Development of the Forest Canopy — A Key to Silviculture

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The leafy crowns of trees in a forest are arranged vertically to form a characteristic forest canopy. The vertical position of various species in the canopy structure changes over time. Three aspects of canopy development have interesting silvicultural implications. Different species (1) grow at different rates throughout their life, (2) reach different final heights and ages and (3) respond differently to different size openings in the canopy. Combining these three principles with knowledge of the characteristic behavior of a given species in a given area can permit some prediction of natural changes in forest canopy structure. This can aid in making silvicultural decisions, reduce the amount of management needed and, in some cases, increase production.

Canopy development in the transition hardwood forest (oak, maple, birch and pine) of central Massachusetts is described below as one example of canopy development but the concepts behind the discussion have implications for mixed species stands in most regions.

Canopy Development

In central Massachusetts, following canopy removal by logging, wind or fire, a site is quickly colonized by a number of tree species (Hibbs, in prep.). The exact composition depends on site quality, seed availability and advanced reproduction. Colonization lasts about 6 to 8 years, after which very few new seedlings can be found. Only hemlock seems able to come into these young but closed forests. As in the northern hardwood forest, pin cherry is frequently the early dominant species, in terms of both size and numbers, but it rarely lives for more than 30 years. Gray birch is a less numerous but also an early, short lived dominant species.

By the time the stand is 40 years old, much of the character of the mature forest has already developed (Hibbs, in prep.). Pin cherry is gone; gray birch is rapidly dying out. Most of the other species, all except hemlock, were present by year 10 and have suffered only about 50% mortality. The dominant trees are now, in order of decreasing density, red oak, red maple, and paper birch.

A most important point is that there is little relationship between the overall commonness of a species and its commonness in the canopy. Red maple is very poor at achieving dominant or co-dominant canopy positions while red oak and paper birch are very good. Red oak, for example, while only making up 7.5% of the stems in a 40 year old stand, can hold 37% of the dominant canopy positions. Oliver (1978) pointing out that this strong dominance of red oak means that fewer stems are needed to acheive good stocking. The low mortality rate of red oak also contributes to its success.

Oliver (1978, 1980) examined the patterns of tree growth and canopy stratification in stands containing red oak, red maple, and black birch. He found that red maple had an initially high growth rate but red oak quickly caught up and overtopped red maple. Black birch also started slowly and eventually grew to be just slightly taller tham red maple. Oliver concluded that there is a definite, although poorly defined, pattern of layering in the forest canopy: red oak is taller than and spreads over red maple and black birch which in turn fill spaces under and between oak. Other

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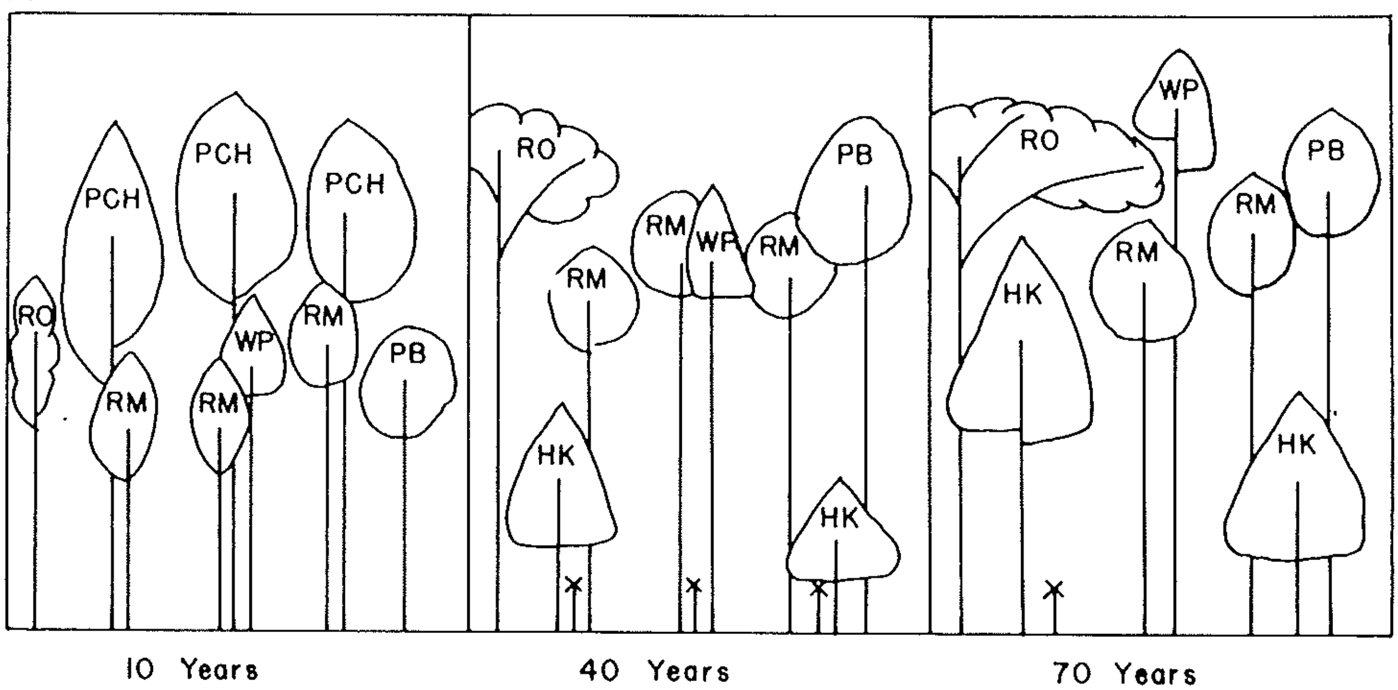
Figure 1. Canopy development in an unevenaged mixed species stand. PCH — pin cherry; RO — red oak; RM — red maple; WP — white pine; PB — paper birch; HK — hemlock.



