EFFECT OF SEASON OF CUTTING ON THE PRODUCTION AND GROWTH OF WHITE AND SHUMARD OAK STUMP SPROUTS IN TENNESSEE

David S. Buckley and Richard M. Evans[†]

ABSTRACT.—The effect of season of cutting on the stump sprouting of white and Shumard oaks was investigated. Replicate plots were cut at 2-month intervals from January through November, 2001. The number of sprouts and the heights and basal diameters of the three tallest sprouts per stump were recorded bi-monthly after cutting. After 4 months of growth following cutting, mean heights of white and Shumard oak sprouts were substantially greater in the September, November, and January cutting treatments than in the May treatment, with nearly a two-fold difference in mean height of Shumard oak sprouts between the September and May treatments. Similarly, mean basal diameters of Shumard oak sprouts were significantly greater in the September and November cutting treatments than in the May treatment. The greatest mean numbers of white and Shumard oak sprouts were produced in the July, September, and November treatments, but differences were not statistically significant. These patterns likely resulted from seasonal differences in stored carbohydrate reserves, and suggest that late summer, fall, and winter cutting is preferable to spring and early summer cutting in order to regenerate oak by coppicing, or to maximize the growth of sprouts from stems damaged during harvesting.

Oak stump sprouts are an important means of regenerating oak stands whenever oak advance reproduction from seed is lacking and survival of oak seedlings and saplings into larger size classes is low due to interspecific competition and additional factors such as deer browsing. The rate of height growth in oak stump sprouts often exceeds that of oak seedlings and saplings originating from seed as a result of the extensive residual root systems of stumps, which contain large amounts of stored carbohydrate reserves (Johnson 1979, Reich et al. 1980, Cobb et al. 1985). The rate of height growth in oak sprouts is very important during the first growing season for establishing their competitive position in the regeneration layer, and also influences the amount of time they are near the ground and are most susceptible to deer browsing and late frosts. The relationship between stump diameter and the rate of stump sprout growth has been investigated in several studies. Sprout growth generally increases as stump diameter increases (Sander 1971, 1972, Johnson, 1979, Reich et al. 1980). The correlation between stump diameter and sprout growth can weaken, however, at diameters greater than 10-20 cm (Johnson 1979, Reich et al. 1980). Working with sprouts from large oak advance reproduction, Sander (1971) recommended ground-line diameters of oak advance reproduction between 1.27 and 2.54 cm in order to produce sprouts with sufficient growth rates to be competitive with sprouts and saplings of other species, yet limited in number. Oak species have a very large number of buds or bud bank that facilitates regrowth of stems, branches, and foliage following a variety of injuries (Ward 1964, Wilson and Kelty 1993). The ability of oak stumps to produce desirable sprouts, however, diminishes with increasing stump diameter and age (Johnson 1977, McGee 1978, Weigel and Johnson 1998). Long-term survival of hardwood stump sprouts is influenced by a number of factors, including intra- and interspecific competition, the type and location of buds producing sprouts, and the ability of the overall sprout clump to maintain the residual root system (Wilson 1968, Kramer and Kozlowski 1979, Johnson et al. 2002). A number of stump sprout thinning or grooming studies (Haney 1962, Lamson 1983, Johnson and Rogers 1984, Lowell et al. 1989) have been conducted to explore means of increasing the growth, form and survival of one or a small number of sprouts on a single stump.

Due to the apparent correlation between stump sprout growth and amounts of carbohydrate reserves stored in residual stump root systems, it can be hypothesized that additional factors affecting amounts of stored reserves could also affect sprout growth, regardless of stump diameter and the associated size of the residual

---

[†]Assistant Professor (DSB), University of Tennessee, Agricultural Experiment Station, Department of Forestry, Wildlife and Fisheries, 274 Ellington Plant Sciences Building, Knoxville, TN 37996-4563; and Superintendent (RME), University of Tennessee, Forestry Experiment Stations, 901 South Illinois Avenue, Oak Ridge, TN 37830. DSB is corresponding author: to contact, call (865) 974-7126 or e-mail at dbuckley@utk.edu.

root system. For example, cutting during months when stored carbohydrate reserves are at their peak should result in the greatest sprout growth rates. Observations of vigorous sprout growth following cutting of oak stems in late summer and early fall provided the impetus for formally testing effects of seasonal differences in cutting on the number and growth of oak stump sprouts produced by sapling-sized white oak (*Quercus alba* L.) and Shumard oak (*Quercus shumardii* Buckl.).

