>A</p>	 <p>B</p>	 <p>C</p> <p>D</p>	 <p>E</p>
<p>Terminal shoot and first whorl curl and turn yellow-red</p>	<p>Orange-red flagging</p>	<p>Red flagging (C); thin foliage density due to poor health (D)</p>	<p>Yellowing of second-year needles throughout the tree in June and early July</p>

Figure 2. Stem Cankers and Resin





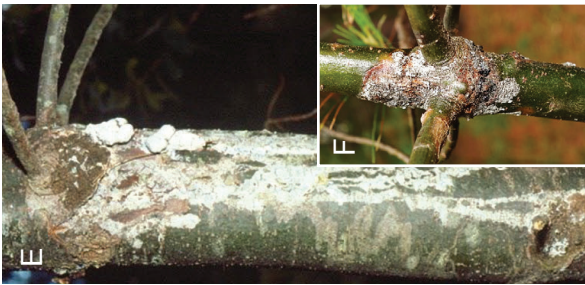


<p>White Pine Weevil</p>	 <p>A</p>	<p>Resin droplet and streaks on terminal shoots (A)</p>
<p>White Pine Blister Rust</p>	 <p>B</p>	<p>Resin on stem coming from a single, diffuse canker, typically associated with a whorl (B)</p>
<p>Calciopsis Canker</p>	 <p>C</p>  <p>D</p>	<p>Profuse pitching from small cankers between whorls on thin-barked portions of the tree (C); older, elongated cankers split the bark, with and without resin (D)</p>
<p>Pine Bast Scale</p>	 <p>E</p>  <p>F</p>	<p>Resin associated with bast scale and <i>Septobasidium pinicola</i> (E) and at a branch whorl with <i>Calciopsis</i> (F)</p>
<p>Red Rot</p>	 <p>G</p>	<p>Resin associated with branch stub (G)</p>

Figure 3. Damage

<p>White Pine Weevil</p>	<p>White Pine Blister Rust</p>	<p>Pine Bast Scale/ Calciopsis Canker</p>	<p>White Pine Needle Damage</p>	<p>Red Rot Damage</p>
 <p>A B</p>	 <p>C D</p>	 <p>E F G</p>	 <p>H</p>	 <p>I J</p>
<p>Multiple stems (A); “Cabbage pine” (B)</p>	<p>Mortality of seedlings/saplings (C); top-kill on mature tree (D)</p>	<p>Embedded canker (E and F); lumber degradation (G)</p>	<p>Reduced growth, as seen in increment cores (H)</p>	<p>Red discoloration and wood decay in stem cross section (I) and in lumber (J)</p>

Figure 4. Signs





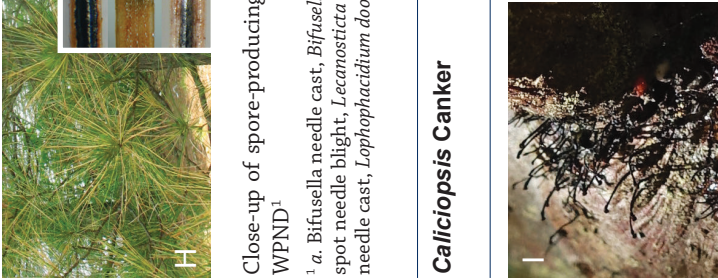
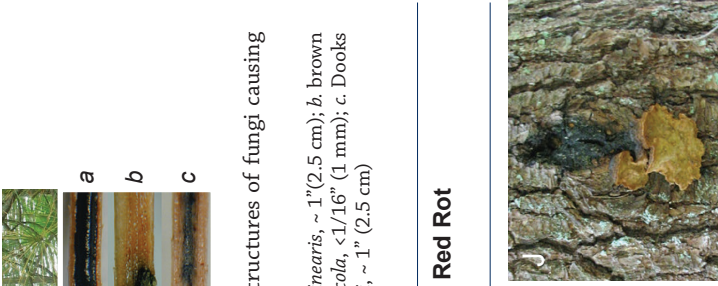
<p>White Pine Weevil</p>	 <p>Weevil larvae feeding on phloem in terminal shoots, early summer (A); pupal chambers (B); adult (C)</p>	<p>White Pine Blister Rust</p>	 <p>Uridia on <i>Ribes</i> in summer (D); aerial blisters on pine stem in spring (E)</p>	<p>Pine Bast Scale</p>	 <p>Adult scale insects feeding at branch whorl (F); overwintering cyst stage, 1/8" (4 mm), black, with white fringe (G)</p>	<p>White Pine Needle Damage</p>	 <p>Close-up of spore-producing structures of fungi causing WPND¹ ¹ a. <i>Bifusella</i> needle cast, <i>Bifusella linearis</i>, ~ 1" (2.5 cm); b. brown spot needle blight, <i>Lecanosticta acicola</i>, < 1/16" (1 mm); c. Dooks needle cast, <i>Lophophacidiium dooksi</i>, ~ 1" (2.5 cm)</p>
	<p>Caliciopsis Canker</p>		 <p>Perithecia 1/16" (2 mm) that look like eye lashes</p>		<p>Red Rot</p>	 <p>Yellow-brown conks grow out of branch stubs</p>	

