Field Production

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Effect of Bare Root and B&B Harvest on Growth and Establishment of Landscape Size Trees

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Index words: transplanting, balled and burlapped, B&B

Significance to the Industry: This study suggests that bare root harvest can be a viable option for ornamental shade trees, but with some caveats. There may be growth reduction with some species of trees harvested bare root that would have to be accepted by landscapers. Bradford pear was slower to leaf out with some treatments suggesting that bare root harvest may not be an ideal harvest technique. This may be a trade off considering the cost of pesticide treatments required for B&B trees. Another consideration is the freight cost of B&B. The 2-inch caliper bare root maples and pears in this test averaged 16 and 36 lbs., respectively; whereas B&B plants averaged 438 and 546 lbs, respectively. Finally, and maybe most important, field nursery soil is not depleted using the bare root harvest method.

Nature of Work: A standard method of harvesting ornamental plants is to bare root during fall and winter after plants have gone dormant. This consists of mechanically lifting plants out of the soil and removing all the soil from the root system. Plants are then placed in cold storage until time to plant. This method has been successfully used for more than 100 years with deciduous shrubs, one or two-year old budded fruit trees and small trees for ornamental and reforestation plantings. Some studies have shown that some species of landscape size trees can be harvested as bare root with the same success as balled and burlap (B&B) (1,2,3,4). In recent years, plants harvested as B&B from quarantine areas have had to meet strict requirements for control of pests such as Japanese beetle grubs and fire ants. Repetitive pesticide applications to the root balls for insect control must be made prior to shipment. Bare root plants have no such requirements. This project compares 2-inch caliper trees harvested bare root and B&B in both fall and spring and their subsequent landscape performance.

Two-inch caliper Pyrus calleryana Decne. 'Bradford' pear and *Acer rubrum* L. 'October Glory' maple were selected for this project at a nursery in Warren County, Tenn. Forty dormant trees of each species from the same nursery block were dug in early Dec. as bare root or B&B using a 28-inch mechanical tree spade. The twenty plants dug as B&B were put into wire baskets lined with burlap. Soil was removed from the other twenty trees with shovels and by hand to generate the bare root treatments. Half of the trees from bare root and B&B harvest were planted in a field plot at the Nursery Research Center in McMinnville, Tenn. The remaining bare root trees were placed in cold storage with temperatures maintained at 35-45F while the remaining B&B trees were left above ground in the field. The following spring (5-7 March), an additional ten each of dormant pear and maple trees were dug as bare root and B&B, and planted in the field plot within 4 days of harvest. Trees that had been dug in Dec and stored were removed from storage and planted at the same time (7-9 Mar). After planting, trees harvested as bare root were staked using a 2-post method with one on either side of the tree and secured about four feet up on the trunk with rubber-protected guy wires. All trees were mulched with about 3 inches of pine bark mulch and watered as needed with drip irrigation. Initial height and caliper were recorded at planting and growth measurements were taken at the end of 2 growing seasons. During spring, leaf out and flowering of Bradford pear was assessed by monthly visual ratings ranging from of 0-100%.

Each species was planted in a completely randomized design with 10 single plant replications and treated separately. All data were subjected to analysis of variance using SAS version 8.2. Treatment means were separated by LSD, with $p<0.05$ level of significance.

Results and Discussion: Survival was excellent for all treatments and none of the trees exhibited stem dieback. October Glory red maple height growth was not affected by time of harvest (Dec. vs. March), but was affected by harvest method (bare root vs. B&B) (Table 1). Trees dug as bare root had less height growth compared to trees harvested as B&B, 108.1 cm vs. 152.7 cm during the 2-year test. Bare root spring planted trees had the lowest caliper growth compared to B&B treatments or to bare root fall planted. The October Glory maples most affected by a bare root treatment were those dug in Mar. Exposure of the root system during harvest and planting reduced the growth performance of October Glory maples.