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species can also be fit into this scheme. My research shows that paper birch is another slow starter that later becomes dominant with red oak. It is not, however, able to maintain height growth as long as red oak and eventually (75 years) drops into a codominant position. White pine is the slowest starter of all, but if initial stand density is low or the pine is buffered within a larger pine group for about 40 years, the rate of growth of pine will exceed that of the hardwoods so that by the time the stand is 80 to 90 years old, white pine becomes an emergent over the hardwoods.

In very old forests, two other factors contribute to continued development of canopy structures and also lead to a consideration of unevenaged forests and group selection silviculture. The first factor is the understory hemlock, some of which has grown into the canopy. The second factor is the wind, insect and disease-caused canopy openings that allow regeneration of species less shade tolerant than hemlock. In older forests there is an increase in the predominance of shade tolerant species as hemlock continues to reproduce under the canopy and as many other species reproduce in the larger canopy gaps. It appears that different size openings favor different species, from hemlock in the smallest to species of only moderate shade tolerance, red oak and white pine in southern New England, yellow birch in northern New England, in the largest. As an example, yellow birch has been found to regenerate best in openings of 0.25 to .075 acres (Hibbs *et al.* 1980).

A recent study (Hill 1977) appears to indicate that patterns of canopy development and structure in the northern hardwood forest are similar to those described for transition hardwoods. In mixed species stands, beech and sugar maple are taller than yellow birch until about 10 years old. Yellow birch then passes beech and maple and, by year 60, has developed into a strongly dominant species. I suspect, however, considering the relatively short life span of yellow birch, that beech (if it survives scale) and maple can maintain height growth longer than birch and would eventually overtop it.

Silvicultural Implications

There are several simple guidelines that come out of these observations. Stocking levels of some species, especially red oak but also paper birch, do not need to be high. Because of the strong dominance and low mortality of these species, a young stand needs only about twice the final crop tree density to be adequately stocked. In addition, because of their strong dominance, TSI has little effect on their survival or growth.

In general, TSI in these young (0-25 years old) stands has little economic benefit. The high density of small stems makes TSI expensive and the short life span of pin cherry and gray birch means they will be removed naturally. The only time TSI in young stands appears useful is selectively around white pine and this only on moderate to dry sites where pine already has some inherent advantage. This early thinning prevents suppression of the pine and gives it time to attain a high growth rate.

Thinning of older stands is usually done on the basis of horizontal spacing: so many stems per acre or trees so many feet apart, etc. If attention is paid to the natural vertical spacing of tree crowns as well, higher residual basal areas and growth rates can be maintained. When the situation arises, red maple and black birch can be left between as well as slightly under oak and paper birch. The benefits are two-fold. Red maple and black birch, being moderately shade tolerant trees, grow reasonably well in less than full sun. Red oak and paper birch, on the other hand, are tall and so their growth is not hindered by red maple and black birch. They may simply grow over them. White pine, when found in this forest, can be left or even encouraged. In the long run, it can form a third canopy layer of scattered emergent trees over hardwoods. Growing pine with hardwoods may have the advantage of reducing weevil damage because young trees tend to be partially shaded by surrounding hardwoods. Hemlock may be entering these stands from below.

The opportunity for unevenaged management is also present. The size of groups taken in a selection cut can determine (given site and seed source) the composition of regeneration: hemlock in small openings, red maple and black birch in moderate sized openings and oak and pine in large openings.

So, next time you are looking at a stand from the point of view of a thinning, consider the vertical structure as well as horizontal spacing of the trees. It may be possible to take advantage of this natural canopy structure to improve the stand and increase output.

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