INFLUENCES OF TREE, STAND, AND SITE CHARACTERISTICS ON THE PRODUCTION OF EPICORMIC BRANCHES IN SOUTHERN BOTTOMLAND HARDWOOD FORESTS

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Abstract—Epicormic branches are adventitious twigs that develop from dormant buds found along the main bole of hardwood trees. These buds may be released at any time during the life of the tree in response to various types of stimuli. Epicormic branches cause defects in the underlying wood and may cause significant reductions in both log grade and subsequent lumber value. Species, stress, and sunlight have been proposed as the three major factors affecting production of epicormic branches, but no definitive research has been conducted to evaluate this hypothesis. This paper reports preliminary evaluations of the influences of several tree, stand, and site characteristics on production of epicormic branches in undisturbed stands of southern bottomland hardwoods. Tree characteristics evaluated include species, diameter class, and crown class; stand characteristics evaluated include stand density and site index. Each characteristic was examined individually and in combination with other characteristics to determine the level of influence on formation of epicormic branches.

INTRODUCTION

Successful management of hardwood forests for sawtimber production depends on development and maintenance of high-quality logs. Log quality, generally expressed as log grade, greatly affects the monetary value of the sawtimber volume produced by the tree. The value of a hardwood log decreases rapidly in the downward progression from grade 1 to grade 3. Consequently, any event or circumstance that reduces log grade also significantly reduces the value of both the tree and the entire stand.

Epicormic branches are adventitious twigs found along the main bole of many hardwood trees. They develop from dormant buds that may be released at any time during the life of a tree in response to a variety of stimuli (Carpenter and others 1989). Because they produce knots in the underlying wood, epicormic branches, if present in sufficient numbers, may reduce log grade in standing trees. As a result, the presence of epicormic branches along the boles of hardwood trees often becomes a serious problem in management of hardwood forests for high-quality sawtimber production.

According to the Forest Service, U.S. Department of Agriculture, standard grading rules for hardwood factory logs (Rast and others 1973), large epicormic branches (>3/8 inch in diameter at the bark surface) are defects on logs of all sizes, grades, and species. In general, small epicormic branches (≥3/8 inch in diameter at the bark surface) are defects on all logs <14 inches in scaling diameter, but only every other one is counted as a defect on logs 14 inches or more in scaling diameter. Small epicormic branches are not counted as defects on black cherry (*Prunus serotina*) logs or on grade 3 logs of soft hardwood species, such as sweetgum (*Liquidambar styraciflua*) and eastern cottonwood (*Populus deltoides*), regardless of log diameter.

The grade and associated value of any hardwood log may be reduced significantly by the presence of a sufficient number of epicormic branches. For example, production of epicormic branches following a seedtree cut in South Carolina was substantial enough to reduce the grade of 44 percent of the cherrybark oak (*Quercus pagoda*) butt logs (Stubbs 1986). In a survey of bottomland oak stands in northeastern Louisiana, Hedlund (1964) found that the presence of epicormic branches on upper logs caused a one-grade reduction in nearly 40 percent of the logs and a two-grade reduction in 23 percent of the logs. Meadows and Burkhardt (2001) reported that production of epicormic branches in a thinned willow oak (*Q. phellos*) stand in Alabama was sufficient to cause a one-grade reduction in 45 percent of the butt logs and 46 percent of the upper logs as well as a two-grade reduction in 7 percent of the butt logs. Meadows and Burkhardt (2001) suggested that, as a general rule, as few as five epicormic branches somewhat evenly distributed on a 16-foot-long log are enough to cause a reduction in log grade.

The seriousness of the presence of epicormic branches on hardwood logs becomes even more apparent when those logs are sawn into lumber at the mill. Epicormic branches produce small knots, or defects, in the underlying wood. These defects may reduce the grade and subsequent value of the lumber produced from those logs. One of the factors used to grade hardwood lumber is the surface area of defect-free wood, called a clearcutting (Hanks and others 1980). Because hardwood lumber grade is affected more by the number and spatial distribution of defects rather than by the size of individual defects, the small knots produced by epicormic branches can affect the length and number of clearcuttings obtained from the lumber and therefore reduce its grade. Because defects caused by epicormic branches limit the size of clearcuttings and because the value of high-grade lumber may be several times greater than the value of low-grade lumber, the presence of epicormic branches on hardwood logs may have a detrimental effect on both lumber grade and its associated value. In one case study in Alabama, over 50 percent of the volume of willow oak lumber that would

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have been classified at one of the highest grades in the absence of epicormic branch defects was reduced to lower grades in the presence of epicormic branch defects. Based on red oak (*Q. rubra*) lumber prices prevailing at the time of the study, defects caused by epicormic branches resulted in a 13-percent loss of value in the lumber produced (Meadows and Burkhardt 2001).

