TREE REPLACEMENT PROGRAMS IN OHIO[1]

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Abstract. Cooperative tree replacement programs between a public utility holding company and its subsidiary and Ohio State University are described. The goals of the cooperative program are to reduce energy demand, reduce line clearance cost, develop production methods for new species, document survival and establishment in urban planting sites and increase the species diversity of urban plantings. Over a five year period, 5000 trees will be grown and transplanted. Presently, over 40 species are in production. The first plantings, established with one and two year old (1.5 to 9 m tall, 1.5 to 2.5 cm caliper) stock, were planted in 1992. Two and three year survival (averaged over all species and years) was high, 80%, but regrowth was slow, averaging 15 cm increase in height and 2.0 cm increase in diameter. Within a species, there was significant site-to-site variation in survival and growth. Successful tree replacement programs are dependent on three factors: high quality planting stock, site quality and aftercare.

This article describes two cooperative tree planting programs: the American Electric Power (AEP) SMART Tree project and the Columbus Southern Power/Ohio Power (CSP/OP) Tree Replacement Program. Columbus Southern Power/ Ohio Power is a subsidiary of American Electric Power. The Ohio State University, Department of Horticulture and Crop Science, is a cooperator in both projects.

The AEP SMART Tree program has two objectives: 1) to reduce the demand for additional electric power generation capacity by planting trees in new home developments to give maximum summer shading, and 2) to remove trees that interfere with power service lines and replace them with large shrubs (trained into tree form) or small trees that have a mature height of under 8 m (25 ft). The goal is to produce and transplant 2800 trees between fall 1994 and spring 1997.

The CSP/OP project is a tree replacement program. The objectives are to remove improperly sited trees and replace them with trees that have a mature height less than 8 m (25 ft). A partial species list is given in Table 1. Many species under consideration are native to North America. The CSP/OP project will plant 2500 trees by spring 1999.

The university's objectives are to develop production techniques and evaluate initial plant performance in the landscape for these species. Many of the species being grown are not readily available from nurseries because of biological limitations. These limitations include low root regeneration potential leading to low transplant survival and slow establishment, and complex seed dormancy mechanisms.

Wherever possible activities will be coordinated with municipal foresters and others responsible for tree planting programs. Tree planting programs coordinated through city foresters give the foresters first hand experience with, and allow them to assess the potential of, AEP SMART Tree species. Knowledge of species' performance will develop a market for the best performers.

The production techniques developed will be transferred to interested nursery managers so that the species with the best performance can be produced on a commercial scale. By developing both the production techniques and the market, the cycle of "We don't grow that tree because nobody orders it.", and "We don't request that tree because nobody grows it." will be broken. A result will be increased species diversity in the urban landscape.

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Economic Justification

The CSP/OP's Tree Replacement Program was justified on a cost savings basis. The time and cost of tree trimming and tree removal activities are given in Table 2. Tree trimming costs $29.47 per tree per trim cycle, or $76,875 per 2,500 trees per trimming cycle. Trees such as silver maple, Siberian elm and cottonwood need to be trimmed every two to three years, so trimming costs of $76,875 are recurring every two to three years. The cost of three trim cycles is $230,625 for 2,500 trees.

Table 1. Species in production for possible use in a tree replacement program. All species will be grown in tree form: a single central leader with minimum of 1.2 m (4 ft) clear trunk.

Acer pensylvanicum	Striped Maple
Asimina triloba	Common Pawpaw
Caragana arborescens	Siberian Peashrub
Carpinus betulus	European Hornbeam
Celtis reticulata	Netleaf Hackberry
Cercis canadensis	Eastern Redbud
Corylus avellana	European Filbert
Diospyros virginiana	Common Persimmon
Eucommia ulmoides	Hardy Rubber Tree
Evodia danielli	Korean Evodia
Hovenia dulcis	Japaneses Raisintree
Koelreuteria paniculata	Goldenraintree
Laburnum anagyroides	Goldenchain tree
Maackia amurensis	Amur Maackia
Magnolia acuminata	Yellow Cucumbertree
Magnolia kobus	Kobus Magnolia
Magnolia virginiana	Sweetbay Magnolia
Ostrya virginiana	American Hophornbeam
Phellodendron amurense	Amur Corktree
Ptela trifoliata	Hoptree
Pterocarya fraxinifolia	Caucasian Wingnut
Pteroceltis tataronowii	Tatar Wingceltis
Quercus acutissima	Sawtooth Oak
Sassafras albidum	Commom Sassafras

Table 2. Tree trimming and tree removal times, rates of pay and total per tree cost for each activity based on 1994 estimates for the Columbus, OH region.

