Silviculture and Stand Dynamics of Hemlock-dominated Stands in Southern New England: Some Lessons from Early Research

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Abstract

In the early part of this century, considerable interest existed in the silviculture of hemlock (*Tsuga canadensis* (L.) Carr.) in the southern New England region, where it occurs in mixture with oak (*Quercus* spp.), white pine (*Pinus strobus* L.), birches (*Betula* spp.), and maples (*Acer* spp.). Difficulties encountered with the regeneration of white pine led to the idea that hemlock should be promoted through management as an alternative conifer sawtimber species. Research at forestry institutions in Connecticut and Massachusetts beginning in the 1920's demonstrated the ease with which hemlock-hardwood stands could be converted to pure hemlock by removing the hardwood overstories. However, early attempts to regenerate hemlock in mature hemlock-dominated stands met with difficulties. Shelterwood and group selection methods failed to establish hemlock dependably; problems were ascribed to the deep litter layer, which inhibited establishment of hemlock more than that of some hardwood species, especially black birch (*Betula lenta* L.). Scarification promoted hemlock regeneration, but also promoted the much faster growing black birch. These case studies provide the basis for predicting stand dynamics pathways for hemlock-hardwood stands under different disturbance regimes, both natural and silvicultural.

Introduction

Eastern hemlock has been the subject of increasing interest in forest management both because the species is increasing in abundance in many areas as the forest matures and because it is threatened by the infestation of the hemlock woolly adelgid (*Adelges tsugae* Annand). Hemlock has not generally been as highly valued for timber as a number of associated species, so little silvicultural research has concentrated on it in recent years. However, there was a period in the early part of this century when researchers at the Yale Forestry School, the Harvard Forest, the Connecticut Agricultural Experiment Station, and the Massachusetts College of Agriculture were interested in the prospect of managing hemlock as a timber species, and they conducted a number of studies to determine appropriate silvicultural strategies. These studies took the form of management trials that would fit under the current concept of 'adaptive management'; they were not replicated experiments with controls, but consisted of very careful, quantified observations made at intervals after stand treatments had been carried out. They give useful information about responses to silvicultural treatments, and can also be used to predict vegetation dynamics in unmanaged stands by considering similarities between specific silvicultural and natural disturbances.

These studies were conducted in Massachusetts and Connecticut, and so they relate directly only to southern New England, in which hemlock occurs with oak, red maple (*Acer rubrum* L.), black birch, paper birch (*Betula papyrifera* Marsh.), gray birch (*Betula populifolia* Marsh.), hickory (*Carya* spp.), and white pine—i.e., the transition hardwood-white pine-hemlock type south to the central hardwood-hemlock type according to the classification of Westveld (1956). Some results may apply in a more general way to northern hardwood-hemlock mixtures.

In the 1920's, when much of this research was being conducted, it was understood that hemlock had been markedly reduced from its prevalence in precolonial forests (Merrill and Hawley 1924). Studies of the last remaining uncut virgin stands in the region suggested that hemlock had dominated much of the landscape (Nichols 1913). Compared to most associated species, hemlock had been affected more by cutting and fire, and was slower to become reestablished on former agricultural land. At the time of these studies, hemlock occurred throughout the region in woodlots that may have been cut repeatedly, but had escaped burning or clearing.

Reasons for Favoring Hemlock in the Early Part of the Century

The earliest interest in harvesting products from hemlock in the Northeast was for the tanbark industry, with the old-growth trees usually being felled and bark removed without the wood being used. However, this industry had died out in southern New England long before the beginning of the 20th century. The potential identified in the 1920's was to use hemlock for dimension lumber and railroad ties. The factors behind this interest included the scarcity of old-growth red spruce and white pine lumber from northern regions, the poor timber quality of the local old-field white pine, and the fading hope of growing better quality white pine in new stands (the difficulty of regenerating white pine during the harvest of old-field stands was becoming apparent in early silvicultural trials) (Merrill and Hawley 1924). The problem of poor quality wood in hemlock logs caused by ring shake was well recognized at the time, but it was believed that this was related to tree age, and that second-growth hemlocks would not have the problem. Thus, hemlock was seen as a good alternative to white pine as a source of conifer wood for the timber industry.

