INTERPRETATION OF CANOPY GAP DYNAMICS WITH THE AID OF DENDROCHRONOLOGICAL TECHNIQUES

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INTRODUCTION

An understanding of disturbance and plant succession is important for developing effective management strategies and predicting impacts of land-use practices. A disturbance is "any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment" (Pickett and White 1985). Succession can be defined as "the non-seasonal, directional, and continuous pattern of colonization and extinction on a site by species populations (Begon et al. 1990)". In most forested systems, the landscape pattern of succession resembles that of a shifting mosaic composed of patches of forest of various ages, size, and species composition (Pickett and White 1985). The actual distribution and abundance of patches depends upon the temporal and spatial characteristics of the disturbance regime (Hobbs and Huenneke 1992). The pattern of succession within any given patch is termed "gap phase replacement" because disturbance creates a canopy gap by removing the canopy dominants and the patterns of secondary succession determine which species will replace them.

Disturbance regimes strongly influence plant composition in most forested ecosystems. Many species are shade-intolerant and require the increased light created by disturbance for establishment. In many instances, multiple disturbances are necessary for a tree to attain canopy dominance. Because of the relationship between disturbance and tree growth and establishment for some species, the distribution and abundance of past disturbances can potentially be determined using dendrochronological. Diagnostic characteristics of tree ring structure that can be beneficial in dating disturbance events include: 1) age and death date of the gapmaker(s), 2) periods of suppression and release, and 3) age of trees around the gap, particularly of shade-intolerant species. These characteristics have been used by competent (i.e., do not need this field week) dendrochronologists in many forested systems to determine characteristics of the disturbance regime.

The objectives of this study were to: 1) learn the standard techniques used in dendroecology, 2) investigate canopy disturbance regimes of mixed hardwood/conifer stands, 3) determine the most effective tree species for quantifying canopy disturbances with dendroecological techniques, stand structure data, and swags (scientific wild ass guesses) 4) provide an excuse for spending time in New Hampshire and not in the office.

STUDY AREA AND METHODS

This study was conducted on the 2600 acre Bartlett Experimental Forest in the White Mountain National Forest near Bartlett, New Hampshire. Elevation in the experimental forest ranges from 680 ft to nearly 3000 ft; temperatures range from -30° F to 90°F. Soils are spodosols that were developed on glacial till derived from granite and gneiss. Common species in this forest include American beech (*Fagus grandifoliia*), red maple (*Acer rubrum*), sugar maple (*A. saccharinum*), yellow birch (*Betula alleghaniensis*), red spruce (*Picea rubens*), and eastern hemlock (*Tsuga canadensis*) among others. The particular stand chosen for this study was mixed hardwood, red spruce, and hemlock located on southeastern facing slopes at about 500m elevation.

Canopy gaps were located by stumbling randomly through the woods until a gap could be located that did not look very difficult to interpret. We selected three gaps in relatively close proximity to the road ($\geq$ 75 m and $\leq$ 40 km) thereby minimizing walking, stumbling, and all other forms of physical exercise. At each gap we identified, measured diameter at breast height (dbh), and mapped all potential gapmakers, perimeter trees, and some interior trees. Gapmakers were defined as those trees responsible for creating the canopy gap. Perimeter trees were the dominant trees surrounding the gap who's crowns formed the boundary of the canopy opening. Interior trees were defined as any trees occurring within the canopy gap area.

To assist in dating the age of the gap, we collected increment cores and/or slabs from gapmakers, boundary trees, and selected interior trees. At two of the three gaps increment cores and/or slabs were taken from all interior trees occurring within 1 m on either side of a 10 m line in each of the 4 cardinal directions. At this location the cardinal directions were parallel and perpendicular to the contours. In addition, other interior trees were selected based upon their potential for recording a release as determined from their relative position in the canopy.

All cores were mounted and sanded at the Bartlett Experimental Research Station following the stringent quality control guidelines established by our team leaders. Initially, we planned on skeleton plotting and cross dating all cores; however, due to difficulties identifying some species, lack of interest, and the general apathy of our group we decided to skeleton plot those cores that were the easiest to interpret. All cores were examined for establishment dates and noticeable periods of suppression and release. All annual rings were then measured and the program COFECHA was used to compare annual ring measurements of our specimens to master chronologies developed from the Nancy Brook New Hampshire Red Spruce Chronology and from chronologies developed by other more motivated groups at the fieldweek. Any errors in crossdating with these chronologies were obviously errors in their chronologies and do not reflect any shortcomings of our group (yeah, right).