Bradford pear height growth was not affected by time of harvest (Dec. vs. March) or by harvest method (bare root vs. B&B) (Table 1). Harvesting method did not affect caliper growth. Trees harvested in spring had statistically greater caliper growth than trees dug in fall. In the spring following planting (2002), trees that had been harvested bare root were very slow to leaf out (Fig. 1) and the leaves were smaller than normal. In July, trees harvested bare root still had significantly less canopy leaf out than other treatments. However, in spring 2003, there was no discernible difference in leaf out among the pears.

There were differences in flower display in the spring of 2003 (data not taken in 2002). On Mar. 29, trees harvested as bare root had less flower display than B&B trees (10.4% vs. 42 %). Within a couple of days of rating, a late frost destroyed significant flowering on all trees. It is therefore not clear whether flowering on the bare root harvested trees was only delayed, or whether fewer flowers were produced as the result of the harvest treatment.

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Table 1. Effect of harvest time and harvest method on height and caliper growth of *Acer rubrum* L. 'October Glory' red maple and Pyrus calleryana Decne. 'Bradford' pear during Mar. 2002 through Oct. 2003.

Harvest method	Height, cm[Z]	Caliper, cm[Y]	Height, cm	Caliper, cm
	'October Glory' maple		'Bradford' pear	
Bare root in fall, planted	106.0b[X]	2.3a	80.9a	2.6b
Bare root in fall, stored	124.7ab	2.1ab	64.7b	2.6b
Bare root in spring, planted	93.6b	2.0b	75.5ab	3.0a
B&B in fall, planted	138.4ab	2.4a	70.2ab	3.1a
B&B in fall, stored	177.0a	2.4a	66.2ab	2.7ab
B&B in spring, planted	128.4ab	2.4a	61.6b	2.9ab
Signifiance[W]				
Harvest method	*	*	ns	ns
Harvest time	ns	ns	ns	*
Interaction	ns	ns	ns	ns

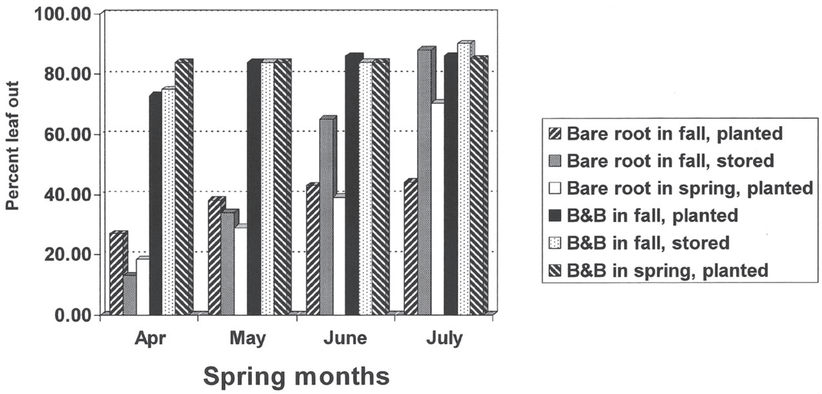
[Z]Height = The difference in height growth from Mar. 2002 until Oct. 2003.

[Y]Caliper= The difference in caliper growth from Mar. 2002 until Oct. 2003 measured at six inches above soil line.

[X]Means between harvest methods with different letters are significantly diiferent at $p<0.05$.

[W]Significance = * = significant at $p \leq 0.05$, ** = significant at $p \leq 0.01$, and ns=non-significant.

Fig 1. Effect of harvest time and harvest method on spring leaf out of Pyrus calleryana 'Bradford' pear, 2002.



Determining the Causes of Manganese Deficiency in Field-grown Red Maple

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Index words: soil pH, bareroot, shadetree

Significance to the Nursery Industry: Many nursery producers assume soil pH between 6.0 and 6.5 is sufficient for tree crops. While this may be generally true, soil pH for red maples should be lower (5.0 to 5.8) to prevent Mn deficiency. Lowering soil pH after planting is difficult and should be avoided. The best management practice for preventing Mn deficiency in red maple is to grow this crop in soils with sufficiently low pH. Every nursery surveyed in this study routinely collects soil samples to guide fertility management decisions. This research provides specific targets for soil and tissue tests, and allows growers to make more informed decisions.