Additional support for favoring hemlock in management came from applying the new principles of succession that had been formulated by Clements (1916). One of the early proponents of basing silvicultural treatments on knowledge of the ecology of unmanaged stands was Harold J. Lutz, who proposed that, where possible, silviculture should follow rather than fight against natural successional processes

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(Lutz 1928). He did not favor the creation of the climax forest type as a matter of doctrine, but suggested that successional trends would make it increasingly difficult and costly to establish early and mid-successional stand types during harvesting, if understories of late successional species were already present. Further, he observed that a climax hemlock-hardwood stand "brings about the most complete utilization of the site" in timber production (Lutz 1928, p. 40), because canopy and root layering reduced competition and allowed greater numbers of trees to grow in a given area. Yield studies had shown that hemlock mixed with hardwoods or pine increased total yield compared to pure hardwood or pine stands (Frothingham 1915), and that pure hemlock had greater yields than oak-dominated hardwood stands (although pure pine produced more than any other stand type). In addition, unlike white pine, hemlock was (at the time) free of insect or fungus problems, and its ability to improve the quality of associated white pine by shading off lower branches had been recognized (Tarbox and Reed 1924).

Conversion of Hemlock-hardwoods to Pure Hemlock Stands

Whereas Lutz suggested hemlock-hardwood mixtures as the appropriate silvicultural objective, others favored conversion of these stands to pure hemlock for greater production of conifer timber by taking advantage of the presence of the hemlock understories. The shade tolerance of hemlock was recognized early; seedlings were observed to become established beneath hardwood canopies, but they did not invade open areas in full sun. Marshall (1927) was the first to quantify the ability of hemlock understory trees to respond to release. Working at the Harvard Forest, he examined growth rings of hemlocks in stands that had been partially cut in the mid-1800's, and found that trees that had been suppressed for 10 to 50 years responded with rapid growth after release (a ten-fold diameter growth increase for the decade after overstory cutting, compared to the previous decade). He concluded that hemlock advance growth should be preserved during logging, as the key to developing the next stand.

At the same time, this growth response was being observed in overstory logging in various hardwood-hemlock stands in southern Connecticut (Merrill and Hawley 1924). In one case described, the hardwood overstory was removed in a series of group selection cuttings; the hemlock understory responded to release, with the entire stand gradually being converted to hemlock. The gradual removal of the hardwood overstory was promoted by Merrill and Hawley as a logical timber management treatment, and the idea was taken up by others, at least on a small scale. For example, a set of demonstration plots was established on the school forest of the Massachusetts Agricultural College near Amherst, in which the red oak overstory was removed to create a pure hemlock stand; this allowed comparison of growth and yield between this hemlock plot and an adjacent untreated oak-hemlock plot. However, there are no records that indicate that this idea was applied operationally on a large scale.

Regenerating Hemlock in Hemlock-dominated Stands

The conversion of mixed stands to pure hemlock was quickly understood to be a simple, straightforward task. However, a sustainable management system based on pure hemlock stands required methods to regenerate hemlock in mature stands. It was not as clear how to accomplish this step, because mature hemlock stands characteristically lack advance regeneration of any species. A study at the Harvard Forest, begun in 1924, was designed in part to address this question (Lutz and Cline 1956). Shelterwood, group selection, and strip clearcut methods were applied to a 75-year-old hemlock-white pine stand on an outwash soil. The shelterwood cut left about one-half canopy cover. The problem posed by the deep conifer litter for obtaining hemlock or pine regeneration was recognized, and because the winter logging had not disturbed the seedbed, a harrow was used the spring following the cut to accomplish the task. However, the harrow treatment was judged to be ineffective, so small plots were scarified with hand tools to test the importance of exposing mineral soil. Following the shelterwood cut, hemlock germinated only on particular microsites—on beds of *Polytrichum* moss, in small moist depressions, or on any area where burning of slash piles or scarification treatments had disturbed the forest floor. For the entire cutting area, mean hemlock regeneration density 6 years after cutting was 10,000 stems/acre. However, many hardwoods had also become established, including paper birch, gray birch, black birch, pin cherry (*Prunus pensylvanica* L.), red maple, and red oak (*Quercus rubra* L.). Black birch comprised 70% of the hardwood stems, with 2000 black birch stems/acre greater than 3 ft; only 500 stems/acre of hemlock were taller than 3 ft. Adjacent to the shelterwood cutting, a group selection cutting was made in which all trees were cut within small patches ranging from 0.01 to 0.1 acres in size; cutting was carried out with little disturbance to the forest floor. Again, black birch dominated the hardwoods 6 years later, with heights up to 7 ft; in this case, few hemlocks became established, and nearly all were less that 2 ft tall. The strip clearcuts were 80-, 110-, and 140-ft wide, on a north-south orientation, to allow maximum exposure to the direct sun; little disturbance to the forest floor occurred during logging. Pin cherry, gray birch, and paper birch were the most common hardwood species in the regeneration, but little white pine germinated, and hemlock was almost completely absent from these stands.

