VALUE AND IMPORTANCE OF HEMLOCK ECOSYSTEMS IN THE EASTERN UNITED STATES

John W. Quimby

Department of Conservation and Natural Resources
Bureau of Forestry
Division of Forest Pest Management
34 Airport Drive
Middletown, PA 17057-5021

ABSTRACT

Little information in the literature quantifies the value of a hemlock (Tsuga *canadensis)* ecosystem. There was a time when hemlocks were large, plentiful, and a considerable economic resource. The old-growth hemlock was exploited for both bark and wood. That era ended approximately a century ago when the last old-growth trees were harvested. However, there can be no doubt that hemlock is still an extremely important component of the forest. The combination of longevity, shade tolerance, and crown density make hemlock unique and invaluable in our forest ecosystems.

HISTORY OF HEMLOCK

Upon arrival in North America, the early European colonists found forests that contained vast numbers of large hemlocks (Frothingham 1915). It was not uncommon for hemlocks to be 100 to 160 feet tall and five to six feet in diameter (Frothingham 1915), and be more than 500 years old (Godman and Lancaster 1990). Examples of these trees, albeit not quite as large or as old, can still be seen in park and natural areas that are under protection (Swartley 1984). Because hemlock survives well in the shade of an overstory, and is very adaptable to a variety of soil types, it successfully encroached into stands that had remained undisturbed for centuries (Brisbin 1970). Although there are no good records of hemlocks' ancient distribution, there is reason to believe that it was once considerably more common than it is today. Whitney (1990) estimated, through the records of one Samuel Dale's 1814-15 land survey of the Allegheny Plateau, that hemlock comprised 19.9 percent of the trees in the forest at that time. A survey conducted in 1973 indicated that the proportion of hemlock (based on trees >5 inches dbh) had fallen to 5.8 percent, roughly 30 percent of what it once was.

ECONOMIC VALUE OF HEMLOCK

From a purely economic perspective, hemlock has probably the most variable record of any tree species. Initially, the most highly prized tree species in the old-growth forests was white pine. Even though hemlock trees were comparable in size, the white pine had superior strength for ships' masts and was the preferred wood for construction and furniture. Hemlock wood is coarse-grained, brash, and difficult to fashion into cabinetry. It is also subject to splitting, a consequence of a defect known as wind shake. However, once the old-growth white pine was gone or inaccessible, the lumber barons looked to hemlock for economic opportunities. Actually, hemlock turned out to be valuable for both its wood and its bark. The bark has high concentrations of tannin and was heavily used by the hide tanneries, and the wood was quite suitable for framing, sheathing, subflooring, and crating. Because of these attributes, the old-growth hemlocks were exploited until that resource was mostly depleted.

During the years subsequent to the old-growth removal, hemlock trees were too small and poorly distributed to be much of an economic consideration. As other sources of tannin were developed, the economic utility of hemlock to the tanneries dropped precipitously. However, the economic status of hemlock is now changing. The second-growth hemlocks have matured sufficiently such that there is now a market for both the lumber and pulpwood (Godman and Lancaster 1990). The consumption of hemlock sawlogs in Pennsylvania in 1988 was 27,000,000 board feet, which was 2.4 percent of the total, and more than twice that of white pine.

One misconception in many of the historic references on hemlock, including Frothingham (1915), is that the hemlock logs were left in the woods to rot after the bark was removed. This perception was challenged by Bennett (1986), who stated that the logs were left in the woods only until after the peeling season was over, whereupon *the crews* would *return to remove* them. Bennett based his conclusion on the observation that there were no remnant logs to be found in the forests of 1986. This finding is consistent with the work of Tyrrell and Crow (1994), who estimated that it takes nearly 200 years for hemlock logs to lose structural *integrity* and *become* partially incorporated into the soil.

Another common misperception about hemlock is that it is toxic. The tea made from hemlock needles is not only tasty, it's rich in vitamin C. The aborigines of North America made a palatable food from the inner bark of hemlock (Swartley 1984). Oil of hemlock, distilled from the leaves of hemlock, was used medicinally for many years (Draemel 1950). Various poultices derived from the inner bark and sap of hemlock have been used effectively to heal wounds. In fact, according to Swartley, no part of the hemlock tree is poisonous.

