FIVE YEARS EXPERIENCE IN MINNESOTA

LARGE TREE MOVING

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Spade-type digger (66 inch) developed in 1966 for large tree moving

OUR modern highways are a far cry from the dirt tracks and gravel lanes of the early nineteen-hundreds. Highway improvements, however, have meant disruption of the landscape and destruction of trees and woody shrubs. A concrete or asphalt strip fringed with grass is the usual result of this disruption.

To develop a desirable highway corridor, the roadside must be re-vegetated to blend into its surroundings. Nursery stock (trees 2 to 3 inches in diameter) is usually used to re-establish the missing woody vegetation.

However, nursery stock is considerably smaller than the surrounding, undisturbed, woody vegetation, and takes many years to grow to a size that has a noticeable, visual impact. The development of mechanical tree transplanting equipment in 1964 and 1966 provided an economical means of hastening the visual impact derived from landscaping materials. Now, an immediate effect can be gained by using larger tree stock, usually 4 to 8 inches in diameter.

The Minnesota Department of Highways initiated a large tree moving program in the fall of 1968. At that time, 179 Green Ash and Silver Maple were relocated (for safety reasons) from an expressway median to two interchanges, one at each end of the highway section involved.

Since this first project was completed, an additional 1,591 large trees and shrubs have been transplanted to 19 different locations.

Today, the Department is moving roughly 400 trees per year. Some of these trees are salvaged from new construction and regrading projects. Others are moved because they create problems or traffic hazards (reduced sight distances, too close to travel lanes, etc.). Most are moved for landscaping purposes, and come from such varied sources as old windbreaks, large tree nurseries, forest tree farms, and wooded portions of the highway right-of-way.

Forty-one different tree and shrub species have been moved to date (Table 1). Included in this total are early plant successional species such as Aspen and Willow, and large, tap-rooted trees such as the Oaks and Pines. More Green Ash and Spruce (both Black Hills and Colorado Green varieties) have been transplanted than any other species.

Statistical evaluations regarding plant survival are difficult to make because of the variable sample size involved. However, trend patterns can be pointed out. Of the 1,770 trees and shrubs moved to date, 1,646 individuals, or 93 percent, have survived. This survival rate is very good considering the size of these plants and their general lack of previous care.

This clam-type digger (72 inch) was developed in 1964 for large tree moving. Authors used clam- and spade-diggers in moving trees.

The high or low success with some of the species may be due to the relatively short time period during which we have been moving trees, and/or the small numbers moved. A longer evaluation period and larger sample size are needed to determine the long range effects of the transplanting technique on these species. As more specimens of satisfactory size and quality are located, they will be included in the program.

All survival evaluations were made in the fall of 1972. The evaluation included classifying the transplants according to the amount of

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TABLE 1. Plant Survival By Species Moved

Species	Number Moved	Number Living	Percent Survival
Spruce (Picea glauca and P. pungens)	666	619	93
Green Ash (Fraxinus pennsylvanica)	358	351	98
Red Pine (Pinus resinosa)	209	197	94
Burr Oak (Quercus macrocarpa)	95	83	87
Aspen (Populus tremuloides and P. grandidenta)	82	69	84
Jack Pine (Pinus banksiana)	39	36	92
Sugar Maple (Acer saccharum)	32	30	94
White Birch (Betula papyrifera)	28	19	68
Eastern Larch (Larix laricina)	25	23	92
Red Maple (Acer rubrum)	21	18	86
Red Oak (Quercus rubra)	21	19	90
Honeylocust (Gleditsia triacanthos)	19	19	100
Silver Maple (Acer saccharinum)	18	18	100
Eastern Redcedar (Juniperous virginiana)	18	18	100
American Linden (Tilia americana)	16	16	100
American Elm (Ulmus americana	13	12	92
Pin Cherry (Prunus pennsylvanica)	12	7	58
Ironwood (Ostrya virginiana)	11	10	91
Apple (Malus spp.)	10	10	100
Willow (Salix spp.)	10	9	90
Crabapple (Malus spp.)	9	9	100
Wild Plum (Prunus americana)	9	9	100
Norway Maple (Acer platanoides)	7	6	86
Speckled Alder (Alnus rugosa)	6	6	100
Black Walnut (Juglans nigra)	6	5	83
Common Lilac (Syringa vulgaris)	5	5	100
Service Berry (Amelanchier alnifolia)	3	3	100
Honeysuckle (Lonicera spp.)	3	3	100
Austrian Pine (Pinus nigra)	3	3	100
Mountain Ash (Sorbus americana)	3	3	100
Hackberry (Celtis occidentalis)	2	2	100
Russian Olive (Elaeagnus angustifolia)	2	2	100
Pin Oak (Quercus palustris)	2	2	100
American Arborvitae (Thuja occidentalis)	2	1	50
Balsam Fir (Abies balsamea)	1	1	100
Ohio Buckeye (Aesculus glabra)	1	1	100
Hawthorn (Crataegus spp.)	1	1	100
Eastern White Pine (Pinus strobus)	1	1	100
Choke Cherry (Prunus virginiana)	1	0	0
Totals	1770	1646	93

