90-24 Wendy Sue

SUSTAINABLE AGRICULTURE RESEARCH AND EDUCATION PROGRAM AND AGRICULTURE IN CONCERT WITH THE ENVIRONMENT

1. FINAL REPORT

2. DATE: March 5, 1993

3. TITLE: Sustainable Sod Production for the Northeast

4. PROJECT STATUS: The project is completed, except for some minor data analysis and publications which are still being prepared.

5. PROJECT COORDINATOR:

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6. MAJOR PARTICIPANTS: no change.

7. COOPERATORS: no change.

8. GRANT NUMBER: USDA COOP Agreement No. 88-COOP-1-3524

9. FUNDING PERIOD: no change.

10. FUNDING TO DATE: no change.

11. ABSTRACTS: no change.

12. OBJECTIVES: no change.

13. PROJECT RESULTS:

A. Findings: Results are listed under grant objectives.

Objective 1: Insect Resistance. We have apparently conclusive evidence that under laboratory conditions germinating seedlings of endophytic grasses resist Japanese beetle larvae. This apparent resistance is greatest among tall fescues, but also is associated with perennial ryegrass, and fine fescues. The effect is greatest among small larvae; less pronounced among mid-size larvae; perhaps non-existent among mature larvae. Dr. Torello at the University of Massachusetts is working to isolate the chemical basis of this resistance, an objective that falls beyond the scope of this grant.

Field results are far less conclusive. In examining natural populations of Japanese beetle grubs, we found no relationship between grub densities and endophyte content of grasses in 2 seasons of examinations at URI and one season at U. Mass. at Amherst. (However, in drawing conclusions from these results, we must reconcile the fact that in N.J. during the summers of 1991 and 1992, there were differences in grub densities apparently attributable to endophyte content in tall fescue.) In confined field studies we have mixed results - sometimes showing statistically significant differences in survival and weight between grubs confined on endophytic and non-endophytic tall fescue. We are now preparing manuscripts on our field results which will explain that there appears to be a real effect of endophytic tall fescue on the Japanese beetle, but it is apparently a small and a complicated one, most pronounced in new plantings and most expressed at high temperatures.

We have also concluded that grub resistance in endophytic tall fescue is largely moot in the Northeast, since grubs are generally incapable of damaging tall fescue turfgrass in this area. Density-dependent mortality factors (disease and competition) appear to limit grub numbers at a level that tall fescue can tolerate without showing damage. Perhaps because of its heat and drought tolerance, this grass is tolerant of Japanese beetle grubs, except possibly under the most adverse growing conditions. It appears that in general endophytic tall fescue, because of its resistance to foliar feeding insects and tolerance to grubs will largely escape insect problems in the Northeast.

Efforts to introduce Acremonium coenophialum into other grass species were unsuccessful, but we learned a lot about new approaches to this problem that should assist others in researching this objective. This work, partially supported through this grant is reported in the MS Thesis of Jennifer Nobel, Dept. of Plant and Soil Science, U. Mass. at Amherst, January, 1992. The abstract of Jennifer's thesis is appended to this report.

Objective 2 (agronomic requirements). Work on this objective was slowed by the availability of plantings of alternative sods. In 1989 there were two plantings: one at URI and one commercial planting of tall fescue mixed with bluegrass. In 1990 we made additional plantings at URI and 4 commercial growers also planted alternative sod mixtures. Growers reported no disease or insect problems with the alternative sod mixes. The severe summer drought demonstrated the ability of tall fescue and fine fescue sods to avoid quality decline or dormancy. The severe downturn in the economy has placed the commercial sod market in a depression. Although the overall market is quiet, interest in the alternative sods has been encouraging. A number of brokers have test marketed quantities of tall fescue materials and a small quantity of materials containing fine fescue + perennial rye sold to the golf course market.

Grass mixtures. In URI plots we evaluated plots of tall fescue mixed with 2%, 5%, and 10% Kentucky bluegrass, concentrating upon the 5% mixtures which we think will be ideal. Cooperating LISA grower Sue Albert has two fields of 95:5% (w/w tall fescue:bluegrass) and other fields planted to various blends of bluegrass mixed with endophytic perennial ryegrass and fine fescues. Another LISA cooperator John Partyka has planted a 12 acre experimental field using 2 cultivars of highly endophytic tall fescue and 5 varieties of Kentucky bluegrass. These 7 grasses are

planted in various combinations at various seeding rates. Two other local growers planted tall fescue sods (one with netting to hold it together) and two are also experimenting with other mixtures of fine fescue and Kentucky bluegrass in their sods. All shared results with URI, but because of market depression, sales volumes have been small and conclusions are limited. Several firms that previously offered only Kentucky bluegrass blends now report offerings of tall fescue, fine fescue, perennial ryegrass, both in species monoculture and in more traditional blends. Turf managers and homeowners who purchased tall fescue sod report high satisfaction levels.

Seeding technique is one aspect on which we have definitive results. Because of segregation of the very different size seeds in the planter, it will be necessary to double-seed fields of tall fescue mixed with bluegrass. In fields that were planted first with one grass and then with the other, we find a uniform stand of mixed grasses. When seeds are mixed before planting, we do not find a uniform stand. It appears that 6-8 lbs. of seed per 1000 square feet will be adequate for most turf-type tall fescues, but leaf texture improves (becomes finer) with increased seeding rates up to 10 lbs.

Fertilization and irrigation. Results to date indicate that fertilizer required for producing tall fescue sod will be in the range of 2-4 lbs. N. per 1000 sq. ft. per year (86-172 lbs./acre) - somewhat less than Kentucky bluegrass sod. It appears that after establishment, little or no irrigation would normally be necessary to produce this sod which will result in a considerable savings over bluegrass sod. The relationship between fertilization, irrigation, and time to maturity is different for tall fescue compared to Kentucky bluegrass. Data indicate that 12-14 months is required to grow a harvestable tall fescue sod with minimal and tolerable soil loss. Kentucky bluegrass takes somewhat less time to reach harvest maturity. Some growers "push" bluegrass sods through the use of high fertilizer rates, a practice with documentable environmental consequences.

Objective 3 (Nutrient dynamics). The tall fescue sod under investigation and the other mixtures under consideration all require less irrigation water and fertilizer than conventional bluegrass sod. Work done to date at URI indicates that there is little or no loss of nitrogen to groundwater unless turf is overwatered and overfertilized. There is a low probability that bluegrass sod management will result in any groundwater contamination, a probability that is even further reduced through the use of tall fescue because of its reduced requirements for nitrogen and irrigation. Lysimeter data indicate that tall fescue is more efficient at capturing nutrients than bluegrass. Soil water percolate has been significantly different under the tall fescue and Kentucky bluegrass at different times in the season. Dry matter measurements and tissue nitrogen concentration indicate that tall fescue removes more nitrogen from the soil solution. The source of plant nitrogen does not appear to have any impact on the efficiency or efficacy of plant absorption.

Objective 4 (Sod persistence). In November, 1990 we harvested the first of these sods from LISA cooperator Sue Albert. We sodded three athletic fields in a demonstration experiment, and we transplanted some of the sod to URI to begin the fertilization/irrigation/wear experiments described in the grant proposal. In the summer of 1991 we sodded a "path" leading from the URI greenhouses with 4

different sod mixtures. These sods, which emphasized either bluegrass, tall fescue, fine fescues, or perennial ryegrass, were protected from wear until established, and then normal foot traffic was allowed on them. They all wore about the same over the late summer and through the fall. In fact, it was difficult to distinguish among the various grasses for either wear tolerance or general appearance. Over the winter, wear continued to a point where had almost bare ground in the middle of the path. In the spring of 1992 the worn areas all recovered - filling in from the sides. As expected, new growth was all Kentucky bluegrass - demonstrating the importance of including some bluegrass in mixes because of its ability to fill in damaged areas. This study indicated that all mixtures wore and recovered about the same and apparently sod age was more important than composition in this study. The TF/Kbg mix was at least as good (actually rated higher) than the older (thatchy) sod of blended bluegrasses.

Objective 5 (Economics). Alan Gu, a URI graduate student in Resource Economics was assigned to the Sustainable Sod project to study the economic aspects of this program. He gathered economic information to establish a framework for evaluating the potential economic implications of producing alternative sod crops. A survey of economic literature was conducted to locate recent articles on production and marketing implications of turfgrass sod. Specialists at state experiment stations in the Northeast were contacted to locate reports describing the farm-level economics of turfgrass sod production. All this information has been used to develop baseline crop budget data for sod production and a manuscript has been prepared from these efforts. This paper, titled "Production cost analysis and marketing considerations for bluegrass and tall fescue production in Rhode Island" is enclosed with this report. It has had limited distribution to date and we are evaluating the merits of editing it and distributing it to sod producers.

B. Case Studies. Three model farms have been evaluated to compare their production of tall fescue and Kentucky Bluegrass sods. All three of these farms are within 8 miles of the University of Rhode Island and they have a great deal in common, including climate, soil types, topography, machinery, labor, etc. Production practices did differ considerably among them, including the fact that one farm used netting to accelerate the date of tall fescue harvest. All three farms, their production strategies, and their economic analyses are completely described in the manuscript on economic analysis.

C. Economic Analysis. These efforts are described under "findings" above and in Alan Gu's manuscript.

D. Dissemination of Findings: We have distributed findings of this project through several vehicles including research publications, extension bulletins, presentations, and demonstration tours including the following:

Publications:

1. Nobel, Jennifer. 1992. Biological control of turfgrass pests by fungal endophytes. M.S. Thesis. Dept. of Plant and Soil Sciences, U. Mass. Amherst. 124 pgs.

2. Gu, Alan. 1992. Production cost analysis and marketing considerations for bluegrass and tall fescue production in Rhode island. Major Paper submitted in

partial fulfillment of MS Degree. Dept. of Resource Economics, Univ. of R.I., Kingston.

3. Johnson-Cicalese, J., R. Casagrande, and H. Faubert. 1992. Effect of acremonium endophytes on Japanese beetle grubs (Popillia Japonica). Agron. Abs. pg. 171.

4. Casagrande, R.A. (and several others). Field studies of endophytic tall fescue and Japanese beetles. Manuscript in preparation. To be submitted to Environmental Entomology.

5. Casagrande, R.A. (and others). Impact of endophytic turfgrasses seedlings upon Japanese beetles in the laboratory. Manuscript in preparation. To be submitted to J. Econ. Entomol.

6. Sullivan, W.M. (and others). Agronomic considerations in tall fescue sod production. Manuscript in preparation.

Extension Literature:

1. Casagrande, R.A. 1992. Endophytes and Japanese Beetles. Turf Notes. Univ. Mass and URI Extension Publication. (A newsletter for professional turf and grounds managers) Vol. 2 (7)

2. Merrill, L.S. 1992. LISA Meets Turf. Turf North. pgs 66-74. April, 1992. (Turf North is a trade magazine distributed to virtually all turf producers in the Northeast. By presenting Lorrain Merrill with this article, we got the results of our Sustainable Sod project into the hands of almost everyone who could have been interested in it - at no expense to us.)

Presentations: My colleagues and I gave an enormous number of presentations on aspects of turfgrass establishment and management during the past two years. Many of these presentations have included results from this LISA projects - particularly some of the presentations of S.R. Alm on insects and N. Jackson on diseases and agronomic aspects of turfgrasses.
Dr. Alm presented these results at the 8th cool season turfgrass insect workshop in Annapolis, Md on Jan. 30, 1991, and at the Penn. State Turf Conference in Pittsburg, PA on Feb 27, 1991.

Dr. Jackson mentioned this work at several of the 10 conferences he addressed last year including the January 17 meeting of the Main GCSA Turf Management Seminar in Falmouth, ME., The National Parks Service Vegetation Seminar on Cape Cod on Feb. 27, 1991, and the GCSAA Regional Turf Disease Seminar in Palm Springs, CA, Apr. 16, 1991.

Dr. Sullivan presented aspects of his LISA work on several occasions including:
1. Agricultural Chemical Reclamation by vegetative filter strips. Amer. Soc. Agronomy. October, 1991. Denver, CO.
2. Environmental impacts of turf. Turf 3B Pesticide Recertification. Meeting. Nov. 21, 1991. Randolph, Vt.
3. Turf and the environment. New Jersey Turfgrass Assoc. Dec. 4, 1991.

4. Nutrient losses from commercial sod production. Amer. Soc. of Agron. NEASA meetings, Durham, N.H. July 8, 1990.
5. The impact of turfgrasses on water quality. Amer. Soc. of Agron. Durham, N.H. July 8, 1990.
6. Environmental impacts of turf. National Institute on Park and Grounds Management. Providence, RI, March 23, 1992.
7. URI "GreenShare" training for Home Depot Garden Centers (throughout N.E.) Feb. 14, 1993.
8. URI "GreenShare" training for R.I. Garden Center Personnel. March 2, 1993.
9. R.I. Greenskeepers Association. March 4, 1993.
10. Riparian Zone management. USDA/ARS/SCS, Atlanta, Ga. March 18, 1993.

Dr. Casagrande's presentations included the following:
1. Low Input Landscapes. Amer. Soc. of Landscape Architects. Oct. 10, 1990. Prov. RI.
2. Low Input Landscapes. National Organic Farming Assn. URI Alton Jones Campus. Feb. 2, 1991.
3. Managing Landscape Pests. R.I. Nurserymen's Shortcourse, Feb. 5, 1991. Newport, RI.
4. Managing Insects around the home. CES Master Gardeners. May 8, 1991.
5. Sustainable Landscape Plants. Amer. Soc. of Landscape Architects. Nov. 1991, Prov. R.I.
6. Endophytic grasses for reducing insect damage in sports turf. National Institute on Park and Grounds Management. March 23, 1992.
7. URI GreenShare Training: March 1992, Feb. 4, 1993, March 16, 1993.
8. URI Master Gardener Training: March 25, 1992, March 3, 1993.

Demonstrations and Tours:
1. Sullivan and Casagrande: URI Annual Turfgrass Field Day. Aug. 21, 1991, August 19, 1992.
2. Sullivan and Casagrande: URI Annual Sodgrowers Field Day. Aug. 22, 1991, August 20, 1992.
3. Casagrande: Greenshare Field Day. URI Campus. October, 1991, October, 1992.
4. Low input grass demonstration plantings.
5. Sod wear demonstration.

E. Producer involvement.
3 Major growers in R.I. are conducting large-scale trials of alternative sods.
Farmers in attendance at workshops - 210 (est.)
Farmers in attendance at field days - 40 (est.)
Farmers in attendance at conferences - 250 (est.)

14. POTENTIAL CONTRIBUTIONS AND PRACTICAL APPLICATIONS:
Dr. Sullivan is working with state and several coastal communities that wish to establish coastal zone landscape management programs. The objective of these efforts is to minimize any potential offsite impacts of landscape manament activity. Adoption of tall fescue and appropriate management techniques will further minimize the probability of negative impacts for turf culture. USDA - SCS is reviewing the possibility of including endophitic tall fescue as a component of materials planted in vegetative filter strips designed to capture nutrients from surface

runoff areas. The inclusion of endophytic tall fescues in these low maintenance structures is part of a large water quality management program nationwide.

The work conducted through the Sustainable Sod grant has provided research support and generated consumer demmand for several new seed mixtures that have been distributed in the past 2 years including the Lofts' Ecology Mixes, Agriturf's "Safelawn", and the "Merner Mix" distributed both locally and through Northern Organics. All of these mixes emphasise endophytic grasses and some such as the "Merner Mix" and Lofts' "Summer Stress" mix emphasize endophytic tall fescue.

It is apparent that turf breeders seeking Japanese beetle resistance will have to substantially increase the amount of loline alkaloids in the root zone to achieve field-level resistance.

15. AREAS NEEDING ADDITIONAL STUDY: We would like to know more about the role of different strains of endophytes and grasses and their impact on insects. It also appears that the temperature response of the endophytes, their associated chemicals, and the responses of insects is an important area that is not adequately understood.

Our plots will be maintained for as long as possible to consider the long term persistence of tall fescue in the landscape. The consequences of practices such as clipping removal and minimal or no supplemental fertilizer will also be assessed.

Poster presented at the 1992 Annual Meetings of American Society of Agronomy
Abstract published in 1992 Agronomy Abstracts, p. 171.

90-24

EFFECT OF ACREMONIUM ENDOPHYTES ON JAPANESE BEETLE GRUBS (Popillia japonica)

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ABSTRACT

Although Acremonium hyphae have not been found in grass roots, the alkaloids associated with these endophytes have been found in roots. Thus, studies on the effects of endophytes on root-feeding white grubs were initiated. Growth chamber trials with first instar grubs feeding on seedling tall fescue, perennial ryegrass, and hard fescue showed significantly higher mortality on the endophyte-infected grasses than on endophyte-free grasses. However, when first instars fed on mature tall fescue plugs in a growth chamber, differences in mortality were not seen. With second and third instars, endophyte status had a small effect on grub weights (higher weights on endophyte-free grass), but not on survival. In field trials, results were also variable. Counts of natural infestations failed to show a relationship between endophyte status and number of grubs.

INTRODUCTION

The discovery and utilization of Acremonium endophytes has had a profound effect on turfgrass pest management. However, the effect of these symbionts on our most serious turfgrass pest, the white grub, is not fully understood. Endophyte mycelia are not found in roots, where grubs feed, but the alkaloids associated with them are present in the roots (Siegel et al., 1987). In addition, fewer root-feeding nematodes were found under endophyte-infected grass (Pederson et al., 1988). In Kentucky, artificial diet containing endophyte-associated alkaloids deterred feeding of scarabaeid grubs (Patterson et al., 1991) but in the field, their results were variable (Potter et al, 1992). In New Jersey, recent field studies found fewer grubs under endophyte-infected tall fescue plots (C.R. Funk, pers. comm.). In Rhode Island, we conducted several studies to further explore endophyte-white grub interactions. This poster describes two of these experiments:

1. Effect of endophyte on a natural infestation of grubs, in a tall fescue variety trial.
2. Effect of endophyte on grub survival under growth chamber conditions. Three larval stages were used and four species of grass.

MATERIALS AND METHODS - GROWTH CHAMBER STUDIES

Preliminary growth chamber studies in 1990 found that first instar survival was not affected by endophyte in mature plugs of tall fescue. However, when tall fescue seedlings were used, first instar survival was significantly affected by endophyte. In 1991, these findings were further investigated by using seedlings of four grass species and first, second, and third instars.

Treatments - a 2x5 factorial design was used with 5 pairs of grass, with and without endophyte:

Titan (E+) and Chieftain (E-) tall fescue,
Shenandoah (E+) and genetically alike PE7 (E-) tall fescue,
Repell (E+) and Tara (E-) perennial ryegrass,
Reliant (E+) and Crystal (E-) hard fescue,
Jamestown II (E+) and genetically similar Jamestown (E-) Chewings fescue

First instar - Eggs for this study were obtained from Japanese beetle adults that had been collected during early July and placed in bins with soil and grape leaves. Plastic cups (50ml) were filled with a mixture of 25ml of moistened soil and 1g of seed. Twenty eggs were then placed in each cup, with a total of 23 cups (replications) per treatment. Cups were kept in a growth chamber at 25^{o} C. Seedlings had begun growing by the time eggs hatched, providing food for the young larvae. The study was initiated July 15-26 and dismantled 30 days later; number of live first instar grubs per cup was recorded.

