SECTION 10
LANDSCAPE

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Crabapple Bloom Sequence at Greeneville, TN, 1994

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Nature of Work: Many new crabapple cultivars have been introduced in recent decades. These have been extensively evaluated for disease resistance and ornamental characteristics in Northern regions of the US. Less evaluation has been done in the South. In 1992, the J. Frank Schmidt & Son Nursery Co. donated an extensive collection of cultivars for evaluation in Alabama (1) and Tennessee. Some cultivars were provided on more than one rootstock. We planted five replications, three trees of each cultivar per replication, in March 1992 at the Tobacco Experiment Station, Greeneville, TN. Each cultivar was assigned a code number so that subsequent evaluations would be blind. Trees were set 18 feet on center. They were fertilized with 0.30 ounce N per tree a month later (provided by 2 ounces 15-15-15). In succeeding years, they were fertilized with 0.50 ounce N per tree in March and again in mid-June. Existing alfalfa in middles was bushhogged as needed. We tried to maintain a vegetation free zone around each tree with the use of Surflan and Roundup. No irrigation was necessary. Survival of all cultivars was excellent except for 'Adirondack'. Plants were pruned to remove broken branches, root suckers, and to build a clear trunk. About one-third of the trees required staking initially to prevent leaning. Bloom data was recorded three times at approximately weekly intervals beginning March 30, 1994 on standardized forms provided by the National Crabapple Evaluation Program (NCEP). Seasonal temperatures were above average and marked by high rainfall. A representative tree in each replication was rated by a single observer for percent of flowers in tight bud, balloon stage, fully open, or petals dropped. Replication scores were averaged and a bloom index calculated for each cultivar on each date by assigning the values of 1, 2, 3, and 4 to the four stages respectively and multiplying that number by the average percent for that stage and summing the values obtained. Cultivars were ranked in descending order according to this index of flower development, with the highest number (4.0) representing 100% petal fall and the lowest number (1.0) indicating 100% of the flowers were in tight bud. Actually a few cultivars were initially ranked less than 1.0 because they were in very tight bud. Ancillary data was recorded on abundance of bloom, location of bloom on the tree, bud and flower color, new leaf color. I had difficulty evaluating fragrance and do not report it here.

Results and Discussion: Table 1 shows nearly all cultivars were in tight bud on March 30. Early and midseason cultivars were showing some bud color. Leaf emergence was beginning to be noticeable. By April 7, 'Radiant' was the first to be in full bloom. Others with more than 20% open blossoms (>2.2) on April 7 were 'Spring Snow', 'Selkirk', M. baccata 'Jackii', 'Louisa', 'Pink Spires', and 'Jewelberry'. By April 16, the 33 cultivars listed in the table above 'Zumi Calocarpa' and 'Floribunda' exceeded 50% petal drop, no doubt influenced by heavy rains. Last to bloom were a group including 'Silver Moon, 'Brandywine', 'Klehm's Improved Bechtel' and 'Coral Burst'. A close examination of the

table shows that not all cultivars proceeded from tight bud to full bloom and petal fall at the same rate. Bud, flower, and leaf color correlated closely with information in the Crabapple Information Chart published in the Schmidt catalog (2) and is thus not reported here.

Significance to Industry: Data on sequence of bloom may be useful to landscapers in choosing early, midseason, and late blooming cultivars of disease resistant crabapples. The primary reason for this test planting is evaluation of disease resistance in the South. We will attempt to evaluate for fire blight, powdery mildew, apple scab, and cedar apple rust for the next several years as opportunity permits, as well as annual observations on spring and fall ornamental characters.

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Table 1. Order of bloom of crabapple cultivars at Greeneville, TN, 1994. Bloom index: l=tight bud, 2=balloon stage, 3=full bloom, 4=petal fall. Flower abundance rating: 1=sparse, 4=very abundant.

	bloom index			flower
CULTIVAR & ROOTSTOCK	3-30	4-7	4-16	abundance
Radiant 111 VC	0.5	3.0	4.0	1
Spring Snow - dwarf	1.0	2.3	4.0	3
Selkirk 111	1.0	2.2	4.0	4
Spring Snow 111	1.0	1.8	4.0	4
Indian Summer 111 VC	1.0	1.95	3.99	4
Robinson VC - dwarf	1.0	1.1	3.99	4
Purple Prince 111	0.5	1.0	3.99	4
Baccata Jackii 111	1.0	2.4	3.95	4
Louisa 111	1.0	2.3	3.95	4
Red Splendor VC - dwarf	1.0	2.1	3.95	4
Dolgo 111	1.0	2.0	3.95	2
Strawberry Parfait 111	0.5	1.9	3.95	4
Profusion 111 VC	1.0	1.8	3.95	3
Professor Sprenger 111	1.0	1.6	3.95	4
Beverly 111	1.0	1.6	3.95	3
Red Baron 111	1.0	1.5	3.95	4
Candied Apple 111 VC	1.0	1.51	3.95	4
Pink Spires 111 VC	1.1	2.9	3.9	4

CULTIVAR & ROOTSTOCK	bloom index 3-30	4-7	4-16	flower abundance
Baskatong 111	1.0	2.1	3.9	2
Tea 111	1.0	1.95	3.85	4
Adams 111 VC	1.0	1.61	3.9	4
Centurion 111	1.0	1.61	3.9	4
Indian Magic 111 VC	1.0	1.91	3.8	4
ormiston Roy 111	1.0	1.2	3.8	4
White Angel 111	1.0	1.1	3.8	4
Adams VC - dwarf	1.0	1.11	3.8	4
Sugar Tyme 111	1.0	1.1	3.75	4
Jewelberry 111	1.0	2.5	3.6	4
Sentinel 111	1.0	1.9	3.6	4
Royalty - dwarf	1.0	1.7	3.6	2
Red Jade - dwarf	1.0	1.5	3.6	3
Bob White 111	1.0	1.0	3.6	4
Floribunda - dwarf	1.0	1.22	3.5	4
Zumi Calocarpa 111 VC	1.0	1.0	3.5	4
Floribunda 111 VC	1.0	1.8	3.45	4
Snowdrift VC - dwarf	1.0	1.0	3.39	3
Red Jade weeping 111	1.0	1.1	3.2	3
Red Jewel 111	1.0	1.0	3.2	4
Sinai Fire 111	1.0	1.1	3.1	4
Snowdrift 111 VC	1.0	1.1	3.1	4
Liset 111 VC	0.5	1.0	3.1	3
Pink Princess 111	0.5	0.9	3.1	1
David 111 VC	1.0	1.1	3.05	4
Donald Wyman 111 VC	1.0	1.5	3.0	3
Prairifire 111	1.0	1.0	3.0	4
Sargent - dwarf	1.0	1.0	3.0	4
Sargent 111	1.0	1.0	3.0	4
Mary Potter 111	1.0	1.25	2.95	4
Velvet Pillar 111	0.5	1.0	2.95	3
Winter Gold 111 VC	0.5	1.0	2.95	4
Liset VC - dwarf	1.0	1.0	2.9	3
Velvet Pillar 111 M-S PP	0.5	1.0	2.8	2
Doubloons 111	1.0	1.0	2.7	1
Silver Moon 111	0.5	1.0	2.2	1
Brandywine 111	1.0	1.0	2.05	1
Klehm's Improved Bechtel 111	0.5	0.8	2.0	1
Coral Burst 111	0.5	1.0	1.97	2

Cold Tolerance of *Lagerstroemia Indica X Fauriei* Cultivars in USDA Zones 7 and 8

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Nature of Work: Crapemyrtles *(Lagerstroemia indica)* are limited in their use due to their susceptibility to cold injury. Hybrids of L. *indica X L. fauriei* may be more cold hardy, thus enabling crapemyrtles to be used in a wider range of locations. Five cultivars of *L. indica X fauriei* hybrids were compared at two USDA hardiness zones (7a and 8b) using differential thermal analysis to determine their relative cold hardiness. *L. indica* (common crapemytrle) use is limited to southern Illinois and south because of its intolerance to severe cold (Dirr, 1977). The hybrid of *L. indica* with *L. fauriei is* expected to enhance the cold hardiness of crapemyrtle. If successful, the economic effect would be significant to the nursery industry.

Some plants have the capacity to deep supercool. Water is retained against vapor pressure gradient, and this water is supercooled to a temperature at which ice spreads from the surrounding tissue into the cell (heterogeneous nucleation) or the cellular water spontaneously freezes (homogeneous nucleation) (Quamme, 1991). The freezing of water is an exothermic reaction, resulting in a release of the "heat of fusion."

Field testing for cold tolerances in the southeastern U.S. is difficult because we can not be assured of a suitably cold winter. Thus, many laboratory tests of cold hardiness have been developed through the years. Differential thermal analysis (DTA) is an excised tissue test that works by detection of the “heat of fusion” that is released when water freezes (an exothermic reaction). Thermocouples are paired from a recording device where one is attached to the excised sample and the other is a dry reference. The recording device is capable of detecting and recording the exothermic events (exotherms) that occur when water freezes. By analyzing the time and size of the exotherms, it is possible to determine what is occurring within the tissue (Quamme, 1991; George et al., 1974).

The cultivars tested were ‘Muskogee’, ‘Natchez’, Osage’, ‘Tuskegee’, and ‘Yuma’. Two sites differing by USDA zones, 7b and 8a, were selected where established plants were available for sampling. The zone 8a site was in Poplarville, MS (30°51' north latitude and 89'°33' west longitude). The zone 7b site was in Starkville, MS (33°28' north latitude and 88°47' west longitude).

Samples for freezing analysis were collected monthly October 1993 throught March 1994 from each site. Differential thermal analysis (DTA) of the crapemyrtle cultivars was conducted using 28 pairs of thermocouples connected to a datalogger (CR-7, Campbell Scientific, Logan, Utah). Stem tissue was cut into 1 to 2-cm lengths, placed onto the thermocouples, and held in place with aluminum foil. The second thermocouple of the pair was not covered to record the reference temperature near

the sample. The sample and reference thermocouples were placed in a box made of insulation board and placed into a programmable freezer. Samples were cooled at a rate of -20°C to -25°C per hour to a minimum temperature between -40°C to 45°C in the freezer preset to -50°C. The reference temperatures (T_{ref}) and the sample temperatures (T_{sam}) were recorded by the datalogger every ten seconds. The differential temperatures ($T_{dif}=T_{ref}-T_{sam}$) were also calculated by the datalogger and recorded. These data were printed and graphed to determine individual temperatures where an exothermic event (exotherm) occurred.

Results and Discussions: Three exothermic events were determined in this study and labeled in the manner reported by Quamme (1972). Exotherm A (T_A) or the high temperature exotherm was the temperature at which extracellular water froze. Exotherm C (T_C) or the second high temerature exotherm was related to T_A associated with acclimation and deacclimation and probably not related to any significant injury. Exotherm D (T_D) or the low temperature exotherm which occured at a temperature associated with xylem tissue death. Exotherm B (T_B) was not detected in this test of crapemyrtle stem tissue.

The first exotherm T_A was observed for all cultivars tested between the temperatures of -4.7'°C and -11.4°C in Starkville and -5.1°C and -10.1°C in Poplarville (data not shown). There was little or no consistent change in this exotherm across the testing dates or between cultivars.

Comparison of the T_D exotherms observed during the mid-winter months of January with tissue from Poplarville, 'Muskogee' had the highest T_D exotherm at 15.4°C while the other cultivars had an average T_D exotherm temperature of -20.7°C. In February, 'Osage' from Poplarville had the highest T_D exotherm temperature of 19.6°C (Table 1). 'Muskogee' had the second highest T_D exotherm of -21.7°C, but it was not different from 'Osage'. The 'Muskogee' T_D showed a lower temperature than recorded in January, but still considerably higher than the average of the other three cultivars, -24.57°C. 'Natchez', 'Tuskegee', and 'Yuma' appeared to be more cold hardy in Poplarville than 'Muskogee' and 'Osage'. No differences between cultivars for the T_D exotherms were oberved in Starkville.

Significance to the Industry: Crapemyrtle, *Lagerstroemia indica, is* currently listed as a USDA zone 7 plant (-12.3°C to -17.7°C), but these data indicate that it may be possible to expand that listing to include zone 6 (-17.8°C to -23.3°C) for the *Lagerstroemia indica x fauriei* hybrids; however, more field testing should accompany this recommendation. With proper care, established crapemyrtles of the cultivars studied could be used further north without suffering large ammounts of damage from low temperature.

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Table 1. Low temperature exotherms (T_D) Of *Lagerstroemia indica x fauriei* stem tissue as influenced by cultivar and time of year. Stem tissue was collected from specimens grown in Poplarville, Mississippi.

Month	Muskogee	Natchez	Cultivar Osage	Tuskegee	Yuma
	Low Temperature Exotherm (T^D) (°C)				
October	-14.2 a[z]	-18.6 b	-14.7 a	-17.3 ab	-16.9a
November	-17.3 a	-20.8 a	-19.0 a	-22.7 a	-21.1 a
December	-13.2 a	—	-18.0 b	-18.4 b	-20.4 b
January	-15.4 a	-20.8 b	-21.8 b	-20.0 b	-20.2 b
February	-21.7 ab	-24.7 b	-19.6 a	-24.2 b	-24.8 b
March	-20.1 ab	-20.5 ab	-16.8 a	-19.4 a	-22.8 b

[z] Means within rows followed by the same letter are not different according to the Least Significant Difference Test (∂=0.05)

Table 2. Low temperature exotherms (TD) Of *Lagerstroemia indica x fauriei* stem tissue as influenced by cultivar and time of year. Stem tissue was collected from specimens grown in Starkville, Mississippi.

	Cultivar				
Month	Muskogee	Natchez	Osage	Tuskegee	Yuma
	Low Temperature Exotherm (T_D) (°C)				
October	-18.1 a	-16.4 a	-16.1 a	-18.1 a	-17.7 a
November	-19.1 a	-20.5 a	-18.4 a	-20.7 a	-21.0 a
December	-18.1 a	-19.1 a	-18.8 a	-21.2 a	-18.2 a
January	-16.8 a	-18.7 a	-16.7 a	-21.6 a	-19.8 a
February	-22.8 a	-21.4 a	-24.7 a	-23.1 a	-18.4 a
March	-19.3 a	-20.8 a	-20.0 a	-19.1 a	-20.7 a

[z] Means within rows followed by the same letter are not different according to the Least Significant Difference Test (a=0.05).