[1] Fifty-one plants died and were removed before accurate size records were compiled.

TABLE 2. Plant Survival By Size -- Class Moved

Size Class (inches)	Number Moved	Number Living	Percent Survival	Root Ball Size Used
Shrubs	41	34	83	42 & 66
2	32	32	100	42
2½	55	55	100	42
3	371	363	98	42
3½	230	223	97	42
4	231	219	95	42 & 66
4½	137	136	99	66
5	145	136	94	66
5½	90	88	98	66
6	86	84	98	66
6½	81	79	98	66 & 72
7	66	58	88	66 & 72
7½	64	62	97	72
8	41	38	93	72
8½	22	20	91	72
9	15	10	67	72
9½	4	4	100	72
10	7	4	57	72
11	1	1	100	72
Unknown[1]	51	0	0	Unknown
TOTALS	1770	1646	93	....

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crown dieback sustained by each plant. The results of this condition evaluation are:

Crown Condition	Plants Effected
0 to 25% dieback	82% of all transplants
25 to 75% dieback	11% of all transplants
Dead plants	7% of all transplants

Trees with crown dieback in excess of 75 percent were considered dead. The small amount of life remaining in these trees is insufficient for healthy growth and survival.

The middle classification (25 to 75% dieback) is especially important because of the temporary, adverse appearance of the trees. These trees do produce new crowns by sprouting along their main branches and trunk, but this crown redevelopment takes many years and requires constant thinning and shaping.

In spite of dieback, a 5-inch diameter transplant still has three to four times the crown volume and visual impact of comparably priced nursery trees 2 to 3 inches in diameter.

The trees which we have moved range in size from 2 to 11 inches in caliper (Table 2). The minimum root ball diameter for the various sizes of trees moved is based on standards set by the American Association of Nurserymen. We have, however, adjusted these A.A.N. standards to cover the mechanical transplanting of wild or semi-wild grown materials. These adjusted standards are:

Tree Trunk Caliper	Minimum Root Ball Diameter
2 to 3½ inches inclusive	42 inches
4 to 6 inches inclusive	66 inches
6½ to 8 inches inclusive	72 inches
all multi-stemmed plants	66 inches

Our best success has been achieved with trees in the 2 to 7½ size range. Trees above 7½ inches in diameter almost invariably develop considerable crown dieback. This is probably due to the disproportionate root system to crown volume ratio which results from the mechanical transplanting of this large a tree. Where optimum results are being sought, only trees under 8 inches in diameter should be transplanted.

We are constantly improving our specifications and special contract provisions to provide for better control of the general quality of our transplanting work. These specifications and special provisions are available to anyone upon request. The installation work we require includes: machine transplanting, staking and guying, removal of competing vegetation, a wood-chip mulch, and trimming to improve tree shape and compensate for root loss.

Post-installation work includes: weekly waterings, pest control work, and maintenance of the guying system and weed-free mulch areas. Both experience and experimentation have shown that of all of these requirements, the pruning and watering are the most critical steps in successful transplanting.