Nature of Work: A common problem of field grown red maple (*Acer rubrum*) is late summer foliar chlorosis. This chlorosis is primarily a result of manganese (Mn) deficiency. However, the exact cause of Mn deficiency and which management practices might prevent the problem were not known.

Manganese can occur as Mn^{2+} or the oxidized form of Mn^{3+} (at high pH, it can also be found as Mn^{4+}). Only Mn^{2+} is available for plant uptake. Mn is not mobile in plants, so deficiency symptoms occur on new growth first. Mn plays three major roles in plant growth and development (Hughes and Williams, 1988). In photosynthesis, it is involved in electron transport within photosystem II. In N metabolism, it plays a role in the reduction of nitrate to ammonium. Most important to the context of this research is its role as a precursor to production of aromatic ring compounds, most importantly auxin. Mn deficiency reduces auxin levels and causes hormone imbalance. Change in the ratio between auxin and other plant hormones could lead to more serious problems than foliar chlorosis, including inhibited lateral root development and decreased root extension.

Mn deficiency in some nurseries is severe, while in others it does not occur. The cause of Mn deficiency is likely related to a combination of soil chemical factors. The objective of this research was to identify the causes of Mn deficiency in an effort to develop management strategies for preventing it.

Nursery producers have reported cultivar differences with respect to the severity of chlorosis. 'Red Sunset' is one of the most popular cultivars produced and has been identified as one of the most prone to Mn deficiency, and so was selected as the test plant for this project. Standard nursery practices in Oregon are to plant tissue culture or rooted cuttings of red maple in the field for a growing season, after which the shoot system is cut to several inches from ground level (some nurseries still graft cultivar buds on seedling rootstock). The following year multiple adventitious buds regrow from the stub, from which the most vigorous bud is selected and trained into a central leader. The plant is then grown for an additional one to three years. 'Red Sunset' samples in this study were chosen from trees during the second year of production (second year root growth, first year selected bud growth). Soil samples and foliar tissue samples were collected from 24 nursery fields. In June, one plot from each field was identified by flagging a 20-tree section within a single row (trees typically planted 1 foot on center within a row). A composite foliar tissue sample and soil sample were collected from each plot. Tissue and soil samples were analyzed for all the parameters listed in Tables 1 and 2, respectively. Trees were also measured for height, caliper, foliar color (rated on a scale from 1 to 10 where 1 is severe chlorosis and 10 is dark green color), foliar chlorophyll content, and overall quality. In August of the same year, the same plot and at least 2 additional plots were sampled in each field using the same procedures (total of 74 independent plots sampled).

Results and Discussion: Trees at every nursery appeared healthy when samples were collected in June. All plants were growing vigorously and had dark green foliar color, all with color ratings of 9 or higher. Despite excellent foliar color, trees varied greatly in levels of absorbed manganese (Mn). Mn levels in maple leaves across sampled nurseries ranged from 10 to 535 ppm. Published foliar Mn sufficiency ranges for this cultivar are from 254 to 305 ppm (Mills and Jones, 1996).

By late August, trees at some nurseries appeared healthy and vigorous, while others were chlorotic. Foliar chlorosis was a result of Mn deficiency. Foliar color ratings increased as foliar Mn concentration increased (Fig. 1). Sufficiency ranges for nutrient concentrations in foliage were determined by calculating the 25th and 75th percentile of each parameter among trees with high foliar color ratings (>9). These data suggest sufficiency range of 70 to 285 ppm foliar Mn (Table 1), far less than those reported by Mills and Jones (1996).

Foliar Mn deficiency was found to be primarily caused by soil pH. Available soil Mn (determined with DTPA extraction) decreased with increasing soil pH (data not shown). With less available Mn, foliar Mn also decreased as soil pH increased (Fig. 2). Sufficiency ranges for soil parameters were also determined (Table 2). Soil pH of high quality 'Red Sunset' were between 5.0 and 5.8.

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Figure 1. Relationship between foliar Mn and foliar color ratings.