In cuttings in hemlock-dominated stands in southern Connecticut, Merrill and Hawley similarly observed that: (1) exposed mineral soil was important to hemlock seedling establishment, and (2) black birch responded prolifically to the same conditions that were favorable for hemlock, and it grew twice as fast (or more) in height as hemlock. They concluded that it would not be practical to attempt weedings of birch and other hardwoods to create pure young hemlock stands. Rather, they proposed a system of growing alternate crops of hardwoods and hemlock. Beginning with a mixed stand, the hardwood overstory would be harvested to release the hemlock; after the hemlock stand reached maturity, the shelterwood method with scarification would be

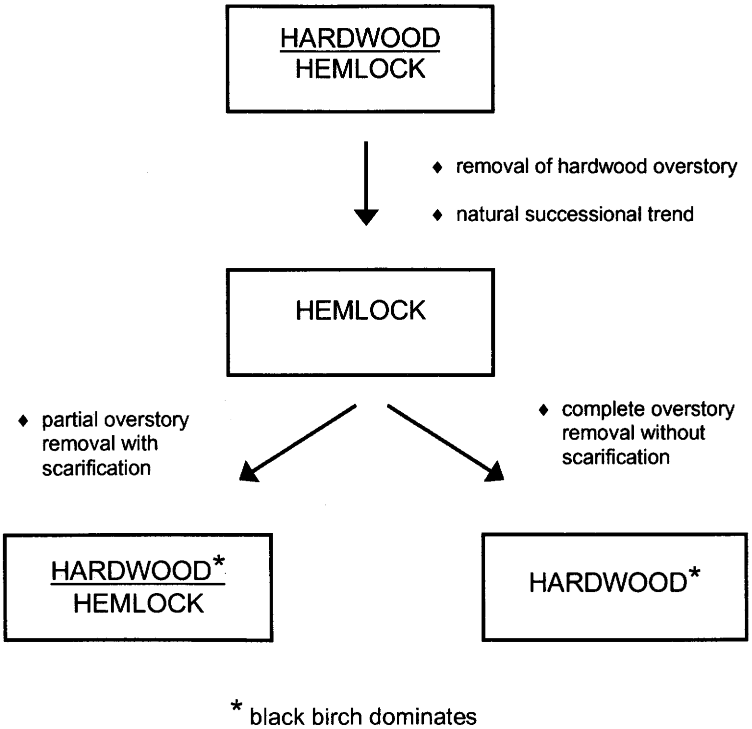

Figure 1.—Diagram of stand dynamics pathways in hemlock-dominated forests in southern New England, as can be inferred from results of early silvicultural studies. See text for further explanation.

carried out to create an even-aged mixed stand with a hardwood upper canopy above a hemlock lower canopy thus completing the cycle.

While this is not necessarily a timber production system to be put into widespread use at present, the stand dynamics pattern it describes (summarized in Fig. 1) is useful as a basis for predicting responses to natural disturbances (e.g., wind damage or mortality from insects) or to specific silvicultural treatments. Especially when questions arise about whether climate change or introduced insect pests such as the hemlock adelgid will bring about entirely new vegetation responses, it is useful to be able to compare current results with patterns of forest dynamics that occurred 75 years ago.

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