The general objective of this research was to compare effects of cutting in January, March, May, July, September, and November on the production and growth of oak stump sprouts. Specific objectives were to: 1) Test the hypothesis that greater growth per sprout would be obtained with cutting in the fall months (September through November) than in the remaining seasons, 2) To compare the sprout growth response of two congeneric species, white oak and Shumard oak, to cutting in different months, and 3) To investigate relationships between the growth of sprouts and stump basal diameter, and between sprout growth and the point of attachment on the stump.

Study Areas

This study utilized monocultures of 240 white and 240 Shumard oak planted in 1992 for another study in a 41.48 x 75.64 m area located within a level, mown field on the University of Tennessee, Cumberland Forestry Experiment Station (CFES) in Morgan County, Tennessee. The portion of the CFES utilized for this study lies near the base of Little Brushy Mountain, which falls within the Cumberland Mountain section of the Appalachian Plateau Province (Fenneman 1938). Annual weather records for CFES from 1957 to 1989 indicate that the study site receives, on average, 1,462 mm of precipitation annually, and that daily average temperatures in January and July are typically 2.6 and 24.4 °C, respectively. Soils belong to the Lily Loam Series, and are classified as Fine-loamy, siliceous, mesic, Typic Hapludults.

Methods

In 1992, nursery seedlings of each species were planted on a 2.44 x 2.44 m spacing within each 20.74 x 75.64 m rectangular half of the overall 41.48 x 75.64 m area planted. Stems for both species averaged 6 cm DBH prior to implementation of treatments for the present study. Eighteen plots of 10 stems (2 x 5 trees) were delineated within each monoculture (white or Shumard oak) in fall 2000. Prior to treatment implementation, there were no statistically significant differences in mean DBH or mean basal diameter at 17 cm above the ground between any of the 18 white oak or 18 Shumard oak plots. Treatments consisted of 6 cutting dates (January, March, May, July, September, and November 2001) that were assigned at random to the 18 plots for each species. All treatments were assigned to three replicate plots of 10 trees for each species, creating a completely randomized design. Cutting was carried out during the last week of each cutting month. All stems were cut with a chainsaw approximately 15 cm above the ground.

Prior to treatments in fall 2000, DBH of all white and Shumard oak stems was measured to the nearest mm with a diameter tape, and basal diameter of all stems 17 cm above the ground was measured to the nearest cm with calipers. Following implementation of a given treatment and the emergence of stump sprouts, sprout and sprout clump characteristics were quantified during the 2001 and 2002 growing seasons (May-September) on a bimonthly schedule patterned after the treatment schedule. The total number of sprouts produced by each stump were counted, and the 3 tallest sprouts per stump were tagged and measured. Sprout height was measured with a meter stick to the nearest cm between the point of sprout origin on the stump and the terminal bud of the terminal leader. Sprout basal diameter was measured to the nearest mm with vernier calipers 4 cm above the point of sprout origin on the stump. Locations of sprouts on stumps were qualitatively categorized as low, intermediate or high if sprouts originated on the lower third, middle third, or upper third of the stump, respectively.

One-way ANOVA was used to detect differences between treatments in sprout height, basal diameter, and numbers of sprouts after four months of post-cutting growth. Tukey's Honestly Significant Difference (HSD) was used to compare cutting treatment means. Analyses of the effects of cutting treatments on sprout heights, basal diameters, and numbers of sprouts were carried out using plot-level means corresponding to each replicate. Differences between species in sprout heights, basal diameters, and numbers of sprouts were also analyzed within a given cutting treatment using one-way ANOVA and plot-level means. Simple linear regression was used to investigate relationships between stump basal diameter and height of the tallest sprout on each stump. Regression analyses were run both within cutting treatments and with data pooled over all cutting treatments. Analyses of sprout height in relation to position of sprouts on the stump were conducted using plot-level means for each type of sprout (low, intermediate, or high on the stump). Data were pooled over cutting treatments for this analysis, and only height of the tallest sprout on each stump and only plots containing all three types of sprout were included in the analysis. One-way ANOVA was used to detect differences in sprout height between low, intermediate, and high positions on stumps. Tukey's HSD was used to compare treatment means. Fourth-month measurements of sprouts originating from stumps cut in May 2001 were missed due to the use of a slightly different measurement schedule in the first year of the study. As a result, all analyses of sprout heights and basal diameters described above were conducted using estimates of height and basal diameter for white and Shumard oak sprouts for the May treatment. These estimates were calculated by averaging height and basal diameters taken 3 and 6 growing-season months after cutting. All statistical analyses were carried out with alpha equal to 0.05.