Production of epicormic branches along the boles of hardwood trees is a poorly understood phenomenon that may be responsible for annual losses of millions of dollars in potential revenue. It once was thought that epicormic branches developed on hardwood trees solely as a result of sudden exposure to direct sunlight, especially after some type of partial harvest operation or other disturbance in the stand. However, mounting evidence indicates that tree health plays a major role in determining the propensity of a hardwood tree to produce epicormic branches (Brown and Kormanik 1970, Erdmann and others 1985, Meadows 1993).

To address this issue, Meadows (1995) proposed that production of epicormic branches is controlled by complex interactions among species, stress, and sunlight. Hardwood species vary significantly in their susceptibility to the production of epicormic branches. For example, most oaks are highly vulnerable, whereas green ash (*Fraxinus pennsylvanica*) generally is not. Stress experienced by individual trees may be caused by climatic events, site and stand conditions, suppression, and both stand-level and tree-level disturbances. High levels of stress may reduce tree health and may stimulate the production of epicormic branches. Within the range of susceptibility associated with any given species, tree health serves as the mechanism that controls production of epicormic branches when the tree experiences some type of stress. Sudden exposure of the bole to direct sunlight following some type of natural or anthropogenic disturbance may trigger the release of dormant buds that develop into epicormic branches. Under this hypothesis, trees of resistant species and healthy trees, even of susceptible species, are less likely to produce epicormic branches than are unhealthy trees.

Because there has been no definitive research to evaluate this hypothesis, we initiated a new research program designed to describe and model the influences of several tree, stand, and site characteristics on the production of epicormic branches on butt logs of hardwood trees of various species in both unthinned and thinned bottomland hardwood forests. This paper reports summaries of data collected solely from unthinned stands.

METHODS

Characteristics of Sample Stands

The portion of the overall research project reported in this paper consists of a comprehensive survey of a variety of undisturbed hardwood stands across the South. Sample stands were selected to represent a range of site and stand conditions, including site type, site quality, stand type, stand age, and species composition. Stands in which logging or other major natural or anthropogenic disturbances have occurred within the past 20 years were excluded from the survey.

Since 2005, we have sampled seven different bottomland hardwood stands in Mississippi (table 1). In general, stands characterized by the elm-ash-sugarberry species association are dominated by green ash, Nuttall oak (*Q. texana*), overcup oak (*Q. lyrata*), willow oak, and American elm (*Ulmus americana*). Green ash, sugarberry (*Celtis laevigata*), American elm, and water hickory (*Carya aquatica*) are the most abundant species in the lower canopies of those stands. In contrast, stands characterized by the red oak-sweetgum species association are dominated by willow oak, cherrybark oak, Nuttall oak, swamp chestnut oak (*Q. michauxii*), and sweetgum. Sweetgum, sugarberry, and swamp chestnut oak are the most abundant species in the lower canopies of those stands.

Sampling Design and Data Collected

Within each sample stand, we systematically established a grid of temporary, circular, 0.1-acre plots. Distance between plots along a transect line and distance between transect lines varied from one stand to another, primarily depending

Table 1—Characteristics of sample stands

Stand number	Stand age	County and State	Predominant soil series	Dominant species association
	years			
1	68	Washington, MS	Sharkey clay	Elm-ash-sugarberry
2	80	Oktibbeha, MS	Mathiston silt loam	Red oak-sweetgum
3	65	Oktibbeha, MS	Mathiston silt loam	Red oak-sweetgum
4	54	Sharkey, MS	Sharkey clay	Red oak-sweetgum
5	74	Washington, MS	Sharkey clay	Elm-ash-sugarberry
6	56	Washington, MS	Sharkey clay	Elm-ash-sugarberry
7	78	Washington, MS	Sharkey clay	Elm-ash-sugarberry

on the terrain and the size of the stand. Minimum distance between plots and between lines was 150 feet. Our goal was to sample at least 25 plots in each stand.