Activity	Worker hours (per tree)	Rate (per hour)	Cost ($ per tree)
Trim	1.52	19.39	29.47
Removal	1.93	19.39	37.42

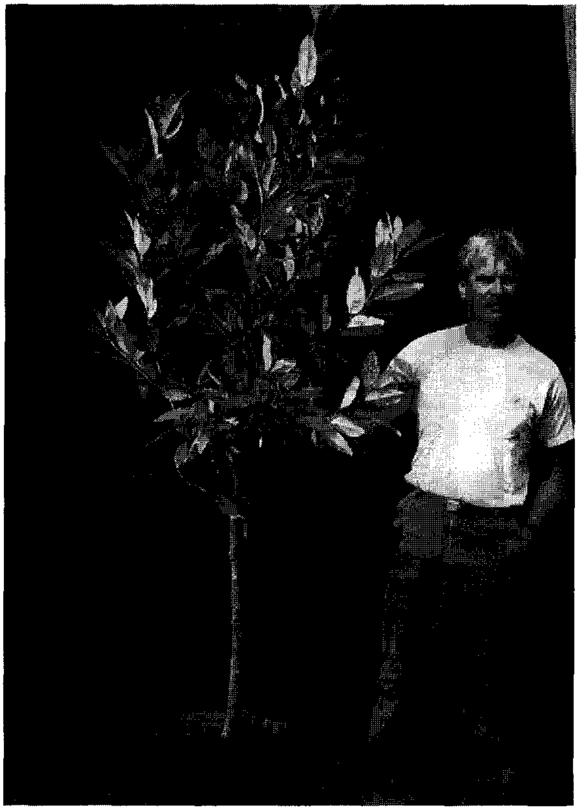

Fig. 1. Two year old tree form *Magnolia virginiana*. The vigorous growth obtained under Ohio Production System conditions allows large shrub species to be grown in tree form. Jim Vent is 1.8 m (5 ft 10 in) tall.

The costs for a tree replacement program are: tree removal ($37.42/tree [Table 2], or $93,550 for 2,500 trees), replacement tree cost ($50/tree, or $125,000 for 2,500 trees) and tree distribution cost ($5.00 per tree, or $12,500 for 2,500 trees). Planting costs would be incurred by the home owner. A tree replacement program would cost $92.42 per tree ($231,050 for 2,500 trees). Tree replacement program costs are non-recurring so, a tree replacement would begin to "pay for itself" after three trimming cycles, as early as six years.

Production Techniques

All plant material used in the studies was produced under the Ohio Production System (OPS) conditions (3). Under OPS conditions, seeds are germinated in February, transplanted to copper-treated (SPINOUT, Griffin Corp., Valdosta, GA) containers and grown in a greenhouse for 10 weeks. Copper-treated containers are used to prevent root malformation. When roots contact the copper-treated interior container surfaces, root elongation is inhibited, which reduces circling and girdling root formation (1).

Plants are transferred outdoors after the spring frost date (May 15 for Columbus, OH) and potted into copper-treated #3 nursery containers. It is possible to produce 2 m tall whips by October, 8 months after seed germination.

The plants are then fall transplanted into copper-treated #10 nursery containers and grown for two additional years in a Pot-in-Pot system (2). After three growing seasons, 4 to 5 cm (1.5 to 2 in) caliper material is ready for planting in the AEP SMART Tree and the CSP/OP Tree Replacement programs. An advantage of OPS-produced AEP SMART Trees is reduced production time. Under traditional production techniques used in USDA Plant Hardiness Zones 5 and 6, 4 to 5 cm caliper trees may require five to eight years to produce. An additional advantage of OPS conditions is that some large shrub species can be grown in tree-

Fig. 2. Five year old *Taxodium disticum* (left) at an Upper Arlington site and at a Columbus (right) site. Both trees were produced under similar conditions and fall transplanted in 1991. These photos demonstrate how site quality and after care practices can modify growth potential. Trees at the Upper Arlington site were transplanted into disturbed soil (a former construction site), received a 1 m mulch ring at planting, two irrigations during the first growing season after planting and no fertilization. The Columbus tree was planted in undisturbed soil (in a residential site), received 1 m mulch ring, six irrigation over a two year period and a fall application of 450 g N per year. Philip is 1.2 m (4 ft) tall. It is unfortunate that the *Taxodium* in the right photo was improperly sited too near overhead utility lines.