Results

After 4 months of post-cutting growth, mean heights of white oak sprouts were greatest in the September, November, and January cutting treatments (Figure 1a). Mean height of white oak sprouts was least in the May cutting treatment, and significantly less in this treatment than in the January and September cutting treatments. Mean height of Shumard oak sprouts in the September cutting treatment was nearly twice that of mean height in the May treatment (Figure 1a). Mean heights of Shumard oak sprouts were significantly greater than those of white oak within the July, September, and November cutting treatments, and the trend in heights of Shumard oak across treatments was similar to that of white oak, with the exception of the July cutting treatment.

No statistically significant differences in mean basal diameter of white oak sprouts were indicated by ANOVA and Tukey's HSD, but mean basal diameters of Shumard oak sprouts in the September and November treatments were significantly greater than in the January, March, May, and July treatments (Figure 1b). The greater basal diameter growth of Shumard oak sprouts on stumps cut during the dormant season than on stumps cut during the growing season and a similar trend in white oak were consistent with height growth in these species (Figures 1a, 1b). Mean basal diameters of Shumard oak sprouts were significantly greater than those of white oak within the July, September, and November cutting treatments.

White oak produced roughly twice the mean number of sprouts per stump produced by Shumard oak across most treatments (Figure 1c). This difference in sprout production between the two species was statistically significant within the March, May, July, and November treatments. Differences in the mean number of sprouts between cutting treatments were not statistically significant for either species, although the trend toward the least number of sprouts produced in the March and May treatments was fairly consistent with the patterns of sprout height and diameter growth in each species.

In all treatments combined, there were significant positive linear relationships between mean sprout heights of white and Shumard oak and stump basal diameter (Figures 2a, 2b). Coefficients of determination, however, were fairly low (Figures 2a, 2b). Regression analyses conducted within cutting treatments also indicated significant positive relationships between sprout heights and stump basal diameters within most cutting month treatments, and coefficients of determination ranged from 0.30 to 0.52. Overall, mean height of Shumard oak sprouts increased more rapidly with increases in stump basal diameter than mean height of white oak sprouts (Figures 2a, 2b).

In all treatments combined, mean height of white oak sprouts was significantly greater in sprouts originating high on the stump than those originating low on the stump near the root collar (Figure 3). The pattern of Shumard oak sprout heights in relation to position on the stump was very similar to that of white oak, but differences were not statistically significant.

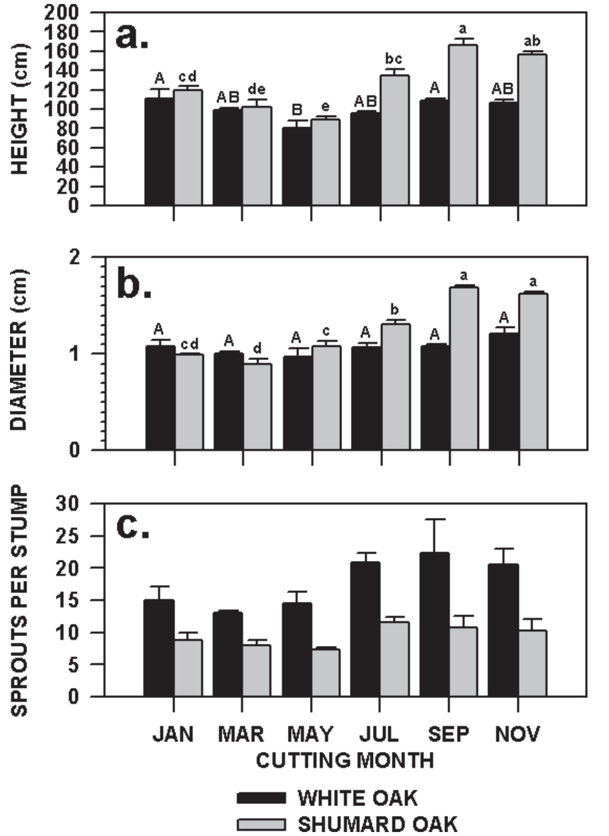

Figure 1.—Mean a.) sprout height, b.) basal diameter, and c.) number of sprouts per stump after 4 months of post-cutting growth in relation to cutting month. Means with the same letters are not significantly different at the alpha = 0.05 level of significance, and no statistically significant differences occurred in numbers of sprouts between treatments.