Figure 5. Factors Increasing Risk of Damage

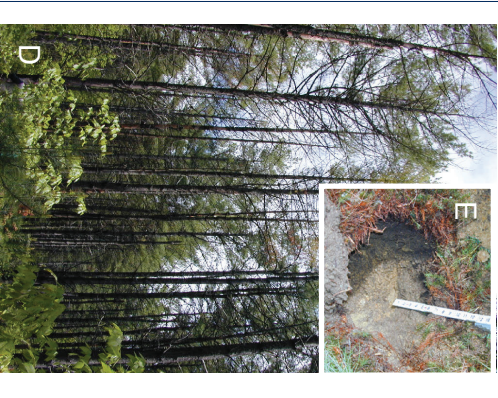
<p>White Pine Weevil/Red Rot</p>	<p>White Pine Blister Rust</p>	<p>Calliclipsis Canker/Pine Bast Scale/Red Rot/White Pine Needle Damage</p>	<p>White Pine Needle Damage</p>																
			 <table border="1"> <caption>June Precipitation in Augusta, ME (Inches)</caption> <thead> <tr> <th>Year</th> <th>Precipitation (Inches)</th> </tr> </thead> <tbody> <tr> <td>2006</td> <td>8.2</td> </tr> <tr> <td>2008</td> <td>2.5</td> </tr> <tr> <td>2010</td> <td>6.5</td> </tr> <tr> <td>2012</td> <td>3.8</td> </tr> <tr> <td>2014</td> <td>8.1</td> </tr> <tr> <td>2016</td> <td>5.2</td> </tr> <tr> <td>2018</td> <td>3.5</td> </tr> </tbody> </table>	Year	Precipitation (Inches)	2006	8.2	2008	2.5	2010	6.5	2012	3.8	2014	8.1	2016	5.2	2018	3.5
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<ul style="list-style-type: none"> • Pine growing in full sunlight (A) - Thick phloem and warm bark favor larval development and survival - Repeated killing of terminal buds results in “cabbage pine” - Dead terminals or “spikes” allow red-rot fungus to enter 	<ul style="list-style-type: none"> • Presence of the alternate hosts, <i>Ribes</i> (B) • Conditions favoring high humidity in late summer (which favor infection by basidiospores): - Dew exposure in open-grown seedlings (C) - Self-shading of lower branches 	<ul style="list-style-type: none"> • Pole-size pine growing under stress increases risk of damage due to: <ul style="list-style-type: none"> - Competition in dense stands (D) - Excessively drained soils - Soils with rooting barriers such as plow pan, texture change (E), water table, bedrock 	<ul style="list-style-type: none"> • Stand age (older stands are more susceptible) • Extended wet periods during spring and early summer, e.g., 5 inches or more of rain in June (F), when spores are produced 																

Figure drawn by W.H. Livingston (University of Maine) based on National Weather Service data.

DESCRIPTIONS AND LIFE CYCLES

White Pine Weevil

Pest & Hosts: The white pine weevil (*Pissodes strobi*) feeds on white pine as well as Norway spruce (*Picea abies*) and up to 20 other conifer species.

