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Top-Pruning Bareroot Hardwoods: A Review of the Literature

David B. South

Professor, Auburn University, School of Forestry, Alabama Agricultural Experiment Station, Auburn University, Alabama

Top-pruning hardwoods before lifting reduces the costs involved with lifting, packing, storing, shipping and planting. This practice also decreases the chance of dieback. For some sites (and some years), top-pruning will increase the probability of survival. Top-pruning hardwoods does not seem to reduce average heights after 5 years in the field and this practice will often increase early height growth. For several species, top-pruning before transplanting appears to have no long-term effect on stem form. There are no reported longterm effects of top-pruning on seedling physiology. This paper reviews research studies that have been published over the last 60 years. Tree Planters' Notes 47(1):34-40; 1996.

Top-pruning or top-clipping ("heading back" in horticultural terms) is a common practice employed by several nursery managers in the southern United States (figure 1). An informal survey of 13 hardwood nurseries determined that 9 managers used top-pruning as a routine practice. Some managers prune about 1 month before lifting, whereas others prune in early fall. There are three main reasons nursery managers top-prune hardwood seedlings:

- to decrease lifting, packing, and shipping costs
- to reduce the chance of stem dieback after planting
- to increase the chance of survival

Figure 1— *Top-pruning hardwoods (photograph courtesy of Sam Campbell, nursery manager, Kimberly-Clark Corp., Elberta, AL).*

In this paper, research studies published over the last 60 years are reviewed to enable managers to make informed decisions about top-pruning (figure 2). A sickle-bar mower is the favored type of mechanical pruner because it makes a relatively clean cut. The following statements from nursery managers describe the details of its use. Stauder (1995) tells us that:

> Some nurseries such as those in Wisconsin top prune hardwood seedlings. The 2-0 hardwood seedlings are top pruned, if necessary, to a height of 12 to 14 inches during the late summer or early fall. Some extremely fast growing species such as sycamore, elderberry or sumac may need to be top pruned during the 1st-year of growth to control height. No major problems have been observed by

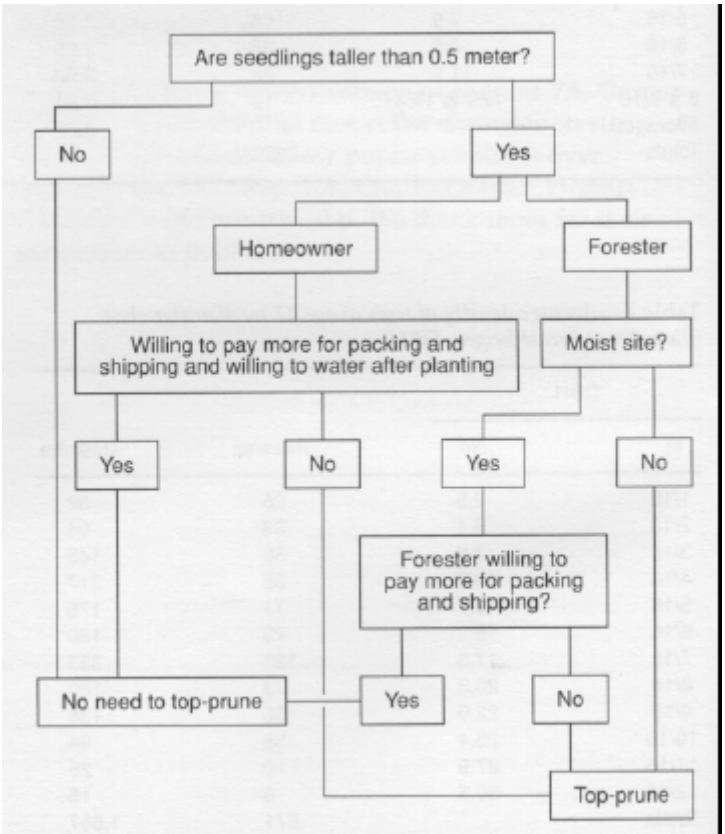

Figure 2—*Flow chart to assist in the decision to top-prune hardwoods.*

> top pruning alternate branching species; however, nursery managers do not top prune opposite branching species such as green ash or white ash, because severe forking may result.