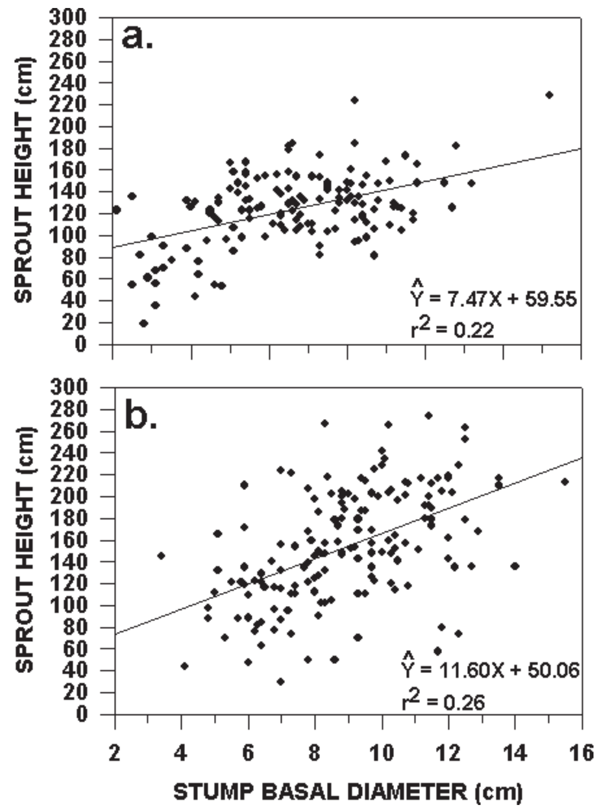

Figure 2.—Relationship between stump basal diameter at 17 cm above the ground and height of the tallest sprout per stump after 4 months of post-cutting growth in a.) white oak and b.) Shumard oak.

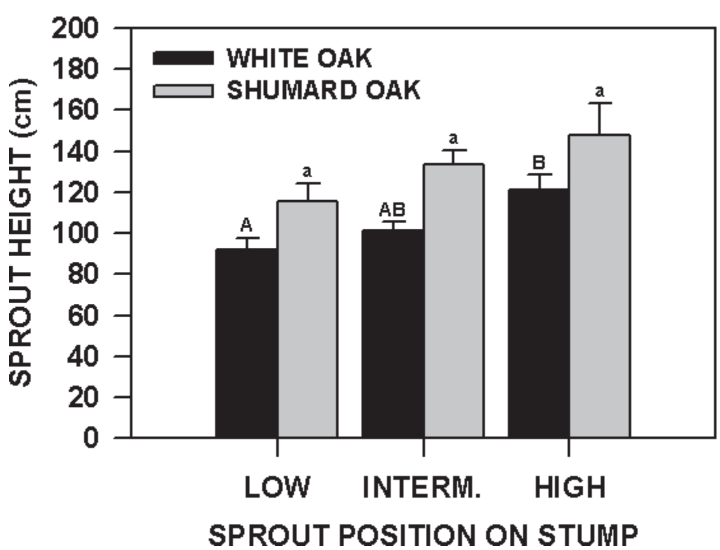

Figure 3.—Mean sprout height after 4 months of post-cutting growth by position on the stump. Means with the same letters are not significantly different at the alpha = 0.05 level of significance.

Discussion

The patterns of height growth, basal diameter growth, and numbers of sprouts observed across cutting months suggest that the overall sprouting capacity of white and Shumard oak stumps was greatest in individuals cut in late summer, fall, and winter. These results are consistent with patterns observed in the sprouting of blackjack oak (*Quercus marilandica* Muenchh.) girdled in different months of the year in Missouri, which Clark and Liming (1953) attributed to differences in the amount of stored carbohydrate reserves available for sprout growth over the course of the year. Wendel (1975) observed greater height growth of red oak (*Quercus rubra* L.) sprouts from stumps cut in the dormant season than sprouts from stumps cut during the growing season, although this difference diminished and was not statistically significant after 10 years.