HEMLOCK ECOSYSTEM

Tsuga canadensis (L.) ranges from Nova Scotia across southern Ontario and northern Michigan to northeastern Minnesota. Also, isolated stands of hemlock occur in Indiana, Kentucky, and Ohio. The species is found throughout New England, New York, Pennsylvania, and the Middle Atlantic States, extending westward from central New Jersey to the Appalachian Mountains, then southward into northern Georgia and Alabama (Godman and Lancaster 1990). Extant hemlock ecosystems are patchy in distribution. Hemlock, because it grows slowly in the understory, usually does not dominate a stand for centuries. Thus, it will be some time before hemlock can regain its presettlement status in the second-growth forests. Hemlock is a long-lived, late-successional/climax species, so if a site remains undisturbed by human development, or other forces, it will eventually dominate a stand.

Hemlock has a very shallow root system. Consequently, it does best in situations where the soil remains moist throughout the year. The best hemlock stands are found on north- and east-facing slopes, and in gorges where there is high humidity and it stays relatively cool (Benzinger 1994a, b, c). Deep, fertile loams of alluvial or colluvial origin seem to be the ideal for hemlock. Hemlock is adaptable, though, to a variety of soils. It can be found on rocky, acid soils, loams, and silt loans, as well as moist benches, flats, and swamp borders that are less well drained and heavier in texture (Hough 1960). Because the roots of hemlock are situated so near the soil surface, any extremes in soil moisture, either too dry or too wet, will quickly and adversely affect hemlocks. Drought or flooding will often lead to mortality of hemlock trees (Graham 1943, McIntyre and Schnur 1936, Secrest et al. 1941, Stickel 1933).

In time, a hemlock stand tends to create an environment that is suitable for perpetuating itself. First, it modifies the environment where it grows. There are no darker, cooler places in the forest than under a hemlock canopy; thus, the soil surface of the stand is kept from drying out. Second, because hemlock is extremely shade tolerant, its regeneration survives well in the understory. The seedlings of other tree species simply cannot tolerate heavy shading and do not survive. In instances cited by Hough (1960), some hemlocks persisted in a suppressed state for more than 350 years and were still quite healthy. Some of the trees mentioned by Hough were more than 100 years old and were only one inch in diameter. According to Lancaster (1985), old, suppressed hemlock trees respond quite well when the overstory is removed either by cutting or natural disturbance. Hemlock's extreme shade tolerance and longevity allows it to outlast other species, so that, given adequate moisture, it is strongly represented in the climax forest (Simpson et al. 1990, Swartley 1984).

Hemlock is susceptible to wind throw because of its shallow root system. It is not uncommon for stands of hemlock to fall domino-fashion during wind storms, particularly if the ground is wet. The forest floor in most eastern hemlock types is marked by hollows and mounds resulting from such blowdowns (Willis and Coffman 1975). Because these windfalls open up hemlock stands to sunlight, and expose mineral soil, other species are allowed to encroach. Yellow birch and sugar maple, especially, benefit from this type of disturbance.

Hemlock possesses genetic attributes that may offer species resistance to hemlock woolly adelgid, the elongate hemlock scale, and other pests. According to Swartley (1984), hemlock appears to be the most genetically complicated of tree species and exhibits a range of variants wider, perhaps, than can be found in any other tree species. While these characteristics do not guarantee hemlock resistance to any particular pest, it is reason for continued study.

ECOLOGICAL VALUE OF HEMLOCK

A number of wildlife species benefit from the environment that exists in hemlock stands. Hemlock is an important cover species for ruffed grouse, turkey, snowshoe hare, and rabbit (Jordan and Sharp 1967). The foliage of hemlock makes a suitable forage and habitat for deer, particularly in the winter (Lapin 1994). Lapin (1994) discusses the importance of hemlock ecosystems to birds, fish, invertebrates, amphibians, reptiles, mammals, threatened and endangered species and communities, and water quality and soils. Among these, she notes a number of *species* that are obligate of eastern and Carolina hemlock (T. caroliniana Engelm.). She lists almost 90 species of birds in Connecticut that use hemlock as a food source, a nesting site, a roost site, or a winter shelter. Benzinger (1994a, b, c) identified three bird species that appear to be hemlock obligates, including the black-throated green warbler, the solitary vireo, and the northern goshawk. Two other classifications, the primary and secondary " facultatives," included 12 other species of birds.