Crabapple Evaluations in Kentucky

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Nature of Work: Since 1985 the University of Kentucky has participated in the National Crabapple Evaluation Program which was first established in 1984. The evaluation site now contains approximately 100 cultivars and is located on the UK Spindletop Research Farm near Lexington, KY. The soil is Maury silt loam. Plants were supplied by several nurseries to the National Crabapple Evaluation Program as budded 3-5 ft. liners which have been planted during various years over the past decade. Plants were established on 20 ft centers, replicated 3 times, and arranged in a completely random design. Since 1986 plant characteristics as well as disease and insect problems have been evaluated by faculty in the departments of Horticulture, Plant Pathology and Entomology.

Research and Discussion: Data has been collected at various times over the decade. Forty-five of the species and cultivars are included in this paper. The reported floral stage and display information(Table 1.) was collected on 26 April 1993. The reported disease rating was made on 1 Sept. 1989(1). The Japanese beetle rating was completed on 23 July 1992(2). The suckers were removed and counted during late winter 1988 and again during late winter 1990. The unidentified rootstocks for the budded liners were noted to vary in coarseness and color at time of planting, thus, rootstocks may be contributing to the differences in number of suckers. No crabapple selection was evaluated superior across all test components.

Significance to Industry: With 100's of crabapple cultivars having entered nursery production, evaluations are needed to establish each plant's true merits. The Univ. of Kentucky evaluation site assists in defining the superior cultivars which will maximize landscape display while minimizing landscape maintenance.

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Table 1. Floral characteristics, disease and insect ratings for selected crabapple species & cultivars.

NAME	FLOWER[V] STAGE				FLOWER[W] DISPLAY			DISEASE[X] RATING			JB[Z] DEFOL.	SUCKERS (removed)	
	TB %	BA %	OPN %	PD %	CL	AB	AES	BO-OB	VE-IN	ER-AM	%	1988 No.	1990 No.
Adams	0	10	90	0	C	5	1.0	1.3 b-f[Y]	0.0 a	0.0 a	49.4	0.0	1.0
baccata v. jackii	4	16	80	0	W	3	2.6	0.3 ab	0.0 a	0.0 a	14.4	8.3	8.6
Beverly	0	4	96	0	W	3	3.0	0.7 a-d	0.0 a	0.0 a	62.8	7.0	12.3
Bob White	3	15	82	0	PW	4	1.0	1.0 a-e	0.0 a	0.0 a	38.3	7.5	9.0
Candied Apple	0	16	84	0	P	3	2.6	1.0 a-e	0.0 a	0.0 a	70.0	6.0	10.6
Christmas Holly	15	45	40	0	W	4	2.0	0.5 a-c	0.0 a	0.5 b	38.3	5.5	7.0
David	15	30	55	0	W	2	1.6	1.0 a-e	0.0 a	0.0 a	31.7	3.3	0.6
Dolgo	0	0	90	10	W	1	3.0	1.7 d-g	0.7 ab	0.0 a	73.3	6.0	13.0
Donald Wyman	0	50	50	0	W	3	1.0	0.5 a-c	0.0 a	0.0 a	53.3	0.0	0.0
floribunda	12	28	55	5	PW	5	1.0	0.0 a	0.0 a	0.0 a	51.7	3.5	3.5
halliana v. parkmanii	5	21	74	0	PW	5	1.0	0.3 ab	0.0 a	0.0 a	37.2	1.3	2.3
Harvest Gold	73	27	0	0	--	4	1.3	0.3 ab	0.3 ab	0.0 a	22.2	1.3	2.0
Henningii	2	8	90	0	W	3	2.0	0.3 ab	0.0 a	0.0 a	43.3	4.6	7.6
Hopa	0	0	100	0	P	2	3.6	0.3 ab	4.0 d	0.0 a	75.6	1.3	2.6
Indian Magic	2	43	55	0	C	5	0.6	0.7 a-d	3.0 c	0.0 a	56.1	5.0	3.6
Jewelberry	10	30	60	0	W	4	2.5	0.7 a-d	1.0 b	0.0 a	7.5	6.3	12.0
Liset	100	0	0	0	M	1	4.0	0.0 a	0.0 a	0.0 a	81.7	4.6	8.6
Mary Potter	43	57	0	0	R	4	1.0	0.0 a	0.0 a	0.0 a	54.4	12.3	13.0

Molten Lava	5	68	27	0	W	3	1.6	0.0 a	0.0 a	0.0 a	39.4	2.0	9.0
Ormiston Roy	2	12	86	0	W	4	1.3	0.0 a	0.0 a	0.0 a	40.0	2.0	4.3
Pink Satin	10	30	60	0	PW	2	2.0	--	--	--	--	--	--
Prof. Sprenger	2	16	82	0	W	5	0.0	1.3 b-f	0.0 a	0.0 a	40.6	10.3	15.0
Profusion	2	36	62	0	CR	5	1.0	1.0 a-e	0.0 a	0.0 a	35.6	1.0	0.3
Radiant	0	0	100	0	P	1	3.6	0.7 a-d	3.3 cd	0.0 a	95.0	6.3	9.6
Ralph Shay	0	5	95	0	W	4	1.3	1.3 b-f	0.0 a	0.0 a	42.2	3.6	5.3
Red Barron	0	13	87	0	R	3	2.3	2.3 fg	0.0 a	0.0 a	45.8	3.3	6.3
Red Jade	0	55	45	0	W	4	1.0	0.5 a-c	0.0 a	0.0 a	30.0	3.0	7.3
Red Jewell	45	50	5	0	W	3	2.0	0.0 a	0.0 a	0.0 a	24.2	6.0	8.0
Red Splendor	0	10	90	0	P	1	3.0	1.5 c-f	0.0 a	0.0 a	94.2	3.0	4.5
Robinson	0	26	74	0	C	4	1.8	1.3 b-f	0.0 a	0.0 a	51.1	2.6	3.6
Royalty	0	30	70	0	M	1	3.0	0.3 ab	1.0 b	0.0 a	86.1	13.6	18.6
Ruby Luster	0	27	73	0	CM	1	4.0	1.3 b-f	2.7 c	0.0 a	78.9	9.3	15.6
sargentii	100	0	0	0	--	3	3.0	0.7 a-d	0.0a	0.0 a	--	3.3	6.6
Selkirk	0	2	85	13	PL	3	2.0	2.0 e-g	0.0 a	0.0 a	67.2	12.3	21.6
Sentinel	0	12	88	0	PW	4	2.0	0.3 ab	0.0a	0.0 a	42.8	5.0	14.3
Silver Moon	100	0	0	0	--	3	2.6	0.0 a	0.0 a	0.0 a	15.0	4.0	6.0
Snowdrift	2	98	0	0	W	5	0.5	1.0 a-e	0.0 a	0.0 a	27.2	1.0	3.3
Strawberry Parfait	0	15	85	0	PW	4	2.0	0.3 ab	0.0 a	0.0 a	43.3	4.6	6.6
Sugar Tyme	0	45	55	0	W	4	1.3	1.0 a-e	0.0 a	0.0 a	51.7	4.0	4.6
tschonoskii	0	0	0	0	--	0	4.0	2.0 e-g	0.0 a	0.0 a	33.3	13.6	13.6
Velvet Pillar	50	50	0	0	--	1	4.0	1.0 a-e	0.0 a	0.0 a	60.0	9.5	8.5

White Cascade	12	25	63	0	W	3	1.0	0.7 a-d	0.7 ab	0.0 a	54.4	2.0	4.0
Winter Gold	97	3	0	0	--	2	2.0	0.0 a	0.0 a	0.0 a	23.3	--	--
yun. v. veitchii	100	0	0	0	--	1	4.0	2.7 g	0.0 a	0.0 a	--	1.6	3.6
v. zumi 'Calocarpa'	16	33	51	0	W	3	3.0	0.7 a-d	0.0 a	0.0 a	24.4	9.3	14.0

[V]TB = Tight bud, BA = Balloon, OPN = Open, PD = Petal drop.

[W]CL = Color; W = white, R = red, P = pink, PW = pink & white, C = carmine, M = maroon, PL = pink lavender.
AB = Abundance; 0 = no flowers, 1 = sparse, 2 = moderate, 3 = abundant, 4 = very abundant, 5 = cornucopia.
AES = Aesthetic; 0 = perfect tree, 1 = very attractive tree, 2 = ornamental, 3 = tree OK, 4 = tree not ornamental.

[X]BO-OB = *Botryosphaeria obtusa*, Frogeye leaf spot
VE-IN = *Venturia inaequalis*, scab
ER-AM = *Erwinia amylovora*, Fire blight
Disease Rating System: 0 = no disease, 1 = trace-10%, 2 = 10-25%, 3 = 25-75%, 4 = 75-100% infected leaves.

[Y]Values followed by the same letter are not significantly different (DMRT, P = 0.05).

[Z]JB Defol. = Japanese beetle defoliation: Based on average ratings of three independent observers. Differences among cultivars are significant (One-way ANOVA following arscine transformation; F = 9.48; df = 41, 112; P< 0.001).

Researching The Landscape Plant Establishment Continuum: Where To Focus For The Best Return On Investment?

Michael A. Arnold
Texas

Nature of Work: Nurserymen and landscapers are no strangers to change in the highly volatile green industry. So too is the land grant university research/teaching/extension system entering a period of radical changes. Discretionary funds (non-entitlement program funds or those not mandated by law) account for most of the USDA Science and Education funding and are a likely target for budget reductions (2). Prospects for most state funds are similarly bleak. Dr. De Hertogh (former department head at North Carolina State University) has predicted that "By the end of this decade, there will only be 6 to 15 Horticultural Departments at U.S. Land Grant Universities." (3). In each state the identification of cost effective fields of horticultural research, positioning of programs for competitiveness for external funding, and identification of mutually beneficial linkages with industry and researchers in other disciplines will be critical to the survival and growth of green industry research. The purpose of this paper is to discuss the identification of cost effective research on the landscape plant establishment continuum and potential funding strategies for such research.

Results and Discussion: Landscape plant establishment can be viewed as a continuum beginning at the wholesale level with propagation, production, and distribution, then moving to the retail level where handling and storage practices are major factors, once purchased the plants enter the installation phase either under the auspices of a landscaper or homeowner, and following installation the post-transplant maintenance phase completes the process. Costs of specific research projects are largely a function of available equipment, facilities, labor, and expertise. Research designed to improve plant establishment can be conducted at any stage along the continuum. However the number of plants affected, number of people who must be convinced to alter present practices, and the magnitude of the effect of changes on the likelihood of successful plant establishment are different for each stage of the process. The cost effectiveness of landscape plant establishment research can be thought of as a trade-off between the impact of the proposed research on the likelihood of successful plant establishment and number of plants impacted versus the research costs, cost of modifications to conventional practices, and the number of people who's actions must be modified. In Texas the number of individuals/firms who would have to be contacted by extension service personnel and convinced to alter their present practices increases along the continuum from 517 wholesale growers (4), 3,886 retail outlets (4), 5,555 landscape firms (4), to 3,695,184 homeowners (owner occupied homes, 1990 US Census). Existing extension programs for contacting each of these groups varies among states. Practices relating to the installation and immediate post-transplant maintenance of plants are most likely to have direct effects on the establishment of any individual plant, but would require contacting and motivating a multitude of people to alter their present methods. Altering the practices of any small group of people at the consumer end of the continuum would affect the establishment of relatively few plants. Altering production/distribution systems

of wholesale producers and retailers would have a less direct effect on the establishment of individual plants, but would allow access to impacting the establishment of a large number of plants while requiring the contacting and convincing of relatively few individuals/firms to accept modifications to existing methods of operation. Modifying practices as simple as seed source selection can significantly alter plant performance during transplant establishment (1). Additionally, many wholesale/retail nurserymen are easily accessible via trade publications, industry organizations, field days or educational meetings, and are likely more motivated to accept changes in methodology than the general public. Thus in terms of the number of potential plant establishment events impacted per individual convinced to alter their present practices, research at the producer/retailer levels would result in the greatest return on investment, assuming similar research costs.

When selecting a research focus area attention must be given to potential funding. An examination of prospects for internal horticultural research funding revealed a priority for attracting external funds. By plotting total appropriated research money from state and federal funds allotted to the Texas A&M University (TAMU) Dept. of Horticultural Sciences, the portion of those funds allocated to salaries, and projection of those funds into the future, it appears that a decreasing amount of funds will be available for research operating budgets (Fig. 1). Based on these projects by fiscal year 1999 all research equipment and operating funds in the TAMU Dept. of Horticultural Sciences must come from external funding sources.

In order to attract external funds, projects must be positioned to address priority research initiatives set by competitive grants programs or produce tangible results that could directly benefit an individual corporation or narrowly definable group of individuals or firms. Environment and natural resources, improved environmental quality, integration of environmental objectives into other goals, encouragement of cost-shared research partnerships with industry and state governments, and promotion of international cooperation are present national research priority areas (2) that might be integrated into landscape plant establishment research. It is difficult to obtain funding for research that benefits broad segments of a society or an industry because the potential benefits from such research to any individual or small consortium of firms does not often justify the costs. Research on the consumer end of the landscape plant establishment continuum would frequently fall in this category. Projects that may potentially result in a new product/service, a new use for an existing product/service, or reduce the cost of producing an existing product/service are more favorably viewed by industry. Intangible results such as increased quality, lesser severity of stress symptoms, better disease resistance, or improved color mean little to firms that might fund research projects. Proposals for research funding to industry should include economically quantifiable characteristics and analysis.

Our program's response has been to initiate research projects and grant proposals in three primary areas: development of model systems for the identification of plant characteristics associated with superior landscape establishment of container-grown trees; the efficacy, cost effectiveness, and environmental impacts of root system modification methods during container production; and the determination of the cost

effectiveness, best management practices, and environmental adaptability of under utilized small trees for Texas' urban environments. Selected low cost studies aimed directly at the transplant process are also being investigated. These projects represent cooperative efforts among the TAMU Departments of Horticultural Sciences and Agricultural Economics, Texas Agricultural Extension Service, the Texas Forest Service, and horticultural industries within the state.

Significance to Industry: While many challenging problems remain to be solved relating to the landscape plant establishment continuum, funds available for pertinent research are limited. A discussion of the cost effectiveness of research along the continuum may help to focus research in areas where the potential return on investment is greatest and stimulate communication among researchers and industry leaders.