White and Shumard oak responded similarly to the treatments, but not identically, as evidenced by significantly fewer and larger sprouts produced by Shumard oak than white oak in some treatments. Little (1938) noted a similar difference in which white oak and post oak (*Quercus stellata* Wangenh.) stumps produced greater numbers of smaller sprouts than members of the Red Oak Group, which includes Shumard oak. In addition, height growth of Shumard oak sprouts was significantly greater in the September than in the January cutting treatment, whereas this was not the case in white oak. The greater height and basal diameter growth of Shumard oak in the September and November cutting treatments supports the hypothesis that greater growth per sprout will be obtained if this species is cut in these fall months.

Although coefficients of determination were fairly low, results of the regressions indicate that stump basal diameter is a reasonable predictor of sprout growth in white and Shumard oak. The distribution of data points around the regression line for white oak across the range of stump diameters included in the study indicates that the relationship between stump diameter and sprout height did not weaken as white oak stump diameters approached the 10 cm range, in contrast to results reported by Reich et al. (1980).

The significantly greater height growth of white oak sprouts located high on the stump compared with those low on the stump and the similar but non-significant differences in Shumard oak in relation to stump position suggest that sprouts originating high on the stump were supplied with greater amounts of resources for growth than those originating low on the stump near the root collar. Dormant buds closer to the root collar are older than those higher up on the bole, and the chances of breaks in bud traces tend to increase with age (Smith et al. 1997). Sprouts high on the stump were much more rare than those with low and intermediate points of attachment. Many plots contained only 1-3 measured sprouts that were high on the stump, so these results are based on relatively few sprouts high on the stump per plot and should be interpreted with caution. Although the possibility of greater initial height growth of sprouts originating high on the stump exists, these sprouts are more likely to produce trees with poor form and decay than sprouts lower on the stump (Smith et al. 1997).

Whether sprouts of hardwood competitors of the oak species studied respond similarly to season of cutting remains an important question. Schier and Zasada (1973) documented a positive relationship between the mass of trembling aspen (*Populus tremuloides* Michx.) suckers and amounts of stored reserves. Wilson (1968) observed more rapid growth in red maple (*Acer rubrum* L.) sprouts from stumps cut in the winter than during the growing season, although levels of overstory competition for the two sets of red maple sprouts were described as being very different. Much heavier overstory competition may have contributed to reduced growth of sprouts from stumps cut during the growing season (Wilson 1968). Wenger (1953) observed a different pattern in sweetgum (*Liquidambar styraciflua* L.) in which sprouting was also reduced late in the growing season despite large amounts of stored reserves in the roots, and attributed this to the action of growth regulators.

An important component of the Brose and Van Lear (1998) shelterwood-burn technique for favoring oak over competitors such as yellow-poplar (*Liriodendron tulipifera* L.) and red maple is to burn in the spring in order to maximize the sprouting disadvantage of these species relative to oak species, which invest more heavily in root systems and stored reserves. If cutting alone is used to regenerate stands and yellow-poplar and red maple behave similarly to the oak species we have studied in their response to season of cutting, it may be beneficial to cut the oak in the fall and delay cutting of these competitors until the spring. Such a technique may be difficult to implement, however, due to potential damage to the developing oak sprouts and other practical concerns. If sweetgum is a dominant competitor and behaves consistently as in Wenger's (1953) study, cutting both oak and sweetgum in the fall would maximize height growth of oak sprouts and coincide with the period of reduced sprouting in sweetgum.

Clearly, these results are short-term, and the long-term survival of sprouts and persistence of these differences in height growth over time remain to be quantified. Shifts in the dominance of red oak sprouts on the same stump have been observed, as well as diminishing differences over time between the heights of red oak sprouts originating from stumps cut during the dormant season and those originating from stumps cut during the growing season (Wendel 1975). It can be argued, however, that rapid first-year height growth of oak stems is critical for subsequent survival of sprouts and sprout clumps on many sites, particularly when competition for light, browsing, and frost damage are intense near the ground. Continued monitoring is planned.