Sam Campbell, a nursery manager with a nursery in south Alabama, recently wrote (1992) that:

> Top pruning is used to control the height growth of seedlings. A [sickle]-bar mower was modified to top clip seedlings at height of 2-2.5 feet above the seedbeds. Top pruning is performed throughout the growing season to maintain even height growth and reduce the number of overtopped and cull seedlings. The tractor speed and blade sharpness [are] critical to make clean cuts and not tear seedlings. After mowing we apply a fungicidal spray to reduce infections on freshly cut surfaces.

One rationale for top-pruning is that few hardwood nursery managers have the luxury of knowing in advance the types of sites where their seedlings will be shipped. Even fewer can accurately predict the weather that will occur after their seedlings are outplanted. Therefore, many managers use various nursery practices that will improve the likelihood of achieving good survival on droughty sites or with spring droughts. As a form of insurance, many nursery managers will top-prune their seedlings to improve the chance of survival and growth under stressful conditions. Typically for hardwood species, the taller the seedling in the nursery, the more difficult it is to get enough roots lifted to minimize transplant shock. The harvested ratio of root dry weight to tree dry weight is higher for top-pruned seedlings than for non-top-pruned seedlings. "Usually the amateur is disinclined to cut back a plant for fear of injuring it, but this pruning is essential in order to promote vigor, and better growth will follow" (Duruz 1953). For some hardwoods, top-pruning (to a height of 20 cm above the root-collar) is a recommended nursery practice (Johnson and others 1986; Ladrach 1992). Therefore, in some studies, all seedlings are routinely top--pruned before outplanting (Filer and Nelson 1987, Hix and others 1994, Mohan and others 1990, Woessner 1972).

Expense of Lifting, Storing, and Shipping Tall Hardwoods

Tall bareroot hardwoods are often cumbersome to lift and expensive to bundle, transport and plant (Woessner 1972). Several researchers have suggested the solution to this problem is top-pruning (Briscoe 1969, Limstrom 1963, Woessner 1972). How much money foresters and companies are willing to spend to plant non-pruned seedlings may depend largely on the size of the area planted. If the area is small, then the nuisance of planting a few tall seedlings is minimal. However, as the acreage increases, the nuisance increases. For example, if it costs $8/thousand more to bundle and store, and an additional $35/ha to ship and plant, then it only costs about $45/ha more. This might not seem like much for 10 ha ($450 more), but it would amount to $45,000 for 1,000 ha. As acreage increases, questions about the need to spend extra money for non-pruned seedlings increases. The following quote by Limstrom (1963) can be found in the handbook "Forest Planting Practice in the Central States."

> Top pruning has no detrimental effect on survival and growth of yellow-poplar and perhaps most other hardwoods; however, some forked trees may develop after top pruning of opposite-budded species such as ash and maple. Packing and shipping are cheaper if hardwood seedlings are top-pruned just after lifting in the nursery. And more top-pruned than unpruned trees can be carried in a planting tray.

Nursery managers who sell seedlings to the public may choose to leave some hardwoods unpruned. Often the uninformed consumer is more concerned with the appearance of the seedling than with reducing the risk of mortality or dieback. Most homeowners irrigate newly transplanted seedlings, which reduces the risk of transplanting stress. Therefore, managers who wish to sell to the public may decide to offer two different stock types (tall unpruned seedlings and short top-pruned seedlings). Tall seedlings might be sold to homeowners for 33 cents each and top-pruned seedlings for reforestation might be sold for 30 cents each. A flowchart like the one in figure 1 can aid nursery managers in deciding if they should top-prune hardwoods.