Life Cycle: After overwintering in the duff below white pine, the weevil emerges in the spring to feed on white pine leaders below the terminal bud cluster. Beginning in late spring as new growth emerges, adult females lay about 100 eggs below the terminal bud cluster. Larvae emerge one to two weeks later, are white, legless, have brown head capsules, and grow to almost 1/2" (1 cm) in length (Fig. 4A). As larvae feed on phloem, the stem is girdled, and the emerging pine growth dies, curls, and turns yellow-red, forming the diagnostic "shepherd's crook" (Fig. 1A). Larvae will excavate pupal cells towards the center pith of the leader, and the 1/4 to 1/3" (1 cm)-long cells are filled with wood chips. Pupation lasts 5 to 6 weeks (Fig. 4B). Beginning in late July, adults (Fig. 4C) emerge from white pine terminal shoots to continue the cycle, feeding on live twig tissue and resulting in resin on the terminal leaders (Fig. 2A).

Damage: After the leader is killed, lateral branches below the leader grow upwards. Many times, multiple leaders compete to become the new leader, resulting in forked or multi-stemmed trees (Fig. 3A). Repeated attacks of the weevil will result in "cabbage pine" (Fig. 3B).

Factors increasing risk of damage: Pine growing in full sunlight are predisposed to weevil damage because thick phloem and warm bark favor larval development and survival (Fig. 5A).

White Pine Blister Rust

Pathogen & Hosts: The causal agent of white pine blister rust (WPBR) is an introduced fungus, *Cronartium ribicola*. The pathogen has a complicated life cycle alternating between currants or gooseberries (*Ribes*) and five-needle pines.

Life Cycle: In the spring, the pathogen produces aecia (blisters) on pine bark (Fig. 4E) releasing aeciospores that infect *Ribes* and produce a leaf spot. Uredia develop on the underside of infected *Ribes* foliage and release another spore type, urediniospores, from June through September, locally infecting other *Ribes* (Fig. 4D) and intensifying disease spread. Before leaf-drop, telia and basidia are produced on *Ribes* foliage releasing another spore type, basidiospores, to infect pine needles. The fungus grows within the needle to the branch and stem tissue, stimulating excessive resin flow during the next few years.

Damage: Infection on pines causes stem cankers (Fig. 2B) which can girdle stems leading to death of branches, seedlings/saplings (Fig. 3C) and top-kill (Fig. 3D).

Factors increasing risk of damage: Presence of the alternate hosts, *Ribes* (Fig. 5B). Also, conditions favoring high humidity in late summer, which favor infection of pine needles by basidiospores (Fig. 5C).

Caliciopsis Canker

Pathogen & Hosts: *Caliciopsis pinea* found on eastern and western white pine, and at least some firs.

Life Cycle: *Caliciopsis pinea* is a perennial fungus producing 1/16" (1-3 mm) ascocarps throughout the spring and summer (Fig. 4I). Ascospores are then rain-splash disseminated or dispersed by insects and small mammals. New infections may start where white pine bast scale insects (next section) are feeding, bark lenticels are open, or where other minute areas of bark separation occur. Cankers are usually limited to 1" (2.5 cm) or less in width (Fig. 3E-F), and the tree response to infection is to produce resin (Fig. 2C). Older cankers can cause a bark "seam" (Fig. 2D).

Damage: As many as 70% of trees in a stand are infected, but mortality is low. However, increased crown transparency and reduced crown density on infected trees suggests tree vigor is reduced (Fig. 1D bottom). Cankers on healthy trees are overwhelmed by tree resin (Fig. 2C) associated with embedded necrotic spots or pitch pockets along annual rings (Fig. 3F). Lumber sawn from infected portions of the tree show embedded cankers and pitch pockets that reduce lumber grade and value (Fig. 3G).

Factors increasing risk of damage: Fungal infections increase on pole-size pine growing under stress due to tree competition in dense stands (Fig. 5D), excessively drained soils, and soils with rooting barriers near the surface such as plow pan, texture change (Fig. 5E), water table, and bedrock.

White Pine Bast Scale

Pest & Hosts: The pine bast scale *Matsucoccus macrocitrices* feeds exclusively on eastern white pine.