All transplants must have their live crowns reduced in direct proportion to the amount of roots that they lose during the digging operation. Improper or insufficient pruning results in massive crown dieback. Our experience has shown that 40 to 60 percent of a tree's crown must be removed in order to avoid this massive dieback.

Even with proper pruning, transplanting will still place most trees in a state of shock. When the trees are in shock, inadequate watering during the hot, dry, growing season will result in additional crown dieback. However, good growth can be maintained if water is applied in sufficient quantities on a regular schedule. Experimentation has shown that, in Minnesota, this watering involves supplying 100 gallons per tree per week during the two growing seasons following transplanting. One season of watering will reduce shock-induced dieback by 50 to 60 percent, but two seasons are needed to completely eliminate the problem.

Many factors must be considered when planning a tree transplanting project. These factors include soil type, rooting habit of the trees, slope of the ground, and susceptibility of tree species to destructive agents.

Mechanically, tree transplanting equipment operates best in sandy soils. However, sandy soil tends to fall away from the root system during transit to the planting site. Consequently, damage occurs to the root hairs, and this damage can kill the tree.

Trees are more difficult to dig out of heavier soils, but damage to the root system does not occur as readily. If trees must be dug from sandy soils, water should be applied to the root ball during the digging operation to plasticize the soil and keep it in the ball.

Soils at the tree source and the new planting site should be similar in texture. Complications can result if there is a significant difference between the soils at the two sites. When a tree is moved from a heavy soil to a sandy soil, water tends to

Massive crown dieback (50 to 75 percent) on 8-inch Burr Oak due to insufficient watering.

Six inch diameter Silver Maple three years after transplanting.

run away from the root ball. Conversely, water tends to run into the root ball when a tree is relocated from a sandy site to a site with heavy soils. In either case, drainage becomes a problem.

In the former case the newly transplanted tree is susceptible to drought, while in the latter situation the tree is subject to flooding. Both of these situations result in considerable crown dieback, and may even result in the death of the newly transplanted tree. It is, therefore, desirable to relocate a tree to the same soil classification as the one in which it was originally found growing.

Ground slope governs the operation and mobility of the mechanical diggers. Slopes in excess of 4 to 1 are too steep for most truck-mounted diggers. Since the digging equipment operates at right angles to the ground surface, the tree must be returned to the same angle of slope. A variation in slope between the tree source and planting sites will result in the trees being established in a non-vertical position, or in a position where part of the root ball is exposed to the elements.

At first, spade-type digging equipment appears poorly adapted to transplanting tap-rooted trees, such as Jack Pine. One assumes that most of the root system is located in the deeper reaches of the soil profile where the diameter of the spade-type digger is smallest.

Conversely, the shallow, lateral-rooted trees appear well suited to the spade-type diggers because a larger proportion of their root system is in the upper soil profile where the digger's diameter is greatest.

Actually, the reverse is true when dealing with wild grown or woods collected stock. A larger proportion

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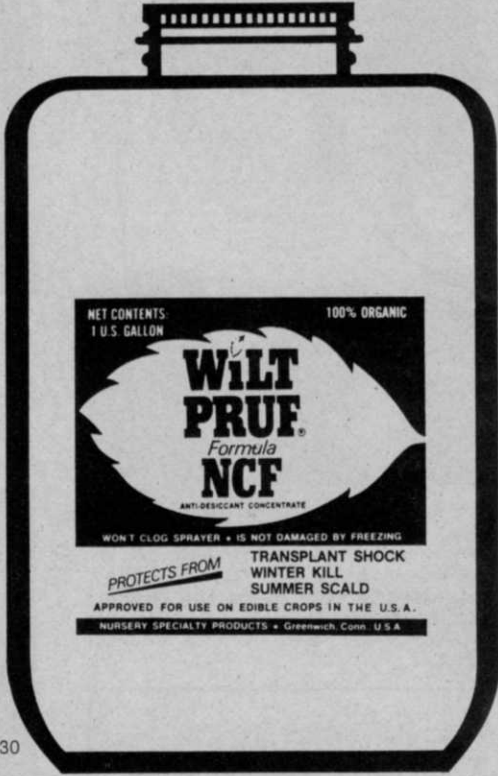