Timing of Top-Pruning

In the southern United States, the typical season for top-pruning pines is during the summer months (from June through September) whereas fall (October to December) is the traditional time for top-pruning hardwoods. For fast growing species like sycamore (*Platanus occidentalis* L), some nursery managers will begin top-pruning in July (Briscoe 1969). In Alabama, 2 managers top-prune hardwoods several times throughout the summer months (figure 1). However, there are only a few studies that report the effects of timing on subsequent growth after transplanting. In a study of northern red oak *(Quercus rubra* L.), seedlings were given a

severe top-pruning treatment (cutting stems back to the groundline). By April (1 month after transplanting), green weights of roots were reduced by 60% or more if top-pruning was done from August to October. However, there was little or no reduction in root growth due to top-pruning if it was done in November, December, or January. Therefore, researchers tend to top-prune seedlings after lifting at time of transplanting (Adams 1985, Johnson and others 1984, Meadows and Toliver 1987, McCreary and Tecklin 1993, Russell 1973, Smith and Johnson 1981, Zaczek and others 1993). Top-pruning woody shoots after leaf fall appears to have no adverse effects (Briscoe 1969) and allows hardwood seedlings to develop large root systems in the nursery.

Short-Term Effects on Physiology

There is only limited information on the effects of top-pruning on hardwood seedling physiology and the results vary with each study. Some researchers have employed extreme top-pruning treatments in order to show a significant treatment effect. However, most studies show ephemeral effects on seedling physiology. Because data are limited, it may be prudent not to generalize the results to all hardwood species. The following is a summary of a few reports.

Crunkilton and others (1992) examined the effects of top-pruning on northern red oak physiology (photosynthetic photon flux density, photosynthesis, transpiration, stomatal conductance, leaf water potential at predawn, and leaf temperature). Shoots of unpruned bareroot seedlings were 56 cm tall. At time of planting, these were top-pruned to 20 cm. Top-pruning seedling shoots before planting had little effect on measured physiological processes.

Transpiration, stomatal conductance and total water use were recorded in a greenhouse study using root or shoot-pruned seedlings of apple *(Males pumila* Mill.), littleleaf linden *(Tilia cordata* Mill.), and silver birch *(Betula pendula* Roth) (Abod and Webster 1990). In this study, top-pruning (removing two-thirds of the shoot) reduced water use for the first 5 weeks after potting. All seedlings were watered twice each day, so apparently all 24 seedlings/ species survived. Top-pruning had no significant effect on stomatal conductance of the linden and birch. For 2 of the 5 sampling periods, top-pruned apple seedlings had more conductance than did control seedlings. Partly because there were only 6 seedlings/ treatment combination, there was no significant effect of toppruning on either shoot growth or root growth of birch. However, shoot-pruning did reduce new root growth of both apple and linden.

Johnson and others (1984) examined the effect of top-pruning on root growth potential of northern red oak. Unpruned (large) 1+0 seedlings were 99 cm tall and toppruned seedlings were 15 cm tall. Top-pruning had no significant effect on new roots, new root weight, or new shoot length. However, only 8 trees were used for each treatment. Larson (1975) reported similar results with root growth when shoots were pruned to 46 cm above the root collar at time of lifting.

The effects of top-pruning on budbreak of black cherry *(Prunes serotina* Ehrh.) was examined in a greenhouse in Tennessee (Farmer and others 1975). Unpruned 1+0 seedlings (heights not reported) were compared to seedlings that were pruned to 6 cm above the rootcollar. Top-pruning significantly increased rate of budbreak.

Dieback After Outplanting Unpruned Hardwoods

Under certain conditions, bareroot hardwood seedlings will die back during the first year after outplanting. For example, northern red oak seedlings (ranging in height from 45 to 66 cm) exhibited dieback on 3 sites for 2 years after planting (Kaczmarek and Pope 1993). On 1 site, the amount of dieback was almost half the original height. Overall, root pruning after lifting resulted in an increase in dieback. To reduce the chance of dieback on this site, it may be appropriate to increase the root weight ratio by top-pruning rather than decrease the ratio by root pruning after lifting. For some species such as yellow-poplar *(Liriodendron tulipifera* L.), new root growth of seedlings transplanted in May can be increased by top-pruning to a height of 15 or 30 cm (Kelly and Moser 1983). This might occur if a tall "unbalanced" seedling produced less foliage than a shorter, top-pruned seedling. If foliage production is reduced (due to moisture stress or dieback), there would likely be a reduction in the amount of current photosynthate available for new root growth. This might explain why roots of top-pruned yellow-poplar seedlings grew more during May, June, and July than at other times (Kelly and Moser 1983).