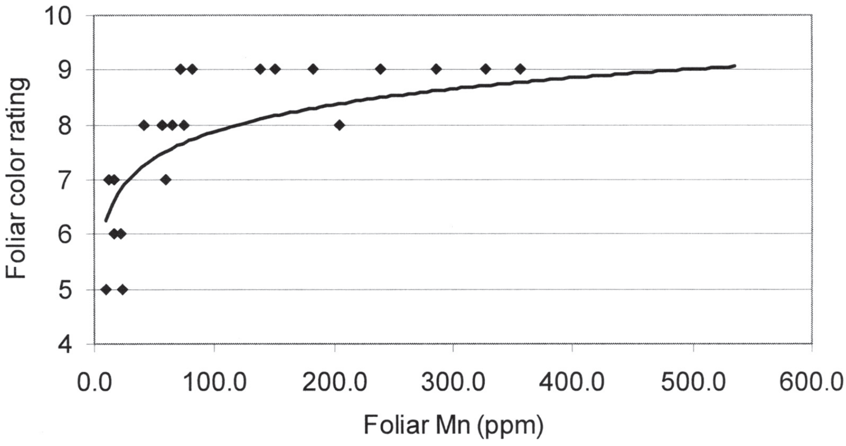

Figure 2. Relationship between soil pH and foliar manganese concentration.

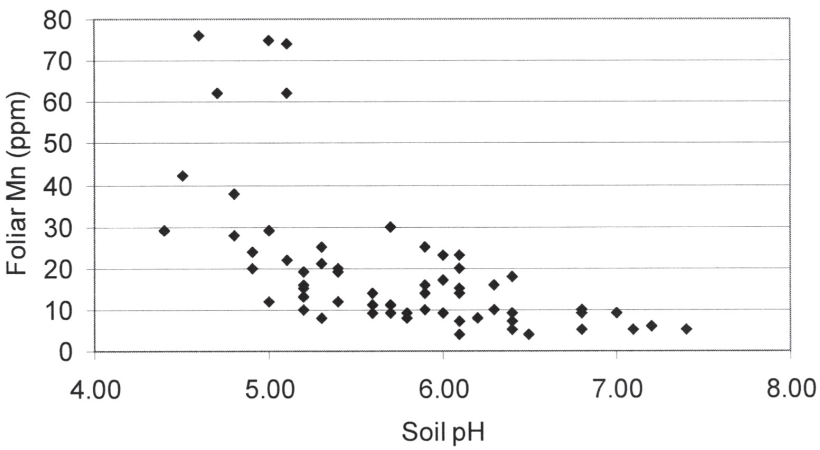

Table 1. Sufficiency range for foliage of high quality 'Red Sunset' maple (*Acer rubrum*).

Nutrient	units	Minimum	Maximum
Nitrogen	%	2.8	3.1
Phosphorus	%	0.28	0.38
Potassium	%	0.9	1.1
Calcium	%	0.45	0.65
Magnesium	%	0.15	0.20
Sulfur	%	0.18	0.22
Iron	ppm	120	250
Manganese	ppm	70	285
Zinc	ppm	45	56
Copper	ppm	6	8
Boron	ppm	13	19

Max and min values were determined by considering only the highest quality plants and calculating the 25th and 75th percentile for each nutrient.

Table 2. Soil properties necessary for growing high quality 'Red Sunset' maple (*Acer rubrum*) in Oregon silt loam soils.

Nutrient	units	Minimum	Maximum
pH		5.0	5.8
SMP pH		6.0	6.4
Organic matter	%	3.0	4.4
Phosphorus	ppm	50	100
Potassium	ppm	160	220
Calcium	meq	6	10
Magnesium	meq	1.0	1.6
Sulfur	ppm	9	18
Iron	ppm	50	120
Manganese	ppm	20	40
Zinc	ppm	1.8	2.7
Boron	ppm	0.2	0.3
Copper	ppm	1.0	2.1
Soluble salts	mmhos	0.2	0.9

Minimum and maximum values were determined by calculating the 25th and 75th percentile for each nutrient or parameter observed in high quality plants.