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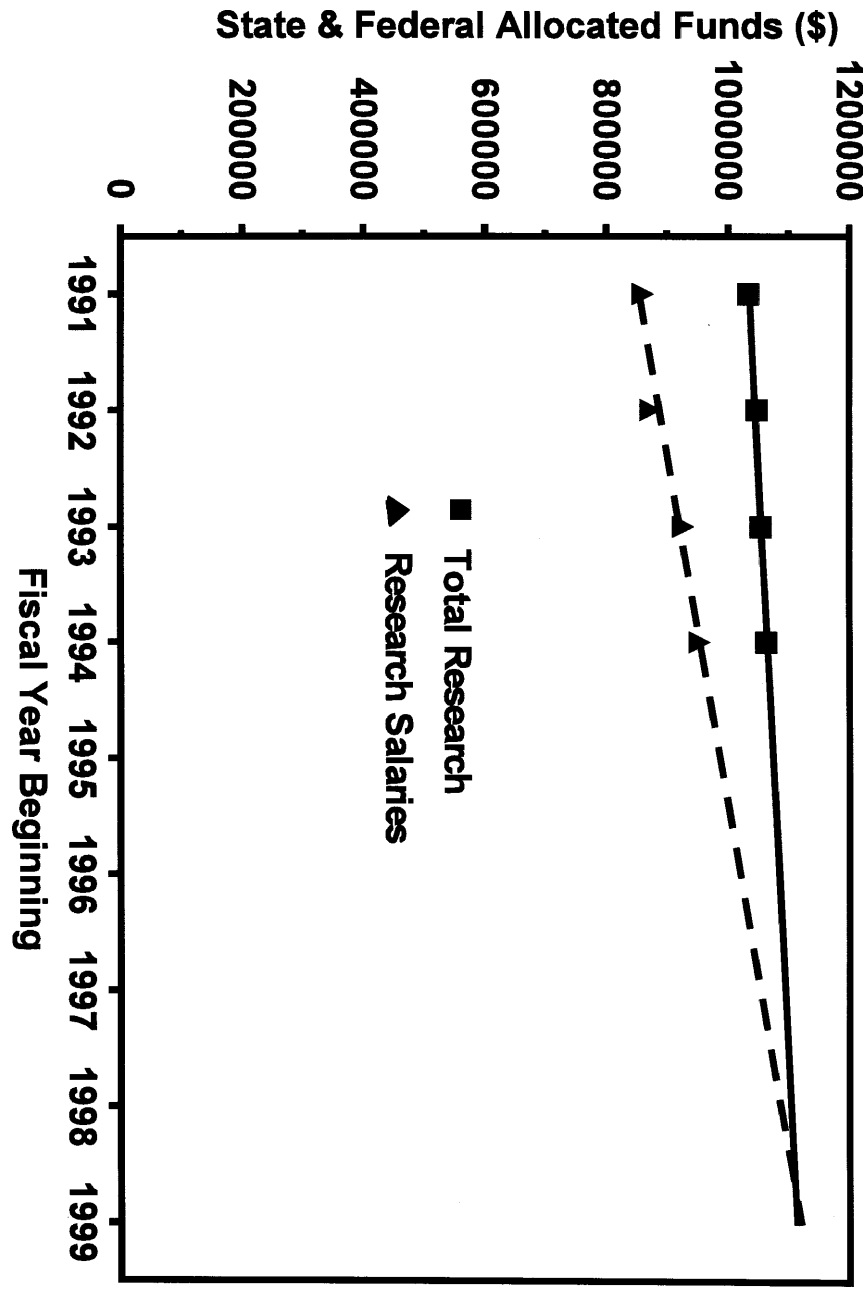
Figure 1. Total state and federal allocated funding for research (□) and research salaries (Δ) for the 1985-86 through 1994-95 fiscal years for the Texas A&M University Department of Horticultural Sciences. Projected total research funding and salaries based on historical data from fiscal years 1990-91 to 1994-95 are represented by the solid ($y=-1.83E^{7}+9.69E^{3}(x)$, $R^{2}=0.97$) and dashed ($y=-6.55E^{7}+3.33E^{4}(x)$, $R^{2}=0.95$) lines, respectively. Data courtesy Dr. R. Daniel Lineberger, Head of TAMU Dept. Horticultural Sciences.


State & Federal Allocated Funds ($)
1200000
1000000
800000
600000
400000
200000
0
1991
1992
1993
1994
1995
1996
1997
1998
1999
Fiscal Year Beginning
Total Research
Research Salaries

Production Method Influences Landscape Establishment Rate

Edward F. Gilman, Richard. Beeson and Diane Weigle
Florida

Nature of Work: Transplanted trees are considered established when annual shoot elongation returns to pre-transplant rates (8). Kramer and Koziowski (6) suggested that reduced shoot growth during this establishment period was due to a greater emphasis on root regeneration. Shoot growth will resume when a natural root:shoot ratio is reestablished. There are data suggesting that the establishment period is 3 months in hardiness zones 9 and 10, and 12 months or more in zones 4 and 5 (4).

During the establishment period, maintaining an adequate tree water status is critical for survival (5). Moderate or severe water stress greatly limits photosynthetic rates (3) and phloem transport (7), severely restricting the availability of photosynthates to the roots. Therefore in plants under severe water stress, several factors combine to limit root growth.

This experiment was designed to determine if trees transplanted from containers establish root systems at the same rate as those from field nursery soil.

In November 1987, 25 *Quercus laurifolia* (laurel oak) were transplanted from 1-gal. plastic containers into 14 in. in-ground fabric containers (FC) (Root Control, Stillwater, OK) and backfilled with native soil (Astatula fine sand) and 25 more trees were transplanted directly into the native soil [field-grown (FG)] at a local tree farm. An additional 25 trees were planted into 15 gal. plastic containers (PC) using a 55:36:9 (pine bark:peat:sand) container mix. Trees were grown for 2 years with irrigation and fertilizer practices consistent with commercial nurseries in the area.

In January 1990, all roots were harvested outside the FC (5 trees) root balls from 90° wedges (centered at the trunk) on the north and south sides of the tree (total 2 wedges per tree). Roots were also harvested from a similar position for 5 FG trees. This represented 50 percent of the root system outside the root ball. Roots were excavated with a shovel, washed free of soil in the field on a 1/8 in. screen, then rewashed in the lab before drying. During excavation, distance from the trunk to the furthest root tip was measured.

In late January 1990, 20 trees from each production method (total 60 trees) were transplanted into an Astatula fine sand within one mile of the production site. Field-grown trees were transplanted with a three-shovel tree spade forming a root ball consistent with AAN root ball standards (1). After hand digging, fabric was carefully removed from the FC trees. Plastic container-grown trees were removed from the container and planted without disturbing the root ball. Backfill soil was washed into place and a water ring was created at the edge of the root ball to hold irrigation water. All trees were staked to anchor them in the soil.

Trees were irrigated daily during the morning hours with 10 gal. of water supplied by spray stakes (Aquaturret; Stuppy Inc., N. Kansas City, MO). After 14 weeks, irrigation frequency was reduced to every other day and the volume increased to 15 gal., except after a rain of at least 1/2 in.

Ten, 26 and 52 weeks after transplanting, regenerated roots were harvested from 3 trees in each production treatment. All roots within a 1/8 wedge on the north and south sides of each harvested tree were excavated and removed back to the edge of the original root ball. Dry weight was measured once a constant oven dry weight was obtained. During excavation, the distance from the trunk to the furthest root tip uncovered was also measured.

Results and Discussion: Root weight outside the root ball at the end of the production period (at transplanting) on FC trees was similar to that on FG trees (Figure 1). The distance between the trunk and the tip of the longest root was also similar on trees in both treatments (data not shown).

Root growth into the landscape soil was slowest for trees planted from containers (PC) during the first year after transplanting (Figure 1). Ten weeks after transplanting, regenerated root dry weight on FG (18 g) and FC (24 g) trees was significantly greater than root dry weight from container trees (2 g). Twenty-six weeks after planting, root weight from FG (240 g) and FC (365 9) trees was similar; whereas, root weight from container trees (52 g) lagged far behind. Regenerated root weight 26 weeks after planting FG and FC trees was similar to root weight outside the root ball at transplanting, indicating that the root system cut off at transplanting had been completely replaced. This indicated that FG and FC trees may have been completely established 26 weeks after transplanting.

By 52 weeks after transplanting (January 1991), root weight outside the root ball on FC and PC trees was less than that on FG trees. Roots on FC trees grew very little between 26 and 52 weeks after transplanting. This may have indicated that FC trees were not yet fully established by 26 weeks after transplanting. The reduction in irrigation frequency from daily to every other day irrigation 14 weeks after transplanting may have slowed root growth on the FC and PC trees.

Significance to the Industry: Trees need regular irrigation to supplement rainfall until they become established. These data suggest that establishment period for field-grown laurel oak is about 12 weeks per inch trunk diameter for field-grown trees in USDA hardiness zone 9. This is similar to the establishment rate for field-grown slash pine (2). Trees planted from containers took longer to establish in the landscape than trees transplanted from a field soil.

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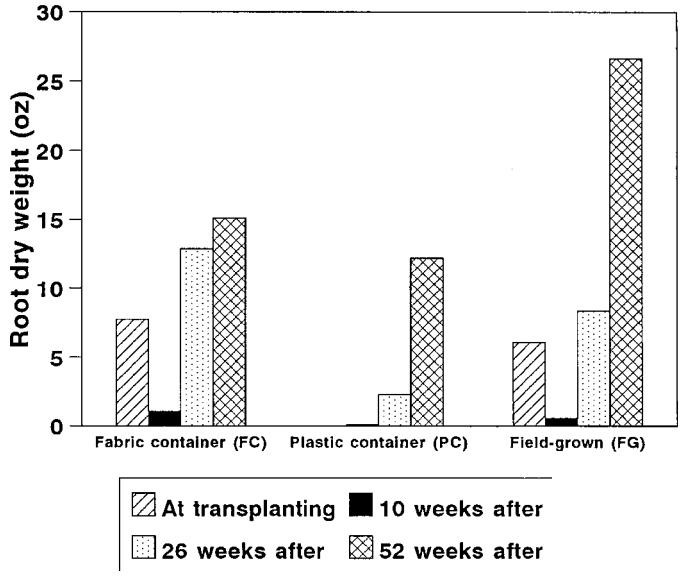
Figure 1. Dry weight of laurel oak roots regenerated into the landscape soil after transplanting.



Trends in Southern Landscape Gardening

M.A. Powell
North Carolina

Nature of Work: There are a number of new trends in landscape design In the YU s that can be identified as being different than previous decades. The interest in gardening and related activities has never been greater, as home gardening has been identified as American's top hobby. Environmental attitudes towards pesticide use, waste reduction, recycling and energy conservation directly impact the way landscapes are designed, installed and managed. These changes in landscape priorities and outdoor spatial use can be observed all across the southeastern United States. Demand for horticultural products and landscape services will remain high, if professionals stay in vogue.

Results and Discussion: The following are examples of landscape gardening activities and landscape design ideas that are becoming standard practices in the landscape industry.

* More emphasis on "user friendly spaces (very practical and functional). Landscape designers are addressing spaces on individual merits and getting away from the "recipe" approach to design. Residential clients place a high priority on outdoor active use spaces and individual perferences.

* Increase use of multiple plant species in a screening area. (getting away from a straight row of a single species type planting)

* The use of herbs, for their ornamental value as well as culinary and medicinal uses.

* Expanded use of ornamental grasses, wildflowers and perennials in a "mixed border".

* Incorporation of plants with aromatic plant parts.

* The use of old-timey or heirloom plants. Many of these plants require very little maintenance and are relatively pest free.

* Creating spaces in the garden that attract wildlife.

* Reducing the size and level of management for turf areas.in stressful locations. Emphasizing natural areas and groundcover plantings in shady areas.

* Water conservation, xeriscaping and the use of drought tolerant plants.

* Emphasis on "hardscaping", with expanded use of construction materials as land scape components.

* The use of containers for plant displays and seasonal color.
* Expanded list of winter annuals for color.

* Incorporation of vines into the landscape. The trellis, lattice fence, and arbor are becoming featured landscape components.

* The use of “garden ornaments”.

* Becoming a landscape “professional”. The landscape profession is quite diversified and specialized. There are title laws (landscape architects and contractors) along with several professional registrations; Certified Plant Professional, Landscape technician, Grounds Maintenance Professional, Certified Pesticide Applicators to name a few. Landscapers realize that to be successful in the 90’s, one can’t continue to implement the same business and horticulture strategies that worked in the 70’s and 80’s.

Significance to Industry: Landscape consumers are requiring a higher level of expertise and ability then ever before, and in order to stay competitive, or to remain a leader in the industry, landscape designers and contractors must continue to stay current in ideas, practices and horticultural techniques. Landscape contractors, aside from being horticulturists, are becoming talented craftsmen also. With the expanded use of construction materials, landscapers realize that being proficient in wood, masonry, and stone construction is economically beneficial to the business. Instead of hiring a sub-contractor to build decks, install pools or lay a dry stack wall, landscapecompanies now employ these artisans, and perform the tasks “in house”. Many landscape contracting businesses have specialized labor crews. It’s not unusual for one team to apply all the pesticides, or another crew to perform all the horticulture/ floriulture installation, and another team to handle all construction. The modern landscape contractor or design/ build firm is capable of numerous outdoor activities. These type businesses provide leadership and set the standards for the rest to follow.

Crabapple Cultivars for Urban and Roadside Landsdcapes

James B. Aitken
South Carolina

Nature of Work: The performance characteristics of flowering crabapple (*MALUS SPP.)* cultivars for use in urban and roadside landscapes, in the humid Southeast, has not previously been investigated. The demand for new plant material to replace trees such as flowering pear is increasing in many areas. This research is part of the National Crabapple Evaluation Program which has numerous test sites around the nation. The project consisted initially of 49 cultivars with 3 replications arranged in a randomized complete block statistical design. The plantings were made in late winter of 1988 and 1989 at the Sandhill Research and Education Center in the midlands of South Carolina. The soil type is a Lakeland sand. Spring and fall evaluations were started in 1991 to quantify the performance factors of each cultivar. Spring data consisted of bloom dates, flower color, flower abundance and fragrance andaesthetic appearance ofthe tree. Fall data consisted of aesthetic rating and evaluation for scab, fire blight, cedar apple rust, and powdery mildew.

Results and Discussion: The data collected each year on the numerous cultivars was compiled for the various parameters. The most important parameter was that of aesthetic ratings. Based on the aesthetic ratings and tree size projections. Ten cultivars were selected for use in urban and roadside landscapes. The size criteria for roadside landscapes was a tree that did not spread more than 20 feet and was more upright in general shape. This type of tree would fit into highway median plantings and into narrow shoulder zones along sidewalks. The selected cultivars are described below in two groups: urban and roadside and urban only.

Urban and Roadside: ADAMS—Height = 20' and spread = 20'. The rounded, dense trees have clusters of carmine buds opening to carmine, single flowers which expand to 1.5 inches in diameter and become clear pink in color. The foliage is green with a reddish tinge to the new growth. The fruit is red, 5/8 inch diameter and generally persist until the next spring. Good to excellent disease resistance .