Tall, non-top-pruned sweetgum *(Liquidambar styraci*flua L.) may die-back when planted on sandy soils. In a study by Kormanik (1986), the percentage dieback in June was related to root-collar diameter (RCD) and the number of lateral roots. Large-diameter seedlings with 13- to 14-mm RCD and more than 6 lateral roots have greater survival and less dieback than small diameter seedlings with 7- to 8-mm RCD and less than 4 lateral roots. However, for a given RCD, taller seedlings tend to die back more (and have less survival) than shorter seedlings. When outplanting 14-mm-RCD sweetgum that were 1.1 m tall, the average length of dieback ranged from 40 to 55 cm. At the end of the first grow-

ing season, heights were less than at time of planting. Dieback is nature's way of top-pruning transplanted hardwoods.

Growth from these dead tops would likely be no different than if the sweetgum seedlings were top-pruned 4 months after outplanting (in June) to a height of 55 to 70 cm. It is conjectured that pruning to this height in the nursery would allow: (1) reduced transplanting stress; (2) greater seedling survival; and (3) positive height growth from planting till June.

Increases in Survival From Top-Pruning

On moist sites where survival is high (>90%), top-pruning of hardwoods will likely not increase survival. In many research trials, there is no significant effect of top-pruning on survival. However, as site conditions worsen and as survival decreases, top-pruning in the nursery can improve the chances of survival (table 1). Selected top-pruning studies are summarized in the following paragraphs.

In Oklahoma, Smith and Johnson (1981) found that top-pruning at transplanting (50% top removal) increased survival of pecan by 25%. In Louisiana, Meadows and Toliver (1987) top-pruned pecan— *Carya illinoensis* Wangenh. (Koch)— seedlings back to a height of 25 cm immediately after planting. On one site, there was no difference in survival (91 %) but on another site with more competition, survival of top-pruned seedlings was 94% whereas the check exhibited 85% survival.

In Saskatchewan, green ash *(Fraxinus pennsylvariica* Marsh.)) and choke cherry *(Prunus virginiana* L.) seedlings are pruned to a uniform height of 46 cm to facilitate mechanical harvesting and sorting operations (Anonymous 1984). Although this practice has been carried out at the Indian Head Nursery for many years, there was no information on the effect of top-pruning on outplanting performance. Therefore, a study was established where 2+0 seedlings were top-pruned to a height of 46 cm. First-year survival of the top-pruned green ash (97%) was significantly higher than that of the non-pruned seedlings (80%). The rate of bud break was significantly higher for the top-pruned seedlings. Top-pruning of choke cherry seedlings had no significant effect on survival or bud break.

In Mississippi, Meginnis (1940) examined several top-pruning treatments for black locust *(Robinia pseudoacacia* L.). The best survival was obtained from seedlings pruned to 23 cm in the fall at lifting (82%); seedlings cut back to 23 cm in the spring at planting (82%); and the 46 cm unpruned checks (79%). Top-pruning seedlings all the way back to the root-collar caused a significant decrease in survival (55 to 70%). Although top-pruning back to the root-collar has been studied by several researchers, this severe treatment is neither a common nursery practice nor a recommended practice.

Table 1—*Effect of top-pruning of bareroot seedlings on field survival of various hardwood species*

	Outplanting height (cm)		% Survival				
Species	Control	Top-pruned	Control	Top-pruned	Difference	Significance	Reference
pecan	?	15	99	93	-6	ns	Toliver and others (1980)
willow oak	?	15	97	97	0	ns	Toliver and others (1980)
green ash	30-46	10	96?	96?	?	—	Woessner & van Hicks (1973)
water oak	?	15	94	100	+6	ns	Toliver and others (1980)
pecan	?	25	91	91	0	ns	Meadows & Toliver (1987)
yellow-poplar	46	10	90+	90+	?	—	Sterling & Lane (1975)
yellow-poplar	45	30	92	92	0	ns	Dierauf & Garner (1993)
yellow birch	?	8	90	79	-11	—	Godman & Mattson (1972)
n. red oak	21-57	10-12	85	85	0	ns	Zaczek and others (1993)
pecan	21	25?	85	93	+8	ns	Meadows & Toliver (1987)
blue oak	25-30	15	81	81	0	ns	McCreary & Tecklin (1994)
green ash	?	45	80	97	+17	**	Anonymous (1984)
choke cherry	?	45	80	78	-2	ns	Anonymous (1984)
black locust	46	23	79	82	+3	ns	Meginnis (1940)
black walnut	45	15	74?	74?	?	—	Russell (1979)
pecan	150	75	75	100	+25	—	Smith and Johnson (1981)
yellow birch	?	8	50	92	+42	—	Godman & Mattson (1972)
yellow poplar	60	15	0	0	0	—	Kelly & Moser (1983)