Sampling was limited to living hardwood trees ≥5.5 inches d.b.h. Data collected on every sample tree included species, d.b.h., crown class, hardwood tree class as defined by Meadows and Skojac (2008), and the number of epicormic branches on the 16-foot-long butt log. The number of large epicormic branches (>3/8 inch in diameter at the bark surface) and the number of small epicormic branches (≤3/8 inch in diameter at the bark surface) were tallied separately on each tree. Other tree variables, such as crown diameter and crown length, were considered for inclusion in the model, but ultimately were rejected. Crown variables are difficult to measure accurately and consistently in standing hardwood trees because the crowns of most hardwood trees are irregularly shaped, both horizontally and vertically.

Stand-level information, such as site type, forest cover type, estimated stand age, site index, stand density, and stand history was collected for each sample stand. Site index was estimated using the technique developed by Baker and Broadfoot (1979). Stand density was determined for each plot and was expressed as square feet of basal area per acre.

We established 503 temporary, 0.1-acre plots and collected data from 5,106 trees ≥5.5 inches d.b.h. across the 7 sample stands. We then discarded data from trees of species unsuitable for sawtimber production, such as American hornbeam (*Carpinus caroliniana*), winged elm (*U. alata*), boxelder (*Acer negundo*), red mulberry (*Morus rubra*), and eastern hophornbeam (*Ostrya virginiana*). We thus included data from 5,057 trees in our evaluations.

Preliminary Data Evaluation

Data collected from all sample stands were pooled and summarized in a variety of combinations to produce preliminary evaluations of five major characteristics that may influence production of epicormic branches on hardwood trees in undisturbed stands: (1) species, (2) site quality, (3) stand density, (4) tree size, and (5) crown class. The latter four characteristics may be indicators of the degree of stress experienced by individual trees. The influence of each characteristic on the number of existing epicormic branches on the butt log was evaluated separately and in combination with other characteristics. Unfortunately, site quality did not differ sufficiently across our sample stands to allow adequate evaluation. Consequently, the influence of site quality on production of epicormic branches is not addressed in this paper.

RESULTS AND DISCUSSION

Number of Sample Trees by Species

After combining data across the 7 sample stands, there were 12 species with more than 75 observations each—6 oak species and 6 non-oak species (table 2). Nuttall, willow, and overcup oaks were particularly numerous among the oaks,

Table 2—Number of sample trees and Meadows (1995) rating of susceptibility to production of epicormic branches, by species, across seven bottomland hardwood stands in Mississippi

Common name	Scientific name	Susceptibility rating	Trees
			number
Green ash	*Fraxinus pennsylvanica*	Low	716
Nuttall oak	*Quercus texana*	High	674
Willow oak	*Q. phellos*	High	662
Overcup oak	*Q. lyrata*	High	517
Sugarberry	*Celtis laevigata*	Low	513
Sweetgum	*Liquidambar styraciflua*	High	468
American elm	*Ulmus americana*	High	376
Water hickory	*Carya aquatica*	Not rated	273
Swamp chestnut oak	*Q. michauxii*	Medium	205
Eastern cottonwood	*Populus deltoides*	Low	129
Cherrybark oak	*Q. pagoda*	Medium	109
Water oak	*Q. nigra*	High	83
Other merchantable species			332
Total			5,057

while green ash, sugarberry, sweetgum, and American elm were the most numerous non-oak species. The data set also included 332 trees representing 16 different species that had fewer than 75 observations each. The more abundant of these species were common persimmon (*Diospyros virginiana*), black tupelo (*Nyssa sylvatica*), honeylocust (*Gleditsia triacanthos*), and Shumard oak (*Q. shumardii*).

Influence of Species on Production of Epicormic Branches

Species is an important characteristic that influences production of epicormic branches on hardwood trees in undisturbed stands. It is the only one of the five characteristics that is not related directly to the degree of stress experienced by a tree. Meadows (1995) hypothesized that each hardwood species can be associated with a general range of susceptibility to production of epicormic branches. For example, some species may be characterized by an inherently low level of susceptibility, whereas other species may be characterized by an inherently high level of susceptibility. Trees of any given species may exhibit a range of variability within the inherent level of susceptibility associated with that species. It is within this range of variability that stress exerts its influence on any particular tree.