Costs of Establishing and Operating Field Production Nurseries Differentiated by Size of Firm, Zone 7

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Index Words: costs, field production, size and scale, nursery plants, budgets

Significance to Industry: USDA reports a decline in the number of greenhouse and nursery crops growers, primarily among small volume producers. At the same time, attendance at getting started in the business workshops has been large, and interest in the industry continues at a brisk pace. To make more informed decisions as to whether to enter, leave, or expand field production, nursery producers require production, marketing, and financial information. Cost models for production of crops representing five categories of field-grown production schemes typical for climatic zone 7 nurseries and two sizes of nurseries (50-acre and 200-acre firms) are developed. Information derived should provide a basis for decision-making for those evaluating the profitability of establishing a new field nursery, expanding an existing field nursery, or shifting from field production to container or greenhouse production.

Nature of Work: Although container production allows greater flexibility in production and marketing, and may even be a less expensive form of production for some plants, risk is reduced when plants are grown in the field. Field-grown plants have greater buffering against variations in moisture, nutrients, and temperature. When subjected to conditions which would kill or severely damage container-grown plants with no over-wintering protection, field-grown plants will often survive with little damage. It is also easier to hold over field grown plants when market conditions are not favorable. However, changes and competition in the industry make it imperative that nursery producers continually and systematically determine production costs.

Several Southern Cooperative Series Bulletins dating from the 1980s were published by members of the S-103 regional research project technical committee (currently known as S-290). Procedures and data developed by these earlier comprehensive studies have proved useful as a template and complementary to this analysis. In this report, two model firms were synthesized using the conceptual framework of economic engineering wherein the best management practices were included in each model. The complete model included developing appropriate production cycles for the specified plants, identifying the resources (land, buildings and structures, machinery and equipment, labor, and capital) needed to accomplish the production, and developing budgets for fixed and variable costs.

The model small nursery of 50 acres had 40 acres of growing space and 10 acres of production facilities, holding area, field bed area, retention pond, and roadways. The large nursery was 200 acres, with 175 acres of growing space and 25 acres of support facilities and areas – a size of firm necessary to use production facilities and equipment in an economically efficient manner. The five species of plants for whom production cycles were modeled included a slow-growing evergreen (Ilex), a rapid-growing evergreen (*Juniperus*), a deciduous shrub (*Viburnum*), a shade tree (*Acer rubrum*), and an ornamental tree (*Cornus*).

Results and Discussion: Fixed costs for all plant categories accounted for a greater proportion of total costs in the 50-acre nursery than in the 200-acre nursery, averaging 54-percent in the small nursery and 35-percent in the large field production nursery. This is attributed to more efficient use of buildings, machinery, and equipment in the larger facility. As for the representative species selected for the five groups of field grown nursery plants, cost differences were caused primarily by space requirements, length of the production cycle, cost of liners (for the trees, liners were purchased rather than propagation), and labor requirements (hours budgeted). Calculations were based on 2003 prices and data obtained from wholesale nurseries and nursery suppliers primarily in Georgia.

Total production costs per salable “B&B” plant by representative species in the 50-acre nursery were $24.94 for slow-growing evergreens, $17.76 for rapid-growing evergreens, $17.11 for deciduous shrubs, $73.63 for shade trees, and $50.74 for ornamental trees, for an average of $28.37 for the aggregate nursery. For the 200-acre field production nursery, comparable figures were $13.18 for slow growing evergreens, $9.99 for fast growing evergreens, $9.99 for deciduous shrubs, $50.41 for shade trees, and $35.49 for ornamental trees, with an average total cost per salable plant for the entire nursery of $17.62.

The estimated capital requirements for the 50-acre nursery totaled $867,800 – land and improvements, $450,000; buildings and structures, $125,400; and machinery and equipment, $292,400. Total annual fixed costs for the 50-acre field nursery were estimated to be $320,535 – land and improvements, $52,000; buildings and structures, $17,855; machinery and equipment, $52,630; general overhead, $190,000; and interest on general overhead, insurance and taxes, $8,050. The estimated capital requirements for the 200-acre field production nursery were nearly $21⁄2 million -- $1,432,000 for land and improvements, $252,300 for buildings and structures, and $804,200 for machinery and equipment. Total annual fixed costs for the 200-acre nursery were $162,640 for land and improvements, $35,320 for buildings and structures, $144,755 for machinery and equipment, $203,500 for general overhead, and $21,850 for interest on general overhead, insurance and taxes.