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of the root system is retained on a tap-rooted tree than on a comparably sized lateral-rooted tree, when both trees are woods collected. Woods collected trees with lateral root systems should be dug with a larger diameter root ball than comparably sized tap-rooted trees. In the nursery, where root pruning is practiced, the original assumptions do hold true, and the tap-rooted trees are the ones which require the larger diameter root ball.

Certain tree species are very susceptible to damage from insects, diseases, and climatic conditions. Susceptibility increases when these trees are weakened by root losses during transplanting operations. These tree species and their primary destructive agents include:

American Arborvitae	—wind burn or desiccation
American Elm	—Dutch Elm Disease
Red Oak	—Oak Wilt
White Birch	—Bronze Birch Borer
White Pine	—White Pine Blister Rust

These species, along with others having a high susceptibility to damage, require considerable care in transplanting because of the increased possibility of loss. We have stopped moving American Elm, Red Oak, and White Pine at the request of the Minnesota State Department of Agriculture. The high incidence of Dutch Elm Disease, Oak Wilt, and White Pine Blister Rust in Minnesota has led to this decision. None of the transplanted trees were actually infected by the diseases, but the potential is still present and can not be ignored.

Like any new technique, our transplanting program has produced its share of disappointments. These disappointments did, however, point out how we could improve our transplanting procedures. Project 6 (Table 3) had the lowest survival rate (73%) of any of our projects. The 18 trees that were lost died because of inadequate watering. Delays in watering of one or two days duration occurred at critical times during the hot, dry, growing season. These repeated delays permanently weakened the trees and many were unable to survive in this weakened condition.

Many of the trees on Project 2 were comparatively large Burr Oak and Sugar Maple. These 8-inch and larger trees were moved with the 72-inch clam digger. Because of the moving chain that cuts through the soil, this machine shakes the root ball while digging the tree. The root system remaining with the tree often receives serious damage from this shaking. In spite of proper pruning and adequate watering, massive crown dieback occurred, probably as the result of damaged root systems.

The 72-inch clam is an obsolete piece of equipment which we no longer use extensively. Because of the moving chain, breakdowns are common and maintenance costs are high. Yet, the 72-inch clam is still the easiest and fastest way to move trees over 6 inches in diameter. Today, we limit its use to trees in the 6 to 8 inch size range, and we only move a few of these large trees on each of our projects.

Our cost for transplanting large trees has varied from a low of $29 per tree to a high of $268 per tree (Table 3). The average cost per tree moved over all of our projects is $132. Most of our tree moving has been accomplished by prime contracts let on a competitive bid basis.

TABLE 3. Summary of Project Survival and Cost

Proj. No.	Season Moved	Number Moved	Number Living	Percent Survival	Project Cost	Unit Cost	Survival Cost
1	Fall, 1968	179	179	100	$21,865	$122	$122
2	Spr., 1969	70	56	80	8,330	119	149
3	Fall, 1969	88	81	92	7,893	90	97
4	Fall, 1969	117	94	80	12,870	110	137
5	Fall, 1969	118	106	90	12,980	110	122
6	Spr., 1970	70	52	74	6,815	97	131
7	Spr., 1970	5	5	100	875	175	175
8	Spr., 1970	30	25	83	5,250	175	210
9	Spr., 1970	97	91	94	2,861	29	31
10[2]	Fall, 1970	96	90	94	25,726	268	286
11	Spr., 1971	53	48	91	5,290	100	110
12	Spr., 1971	57	56	98	2,888	51	52
13	Spr., 1971	43	41	95	2,176	51	53
14	Fall, 1971	118	93	79	20,886	177	225
15	Spr., 1972	60	60	100	13,860	231	231
16	Spr., 1972	209	209	100	39,564	189	189
17	Fall, 1972	172	172	100	20,468	119	119
18	Fall, 1972	144	144	100	17,353	121	121
19	Fall, 1972	27	27	100	2,783	103	103
20	Wtr., 1972	17	17	100	2,465	145	145
TOTALS	Incl., 1972	1770	1646	93	$233,198	$132	$142
	Before 1972	1141	1017	89	$136,705	$120	$134

[2] Project costs include a two year experimental watering program.