BOB WHlITE—Height = 20' and spread = 20'. Dense, rounded tree form. The midseason flowers are pink in bud, opening to white, 1 inch, single blossoms. The leaves are slightly glossy, light green and less than 2 inches long giving a finetextured foliage. Fruit is yellow, 5/8 inch across. and persist until eaten by birds in late winter. Good to excellent disease resistance .

DAVID—Height = 12' and spread = 12'. A rounded, compact tree. Buds are light pink, opening to 1 1/2 inch, single white blossoms in mid-season. Foliage is light green and glossy. The fruit is about 1/2 inch diameter, scarlet red, attractive and persistant. David is slightly susceptible to fire blight. This cultivar has good year round appearance.

INDIAN MAGIC—Height = 15' and spread = 15'. Tree has an upright, spreading shape with dark green foliage. Red buds open to rose-pink, single flowers that measure 1 1/2 inches across. The fruit is 1/2 inch diameter,elongate, glossy red changing to golden orange; it remains attractive long after the foliage drops in the fall. It is sometimes moderately affected by scab but still retains the leaves until fall.

PROFESSOR SPRENGER—Height = 20' and spread= 20'. The trees uprightspreading form is sometimes not apparent because of its very dense growth. Pink buds open to very showy white single flowers. The fruit is orange-red in color and 1/2 to 5/8 inch diameter and remains attractive from mid-September until the first hard frost, and may last until November or even as late as Christmas. This cultivar is disease resistant.

RED JEWEL— Height = 15' and spread = 12'. A compact, upright-spreading tree with horizontal branching habh. The flowers are numerous, white and single. Leaves are 2 to 3 inches in length and are dark green. This cultivar is outstanding in autumn with numerous, persistent, glossy, bright cherry-red fruit, 1/2 inch in diameter. Good scab and fire blight resistance .

SENTINEL— Height = 20' and spread = 12'. A narrow-upright type tree with palepink single blossoms. The leaves are 3 inches long by 1 1/2 inches wide. The bright red, persistent fruit is 1/2 inch diameter and starts to color by mid-August. It is slightly susceptible to scab.

WINTER GOLD— Height = 25' and spread = 20'. A relatively small, rounded tree with attractive, medium green foliage approximately 2 inches in length. Deep carmine-colored buds precede the white, 1 inch, single flowers, which open late in the bloom season. The yellow fruit is the outstanding feature of this cultivar; 1/2 inch in diameter, it is abundant and persistant. It is moderately susceptible to scab and slightly susceptible to powdery mildew

URBAN ONLY: MARY POTTER — Height = 10' and spread = 15'. This cultivar has horizontal and low spreading shape with dark green foliage. Buds are pink with white, single flowers. The fruit is red, 318 inch and persistent One of the showiest crabapples in bud and flowering stages. Beloved by birds.

RED BARRON — Height = 18' and spread = 8'. This narrow, columnar shaped tree has purple foliage that ages to bronze-green, giving good fall color. The flowers are dark red and single. The dark red fruit is 1/2 inch diameter and persistent. Scab resistance is fair and other disease resistance is good.

Significance to Industry: The selection of flowering crabapple cultivars that will perform well in the humid Southeast offers new marketing opportunities for the nursery industry. As the cultivars become available, more utilization will take place in the landscape trade.

Native Grasses for Southeastern Wildflower Meadows

W. L. Corley and K. R. Reynolds
Georgia

Nature of Work: Wildflowers can be used to provide cost-efficient landscape color in areas where high maintenance ornamentals or turf are traditionally grown. Beauty spots of floriferous annual and perennial wildflowers are often grown in areas formerly planted with high maintenance bedding plants (1). In more naturalistic settings, a meadow of reseeding annual and perennial wildflowers with companion native grasses can be planted on roadside backslopes, park areas where turf meets shrubs or trees, and in home landscapes if space permits. A wildflower meadow can reduce landscape maintenance inputs while giving cost-efficient landscape color and providing wildlife habitat (2, 3).

Results and Discussion: Only a few native southeastern grasses are available in the seed trade. Common broomsedge, little bluestem, switchgrass, and Indian grass are available from Midwestern sources. Most grasses prefer full sun exposures, but will tolerate light shade. Broomsedge (bluestem) species are slow growing and require two years for maturation in a meadow. The major native grasses for consideration are:

Andropogon virginicus, common broomsedge, is the most ubiquitous of the clump-forming native grasses. If you can't wait for it to naturally invade your planting, seed at 10 lbs./ acre pls.

Panicum virgatum, switchgrass, is a robust bunch grass growing 3 to 5 feet tall and prefers mesic to wet sites. Seed at 8 lbs./acre.

Scbizacbyrium scoparium, little bluestem, is shortest of the broomsedge group at 2 to 3 feet and casts a reddish color in the fall. It prefers dry to mesic sites. Seed at 5 lbs./ acre.

Sorghastrum nutans, Indian grass, grows 4 to 6 feet tall where moisture is adequate. Foliage turns yellow-bronze in fall. Usually found in mesic sites and seed at 5 lbs./acre.

If resources are available for collecting seeds or harvesting wildflower hay, other species to consider are bushy broomsedge, silver broomsedge, beard grass, plume grass, muhly grass, purple love grass, and purpletop.

Companion wildflowers are usually a matter of personal choice. A good southeastern mix will perform well as companions for shorter growing grasses. An aggressive mix of wildflowers will complement the taller grasses.

Significance to Industry: In less formal and naturalistic areas, native grasses enhance the true wildflower meadow. Functional grasses provide support and protection for tall flowers, lend color and texture to the meadow, and help in preventing soil erosion.

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Effect of Cultural Levels on the Appearance of Open Celled Pavers

David B. Nichols
Georgia

Nature of Work: Open celled pavers are precast materials manufactured from either concrete or plastic. Open cells within the pavers are filled with soil as a medium for the growth of turfgrass or other plant materials. The pavers are used primarily for infrequent vehicular parking such as overflow parking for commercial facilities, church parking lots, or residential driveways and guest parking spaces. In retail nurseries, they show great potential for use in parking areas as well as for outdoor walkways in display areas (3). For wholesale growers, they may be used to improve vehicular access to fields by increasing the soil bearing strength in areas that remain damp and soft for long periods of time.

The pavers offer a number of environmental benefits when compared to traditional paving materials. A reduction in stormwater runoff, filtration and reduction of nonpoint pollutants, moderation of surface air temperatures, and a competitive price with traditional paving materials requiring stormwater collection systems are among the many benefits of these pavers (1,2,4).

A study was begun at The University of Georgia in 1992 to attempt to determine if there existed significant perceived differences in the appearance of pavements composed of the various brands of open celled pavers. The first study in the series established several varieties of turfgrass plots of the pavers. The turfgrasses were selected on the basis of their popularity in the Southeast. After initial establishment, the plots were maintained under a low intensity of culture. The results of the first study indicated that under a low intensity of culture, common bermudagrass became the dominant grass in all of the plots. The study also found that one brand of paver, Checkerblock by the Hastings Pavement Company was perceived as providing a superior appearance in comparison with the other pavers (3).

In September of 1993, the plots were completely renovated. Three cultivars of tall fescue, 'Anthem', 'Rebel II', and 'Ky. 31' were established in the plots. All of the plots were seeded at the rate of 7 lbs. per 1000 square feet in mid-September. After an initial establishment period, the plots were maintained under a moderate level of culture. The plots were fertilized on March 7 and April 18, 1994 at a rate of 0.5 lb. of nitrogen per 1000 square feet on each date. No herbicide or pesticide treatments were made on the plots. After initial establishment, no supplemental irrigation was supplied. The plots were mowed at 7 - 10 day intervals as needed at a 2.25 inch mowing height.

The plots were evaluated on May 5 and 6, 1994 by 22 landscape architects. The evaluators were asked to assign a score for each plot from 0 (lowest) to 4 (highest) based solely upon the perceived visual appearance of the paver / turfgrass combination. The seven brands of pavers tested were: Eco Stone by SRM Inc., Turflock by Paver Systems Inc., Checkerblock by Hastings Pavement Co., Geoblock by Presto Products

Inc., GrassRoads Paver II Plus by Bartron Corp., Grassrings 2 by Invisible Structures, and Grassy Pavers by R-K Manufacturing. Eco Stone, Turflock, and Checkerblock are manufactured from concrete; the other brands are composed of plastic.

Results and Discussion: Overall, the mean scores of the plots increased significantly between the 1994 evaluations and those of the previous year. The mean score of all of the plots combined rose by over one point from 1.5486 in the 1993 study to 2.5725. Of the seven paver brands tested in 1994, there was no significant difference in the mean scores except for that of the Geoblock Paver which was perceived to provide a slightly less satisfactory appearance than the others. As far as the tall fescue cultivars were concerned, the 'Rebel II' and 'Ky. 31' were perceived as providing a virtually identical level of appearance. The 'Anthem' fescue finished slightly behind the other two cultivars.

Significance to Industry: While these pavers offer a number of environmental benefits compared to traditional paving materials, a concern over the visual appearance of pavements composed of the pavers has somewhat limited their use. The results of this study indicate that an acceptable appearance can be achieved with any of the top six brands of pavers under a modest level of maintenance. Further, in the northern piedmont region of the Southeast, either of the three cultivars of tall fescue tested appears to provide an acceptable level of appearance approximately eight months after establishment.

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A New Approach to Measuring Hydraulic Properties of Urban Soils

William C. Fonteno and Stuart L. Warren
North Carolina

Nature of Work: Two of the major problems presented by urban soils are compaction and drainage. To successfully ameliorate these problems, organic matter is often added to the soil. Empirical data is needed on water transport factors such as drainage, percolation, and hydraulic conductivity, as well as for capacity factors of porosity, aeration, and available water. While limited information is available for specialized systems, such as golf green construction, there is no such information for urban soils. The following is a suggested approach to analyzing the effects of additions of organic matter to urban soils using empirical data and mathematical models.

For illustration, a loamy sand (82% sand, 12% silt, 6% clay) was amended with 0, 10, 20, 30, 40, and 50% composted poultry litter (CPL) by volume. Total porosity (TP) was determined for each treatment combination using the NCSU Porometer™, following the procedures of Warren and Fonteno (1993). An estimate of unavailable water (UW) was defined as the amount of water held at 1.5 MPa, using procedures of Milks et al. (1989). Data were collected for moisture retained at 10 moisture tensions from 0 to 30 kPa using a pressure plate apparatus and procedures of Milks et al. (1989) . After the measurement at 30 kPa, each sample was removed and bulk density determined by calculating its volume and weighing each sample after it was dried 24 hr at 105 C (Klute, 1986). A nonlinear, fiveparameter function developed for soils by Van Genuchten and Nielsen (1985) and adapted to horticultural media by Milks et al. (1989) was used to describe the moisture retention data.

In order to determine the effects of organic matter additions on the parent soil at various depths, a landscape soil profile model was developed. TP and UW were equal to the volume wetness at saturation and 1.5 MPa, respectively. Water content (WC) was predicted based on the Equilibrium Capacity Variables (ECV) model refined by Milks, et al. (1989). The soil column to be modeled was mathematically sectioned into 0.5 cm tall increments. The nonlinear equation was used to predict the percentage of water values at the midpoint of each 0.5 cm section. Multiplying the percentage of water value by the volume of each soil column section gave the water volume held in that section at field capacity. The water volumes of all zones were summed to give the total water volume in the soil column at field capacity. Air space (AS) was calculated as the difference between TP and WC. AW was calculated as the difference between WC and UW.

Results and Discussion: Total porosity increased linearly with increasing rate of CPL amendment from 42 to 55% (Table 1). Bulk density decreased linearly, as reflected by increasing pore space. Twenty percent and higher rates of CPL were within the ideal bulk density range proposed by Craul (1986).

Using the landscape drainage profile, water content increased with increasing CPL rate (Figure 1). Water content was increased from 10 to 35% within the upper 35 cm of soil.

Although most organic matter has high water retention capacity, much of it is held at potentials > 1.5 MPa, and is unavailable to plants. This is reflected in the increasing UW with increasing CPL rates (Table 1). Any increase in water content should be divided into available and unavailable water before the value of the organic amendment can be evaluated. In this loamy sand, increasing CPL additions improved overall water content from 10 to 34%, while the AW was only increased from 6 to 12%. CPL reduced air space from 33% to 18% within the top 35 cm. The largest decrease in AS occurred between the 20 and 30% CPL rates.

Significance to Industry: The landscape drainage profile can be adjusted to model incorporation of organic matter to other depths. For practical purposes, models from 10 to 90 cm have been developed (not shown). This allows the examination of organic matter additions at any rate and to any depth of incorporation. These models and empirical data, combined with appropriate field information such as percolation and slope could provide a systems approach to understanding the hydraulic properties of urban soils.

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Table 1. Effect of composted poultry litter (CPL) amendment on total porosity, unavailable water, and bulk density of a loamy sand soil.

CPL amendment (% vol)	Total porosity (% soil volume)	Unavailable water (% soil volume)	Bulk density (Mg/m^3)
0	42.0	4.0	1.48
10	45.2	7.1	1.39
20	46.9	8.9	1.33
30	47.0	14.4	1.29
40	49.4	21.3	1.20
50	55.5	21.4	1.08
Significance[z]			
Linear	***	***	***

[z]Significant at 0.001 level.

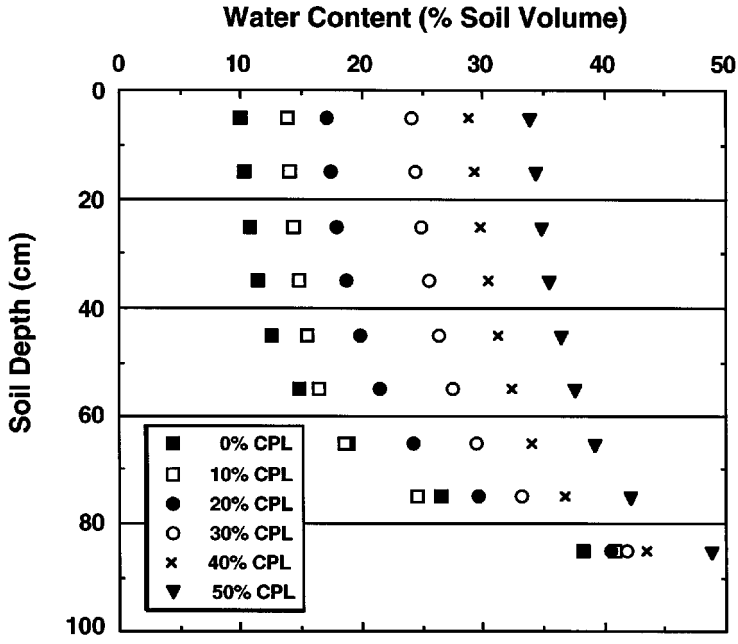

Figure 1. Effect of composted poultry litter (CPL) on water content of a loamy sand soil.