As to the representative species of the five plant groups, on the 50-acre nursery the annualized costs were:

	Fixed Costs	Variable Costs	Total Costs	Salable Plants	Cost/ Salable Plant
Ilex	$64,107	$39,120	$103,227	4,140	$24.94
Juniperus	$64,107	39,083	103,190	5,810	17.76
Viburnum	64,107	42,085	106,192	6,208	17.11
Acer rubrum	64,107	73,509	137,616	1,869	73.63
Cornus	64,107	74,518	138,625	2,732	50.74

For the 200-acre nursery, the annualized costs were:

	Fixed Costs	Variable Costs	Total Costs	Salable Plants	Cost/ Salable Plant
Ilex	$113,613	$125,701	$239,314	18,156	$13.18
Juniperus	113,613	140,265	253,878	25,418	9.99
Viburnum	113,613	157,825	271,438	27,162	9.99
Acer rubrum	113,613	298,613	412,226	8,177	50.41
Cornus	113,613	310,621	424,234	11,954	35.49

Conclusions: Large scale commercial field production nurseries use facilities, machinery, and labor more efficiently than small-size field nurseries. As a result, larger nurseries have a lower cost per salable plant, primarily due to a lower proportion of total cost in fixed costs attributed to the use of assets and resources. Variable costs per salable plant, while having wide variations among species, remain reasonably constant when comparisons were made between the two sizes of firms. As the size of nursery increased, costs for fixed items of production were spread over more salable units, thereby reducing the fixed cost per salable plant.

For the industry, selling nursery products below cost implies that well-established nurseries, operating essentially debt free, would have strong staying power, whereas those which have just started or are heavily in debt may not be able to survive, especially if they are relying on their field operations to meet all overhead expenses and marketing their nursery products at prevailing climatic zone 7 prices. At current prices for nursery products, the return on investment for establishing new, independently operating, 50-acre field nurseries in climatic zone 7 would be marginal, if not negative.

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Effect of Weed Control on the Growth of Field-grown Shade Trees in Central Arkansas

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Index Words: herbicides, red maple, Callery pear, willow oak

Significance to industry: Weed control is a common recommendation for overall best management practices in field shade tree production. While the recommendation makes good common sense, little data exists to quantify the impact of this cultural practice. Overall results indicate that the implementation of vegetation control within the tree row has a significant effect on growth and mortality of shade trees.

Nature of Work: While the literature (2,3) encourages the use of a vegetative-free area around the base of shade trees in a field nursery, there is little data to quantify the impact on shade tree growth (6). Data have been published on the effect of vegetation-free zones in fruit and nut crops (1,4,5).

Research was conducted at a commercial nursery in central Arkansas. Plants included in this study were *Acer rubrum*, *Pyrus calleryana* 'Cleveland Select', and *Quercus phellos*. Trees had been planted from containers (1-gal *Acer rubrum* (seedlings), 5-gal Pyrus calleryana 'Cleveland Select', and 5-gal *Quercus phellos*) on 22 April, 2002 by the nursery. Plants were watered as needed by drip irrigation. The standard practice in the nursery is to mow the aisle between rows of trees but not to use any mechanical or chemical weed control within a row of trees. Tree spacing is 8' O.C. The pattern of tree row spacing is 3 rows of trees separated by a 10' tall fescue/bermudagrass aisle, an 18' grassy aisle, and then another set of 3 tree rows each separated by a 10' grassy aisle.

Weed control consisted of two treatments: vegetation-free 1' on either side of the tree row (16 ft^2 rectangle) versus a vegetative ground cover within the tree-row. Weed control was accomplished during 2002 and 2003 using a spring and fall application of pendimethalin (3 lb a.i./A) pre-emergent herbicide and two spot applications during each growing season with glyphosate.

Herbicide treatments were imposed on trees growing in a commercial nursery. Treatments were assigned in a completely randomized design. Treatments consisted of a single plant replicate, however, the number varied depending on the species. The study included 47, 45, and 23 single plant replicates, respectively, for willow oak, red maple, and Callery pear. Final shoot growth and trunk caliper was measured on 6 November, 2003.