Fig. 3. Five year old *Quercus shumardii* at a Cleveland (left) and Columbus (right) site. The plants were produced under similar conditions and fall transplanted in 1991. The photos demonstrate how site quality and after care can modify growth potential. The Cleveland tree received no after care. The Columbus tree had a 1 m mulch ring placed around it at planting and was irrigated bi-weekly during the first growing season. The measuring stick near the Cleveland oak is held at 1.5 m (5 ft) height. Philip, in the left picture, is 1.2 m (4 ft) tall.

form (Fig. 1).

Survival and Regowth Potential

Survival, averaged over two or three years after planting for all species, was 80% (Table 3). Most of the mortality occurred after the severe winter of 1992-1993.

Regrowth in "typical" city sites has been less than reported for OPS-produced plants transplanted into a site with more favorable soil conditions (a former agricultural field) (4). The first plantings used one- and two-year old planting stock 1.5 to 3 m tall and less than 2.5 cm in caliper; this is smaller than that typically used for curb lawn planting sites.

An observation (based on the early results and a small sample size) is that the high survival and regrowth potential of AEP SMART Trees can be modified by site conditions and post-transplanting management practices. This is illustrated by data from baldcypress (*Taxodium disticum*). All trees were produced under OPS conditions and fall transplanted into four sites in 1992. Survival ranged from 100% (in Upper Arlington) to 25% (at Worthington). At the Upper Arlington site (Fig. 2), the plants received the following post-transplanting care: a 1 m diameter mulch ring, once per year Round-up application within the mulch ring, two irrigations during the first year after transplanting and no fertilizer. After three growing seasons, plant height increased by an average of 50 cm (20 in). Trunk caliper averaged 5.3 cm (in). In contrast,

Table 3. Two and three year survival and growth of 16 taxa produced under Ohio Production System conditions and transplanted into curb lawn and lawn sites in Ohio. The plant material was one or two years old at transplanting.

Species	Location	Number planted	Year transplanted	Survival (%)	Initial ht (cm)	Initial cal. (cm)	1995 ht (cm)	1995 cal.(cm)
Black Oak	Cleveland	8	1993	75	183	2.3	176	2.5
(Quercus velutina)	Pickerington	3	1992	66	150	NA	155	2.8
	Powell	2	1992	50	185	NA	260	4.0
	Upper Arlington	3	1992	66	235	NA	270	3.1
Bur Oak	Cleveland	6	1993	83	175	2.1	215	2.8
(Q. macrocarpa)	Cleveland	30	1992	93	191	NA	245	3.5
	Powell	1	1992	0	225	NA	-	-
	Upper Arlington	5	1992	100	225	NA	320	5.1
Chestnut Oak (Q. prinus)	Upper Arlington	1	1992	100	235	NA	260	3.9
English Oak	Pickerington	3	1992	100	218	NA	260	5.0
(Q. robur)	Powell	1	1992	100	165	NA	230	4.0
	Upper Arlington	2	1992	50	250	NA	280	4.0
Red Oak	Cleveland	5	1993	100	242	2.3	278	3.1
(Q. rubra)	Powell	1	1992	100	215	NA	210	3.0
Sawtooth	Cleveland	24	1992	92	162	2.0	315	5.7
(Q. acutissima)	Upper Arlington	2	1992	100	228	NA	295	5.2
Scarlet Oak	Powell	1	1992	100	175	NA	250	3.0
(Q. coccinea)	Upper Arlington	2	1992	100	233	NA	262	3.1
	Worthington	1	1992	100	195	NA	120	2.5
Shingle Oak (Q. imbricaria)	Worthington	1	1992	100	170	NA	215	2.5
Shumard Oak (Q. shumardii)	Cleveland	6	1992	100	209	2.4	214	2.6
Swamp Chestnut Oak	Powell	8	1992	38	241	NA	311	3.8
(Q. michauxii)	Upper Arlington	1	1992	100	265	NA	240	4.1
Swamp White Oak	Cleveland	10	1993	70	164	2.2	204	2.7
(Q. bicolor)	Cleveland	9	1992	100	226	NA	251	3.8
	Powell	1	1992	100	200	NA	320	5.5
	Upper Arlington	1	1992	100	325	NA	400	6.2
	Worthington	2	1992	100	210	NA	295	3.4
White Oak	Cleveland	8	1993	50	176	2.5	233	3.6
(Q. alba)	Pickerington	3	1992	100	165	NA	223	4.5
	Powell	3	1992	100	168	NA	223	4.3
	Worthington	1	1992	100	150	NA	220	3.9
Kentucky Coffee Tree	Cleveland	9	1993	89	136	2.0	156	2.3
(Gymnocladus dioicus)	Pickerington	4	1992	100	203	NA	182	3.4
	Powell	3	1992	66	185	NA	265	4.0
	Upper Arlington	8	1992	75	192	NA	283	4.1
	Worthington	1	1992	100	145	NA	115	1.8
Blackgum	Cleveland	5	1993	40	187	1.9	18	2.4
(Nyssa sylvatica)	Cleveland	4	1992	100	205	NA	236	3.3
	Cleveland	16	1993	50	154	2.0	173	3.0
Baldcypress	Cleveland	12	1993	75	186	3.3	190	3.5
(Taxodium distichum)	Cleveland	6	1992	83	155	NA	264	5.5
	Powell	1	1992	100	150	NA	300	6.0
	Upper Arlington	6	1992	100	187	NA	237	5.3
	Worthington	8	1992	25	175	NA	148	4.4
Goldenrain Tree	Pickerington	4	1992	100	155	NA	115	2.0
(Koelreuteria paniculata)	Upper Arlington	9	1992	60	175	NA	326	6.6