Acknowledgment

We are grateful to Brien Ostby, Research Assistant, for spending many long hours in the field capturing data on large populations of oak sprouts, and to Martin Schubert, Manager of the Cumberland Forestry Experiment Station, for implementing the treatments and monitoring the study site. This study was made possible by McIntire-Stennis funds.

Literature Cited

Brose, P.H.; Van Lear, D.H. 1998. **Responses of hardwood advance regeneration to seasonal prescribed fires in oak-dominated shelterwood stands.** Canadian Journal of Forestry Research 28:331-339.

Cobb, S.W.; Miller, A.E.; Zahner, R. 1985. **Recurrent shoot flushes in scarlet oak stump sprouts.** Forest Science 31:725-730.

Fenneman, N.M. 1938. **Physiography of the eastern United States.** McGraw-Hill, New York. 714. p.

Haney, G.P. 1962. **Growth of thinned white oak sprouts.** Journal of Forestry 60:644-645.

Johnson, P.S. 1977. **Predicting oak stump sprouting and sprout development in the Missouri Ozarks.** USDA For. Serv. North Central Forest Experiment Station Res. Pap. NC-149. 11 p.

Johnson, P.S. 1979. **Shoot elongation of black oak and white oak sprouts.** Canadian Journal of Forestry Research 9:489-494.

Johnson, P.S.; Rogers, R. 1984. **Predicting 25th-year diameters of thinned stump sprouts of northern red oak.** Journal of Forestry 82:616-619.

Johnson, P.S.; Shifley, S.R.; Rogers, R. 2002. **The ecology and silviculture of oaks.** CABI Publishing, New York. 503 p.

Kramer, P.J.; Kozlowski, T.T. 1979. **Physiology of woody plants.** Academic Press, New York. 811 p.

Lamson, N.I. 1983. **Precommercial thinning increases diameter growth of Appalachian hardwood stump sprouts.** Southern Journal of Applied Forestry 7:93-97.

Little, S. 1938. **Relationships between vigor of resprouting and intensity of cutting in coppice stands.** Journal of Forestry 36:1216-1223.

Lowell, K.E.; Garrett, H.E.; Mitchell, R.J. 1989. **Early thinning can improve your stand of coppice-regenerated oak.** USDA For. Serv. North Central Forest Experiment Station Gen. Tech. Rep. NC-132. 6 p.

McGee, C.E. 1978. **Size and age of tree affect white oak stump sprouting.** USDA For. Serv. Southern Forest Experiment Station Res. Note SO-239. 2 p.

Reich, P.B.; Teskey, R.O.; Johnson, P.S.; Hinckley, T.M. 1980. **Periodic root and shoot growth in oak.** Forest Science 26:590-598.

Sander, I.L. 1971. **Height growth of new oak sprouts depends on size of advance reproduction.** Journal of Forestry 69:809-811.

Sander, I.L. 1972. **Size of oak advance reproduction: key to growth following harvest cutting.** USDA For. Serv. North Central Forest Experiment Station Res. Pap. NC 79. 6 p.

Schier, G.A.; Zasada, J.C. 1973. **Role of carbohydrate reserves in the development of root suckers in *Populus tremuloides*.** Canadian Journal of Forest Research 3:243-250.

Smith, D.M., B.C. Larson, M.J. Kelty, and P.M.S. Ashton. 1997. **The practice of silviculture: Applied forest ecology.** Wiley & Sons, New York. 537 p.

Ward, W.W. 1964. **Bud distribution and branching in red oak.** Botanical Gazette 125:217-220.

Weigel, D.R., and P.S. Johnson. 1998. **Stump sprouting probabilities for southern Indiana oaks.** USDA For. Serv. North Central Research Station Tech. Brief NC-7. 6 p.

Wendel, G.W. 1975. **Stump sprout growth and quality of several Appalachian hardwood species after clearcutting.** USDA Forest Service Northeastern Forest Experiment Station Res. Pap. NE-329. 9 p.

Wenger, K.F. 1953. **The sprouting of sweetgum in relation to season of cutting and carbohydrate content.** Plant Physiology 28:35-49.

Wilson, B.F. 1968. **Red maple stump sprout development the first year.** Harvard Forest Paper 18.

Wilson, B.F.; Kelty, M.J. 1993. **Shoot growth from the bud bank in black oak.** Canadian Journal of Forestry Research 24:149-154.