Results and Discussion: The use of weed control within the tree row had a significant effect on tree growth during the second growing season (Table 1). Red maple was most responsive to vegetation control with final shoot height

22% taller, and mean trunk caliper 111% larger, for red maple trees growing in vegetation-free zones. Mean trunk caliper for Callery pear and willow oak was 50% larger at the end of two growing seasons when vegetation was absent near the tree base. Tree mortality was higher for red maple and willow oak when vegetation was not removed from the nursery row (Table 2).

Table 1. Effect of vegetative-free zones (16 ft^2) on shoot height and trunk caliper at the end of 2003 for 3 tree species.

	2003 Mean Shoot Height (cm)			2003 Mean Trunk Caliper (cm)		
	Red Maple	**Callery Pear**	**Willow Oak**	**Red Maple**	**Callery Pear**	**Willow Oak**
Vegetation-free	155 az	309 a	287 a	1.9 a	5.1 a	3.6 a
Vegetation	121 b	260 b	269 b	0.9 b	3.4 b	2.4 b

[z]Numbers within a column followed by the same letter are not significant at the 5% level.

Table 2. Effect of vegetation-free zones (16 ft^2) on percent mortality at the end of 2003.

	Mortality (%) after 2 growing seasons		
	Red Maple	**Callery Pear**	**Willow Oak**
Vegetation-free	30	0	2
Vegetation	45	0	25

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Effect of Rootball Type and Season of Transplanting on Growth of Sugar Maple and Red Oak

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Index Words: *Acer saccharum*, fall, *Quercus rubra*, spring

Significance to the Industry: Sugar Maple transplants well either B&B or bare root. However, best post-transplant growth can be expected with B&B plants. Fall- and spring-transplanted Sugar Maples will grow at equal rates, so choice of planting date can be made without future tree growth in mind. Red Oak does not bare root well at the size used in this study (approximately 2-in caliper). Fall-transplanted B&B Red Oaks can be expected to outgrow spring transplants for at least three years.

Nature of Work: Landscape contractors and municipal horticulturists are searching for the most effective and economical ways to establish shade trees. Transplanting field-grown trees bare root instead of with intact rootballs can be an attractive transplanting option because the lighter rootballs are cheaper and easier to handle. In addition, seasonal transplant timing has been shown to affect transplant success for some species and may offer a way to better insure transplant success. This study investigated the response of two field-grown Virginia natives, Sugar Maple (*Acer saccharum*) and Red Oak (*Quercus rubra*), to transplanting with either intact or soil-free root balls and in fall or spring.

Fall transplanting offers a number of potential advantages over traditional spring transplanting, including a greater opportunity for trees to grow new roots and develop contact between the roots and soil (Buckstrup and Bassuk, 2000) and more time for trees to acclimate to the physiological stresses of transplanting before growth resumes in spring (Harris and Fanelli, 1999). A study addressing early root system regeneration of Sugar Maple and Red Oak determined that October-transplanted trees began root system regeneration earlier and produced more roots in the first-season post-transplant than March-transplanted trees (Harris, et al., 2002). In Blacksburg, VA, no new roots were evident for November-transplanted northern Red oak or Willow oak (*Quercus phellos*) when subsamples were excavated in January, but November transplants apparently began root growth earlier than March transplants. Total amount of early new root growth was relatively small, however, and no apparent advantage to the earlier root growth was evident in terms of canopy development (Richardson-Calfee, et al., 2004). Fall transplanting of some species has been reported to be inferior to spring planting (Buckstrup and Bassuk, 2000; Harris and Bassuk, 1994; Larson, 1970; Watson, et al., 1986), or to have no advantage over spring planting (Harris, et al., 2001; Watson and Himelick, 1982; Watson, et al., 1986). This lack of agreement is a result of climate, age, size, type of planting stock, species, and experimental differences.