RESULTS

Several species of trees were cored including American beech, yellow birch, eastern hemlock, red spruce, sugar maple, and striped maple (*A. pennsylvanica*). These could be classified into two categories depending upon their degree of difficulty in coring and crossdating. American beech, yellow birch, striped maple and sugar maple were "royal pains" whereas red spruce and eastern hemlock were "workable". The annual rings of the hardwoods were often difficult to delineate; American beech was by far the worst (as determined by the number of cores lying under the table) demonstrating very complacent growth. American beech was of little value, therefore, for identifying releases resulting from canopy disturbance. Yellow birch slabs were somewhat more workable but red spruce and eastern hemlock were the most sensitive to light conditions and were the most valuable for this study. As a result, most canopy gap interpretations are based on red spruce, eastern hemlock, and to a lesser extent, yellow birch. All dates mentioned for suppressions and releases are general estimates as the actual date may vary by 1-4 years for any given tree.

All canopy gaps were characterized by multiple periods of suppression and release. Canopy gap 1 was a big mistake as it was totally out of control. Multiple gap makers were identified including a large snapped eastern hemlock, a decayed spruce or hemlock, the snapped top of a maple, as well as two remnant stumps. Analyses indicated that six trees experienced a release around 1951 which continued until 1970. Three additional trees, which did not release during 1951, released in early 1961. Suppressions for gap 1 trees were identified in the early to mid-1970s and in the early 1980s. At press time, identification of the gapmaker(s) for gap 1 was not completed.

Gap 2 was most recently formed by a standing dead spruce and crossdating to the Nancy Brook chronology was used to determine the tree died in 1982. A synchronous release was observed for 8 spruce trees starting around 1954-1955 and was sustained until the early to mid-1970's for 7 specimens and until 1980 for the final specimen. Prominent periods of suppression were evident for 7 specimens from 1948-1954, for 1 specimen from 1935-1940, and for 3 from the early 1980's to early 1990's.

Gap 3 was created by the natural felling of two large eastern hemlocks. The growth of released trees was very dynamic particularly for the interior trees. Eight interior red spruce showed releases during the late 1950's; no perimeter trees showed signs of release. Analyses of slabs indicated that two yellow birch established 35-40 years ago which would coincide with the releases of the interior trees. Two specimens (one interior and one perimeter tree) showed signs of suppression during the late 1940's to early 1950's.

Results obtained from COFECHA indicated that our chronologies did not fit well with the Nancy Brook chronology but fit satisfactorily with the chronology developed by fellow classmates. The ring width measurements, however, verified the suppression release patterns that we had previously identified in our skeleton plots.

DISCUSSION

The results of this study suggest that dendrochronological techniques can be used to identify canopy disturbance patterns in some situations; however, as gap complexity increases and the skill of the researchers decreases success rates can decline precipitously. Species composition, the spatial and temporal distribution of gapmakers, asynchronous responses of surrounding trees to gap formation, and rapid decay of gapmakers are potential limitations of this technique. In general, hardwood species were less desirable for identifying gap-related responses which may be related to our lack of experience and desire to perform difficult tasks. This was particularly true for American beech because of its complacent growth and non-distinct annual ring boundaries. Relatively good success was observed with yellow birch, particularly with slabs.

Red spruce and eastern hemlock were the most desirable for identifying periods of suppression and release because of their relatively rapid responses to increasing light and resource availability. These same characteristics, however, make these specimens difficult to crossdate with master chronologies from regional areas and emphasize the importance of developing local chronologies.

Many samples demonstrated periods of extreme suppression which caused missing rings and decreased confidence in crossdating (as if we had any to begin with). In determining gap dynamics, however, the most desirable specimens are those where the overriding growth response is to microclimatic variation within the gap (or future gap) area rather than growth responses to local and regional environmental conditions. Several cross sections from red spruce and eastern hemlock had multiple areas of compression wood. Determination of ring width was complicated since it was a function of where the cross section was sampled. Selection of an area that was not affected by the compression wood was often impossible and was subjective to the individual measuring the ring width. Several samples had 2 or 3 different zones of compression wood which further increased the difficulty of analysis.

LITERATURE CITED

You fool! Do you think after reading this document we actually read any of that literature?