Second instar - On August 5, cups were filled with soil and seed as in the first instar study. Eight days later, after seedling emergence, second instar larvae were collected from the field and placed in the prepared cups, one grub per cup, 20 cups per treatment. The cups were held in the growth chamber and on September 10, survival and larval weights were recorded.

Third instar - On September 13, cups were filled with soil and seed. Ten days later, third instar larvae were collected and placed in the cups, one grub per cup, 20 cups per treatment. On October 22, survival and weights were recorded.

RESULTS - GROWTH CHAMBER STUDIES

First instar - In tall fescue, perennial ryegrass, and hard fescue, Acremonium endophytes significantly reduced first instar survival. In Chewings fescue, survival was better on the endophyte-infected grass.

Second instar - As grubs matured the effects of endophyte became less significant. Only on one tall fescue pair and on Chewings fescue was survival better on the endophyte-free grass. Weights were higher on both endophyte-free tall fescues and the Chewings fescue.

Third instar - When larger third instar larvae were used, neither survival nor weight was affected by endophytes in any of the grass species pairs.
However, when data were pooled, larval weights on endophyte-infected grasses were significantly different from larval weights on endophyte-free grasses ($F=3.80$, $df=1$, $P<0.05$).

Table 1. Effect of endophyte on grub survival and grub weight on seedlings of 4 grass species, under growth chamber conditions.

Endophyte	Species-cultivar[1]	1st instar % survival	2nd instar % surv.	2nd instar Wt.	3rd instar % surv.	3rd instar Wt.
+	Tall fescue-Titan	9.83**	85	0.112**	100	0.197
-	Tall fescue-Chieftain	37.43	90	0.155	85	0.222
+	Tall fescue-Shenandoah	11.17**	75*	0.118**	85	0.208
-	Tall fescue-PE7	40.43	100	0.193	75	0.229
+	Per. ryegrass-Repell	22.70**	100*	0.164	100	0.218
-	Per. ryegrass-Tara	38.44	80	0.168	95	0.206
+	Hard fescue-Reliant	27.39**	80	0.167	90	0.219
-	Hard fescue-Crystal	40.65	75	0.153	80	0.238
+	Chewings fescue-J II	37.04*	80*	0.143*	75	0.211
-	Chewings fescue-Jamestown	28.17	100	0.176	95	0.228

[1] Grasses are arranged in complimentary pairs, with (+) and without (-) endophyte.
*,** Means within pairs differ at P=0.05 or 0.01, respectively, according to the pairwise t-test for 1st instar survival, and 2nd and 3rd instar weights, or Chi-square test for 2nd and 3rd instar survival.

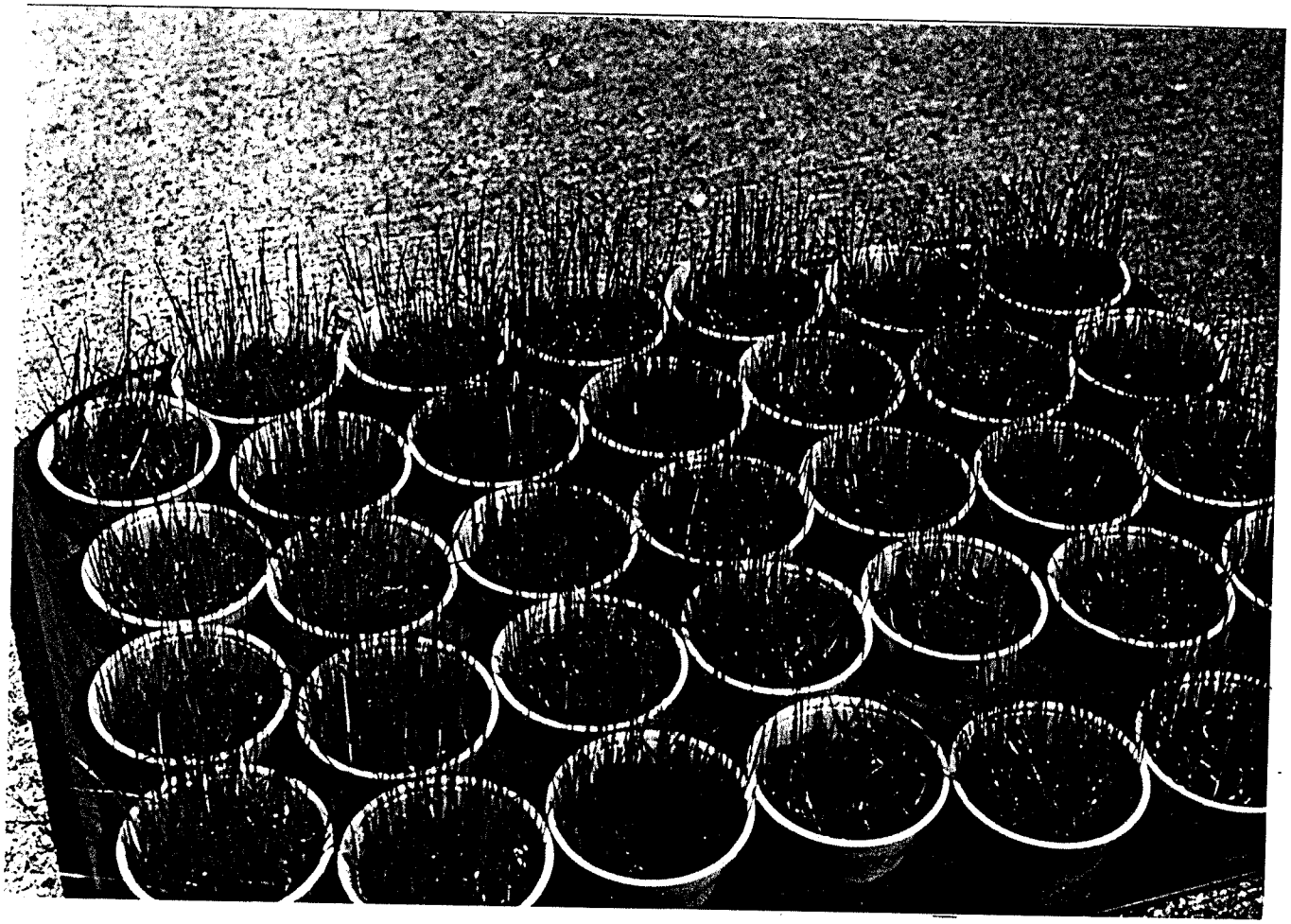

Figure 1. Cups of seedling grass in which white grubs were confined in growth chamber studies.

MATERIALS AND METHODS
NATURAL GRUB INFESTATION IN TALL FESCUE

Test area - established September 1987 and consisted of 68 entries in the National Tall Fescue Test. Plots were 1m by 2m and replicated three times in a randomized complete block design. The test received approximately 146kg N/ha per year, irrigated as necessary to avoid drought stress, and mowed at 5 cm.

Grub counts - taken September 25-27, 1990 on 17 entries in all three replications. Counts were made by running a sod cutter over the plot, lying back a 0.3m by 1.0m strip of sod and counting all exposed grubs *(Popillia japonica)* in the sod and in the soil below (Fig. 4).

Grub weights - ten randomly selected grubs per plot were weighed.

Endophyte content - Ten tillers were randomly selected from plots in Rep 3 and five tillers per plot in Reps 1 and 2. Leaf sheath tissue from each tiller was microscopically examined for endophyte mycelium and percent infection was determined.

RESULTS - NATURAL GRUB INFESTATION IN TALL FESCUE

Endophyte content did not explain a significant amount of the variation in grub numbers or grub weights when data were analyzed using analysis of covariance (endophyte was the covariate) (Fig. 2 and 3). However, a small negative correlation was obtained between endophyte and grub weight ($r=-0.295$, $P<0.044$) suggesting Acremonium endophyte may have a minor effect on white grub development in the field.

Of perhaps more interest was the significant differences in grub numbers found among tall fescue cultivars ($F=3.05$; $df=16$; $P<.004$) (Table 2). These findings suggest that screening cultivars for genetic resistance to grubs may be worthwhile. Our grub counting method, although not an absolute count, may prove useful in screening large numbers of grass selections because it is very rapid and not destructive to turf plots.

White grubs are not usually considered important pests of tall fescue, perhaps because tall fescue is more tolerant of grub feeding. Even with the large number of grubs found under this test area (19.6 per.09 m^2) there was no visible grub damage. However, high amounts of rainfall during September may have masked the effects of their feeding. The lack of drought or other stresses may have also reduced the level of endophyte and/or alkaloids ingested by grubs.

Table 2. Grub number, grub weight and percent endophyte of 17 tall fescue cultivars and selections.

Cultivar	Grub number[1]	Grub weight[2]	% endophyte[3]
Arid	14.7 a	0.129	69.0
URI P345	17.7 ab	0.159	23.3
Trailblazer	18.7 ab	0.172	6.7
PST 5MW	19.7 ab	0.144	10.0
URI P160	20.3 ab	0.144	36.7
Tribute	21.0 ab	0.146	46.7
Bel 86-1	21.3 ab	0.151	0
Shenandoah	23.3 ab	0.156	50.0
Titan	25.0 ab	0.123	70.0
Hubbard 87	29.3 abc	0.178	0
Kentucky 31	29.7 abcd	0.143	0
PST 5HF	30.7 abcd	0.150	13.3
Mesa	34.3 abcd	0.178	40.0
PST DBC	36.3 bcd	0.156	73.3
Aztec	45.7 cde	0.174	0
Rebel	50.0 de	0.157	6.7
Tip	58.7 e	0.177	10.0
Mean	29.2	0.155	26.9

[1]Number of grubs per $0.3m^2$, means followed by the same letter are not significantly different (LSD, $P<0.05$)
[2]Mean grub weight, 10 grubs per plot
[3]Percent endophyte content in 5-10 tillers per plot

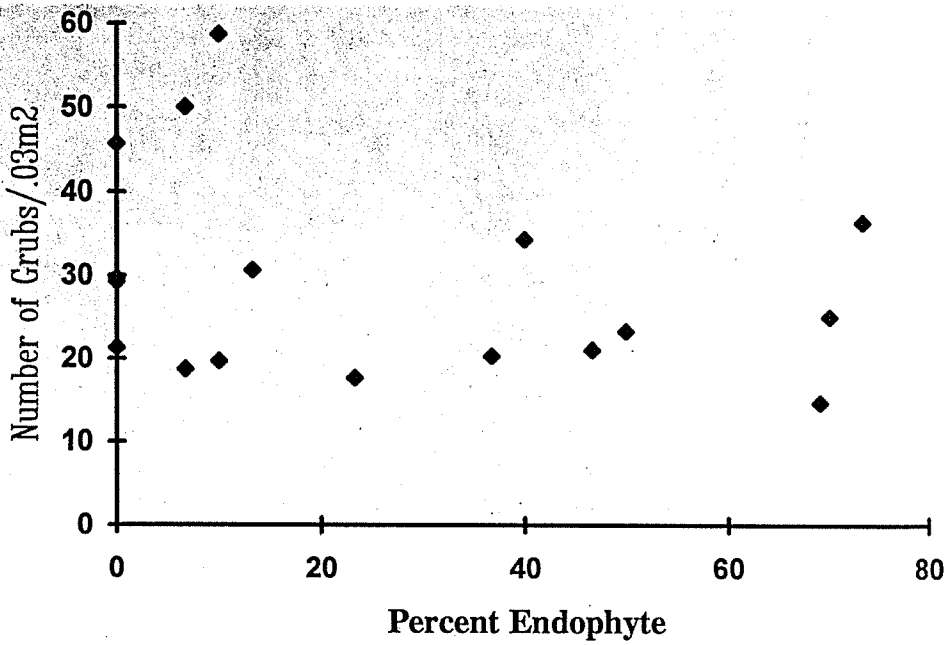

Figure 2. Effect of endophyte on grub numbers in a tall fescue variety trial.

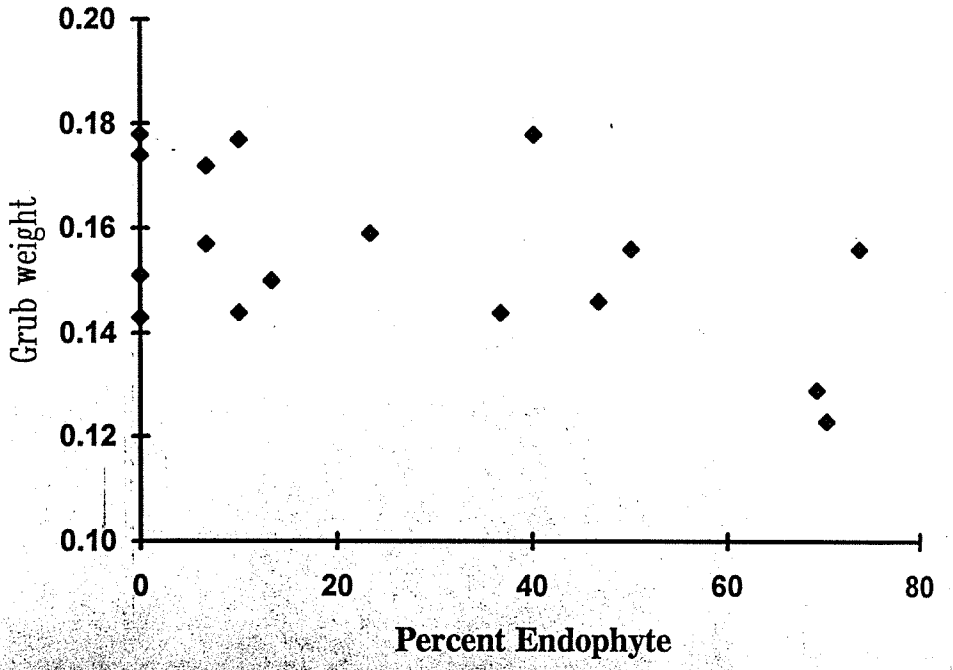

Figure 3. Effect of endophyte on grub weights in a tall fescue variety trial.

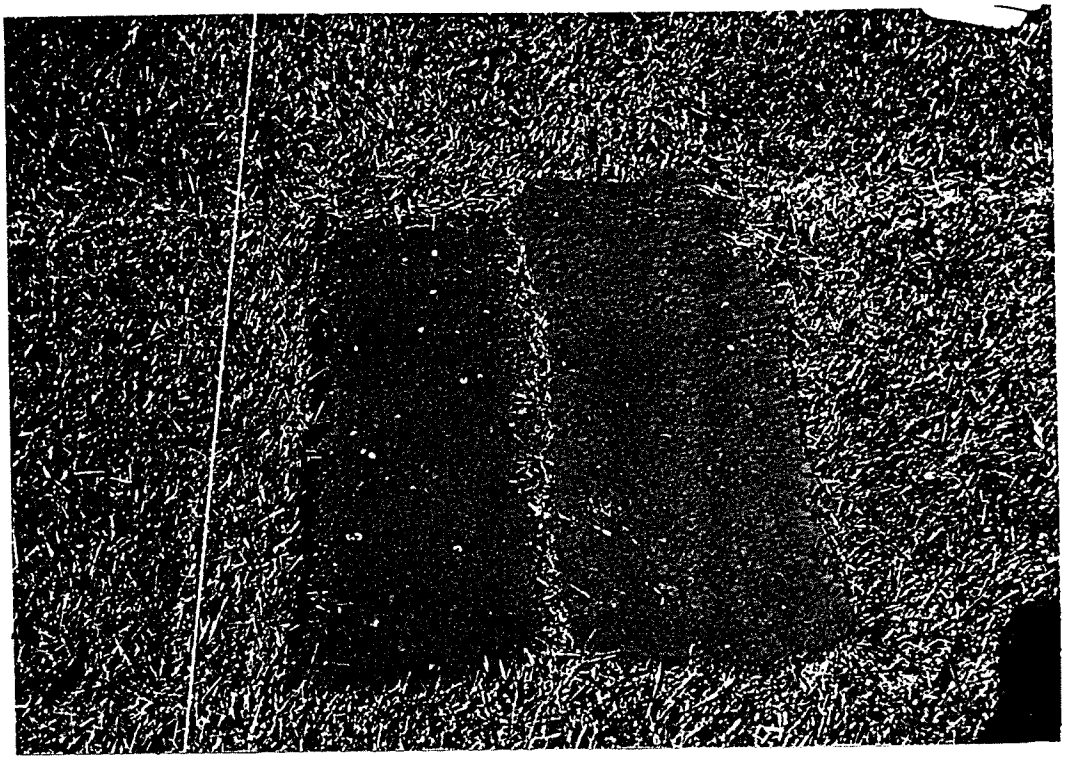

Figure 4. Grub counting method, when strip of sod is laid back, numerous white grubs are exposed.

Figure 5. Second instar grubs of the Japanese beetle.

CONCLUSIONS

The results from these studies indicate that young Japanese beetle larvae are adversely effected by Acremonium endophytes in grass seedlings. Because it takes a few weeks for the mycelium to colonize a seedling, it is more likely that the alkaloids in the seed itself leached into the soil and were ingested by grubs. This is consistent with J.B. Oliver's finding of reduced survival of first instar grubs exposed to leachate from endophyte-infected tall fescue seed (pers. comm.). If this also occurs in new seedings in the field, it may enhance establishment of endophyte-infected grasses.

In conclusion, the natural grub infestation described here, and additional field studies conducted at Rhode Island and elsewhere, suggest that the effect of endophyte on white grubs is minimal and is probably influenced by environment, the plant species and genotype, and the fungal strain.

LITERATURE CITED

Patterson, C.G., D.A. Potter & F.F. Fannin. 1991. Feeding deterrency of alkaloids from endophyte-infected grasses to Japanese beetle (Coleoptera:Scarabaeidae) grubs. Entomol. exp. appl. 61:285-289.

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Siegel, M.R., G.C.M. Latch & M.C. Johnson. 1987. Fungal endophytes of grasses. Ann. Rev. Phytopathol. 25:293-315.