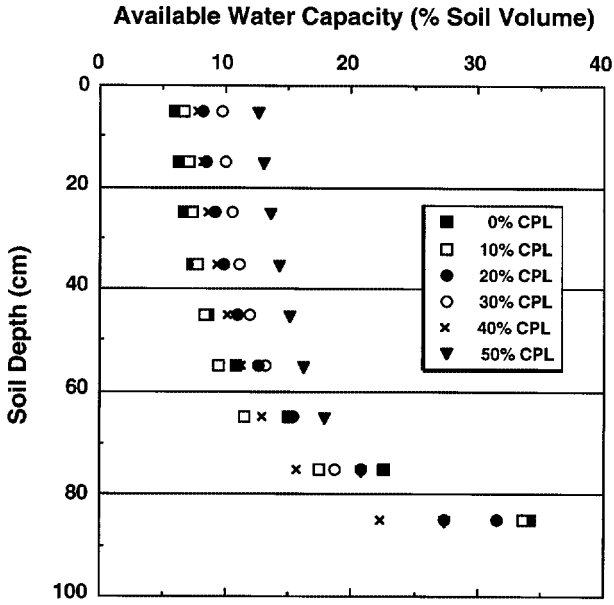

Figure 2. Effect of composted poultry litter (CPL) on available water capacity of a loamy sand soil.

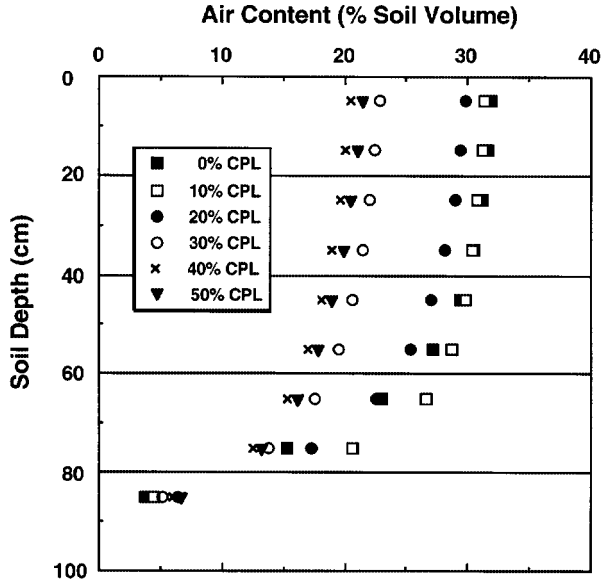

Figure 3. Effect of composted poultry litter (CPL) on air space of a loamy sand soil.

North Carolina Urban Tree Evaluation Program

Thomas G. Ranney and Richard E. Bir
North Carolina

Nature of Work: The North Carolina Urban Tree Evaluation Program is a cooperative venture among cities, corporations, commercial nurseries, community groups, community colleges, professional associations, the North Carolina Urban Forest Council, the North Carolina Division of Forest Resources, and the North Carolina State University,. The primary purpose of the North Carolina Urban Tree Evaluation Program is to develop an information data base on the survival, performance, and limitations (disease, insect, and cultural problems) of a wide assortment of tree species and cultivars in North Carolina spanning USDA hardiness zones 6a-8a. The project is coordinated by Thomas G. Ranney and Richard E. Bir, Department of Horticultural Science, N.C.S.U.

One tree of each taxa is planted at each of 15 sites across the state (Fig. 1.). Local cooperators at each site take responsibility for planting, maintenance, and data collection at each site. Planting and maintenance are standardized. Data being collected include survival, trunk diameter, and tree height. Plants are also periodically scouted and rated for presence of diseases and insects.

Results and Discussion: Trees were distributed for evaluation in 1993 and 1994 and include 45 different taxa of trees. Trees currently in the evaluation are: *Acer campestre* 'Evelyn' Queen Elizabeth® (hedge maple); *A. x freemanii* 'Indian Summer' (Freeman maple); *Acer x freemanii* 'Jeffsred' Autumn Blaze® (Freeman maple); *Acer ginnala* 'Flame' (Amur maple); *Acer saccharum* ssp. *floridanum (A. barbatum)* (southern sugar maple); *A. truncatum x platanoides* Norwegian Sunset (Norwegian Sunset maple); A. *tuncatum x platanoides* Pacific Sunset (Pacific Sunset maple); *Amelanchier x* Trazam' Tradition™ (Tradition serviceberry); *Betula ermanii* (Erman birch); *Betula platyphylla* var. *japonica* ' Whitespire'/ *B. nigra* ('Whitespire' Japanese birch grafted on river birch rootstock); *Betula platyphylla* var. *kamchatica* (sand birch); *Carpinus betulus* 'Fastigiata' (pyramidal European hornbeam); *Cercis canadensis* ssp *texensis* 'Oklahoma' (Texas redbud); *Chamaecyparis thyoides* (Atlantic whitecedar); *Chionanthus retusus (Chinese* fringetree); *X Chitalpa ttashkentensis* (chitalpa); *Cladrastis kenttukea (C. lutea) (American* yellowwood); *cornus angustata* (oriental dogwood); *Cornus mas* 'Spring Glow' (corneliancherry dogwood); *Evodia hupehensis (hupeh* evodia); *Fraxinus pennsylvanica* 'Cimmzam' Cimmaron™ (Cimmaron green ash); *Halesia diptera* var. *magniflora* (two-winged silverbell); *Halesia tetraptera (H. carolina)* (Carolina silverbell); *Lagerstroemia fauriei* 'Townhouse' (Townhouse crapemyrtle); *Lagerstroemia indica X fauriei* 'Choctaw' (Choctaw crapemyrtle); *Liquidambar styraciflua* Rotundiloba' (fruitless sweetgum); *Liriodendron tulipfera* 'Arnold' (Arnold tuliptree); *Magnolia x 'Galaxy'* (Galaxy magnolia); *Malus* 'Adirondack' (flowering crabapple); *Malus 'Doubloons'* (flowering crabapple); M. 'Golden Raindrops' (flowering crabapple); *Malus* 'Royal Fountain' (flowering crabapple); *Malus* 'Sinai Fire' (flowering crabapple); *Malus* 'Sutyzam' Sugar Tyme® (flowering crabapple); *prunus x* "Okame' (flowering cherry); *Prunus x* 'Schmidtcis' Big Cis™ (flowering plum); *Prunus ttomentosa* (Nanking cherry);

Prunus x 'White Glory' (weeping nectarine); *Ptelea trifoliata* (hoptree); *Quercus acutissima* (sawtooth oak); *Quercus frainetto* "Schmidt' Forestgreen® (Forest Green Hungarian oak); *Q. nuttallii* (Nuttall oak); *Styrax japonicus* 'Emerald Pagoda' (Sohuksan) (Emerald Pagoda Japanese styrax); *Tilia tomentosa* 'Sterling' (silver linden); *Xanthoceras sorbifolium (yellowhorn)*.

Significance to Industry: This program will provide extensive evaluation of new and underutilized trees for potential use in the S.E. U.S. In addition to providing information on plant performance and limitations, the program will also help to promote and market new plants by allowing practitioners the opportunity to grow and evaluate these plants in regional landscape plantings.

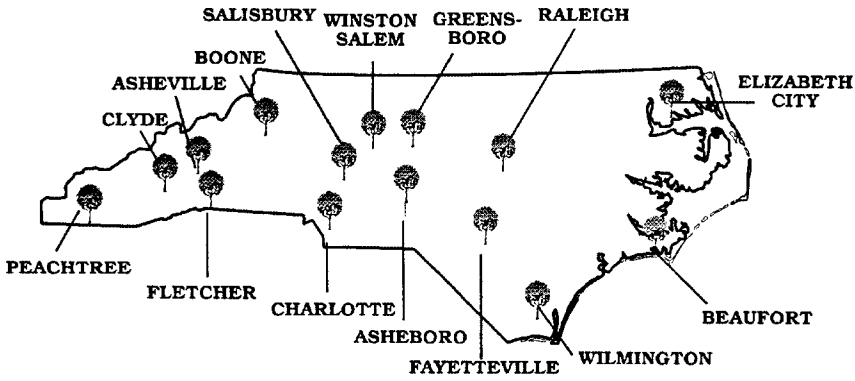

Figure 1. Location of tree evaluation sites in North Carolina.

Small Trees and Shrubs for Use Under Power Lines

Bonnie Appleton and Barbara Touchette
Virginia

Nature of Work: Utility companies spend over $1 billion annually for tree pruning and removal caused by the selection and planting of tree species with inappropriate mature heights (6). Despite publicity warning against the use of trees that are too tall, poor tree species selection continues. Though not always the fault of the utility companies, much of their line-clearance pruning damages the trees both physiologically and aesthetically (4, 5).

Numerous options exist to deal with utility line - street tree competition (1, 2, 3, 6). On one extreme, new tree planting in utility easements can be prohibited, and all existing trees in utility easements removed and not replaced. On the other extreme, planting of trees whose mature height exceeds utility line heights can continue, with accompanying tree disfiguring and weakening pruning. Between these extremes are options such as use of tree growth regulators, installing utility lines underground, using offset tree spacing, and starting tree pruning prior to line interception.

An additional option is to plant under utility lines smaller trees and large shrubs that can be trained into tree forms. The purpose of this ongoing project is to identify and track the growth of more appropriately-sized plants.

Results and Discussion: Surveys of municipal and utility arborists in the Mid-Atlantic region were conducted to collect information about species of trees currently used as street trees. Ranked in descending order the major genera used were: *Acer, Quercus, Pinus, Pyrus, Platanus, Prunus, Cornus, Lagerstroemia, Malus, Fraxinus, Gleditsia, Cercis, Liriodendron, Ilex, Tilia, Ulmus, Nyssa, Cupressocyparis, Zelkova, Carya, Crataegus, Juniperus, Sassafras*, and *Thuja*. Ranked in descending order the top ten specific trees used were: *Pyrus calleryana, Quercus palustris, Cornus florida, Quercus phellos, Acer rubrum, Pinus strobus, Lagerstroemia indica, Platanus occidentalis, Acer saccharinum*, and *Malus*. Upon examining these street tree lists it is obvious that certain species will have mature heights that will remain below or only slightly intercept utility lines (usually strung at 25' or 35'), while many will greatly exceed the height of the lines, necessitating pruning.

Respondents were also asked to list and rank desirable characteristics for trees and shrubs to be used under utility lines, and to suggest possible alternative species. The list of desirable characteristics in descending order was:

Not overly tall at maturity; Hardy and tolerant of urban conditions; Possessing branches with wide crotch angles; Disease and insect resistant or tolerant; Straight trunks and high branching (or can be limbed-up); Low maintenance requirements (no litter or hazards); Deep roots to prevent sidewalk or water line damage; Long-lived (10-15 yrs. minimum); Seasonal interest; and Crown density permitting light penetration.

In descending order of response, alternative trees and shrubs suggested for use under utility lines included: *Prunus* (x *cistena*, *yedoensis, subhirtella, serrulata*), *Cornus* (*kousa, amomum*, *racemosa*), *Acer* (*campestre, ginnala, griseum, carpinifolium*), *Malus* ('Red Jewel', *sargentii*), *Ilex* (x *attenuata, yaupon*), *Chioanthus virginicus, Amelanchier canadensis, Crataegus* (*crusgalli* var. *inermis, viridis*), *Vibernum prunifolium, Oxydendrum arboreum, Koelreuteria paniculata, Carpinus caroliniana, Cercidiphyllum japonicum, Albizia julibrissin, Asimina triloba, Euonymous alatus, Vitex negundo, Pistacia chinensis, Cladrastis kentukea, Evodia daniellii, Gordonia lasianthus, Ostrya virginiana, Photinia* (x *fraseri, serrulata*), *Halesia carolina, Magnolia stellata, Rhus* spp., *Syringa* spp., *Myrica cerifera*, and *Hamamelis vernalis*.

Significance to Industry: To help reduce physical and aesthetic tree destruction, and to aid in the selection of appropriately-sized trees and shrubs, a demonstration "utility arboretum" is being developed at the Hampton Roads Agricultural Research and Extension Center, Virginia Beach, to trial many of the alternative tree and shrub species suggested by municipal and utility arborists. By demonstrating to the "green industry" and the general public that acceptable alternative species for planting under or near utility lines exist, it is hoped that the planting of inappropriately tall trees under utility lines will be reduced. It is also hoped that a production niche will be created for the nursery industry, or that nurseries form alliances with utility companies, since some utility companies are starting their own nurseries to grow these more appropriately sized plants.

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Observations of Daylily Performance During the First Year in the Field

Winston Dunwell
Kentucky

Nature of Work: Consumers are looking for a long bloom period as well as desirable color, size, and foliage characteristics when selecting *Hemerocallis* cultivars. The number of divisions produced by a cultivar during a growing season is also important if nurseries are to satisfy consumer demand and reduce the production costs. This work was undertaken to evaluate *Hemerocallis* cultivars for favorable production characteristics, long-term aesthetic appeal in the landscape, and fall flowering. Twenty-seven cultivars, supplied by Schott Gardens of Bowling Green, Kentucky, were dug and divided on August 20, 1992. The plants (single fan plantlets) were planted into 6-ft. wide beds at the University of Kentucky Research and Education Center (UKREC) in Princeton, KY on August 21, 1992. The plants were watered weekly for the first four weeks after planting. No additional fertilizer or water was supplied after the fourth watering. These plants were divided, by the method described by Munson (2), on September 24, 1993, the number of divisions (plantlets, ramets, fans) from each plant recorded, and a single fan planted for a second year of observations as one year old divisions. The date of first bloom, the color of the bloom, and the date of last bloom were recorded twice weekly during the summer of 1993. Data collected on date of first bloom is reported for 1994 through July 21, 1994.

Results and Discussion: Mean observations for 1993 are presented in Table 1 (1). It was common for plants to have scapes and buds, but not have flowers for several observations before the dates of first bloom reported and/or after the date of last bloom reported. 'Siloam Sunburst' was the only cultivar to bloom during the period from August 2,1993 to August 17, 1993. 'College Try', had no blooms observed from July 21, 1993 to September 21. 1993, but was a welcome sight in late September and October. While no cultivars outperformed 'Stella d'Oro' in the length of the bloom period and in the number of divisions, there were several cultivars that appear to hold promise relative to the number of divisions produced and the length of bloom period. In 1993 'Stella d'Oro', 'College Try', 'Best of Friends', and 'Siloam Sunburst' bloomed in the fall. An effort was made to determine which parameter to use for measuring the time of the appearance of the first bloom, Table 2. Julian days were highly correlated with Growing Degree Days in 1993 (r=0.998) and in 1994 (r=0.999). The correlation coefficient for Julian days of 1993 and 1994 (r=0.846) was not significantly different (0.05 level) from the correlation coefficient for the Growing Degree Days of 1993 and 1994 (r=0.827) (3).