** = significant at the 1% level of probability; ns = no significant difference; — = statistics not reported; ? = data not reported.

Increases in Growth From Top-Pruning

Top-pruning of bareroot hardwoods before transplanting will often increase early height growth. In many cases, total height after 3 or more years in the field is no different for top-pruned than for non-pruned seedlings (Briscoe 1969). However, in a few studies, the growth of top-pruned seedlings surpasses that of non-pruned seedlings. This might result on sites where tall, non-pruned seedlings never fully recovered from the shock of transplanting. When "natural" top-pruning occurs (for example, deer browse after outplanting), hardwoods often grow well after winter browsing (Jacobs 1969, Wilson 1993). Selected studies in which height growth was increased are reviewed in the following paragraphs.

In California, McCreary and Tecklin (1994) conducted a top-pruning study on blue oak– *Quercus douglasii* Hook. & Arn. Seedlings were immediately top-pruned after planting to a 15-cm height and were compared with unpruned seedlings (25 to 30 cm tall). Survival was the same for both treatments (table 1). After 2 years of growth, the top-pruned seedlings were 10 cm taller than the unpruned seedlings because they grew more during the first and second year after outplanting. The top-pruned seedlings were also larger in diameter.

In Louisiana, water oak (*Quercus nigra* L.) seedlings were planted and then were either left unpruned (46 cm tall) or pruned to 23 cm or 2.5 cm from the root-collar (Adams 1985). After 2 years, the 2.5-cm treatment had not yet equaled the total height of the check (were 12 cm shorter), but they were growing at a much faster rate and appeared to be in a higher state of vigor than unpruned seedlings. For this treatment, height growth during the first 2 years was 52% greater than for the unpruned seedlings.

In South Carolina, yellow-poplar seedlings were lifted and then either left unpruned or were pruned 10, 15, or 20 cm from the root-collar (Sterling and Lane 1975). After 1 year in the field, growth of seedlings receiving no root-pruning was inversely related to height after top-pruning. On the better site, the 10-cm treatment had the most height growth (107 cm) and the control treatment had the least (93 cm). Overall, height growth was reduced by pruning roots after lifting.

In Tennessee, black walnut *(Juglans nigra* L.) seedlings were top-pruned immediately before planting to 15 cm above the root-collar, whereas control seedlings were about 46 cm tall. Annual growth of top-pruned seedlings was significantly better during the first 3 years after planting. During these dry years, top-pruned seedlings grew almost 5 times faster than unpruned seedlings (Russell 1979).

In Tennessee, northern red oak seedlings were toppruned at time of planting to 13 cm above the root-collar whereas control seedlings were about 25 cm tall (Russell 1973). Annual growth of top-pruned seedlings was as good as control seedlings. On a plateau site, both treatments were 1.3 m tall after 5 years. On a cove site, top-pruned seedlings were 1.2 m tall and control seedlings were 1.3 m tall. Top-pruning of tops stimulated the formation of multiple leaders but this had no serious long-term effects.

In Texas, green ash seedlings were top-pruned to 10 cm or 20 cm above the root-collar at time of planting. Control seedlings were about 30 to 46 cm tall (Woessner and van Hicks 1973). After 3 years, height of top-pruned seedlings (3.23 m) was as good as control seedlings (3.20 m).