ABSTRACT

BIOLOGICAL CONTROL OF TURFGRASS PESTS

BY FUNGAL ENDOPHYTES

FEBRUARY 1992

JENNIFER NOBEL, M.S., UNIVERSITY OF MASSACHUSETTS

Directed by: Dr. William A. Torello

Grasses infected with a fungal endophyte may have a negative effect not only on foliar feeding insects but on root feeding turfgrass pests. The goal of this work was to evaluate the effectiveness of endophyte-infected (EI) grasses for the biological control of Japanese beetle larvae. In the first field season, larvae were implanted at densities of 0,10,20,40,60, and 90 grubs/ft^2 into cores on field plots of EI and endophyte-free (EF) cultivars of a variety of grass species. High variation resulted in all comparisons being nonsignificant. In the second year, second instar larvae were introduced at densities of 0,20,40, and 60 grubs/ft^2 into EI and EF tall fescue, and Kentucky bluegrass planted in pots submerged in the ground. Grubs feeding on infected grasses exhibited significantly lower survival and weight, suggesting a possible deterrence or antibiosis effect. Tolerance of grasses was assessed through comparision of clipping yields. The study is consistant with no-choice pot studies by Potter et.al. (1991) and Oliver (1990) showing an effect of EI grasses on Japanese beetle larvae. It is in contrast to results of an almost identical study at U.R.I. (R.A. Casagrande, personal communication) Thus under natural conditions, other factors may influence the effect of EI grasses on root feeders.

A greater understanding of the relationship between endophyte and host grass can be achieved more easily in <u>in vitro</u> experiments. Endophyte was isolated from various grasses and cultures were used to inoculate mycelium into seed and seedling grasses as well as embryogenic, initiating, and mature callus of EF grasses. Failure to detect endophyte in inoculated grasses may relate to isolate variability which operates at many levels and affects cross-compatability of host and endophyte.

UNIVERSITY OF MASSACHUSETTS AND UNIVERSITY OF RHODE ISLAND
COOPERATIVE EXTENSION SYSTEMS

TURF Notes

A newsletter for professional turf and grounds managers.

Volume 2, Number 7 June/July 1992

ENDOPHYTES AND JAPANESE BEETLES

By now, just about everyone associated with the turf industry is aware of endophytes and many are using endophytic perennial ryegrass, fine fescues and tall fescues because of their resistance to insect pests. In controlling damage by chinch bugs, webworms, billbugs, and other stem and foliage feeders, these grasses harboring friendly fungi solve about half of our turf insect problems. But the remainder of the insect problems in the Northeast are caused by white grubs, most often Japanese beetles. Conventional wisdom is that endophytes have no effect on white grubs, but is that true?

A few years back I served on a review team for the Department of Entomology and Plant Pathology at the University of Tennessee. In preparing for the review, I read a description of Jason Oliver's research on impact of endophytes on Japanese beetles - the first hint I ever heard that endophytes might affect white grubs. Previously, I had understood that since endophytes were not found in turf roots, there was no reason to suspect that they would impart resistance to root feeders.

While at Tennessee, I learned that Jason's results were equivocal - sometimes showing resistance, more often, not. But nematologist Ernie Bernard and plant pathologist Kim Gwinn were finding excellent inhibition of several species of root feeding nematodes in endophytic tall fescue. Upon returning to URI, I called my friend Dan Potter in the entomology department at the University of Kentucky and found that he and his colleagues had just completed a series of studies showing that endophytic tall fescue produced several compounds that moved into the root zone. Furthermore, one of these materials, N-formyl loline, was present in levels that killed Japanese beetles in petri dishes. In evaluating the impact of endophytic tall fescue in the greenhouse and in the field, Dan was getting results not unlike those in Tennessee: sometimes the endophyte inhibited grubs, more often it did not. With Dan's encouragement, I started a series of experiments to evaluate the potential for resistance using new turf-type tall fescues under our growing conditions in southern New England. In these tests we used the highly endophytic tall fescue varieties *Shenandoah*, *Titan*, and *Tribute*. After three season's research in growth chambers, greenhouses, and field plots, both at URI and at UMass, working with my colleagues Bill Torello, Jennifer Nobel, Jennifer Johnson-Cicalese, and Liz Hill, I have come to a conclusion: **sometimes endophytes work on Japanese beetles, more often they don't.**

Many of our experiments are still being statistically analyzed, and we are now interpreting results and preparing manuscripts for publication, but we understand enough to report our results in general terms and try to explain the mixed results obtained by all of us who have studied this problem.

GROWTH CHAMBER STUDIES

The one place we tend to get consistent results is when we confine germinating seeds of endophytic grasses with small Japanese beetle grubs in the growth chamber. Using newly hatched (first-stage) larvae confined with newly germinated grasses, we get over 90% mortality with endophytic tall fescue vs. roughly 70% mortality with other endophytic grasses,

compared to 50% mortality with comparable non-endophytic grasses. This effect is considerably reduced when we confine 2nd-stage larvae on these germinating grasses, and with large 3rd-stage larvae we are unable to measure any impact with the endophytes. We're still sorting out the source of this resistance in seedlings, but it is obvious that larger larvae are less susceptible to the negative effects of the endophytes.

NATURAL FIELD INFESTATIONS

One of our favorite means of evaluating resistance to white grubs involves running a small sod cutter across research plots and counting exposed grubs. This method is fast, easy, and gives a good indication of grub populations when done in spring and in late summer when grubs are near the surface. Using this technique for several seasons in our research plots and in the tall fescue variety trials, we have been unable to determine any relationship between grub density and endophyte content in any of the grasses, including tall fescue. Jennifer Nobel and Bill Torello report similar results at the UMass turf farm. However, colleagues in New Jersey did find differences last year in white grub densities between *Shenandoah* tall fescue and its non-endophytic counterpart, *PE7*. Following an unusually hot, dry summer, Jim Murphy and Lou Vasvary found *Shenandoah* to look considerably better than *PE7* and in addition to finding 20 times fewer billbugs on *Shenandoah*, they also found it to have about 1/3 as many Japanese beetles as they found on the non-endophytic grass.

The results appear to show that in the field, Japanese beetle resistance is only expressed in conditions of extreme drought and heat. But evaluating these natural infestations is complicated by the very uneven distribution of insects within plots which would tend to mask small treatment effects. To solve this difficulty we performed a series of experiments where we introduced larvae into confined enclosures within the turf varieties.

CONFINED STUDIES

For three seasons at URI and two summers at UMass we have confined Japanese beetle grubs in plots of endophytic and non-endophytic grasses in a range of insect densities (up to 120 grubs/sq ft). Some of these tests were conducted under rain-out shelters under conditions of moderate drought stress. We also brought grubs into the greenhouse in the fall where they were confined on grasses grown and maintained in the greenhouse and on grass plugs removed from our field plots. These experiments have resulted in some of the most confusing data I have ever seen.

Generally, the field tests do not show significant differences in survival or weight gain of grubs confined on endophytic grasses relative to their non-endophytic counterparts. However, in a few cases we did get significant results. Last summer at the Amherst, Mass. site Jennifer Nobel found survival on *PE7* tall fescue to average about 30% higher than on *Shenandoah*, its endophytic counterpart. This statistically significant difference was backed up by greater larval weight gain and increased root damage on the non-endophytic grass. Unfortunately, at URI, using the same grasses and even grubs from the same collection we got the opposite results: grubs survived slightly better on the endophytic grass.

This was not the only time we saw higher survival of Japanese beetle grubs confined on endophytic tall fescue. In one case where we brought grubs and field plugs into the greenhouse for the fall, we found 2.5 times higher survival in the presence of the endophyte. However, at the same time we confined the same larvae on greenhouse-grown plants and found 10 times less survival on the endophytic tall fescue.

CONCLUSIONS

So we're beginning to narrow this down. **Endophytic tall fescue either increases grub survival, decreases it, or has no effect at all.** Actually, I think that depending upon environmental conditions, it may do all of the above. Clearly, germinating seedlings are resistant to grubs, but that's of limited practical consequence. Among established stands it appears that Japanese beetle resistance is only expressed in conditions of extreme drought and/or heat. This explains the resistance seen in New Jersey last summer, in the greenhouse-grown plants at URI, and the rain-out experiment at Amherst (where the plants were apparently considerably warmer and drier than at the URI test). This explanation is consistent with the observations that Jane Breen made while at

Rutgers, that increased temperatures resulted in increased growth of endophytes and the chemicals associated with their resistance in tall fescue and perennial ryegrass. She felt that the optimal temperatures for endophytes in tall fescue is in the range of 77-85F.

Under the normal (near ideal) growing conditions experienced in our research plots at URI and in Amherst, these plants are either producing less of the loline alkaloids associated with endophytes in tall fescue, or these chemicals are leaving the root zone. Under conditions of slight to moderate drought stress, perhaps low levels of alkaloids are stimulating feeding activity and increasing survival by the grubs (Clay and Cheplick noticed such a response in fall armyworms). Or perhaps because the endophytic plants are performing better under moderate stress, the insects feeding upon them are also doing better. I think we'll be a while sorting this out - if we ever do!

From a purely practical perspective, we'd have to say that presently available endophytic tall fescues do not have a useful level of resistance to Japanese beetles. Few turf managers would choose to expose tall fescue to the extreme heat and drought which apparently is necessary to get measurable levels of resistance. There is hope that in the future turf breeders will develop endophytic tall fescues (and maybe other grasses) which produce high enough levels of loline alkaloid to provide Japanese beetle control under good growing conditions.

An interesting sidelight to our observations at URI is that we saw no visible damage in tall fescue plots that had very impressive numbers of white grubs - in many cases exceeding 40 grubs per square foot. In experiments where we introduced enormous numbers of grubs into test plots, we found that the grub densities appear to be self-limiting: they apparently kill each other if overcrowded. Based upon our research and the observations of colleagues, I think we will rarely, if ever, get visible damage from Japanese beetle grubs on tall fescue. Under good growing conditions, and even under moderate stress, the plants apparently outgrow the root feeding. Of course, we may produce a whole lot more adult beetles than we would like - and they're a decent pest also, but the turf should look good. We don't have enough experience to draw any conclusions yet about the skunk damage that is often associated with high white grub densities, but so far the skunks haven't damaged our tall fescue plots - perhaps because it doesn't roll back in the same way as our nearby plots of Kentucky bluegrass and bentgrasses.

RECOMMENDATIONS

If you're looking to control Japanese beetles with endophytes, have a word with the turf breeders and then be patient. I don't think it's going to happen for several years. I'd still use endophytic grasses where possible because of the control potential they offer for the other insect pests. In our area only about 1 lawn in 6 shows any damage from white grubs in a given year. If you don't want to experience this damage or treat to prevent it, then you may want to consider using endophytic tall fescue because of its ability to out-grow white grub feeding damage. Perhaps this will give the white grub's natural enemies (parasites, diseases, and nematodes) a chance to provide control.

R.A. Casagrande
University of Rhode Island

COMMON LAWN BROADLEAF WEED CONTROL WITH PHENOXY AND NON-PHENOXY HERBICIDES

In any successful golf course or landscape management operation, weed control is a key component. A successful management program for turfgrass results from an integration of cultural practices and an effective weed control program. Producing a dense, healthy stand of turfgrass is one way to control annual weeds. The proper mowing height and frequency, fertilization, irrigation, as well as insect and disease control all are part of the management program and should be practiced throughout the growing season.

Regardless of the type of turf one manages, it is important to understand weed control principles, so that the decisions one makes are economically and environmentally sound. At the same time, however, these decisions must produce good results. To conduct a successful weed control program turfgrass managers should: a) know the specific problem weeds and their life cycles (grassy vs broadleaf; annual vs perennial);

and, b) select the most effective herbicide. The purpose of this article is to provide an overview on postemergence herbicides used for broadleaf weed control in cool-season turfgrass.

Broadleaf weeds are, in general, difficult to control primarily because of mixed populations of various species. These species represent annuals, perennials and biennials. Some of the commonly found broadleaf weeds in lawns in Massachusetts are black medic, chickweeds, clovers, dandelions, plantains, heal-all, henbit, hop clover, ground ivy, spurge, knotweed, yellow wood sorrel and red sorrel.

CONTROL WITH PHENOXY COMPOUNDS

What are phenoxy compounds? The most commonly used herbicides to control broadleaf weeds are 2,4-D, mecoprop (MCPP), dichlorprop (2,4-DP), and dicamba. These are phenoxy herbicides with the exception of dicamba. Phenoxy herbicides are characterized by a unique chemistry involving a phenyl ring attached to an oxygen molecule which in turn is attached to an aliphatic acid. Some of the other examples are MCPA and 2,4-DB. The commonly used herbicide products are listed in Table 1.

Table 1. Commonly used broadleaf herbicide mixtures and the ratio of each product in the mixtures for postemergence weed control.

Herbicides	Trade Name	Ratio	Manufacturer
2,4-D + MCPP	2 plus 2	1:1	Fermenta
	Lescopar	1:2	Lesco
	2,4-D-MCPP	2:1	Cleary's
2,4-D + 2,4-DP	Chipco Weedone DPC Ester	1:1	Rhone-Poulenc
	Chipco Weedone DPC Amine	1:1	Rhone-Poulenc
	Turf D + DP Ester	1:1	Riverdale
2,4-D + dicamba	Eight-one selective herbicide	8:1	Lesco
	Riverdale 81 selective weed killer	8:1	Riverdale
	Riverdale 101 weed killer	10:1	
2,4-D + 2,4-D +MCPP	Weedestroy Triamine	1:1:1	Riverdale
	Weedestroy Triester	1:1:2	Riverdale
MCPA + MCPP + 2,4-D	Weedestroy Triamine II	1:1:1	Riverdale
2,4-D + MCPP + dicamba	Three way selective herbicide	1:0.5:0.009	Lesco
	Trimec classic	1:0.5:0.1	Gordons
	Bentgrass selective	0.5:1.5:0.2	Lesco
	Triplet	2.44:1.3:0.22	Riverdale
2,4-D + triclopyr	Turflon D Ester	2:1	Dow
	Turflon II Amine	2.6:1	Dow

Importance of 2,4-D. Of the above mentioned materials, 2,4-D is the most widely used for broadleaf weed control. It controls many of the common lawn broadleaf weeds but does not provide good control for certain weeds such as chickweed, heal-all, and black medic. Fortunately, the other herbicides mentioned will control many weeds tolerant to 2,4-D. Since some weeds are tolerant to each of the herbicides when used alone, a commonly accepted practice has been to use combinations of two or more herbicides. The combination of 2,4-D, mecoprop, and dicamba (TRIMEC) is widely used. This combination is effective on almost all species of commonly found lawn weeds. Other combinations such as 2,4-D plus mecoprop, 2,4-D plus dicamba, and 2,4-D plus dichlorprop (2,4-DP) are also effective.

CONTROL WITH NON-PHENOXY COMPOUNDS
There are several products that do not contain 2,4-D (Table 2). Therefore, we can refer to them as non-phenoxy compounds. Non-phenoxy compounds do not have a phenyl ring. These products give broad spectrum broadleaf weed control. Chlorflurenol (BREAKTHRU), clopyralid (LONTREL), dicamba (BANVEL), and triclopyr (TURFLON) are examples of non-phenoxy compounds.

Chlorflurenol (BREAKTHRU) is recommended for broadleaf weed control in turf. It controls black medic, chickweed, clovers, cudweed, dandelions and other easy-to-kill weed species. For the control of more difficult-to-kill weed species such as oxalis, ground ivy, knotweed and wild carrot, chlorflurenol can be used in combination with other turfgrass herbicides. These include dicamba, triclopyr and others.

Dicamba (BANVEL) can be used for broad spectrum weed control including weed species such as butttercup, carpetweed, chickweeds, clovers, dandelions, ground ivy, hawkweeds, henbit, knotweed, red sorrel, spurges, wild carrot, oxalis and many other species.
In general, dicamba is more effective when used in combinations rather than alone.

Triclopyr (TURFLON) is effective against several difficult-to-kill weeds. The combination of 2,4-D and triclopyr (TURFLON D) is gaining wide acceptance in broadleaf weed control. The combination treatment will provide a broad-spectrum control of lawn weeds such as black medic, buttercup, chickweeds, clovers, dandelion, ground ivy, henbit, hop clover, oxalis, spurge, wild carrot and others.

Clopyralid (LONTREL) is effective in controlling dandelion, clovers, pineappleweed, Canada thistle, groundsel, smartweed, and ox-eye daisy.

Table 2. Trade name, common name,formulation, and use rates of herbicide combinations without 2,4-D for broadleaf weed control in turfgrass.

Trade name	Common name	Formulation pounds/gallon	Use rate Oz/1000sq	Pints/acre
CONFRONT (Amine)	Triclopyr + Clopyralid	3.0 EC	0.37	1
WEEDSTROY MCPP-4	MCPP	3.97 S	1 to 1.5	2.25
TRIMEC ENCORE	MCPA + MCPP + Dicamba	3.75 EC	1.2 TO 1.5	3 TO 4

Table 3. Suggested treatments for hard-to-control broadleaf weeds.

Weeds	Trade Name	Comments
Ground ivy (Glachoma hederacea)	Turflon D Super Trimec Weedone DPC	Very difficult to control in summer. Fall application is desirable.
Prostrate knotweed (Polygonum aviculare)	Same as ground ivy	Diffcult to control in summer.
Creeping speedwell (Veronica filliformis)	Turflon D Weedone DPC Trimec	Difficult to control. There are several other species which are hard to control.
Spurge (Euphorbia supina)	Turflon D Trimec Weedone DPC	Spring or summer application is desirable.
Wild violets (Viola supp.)	Turflon Turflon D Turflon II Weedone DPC Trimec	Very difficult to control; usually requires follow-up application 1 to 4 weeks after first application.
Yellow woodsorrel (Oxalis stricta)	Turflon D Super Trimec	Spring applications of preemergence herbicides.

Hard-to-Control Perennials

In general, most hard-to-control weeds such as wild violet, woodsorrel, and ground ivy, are perennials. Perennials have extensive root systems. For effective control, these root systems must be killed. In order for an herbicide to be effective, it must enter and then move throughout the plant. Some weed species absorb herbicides rapidly, while others absorb slowly. The primary route of entry of postemergence herbicides is directly through the leaf surface. Therefore, it is important to have good coverage of the weeds, regardless of their growth stage.

For post-emergence control, mixtures of two to three herbicides are commonly used because they are more effective than any single herbicide in controlling hard-to-control weeds. Several products are suggested for use in controlling some of the hard-to-control weeds (Table 3).

Timing and Application Directions

Timing is very important for postemergence control of broadleaf weeds. If application timing does not coincide with the growth stage which is most susceptible to herbicide treatment, control results may be erratic or poor. In general, the best time to treat is early fall or mid-spring. Time of application of these treatments may vary depending the species and their life cycle **(consult the 1992 Massachusetts Professional Turfgrass Management Guide, available from the editor of this newsletter - see last page).**

A spring application of a product containing two or three herbicides is a standard treatment for broadleaf weed control. However, post-emergence herbicides can also be applied in the fall for certain weed species, such as ground ivy, hawkweed, plantain, wild strawberry, thistles. The fall-applied treatment also controls many

seedlings of winter annuals which germinate in late August or early September. Common chickweed, corn speedwell, and henbit are among the many winter annuals. Repeat applications, if necessary, should be made four weeks apart to minimize turfgrass injury.

Ester vs amine formulations

Choose the formulation of a product that is best suited to your needs. Ester and amine formulations have different activity due to different properties. Amines are soluble in water, while esters are oil soluble. Esters are generally better products in controlling weeds than the corresponding amine products. Esters tend to penetrate into the leaf better than amines. However, esters are slightly volatile. This volatility loss can result in injury to non-target susceptible plants in the landscape. Avoid using during hot weather.

