

species. The important growing conditions are directly related to the density of trees (or competitors) and their growth rates. Overstocked (crowded) stands have many trees with short, narrow crowns. Understocked, thinned stands, and stands where variable growth rates have produced good crown class differentiation have trees with longer, wider crowns. Crown size varies with crown class; dominant trees have wider, longer crowns than suppressed trees. The short, narrow crowns of trees in overstocked stands represent another kind of poor-to-fair vigor. When stands are thinned, the residual trees expand their crowns, both in terms of foliage density (usually within 1 to 2 years) and crown width and length. The increase in crown size takes longer, from 3 to 10 years depending upon the thinning intensity. During crown expansion, trees may be under more stress than their crown condition suggests since they are still adjusting to the new conditions in the thinned stand environment. The response is called thinning stress or shock. Crown size, not included in the

photographs, is a variable to be considered when evaluating tree vigor.

Applications

Risk and Hazard Rating

A number of studies have examined the relationship between the crown condition of oaks (and other species) and the percent probability of dying following first-time gypsy moth defoliation (Gansner and Herrick 1984, Herrick 1982, Herrick and Gansner 1987a,b, Campbell and Sloan 1977, Campbell and Valentine 1972). These studies spanned the New England seaboard and upland, the glaciated Allegheny Plateau and Ridge and Valley areas of the Pocono Mountains in eastern Pennsylvania, and the Ridge and Valley area of central Pennsylvania. Across this wide area, the same trend of crown condition versus mortality probabilities held: poor-crown trees > fair-crowned trees > good-crown trees:

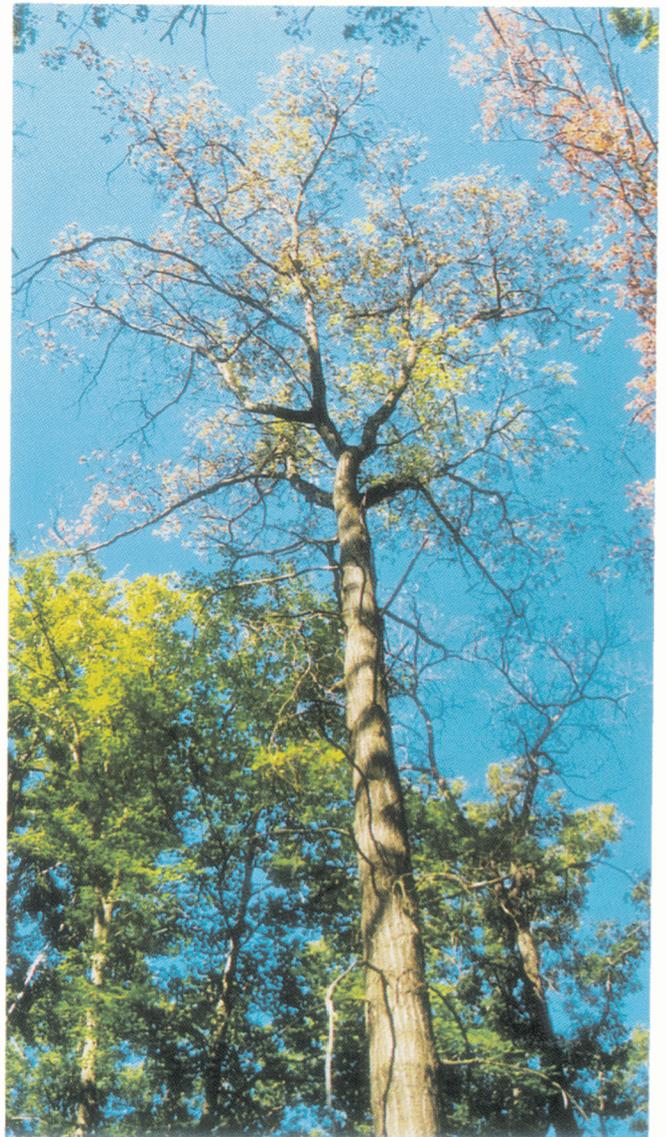


Figure 5. — Comparison of fair crowns of northern red oak (left) with scarlet oak (right).