Significance to the Industry: Kentucky Farmers and Nurserymen are seeking additional ways to diversify their farms and nurseries to reduce the financial risk associated with a limited number of crops. The popularity of *Hemerocallis* has increased in recent years thanks in part to the long flowering period and availability of 'Stella d'Oro' and similar daylilies. Using the actual date of first bloom is a satisfactory

measurement for establishing the time of first bloom of daylily cultivars. Continuing to evaluate the daylilies through the season until a late September dividing date has provided information on fall flowering to growers that sell crops, for example, mums, cut flowers, pumpkins, etc. from the field in the fall. The presence of a fall bloom could enhance daylily sales. The UKREC daylily planting is available for public viewing throughout the growing season.

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Author's Note: Appreciation to Amy Perkins and June Johnston for data collection and Dwight Wolfe for data analysis.

Table 1. 1993 Daylily characteristics observations

Cultivar	Date of First Bloom	Date of Last Bloom	Color	Average Number Divisions
Stella d'Oro	03JUN93	24SEP93[1]	Gold	17.5
Sun Flare	28JUN93	22JUL93	Yellow	4
Dragon Lore	21JUN93	08JUL93	Red/Yellow	4
Lights of Detroit	17JUN93	15JUL93	Yellow	3.5
Cha Cha Cha	24JUN93	22JUL93	Peach	2.5
Dutch Lady	21JUN93	01JUL93	Yellow	3
College Try	21JUN93	30SEP93	Red	4.25
Lullaby Baby	14JUN93	29JUL93	Peach	3
Ruffled Magic	[2]			2.5
Lavender Patina	24JUN93	22JUL93	Lavender	3
Buddah	17JUN93	12JUL93	Red/Yellow	3
Siloam Red Toy	17JUN93	8JUL93	Dark Red	3.66
Best of Friends	17JUN93	245ep93[1]	Pink/Green	2.5
Yesterdays Memories	28JUN93	12JUL93	Pink	2.33
Cisty	24JUN93	15JUL93	Pink	3
Prairie Blue Eyes	21JUN93	12JUL93	Lavender	3.5
Attribution	14JUN93	08JUL93	Pink	5.5[3]
Evening Bell	06JUL93	12JUL93	Yellow	2
Purple Oddity	19JUL93	29JUL93	Wine/Yellow	5
Homecoming Queen	21JUN93	08JUL93	Orange	2
Yellow Kitten	NO[4]			2
Ribbon Candy	NO			2
Dream Awhile	14JUN93	01JUL93	Pink	1
White Temptation	NO			2
Peach Souffle	06JUL93	17AUG93	Yellow	3
Siloam Sunburst	08JUL93	16SEP93	Red/Orange	4
My Son Bob	NO			1

[1]Blooms still on when divided. [2]Ruffled Magic put up a scape, never bloomed. [3]Very easy to divide. [4]No=No blooms observed

Table 2. Daylily Date of First Bloom

Cultivar	1993 Date of First Bloom (Julian)	1993 GDD[1]	1994 Date of First Bloom (Julian)	1994 GDD
Stella d'Oro	03JUN93 (154)	882	01JUN94 (152)	906
Sun Flare	28JUN93 (179)	1522	27JUN94 (178)	1622
Dragon Lore	21JUN93 (172)	1337	20JUN94 (171)	1432
Lights of Detroit	17JUN93 (168)	1226	13JUN94 (164)	1201
Cha Cha Cha	24JUN93 (175)	1420	[2]	
Dutch Lady	21JUN93 (172)	1337	[3]	
College Try	21JUN93 (172)	1337	20JUN94 (171)	1432
Lullaby Baby	14JUN93 (165)	1148	09JUN94 (160)	1100
Ruffled Magic	[2]		16JUN94 (167)	1298
Lavender Patina	24JUN93 (175)	1420	27JUN94 (178)	1622
Buddah	17JUN93 (168)	1226	16JUN94 (167)	1298
Siloam Red Toy	17JUN93 (168)	1226	13JUN94 (164)	1201
Best of Friends	17JUN93 (168)	1226	23JUN94 (174)	1530
Yesterdays Memories	28JUN93 (179)	1522	llJUL94 (192)	2020
Cisty	24JUN93 (175)	1420	27JUN94 (178)	1622
Prairie Blue Eyes	21JUN93 (172)	1337	16JUN94 (167)	1298
Attribution	14JUN93 (165)	1148	20JUN94 (171)	1432
Evening Bell	06JUL93 (187)	1778	05JUL94 (186)	1854
Purple Oddity	l9JUL93 (170)	2204	[2]	
Homecoming Queen	21JUN93 (172)	1337	27JUN94 (178)	1622
Yellow Kitten	NO[4]		[2]	
Ribbon Candy	NO		[2]	
Dream Awhile	14JUN93 (165)	1148	20JUN94 (171)	1432
White Temptation	NO		[2]	
Peach Souffle	06JUL93 (187)	1778	05JUL94 (186)	1854
Siloam Sunburst	08JUL93 (189)	1845	[3]	
My Son Bob	NO		20JUN94 (171)	1432

[1] GDD=Growing Degree Days base 50 degrees fahrenheit [2] formed a scape, no bloom observed [3] no plants [4] NO=No blooms observed

1993-94 Winter Hardiness Evaluations in the NCSU Arboretum

J. C. Raulston
North Carolina

Nature of Work: Winter hardiness is commonly perceived to be one of the most important measures of plant adaptability in evaluating woody plants for long-term landscape use. So many factors (photoperiod, temperature, nutrition, watering, etc.) affect the conditioning and hardening of woody plants to tolerate low temperatures that it is difficult to fully accertain the precise hardiness a given plant may actually have in landscape use even after extensive field and laboratory research (8). Data slowly accumulates from field experience in trials of new species and cultivars in varied landscape environments and cultural regimes. As more experience and data is obtained over many years of time, this information is used in technical references and industry guides to help growers and homeowners better know where and how new plants may be successfully used (2). Much such information on rare plants is first available in reference materials from England (1,3,7), Germany (5,6), or the U.S. west coast (4), but the total environment of the southeastern U.S. is so different that many plants from the same USDA hardiness zones i n the three areas may have markedly different tolerance to cold. For example, *Gardenia*, *Lagerstroemia*, and *Nandina* are winter-killed in areas which never go below 20F in England, yet tolerate conditions below 10F routinely in Raleigh with no injury thanks to high summer temperatures here which allow carbohydrate accumulation and hardening of wood. "Local" information over many years is still needed to know the true winter hardiness of a plant for any given area.

The NCSU Arboretum focuses on field trials of rare woody plant taxa to determine adaptation potential and ornamental merit in USDA Zone 7 in the southeast U.S. Piedmont region. Over 9,000 taxa have been accessioned in the 18 years of the arboretum's life, and the current collections contain an estimated 5,000 taxa of shrubs and trees. Many of these plants are new to U.S. cultivation from exotic climates and many are new hybrids or cultivars which have not been tested for specific genotype stress tolerance. During the winter of 1993-94, the coldest temperatures registered in 9 years were experienced with many hundreds of new and/or rare plants being exposed to temperatures below 10F for the first time.

Results and Discussion: The following compilation presents information on response of uncommon woody plants to a low of 2F in a period of several days with temperatures below 10F. Observations through the arboretum showed the wildly variable patterns commonly seen in exceptional winter periods, with some familiar plants of "known" hardiness which "should be killed" showing little or no injury (e.g. *Mahonia lomarifolia*), others which "should have no injury" being killed (e.g. *Trachycarpus fortunei* , which went through 10 degrees colder weather 10 years ago with no injury), and others ranging in injury depending on exposure (e.g. *Mahonia* X *intermedia* 'Arthur Menzies' ranging from no injury to dead at two sites 100' apart). Wind and sun exposure markedly affected injury ratings of broadleaved evergreens and was particularly

dramatic at a lath house environment where branches extending through the lath were killed on the outside and had no injury inches away on the inside. Thus, all information below should be considered observational, but in many instances this information is the first to be recorded for these taxa in this temperature regime and can be used for a starting point of potential adaptations for the southeast U.S.

Uncommon woody plants which demonstrated no damage at 2F:
Abelia chinensis - deciduous flowering shrub from Asia.
Bischofia polycarpa - deciduous shade tree from Asia.
Callicarpa kwangtungensis - deciduous fruiting shrub from Asia.
Camptotheca acuminata - deciduous tree from Asia (Morris Arboretum germplasm source only - others killed).
Castanopsis cuspidata - evergreen tree from Asia.
Celtis bungeana, jessoensis, *sinensis* - deciduous trees from Asia.
Cercis chingii, gigantea, glabra, *yunnanensis* - deciduous flowering trees from Asia.
Chimonanthus nitens , *zhetangensis* - evergreen shrubs from Asia.
Choisya ternata, *C. ternata* 'Sundance' - evergreen shrubs from Mexico.
Clerodendrum cryptophyllum - deciduous summer flowering shrub from Asia.
Cupressus chengiana, duclouxiana, lusitanica, macnabiana, macrocarpa - conifer trees.
Cyclocarya palouris - deciduous tree from Asia.
Dalbergia hupehana - deciduous tree from Asia.
Daphniphyllum macropodum - evergreen tree from Asia.
Dendropanax trifidus - evergreen tree from Asia.
Echinosophora koreensis - deciduous shrub from Korea.
Ehretia acuminata - deciduous tree from Asia.
Emmenopterys henryi - deciduous tree from Asia.
Enkianthus serrulatus - deciduous shrub from Asia.
Fokienia hodgsinii - conifer tree from Asia.
Gardenia 'Kleim's Hardy' - selection of evergreen shrub from Asia (all other cultivars killed to ground).
Gymnocladus chinensis - deciduous tree from Asia.
Halesia diptera var. *magniflora* - Florida ecotype of native deciduous tree.
Illicium anisatum, floridanum, henryi, mexicanum, parviflorum - evergreen shrubs.
Itea chinensis - evergeen shrub from Asia.
Kadsura japonica cultivars - evergreen vines from Asia (defoliated but not stem injury).
Keteeleria davidiana - conifer tree from Asia.
Liquidambar acalycina - deciduous tree from Asia.
Lithocarpus chinensis, glaber, henryi - evergreen trees from Asia.
Magnolia biondii, zenii - deciduous trees from Asia.
Magnolia scheidiana - evergreen tree from Mexico.
Mahonia gracilis - evergreen shrub from Mexico.
Manglietia yunnanensis - evergreen tree (Magnolia relative) from Asia.
Pinus kwangtungensis, pinea, quadrifolia, yunnanensis - conifer trees.
Pittosporum bicolor, heterophyllum, undulatum - evergreen shrubs from Asia.
Poliothrysis sinensis - deciduous tree from Asia.

Pteroceltis tatarinowii - deciduous tree from Asia.
Pyracomeles vilmorinii - bigeneric hybrid evergreen shrub.
Quercus cambyi, polymorpha, risophylla - evergreen trees from Mexico (defoliated but no branch injury).
Rehderodendron macrocarpum - deciduous tree from Asia.
Sapindus mukorossi - deciduous tree from Asia.
Sinocalycanthus chinensis - deciduous shrub from Asia.
Sinojackia rehderiana, xylocarpa - deciduous trees from Asia.
Styrax youngae - deciduous tree from Mexico.
Taiwania cryptomerioides - conifer tree from Asia.
Zizyphus jujuba - deciduous tree from Middle East.

Uncommon woody plants which were damaged or killed at 2F:
Acer pentaphyllum - deciduous tree from Asia.
Athrotaxis cupressoides - conifer tree from Tasmania.
Azara microphylla - evergreen shrub/tree from Chile.
Callistemon citrinus, salignus, subulatus, viminalis - evergreen shrubs from Australia (to ground; resprouted).
Callitris oblonga, presissii, rhomboides - evergreen conifers from Tasmania
Celtis choseniana - deciduous tree from Asia (multiple accessions).
Cercis racemosa - deciduous tree from Asia (20-30% killback).
Chamaerops humilis - palm from Europe.
Cinnamomum japonicum, porrestris - evergreen trees from Asia.
Clethra pringlei - deciduous tree from Mexico (young plant killed to ground - resprouted).
Colletia armata, paradoxa - evergreen shrubs from South America.
Diospyros palmeri - deciduous shrub from Texas (60% killback).
Fitzroya cupressoides - conifer tree from New Zealand.
Heteromeles arbutifolia - evergreen tree from California (30% killback).
Heteropsis argentea - deciduous shrub/vine.
Laurus nobilis X *Umbellularia californica* - evergreen tree hybrid (killed to ground - resprouted).
Machlius grijiei, thunbergi - evergreen trees from Asia *(thunbergi* killed to ground - resprouted).
Paliurus spina-christi - deciduous shrub/tree from Middle East.
Phoebe chekiangensis, shearei - evergreen trees from Asia.
Pileostegia viburnoides - evergreen woody vine from Asia.
Pittosporum tobira - evergreen shrub from Asia (all clones except one Korean accession).
Prunus campanulata - deciduous tree from Asia (40% killback).
Rhus lancea - evergreen tree from South Afriva (killed to ground - resprouted).
Stachyurus himalaicus - deciduous shrub from Asia.
Trachycarpus fortunei - palm from Asia.
Viburnum davidii, suspensum - evergreen shrubs from Asia.
Xylosma congestum - evergeen shrub from Asia.

Significance to Industry: The winter of 1993-94 was the coldest in N.C. in 9 years and gave valuable data on hardiness of a variety of uncommon woody plants. Of those plants which showed no injury at 2F, the most promising uncommon plants for ornamental value, hardiness, and nursery production potentials for landscape use would include: *Castanopsis cuspidata, Daphniphyllum macropodum, Gardenia* 'Kleim's Hardy', *Keteeleria davidiana, Manglietia yunnanensis, Pittosporum undulatum, Sinojackia rehderiana,* and *Taiwania cryptomerioides.*

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Trumpetvines (Campsis) for Landscape Use

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Nature of Work: Vines have traditionally been a difficult and awkward group of plants for the nursery production and retailing market to handle with often rampant growth and resulting control and confinement issues to master. A perception exists also in the landscape and public mind that all vines are uncontrollably aggressive and must be used with great restraint or in areas where high pruning maintenance can be provided. However a wide range of vines exist with evergreen (8) and deciduous types which encompass diverse ornamental characteristics, seasons of interest and growth rates (4). In recent years, southeast nurseries have found a ready market for good vines well grown as trellised container plants, and the rapid growth of most makes this marketing highly profitable when sales are good (3,7).