Life Cycle: *Matsucoccus macrocitrices* has a two-year life cycle in the north, and one year in the south. Adult females are 1/8" (3.6-4.0 mm) and wingless. Adults emerge from the overwintering cyst stage (Fig. 4G) in late spring to lay eggs in bark crevices, cankers, and under lichens. Eggs hatch into 1/16" (0.6-1.5 mm) yellow-brown crawlers which nestle into *Septobasidium pinicola* fungal mats or lichen to feed for two years (in the north) in a legless juvenile stage before maturing. Adult males are winged but do not fly and emerge from waxy cocoons made by the prepupa. *Matsucoccus macrocitrices* is easiest to see with the naked eye in the spring just before they emerge from the cyst stage. It is often found occurring mutualistically with the fungus *S. pinicola* (Fig. 2E) and is believed to be associated with *Caliciopsis* cankers (Fig. 2F).

Damage: Scale feeding and subsequent infection by pathogenic fungi, such as *C. pinea*, can result in branch flagging (Fig. 1C) and mortality of saplings. On pole-size trees, the insect is thought to facilitate infection and damage associated with *Caliciopsis* cankers

Factors increasing risk of damage: Similar to those listed for *Caliciopsis* canker.

White Pine Needle Damage

Pathogen & Hosts: Three main pathogens may be encountered in the Northeast causing early summer yellowing and premature defoliation in eastern white pine stands: Brown spot needle blight (*Lecanosticta acicola*), *Bifusella* needle cast (*Bifusella linearis*), and Dooks needle blight (*Lophophacidium dooksii*). In addition, the role of *Septoriodes strobi* has yet to be firmly established.

Life Cycle: These pathogens begin sporulating during wet periods in spring on residual needles infected in the previous year. Spore dispersal continues into the summer infecting current-year needles during elongation. Initial infections do not change the color of new growth, but pathogen-specific symptoms appear later in summer including yellowish spots or bands on needles; dark, water-soaked bands and spots possibly surrounded by a yellow halo and/or associated with resin droplets; or brown needle tips. Reproductive structures may form on needles (Fig. 4H insert) by late summer with some already producing spores in early spring (*Bifusella*, Dooks needle cast). Most symptom development and spore dispersal occur during June of the following year, when the whole needle eventually turns yellow to reddish brown or straw-colored (Fig. 1E and Fig. 4H). Identification of pathogens affecting a stand is based on the shape and size of spore-producing structures on infected needles and spore characteristics. Several pathogens may co-occur in the same stand, and even the same tree.

Damage: High disease levels in consecutive years creates a chronic stress, reducing growth (Fig. 3H) and potentially predisposing trees to other insect and disease agents of tree-health decline.

Factors increasing risk of damage: These pathogens and their infection cycles are driven by extended wet periods during the optimal infection period in spring/early summer (Fig. 5F). Any stand characteristics supporting extended periods of high relative humidity may favor infection.

Red Rot

Pathogen & Hosts: Red-rot disease, also known as pencil rot and red-ring rot, is caused by the fungus *Porodaedalea pini* (formerly *Phellinus pini*), a common decay on conifers.

Life Cycle: The red-rot fungus may produce conks 1-3" (2-8 cm) or larger on live trees (Fig. 4J), and can fruit prolifically on dead trees, especially those that have fallen and are in contact with the soil. Windborne spores spread primarily in the spring and late fall. They infect wounds from logging or broken branches on large and small trees, as well as spikes from weeviled terminal leaders (Fig. 1A). Although trees can be infected when they are very young, decay progresses slowly. Hard sterile fungus masses may develop at branch stubs causing bark swellings or "punk knots," which keep stem wounds open and seeping resin (Fig. 2G), interrupt compartmentalization, and provide oxygen to the fungus. Following a long period of gradual spread and minimal decay, red rot may progress rapidly as trees age.

Damage: Red rot is generally non-lethal and develops slowly. An early symptom of incipient decay is pinkish to red staining (Fig. 3I-J). Decay first appears as a mottled white pocket rot, developing along growth rings into a red-ring rot (hence the name).

Advanced decay is light-colored and stringy until cavities develop. Red rot has been associated with 63% of trunk infections and 90% of volume loss in white pine. Although it can be a butt rotter, it is usually not a cause of windthrow or snap.

Factors increasing risk of damage: Extensive decay due to red rot is more likely (i) in trees growing slowly (Fig. 5D) because wounds close more slowly, and the rate of decay outpaces new growth; (ii) in co-dominant/dominant white pine affected by weevil spikes on young trees (Fig. 1A) because decay can develop over long periods of time; (iii) on bottomland sites where moist conditions promote fungal fruiting and infection; (iv) with long rotations due to longer times for decay to develop; and (v) when pruning large-diameter branches because the larger wound and closure time increases the likelihood of infections.