Apply recommended use rate of herbicide(s) in enough water to make 50 to 150 gallons of total spray per acre to control broadleaf weeds. Most of these products can safely be used in tall fescue, bluegrass, or perennial ryegrass turf.

Dr. Prasanta Bhowmik
University of Massachusetts

MINIMIZING PESTICIDE DRIFT AND VOLATILITY FROM TURFGRASS AREAS

Drift and volatilization are two routes a pesticide can take to neighboring properties. Common sense and proper application methods can minimize and even eliminate movement by these means.

DRIFT

Drift occurs when wind blows pesticides off target. Spray droplets or dry particles can drift, and any application producing fine spray, mist or dust has the potential to drift.

Drift poses a problem because it not only reduces the uniformity of the pesticide treatment, but more importantly, it may injure non-target plant materials or other organisms. Drift from post-emergence herbicides such as 2,4-D, dicamba and glyphosate can significantly damage nearby ornamentals.

There has been little research on drift from turf pesticide applications. However, agricultural research indicates that when farmers use proper application methods, chemical drift to non-target areas can be one percent or less. Following a few basic guidelines can minimize the potential for chemicals to drift from treated areas. The most important precaution is to avoid making spray applications when wind speed exceeds 4 to 5 miles per hour. Because of time constraints and the cost of rescheduling, this may be more of a problem for lawn care companies and custom applicators than for golf courses or parks.

The application equipment you use also affects potential drift through its influence on droplet size. Mist blowers or aerial spray equipment create extremely fine sprays. Fortunately, turf managers seldom use these types of sprayers.

Most sprayers for turfgrass applications operate at low pressure and produce large spray droplets which are much less likely to drift. Before spraying, you need to be sure that the equipment is operating at the correct pressure, or misting may occur. The operating pressure at the nozzle for boom sprayers with standard flat fan nozzles should be 20 to 50 psi. Pressures between 20 and 30 psi will cause medium sized droplets to form, giving adequate coverage with little drift potential.

Be sure to determine spray pressure at the nozzle rather than at the tank. Pressure is lost by friction as the spray solution travels through hoses, valves and other system components. One way to measure pressure at the nozzle is to temporarily replace a nozzle with a pressure gauge.

The boom's height above the turf surface can influence drift potential. The air near the surface is relatively calm, but it picks up speed and turbulence as it moves higher above the surface. The closer the boom is to the ground, the less wind there is to blow the spray. Set spray booms no more than 18 to 20 inches above the turf. At this height, there will be proper coverage.

Though we are most concerned about drift from liquids, remember that granular materials can also drift. Wind can blow fine particles or dust into nearby ornamental beds. Chemicals drift more easily from rotary than from drop spreaders.

August 19, 1992. University of Rhode Island Annual Turfgrass Field Day, URI Research Farm, Kingston, RI. Exhibits: 8 am to noon; research plot tour: 1:30 to 4 pm. There will also be a special ceremony honoring the university's centennial. A steak lunch will be available. Contact Dr. Noel Jackson at 401-792-2932 or Dr. Bridget Ruemmele at 401-792-2481 or write to either at the Department of Plant Sciences, Woodward Hall, URI, Kingston, RI 02881.

September 20, 1992. URI Green Share Field Day & Trade Show, 10 am to 4 pm. The goal of this Field Day is to bring URI faculty, Cooperative Extension Education Center staff, Green Share Garden Centers and the general public together with vendors of gardening products and non-profit groups for an informative and educational day. Demonstrations, tours and other activities will be available. The New England Sod Producers will answer questions about turf and display some endophytic varieties. Contact: Susan Sanders (401) 792-2900.

November 16-19, 1992
The Professional Lawn Care Association of America's (PLCAA) 13th Annual Conference Indianapolis, Indiana. Contact: PLCAA Conference, 1000 Johnson Ferry Road, NE Suite C-135, Marietta, GA 30068-2112.

February 3-4, 1993. New England Grows, Hynes Convention Center, Boston, MA. Contact: New England Grows, 200 H Linden Street, Box 290 Wellesly, MA 02181, (617) 431-1622.

March 1, 2, 3, 1993 (Monday, Tuesday, Wednesday) Massachusetts Turf Conference and Industrial Show, Springfield Civic Center Springfield, MA. Contact: Mass. Turf & Lawn Grass Assoc., P.O. Box 489, Hadley, MA 01035, (413) 549-5295; or, Mary Owen, UMass Cooperative Extension System, 812 Millbury Street, Worcester, MA 01607, (508) 831-1225.

ERRATA

Please note that in the April/May edition of Turf Notes, the phone number for Karen Idoine, Cooperative Extension Regional Nursery and Landscape Specialist was listed incorrectly. Karen can be reached at (413) 545-4768.

RABIES EXPECTED TO APPEAR IN MASSACHUSETTS IN EARLY 1992

A mid-Atlantic strain of rabies carried by raccoons is expected to enter Massachusetts in 1992, according to the state Department of Food and Agriculture's Division of Animal Health. There were some 200 cases of raccoon rabies in western Connecticut and almost 400 in New York state last year.

In an advisory issued recently, Mabel Owen, state Director of Animal Health, notified cities and towns that all dogs must be licensed and strongly recommended that cats also be vaccinated. According to Massachusetts state law, all dogs, six months or older, must be licensed. Proof of rabies vaccination must be provided before a license will be issued.

Rabies vaccination in dogs and cats usually begins before the age of six months, is repeated one year later, and then again at one to three year intervals depending on the vaccine used.

"Every traditional method of rabies protection must be complied with fully", Owen stated. "A thoroughly vaccinated dog population will provide a buffer between infected wildlife and people." Rabies in humans is a fatal disease.

Officials recommend discouraging wildlife, particularly bats, skunks, raccoons and foxes, from harboring in or near your home by closing off any openings through which they could enter and by not leaving pet food outdoors.

Experts also advise against attempting to feed or handle any wild animal, especially those behaving abnormally, and suggest warning children against approaching wild animals. Abnormal behavior may include a nocturnal animal abroad in daylight, a wild animal acting docile or disoriented, or a wild animal showing aggressive behavior toward other animals or people. Anyone observing such behavior in a wild animal should try to keep the animal within sight and call their city or town animal control officer. Do not attempt to catch or handle the animal yourself.

Some cities and towns will be conducting vaccination clinics offering low-cost inoculations. For more information contact the Division

of Animal Health at 617-727-3018, extensions 165 or 162, your town clerk's office or your local board of health.
[Ed. note: I have a Massachusetts Department of Public Health fact sheet on Rabies which I will be happy to copy and send to anyone upon request. Call (508)831-1225 and ask for the rabies fact sheet from Mary Owen.]

TURF NOTES

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TURF NOTES
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TURF NOTES

A newsletter for professional turf and grounds managers, written and produced by the University of Massachusetts and the University of Rhode Island Cooperative Extension Systems.

IN THIS ISSUE

SUSTAINABLE TREES AND SHRUBS FOR SOUTHERN NEW ENGLAND

Prepared by:

Richard A. Casagrande, Brian K. Maynard, Roberta A. Clark, Susan H. Gordon, Kenneth Lagerquist, William A. Green and Angelo E. Simeoni, Jr.

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Clem Desjardins	Arborscape, Providence, RI
Glenn Dreyer	Connecticut College Arboretum, New London, CT
Larry Englander	University of Rhode Island, Kingston, RI
Richard Gagne	Gem Evergreen Co., Hooksett, NH
Lisa Gould	RI Wild Plant Society
Robert Gouveia	Jackson Nurseries, MA
Tom Green	The Morton Arboretum, IL
James Hallene	Prides Corner Farm, Inc., Lebanon, CT
Noel Jackson	University of Rhode Island, Kingston, RI
Warren Johnson	Cornell University, Ithaca, NY
Todd Kennedy	The Kennedy Nurseries, Greenwich, CT
David Kmez	Windy-Lo Nursery, Inc., Northboro, MA
Gary Koller	The Arnold Arboretum, Jamaica Plain, MA
John McGuire	University of Rhode Island, Kingston, RI
Wayne Mezzitt	Weston Nurseries, MA
Steve Pagliarini	Central Nurseries, Inc., Johnston, RI
Barbara Petrarca	RIDOT, Providence, RI
Charlotte Smith	Sylvan Nursery, Westport, MA
Deborah Swanson	UMass CE, MA
Floyd Swink	The Morton Arboretum, IL
Bruce Vanicek	The Rhode Island Nurseries

Univerisity of Rhode Island and University of Massachusetts
COOPERATIVE EXTENSION SYSTEMS

The University of Rhode Island, University of Massachusetts, and the United States Department of Agriculture cooperating. The Universities of Rhode Island and Massachusetts offer affirmative action and equal opportunity in programs and employment.

Sustainable Trees and Shrubs for Southern New England

INDEX **PAGES**

AN INTRODUCTION TO THE SUSTAINABLE PLANT LIST

Plant lists are invaluable resources for garden enthusiasts, designers, nursery trades people and landscape architects. We constantly consult books and nursery catalogs which list landscape plants, especially those that organize plants by their characteristics and landscape uses. As times and fashions change, new plants emerge, old plants are rediscovered, and others lose favor and disappear from these lists. But one point remains clear: listing plants encourages their widespread distribution and use. The purpose of this publication is to encourage the production and use of landscape plants that are more sustainable: those which require reduced inputs of pesticides, water, and maintenance and are not invasive.

Why Sustainable?

Not long ago, plants from around the world could be introduced into the landscape and provided with the care needed to ensure their long-term beauty and success. Pesticide use was widespread and its effectiveness unquestioned, labor for intensive care was available and affordable, and the supply of natural resources was considered limitless. Much has changed in recent decades and we have become painfully aware of the limits of our natural resources and the precarious balance of nature in which we play a pivotal role. Many in our society are looking for ways to reduce our impacts on the environment. Others lack the time or resources to manage pests or maintain shrubs that require frequent pruning or irrigation. These people should find the sustainable plant list an invaluable resource. Careful plant selection is the key first step in developing a balanced and self-perpetuating landscape. However, plant survival with minimal maintenance is not the only issue in sustainability. We are having increased difficulties with invasive exotic plants which have escaped from managed landscapes, displacing native plants and disrupting natural ecosystems. Use of these potential invasives cannot be seen as sustainable except in very controlled situations.

This list of sustainable plants is not offered as the entire answer. Proper siting and planting also is necessary for a plant to prosper in the landscape. Therefore, climatic conditions, exposure to sun and wind, subsurface soil and moisture conditions, etc. must be considered when selecting

plants for a particular location. Sustainable or not, if one ignores the site and a plant's cultural requirements, that plant will suffer.

A List for Professionals

In preparing this list and the accompanying plant descriptions, we have targeted a professional audience with an expectation that through time, as these plants become more available, this information will filter down to the consumers. To maximize distribution and facilitate revisions, we have kept the price of this publication low by avoiding illustrations. Plants on this list are proven performers in Southern New England (USDA Hardiness Zones 7a - 5b) and many of them can be grown both north and south of here (although the pest complexes might change). This list is dynamic - presently in its third revision, and it will continue to change as new plants and pests are introduced and we learn more about existing ones.

The list is only a guide. Plants are included on this list which have qualities appealing to designers and plant lovers alike. Plant descriptions include color, form, texture, and growth habits as well as maintenance requirements and hardiness. Many of the plants on the list are well known and currently under production while others need to be grown and distributed more. We are well aware that it will take a decade or more before some of the newer plants are readily available in the trade.

Many of our favorite plants are not on the list because serious pests threaten their existence or their maintenance requirements are too high for them to be considered sustainable. That doesn't mean that we won't include a few of them in our landscapes. Life would be dull, indeed without a rose, but none of us would want to maintain a half-acre of them. Plants with occasional pest problems or those with relatively minor problems are included on the list with cautionary notes. It is only those plants with life-threatening or chronic pest problems that are omitted from the list, along with seriously invasive species. The list is not intended to eliminate the production of high maintenance plants with desirable traits. Instead, it is intended to encourage the broader distribution of plants which seem to be better suited to satisfying not only our horticultural requirements, but also our environmental concerns.

Native Plants

There is renewed interest in native plants (those found growing outside of cultivation in this region during pre-Colonial times), which often are better acclimated, less pest prone, and more favorable for native wildlife than exotic plants. Native plants are identified in Appendix 2. However, it should be noted that many exotic insect and disease pests have been introduced in the past 300 years. They have virtually eliminated some of our native plants and become serious pests of others. In these cases it is useful to look to other parts of the world where plants have evolved resistance to these pests. Even without introduced pests, some native plants have problems in our landscapes where they are far removed from their natural environments. A fabulous forest shrub can have serious difficulties when sited between a driveway and a sidewalk. It is likely that a sustainable landscape will feature many native plants, but we think there are many non-natives which should be considered as well.

PLANTING FOR SUSTAINABLE LANDSCAPES

INTRODUCTION

Giving plants a healthy start begins with proper planting. Problems showing up on established plants more often than not can be traced back to poor planting. Traditional ways of planting are often passed down through generations of landscapers. While some of the old ways are still recommended today, many planting practices are changing to reflect current research and technology. Well-informed landscapers and arborists should be aware of the latest planting and transplanting techniques. The objective of this chapter is to have you learn the techniques and procedures used to plant and transplant trees and shrubs, and to have you understand how the use of proper planting techniques can improve survival and accelerate establishment.

SELECTING AND PURCHASING PLANTS

The Right Plant

A key to sustainable planting is matching the plant and the conditions of the planting site. The best planting procedures known will not save a plant that is poorly suited for it's site. Plants naturally vary in their ability to tolerate site conditions such as extreme heat or cold, wet or dry soils, sun or shade. The plant also should not outgrow it's allotted space. Plants should be healthy and vigorous when planted. The condition of the roots in particular affects transplant success. The roots should be white and numerous; brown or black roots indicate a health problem.

Handling New Plants

Trees and shrubs are available from the nursery in one of three forms; bare root, balled and burlapped or container-grown. Depending upon site requirements and planting specifications, each form has its advantages and disadvantages.

Bare root plants have had the soil shaken from their roots after digging. Most bare trees and shrubs plants are purchased by mail order and planted during the dormant season, before roots and buds begin to grow. Since there is no soil on the roots, it is vital that they be kept moist, and if not planted immediately, that they be stored cold (32°-40°F), with moist packing around the roots. When planted, the roots of bare root plants should be spread evenly in the planting hole.

Container-grown plants have been grown for months or years in the container in which they are sold. Container-growing is becoming very popular in the nursery trade. Container-grown plants may be planted anytime the soil is workable, but may need special attention to correct compacted or circling roots. When selecting container-grown trees and shrubs, always check the roots. For example, not all plants purchased in containers are container-grown. Often bare root trees or shrubs are potted in containers, grown on for a short time and sold from the nursery. If they are not held for at least a year, the roots may not have established in the container. On the other hand, if plants are grown in their container for too long, the roots may have grown in circles. These roots must be separated and spread out during planting. If the roots are densely matted, the outside of the root mass should be sliced vertically with a sharp knife in a few places to help separate the roots. And unless the container is biodegradable, such as a natural peat pot, it must be removed before planting.

If properly watered and maintained, container-grown trees can be planted any time of the year. Early fall planting is especially advantageous because the roots can begin to establish before the plant goes dormant for winter. Early spring, before bud break, is also a good time to plant because the roots begin to grow immediately, and light, temperature and soil moisture levels are optimal. Perhaps the most important factor in successfully transplanting container-grown trees is maintaining adequate soil moisture, which encourages roots to grow into the surrounding soil.

Many trees and shrubs are dug in the nursery with root balls intact, and wrapped with burlap. Be aware that as much as 95% of the absorbing roots can be lost in digging, though some roots are preserved in the root ball. When selecting a balled and burlapped plant be sure the ball is solid, with little or no movement of the trunk. The burlap used to wrap the root ball holds the soil ball together and keeps the roots from drying out. Natural fiber burlap is biodegradable, and may be left in the hole, though it should be rolled back and completely covered with soil. Some nurseries use treated burlap or synthetic burlap, this should be removed at planting. All twine or rope holding the burlap together or tied around the trunk must be removed to avoid girdling. Some larger balled and burlapped trees come in wire baskets that keep the ball together during handling. Although the baskets do not have to be removed, it is best to cut the upper rows when planting. This eliminates interference with rakes or lawn mowers if the tree is planted shallow, and allows roots to grow and spread freely near the surface.

PLANTING

The Planting Hole

Installing trees and shrubs properly involves more than just digging holes and setting in plants. The quality of the planting hole will determine the long term health of the root system, and thereby the entire plant. In general, the planting hole should be at least 18 to 24 inches wider in diameter than the root ball. If the soil is compacted, or of poor quality, the hole should be even larger - 3 to 5 times the width of the root ball. The hole should be wider at the top than the bottom, with sloped walls, because most of the root growth will be shallow and horizontal. Planting too deeply can stress the plant and drown or suffocate the roots. The easiest way to avoid this is never to dig the hole deeper than the root ball. Soft fill should not be left in the bottom of the hole, as the root ball will settle and be planted too deep. In almost all types of soil, the tree should be planted slightly shallow, with the top 2-4 inches of the root ball sitting above the surrounding soil grade. Remember, the exposed portion of the root ball will be covered with 2-3 inches of mulch by the time you are finished planting.

Drainage is also an important consideration in successful planting. Poor drainage kills more plants than any other cause. A poorly prepared planting hole may act as a dish and hold water, especially in clay soils. Oxygen levels are low in the bottom of such holes, and not conducive to healthy root growth. Do not put gravel in the bottom of the planting hole; it does not aid drainage.

The Root Ball

Handle roots carefully during planting - small absorbing roots are easily broken. Check balled and burlapped plants to ensure the roots originate near the surface of the ball. When setting the plant in the hole, make sure these roots are no deeper than the soil grade.

Backfilling

In most cases it is best to backfill the hole with the same soil that came out of the hole. Research has shown that soil amendments do not improve plant establishment or growth. However, if the natural soil is extremely poor, topsoil may be the only alternative. Strive to match the backfill soil type to the soil type of the site, as closely as possible. Backfilling with a sandy loam in heavy clay soils may cause the planting hole to collect water and suffocate the roots. If soil must be brought to the site, or the backfill must be amended, the hole should be extra wide. This will allow for several years growth within the new soil. While backfilling, work the soil around the ball so that no air pockets remain. Large pockets of air can allow roots to dry out. Firm the soil so that the plant is vertical and adequately supported, but do not pack the soil. Water thoroughly while backfilling. The remaining soil should be mounded into a berm, on the outer edge of the hole, to collect water over the root zone, especially on sloped sites. Remove all tags or labels so that they will not girdle the trunk or branches as the plant grows.