In 1985 The NCSU Arboretum collected plants in Korea as a part of an expedition in cooperation with the U. S. National Arboretum and the University of British Columbia Botanical Garden (9). One species specifically targeted for collection was the Asian trumpetvine, *Campsis grandiflora* (Thunb.) K. Schum (Bignoniaceae). Although it has been in western cultivation since 1800 (6), little of the genetic diversity reported in the wild species is available in cultivated materials. Botanically it is reported to exist in a wide flower color range from almost pure yellow, through the normal orangish-red, to almost pure red. One goal of the expedition was to search for better color forms for introduction to the U.S. nursery industry.

Although native to Korea, it is now rare in the wild there and in several months of hunting it was never found except as artifically maintained cultivated plants at farmsteads and in nurseries as collected plants. We have noted that isolated plants are apparently self-sterile and at this extreme low population level it is now maintained almost strictly as cultivated, vegetatively propagated clonal material. *Campsis* vegetative cuttings do not store well with defoliation normal after even one day of collection, and it was found to be impossible to collect in the wild and get viable cuttings back to horticultural facilities in Seoul. An attractive clone was finally successfully collected by digging root pieces and was returned to N.C. for evaluation.

Subsequent growth and spectacular flowering attracted much attention and in 1991 this plant was selected for the North Carolina Association of Nurserymen formal introduction and promotion program. Although the plant is in high demand and sells well when in flower, several production and use issues have arisen which need discussion for nursery industry awareness. Also, the native U.S. species and several horticultural cultivars and hybrids are in commercial trade and their differences and characteristics warrent discussion.

Results and Discussion: The following taxa of trumpetvines are listed in existing literature:

Campsis grandiflora (Thunb.) K. Schum. - "Chinese Trumpetvine". Native to China and Korea; introduced to cultivation in 1800 and received an Award of Merit from the Royal Horticultural Society in 1949. It can reach 20' with age and develops large coarse pinnate glabrous leaves with 7-9 leaflets. It is a sprawling, clambering plant with few aerial rootlets for a climbing mechanism. With age it develops a woody, shrubby nature and spectacular hundred year-old, 10' diameter plants can be found in the U.S. Flowers are much larger than the native U.S. species reaching 2-4" in diameter with striking orange-red color on the flaring corolla. It flowers as early as June in Raleigh and if seed pods are removed (resulting from hybridization with native populations and other taxa in our collection), flowering will repeat sporadically through the summer into fall. Generally considered less hardy than *C. radicans* with potential use in USDA Zone 7 - but this likely varies with ecotypic variation in where the original germplasm was collected. The Korean material is likely useful in USDA Zone 6.

Campsis grandiflora 'Morning Calm'. Recently the decision was made to distinguish the Korea-collected, NCSU Arboretum-distributed clonal plant which is spreading through the nursery industry by assigning it a cultivar name. 'Morning Calm' was selected to honor the country of origin as Korea is widely known as "the land of morning calm".

Campsis grandiflora 'Thunbergii'. A form selected and introduced by Siebold in 1856 which has shorter-tubed trumpets and reflexed lobes - reported as red in one reference (6) and orange in another (5). Although common in most literature, this clone may possibly no longer exist in cultivation.

Campsis radicans (L.) Seem. - "Trumpetvine". Native to southeastern U.S. (Florida to New Jersey and west to Missouri and Texas) and introduced to European cultivation in 1640. Very vigorous and tall growing species which can reach 50' climbing with aerial rootlets ("radicans" = "aerial roots"). Root suckers spread colonies from parent plants. It has foliage with 9-11 leaflets that are downy on the undersides and generally finer-textured than the Asian species. Flowers are red or orange with longer tubular flowers and smaller flaring corollas (1-2" diameter) than the Asian species. Hardy in USDA Zone 5.

Campsis radicans 'Atropurpurea' - "Purple trumpetvine." No details, just listed as a purple-flowering form (11).

Campsis radicans 'Crimson Trumpet' - "Crimson Trumpet Trumpetvine." Described as vigorous, lush deep green leaves and large, deep velvety red flowers (5); possibly a recent renaming of the old 'Praecox'?

Campsis radicans 'Flamenco' - "Flamenco Trumpetvine". A recent clonal introduction in the English market and its distinctive characteristics are not yet in available literature. Recently acquired and now in The NCSU Arboretum collection for future observation.

Campsis radicans 'Flava' (Bosse) Rehd. - "Yellow Trumpetvine". A color variant selected from the wild before 1842 with clear yellow flowers. Received an Award of Merit from the Royal Horticultural Society in 1969.

Campsis racidans 'Minor' - "Dwarf Trumpetvine." No details, just listed as a dwarf form (11).

Campsis radicans 'Praecox' (Jaeg.) Schneid. - "Scarlet Trumpetvine". A color variant selected from the wild before 1864 with scarlet-red flowers.
Campsis radicans 'Speciosa' (Parsons) Rehd. - "Shrub Trumpetvine". A variant with long-branched shrubby growth, normally a bush, and small orange-red flowers. Selected before 1902.
Campsis X tagliabuana (Vis.) Rehd. - "Hybrid Trumpetvine". The two existing species hybridize readily and the resulting seedlings are variable in nature but intermediate in habit and characteristics between the two parents - first reported in1858 by De Visiani in the Tagliabue Nursery, Lainate, Italy. Leaflets vary from 7-11 and are intermediate in downy character. Hardiness intermediate between parents - likely USDA Zone 6.
Campsis X tagliabuana 'Coccinea'. Developed by Simon Louis Freres of Plantieres Nursery, Montpellier, France; described as having brilliant red flowers (5,6).
Campsis X tagliabuana 'Guilfoylei'. A recent Australian hybrid introduction - less showy than the better known 'Madame Galen' with smaller red trumpets more like *C. radicans*. Available in the American nursery trade through introduction and sales by Duncan & Davies Nursery, NZ.
Campsis X tagliabuana 'Madame Galen'. The most widely known and grown hybrid clone which was introduced in 1889 by Sahut, Montpellier, France and received an Award of Merit by the Royal Horticultural Society in 1959. Vigorous climber which requires support. Produces large showy salmon-red flowers in summer.

Propagation can be achieved by seed, softwood cuttings, hardwood cuttings, root cuttings, layering, and budding (2,5) depending on the characteristics of the taxa to be produced and clonal integrity. As N.C. growers worked to meet high market demands it was noted that cuttings from the parent stock plant at The NCSU Arboretum were very difficult to root and slow growing once potted. In 1993 we also became aware of growers reporting plants which grew vigorously but did not flower making marketing more difficult.

Discussions with Greg Grant of Lone Star Nursery, San Antonio, TX who had observed and studied *Campsis* in detail as a personal interest for many years, lead to the previously unreported conclusion that *C. grandiflora* has marked juvenile:adult stages similiar to the classic "type plant" for this behavior - *Hedera helix*. Further observation has shown that adult wood has large, coarse foliage with short internodes, is very difficult and slow to root from softwood to semi-hardwood cuttings, and blooms heavily as small plants. Juvenile wood is vigorous with long internodes and foliage a quarter or smaller in size than adult leaves, is very easily rooted from summer cuttings, but does not flower readily as a young plant. Basal sprouts are more juvenile in character and root cuttings produce strongly juvenile growth.

Apparently within the production industry growers are subconsciously selecting for more easily rooted and faster growing wood - which then does not flower for marketing. A grower has reported best success in propagating adult wood by using a 10,000 ppm IBA quick dip on softwood cuttings taken as early in the season as possible just as new shoots emerge. We have grafted (terminal cleft grafts) adult wood to juvenile wood plants produced in commercial container culture and find the adult wood blooms quickly

only weeks after grafting, and also that the juvenile wood "rootstock" also blooms within a few weeks later. It is not known at this point how long it will take ungrafted, fully juvenile vines to bloom in the landscape - with estimates ranging from months to several years at this point. Because of the magnitude of concern among our growers, and the unawareness of juvenile:adult propagation:growth issues in *Campsis,* it was felt worthy of announcing through this SNA mechanism for growers to consider and observe. Further information on propagation techniques to successfully propagate adult wood, and information on the time to flowering of juvenile wood in landscape situations is needed.

Significance to the Industry: Recognition should be made of the new cultivar name, 'Morning Calm' recently assigned to the Korea clone introduced to the nursery industry by The NCSU Arboretum. The issues of juvenile:adult tissues in propagation and flowering of the Chinese Trumpetvine have not been reported before and growers must address these issues in their production and use of this very beautiful and potentially important nursery crop.

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Prunus Laurocerasus Evaluations in the NCSU Arboretum

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Nature of Work: Broadleaf evergreen shrubs are perhaps the most important woody ornamental plant group in the landscape industry of the southeastern United States with heavy use for specimens, medium height groundcovers, foundation plantings and screening. Among the many widely diverse taxa of broadleaved evergreen shrubs, the Cherry Laurel or Laurel Cherry, *Prunus laurocerasus,* is one of the most widely used and successful of such plants for effective landscape use. This large shrub/small tree species is native to southeastern Europe and Asia Minor around the Black Sea in the Caucasus and Transcaucasia mountains of Anatolia, Bulgaria, and Serbia - reaching 20-25' in height as old specimens (1).

It has likely been cultivated since antiquity in its native region, and was recorded as an introduced exotic species in western Europe by 1576. It is a widely variable species in growth rate, ultimate size, form, foliage characteristics, bloom time and ornamental quality. As a very easily propagated species (stem cuttings at most any time of year (3)), many selections have been made for various ornamental qualities and at least 45 cultivars have been named (5,6,11). Taxonomic keys to sorting out the main cultivars by foliage characteristics are available (5,10). The vast majority of the cultivars have been made in Europe and the ones now in most common use in the U. S. are old European cultivars (1889 and 1898) which were likely imported before contemporary U.S. plant quarantine bans on all *Prunus* introduction. In general, most of the large-leaved forms originate from Caucasus Mountains germplasm, and the small-leaved forms from the Balkan Mountains (5). Also, in general the small-leaved forms tend to have greater cold resistance than do large-leaved forms. Most cultivars perform well in USDA Zones 7-8, with the hardier ones extending into Zone 6 and possibly 5.

No serious biological problems commonly exist in landscape use. Leaf shot-hole, a *Pseudomonas* bacteria problem, can be serious under the high water, frequent overhead irrigation schemes normally used in modern container nursery production (7). It can be controlled by chlorination/bromination of irrigation water or by using media-applied drip irrigation during production to keep foliage dry. Root decline in the landscape occurs with poor drainage and excess water during high temperature months. In hot southern environments, planting beds should be engineered for good aeration and drainage. *Prunus laurocerasus* taxa have been under evaluation in The NCSU Arboretum for cultural and ornamental characteristics in USDA Zone 7 for over a decade.

Results and Discussion: The following list summarizes 45 taxa listed in the literature and their general ornamental attributes when known or given. Invalid synonyms are presented in parentheses. The 10 cultivars currently in The NCSU Arboretum collection are indicated by **bold type**.

'Angustifolia' (4,5,11) - tall, narrow leaves, 1802 by A. Leroy of Angers, France.
'Barmstedt' (11) - no description available.
'Benardii' (5) - large leaved form, 1920 by G. Benard & Cie of Orleans, France, likely no longer in existance.
'Bruantii' (5) - vigorous, ascending & open, less hardy, 1913 France.
'Camelliifolia' (4,5,6,8) - vigorous growth, dramatic curled & curved leaves, originated 1901, widely grown in England today and in some production in western U. S.
'Castlewellan' ('Marbled White') (4,6,11) - narrow, dense, upright, densely speckled white foliage resembling "marbelized wood" of 19th century decor, originated at the Castlewellan Estate in Northern Ireland in 1811; given Award of Merit by Royal Horticultural Society in 1986. The foliage variegation is showiest in cool climates of the U.S. Pacific Northwest and England - but as our plants have aged they become consistently more attractive. Very fast growing and taller than other cultivars. Worthy of greater production for specimens and hedging, and potential use for florist industry cut greens.
'Caucasica' (4,5,6,8,11) - vigorous, upright, hardiest large-leaved cultivar, light green, glossy.
'Caucasica Nana' (2) - small, compact, thick, rich green leaves.
'Cherry Brandy' (6,11) - new English cultivar; name only, no published description available
'Colchica' (5) - broad, thin dull lvs., heavy flowering, 1853 England.
'Dart's Good News' (11) - new English cultivar; name only, no published description available.
'Dart's Low Green' (6) - new English cultivar; name only, no published description available.
'Erect' (5) - vigorous, 1960 by P. Lombarts of Zundert, Holland.
'Forest Green' - chance seedling from Dr. Floyd Smith, Bear Garden Nurseries, Silver Spring, MD with broader and darker green foliage than 'Schipkaensis' and reported by him to not foliage burn at -15F. Grows to 4-6' height. Received by U.S. National Arboretum in 1977 (Accession #41215), and distributed by The NCSU Arboretum to N. C. growers in 1984.
'Goldglanz' ('Golden Lustre') (11,12) - leaves yellowish, broad upright habit, new Holland selection.
'Golden Splash' (6) - name only, no published description available.
'Green Carpet' ('Grunerteppich') (6) - name only, no published description available.
'Green Mantle' (4,11) - wide-spreading and open habit with dark glossy green leaves, Hillier Nursery 1965.
'Green Marble' (6) - new English cultivar; name only, no published description available.
'Greenpeace' (11) - new English cultivar; name only, no published description available.
'Herbergii' (4,5,6,8,11) - dense pyramidal shape to 6', for hedging, oblanceolate polished green leaves, very hardy, 1930 by Herberg of Germany.
'Holstein' (11) - name only, no published description available.
'Latifolia' ('Magnolifolia', 'Macrophylla') (2,4,5,6,8) - largest leaved cultivar (12") with dark green leaves, 1869 in Versailles, France; rated a "superb plant" Dirr (2) who reports a 25' specimen in KY.
'Mari' (9) - wide shrub with upright branches, leathery, dark glossy green leaves, very