WHITE PINE SILVICULTURE

Low-Density/Crop-Tree Management

Reducing risks to white pine health can be achieved through silviculture, especially maintaining low densities in white pine stands, i.e., below the C line on the Leak and Lamson (1999) stocking guide (Fig. 7). Low density management, also known as crop-tree management, reduces competition and increases live-crown ratios which:

- Favors rapid production of high-value sawtimber trees
- Reduced health risks and increases resilience

Key considerations

White Pine Silvics

- Intermediate shade tolerance
- Abundant seed production every 3-5 years
- Best rooting in deep, sandy soils
- Strong competitor with grass
- Once established, exhibits excellent height and diameter growth. Annual volume growth remains high even in large (>24" (61 cm) DBH), mature trees

Site Selection

Select sites with deep, sandy, well-drained soils.

- What to avoid:
 - Locations with *Ribes* (Fig. 5B). If present, need to be killed using herbicides
 - High-quality sites that favor hardwood competition
 - Excessively drained soils, such as those that favor pitch pine
 - Soils with rooting restrictions such as plow pans, texture change (loamy cap over sand), high water tables, or bedrock (Fig. 5E)



Figure 6. Mature white pine

Regeneration Method – Extended Shelterwood

- Remove the overstory in two or more cuts
- May need herbicide treatment prior to or soon after first cut if hardwood competition is present, but treatments need to avoid exposing white pine foliage to herbicides
- First (establishment) cut
 - Conduct in a good seed year to favor white pine regeneration (Fig. 8)
 - Maintain 40-50% canopy closure
 - Keep best trees as seed source and for future timber value
 - Scarify to expose mineral soil and reduce competition
 - Favors a high density of white pine regeneration
- Second (partial overstory removal) cut
 - Conduct in year 10
 - Maintain 20-30% canopy closure (can remove overwood completely if dense white pine regeneration is present and crop trees are not an option)
 - Operate with snow cover to reduce logging damage to regeneration
- Third and final (overstory removal) cut
 - Conduct in year 15-20 or when white pine saplings are 10-20 ft. (3-6 m) tall
 - Remove overstory trees to maintain height growth of saplings
 - Can keep crop trees with live-crown ratios of 50% or greater and without indicators of red rot (Fig. 2G, 4J)
- Reduced health risks
 - White pine weevil: Partial shade reduces leader diameter and temperature of seedlings, resulting in lower infestation levels
 - White pine blister rust: Partial shade reduces incidence of dew, lessening the chance of basidiospore infection
 - Deep, well-drained sandy sites without rooting barriers reduce the incidence of hardwood competitors, *Ribes*, and future susceptibility to drought stress

Intermediate Treatments

- Can be used with extended shelterwood or in other young stands containing dominant white pine saplings

Precommercial thinning

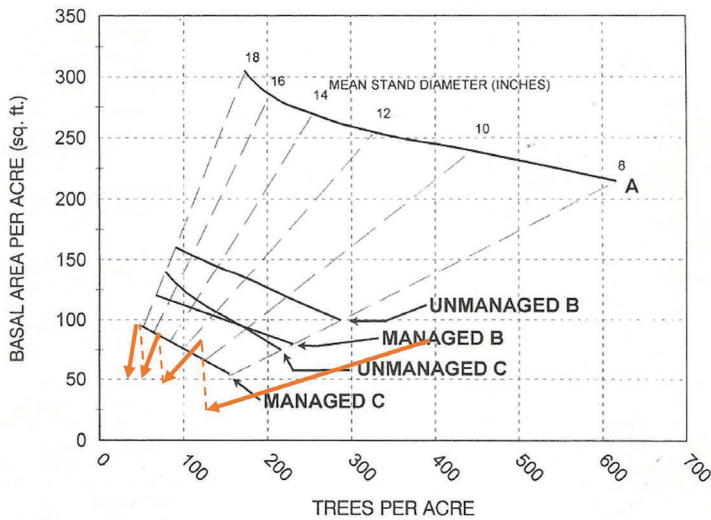
- Maintain high white pine densities until saplings are ≥ 1 log or about 20 ft (6 m) tall (Fig. 9)
- Thin to 200-300 trees/acre (490-740 trees/ha), or a spacing of about 12-15 ft (4-5 m)
 - Leave shade-tolerant saplings as “trainers” to favor white pine branch shedding
 - Remove white pine with weevil damage or white pine blister rust cankers
 - Trees with live-crown ratios $<25\%$ are unlikely to respond to release and should be removed
- Thinning should initiate improvement in live-crown ratios, increasing towards 40%
- Reduced health risks
 - High densities through sapling stage result in thin leaders and fewer weevil infestations
 - Stems that are damaged quickly straighten due to competition for light