<u>Study area and date</u>	<u>Mortality rate (percent)</u>		
	<u>Good crown</u>	<u>Fair crown</u>	<u>Poor crown</u>
New England 1911-31	15	35	45
Pocono Mts., PA 1975-1980	5	24	79
Ridge & Valley, PA 1979-1985	10	21	49

These individual tree rates have been incorporated into vulnerability rating guides for individual trees that require crown condition as one of their inputs. Two stand-vulnerability rating guides were developed for the Poconos; the guides also use information on number or percentage of live trees per acre with poor crowns (Gansner 1981, Gansner and Herrick 1984, Gansner and others 1978).

Silvicultural Treatments

Silvicultural treatments to minimize gypsy moth impacts also utilize crown condition of individual trees to determine marking

priorities for trees to be removed (Gottschalk 1993). For example, presalvage thinning is designed to reduce damage by removing highly vulnerable trees before they are defoliated and die. Priorities for marking trees to be removed are (highest to lowest). 1) oaks with poor crowns, 2) non-oak species with poor crowns; 3) oaks with fair crowns, and 4) non-oak species with fair crowns. These priorities are integrated with the normal marking priorities of maintaining the desired residual stand density, removing unacceptable growing stock trees before better quality trees (also could include species priorities), and achieving the desired stand structure. Heavily overstocked stands may have few good crowns; in this situation, light thinnings to develop and build crowns are called for rather than a heavy thinning.

When gypsy moth has already defoliated an area, salvage thinning is used to obtain the economic value from all of the dead trees and the remaining live trees are thinned to reduce susceptibility and vulnerability. Priorities for marking trees to be removed are (highest to lowest): 1) dead trees, 2) oaks with

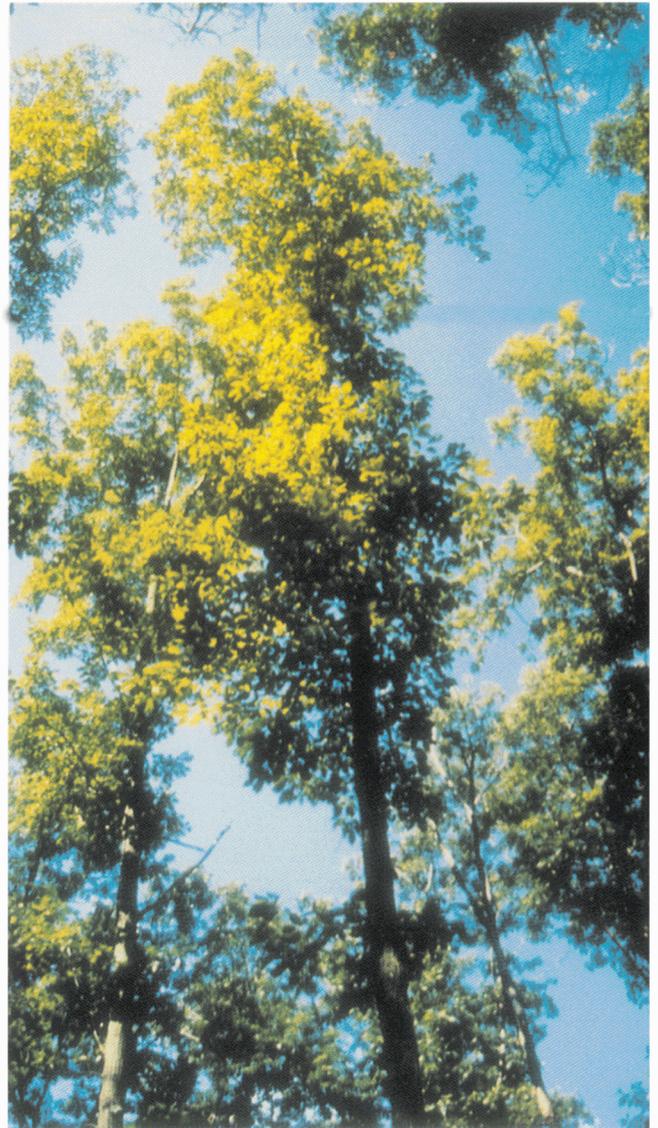


Figure 6. — A white oak (left) and a chestnut oak (right) of good crown condition.