Species varied considerably in their tendency to produce epicormic branches, even in undisturbed stand conditions (fig. 1). Among the 12 species evaluated here, epicormic branches were generally more numerous on oak species than on non-oak species. This general observation appears to be true not only for the total number of epicormic branches on the butt log, but also for the number of both large and small epicormic branches, as defined by Rast and others (1973). However, cherrybark oak had very few epicormic branches and appears to be an exception to this general observation. Based on published information (Burns and Honkala 1990, Putnam and others 1960) and on personal experience and observations, Meadows (1995) qualitatively rated most oaks, including Nuttall, willow, water (*Q. nigra*), and overcup oaks, as highly susceptible to the production of epicormic branches, but rated both cherrybark and swamp chestnut oaks as only moderately susceptible (table 2). To date, our results generally support these ratings, with the exception that we found swamp chestnut oak to be more than moderately susceptible, in contrast with Meadows (1995).

Among the six non-oak species shown in figure 1, green ash, water hickory, and eastern cottonwood had very few epicormic branches on the butt log. The average number of epicormic branches was moderately low on sugarberry and moderately high on sweetgum and American elm. Our results generally agree with the qualitative ratings published by Meadows (1995), who classified green ash, sugarberry, and eastern cottonwood as slightly susceptible to the production of epicormic branches, but classified sweetgum and elms as highly susceptible (table 2). Meadows (1995) did not classify water hickory, but rated a similar species, pecan (*Carya illinoinensis*), as slightly susceptible. Our results tentatively suggest that sugarberry may need to be reclassified as moderately susceptible.

Species also varied substantially in the relative proportions of large and small epicormic branches found on the butt log (fig. 1). Large epicormic branches accounted for roughly 50 percent of the total number of epicormic branches on Nuttall,

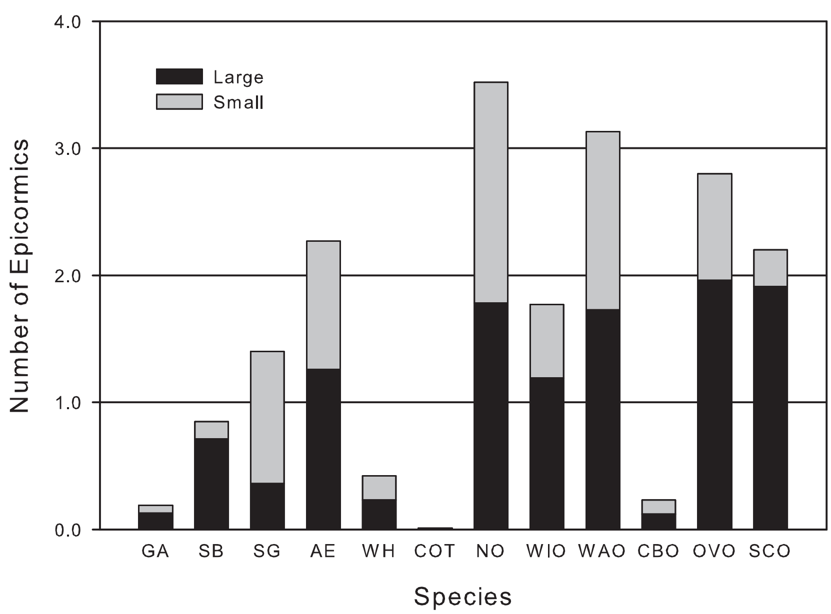

Figure 1—Mean number of large and small epicormic branches on the butt log, by species. Species include green ash (GA), sugarberry (SB), sweetgum (SG), American elm (AE), water hickory (WH), eastern cottonwood (COT), Nuttall oak (NO), willow oak (WIO), water oak (WAO), cherrybark oak (CBO), overcup oak (OVO), and swamp chestnut oak (SCO). Sample sizes are listed in table 2.

water, and cherrybark oaks, as well as on American elm and water hickory. The proportion of large epicormic branches was >50 percent on willow, overcup, and swamp chestnut oaks, as well as on green ash and sugarberry. In contrast, the proportion of large epicormic branches on the butt log of sweetgum was <50 percent.

The relative proportions of large and small epicormic branches observed among these 12 species may be indicative of the expected longevity of the epicormic branches produced on the butt log. If so, species with high relative proportions of large epicormic branches, such as some oaks, may tend to produce epicormic branches that are somewhat persistent. In these species, new epicormic branches produced on the bole tend to survive and persist year after year, even after they have grown large enough to be classified as large epicormic branches. In contrast, species with low relative proportions of large epicormic branches, such as sweetgum, may tend to produce epicormic branches that are more ephemeral. In these species, new epicormic branches produced on the bole tend to survive only a short time and generally die before they grow large enough to be classified as large epicormic branches. More research is needed to evaluate these proposed scenarios.