- Rapid shedding of lower branches decreases the risk of blister-rust infection
- After trees are taller than 20 ft (6 m), precommercial thinning lowers densities and improves tree growth and vigor, reducing the risk of future health problems

Commercial thinning, pruning

- Do not start low-density commercial thinning if BA is > 150 ft²/acre (35 m²/ha) and height > 60 ft (18 m) due to risk of windthrow
- Better to start commercial thinning when:
 - White pine are 45-50 ft (12 -15 m) tall
 - DBH is 6-7" (15-18 cm) if precommercially thinned, 10" (25 cm) if not
- When thinning stands:
 - Prevent injuries; the benefit of frequent entries is lost if it results in a high incidence of wounding and subsequent decay
 - Practice sanitation by discriminating against trees in intermediate and suppressed crown positions, and defective trees with large branches, broken tops, wounds, weevil spikes, and stem resin (Fig. 2B-G), as well as punk knots and conks (Fig. 4J); trees with just *Caliciopsis* symptoms (Fig. 2C) have 30-50% less value
- Thin to 100-120 trees/acre (250-300 trees/ha), or a spacing of 20 ft (6 m) (Fig. 7 and 10)
 - Spacing to height ratio should be about 1:2
 - Thin below the C-line on the stocking guide (Fig. 7)
- Prune boles to a height of 25 ft (7.5 m) to prevent black knots in the first two logs
- Avoid pruning during moist conditions such as early spring and late fall to reduce risk of red-rot infection
- Treatments should increase live-crown ratio to 50% and higher
- Conduct second commercial thinning to 60-70 trees/acre (150-170 trees/ha) when tree heights are about 60 ft (18 m), DBH about 12-14" (30-36 cm) (Fig. 7)
- Conduct final commercial thinning to 30-40 trees/acre (75-100 trees/ha) when tree heights about 80 ft (24 m), DBH about 18-20" (45-50 cm) (Fig. 7)
 - Time final commercial thinning with good seed year to ensure white pine regeneration
 - Final commercial thinning corresponds with establishment cut of extended shelterwood
- Reduced health risks
 - Less competition for water and light reduces stress from droughts
 - Less stress reduces *Caliciopsis*, pine bast scale, and red-rot damage
 - Improved crown health increases tolerance of needle loss
 - More-open stand encourages faster drying of needle and stem surfaces and reduce the chances of fungal infection by *Caliciopsis* and needle fungi
 - Fewer defective trees
 - Faster growth and shorter rotations reduce the potential loss to decay

Figure 7. Stocking guide by Leak and Lamson (1999), adapted by R. Seymour (University of Maine) to show trajectory (orange line) of example white pine stand managed at a low density through precommercial and commercial thinning.



Extended Shelterwood with Crop Trees

- Final target for low-density white pine management (Fig. 11) is:
 - 30 trees/acre (75 trees/ha)
 - DBH 28-30" (71 -76 cm), or up to mill diameter limits such as 36" (91 cm) or larger
 - Tree heights about 100 ft (30 m)
- Overstory is removed over an extended period to reach final targets; white pine volume growth remains high on residual trees where wood quality and value are the highest
- Final cut is made when trees reach maximum size for mill



Figure 8. First cut of extended shelterwood system with 50% cover



Figure 9. Dense regeneration of saplings to maintain straight stems and promote natural branch shedding



Figure 10. Proper spacing of pole-size trees after thinning; pruning reduces black knots in lumber



Figure 11. Extended shelterwood with crop trees. Stand resulted from white pine grown in dense stands as saplings with shade-tolerant trainers to retain straight boles, followed by thinning. Final thinning promotes regeneration of next stand and retains crop trees as they increase in value

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PHOTO CREDITS

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