Other species that flourish on the kind of habitat provided by hemlock stands include leatherwood, rattlesnake plantains, bunchberry, goldthread, *Lycopodium* spp., bluebead, Canada mayflower, wood sorrels, and many other herbs and shrubs (Willis and Coffman 1975, Alverson et al. 1988). The ground cover of hemlock-northern hardwood forests is strongly influenced by the amount of hemlock in the overstory. Low light levels, acidic, nutrient-poor litter, and reduced precipitation reaching the forest floor may all be responsible for a marked reduction in ground cover and species diversity (Simpson et al. 1990). Brook trout are found more commonly in streams in hemlock *ecosystems* because of the cooling effect of the hemlock canopy. Studies show that the removal of the riparian vegetation, especially that within 80 feet of the stream, can cause a temperature elevation of 6 to 9 degrees Celsius (Lapin 1994). In short, while species diversity tends to be limited within *dense* hemlock stands, the species that are there are dependent on those conditions, and many would be negatively affected in the absence of the hemlock ecosystem (Black and Mack 1976). Studies on a hemlock ecosystem conducted at the Delaware Water Gap National Recreational Area during the past three years have shown a considerable number of associations among both plants and animals in hemlock stands there. I will defer to Richard Evans to tell you about those observations later in these proceedings.

Devlin and Crownover (1983) estimated the value of coniferous forest cover, of which hemlock is a significant component in Pennsylvania, to be worth at least $40 per acre per year in its contribution to wildlife welfare. They considered the economic value based on sport hunting as well as the social values related to nonconsumptive *activities*. However, ecological values proved to be too intangible to quantify. They did state that "many wildlife species depend on coniferous cover in some form for either food, cover, or nesting sites," and that a minimum of five percent coniferous cover in the forest is essential to support adequate numbers and diversity of wildlife species.

AESTHETIC VALUE OF HEMLOCK

Aesthetically, the hemlock has no equal in the east. Frothingham (1915) stated, "During youth, hemlock is the most graceful and beautiful of eastern conifers." Even as a mature tree, hemlock is broadly appealing. These attributes no doubt helped prompt Gifford Pinchot to nominate eastern hemlock to be the official "state tree" of Pennsylvania.

Hemlock's habit of growing along mountain streams and lakes, plus the shade afforded by its dense foliage, makes it ideal for recreational habitats (Burnham et al. 1947). One would need to visit only a sampling of state or national parks in the northeastern United States to validate that hemlock stands are attractive to humans. This should come as no surprise. Hemlock stands are cooler than hardwood stands in the summer because of the dense shade they provide. Paradoxically, hemlock stands may seem warmer than the hardwoods in the winter by *virtue of the* protection from winds afforded by the trees' crowns. These parks provide recreational opportunities for millions of people annually and, doubtless, the popularity of woodland parks would be considerably lower if hemlocks were not present.

There is also no disputing the appeal of hemlock in the landscapes of our homes, cities, parks, cemeteries, and other public areas. According to Swartley (1984), there are 274 cultivars of eastern hemlock, making it one of the most cultured and cultivated landscape tree species. Hemlock is popular as a hedge, for shrubbery, as Christmas trees, and as trees for the yard or border (Hough 1960). The dark green boughs of hemlock make it a splendid backdrop for many flowering trees and shrubs. Hemlock makes the ideal landscape plant; it provides habitat for birds and other wildlife, moderates the heat in the summer, blocks the wind in the winter, is an excellent noise absorber, and is aesthetically pleasing. Two drawbacks of hemlock in the landscape are that it can get too large for the site in which it is planted (although probably not in your lifetime), and it is susceptible to a number of insect and disease pests, including: the hemlock woolly adelgid *(Adelges tsugae),* the elongate hemlock scale (*Fiorinia externa),* the hemlock looper *(Larnbdina fisceIlaria),* and, when it is under drought stress or any other stress, it can be easy prey to the hemlock borer *(Melanophila fulvoguttata)* and the shoestring root rot (Armillaria mellea). The latter two pests are usually fatal to the tree when they successfully invade it.

LITERATURE CITED

ALVERSON, W.S., WALLER, D.M., SOLHEIM, S.L. 1988. Forests too deer: edge effects in northern Wisconsin. Conserv. Biol. 2(4): 348-358.

BENNETT, A. L. 1986. Its time to debunk the myths of early logging practices. Pa. For. 76(5): 14-15.

BENZINGER, J. 1994a. Hemlock decline and breeding birds. I. Hemlock ecology. Rec. N. J. Birds. N. J. Audubon Soc. 20(1): 2-12.

BENZINGER, J. 1994b. References for hemlock decline and breeding birds. I. Introduction. Rec. N. J. Birds. N. J. Audubon Soc. 20 (addendum): 1-8.

BENZINGER, J. 1994c. Hemlock decline and breeding birds. H. Effects of habitat changes. Rec. N. J. Birds. N. J. Audubon Soc. 20(2): 34-51.