Mulching

After filling the planting basin with water and letting it drain, fill the basin with 2 to 3 inches of an organic mulch. This will conserve soil moisture, moderate soil temperature extremes and reduce competition from weeds and turf. Many organic mulches, such as pine needles, bark or wood chips, are fine. Make certain the mulch is not touching the plant stem, as this could promote bark decay, crown rot, winter injury and rodent damage. Do not use black plastic or landscape fabric under the mulch, since these materials, sooner or later, restrict water movement and oxygen availability to the roots.

Water and Fertilizer

Planting is a major operation from which most trees and shrubs recover slowly. A major portion of the root system is lost in digging, and the plant must reestablish sufficient roots to sustain itself. In this time, the plant's ability to obtain and transport water and minerals is greatly reduced. The result are varying degrees of water stress and transplant shock. For this reason, proper watering is a key to the survival of newly planted trees and shrubs. If rainfall is not sufficient (generally 1 inch/week), the tree should be watered every five to seven days. A slow gentle soaking of the root zone is preferable. Your watering patterns should be appropriate for the soil type and drainage - remember that excess water in the planting hole is a leading cause of transplant death.

Since the root system functions of a newly planted tree are limited, fertilization often is not recommended at the time of planting. Excessive fertilizer in the root zone can be damaging, so do not add fertilizer to the backfill. If fertilizer must be used at planting or in the first growing season, apply a controlled-release fertilizer or liquid feed. Fertilizing in the fall, when the roots are active, can be beneficial. However, most plants received from the nursery require no fertilizer in the first year of establishment.

Pruning

Plants grow and establish fastest if pruning is minimized at planting. Beyond the removal of broken or damaged branches, it is usually best to avoid heavy pruning.

Staking and Guying

Most shrubs do not need to be supported after planting. In general, trees under 8 feet in height do not need support either. In fact, staking can have detrimental effects on the development of trunk taper and root growth. Too often, staking materials end up injuring or girdling the tree.

Trees may be supported by up to three stakes. If a single stake is used, it should be placed on the upwind side of the tree. The material used to attach the tree to the stake should be broad, smooth and somewhat elastic. The tree may be attached to the stake at several points along the trunk. However, do not stake the tree too rigidly, as the tree will develop a less sturdy root system and be more subject to girdling. If two support stakes are used, a single, flexible tie attached to the tops of the stakes will be sufficient. Triple staking provides more protection against strong wind and lawn mowers. Support stakes and guy wires generally should be removed after one growing season. If staking is left in place for more than two years the tree's ability to stand alone may be reduced, and the chances of girdling injury are increased.

Based on information found in the International Society for Arboriculture Arborist's Certification Study Guide, the Penn State University Master Gardener Manual, and Arboriculture: Integrated Management of Landscape Trees, Shrubs, and Vines, by Richard W. Harris.

INDEX OF COMMON NAMES

INDEX OF COMMON NAMES (ctd)

INDEX OF COMMON NAMES (ctd)

SUSTAINABLE TREES AND SHRUBS FOR SOUTHERN NEW ENGLAND

Abies cilicica **Cilician Fir** **zone 5-7** **60-70' x 20-30'**

Tolerates heavy clay soils, cold temperatures.

Abies concolor **White Fir** **zone 4-7** **30-50' x 15-30'**

Moist, well drained, sandy-gravelly loams, tolerates heat, drought, cold, intolerant of wet soils. Full sun preferred. Blue-gray needle color, gray to purple upright cones.

Abies homolepis **Nikko Fir** **zone 5-6** **30-50' x 20-30'**

Moist, well drained soil, pH adaptable, little maintenance required.

Acanthopanax sieboldianus **Fiveleaf Aralia** **zone 4-8** **8-10' x 8-10'**

Easily transplanted, withstands adverse conditions, tolerates dry soils, urban tolerant, tolerates clay-sand-acid soils, sun-shade. Suckers readily: may be maintenance problem if not sited correctly and allowed ample room; thorny.

Acer buergerianum **Trident Maple** **zone 6-8** **20-25' x equal spread**

Well drained, acid soil; good drought resistance, full sun. Good under utility lines. Attractive bark on mature specimens.

Acer campestre **Hedge Maple** **zone 5-8** **25-35' x equal spread**

Adaptable species, prefers average garden soils but tolerates dry conditions and compaction, acid-alkaline, sun-light shade, withstands shearing. Good under utility lines.

Acer ginnala **Amur Maple** **zone 2-8** **15-25' x equal spread**

Moist, well drained soils but adaptable to wide range of conditions, sun-shade, tolerates shearing. Usually multi-stemmed but can be purchased as a single stemmed specimen; can also be grown as a container specimen. Good under utility lines. Potentially invasive.

Acer griseum **Paperbark Maple** **zone 5-8** **20-30' x equal spread**

Full sun-partial shade, moist well drained soils. Relatively maintenance free. Outstanding cinnamon colored exfoliating bark and red-scarlet fall foliage offer year round interest in the landscape. Slow growing.

Acer palmatum **Japanese Maple** **zone 5-8** **15-25' x variable**

Moist, well drained soils high in organic matter, full sun to dappled shade, dissectum types scorch in full sun if drought stressed. Sited properly, this is an excellent low maintenance plant. Red leaf forms seem to be somewhat more hardy and stress tolerant than the green leaf forms.

Acer pseudoplatanus **Sycamore Maple** **zone 4-7** **40-60' x equal spread**

Adaptable to soil types, very salt and wind tolerant, excellent for coastal areas, full sun-light shade. Coarse textured dark green leaves with no fall color. Several improved cultivars available. Potentially invasive.

Acer rubrum **Swamp/Red Maple** **zone 3-9 40-60' x equal spread**

Tolerates most soils but prefers moist, acid conditions, excellent for wet conditions. An important tree for urban landscapes; in full sun it will develop clear red fall foliage; many excellent cultivars available, e.g. 'October Glory', 'Red Sunset'.

Acer tataricum **Tatarian Maple** **zone 3-8 20' x equal spread**

Adaptable to a wide range of conditions, drought tolerant once established, sun-light shade. Similar to *A. ginnala* in attributes.

Acer triflorum **Three-flowered Maple** **zone 5-7 20-30' x equal spread**

Moist, acid soils, full sun-partial shade. A good small tree with exfoliating bark, the trifoliate leaves develop a warm yellow to red color in the fall. Good for many different landscape uses.

Aesculus parviflora **Bottlebrush Buckeye** **zone 4-8 8-12' x 8-15'**

Moist, well drained soil with high organic matter, drought intolerant, pH adaptable, prefers acid, sun-shade. Large white flowers are formed in July, overall growth habit is clumping, as it suckers readily from the base. Good yellow fall color.

Aesculus pavia **Red Buckeye** **zone 5-8 20/25' x equal spread**

Moist, well drained soils, full sun/light shade, red flowers in 4"- 8" panicles in mid spring. Dark green leaves with no appreciable fall color; early fall abscission. Less prone to leaf scorch than *A. hippocastanum* but subject to blotch. Variability in flower color in the species, 'Atrosanguinea' has consistent deep red flowers.

Alnus incana **White Alder** **zone 3-6 40/60' x 20/40'**
A. glutinosa **Common or Black Alder**

Moist to wet soils, full sun/light shade, pH tolerant, does well on infertile sites as it fixes nitrogen. Several cultivars available, including 'Aurea' with yellow leaves and 'Laciniata', a bright green cut-leaf form. Especially useful for wet or naturalized areas. *Alnus rugosa* (Speckled Alder) is a native shrub that reaches 15/20' and is useful for wetland plantings. Somewhat invasive in the northeast.

Amelanchier arborea **Shadbush, Serviceberry** **zone 4-9 variable**
A. canadensis, A. laevis

Moist, acid soils, good for wet and-or naturalized areas, sun-shade. Newer cultivars are reported to be less subject to pest and disease pressure. Generally multi-stemmed with white flowers in early spring followed by purple-black berries in summer. Good fall foliage.

Aralia spinosa **Hercules Club** **zone 4-9 10/20' x wide**

Tolerant of adverse soil conditions, full sun/light shade, pH tolerant. Spiny stems and pinnately compound leaves that reach 64" in length. Careful siting required due to a proliferation of shoots from the base; can become an impenetrable thicket. Potentially invasive.

Arctostaphylos uva-ursi **Bearberry** **zone 2-5 6-12" x 2-4'**

Does best in poor, dry, sandy soils, difficult to transplant, full sun, acidic conditions. Should be grown as container plants. Native.

Aronia arbutifolia **Red Chokeberry** **zone 4-9** **6-10' x 3-5'**
A. melanocarpa **Black Chokeberry**

Adaptable to various soils, tolerates both wet and dry soils, sun-light shade but best fruit production in full sun. Good for massing or naturalizing. White flower clusters in spring, red berries that persist into winter. *Aronia melanocarpa* is a smaller shrub with black fruit.

Aucuba japonica **Japanese Aucuba** **zone 7+** **6' x 6'**

Moist soils high in organic matter, must be planted in shade, will scorch in full sun; red berries on female plants, leathery green leaves will be evergreen in a mild winter. Variegated cultivars available.

Azalea **see *Rhododendron.***

Berberis gladwyensis **William Penn Barberry** **zone 7+** **4' x 4'**

Moist, acidic soils, full sun to light shade, transplants easily. Yellow flowers in April; dark evergreen leaves turn bronze in winter.

Berberis julianae **Wintergreen Barberry** **zone 5-8** **6/8' x 10/12'**

Tolerant of most soil conditions except wet. Full sun/light shade. Dark green spiny evergreen leaves, may show winter damage in exposed, windy locations; considered the hardiest of the evergreen barberries. Best left unpruned; makes an effective thorny hedge.

Berberis* x *mentorensis **Mentor Barberry** **zone 6-8** **5' x 5'**

Culture similar to the above; stiff, upright growth habit, dark green leathery foliage, semi-evergreen. As above, best left unpruned; an excellent hedge material.

Berberis verriculosa **Warty Barberry** **zone 6-8** **3/6' x 3'**

Culture similar to the above; leaves dark green above, whitish undersurface turning a dark purple in winter. Good compact growth, useful as hedging material, may show winter damage in exposed, windy locations.

Betula nigra **River Birch** **zone 4-9** **40-70' x 40'**

Less susceptible to leaf miner, resistant to bronze birch borer; prefers moist well drained soils but tolerates dry conditions once established. 'Heritage' is a superior cultivar with exfoliating bark that is a lighter salmon color than the species. It is a rapid grower once established in the landscape.

Callicarpa dichotoma **Purple Beautyberry** **zone 5-8** **3-4' x 3'**

Moist, well drained soils, full sun for best fruiting; should be pruned hard in late winter for best fruiting effects, may be considered a maintenance problem for this reason. Produces abundant purple berries on arching branches in the fall.

Calycanthus floridus **Carolina Allspice** **zone 5-9** **6-9' x 6-12'**

Adaptable to many soil conditions, pH adaptable, sun-shade. Produces fragrant reddish-brown flowers in late spring; a useful shrub for the border.

Carpinus betulus **European Hornbeam** **zone 4-7** **40-60' x 40'**

Tolerates wide range of soil conditions, prefers moist, well drained soils but moderately drought tolerant once established, full sun-light shade, tolerates shearing. A good landscape tree with smooth gray bark, is often used as hedging or screen; many excellent cultivars available, including fastigiate.

Carpinus caroliniana **American Hornbeam** **zone 3-9** **20-30' x equal spread**

Moist, acid soils, tolerates drier sites, partial-deep shade. Smooth gray, beech-like bark, useful as an understory tree.

Cephalotaxus harringtonia **Japanese Plum Yew** **zone 5-9** **5-10' x spreading**

Moist, well drained soil, tolerates drought once established, excellent for shade-part sun.

Cercidiphyllum japonicum **Katsura Tree** **zone 4-8** **40-60' x 20-30'**

Moist, well drained soil preferred, will need supplemental water during establishment if dry conditions occur. Tends to develop multi-stemmed character if not trained to a single trunk. Attractive opposite, heart-shaped leaves with beautiful golden to apricot fall color.

Chamaecyparis nootkatensis **Alaska-cedar** **zone 5-7** **30-45' x narrow**

Moist, well drained soil, humid atmosphere, sun. 'Pendula' is a graceful weeping form with dark green foliage.

Chamaecyparis obtusa **Hinoki Falsecypress** **zone 5-8** **varies**

Moist, well drained soil, full sun, some protection from wind. Many cultivars available.

Chamaecyparis pisifera **Sawara Falsecypress** **zone 4-8** **varies**

Moist, well drained, acid soils, full sun, tolerates wind. One of the toughest evergreens for seaside and street side locations; tends to self shade its inner branches causing the inner needles to turn brown.

Chamaecyparis thyoides **Atlantic Whitecedar** **zone 3-8** **40-50' x 10-20'**

Moist soils, full sun; found in wet and boggy areas as a native plant.

Chionanthus retusus **Chinese Fringetree** **zone 6-8** **25-30' x equal spread**

Moist, well drained soil, full sun-part shade, tolerates air pollution. Tree form with gray bark, white feathery flowers in May.

Chionanthus virginicus **White Fringetree** **zone 4-9** **12' x 20'**

Very adaptable to soil types, prefers moist, well drained, full sun. Grows very wide so careful siting of the plant is important. Fragrant creamy-white flowers in June followed by blue-black fruit in September; dioecious plants. Fruit is attractive to birds.

Cladrastis kentukea (lutea) **Yellowwood** **zone 4-8** **30-50' x 40'**

Well drained soils, alkaline conditions, tolerates acidic soils, full sun. Can be weak wooded due to narrow branching angles of major limbs. Can be sensitive to drought-heat, does not like compacted soils.

Clethra alnifolia **Sweet Pepperbush** **zone 3-9** **3-8' x 4-6'**

Dry to moist, acidic soil supplemented with organic matter, light shade-sun, salt tolerant. Generally pest free; mites may be a problem in a hot, dry location. Fragrant flowers in late summer; pink flowered cultivars are also available. Blooms best in full sun.

Clethra barbinervis **Japanese Clethra** **zone 6-8** **10-15' x 8-10'**

Prefers a soil supplemented with organic matter, considered drought intolerant, full sun-part shade. Attractive bark, fragrant, white flowers in drooping panicles in late summer.

Comptonia peregrina **Sweet Fern** **zone 2-7** **2' x 4-6'**

Well adapted to poor, dry infertile soils, full sun-light shade. Difficult to transplant, best when container grown. Somewhat invasive although slow growing. Good for naturalizing or on embankments.

Cornus kousa **Kousa Dogwood** **zone 5-8** **20-30' x equal spread**

Performs well in moist, well drained soils, does well in sandy soils supplied with organic matter, prefers sun, more drought tolerant and cold hardy than flowering dogwood, resistant to dogwood anthracnose (resistant to gypsy moth). Blooms after the foliage has emerged in June, creamy white bracts persist for several weeks; large red-orange fruit effective in the fall. Exfoliating bark on mature specimens.

Cornus mas **Cornelian-Cherry** **zone 4-8** **20-25' x 25-30'**
C. officinalis **Japanese Cornel**

Adaptable as to soil types, good drought tolerance once established, sun-light shade. One of the earliest spring flowering shrubs with yellow flowers in April, attractive bright red fruit in late summer. *C. officinalis* has reddish-brown exfoliating bark. May be sheared into hedges. Fruit of *C. mas* can be messy and attract bees.

Cornus racemosa **Gray Dogwood** **zone 4-8** **10-15' x very wide**

Adaptable to wet or dry soils, full sun -light shade. Spreads rapidly by root suckers; siting important to avoid maintenance problems. Best for naturalized areas. Most drought tolerant of the native shrub dogwoods.

***Cornus* x 'Stellar' series** **Hybrid Dogwoods** **zone 5-8** **20-25' x equal spread**

Interspecific hybrids developed at Rutgers University, show typical hybrid vigor, appear to be resistant to dogwood borer and dogwood anthracnose. Blooms between *C. florida* and *C. kousa.* Of the six cultivars, one is pink and the rest are creamy white.

Corylus colurna **Turkish Hazel** **zone 4-7** **40-50' x 12-15'**

Adaptable to adverse conditions, adaptable to pH, very drought tolerant once established. Broadly pyramidal in habit, useful as a street tree as well as landscape specimens.

Cotinus coggygria **Common Smoketree** **zone 4-8** **10-15' x 10-15'**

Prefers well drained soil but will tolerate a wide range of conditions, sun-light shade. Small five-petaled flowers are surrounded by 6"-8" pinkish hairs which impart a "smokey" appearance from late June-August. Several forms are available with differing foliage colors.

Cotinus obovatus **American Smoketree** **zone 4-8** **20-30' x 15'**

Adaptable to a wide range of soils, tolerates drought and alkaline soils, sun. Best growth is made in full sun. A small tree with outstanding fall foliage.

Cotoneaster adpressus **Creeping Cotoneaster** **zone 5-8** **1/1.5' x 4/6'**

Moist, well drained soils, full sun, drought tolerant once established, pH tolerant and adaptable to seaside conditions. Compact ground cover with glossy green leaves, white blossoms in May, red fruits effective in fall and winter. Subject to mites under hot dry conditions; also subject to Hawthorn lace bug.

Cotoneaster divaricatus **Spreading Cotoneaster** **zone 4-7** **5/6' x equal spread**

Culture similar to the above; multi-stemmed shrub with arching branches, dark green foliage with yellow to red fall color; white flowers in May with red, egg shaped fruit effective in the fall and winter. Less subject to problems than others in this genus.

Cotoneaster salicifolius **Willowleaf Cotoneaster** **zone 6-8** **10/15' x 10'**

Culture similar to the above; large evergreen shrub with arching branches, dark green foliage turns purple in winter; bright red persistent fruit effective fall through winter. Usually available as low growing cultivars such as 'Emerald Carpet', 'Repens' and 'Scarlet Leader'.

Cratageus viridis **'Winter King' Green Hawthorn** **zone 4-7** **20-25' x equal spread**

Tolerates poor soil conditions and windy sites. Less susceptible to disease-insect pressure than other hawthorns. Attractive bark and showy red fruit are good winter characteristics.

x ***Cupressocyparis leylandii*** **Leyland Cypress** **zone 7-10** **60-70' x 10-15'**

Adaptable to soil conditions, full sun required, tolerates salt spray. A vigorous grower.

Deutzia gracilis **Slender Deutzia** **zone 4-8** **2-6' x 3-4'**

Tolerates most soil conditions as long as well drained, full sun-light shade. May require pruning of dead wood in spring. White flowers in late May; 'Nikko' is a good, compact cultivar that is useful as a groundcover.

Deutzia scabra **Fuzzy Deutzia** **zone 5-7** **6/10' x 8'**

Average garden soil, full sun, pH tolerant. White flowers in late May, somewhat arching growth habit. Requires annual pruning to remove dead wood. Several cultivars available.

Diervilla sessilifolia **Dwarf Bush Honeysuckle** **zone 4-8** **3/5' x 3/5'**

Vary adaptable to soil conditions, drought and wind tolerant once established, full sun/light shade. Spreads by underground stems, will form a large mass, useful as a ground cover in rough areas.