Our results support the hypothesis proposed by Meadows (1995) that species is an important characteristic affecting the susceptibility of hardwood trees to production of epicormic branches, at least in the 12 species evaluated in this paper. Data collected on the other 16 merchantable species in this study (those with fewer than 75 observations each) were insufficient to permit sound discussion.

Influence of Stand Density on Production of Epicormic Branches

Stand density is another important characteristic that we believe influences production of epicormic branches on hardwood trees in undisturbed stands. There is a general relationship between stand density and the degree of stress experienced by individual trees in a stand. Low to moderate levels of stand density generally do not cause undue stress in most trees in undisturbed stands. However, high stand density produces overcrowded conditions, which lead to intense competition among trees for limited resources. All trees in dense stands experience at least some degree of stress due to overcrowding. In closed stands, large trees have a competitive advantage over small trees, such that the degree of stress suffered as a result of high stand density is typically higher among small trees than among large trees. Meadows (1995) proposed that increased stress lowers tree health and leads to the production of epicormic branches along the boles of hardwood trees, even in undisturbed stands. To evaluate the concept that high stand density in undisturbed stands leads to increased competition, increased stress, reduced tree health, and a subsequent increase in the production of epicormic branches, we compared the average number of large epicormic branches on trees across a wide range of basal area classes, not only for trees of all merchantable species combined but also for trees of four representative species: green ash, sweetgum, Nuttall oak, and willow oak (fig. 2).

Stand basal area had little or no effect on the number of large epicormic branches on trees in undisturbed stands (fig. 2). When averaged across trees of all merchantable species, the number of large epicormic branches remained

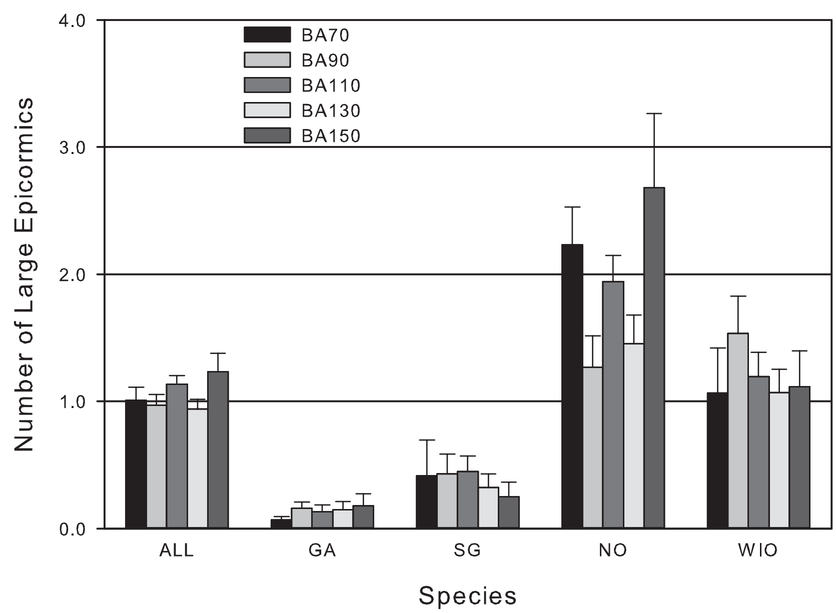

Figure 2—Mean (±SE) number of large epicormic branches on the butt log, by basal area class (square foot per acre), for all merchantable species combined (ALL) and for green ash (GA), sweetgum (SG), Nuttall oak (NO), and willow oak (WIO). Sample sizes are listed in table 2.

nearly constant across the range of basal area classes. We observed the same nearly level pattern in green ash, sweetgum, and, to a lesser extent, willow oak. Nuttall oak, on the other hand, produced more large epicormic branches under conditions of both low stand density and high stand density than it did under conditions of moderate stand density. The number of large epicormic branches on Nuttall oak not only fluctuated across the range of basal area classes, it also varied within each basal area class, as evidenced by relatively high standard errors. Even though it appears that stand density influences production of epicormic branches on Nuttall oak, the degree of variability both within and among basal area classes limits our ability to conclusively assess the role played by stand density in this species.

Results obtained so far in this study tend to disagree with the notion advanced by Meadows (1995) that high stand density imposes stress severe enough to promote the production of epicormic branches on hardwood trees in undisturbed stands, even though data collected on Nuttall oak appear to support the concept. More data clearly are needed to fully evaluate the possible influence that stand density may have on production of epicormic branches in various hardwood species.