NA: Data not available.
-: Plant dead when measured June, 1995.

one baldcypress was transplanted into a residential site (Fig. 2). This tree received six irrigation treatments during the first two seasons after transplanting, an annual 450 g (1#) fall application of nitrogen and a 1 m diameter mulch ring. This tree is 4.75 m (15.6 ft) tall and 12.5 cm (5 in) in caliper. The contributions to the growth potential of the various post-transplanting practices are unknown.

Another example of site modified regrowth potential are six Shumard oak planted at one Cleveland site (Fig. 3) and one Columbus site (Fig. 3). Survival at Cleveland was 100%, but height increase only 5 cm (2 in) in three years. Caliper averaged 2.6 cm (1 in). In contrast, one 1.3 m (5 ft) tall Shumard oak was transplanted in 1991. This tree is now 7.3 m (24 ft) tall and 13 cm (5 in) in caliper. The homeowners watered and fertilized the plant for the first two growing seasons after transplanting. Research is needed to determine the effects of irrigation, mineral nutrition and site quality on transplant survival and regrowth so that city foresters can allocate scarce resources to the practices that most affect survival and growth. It is possible that the quality of the urban forest can be improved at minimal cost.

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Résumé. Cet article contient une description des programmes coopératifs de remplacement d'arbres entre une compagnie de service électrique et l'Université de l'état de l'Ohio. Les buts du programme sont de réduire la demande en énergie, de diminuer le coût de dégagement des lignes électriques, de développer des méthodes de production pour de nouvelles espèces, de documenter le taux de survie et la facilité d'implantation en milieu urbain et enfin d'accroître la diversité des espèces plantées en milieu urbain. Sur une période de cinq ans, plus de 5000 arbres seront produits et transplantés.A l'heure actuelle, plus de 40 espèces sont en production. Les premières plantations, effectuées à partir de vieux lots de une et deux années d'age, ont été réalisées en 1992. Le taux de survive après la seconde et la troisème année était faible avec une moyenne de 15 cm en hauteur pour 2 cm en diamètre. Il existait des différences significatives entre les divers sites en ce qui touche le pourcentage de survie et le taux de croissance.

Zusammenfassung. In diesem Bericht wird über kooperative Baumpflanzungsprogramme zwischen einer öffentlichen Einrichtung und der Universität des Staates berichtet. Ziel dabei ist es, den Energieverbrauch und die Kosten für Rodungsarbeiten zu reduzieren, für neue Arten Produktionsmethoden zu entwickeln, das Überleben und die Standortakzeptanz der Bäume im urbanen Bereich zu dokumentieren und die Artenvielfalt bei urbanen Pflanzungen zu erhöhen. Über einen Zeitraum von fünf Jahren sollen 5000 Bäume gezogen und verpflanzt werden. Gegenwärtig sind über 40 Arten in der Produktion. Die ersten Pflanzungen, die aus ein- und zwei jährigen Jungpflanzen bestanden, wurden 1992 gepflanzt. Die Überlebensrate im zweiten und dritten Jahr war hoch (80%) aber die Entwicklung war langsam: durchschnittlich 15 cm Zuwachs in der Höhe und 2 cm Zuwachs im Umfang. Es bestanden an den einzelnen Standorten signifikante Unterschiede im Überleben und im Wachstum.