hardy - taking -15F without injury. Bred by Dr. M. Jozsa of Szombathely, Hungary.
'Microphylla' (5) - narrow leaves, 1873 France. Probably no longer in cultivation.
'Mischeana' (4,5,6,8,11) - dense, flat & wide, dark green glossy foliage, flowers spring & fall, 1898 by Spath of Berlin, Germany from Balkans Mountains collection, highly valued form in Europe, "the most ornamental clone (4)", needs import and introduction into U.S. culture.
'Mount Vernon' (2,6,11) - described as small and compact - a 1-2' groundcover spreader - but plants brought from the Pacific Northwest to The NCSU Arboretum change form and grow more vigorously upright and have now reached 6' in height. Introduced by Wells Nursery of Mount Vernon, WA.
'Otinii' (5) - compact, strongly upright, darkest green of large leaved cultivars, lustrous, 1873 by Otin of St. Etienne, France.
'Otto Luyken' (2,4,5,6,8,11) - broad habit, 3-4' high by 6-8' wide, dense & compact, vertically oriented leaves, very free flowering, selected 1940 by Herm. A. Hesse Nursery of Weener, West Germany - introduced to trade in 1953, Royal Horticultural Society Award of Merit 1968, Award of Garden Merit 1984. One of most widely grown cultivars in the south and an excellent landscape plant.
'Parkway' - recent introduction by Woodlander's Nursery, Aiken, SC from turn-of-century plant in Aiken. Parent plant is globe-shape, 15' X 15', dense and compact; has large glossy foliage and dense symmetrical growth without shearing on young plants.
'Piri' (9) - compact semi-globe reaching 2-3', obovate dark green leaves, better winter hardiness than 'Otto Luyken' taking -15F without damage, new selection bred by Dr. M. Jozsa of Szombathely, Hungary.
'Pyramidalis' (5) - pyramidal, 1920 Renault Nurseries of Orleans, France, doubtful if still in cultivation.
'Renlo' ('Renault Ace' TM) (12) - upright habit excellent for hedges, glossy green leaves.
'Reynvaanii' (4,5,6,8,11) - small, slow-growing, dense upright to 6', 1913 by A. J. Reynvaan of Velp, Holland.
'Rotundifolia' (4,5,6,11) - broad erect habit, light non-glossy leaves, 1865 by L. C. B. Billard & Barre of Fontenay-aux-Roses, France - widely grown in Europe.
'Rudolf Billeter' (5,6,11) - low, broadly ascending (unattractive?), 1930 Stafa, Switzerland.
'Rufescens' (4) - slow, small, flat-topped, small neat oval to obovate leaves, Hillier Nursery.
'Schipkaensis' (2,4,5,6,8,11) - broad to vase-shaped to 6', heavy flowering, selected in 1889 from Schipka Pass at 4,000' near Kasanlik, Bulgaria by Spath of Berlin, very winter hardy to USDA Zone 5, Royal Horticultural Society Award of Merit 1959. Widely grown in southeastern U.S.
'Schipkaensis Compacta'(5) - broad to 3' in height, 1914 by W. Klenert Nursery in Graz, Austria.
'Schipkaensis Holland' (4,5,11) - probably a seedling of 'Schipkaensis' named by Dutch nurseries in 1970; differs primarily by smaller more distinctly toothed leaves, flowers profusely.
'Schipkaensis Macrophylla' (5,11) - differs by open, broadly upright habit to 6', abundant flowers, fruits well, 1940 by G. D. Bohlje, Westerstede, Germany, one of most popular cultivars in Europe.

'Schipkaensis West Coast' - a mystery plant in true identity and origin - appearing originally in southeast nurseries from liners purchased in from the Pacific Northwest as 'Schipkaensis', but growth is more rapid and more upright than normal 'Schipkaensis' and makes a larger plant. Proving popular and being propagated, grown and normally sold as 'West Coast Schipkaensis'.
'Serbica' (4,5,11) - broad & dense, twiggy, obovate rugose leaves, geographical form from Yugoslavia to Germany in 1877.
'Taff's Golden Gleam' ('Aureovariegata') (6,8) - shrub to 12', striped yellow foliage.
'Van Nes' (5,6,11) - wide & dense, very hardy mountain form from Caucasus Mountains, 1935 by P. van Nes AZ in Boskoop, Holland, highly valued form in Europe.
'Variegata' (2,4,5,6) - narrowly upright, dense, white striping in leaves - unstable variegation and quite variable, 1811 from France, likely more of hobbyist/collector interest than for commercial landscape use.
'Zabeliana' (2,4,5,6,8,11) - low spreading habit, 3-5' high by 12-25' wide, long narrow willow-like leaves, very free flowering, very winter hardy, 1898 by L. Spath of Berlin from Bulgaria collection, Royal Horticultural Society Award of Garden Merit 1984, very widely grown and used in U.S..

Significance to Industry: *Prunus laurocerasus* cultivars 'Otto Luyken', 'Schipkaensis', 'West Coast Schipkaensis', and 'Zabeliana' are currently common in the southeast U. S. nursery trade and make excellent problem-free landscape plants for hedges, specimens, foundation plantings, and mid-height groundcovers. Observations at The NCSU Arboretum indicate that 'Castlewellan', 'Forest Green', and 'Latifolia' offer good potential for future market development for the southeastern U. S. market. There are many other cultivars in widespread use in Europe which offer much potential for trial and production. Potential industry long-term value of these cultivars would probably justify attempts to import the best forms through the long and difficult USDA quarantine isolation procedure.

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Cupresses Evaluation in the NCSU Arboretum

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Nature of Work: In general, conifers are a relatively small percentage of the total nursery and landscape ornamentals market in the southeastern U.S. Most commercial offerings come from a few prominent genera with *Chamaecyparis, Juniperus, Pinus, Platycladus,* and *Thuja* heavily dominating the conifer market at this time. During the past 20 years, The NCSU Arboretum has actively collected and evaluated adaptability and ornamental potential of a wide array of conifers in almost all existing genera. The conifer genus *Cupressus* (Cupressaceae) is a diverse one with about 100-115 taxa currently listed (14) from 15-20 species native to the southeastern U.S. and Mexico, the Mediterranean region from southern Europe around the Middle East into Northern Africa, and in the Himalayas and southern China. The group is a difficult one taxonomically with many varied naming and classification schemes of the species. The American complex alone is considered to be anywhere from 6 to 15 species (5). Various taxonomic keys to the species are available (5,8,9,13).

Most species eventually form tall evergreen trees though some remain shrubs. With a few exceptions, the majority of species come from arid areas of subtropical to tropical regions which would seem to limit adaptability for use in the southeastern U.S. - with likely potential problems of summer root rots typical of most Mediterranean woody plant species brought to this region, or of inadequate winter hardiness in the upper reaches of the southeast.

Results and Discussion: With such "rare minor taxa" published information is often difficult to locate and the following general guides will offer the best potential for further search (1,5,7,9,11,13,14). Most species are easily propagated by cold-stratification of seed which is readily available from commercial sources (4). Many early cultivars were produced by grafting but the economics of this technique have lead to the development of cultivars in the last decade specifically selected for their ability to be cutting propagated. Development of numerous commercial cultivars of *C. glabra* and *macrocarpa* has been extremely active in Australia, England and New Zealand where these two species are well adapted for landscape use and grown in large quantities from seed allowing selection of distinct variants in this population. Various source guides report 18 *Cupressus* taxa currently being sold in Holland (12), 28 in the U. S. (8) and 53 in England (10).

Nearly 50 accessions of *Cupressus* have been received by The NCSU Arboretum over the years, and about 22 taxa are presently growing in the collections. Performance of some *Cupressus* taxa which have been evaluated in The NCSU Arboretum is presented below with brief information on origin, general plant character, propagation, hardiness, and present status in the nursery industry. **Bold type** indicates plants which have been in the collection at some point with those presently growing indicated by asterisks (*).

To our surprise, summer root rotting in our heavy clay soils has been less of a problem than expected with most species apparently having decent tolerance. The genus is noted for rootbinding problems when grown in container production with subsequent anchorage and topple problems in the garden. Field grown and transplanted plants probably make better long-term landscape plants. Foliar diseases have also been less prevalent than expected and all mentioned are more useful in this regard than some other existing commercial conifers such as the *Juniperus scopulorum* cultivars.

Winter hardiness is variable with species - but most listed below are dependable in USDA Zone 7 to the 5F range; with the hardiest species coming from the mountains of Oregon (*C. bakerii*) and Arizona (*C. glabra*) and hardy to USDA Zone 6. All species except these two were either severely damaged or killed in the record low winter of 1985 when temperatures reached -7F and most were replanted for further evaluation at that time. An unusual adaptation issue noted in our trials has been snow breakage tolerance. Most species come from arid, snow and ice-free regions and all of these have shown marked susceptibily to limb flux and breakage with even moderate snow loads. The two species which come from heavy snowfall regions, *C. bakeri* and *glabra*, are structurally sound through generations of genetic selection in native habitats and have shown no damage in our trials.

Perhaps the most unfortunate generalization from observations of this genera is that while very beautiful plants with widely variable ornamental features are available - few seem to age well and remain with attractive form and character beyond 10-20 years of age. Most open up to loose habit and unsymmetrical character with age limiting long-term usage.

C. arizonica - native to Arizona, California, New Mexico, Texas and Mexico. One of the most complex "groups" taxonomically with up to 7 botanical varieties/species within this "species" by various authors. Horticultural cultivars are bounced back and forth between this designation, *C. arizonica* var. *glabra* (10), and *C. glabra* (14) (which this paper will use).

****C. bakeri*** - native to southern Oregon and coastal northern California; blue-grey foliage; very hardy and snow tolerant; attractive; seed propagated - we have never rooted cuttings successfully from our plants.

C. cashmeriana - not known in the wild and its true origin and identity is debated, reputedly from Kashmir and Tibet; blue-grey color and pendulous growth habit; unquestionably the most beautiful *Cupressus* and one of the most magnificent ornmental plants in the world; no frost tolerance and grown strictly as an interior foliage plant; cutting propagated.

****C. chengiana*** - native to western China and only discovered and named in 1964.

****C. duclouxiana*** - native to China (Yunnan, Szechwan, Kansu).

****C. funebris*** - native to China; at times classified as a *Chamaecyparis* species.

****C. glabra*** - as discussed above, often considered a form of *C. arizonica*. Nearly 30 cultivars have been introduced with most coming from Australia and New Zealand. The group of cultivars from this species likely makes up 90%+ of the *Cupressus* production and use in the southeastern U.S. at present.

***C. glabra* 'Arctic'** - 1984 introduction by Duncan & Davies Nursery, NZ; green foliage with bluish (whitish) tips (apparently only in cool climates; not seen at NCSU); open habit; cutting propagated.

***C. glabra 'Blue Ice'** - introduced by Kemp's Nursery, Aldgate, Australia 1957 and recently imported into U.S. in quantities by Duncan & Davies Nursery, NZ; excellent frosty grey-blue foliage with upright symmetrical habit; cutting propagated.

***C. glabra* 'Carolina Sapphire'** - 1987 introduction by Forestry Department, Clemson University, SC; dark steel-blue foliage; loose habit; extremely fast with up to 6' per year possible on young plants; cutting propagated; in rapid buildup and promotion in the N.C. market at present.

***C. glabra* 'Clemson Greenspire'** - 1980 introduction by Forestry Department, Clemson University, SC; bright green foliage; fast growth; cutting propagated.

***C. glabra* 'Gareei'** - 1958 selection by M. Garee, Nobles Nursery, OK; 1973 introduction by Monrovia Nursery, CA ; good blue color and form; not easy from cuttings and normally grafted - accounting for its slow decline in market share as newer and easier propagating clones have entered the market.

***C. glabra 'Golden Pyramid'** - originated by R. Levy of Brisbane, NZ and a 1972 introduction by Duncan & Davies Nursery, NZ; very showy golden color in sun.

***C. glabra* 'Silver Smoke'** - 1984 introduction by Duncan & Davies Nursery, NZ; silvery-grey foliage; compact growth; cutting propagated.

C. goveniana - native to central coastal California.

C. guadelupensis - native to Guadulupe Island in southwest California and Baja California.

C. lusitanica - native to Guatemala, Honduras, and Mexico; in European cultivation since 1682.

C. macnabiana - native of southern Oregon and northern California; reported to be the most frost and drought tolerant of all *Cupressus* species (13).

C. macrocarpa - smallest native range of any *Cupressus* species with only 2 groves at Monterey Bay on the central California coast. Widely grown in Australia and New Zealand forestry production - probably accounting for the large relative proportion of the over 45 cultivars which have been named coming from these countries in observation of the seedling populations for variations.

***C. macrocarpa** 'Coneybearii Aurea' - found in 1920's and introduced 1933 by Hazelwood Bros. Nursery, Australia; now sold commercially in U.S. by Duncan & Davies, NZ as 'Saligna Aurea'; very attractive plant with pendulous golden thread foliage; grafted.

***C. macrocarpa* 'Goldcrest'** - 1948 introduction from Treseder Nursery, England. Grown by the millions in recent years in the European greenhouse industry for interior foliage plant use; cutting propagation.

***C. macrocarpa* 'Golden Pillar'** - 1979 introduction from Jackman Nursery, England; golden foliage; columnar; cutting propagation.

***C. macrocarpa* 'Horizontalis Aurea'** - 1898 introduction from Brunning's Nursery, Australia; golden foliage; the name and actual growth form are confusing ("for some reason . . nurserymen have seen fit to give [this name] to an upright grower . . It took me some time to appreciate the fact, though I will never appreciate the logic" - Adrian Bloom (2)).

C. sargentii - native to north and central coastal/foothill California.
****C. sempervirens*** - native to Asia Minor and the eastern Mediterranean as far east as north Iran - distributed through widely variable climatic regions for considerable ecotypic variation potential. Cultivated since antiquity and normally seen in American cultivation in the tightly columnar forms (widely used in the southwest - Texas through California) but in the wild it varies greatly in form. The NCSU Arboretum recently received plants supposedly from the coldest portion of the native range in Turkey mountains and will be evaluating these for potentially greater cold hardiness.
****C. sempervirens*** **'Glauca'** - 1989 introduction by Monrovia Nursery, CA; blue-grey foliage; columnar.
****C. sempervirens*** **'Swane's Golden'** - selected in 1944 by Swane Bros. Nursery, Australia; introduced 1956; gold foliage; columnar; has been less successful at NCSU than the species requiring lathhouse culture in well-drained bark beds to perform well.
C. torulosa - native from western Himalayas to China (Szechwan).

Significance to the Industry: A large variety of *Cupressus* taxa can be grown successfully in the southeastern U. S. but most would fit more in speciality hobbyist markets without widespread commercial landscape potential due to long-term survivability and age aesthetics problems. The most commercial at the moment is *C. glabra* 'Carolina Sapphire' with its bluish-grey color, cutting propagation ability and exceptionally fast growth of up to 6' per year for maximum profitability to growers, and relative low resulting price for the purchaser. The New Zealand Duncan & Davies Ltd. cultivars *C. glabra* 'Blue Ice' , 'Golden Pyramid', and 'Silver Smoke' also produce well and have very attractive landscape appeal. The speciality markets of interiorscaping and annual patio plants using more tender taxa such as *C. macrocarpa* cultivars and *C. cashmeriana* should be pursued in the southeast in light of the enormous success with these plants in the European market over the last decade.

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