Figure 7. — Two white oaks; one of fair crown condition (left) and one of poor crown condition (right).

poor crowns that are likely to die, 3) other species with poor crowns that are likely to die, and 4) trees with fair crowns. These priorities are to be integrated with the normal ones of maintaining the desired residual stand density, removing unacceptable growing stock trees before better quality trees, and achieving the desired stand structure. In stands that receive a salvage cutting treatment, dead and dying trees are economically salvaged. Marking priorities are simple—only dead and dying trees should be cut and removed because all of the live trees are needed to carry the stand to maturity (or to the next thinning). Trees with very poor crowns that will not recover are considered the same as dead.

Conclusions

Forest managers dealing with the gypsy moth can use crown condition ratings to improve their management of oak stands through tree and stand vulnerability rating systems that utilize crown condition and through marking guides for silvicultural treatments to minimize gypsy moth impacts. This photo-

graphic guide provides these managers with the tools to develop their own ability to do crown condition ratings.

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References

Campbell, Robert W.; Sloan, Ronald J. 1977. **Forest stand responses to defoliation by the gypsy moth.** Forest Science Monograph 19. 34 p.

- Campbell, Robert W.; Valentine, Harry T. 1972. **Tree condition and mortality following defoliation by the gypsy moth.** Res. Pap. NE-236. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 331 p.
- Gansner, David A. 1981. **Estimating forest stand vulnerability to gypsy moth.** In: Hedden, R.L.; Barras, S.J.; and Coster, J.E.; eds. Symposium of Proceedings, Hazard-rating systems in forest insect pest management; 1980 July 31-Aug. 1. Athens, GA: Gen. Tech. Rep. WO-27. Washington, DC: U.S. Department of Agriculture, Forest Service: 159-164.
- Gansner, David A.; Herrick, Owen W. 1984. **Guides for estimating forest stand losses to gypsy moth.** Northern Journal of Applied Forestry. 1: 21-23.
- Gansner, David A.; Herrick, Owen W.; White, William B. 1978. **Economic analysis of the gypsy moth problem in the Northeast. IV. Forest stand hazard ratings for gypsy moth.** Res. Pap. NE-410. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 3 p.
- Gottschalk, Kurt W. (1993) **Silvicultural guidelines for forest stands threatened by the gypsy moth.** Gen. Tech. Rep. NE-171. Radner, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 50 p.
- Herrick, Owen W. 1982. **Hazard rating forest trees threatened with gypsy moth invasion.** In: Proceedings, Coping With the Gypsy Moth. Penn State Forestry Issues Conference; 1982 February 17-18; University Park, PA. University Park, PA: Penn State University: 38-42.
- Herrick, Owen W.; Gansner, David A. 1987a. **Mortality risks for forest trees threatened with gypsy moth infection.** Res. Note NE-338. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.
- Herrick, Owen W.; Gansner, David A. 1987b. **Gypsy moth on a new frontier: forest tree defoliation and mortality.** Northern Journal of Applied Forestry. 4: 128-133.
- Kozlowski, T. T. 1969. **Tree physiology and forest pests.** Journal of Forestry. 67: 118-123.
- Millers, Imants; Lachance, Denis; Burkman, William G.; Allen, Douglas C. 1991. **North American Sugar Maple Decline Project: organization and field methods.** Gen. Tech. Rep. NE-154. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 26 p.
- Millers, Imants; Allen, Douglas C; Lachance, Denis. 1992. **Sugar maple crown conditions improve between 1988 and 1990.** Tech. Pap. NA-TP-03-92. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area State & Private Forestry and Forestry Canada. 10 p.
- Wargo, Philip M. 1978a. **Insects have defoliated my tree - now what's going to happen?** Journal of Arboriculture. 4: 169-175.
- Wargo, Philip M. 1978b. **Judging vigor of deciduous hardwoods.** Agric. Inf. Bull. No. 418. Washington, DC: U.S. Department of Agriculture. 15 p.

Gottschalk, Kurt W; MacFarlane, W. Russ. 1992. **Photographic guide to crown condition of oaks: use for gypsy moth silviculture.** Gen. Tech. Rep. NE-168. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Color photographs as guides to assessing crown condition of oaks are provided. Use of crown condition for gypsy moth vulnerability rating and silvicultural treatments to minimize gypsy moth impacts are presented.

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