Enkianthus campanulatus **Redvein Enkianthus** **zone 4-7** **12-15' x 5-6'**

Requires acid soil supplemented with organic matter, culture similar to *Rhododendron*, sun-light shade. Bright green, whorled leaves with variable fall color; bell-shaped creamy flowers in late May-early June. Bright scarlet fall foliage.

Eucommia ulmoides **Hardy Rubber Tree** **zone 4-7** **40-60' x equal spread**

Adaptable, drought tolerant, full sun, pH adaptable.

Evodia daniellii **Korean Evodia** **zone 6-8** **25-30' x equal spread**

Moist, well drained soils but is adaptable, tolerates drought once established, full sun. Small white flowers in flat topped clusters in mid summer; attractive to bees.

Exochorda racemosa **Pearlbush** **zone 4-8** **9-15' x equal spread**

Well drained, acid soils, full sun to light shade, drought and heat tolerant once established. Flower buds arranged like pearls along the stem, opening into five petaled, white flowers in April. Eriophyid mite damage to foliage requires occasional treatment.

Fagus sylvatica **European Beech** **zone 4-7** **50-60' x 100-120'**

Tolerates soil conditions, likes acid, well drained conditions, full sun. Shallow rooted, big for the average residential landscape but excellent for parks, golf courses, other open spaces; needs room to develop into a mature specimen. Many fine cultivars available in green and purple leaf form, weeping, cutleaf, etc.

Forsythia* x *intermedia **Border Forsythia** **zone 6-8** **8/10' x 10/12'**
F. suspensa **Weeping Forsythia**

Reasonably adapted to all soil conditions except poor drainage, full sun. Flower buds may suffer winter kill. Best grown unpruned in adequate space; may become too large for the average landscape hence annual pruning is required to maintain good shape.

Fothergilla major **Large Fothergilla** **zone 4-8** **6-10- x equal spread**

Acid, sandy loam supplemented with organic matter, full sun-partial shade. Not particularly drought tolerant. White, bottle-brush shaped flowers appear in late April-early May, fragrant. Good dark green foliage with orange-red fall coloration.

Ginkgo biloba **Ginkgo / Maidenhair Tree** **zone 3-8** **50-80' x 30-40'**

Adaptable to soil conditions and pH, full sun, tolerates air pollution, good salt tolerance, good heat tolerance. Must use male cultivars as decomposing fruit on female trees in the fall are malodorous (however,the nuts are considered a delicacy). Slow to establish.

Gymnocladus dioicus **Kentucky Coffee Tree** **zone 3-8** **60-75' x 40-50'**

Adaptable to various soil conditions but prefers deep, rich loam, full sun, tolerates drought and urban conditions; a large tree for park-like surroundings. Wood may be somewhat brittle. Slow to establish.

Halesia carolina **Carolina Silverbell** **zone 4-8** **30-40' x 20-30'**

Moist, acid soils, sun-light shade. White, bell-shaped flowers in early spring before foliage emerges.

Hammamelis* x *intermedia **'Arnold Promise'** **zone 6-8** **20' x 15'**
H. mollis **Chinese Witchhazel**
H. vernalis **Vernal Witchhazel**
H. virginiana **Common Witchhazel**

Generally prefers moist, acid soils high in organic matter, sun-part shade. *H. vernalis* is native to neutral to slightly alkaline soils; requires good soil aeration. Flowers appear in late winter; four petaled, fragrant. *H. virginiana* blooms in the fall.

Hovenia dulcis **Japanese Raisintree** **zone 6-7** **30' x 20'**

Adaptable to soils, will not tolerate wet conditions, full sun.

Hydrangea arborescens **Smooth Hydrangea** **zone 3-9** **3-5' x greater spread**

Adaptable, prefers well drained, moist soil, partial shade. Will tolerate full sun if ample moisture is available. *H. arborescens*, f. *grandiflora* and 'Annabelle' are improved selections.

Hydrangea macrophylla **Bigleaf Hydrangea** **zone 6-9** **3-6' x equal spread**

Prefers a moist soil supplemented with organic matter, tolerates coastal conditions, sun-light shade. Pruning is an art with this species, flower buds are less hardy than the rest of the plant, frequently winter killed. Soil pH governs color. 'Nikko Blue' is a good, older selection with dark blue color. While most cultivars bloom on the previous year's growth, 'All Summer Beauty' is reputed to flower on current season growth.

Hydrangea paniculata **Panicle Hydrangea** **zone 3-8** **6-10 x 6-10'**

Prefers loamy soil but is adaptable, sun-part shade, urban tolerant. 'Grandiflora' and 'Tardiva' are improved selections. Extremely long flowering period as the dry flowers persist well into the fall.

Hydrangea quercifolia **Oak leaved Hydrangea** **zone 5-9** **4-6' x equal spread**

Moist, fertile, well drained soils, sun-part shade, likes cool, moist root environment. Siting important to provide these conditions. 'Snow Queen' is an improved selection. Excellent fall foliage.

Ilex aquifolium **English Holly** **zone 7+** **30' x 20-25'**

Moist acidic soils well supplemented with organic matter; sun-shade; dark blue-green spiny leaves, bright red berries on female plants. Numerous cultivars available.

Ilex cornuta **Chinese Holly** **zone 7+** **8-10' x 10'**

Moist acidic soils well supplimented with organic matter; sun-shade; dark green leaves with three spines at apex, older leaves have fewer spines. More adaptable to site conditions than other hollies, tolerant of heat and drought. Many cultivars available.

Ilex crenata **Japanese Holly** **zone 6-7** **varies**

Moist, well drained acid soils, full sun-part shade, fairly adaptable.

Ilex glabra **Inkberry** **zone 5-9** **6-8' x 8-10'**

Moist soils to wet soils, shade tolerant but not especially drought tolerant. 'Compacta' is a better-shaped plant than the species.

Ilex latifolia **Lusterleaf Holly** **zone 7+** **20-25' x ?**

Moist acidic soil well supplimented with organic matter; sun-shade; dark evergreen leaves with dull red berries in clusters on female plants.

***Ilex* x *meserveae* hybrids** **Blue Holly** **zone 5-8** **varied**

Moist, well drained soil supplemented with organic matter, acid conditions, sun-part shade. Dark blue-green leaves, bright red berries. Well adapted to New England.

Ilex pedunculosa **Long-stalk Holly** **zone 5** **15-25' x 15'**

Moist, acid soil supplemented with organic matter, sun-part shade, resistant to the holly leaf miner. Leaves resemble Mountain Laurel, bright red berries on long stalks.

Ilex verticillata **Winterberry** **zone 3-9** **6-10' x equal spread**

Moist, acidic soils supplemented with organic matter, does well under wet conditions, also in lighter soils but is considered drought intolerant, sun-light shade. Plants are dioecious, both sexes required for pollination and berry production. Many cultivars available; fruit colors up after the first frost and is often retained through the winter. Tolerates heavy pruning; fruits on new wood. The hybrid 'Sparkleberry', a National Arboretum introduction, is noted for its persistent berries.

Itea virginica **Virginia Sweetspire** **zone 5** **3-4' x 6'**

Moist, fertile soils, tolerates wet conditions, full sun-part shade. Cultivar 'Henry's Garnet' sports white flowers in upright spikes in June-July; foliage has reddish-purple color in fall.

Juniperus chinensis **Chinese Juniper** **zone 3-9** **dependent on cultivar**

Moist, well drained soils, pH adaptable, sun. May be used as a groundcover, shrub, screen, etc., depending on the cultivar. Many cultivars are susceptible to Phomopsis or Kabatina blights which can cause serious twig dieback. The following cultivars are reported to be resistant to one or both of the above fungi: 'Foemina' (P), 'Iowa' (P), 'Keteleeri' (P), 'Pfitzeriana-aurea' (P+K), 'Robusta Green' (P), var. *sargentii* 'Glauca'(P+K), 'Gold Coast' (K).

Juniperus conferta **Shore Juniper** **zone 6-9** **1.5' x spreading**

Adaptable to poor, dry soils, full sun, salt tolerant, good for coastal locations. Low-growing groundcover, intolerant of wet soils.

Juniperus virginiana **Eastern Red Cedar** **zone 2-9** **15-30' x 8-20'**

Adaptable to poor, draughty soils, pH adaptable, full sun, salt tolerant. Alternate host for Cedar-apple rust. Tough native plant for screening, naturalizing, coastal planting.

Kalmia latifolia **Mountain Laurel** **zone 5-9** **7-15' x similar spread**

Requires acid, moist soil supplemented with organic matter, good drainage, full sun-light shade. A good native plant if sited correctly. Many new cultivars available; red and pink flowered forms need full sun to develop good flower color.

Kalmia angustifolia **Sheep Laurel** **zone 2-6** **1-3' x 2'**

Foliage may be poisonous. Tolerates poor, sterile soils. Prefers moist sites. Cultivar 'Hammondasset'.

Kalopanax pictus **Castor-Aralia** **zone 4-7** **40-60' x equal spread**

Moist soils, full sun. Tolerant of alkaline soil and long lived. Coarse textured plant provides tropical effect in the landscape.

Koelreuteria paniculata **Golden Rain Tree** **zone 5-9** **30-40' x equal spread**

Adaptable to a wide range of soils, tolerates drought, heat, wind, pH and air pollution. Yellow blossoms in mid-summer in loose, 12"-15" panicles.

Kolkwitzia amabilis **Beautybush** **zone 4-8** **6-10' x 8'**

Adaptable to a variety of soil conditions; prefers moist, well drained, full sun. Usually requires annual pruning out of older canes to retain form and prevent legginess.

Ligustrum amurense **Amur Privet** **zone 3-7** **12-15' x 9-12'**

Adaptable to soil conditions, full sun-part shade, drought and salt tolerant. Several insect and disease problems occur on Privet, but they seem to be able to withstand them without a great deal of harm. Seeds readily and may be invasive.

Maackia amurensis **Amur Maackia** **zone 3-7** **20-30' x equal spread**

Appears to be very adaptable, full sun, pH tolerant. Summer flowering. Reputed to be extremely drought tolerant.

Magnolia acuminata **Cucumbertree Magnolia** **zone 3-8** **50-80' x equal spread**

Prefers moist, well-drained acid soils, but performs well in calcarious soils also. Not tolerant of extreme drought or wetness, or air pollution.

Magnolia kobus **Kobus Magnolia** **zone 4-8** **30-40 x equal spread**

Performs well on a variety of soil, including high pH.

Magnolia* x *loebneri **Loebner Magnolia** **zone 5-9** **15-20' x variable**

Adaptable to soils except extremes of moist or dry, pH adaptable, sun-part shade. Vigorous growers, extremely tolerates urban conditions. Many improved cultivar selections i.e., 'Ballerina', 'Leonard Messel', 'Merrill'. April blooming.

Magnolia* x *soulangiana **Saucer Magnolia** **zone 4-9** **20-30' x var. spread**

Prefers moist, deep, acidic soils and full sun. Plant to avoid late spring frosts that nip emerging flowers.

Magnolia stellata **Star Magnolia** **zone 4-8** **15-20' x 10-15'**

Moist, well drained soil supplemented with organic matter. Full sun to light shade.

Magnolia virginiana **Sweetbay Magnolia** **zone 5-9** **10-20' x equal spread**

Does well in wet soils, considered drought intolerant, prefers acid soil, tolerates light shade. Semi-evergreen in protected areas.

***Malus* species** **Crabapple** **zone 4-7** **variable**

Quite adaptable as to soil type, as long as it is well drained, prefer acid conditions, full sun, salt tolerant. The best crabapples flowers annually and are disease resistant. See Appendix 1 for a listing. Crabapples are particularly attractive to Japanese beetle adults, and may need protection when beetle populations are high.

Microbiota decussata **Russian Arborvitae** **zone 3-8** **12" x very wide**

Moist soils, tolerant of shade, very cold hardy. Low evergreen shrub, bright green summer foliage turning purple-brown in winter. Graceful branchlets arranged in flat sprays.

Myrica pensylvanica **Bayberry** **zone 3-6** **5-12' x variable**

Does extremely well in poor sandy soils, may be adaptable to heavy soils, full sun-light shade.

Nyssa sylvatica **Tupelo** **zone 3-9** **30-50' x 20-30'**

Moist, well drained soils, tolerates wet soils, will also grow on upland areas. Full sun-light shade. Difficult to transplant, should be grown as a container plant. Excellent fall foliage.

Ostrya virginiana **Ironwood / Hop Hornbeam** **zone 3-9** **25-40' x 20-30'**

Moist, well drained soils, slightly acid, tolerates dry conditions once established, full sun-part shade. One of the most drought tolerant and salt resistant small trees.

Oxydendrum arboreum **Sourwood / Sorrel Tree** **zone 6-9** **25-30' x 20'**

Moist, well drained soils, slightly acid, tolerates dry conditions, full sun-part shade. Drooping flower clusters in mid-summer; excellent burgundy fall foliage.

Parrotia persica **Persian Parrotia** **zone 5-8** **20-40' x 15-30'**

Extremely tolerant once established, sun-part shade. Exfoliating bark on older branches, yellow-orange fall foliage.

Phellodendron amurense **Amur Corktree** **zone 3-7** **30-45' x equal spread**

Adaptable to a wide range of soils, tolerates pH, drought, air pollution and full sun. Gets large, siting important; fruit can be messy.

Picea omorika **Serbian Spruce** **zone 4-7** **50/60' x 25'**
P. orientalis **Oriental Spruce**

Moist, well drained soils, light shade, pH tolerant, would benefit from shelter against winter winds. Considered urban tolerant. Tall, narrow profile may lend it to being planted as an evergreen street tree. *Picea orientalis* prefers clay-loam soils but is tolerant of poor soil conditions, pH adaptable, benefits from shelter against winter winds.

Pieris floribunda **Mountain Pieris** **zone 4-8** **2-6' x equal spread**

Moist, well drained soil, more tolerant of high pH than *P. japonica* and also apparently resistant to the lacebug. The flower structure is upright panicles; an interspecific hybrid, 'Brouwer's Beauty', has flower clusters that are more horizontal and arching as well as having a more compact growth habit, and it is less susceptible to lacebug although it can become infested if planted in full sun (Lacebug problems on *P. japonica* are also greatly reduced in the shade). The species is susceptible to Phytophthora root rot if not sited in a well drained location.

Pinus cembra **Swiss Stone Pine** **zone 5-7** **30-40' x 15-20'**

Well drained, acidic soil, good air circulation, full sun. Very slow growing. Subject to white pine weevil damage to terminal.

Pinus koraiensis **Korean Pine** **zone 5-7** **30-40' x 20-30'**

Adaptable as to soil types, full sun-light shade, very hardy.

Pinus parviflora **Japanese White Pine** **zone 5-7 25-50' x similar spread**

Requires good drainage but tolerates most soil conditions including soil compaction, salt tolerant, drought tolerant once established.

Pinus strobus **Eastern White Pine** **zone 3-8** **50-80' x 20-40'**

Moist, well drained soils but tolerates dry conditions, full sun-light shade, rapid growing when young. Subject to White pine weevil damage to terminal, intolerant of salt. An excellent native evergreen.

Potentilla fruticosa **Bush Cinquefoil** **zone 2-7** **1-4' x 2-4'**

Moist, well drained soils but is very adaptable, will do well under dry conditions, full sun-light shade, likes neutral to alkaline conditions. Extremely cold hardy. Long bloom period. Many improved cultivars available.

Prunus maritima **Beach Plum** **zone 3-6** **6' x equal spread**

Adaptable to most soil conditions except wet, drought tolerant once established, full sun, salt tolerant. White flowers in May followed by purple fruit in late summer. Relatively pest free but subject to tent caterpillar, brown tail knot, plum pockets, and eriophyid mites. Good for naturalizing in coastal plantings.

Prunus sargentii **Sargent Cherry** **zone 5-9** **40/50' x 20/30'**

Moist, well drained soils, full sun/light shade. Single pink blossoms borne in spring before the foliage, fall colors of yellow to red. Considered short lived, relatively free of problems in a trouble prone genus.

Prunus subhirtella **'Autumnalis'** **Higan Cherry** **zone 4-8** **20/40' x 15/30'**

Culture similar to the above; semi-double pink flowers in spring, occasionally reblooming in fall. Considered short lived, relatively pest free.

Pseudolarix kaempferi **Golden-larch** **zone 4-7** **30-50' x 20-40'**

Light, well drained soil in full sun, tolerates air pollution, intolerant of alkaline conditions.

Pseudotsuga menziesii **Douglas-fir** **zone 4-6** **40-80' x 12-20'**

Moist well drained soils, neutral to slightly acid conditions, not particularly drought tolerant. Do not plant near spruce (alternate host for Cooley spruce gall adelgid).

Prunus maackii **Amur Chokecherry** **zone 2-6** **35' x 20'**

Well drained soil preferred, pH tolerant, sun-shade. Considered weak wooded and short lived.

Ptelea trifoliata **Hoptree** **zone 3-9** **15-20' x equal spread**

Moist, well drained soils but very adaptable, sun-light shade. An interesting native tree with trifoliate leaves and fragrant flowers in June..

Pterostyrax hispida **Epaulette Tree** **zone 4-8** **20-30' x equal spread**

Prefers moist, acid, well drained soils, sun-light shade.

Pyrus calleryana **cultivars** **Callery Pear** **zone 5-8** **30-50' x 20'**

Adaptable to varying soils, air pollution, etc. Narrow branch crotches are prone to breaking. Fire blight is a serious problem in warmer areas. 'Aristocrat' has more horizontal branching and is less prone to breakage than 'Bradford'; 'Chanticleer' is more narrowly upright and shows better fire blight resistance. White flowers in clusters in spring, good fall foliage.

Quercus acutissima **Sawtooth Oak** **zone 6-8 35/45' x var. spread**

Prefers acid, well drained soils but adaptable to varying conditions, may develop chlorosis on high pH soils, full sun. Simple foliage with serrate edges, develops yellow fall color.

Quercus alba **White Oak** **zone 3-9 50-80' x equal spread**

Adaptable to soil types, prefers moist, acid conditions, full sun. Dark blue-green lobed leaves, fall color not dependable; burgundy in good years. White oaks are more likely to die from gypsy moth attack than other oak species.

Quercus bicolor **Swamp White Oak** **zone 3-8 50-60' x equal spread**

Moist, acid soils but very drought tolerant once established, broadly lobed, leathery leaf, good dark green color, yellow fall foliage. Several pests and diseases attack this plant but cause no significant damage.

Quercus palustris **Pin Oak** **zone 4-8 50-60' x 25-30'**

Moist, acid soils, intolerant of high pH, full sun, tolerates wet soils and urban conditions. Deeply lobed leaves with pyramidal growth habit; lower branches droop.

Quercus phellos **Willow Oak** **zone 5-9 40-60' x equal spread**

Adaptable to soil conditions, full sun, fibrous root system allows for ease of transplanting; narrow, simple leaves.