However, some trees were transplanted through supplemental agreements in general highway construction contracts, and some trees were moved by our own maintenance forces using rented equipment. These latter two means of transplanting have usually resulted in higher and lower costs, respectfully. Normally, bids of approximately $120 per tree can be expected if the transplanting is done by prime contract with a minimum of 80 trees to be moved.

Factors which affect this bid price are:
— the number and size of trees to be moved,
— the distance of the haul (15 miles or less),
— accessibility of the tree source and planting sites,
— the amount of post-transplant work required.

Contracts which include a plant establishment period (1 year of watering and care) have exceeded our average price by as much as $98 per tree. However, experience has shown that $78 per tree is a realistic cost estimate for this added work. All things considered, our average cost of $142 per surviving tree (Table 3) is very economical, indeed, when compared with the costs of installing comparably sized trees by other methods.

Large, transplanted trees have many uses, especially in a highway situation. Besides blending the highway into its surroundings, large tree transplanting provides:

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This Jack Pine was dug with a 42-inch spade. Note that the root system was retained. Tree is about 2½ inches in diameter.

Root system retained on a 2½ inch diameter Bigtooth Aspen when dug with a 42-inch spade.

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1. immediate shade and vegetative cover at rest areas.
2. softening touches around overpasses, interchanges, and service buildings.
3. a means of saving quality trees and rare species which would otherwise be destroyed during construction.
4. a means of establishing noise barriers, headlight glare screens, and greenbelts along urban and suburban roadways.
5. a means of establishing aesthetically appealing, special facilities (one of our projects was designed to stimulate actual driving conditions by creating blind corners at a driver examination center).

Along with having this multitude of uses, large tree transplanting has proven very successful and very economical in practice.

Large wild or woods collected material can be successfully transplanted if good horticultural practices are employed in the transplanting work. Once the tree has been moved, water must be applied in sufficient quantities and at regular intervals to prevent crown dieback from occurring.

Crown dieback, from whatever cause, is the most common, adverse effect of the transplanting technique, and is the warning flag of improper project planning.

Proper project planning is an exacting science which requires the balancing of many interrelated factors, some of which have been mentioned here. The Minnesota Department of Highways, through five years of experience in transplanting, has found that large tree moving is a viable landscaping tool which will be used with greater frequency in the coming years. □

Special Wage/Hour Summary Published by AAN and NLA

The American Association of Nurserymen, in cooperation with the National Landscape Association, has recently published a "Special Summary of Wage/Hour Laws Affecting Government Contracts." This summary has been prepared by the AAN and NLA staffs jointly with the AAN attorneys to inform nursery businessmen, in plain non-legalistic language, how wage-hour laws affect firms which obtain government contracts.

"Many AAN firms bid on government contracts, particularly those which provide landscape services," points out Leo Donahue, administrator of the American Association of Nurserymen. "Both AAN and NLA have published in their respective newsletters information on the wage-hour aspects of bidding such contracts. There is nowhere, however," Donahue comments, "a brief publication summarizing the wage-hour laws affecting government contracts. That was our objective in writing this special summary."

Lack of knowledge in this specific area can prove extremely costly. Some firms have avoided bidding government contracts because of the complexity of the wage-hour laws. Therefore, this special summary should prove welcome news to all AAN firms involved in this particular area of landscaping. The AAN urges nursery businessmen to seek the advice of their attorneys regarding any specific problems which they may encounter.

The "Special Summary of Wage/Hour Laws Affecting Government Contracts" is available only to AAN members. It can be purchased for $2.00 by writing the AAN. 230 Southern Building, Washington, D.C. 20005.