Influence of Tree Size on Production of Epicormic Branches

Another important characteristic that may influence production of epicormic branches on hardwood trees in undisturbed stands is tree size. We selected d.b.h. to indicate tree size because it can be measured easily, quickly, and accurately. Other variables, such as crown size and tree height, also indicate tree size, but these traits are difficult and time consuming to measure accurately and reliably. In even-aged stands, tree size may be an indicator of the degree of stress experienced by a tree. In most cases, small-diameter trees are at a competitive disadvantage to large-diameter trees. They often are suppressed by larger trees and therefore have limited growing space and limited access to resources necessary for survival and growth. Meadows (1995) hypothesized that, because small-diameter trees suffer from suppression in even-aged stands, they experience more stress and are less healthy than large-diameter trees. If so, we expect to find more epicormic branches on small-diameter trees than on large-diameter trees, even in undisturbed stands. To assess this idea, we compared the average number of large epicormic branches on trees across four tree size classes: (1) poletimber, 5.5 to 11.9 inches d.b.h.; (2) small sawtimber, 12.0 to 17.9 inches d.b.h.; (3) medium sawtimber, 18.0 to 23.9 inches d.b.h.; and (4) large sawtimber, 24.0 inches d.b.h. and larger. Comparisons among these four tree size classes were made for trees of all merchantable species combined, and for trees of four representative species: green ash, sweetgum, Nuttall oak, and willow oak (fig. 3).

When averaged across all merchantable species, the number of large epicormic branches decreased uniformly with increasing tree size (fig. 3). A similar pattern was observed in Nuttall oak. In both sweetgum and willow oak, the number of large epicormic branches decreased sharply with increasing tree size. For both species, there were many more large epicormic branches on trees in the poletimber class than on trees in the three sawtimber classes. Small-diameter willow oak trees were especially prone to production of epicormic

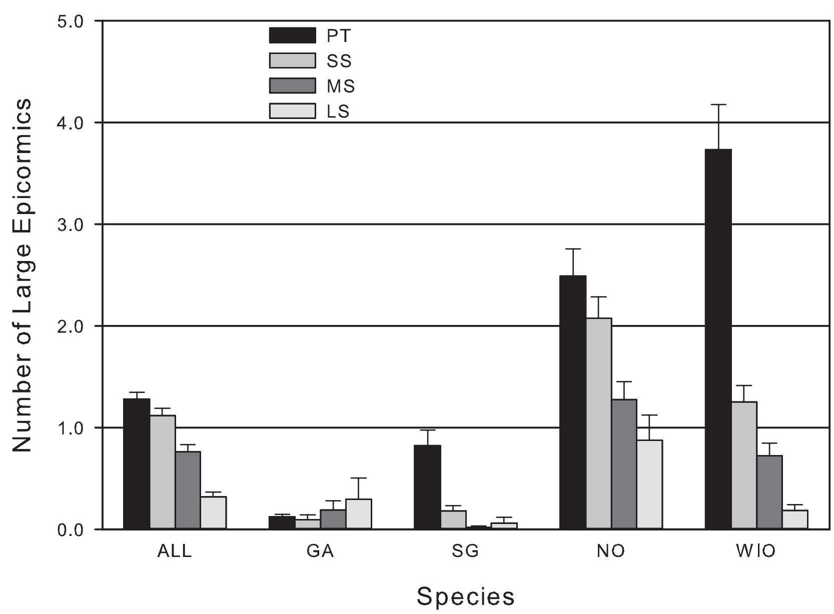

Figure 3—Mean (±SE) number of large epicormic branches on the butt log, by tree size class, for all merchantable species combined (ALL) and for green ash (GA), sweetgum (SG), Nuttall oak (NO), and willow oak (WIO). Tree size classes include poletimber (PT), small sawtimber (SS), medium sawtimber (MS), and large sawtimber (LS). Sample sizes are listed in table 2.

branches, probably an indication that these trees were highly stressed and unhealthy. In contrast, green ash had very few large epicormic branches regardless of tree size.

Our results strongly support the contention proposed by Meadows (1995) that, in undisturbed even-aged stands, small-diameter trees are generally less healthy than large-diameter trees and are therefore more susceptible to the production of epicormic branches. The high level of stress experienced by small-diameter trees is the primary factor that stimulates increased production of epicormic branches. Similarly, the low level of stress experienced by large-diameter trees is insufficient to promote production of epicormic branches.