Quercus rubra **Red Oak** **zone 4-8 60-75' x 75'**

Moist, acid soils, full sun. Intolerant of high pH, tolerates urban conditions. Easily transplanted.

Rhododendron **species and cultivars** **zone 2-9 ground cover/sm. tree**

Over 900 species and thousands of hybrids exist, most are low maintenance plants when grown in good sites. They generally prefer moist well-drained acid soils high in organic matter and perform best in partial shade. In full sun winter injury and blossom fading is more pronounced as are problems with lace bugs. In southern New England 'Dora Amateis' and *R. maximum* are particularly susceptible to lacebug when grown in full sun and to our south lacebug problems are much more widespread. With the exception of some of the heavily indumented rhododendrons (*R. yakushimanum, R. smirnovii,* and hybrids) all are susceptible to the black vine weevil which can kill small plants. (See discussion under *Taxus.*)

Among the large leaved rhododendrons *R. fortunei* and its hybrids ('Scintillation') are very attractive to deer. Small leaved rhododendrons, including 'PJM', 'Silvery Pink', 'Anglo', etc. are particularly cold tolerant as are deciduous azaleas (*R. schlippenbachii, R. calendulaceum, R. viscosum,* etc.). The deciduous Exbury hybrids, however, have too many insect and disease problems to be included on this list.

There are thousands of good hardy hybrid evergreen azaleas including 'Hino crimson', 'Delaware Valley White', *R. poukhenensis,* etc. However Belgian or florist azaleas are often mistakenly sold as hardy. As a rule of thumb if the flower looks too good to be true, it is probably not hardy.

Several species are native to southern New England, including *R. maximum, R. viscosum, R. prinophyllum R. canadense* and *R. periclymenoides.*

Rhus aromatica **Fragrant Sumac** **zone 3-9 2'-4' x 6-8'**

Adaptable to various soil conditions, full sun. Spreading habit of cultivar 'Gro-Low' makes a good choice for embankments or a ground cover.

Rhus chinensis **Chinese Sumac** **zone 5-7** **24' x suckering**

The cultivar 'September Beauty' is in all ways superior to the species. As with most sumacs, it will sucker and form colonies. Useful only in limited areas due to its habit of forming colonies.

Rhus copallina **Shining Sumac** **zone 4-9** **20' x suckering**

Good for dry, rocky areas, embankments, etc. Careful siting is important as it will form large colonies due to suckering.

Rosa rugosa **Saltspray Rose** **zone 2-7** **4-6' x equal spread**

Well drained soils but is very adaptable, grows well on dry, exposed sites, salt tolerant, full sun. Generally Pink, red and white flowered forms available.

Sciadopitys verticillata **Japanese Umbrella Pine** **zone 4-8** **20-30' x 15-20'**

Moist, well drained soils, full sun, some protection from wind. Drought tolerant once established. Slow growing.

Sophora japonica **Japanese Scholar Tree** **zone 6-8** **50-75' x variable**

Well drained soil supplemented with organic matter, drought and urban tolerant. White, fragrant flowers in mid summer. 'Regent' is reputed to flower earlier than the species.

Sorbus alnifolia **Korean Mountain Ash** **zone 4-7** **40-50' x 20-30'**

Adaptable to soils as long as they're well drained, pH tolerant, full sun. Resistant to borers; fire blight may be a problem in warmer areas. White flowers in flat topped clusters in May followed by orange-reddish fruit which persists into winter. Does not resemble the European Mountain Ash.

Spirea* x *bumalda **Bumald Spirea** **zone 5-8** **3-4' x 4-5'**

Bumald spirea is a tough plant in the landscape, annual pruning required for best effect.

Spiraea* x *vanhouttei **Vanhoutte Spirea** **zone 3-8** **6/8' x 10'**

Adaptable to various soil types, full sun. White flowers on arching stems in May. May require pruning of dead wood in spring.

Stephanandra incisa **'Crispa'** **Cutleaf Stephanandra** **zone 5-7** **2-3' x spreading**

Well drained soils supplemented with organic matter, considered drought intolerant, full sun-part shade.

Stewartia pseudocamellia **Japanese Stewartia** **zone 6-9** **20-30' x 10-15'**
S. koreana **Korean Stewartia**

Moist, acid soil supplemented with organic matter, sun-shade. Summer flowering with camellia-like blossoms. Exquisite bark, fall color!

Styrax japonica **Japanese Snowbell** **zone 6-8** **20-30' x equal spread**

Moist, well drained, acid soil supplemented with organic matter, full sun-part shade. May be subject to winter damage in cold situations. White, bell-shaped, pendulous flowers in May.

Symphoricarpos* x *chenaulti **Chenault Coralberry** **zone 4-7** **2' x 12'**

A cross between *S. microphyllus* and *S. orbiculatus*. 'Hancock' is a beautiful low-growing type.

***Syringa meyeri* 'Palibin'** **Meyer Lilac** **zone 4-7** **4-8' x equal spread**
S. microphylla **Littleleaf Lilac**
***S. patula*"Miss Kim'** **Manchurian Lilac**

Adaptable to various soil conditions, full sun, resistant to powdery mildew.

Syringa reticulata **Japanese Tree Lilac** **zone 4-7** **20-30' x 12-15'**

Well drained, moist soil, pH tolerant, full sun. Salt and wind tolerant. Resistant to lilac borer and powdery mildew. Early summer flowering. 'Ivory Silk' and 'Summer Snow' are excellent cultivars.

Taxodium distichum **Baldcypress** **zone 4-9** **50/70' x 20/30'**

Moist acid soils, very adaptable to wet soils, full sun. A large tree for parks, estates or wet areas.

***Taxus* species and cultivars** **Yews**

Black vine weevil is a very serious pest of young yews, particularly in the nursery. Larger plants sited in the landscape are reasonably tolerates this pest, but because yews can harbor large populations of weevils, landscapers should exercise care in planting small susceptible plants (azaleas, euonymus, etc.) near infested yews. The foliage and fruit of yew are toxic to children if ingested.

***Taxus baccatta* 'Repandens'** **Spreading English Yew** **zone 5-7** **2-4' x 12-15'**

Hardy dwarf, spreading form has pendulous branch tips and dark green needles.

Taxus cuspidata **Japanese Yew** **zone 4-7** **10-40' x equal spread**

Prefers a moist, sandy loan, does not tolerate wet soils for any length of time.

***Taxus* x *media* cultivars** **zone 4-7** **variable**

This hybrid of *T. baccatta* and *T. cuspidata* resembles *T. cuspidata* in many respects. Common cultivars include: 'Brownii', 'Densiformis', 'Hatfieldii', 'Hicksii', 'Nigra' and 'Tauntonii'. See *T. cuspidata* for cultural considerations.

Thuja plicata **Giant / Western Arborvitae** **zone 5-7** **50-70' x 15-25'**

Moist, fertile soils but tolerant of dryer soils; sun-shade; pH adaptable. A fast growing narrow pyramidal tree with dark evergreen leaves and reddish-brown fibrous bark.

***Tsuga* species** **Hemlocks**

Hemlock wooly adelgid is now a serious pest of both *Tsuga canadensis* and *T. caroliniana* throughout southern New England. Hence, we urge caution in the use of these important landscape species. Left untreated, this pest will rapidly kill susceptible hemlocks, but yearly applications of insecticides provide effective control in the landscape. Species resistant to the adelgid include *T. diversifolia, T. heterophylla, T. chinensis* and *T. mertensia. T. sieboldii* has apparent tolerance. While all of these species are being evaluated for regional adaptability, only *T. diversifolia* and *T. heterophylla* can be recommended with reasonable confidence at this time.

Tsuga diversifolia **Northern Japanese Hemlock** **zone 5-7** **35-60' x 20-30'**

Slow growing, often multi-stemmed tree with dense, dark green foliage. Prefers moist sites in full sun, easily transplanted. At least one R.I. nursery has been growing this plant for years, and it appears to be well suited to our climate.

Tsuga heterophylla **Western Hemlock** **zone 6-8** **100' x 30'**

Looks very much like Canadian hemlock but not quite as "soft" in appearance. Prefers a humid climate and moist soil. Cold hardiness is marginal in New England; plants from northern Idaho show very slight winter damage, coastal material is probably not hardy here.

Ulmus parvifolia **Lacebark Elm** **zone 4-9** **40-50' x 40'**

Adaptable to soil and pH conditions, good for urban areas, resistant to Dutch elm disease, elm leaf beetle and Japanese beetle. Several new cultivars recently introduced; excellent bark and foliage.

Vaccinium corymbosum **Highbush Blueberry** **zone 3-8** **6-12' x 8-12'**

Native to swamps but does well in dry, acid, poor and sandy soils in full sun or partial shade. Mulch.

Viburnum x carlecephalum **Fragrant Viburnum** **zone 7+** **10' x 10'**

Adaptable to soil conditions, prefers moist acidic soils; sun-light shade; easily transplanted. Loose, somewhat open habit, coarse textured leaves; pink buds opening to fragrant white flowers in clusters in May. One of the latest viburnums to bloom.

Viburnum dentatum **Arrowwood** **zone 2-8** **6-8' x 15'**

Adaptable to various soil conditions, sun-part shade. Forms large clumps.

Viburnum farreri **Fragrant Viburnum** **zone 5-8** **8-12' x 6-8'**

Early to flower, flower buds may be damaged by late frost.

Viburnum x Juddii **Judd Viburnum** **zone 4-7** **4-5' x 4-8'**

Moist, well drained soil, full sun. Highly fragrant, semi-snowball type of inflorescence.

Viburnum lantana **'Mohican'** **Wayfaring Tree** **zone 4-8** **10-15' x equal spread**

Adaptable, drought tolerant, tolerates high pH.

Viburnum plicatum f. tomentosum **Doublefile Viburnum** **zone 6-8** **8-10' x 9-12'**

Moist, well drained soils, not particularly drought tolerant. Preferred cultivars include 'Mariesii' and 'Shasta'.

Viburnum prunifolium **Blackhaw Viburnum** **zone 4-9** **12-15' x 8-12'**

Adaptable to various soil conditions, drought tolerant once established, sun-part shade. A good shrub or small tree.

Viburnum* x *rhytidophylloides **Lantanaphyllum Viburnum** **zone 4-8** **8/10' x equal spread**

Adaptable to soil conditions, full sun/light shade, needs protection from winter wind. White flat topped flower clusters in April followed by black fruit effective in the fall. Dark green leathery leaves persist in the fall. 'Allegheny' and 'Willowwood' are fine selections.

Viburnum rhytidophyllum **Leatherleaf Viburnum** **zone 5-8** **10-15' x equal spread**

Well drained soils, somewhat adaptable, shade tolerant, protection from winter wind desirable.

Viburnum sargentii **Sargent Viburnum** **zone 4-7** **12-15' x equal spread**

Adaptable to soil conditions, pH tolerant, full sun-light shade; a number of USDA introductions look promising, i.e. 'Onondaga' and 'Susquehanna'.

Viburnum sieboldii **Siebold Viburnum** **zone 5-7** **15-20' x 10-15'**

Adaptable to soil conditions but prefers moist, well drained, pH adaptable, sun-part shade, not particularly drought tolerant. 'Seneca' has very persistent fruit.

Viburnum trilobum **American Cranberrybush** **zone 3-8** **8-12' x equal width**

Adaptable to soil conditions, easy to grow, full sun-part shade. A native plant.

Viburnum wrightii **Wright Viburnum** **zone 6-7** **6-10' x equal spread**

Similar to other viburnums in preferences. White flat topped flower clusters in May, showy red fruit in fall.

Weigela florida **Weigela** **zone 5-8** **6-9' x 9-12'**

Adaptable but prefers a moist well drained soil, full sun, tolerates pollution. Requires rejuvenation pruning to maintain decent shape; many improved cultivars available. Early summer blooming.

Xanthorhiza simplicissima **Yellowroot** **zone 3-9** **2-3' x spreading**

Moist, well drained soils, tolerates heavy soils, sun-shade, tolerates dry conditions.

Zelkova serrata **Japanese Zelkova** **zone 5-8** **50-80' x equal spread**

Moist, well drained soils, tolerates drought and wind once established, pH adaptable; 'Village Green' recommended by Prof. Michael Dirr as a superior selection, more cold hardy, resistant to Dutch elm disease and elm leaf beetle, as well as having better fall color. Susceptible to wind damage, branch drop.

APPENDIX 1: URI Crabapple Tree Disease Evaluations: 1992-93

					RESISTANCE TO DISEASE			
CULTIVAR	FLWRS/FRT	SHAPE	HXW	NOTES	APPLE SCAB	FIRE BLIGHT	CEDAR APPLE RUST	POWDERY MILDEW
Brandywine	Pink/Yellow	Upright/Spreading	20x20	2	Fair	Excellent	Fair	Excellent
Centurion	Red/Red	Upright/Spreading	20x15	3	Good	Excellent	Excellent	Excellent
Christmas Holly	Wt/Red	Spreading	10x12	4	Good	Good	Excellent	Excellent
David	Wt/Red	Round	15x15	1	Good	Good	Excellent	Excellent
Dolgo	Wt/Red	Upright/Spreading	30x40	1,2,6	Good	Good	Excellent	Excellent
Donald Wyman	Wt/Red	Round	15x15	1,4	Good	Poor*	Excellent	Good
floribunda	Pink-Wt/Red	Horizontal	20x25	2,5	Good	Fair*	Excellent	Good
Harvest Gold	Wt/Gold	Upright	30x15	3,4	Good	Excellent	Excellent	Excellent
Henningi	Wt/Or	Upright	25		Good	Excellent	Good	Excellent
Henry Kohankie	Pink-Wt/Red	Round	20x20	4	Good	Excellent	Good	Excellent
Indian Magic	Pink/Red-Or	Round	15x15	1,3,4	Fair	Excellent	Good	Excellent
Indian Summer	Red/Red	Upright/Spreading	20x20		Good	Good	Excellent	Excellent
Jewelberry	Wt/Red	Shrub	12x15	4,5	Good	Good	Excellent	Excellent
Liset	Red/Maroon	Horizontal	15x20		Good	Good	Excellent	Good
Mary Potter	Wt/Red	Shrub	15x30	1,3,4,5	Good	Good	Excellent	Good
Molten Lava	Wt/Red	Horizontal	15x15	3,4,5	Good	Good	Excellent	Excellent
Ormiston Roy	Wt/Yel-Red	Upright/Spreading	20x25	4	Good	Good	Good	Excellent
Pink Spires	Pink/Maroon	Upright	25		Good	Good	Excellent	Excellent
Prairiefire	Red/Red	Upright/Spreading	20x20		Good	Excellent	Excellent	Excellent
Professor Sprenger	Wt/Or	Round	25x25	3	Excellent	Excellent	Excellent	Excellent
Profusion	Red/DkRed	Round	15x15		Fair	Good	Excellent	Good
Ralph Shay	Wt/Red	Upright Spreading	-	3	Good	Excellent	Excellent	Good
Red Barron	Red/Dk Red	Narrow	18x10	3	Fair	Good	Good	Excellent
Red Jade	Wt/Red	Weeping	15x15		Fair	Fair*	Excellent	Fair*
Red Jewel	Wt/Red	Horizontal	15x12	4	Fair	Poor*	Excellent	Good
Red Splendor	Pink/Red	Upright Spreading	25x25		Fair	Fair*	Good	Fair
Robinson	Red/Red	Upright Spreading	25x25	3	Good	Excellent	Excellent	Excellent
sargentii	Wt/Red	Shrub	8x15	1,2,4	Excellent	Good	Excellent	Excellent
Selkirk	Red/Red	Vase	25x25		Fair	Good	Excellent	Fair*
Sentinel	Wt/Red	Upright Spreading	15x10	4	Good	Good	Excellent	Excellent
Silver Moon	Wt/Red	Upright Spreading	25x25	4	Good	Poor	Excellent	Good
Snowdrift	Wt/Or	Round	20x20	4,5	Good	Fair*	Excellent	Excellent
Strawberry Parfait	Pink/Red	Vase	20x25	I	Good	Excellent	Excellent	Excellent
Sugar Tyme	Wt/Red	Round	20x20	1,2,3,4	Good	Fair*	Excellent	Excellent
tschonoskii	Wt/Yellow	Pyramid	28x14	3	Good	Poor*	Excellent	Excellent
Velvet Pillar	Red/Red	Narrow Upright	20x14		Fair	Fair*	Excellent	Good
White Candied Apple	Pink/Red	Weeping	15x15	3,4	Fair	Excellent	Excellent	Excellent
White Angel	Wt/Gr&Red	Upright Spreading	20x20	4	Good	Fair*	Fair	Excellent
White Cascade	Wt/Coral	Weeping	15x15		Good	Excellent	Excellent	Excellent
Winter Gold	Wt/Yellow	Round	25x25	4	Fair	Fair*	Excellent	Good
yunnanensis 'Veitchii'	Wt/Brown	Narrow	20x10	3	Good	Fair*	Excellent	Good
zumi 'Calocarpa'	Wt/Red	Horizontal	25x30	2,5	Good	Fair*	Excellent	Good

KEY TO NOTES

1 - Flowers lightly in alternate years
2 - Fragrant flowers
3 - Colorful fall foliage
4 - Persistent fruit
5 - Birds favor fruit
6 - Messy frui t drop in midsummer

KEY TO DISEASE RESISTANCE

EXCELLENT	No problem with disease
GOOD	Some leaves affected
FAIR	Most leaves affected; Little or no defoliation
POOR	Consistently defoliates

* Although we've seen no evidence of the potentially lethal fire blight, or the less serious powdery mildew, conditions in the northeast may favor these diseases.

Please note, this compilation is composed of local data collected over the last three years, tempered with national disease ratings from NCIP plantations across the country. We have dropped from this list the plants most susceptible to apple scab (Hopa, Radiant, and Royalty). This list was compiled by Marsha Browning and Larry Englander, Department of Plant Sciences, URI.