In Oklahoma, pecan seedlings were top-pruned to 75 cm above the root-collar at time of transplanting. Control seedlings were about 150 cm tall (Smith and Johnson 1981). After 2 years, total shoot growth of top-pruned seedlings (3.1 m) was greater than non-pruned seedlings (1.97 m).

Top-Pruning and Tree Form

Some have expressed the view that top-pruning hardwoods will always result in poor tree form. However, field checks with sycamore have failed to show that top-pruning increases the proportion of forked stems (Briscoe 1969). Stem form will likely be unimportant for pulpwood. For example, some organizations use short-rotations where 6-year-old sweetgum are top-pruned (that is, harvested) to a 15-cm stump and allowed to sprout back. These sprouts are later harvested for pulpwood. According to Dr. Stienbeck at the University of Georgia, sweetgum has strong apical dominance. After 6-year-old trees are coppiced, a stump may have 12 to 24 sprouts the first year; 6 to 8 sprouts the second year; and 1 to 3 sprouts the third year. Top-pruning in the nursery would likely not result in many sweetgum trees with 2 dominant stems after 10 years of growth. Even if it did, this treatment would not decrease volume growth per hectare.

Apparently top-pruning does not cause poor tree form for northern red oak (Russell 1973, Zaczek and others 1993). Even where deer browsing is heavy, the formation of a strong central shoot will occur as long as seedlings are undergoing rapid growth. When grown for sawlog production, several top-pruned hardwoods will have adequate tree form after 22 years (Stout 1986).

Because of the strong apical dominance of eastern cottonwood— *Populus deltoides* Bartr. Ex Marsh.)— many foresters are not concerned about the stem form when

planting cuttings. Unrooted cuttings are stem segments that have had their tops removed (equivalent to severe top-pruning). A side bud near the top of the cutting forms a shoot and this side-branch develops into the main leader. This species can also be regenerated using taller seedlings (Phares and White 1972) or rooted whips with intact terminal buds (Burkhardt and King 1983). Use of seedlings or whips would avoid the sprouting that occurs with unrooted cuttings. However, because stem form resulting from sprouting is not a problem, unrooted cuttings are the preferred stock type for this species.

Some suggest that forked trees may develop after top-pruning of opposite-budded species such as green ash (Campbell 1992, Limstrom 1963, Stauder 1995). Many nursery managers have seen a double-leader develop after top-pruning green ash. However, we do not know for how long the double-leader persists. Some claim the effect is ephemeral; and for this reason, nursery managers in Oklahoma and Saskatchewan routinely top-prune green ash.

Further Research

Top-pruning studies have not been conducted on every hardwood species. Therefore, some foresters may question if field survival of all hardwood species is increased by top-pruning. A simple way to determine the effects of top-pruning on a specific species is to outplant equal amounts of top-pruned and non-pruned seedlings on various sites. To be an effective comparison, the difference in height after top-pruning should be at least 30 cm (both height of controls and height of pruning treatment should be reported). The study should be well replicated with more than 100 seedlings/ treatment. Dieback can be recorded in midsummer following outplanting and survival can be measured after 1 year. However, form and growth should be measured 5 years after outplanting. This information would provide a good data base from which sound recommendations could be made. Conclusions based on only 6 trees/treatment might not be very meaningful.

Conclusions

Top-pruning in the nursery is a way to reduce the costs involved with lifting, bundling, packing, storing, shipping, and planting hardwoods. The flow-chart in figure 2 can help nursery managers make decisions about top-pruning. Top-pruning hardwoods can decrease the chance of dieback. For some sites (and in some years), top-pruning will increase the probability of survival. Height growth during the first 2 years after transplanting can be greater for top-pruned seedlings than for taller non-pruned seedlings. Therefore, top-pruning hardwoods does not seem to reduce average heights after 5 years in the field. Top-pruning is recommended for species like northern red oak (Johnson and others 1986), sycamore (Briscoe 1969) and for some tropical species (Djapilus 1990, Ladrach 1992, Mohan and others 1990). For field foresters, there are economic reasons to top-prune hardwoods that are taller than 0.5 m.

Address correspondence to: Dr. David South, School of Forestry, Auburn University, AL 36849-5418.

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