Influence of Crown Class on Production of Epicormic Branches

Crown class is an extremely important characteristic that influences production of epicormic branches on hardwood trees in undisturbed stands. Crown class is widely recognized as a reliable indicator of the degree of stress experienced by trees in even-aged stands. In general, trees in the dominant and codominant crown classes have large, healthy crowns that promote vigorous tree growth. The level of stress experienced by dominant and codominant trees is generally low. In contrast, trees in the intermediate and overtopped crown classes typically have small, weak crowns that are able to support only minimal tree growth. The level of stress experienced by intermediate and overtopped trees is generally high. Meadows (1995) asserted that healthy trees are much less likely to produce epicormic branches than are unhealthy trees. If so, we expect to find more epicormic branches on trees in the intermediate and overtopped crown classes than on trees in the dominant and codominant crown classes. To evaluate this concept, we compared the average number of epicormic branches on trees across the four crown classes. Initial comparisons were made for both large and small epicormic branches on trees of all merchantable species combined (fig. 4).

When averaged across all merchantable species, the total number of epicormic branches and the average numbers of both large and small epicormic branches clearly increased across the spectrum of crown classes from dominant trees to overtopped trees (fig. 4). Both large and small epicormic branches were especially numerous on overtopped trees. The proportion of large epicormic branches, relative to the total number, remained fairly constant across crown classes and ranged from 52 percent for codominant trees to 63 to 64 percent for trees in the other three crown classes.

To investigate the influence of crown class on production of epicormic branches in more detail, we separated and summarized the data for six commercially important timber species: green ash, sweetgum, and Nuttall, willow, water, and cherrybark oaks (fig. 5). Because there were insufficient data within each species to allow an adequate evaluation across each of the four crown classes, we combined data into two classes: (1) dominant and codominant (D/CD), or upper crown-class trees; and (2) intermediate and overtopped (INT/OT), or lower crown-class trees. We also limited our evaluations to the number of large epicormic branches only. Similar to the trend observed when data were averaged across all merchantable species (fig. 4), the average number of large epicormic branches was substantially greater on lower crown-class trees than on upper crown-class trees of all species except green ash, which had few epicormic branches regardless of crown class (fig. 5). The largest differences

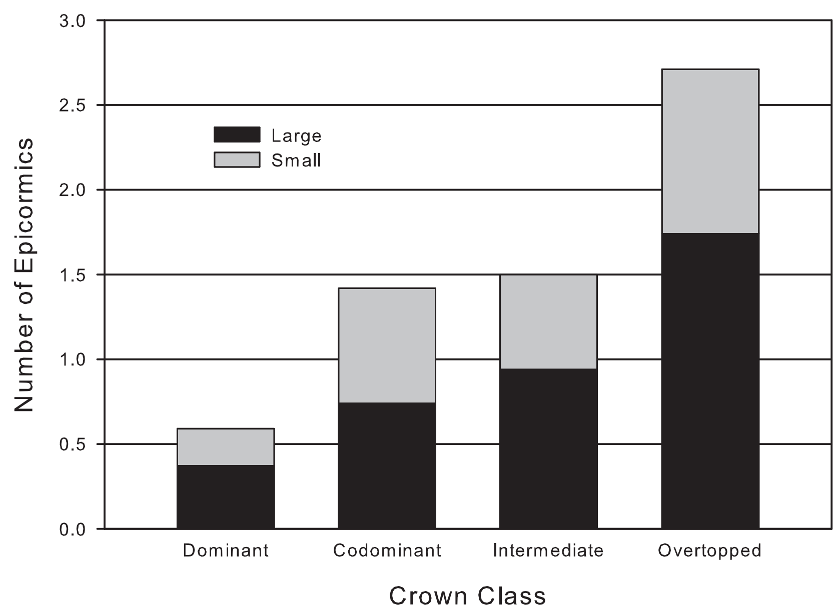

Figure 4—Mean number of large and small epicormic branches on the butt log, by crown class, for all merchantable species combined. Crown classes include dominant (*n* = 458), codominant (*n* = 1,651), intermediate (*n* = 1,606), and overtopped (*n* = 1,342).