BLACK, R.A., MACK, R.N. 1976. *Tsuga canadensis* in Ohio: Synecological and phytogeographical relationships. Vegetatio 32(1): 11-19.

BRISBIN, R.L. 1970. Eastern hemlock. American Woods FS-239. U.S. Dept. of Agriculture, Forest Service. 8 p.

BURNHAM, C. F., FERREE, M.J., CUNNINGHAM, F.E. 1947. The white pine-hemlock forests of the Anthracite Region. NEFES Stn. Pap. No. 11. U. S. Dept. of Agriculture, Forest Service. 23 p.

COLLINGWOOD; G.H., BRUSH, W. D. 1947. Knowing your trees. American Forestry Association.

DEVLIN, D.A., CROWNOVER, N. 1983. Wildlife benefits associated with the Bureau of Forestry production and planting of trees for coniferous cover. Intraoffice report, Pennsylvania Bureau of Forestry. 2 p.

DRAEMEL, M. F. 1950. Hemlock - The state tree of Pennsylvania. Misc. Publ. Pennsylvania Dept of Forests and Waters. 30 p.

FROTHINGHAM, E.H. 1915. The eastern hemlock. Bull. No. 152. U. S. Dept. of Agriculture. 43 p.

GODMAN, R.M., LANCASTER, KENNETH. 1990. *Tsuga canadensis (L.) Carr.* Eastern Hemlock Pinaceae. Pine family. Pp. 605-612 In Silvics of North America, vol. 1. Conifers, ed. Russell M. Burns and Barbara H. Honkala. Agriculture Handbook 654. Washington, D. C.: U. S. Department of Agriculture, Forest Service. 675 p.

GRAHAM, S.A. 1943. Causes of hemlock mortality in northern Michigan. Bull. No. 10. Ann Arbor: University of Michigan, School of Forestry and Conservation. 61 p.

HOUGH, A.F. 1960. Silvical characteristics of eastern hemlock. NEFES Stn. Pap. 132. U. S. Dept. of Agriculture, Forest Service. 23 p.

JORDAN, J.S., SHARP, W. M. 1967. Seeding and planting hemlock for ruffed grouse cover. Res. Pap. NE-83. U. S. Dept. of Agriculture, Forest Service. 17 p.

LANCASTER, K.F. 1985. Managing eastern hemlock. A preliminary guide. NE Area NA-FR-30. U. S. Dept. of Agriculture, Forest Service. 7 p.

LAPIN, B. 1994. The impact of hemlock woolly adelgid on resources in the Lower Connecticut River Valley. Report for the NE Center for Forest Health Research. Hamden, Conn.: U. S. Dept. of Agriculture, Forest Service. 45 p.

MCINTYRE, A.C., SCHNUR, G.L. 1936. Effects of drought on oak forests. Bulletin 325. The Pennsylvania State College, School of Agriculture and Experiment Station. 43 p.

SECREST, H.C., MACALONEY, H.J., LORENZ, R.C. 1941. Causes of the decadence of hemlock at the Menominee Indian Reservation, Wisconsin. J. For. 39: 3-12.

SIMPSON, T.B., STUART, P.E., BARNES, B.V. 1990. Landscape ecosystems and cover types of the reserve area and adjacent lands of the Huron Mountain Club. Occasional Papers of the Huron Mountain Wildlife Foundation. School of Natural Resources, The University of Michigan, Ann Arbor. 128 p.

STICKEL, P.W. 1933. Drought injury in hemlock-hardwood stands in Connecticut. J. For. 31: 573-577.

SWARTLEY, J.C. 1984. The cultivated hemlocks. Timber Press. 186 p.

TUBBS, C.H. 1978. How to maintain eastern hemlock in the Lake States. NCFES. U. S. Dept. of Agriculture, Forest Service. 4 p.

TYRRELL, L.E., CROW, T.R. 1.994. Dynamics of dead wood in old-growth hemlock-hardwood forests of northern Wisconsin and northern Michigan. Can. J. For. Res. 24: 1672-1683.

WHITNEY, G.G. 1990. The history and status of the hemlock-hardwood forests of the Allegheny Plateau. J. Ecol. 78: 443-458.

WILLIS, G.L., COFFMAN, MS. 1975. Composition, structure, and dynamics of climax stands of eastern hemlock and sugar maple in the Huron Mountains, Michigan. Tech. Bull. No. 13. Ford Forestry Center, Michigan Technological University. 43 p.