Red Oak and Sugar Maple liners were obtained from J. Frank Schmidt and Son Nursery (Boring, OR) and grown up to landscape size in field beds at the

Urban Horticulture Center near the Virginia Tech campus in Blacksburg, VA. Treatments were randomly assigned to trees of both species in fall of 1998. Beginning mean trunk diameter (caliper) was measured 6 in (15.2 cm) above the soil surface and was 1.8 in (4.84 cm) and 1.6 in (4.18 cm) for Red Oak and Sugar Maple, respectively. The experimental design was a completely randomized factorial within each species, with treatments of fall or spring transplant dates and intact or bare-rooted rootballs. There were six replications per treatment for each species. All trees were harvested with a tree spade so that root balls were 28-in (71.1-cm) diameter. Intact rootballs were placed in burlap and wire baskets (B&B) and rootballs of bare-root trees were shaken and washed free of soil (BR). Fall-transplanted trees were dug on 18 November, 1997 and heeled in with wet sawdust until planting three days later. Planting holes were hand dug, 10 ft (3.0 m) apart in a single row, and they were approximately 56-in (142.2 cm) diameter. Top sections of burlap and the top rung of wire baskets were removed from B&B trees, and all trees were planted so that the beginning of root flares was at the surface of the backfill. Backfill was the soil removed when digging the planting holes. Newly transplanted trees were irrigated at transplanting and twice weekly for three weeks. Irrigation was only occasional throughout 1998, and trees were not irrigated in 1999 or 2000. Spring-transplanted trees were handled in a similar manner as fall transplants. Fall harvest was on 17 March, 1998 and planting was three days later. No fertilizer was applied at transplanting for fall- or spring-transplanted trees, but a topdressing of slow-release fertilizer (Osmocote: 18N-2.6P-9.9K (18-6-12)) was evenly applied over a 3-ft (0.9-m) diameter circle over the root balls of each tree at the rate of 2 lbs actual N per ft^2 (9.8 g per m^2) of soil surface in March of 1999 and 2000. Caliper was measured in mid-November 1998, 1999, and 2000. Beginning and yearly caliper was graphed for each species, and statistical analysis of final caliper was performed within the GLM procedure of SAS statistical software (SAS Institute, Inc., Carey, NC).

Results and Discussion: *Sugar Maple*. Survival was 92% (23/24) overall. One spring-transplanted BR tree died. The BR transplant method is therefore a viable method for sugar maple. All trees grew slowly the first year (1998) after transplanting (Fig. 1), with B&B trees growing somewhat faster the second (1999) and third (2000) year after transplanting. Statistical analysis of final caliper revealed evidence for increased growth of B&B trees compared to BR trees (P=0.04). There was no evidence of a seasonal effect (P=0.77) or an interaction between season and rootball type (P=0.74). When resources allow, landscape contractors and municipal horticulturists can therefore expect better growth for at least three years after transplanting if trees are planted B&B instead of BR. On the other hand, Sugar Maple had high survival and acceptable growth if planted BR. Urban horticulturists most often have very limited budgets and therefore use volunteers such as citizen advocacy groups to plant shade trees. The use of BR vs. B&B sugar maples may be a prudent decision in such situations. Since no advantage to fall vs. spring transplanting was evident, planting schedules can be based on convenience and not expectations of future growth.

Red Oak. Survival of Red Oak was 67% (16/24) overall. Most incidences of death occurred within the BR treatment (42% or 5/12), with 3 of 6 fall-transplanted trees dying and 4 of 6 trees dying for spring-transplanted trees. Only one B&B tree died, a fall-transplanted tree. The BR method of transplanting therefore cannot be recommended for this size Red Oak. Smaller sizes may transplant better since survival of the 1.5-m tall liners was 100% when the original nursery beds were planted. However, the surviving transplanted larger trees grew well (Fig. 1). The BR trees were excluded from statistical analysis because of the high mortality. For B&B trees, little growth occurred the first year after transplanting, but recovery was rapid for year 2 and 3 (1999 and 2000). As with Sugar Maple, fall-transplanted Red Oaks generally outgrew the spring transplants (p=0.06). Practitioners should therefore plant in fall for the best results and avoid planting Red Oaks BR altogether.

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Figure 1. Trunk diameter of Sugar Maple and Red Oak, transplanted B&B or bare root in fall of 1997 or spring of 1998. Bars represent SE of the mean. n=6.