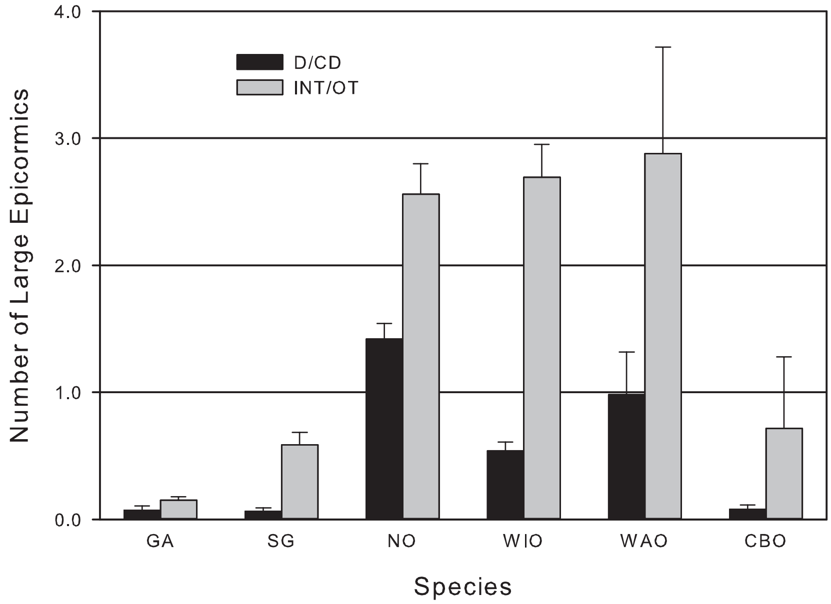

Figure 5—Mean (±SE) number of large epicormic branches on the butt log, by combined crown class, for six commercially important tree species: green ash (GA), sweetgum (SG), Nuttall oak (NO), willow oak (WIO), water oak (WAO), and cherrybark oak (CBO). Combined crown classes include dominant and codominant (D/CD) and intermediate and overtopped (INT/OT). Sample sizes are listed in table 2.

between lower crown-class trees and upper crown-class trees were found on willow and water oaks and, to a lesser degree, on Nuttall oak. An average difference of less than one epicormic branch was observed on both cherrybark oak and sweetgum.

The trends illustrated in figures 4 and 5 clearly demonstrate that the degree of stress experienced by an individual tree, as reflected by its crown class, plays a major role in the production of epicormic branches along the boles of trees of most hardwood species, with the exception of those species, such as green ash, that inherently produce few epicormic branches. As a general rule for most hardwood trees in undisturbed stands, as the level of stress experienced by a tree increases, the propensity of that tree to produce epicormic branches also increases. Our results strongly support the hypothesis advanced by Meadows (1995) that healthy trees under low levels of stress are much less likely to produce epicormic branches than are unhealthy trees under high levels of stress. Our results further demonstrate that crown class accurately and reliably reflects the level of stress experienced by an individual tree. Consequently, crown class appears to be a strong indicator of the propensity of an individual tree to produce epicormic branches in an undisturbed stand.

PRELIMINARY FINDINGS

Results presented in this paper are preliminary. We plan to collect data from perhaps as many as 20 additional sample stands over the next few years. Data from all undisturbed stands eventually will be combined with data from thinned hardwood stands to (1) revise the Meadows (1995) ratings of southern bottomland hardwood species for susceptibility to production of epicormic branches, and (2) develop models to predict epicormic branch production as a function of various tree, stand, and site characteristics in both unthinned and thinned stands. Separate models will be developed for each species and may be developed for different stand conditions and different site types. Our findings to date are:

1. Hardwood species vary considerably in their propensity to produce epicormic branches. Most oak species, except cherrybark oak, produce several epicormic branches, even in undisturbed stands, whereas green ash produces few epicormic branches.
2. Stand density appears to exert little influence on production of epicormic branches by most hardwood species in undisturbed stands. Preliminary results indicate that production of epicormic branches on Nuttall oak, however, may be somewhat sensitive to stand density.
3. In undisturbed, even-aged hardwood stands, production of epicormic branches generally decreases with increasing tree diameter. Small-diameter willow oaks are especially susceptible to the production of epicormic branches.
4. Crown class strongly influences production of epicormic branches in undisturbed hardwood stands. In general, upper crown-class trees produce few epicormic branches, whereas lower crown-class trees produce many epicormic branches. The influence of crown class is most pronounced in trees of highly susceptible

species, such as willow oak, and is least pronounced in trees of resistant species, such as green ash.

5. Our preliminary evaluations support an earlier hypothesis by Meadows (1995) that, in undisturbed hardwood stands, the number of epicormic branches present on the butt log of any given tree is primarily a function of species and the degree of stress experienced by that tree. Crown class appears to be a strong indicator of that degree of stress.

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