APPENDIX 2: Trees and Shrub Selections for Demanding Situations

DROUGHT OR DRY SOILS

Acanthopanax sieboldianus
Acer campestre
Acer ginnala
Acer tataricum
Aesculus pavia
Aralia spinosa
Arctostaphylos uva-ursi
Berberis x mentorensis
Carpinus betulus
Cladrastis lutea
Comptonia peregrina
Cornus racemosa
Corylus colurna
Cotinus coggygria
Cotinus obovatus
Cotoneaster adpressus
Cotoneaster divaricatus
Cotoneaster salicifolius
Cratageus viridis 'Winter King'
Diervilla sessilifolia
Eucommia ulmoides
Evodia daniellii
Fagus sylvatica
Ginkgo biloba
Gymnocladus dioicus
Hammamelis mollis
Hammamelis vernalis
Hammamelis virginiana
Hammamelis x *intermedia* 'Arnold Promise'
Hydrangea arborescens
Juniperus chinensis
Juniperus conferta
Juniperus virginiana
Koelreuteria paniculata
Kolkwitzia amabilis
Maackia amurensis
Malus species
Myrica pensylvanica
Oxydendrum arboreum
Phellodendron amurense
Pinus cembra
Pinus koraiensis
Pinus parviflora
Pinus strobus
Potentilla fruticosa
Prunus maritima
Prunus sargentii
Pyrus calleryana cultivars
Quercus acutissima
Quercus alba
Quercus rubra
Rhus aromatica 'Gro-Low'
Rhus chinensis
Rhus copallina
Rosa rugosa
Sophora japonica
Spiraea x *bumalda* 'Anthony Waterer'
Spiraea x *vanhouttei*
Symphoricarpos x *chenaulti*
Syringa reticulata
Ulmus parvifolia
Vaccinium corymbosum
Viburnum prunifolium
Viburnum sieboldii
Xanthorhiza simplicissima
Zelkova serrata

WET SOILS OR FLOODING

Acer rubrum
Aesculus pavia
Alnus glutinosa
Alnus incana
Amelanchier laevis
Aronia arbutifolia
Betula nigra
Calycanthus floridus
Cercidiphyllum japonicum
Chamaecyparis nootkatensis
Chamaecyparis obtusa
Chamaecyparis pisifera
Chamaecyparis thyoides
Chionanthus retusus
Chionanthus virginicus
Clethra alnifolia
Clethra barbinervis
Cornus racemosa
Enkianthus campanulatus
Forsythia intermedia
Forsythia suspensa
Fothergilla major
Hydrangea arborescens
Hydrangea macrophylla
Hydrangea paniculata
Hydrangea quercifolia
Ilex crenata
Ilex glabra
Ilex pedunculosa
Ilex verticillata
Ilex x *meserveae* hybrids
Itea virginica
Kalmia angustifolia
Kalmia latifolia
Kolkwitzia amabilis
Magnolia virginiana
Nyssa sylvatica
Phellodendron amurense
Quercus bicolor
Quercus palustris
Quercus phellos
Stephanandra incisa 'Crispa'
Taxodium distichum
Vaccinium corymbosum
Viburnum dentatum
Viburnum prunifolium
Xanthorhiza simplicissima

SHADE

Acanthopanax sieboldianus
Acer ginnala
Acer griseum
Acer triflorum
Amelanchier arborea
Amelanchier canadensis
Amelanchier laevis
Aronia arbutifolia
Aronia melanocarpa
Carpinus caroliniana
Cephalotaxus harringtonia
Chamaecyparis obtusa
Chionanthus virginicus
Clethra alnifolia
Cornus kousa
Cornus mas
Cornus officinalis
Cotoneaster salicifolius
Enkianthus campanulatus
Halesia carolina
Hammamelis mollis
Hammamelis vernalis
Hammamelis virginiana
Hammamelis x *intermedia* 'Arnold Promise'
Hydrangea arborescens
Hydrangea quercifolia
Ilex crenata
Ilex glabra
Ilex pedunculosa
Ilex verticillata
Ilex x *meserveae hybrids*
Itea virginica
Ligustrum amurense
Magnolia virginiana
Myrica pensylvanica
Pieris floribunda
Rhododendron species & cultivars
Stephanandra incisa 'Crispa'
Styrax japonica
Taxus baccatta 'Repandens'
Taxus cuspidata
Taxus x *media* cultivars
Tsuga diversifolia
Tsuga heterophylla
Vaccinium corymbosum
Viburnum dentatum
Viburnum prunifolium
Viburnum sieboldii

APPENDIX 2: (continued)

SOIL SALT

Acer campestre
Acer ginnala
Acer griseum
Acer palmatum
Acer pseudoplatanus
Acer tataricum
Aesculus parviflora
Aesculus pavia
Amelanchier arborea
Amelanchier canadensis
Amelanchier laevis
Arctostaphylos uva-ursi
Aronia arbutifolia
Aronia melanocarpa
Betula nigra
Carpinus caroliniana
Cercidiphyllum japonicum
Chamaecyparis nootkatensis
Chamaecyparis obtusa
Chamaecyparis pisifera
Chamaecyparis thyoides
Comptonia peregrina
Cotoneaster adpressus
Cotoneaster divaricatus
Cotoneaster salicifolius
Cupressocyparis leylandii
Diervilla sessilifolia
Hydrangea arborescens
Hydrangea macrophylla
Hydrangea paniculata
Hydrangea quercifolia
Ilex crenata
Ilex glabra
Juniperus chinensis
Juniperus conferta
Juniperus virginiana
Koelreuteria paniculata
Ligustrum amurense
Magnolia acuminata
Magnolia kobus
Magnolia virginiana
Magnolia x *loebneri*
Magnolia x *soulangiana*
Myrica pensylvanica
Nyssa sylvatica
Oxydendrum arboreum
Phellodendron amurense
Potentilla fruticosa
Prunus maritima
Prunus sargentii
Quercus acutissima
Quercus alba
Quercus bicolor
Quercus rubra
Rhus aromatica 'Gro-Low'
Rhus chinensis
Rhus copallina
Rosa rugosa
Sciadopitys verticillata
Sophora japonica
Sorbus alnifolia
Syringa meyeri 'Palibin'
Syringa microphylla
Syringa patula 'Miss Kim'
Syringa reticulata
Taxodium distichum
Taxus baccatta 'Repandens'
Taxus cuspidata
Taxus x media cultivars
Ulmus parvifolia
Vaccinium corymbosum
Viburnum dentatum
Viburnum prunifolium
Viburnum sieboldii
Zelkova serrata

WIND

Abies concolor
Acanthopanax sieboldianus
Acer ginnala
Acer pseudoplatanus
Comptonia peregrina
Cornus racemosa
Corylus colurna
Cotoneaster divaricatus
Cratageus viridis 'Winter King'
Diervilla sessilifolia
Eucommia ulmoides
Euonymus alatus
Ginkgo biloba
Gymnocladus dioicus
Juniperus chinensis
Juniperus conferta
Juniperus virginiana
Ligustrum amurense
Myrica pensylvanica
Pinus cembra
Potentilla fruticosa
Prunus maritima
Pseudotsuga menziesii
Ptelea trifoliata
Pyrus calleryana cultivars
Quercus alba
Quercus bicolor
Rhus aromatica 'Gro-Low'
Rosa rugosa
Symphoricarpos x *chenaulti*
Vaccinium corymbosum
Viburnum lantana 'Mohican'

OCEANSIDE, ROADSIDE OR AERIAL SALT

Acer pseudoplatanus
Amelanchier canadensis
Arctostaphylos uva-ursi
Aronia arbutifolia
Aronia melanocarpa
Chamaecyparis pisifera
Clethra alnifolia
Clethra barbinervis
Comptonia peregrina
Cotoneaster adpressus
Cotoneaster divaricatus
Cotoneaster salicifolius
Cupressocyparis leylandii
Halesia carolina
Hydrangea arborescens
Hydrangea macrophylla
Ilex glabra
Juniperus chinensis
Juniperus conferta
Juniperus virginiana
Ligustrum amurense
Myrica pensylvanica
Nyssa sylvatica
Pieris floribunda
Potentilla fruticosa
Prunus maritima
Quercus alba
Rhus aromatica 'Gro-Low'
Rhus chinensis
Rhus copallina
Rosa rugosa
Sophora japonica
Spiraea x *bumalda* 'Anthony Waterer'
Spiraea x *vanhouttei*
Taxus cuspidata
Ulmus parvifolia
Vaccinium corymbosum
Viburnum dentatum

TOLERANT OF PH 4.5 OR LOWER

Arctostaphylos uva-ursi
Chamaecyparis thyoides
Comptonia peregrina
Hydrangea macrophylla
Ilex crenata
Ilex glabra
Ilex pedunculosa
Ilex verticillata
Ilex x *meserveae* hybrids
Kalmia angustifolia
Kalmia latifolia
Myrica pensylvanica
Vaccinium corymbosum

APPENDIX 2: (continued)

TOLERANT OF PH 5.0

Abies cilicica
Abies concolor
Abies homolepis
Acer buergerianum
Acer rubrum
Acer triflorum
Amelanchier arborea
Amelanchier canadensis
Carpinus caroliniana
Chamaecyparis obtusa
Chamaecyparis pisifera
Chionanthus virginicus
Clethra alnifolia
Enkianthus campanulatus
Forsythia suspensa
Fothergilla major
Halesia carolina
Hammamelis mollis
Hammamelis vernalis
Hammamelis virginiana
Hammamelis x intermedia 'Arnold Promise'
Juniperus virginiana
Magnolia acuminata
Magnolia stellata
Magnolia virginiana
Magnolia x soulangiana
Malus species
Nyssa sylvatica
Oxydendrum arboreum
Pieris floribunda
Pinus cembra
Pinus strobus
Pterostyrax hispida
Quercus acutissima
Quercus alba
Quercus bicolor
Quercus palustris
Quercus phellos
Quercus rubra
Rhododendron species & cultivars
Stewartia koreana
Stewartia pseudocamellia
Styrax japonica
Taxodium distichum
Viburnum prunifolium

TOLERANT OF PH 7.5 OR HIGHER

Abies concolor
Acanthopanax sieboldianus
Acer buergerianum
Acer campestre
Acer ginnala
Acer griseum
Acer palmatum
Acer pseudoplatanus
Acer tataricum
Acer triflorum
Aesculus pavia
Alnus glutinosa
Alnus incana
Amelanchier arborea
Amelanchier canadensis
Amelanchier laevis
Aralia spinosa
Berberis julianae
Berberis verriculosa
Berberis x *mentorensis*
Carpinus betulus
Cercidiphyllum japonicum
Chionanthus retusus
Chionanthus virginicus
Cladrastis lutea
Cornus kousa
Cornus mas
Cornus officinalis
Cornus racemosa
Cornus x'Stellar' series
Corylus colurna
Cotinus coggygria
Cotinus obovatus
Cotoneaster adpressus
Cotoneaster divaricatus
Cotoneaster salicifolius
Cratageus viridis 'Winter King'
Diervilla sessilifolia
Eucommia ulmoides
Euonymus alatus
Evodia daniellii
Forsythia intermedia
Forsythia suspensa
Ginkgo biloba
Gymnocladus dioicus
Hammamelis vernalis
Hammamelis virginiana
Hovenia dulcis
Hydrangea arborescens
Hydrangea macrophylla
Hydrangea paniculata
Hydrangea quercifolia
Juniperus chinensis
Juniperus conferta
Juniperus virginiana
Koelreuteria paniculata
Kolkwitzia amabilis
Ligustrum amurense
Maackia amurensis
Magnolia acuminata
Magnolia kobus
Magnolia stellata
Magnolia x *loebneri*
Malus species
Ostrya virginiana
Phellodendron amurense
Picea omorika
Picea orientalis
Pinus cembra
Pinus koraiensis
Pinus parviflora
Pinus strobus
Potentilla fruticosa
Prunus maritima
Prunus sargentii
Prunus subhirtella 'Autumnalis'
Pseudotsuga menziesii
Ptelea trifoliata
Pyrus calleryana cultivars
Quercus bicolor
Quercus phellos
Rhus aromatica 'Gro-Low'
Rhus chinensis
Rhus copallina
Rosa rugosa
Sophora japonica
Sorbus alnifolia
Spiraea x *bumalda* 'Anthony Waterer'
Spiraea x *vanhouttei*
Stephanandra incisa 'Crispa'
Symphoricarpos x *chenaulti*
Syringa meyeri 'Palibin'
Syringa microphylla
Syringa patula 'Miss Kim'
Syringa reticulata
Taxodium distichum
Ulmus parvifolia
Viburnum dentatum
Viburnum farreri
Viburnum lantana 'Mohican'
Viburnum plicatum f. *tomentosum*
Viburnum prunifolium
Viburnum rhytidophyllum
Viburnum sargentii
Viburnum sieboldii
Viburnum trilobum
Viburnum wrightii
Viburnum x *judii*
Viburnum x *rhytidophylloides*
Weigela florida

APPENDIX 2: (continued)

NATIVE SPECIES

Acer rubrum
Aesculus parviflora
Aesculus pavia
Amelanchier species
Aralia spinosa
Arctostaphylos uva-ursi
Aronia species
Betula nigra
Calycanthus floridus
Carpinus caroliniana
Chamaecyparis thyoides
Chionanthus virginicus
Cladrastus kentukea
Clethra alnifolia
Comptonia peregrina
Cornus racemosa
Cotinus obovatus
Cratageus viridis
Diervilla sessifolia
Fothergilla major
Gymnocladus dioicus
Halesia carolina
Hammamelis vernalis
Hammamelis virginiana
Hydrangea arborescens
Hydrangea quercifolia
Ilex glabra
Ilex verticillata
Itea virginica
Juniperus virginiana
Kalmia angustifolia
Kalmia latifolia
Magnolia acuminata
Magnolia virginiana
Myrica pensylvanica
Nyssa sylvatica
Ostrya virginiana
Oxydendrum arboreum
Pinus strobus
Prunus maritima
Quercus alba
Quercus bicolor
Quercus palustris
Quercus phellos
Quercus rubra
Rhododendron species
Rhus aromatica
Rhus coppalina
Rhus copallina
Taxodium distichum
Vaccinium corymbosum
Viburnum dentatum
Viburnum prunifolium
Viburnum trilobum
Xanthorhiza simplissima

USEFUL BENEATH POWER LINES

Acer buergerianum
Acer campestre
Acer ginnala
Acer tataricum
Alnus glutinosa
Alnus incana
Amelanchier canadensis
Amelanchier laevis
Carpinus caroliniana
Chionanthus retusus
Cornus kousa
Cornus mas
Cornus officinalis
Cornus racemosa
Cornus x'Stellar' series
Cotinus coggygria
Cratageus viridis 'Winter King'
Enkianthus campanulatus
Evodia daniellii
Hammamelis mollis
Hammamelis vernalis
Hammamelis virginiana
Hammamelis x *intermedia* 'Arnold Promise'
Hovenia dulcis
Hydrangea paniculata
Ilex pedunculosa
Koelreuteria paniculata
Maackia amurensis
Magnolia stellata
Magnolia virginiana
Magnolia x *loebneri*
Magnolia x *soulangiana*
Malus species
Ostrya virginiana
Parrotia persica
Prunus maackii
Prunus maritima
Prunus sargentii
Prunus subhirtella 'Autumnalis'
Ptelea trifoliata
Pterostyrax hispida
Pyrus calleryana cultivars
Sorbus alnifolia
Stewartia koreana
Stewartia pseudocamellia
Styrax japonica
Syringa reticulata

URBAN CONDITIONS

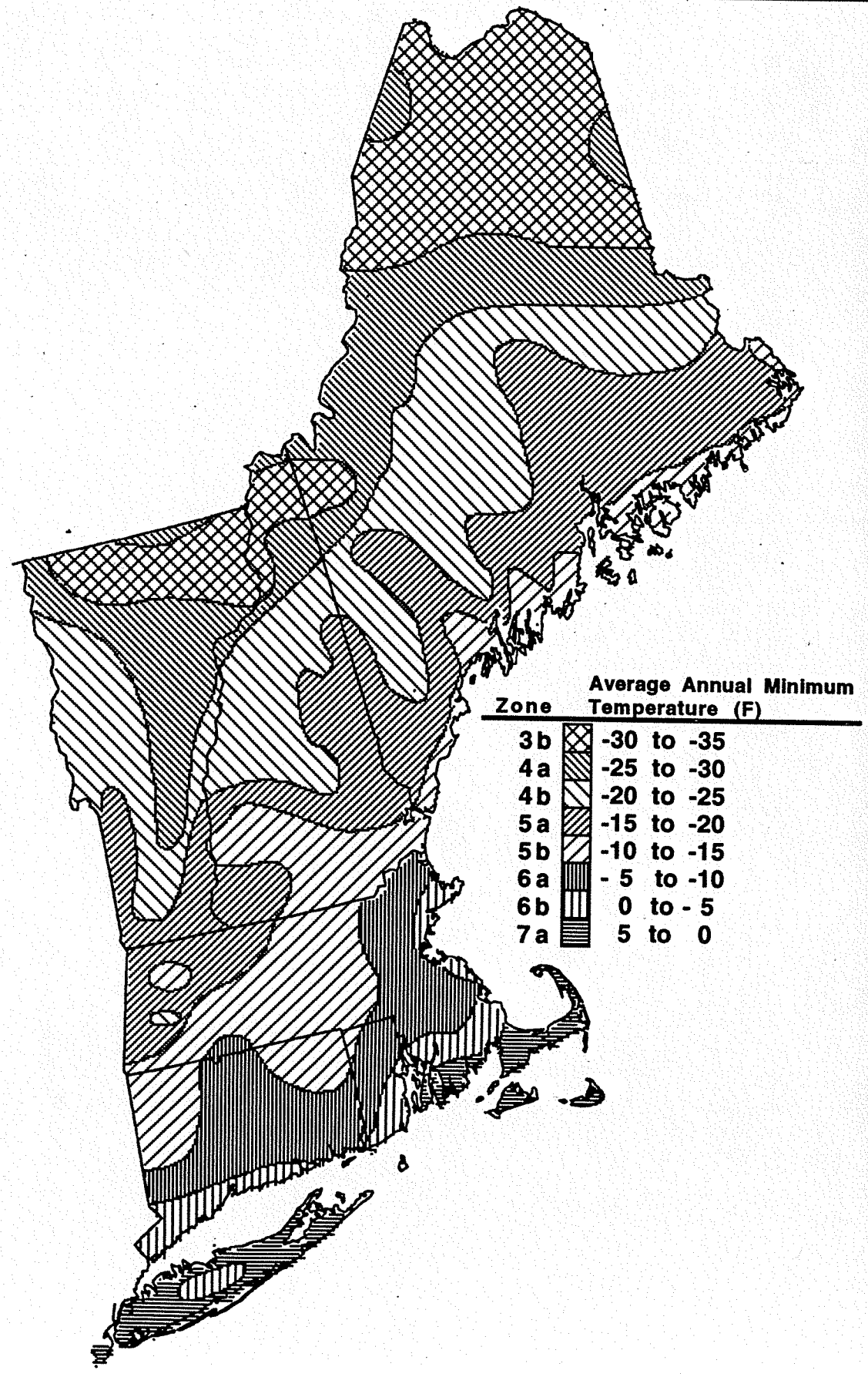
Abies concolor
Acer buergerianum
Acer campestre
Acer ginnala
Acer pseudoplatanus
Acer rubrum
Acer tataricum
Aesculus parviflora
Aesculus pavia
Alnus glutinosa
Amelanchier canadensis
Betula nigra
Carpinus betulus
Carpinus caroliniana
Cercidiphyllum japonicum
Chamaecyparis nootkatensis
Cladrastis lutea
Corylus colurna
Cratageus viridis 'Winter King'
Eucommia ulmoides
Ginkgo biloba
Gymnocladus dioicus
Koelreuteria paniculata
Maackia amurensis
Magnolia stellata
Magnolia x *soulangiana*
Malus species
Nyssa sylvatica
Ostrya virginiana
Phellodendron amurense
Pyrus calleryana cultivars
Quercus acutissima
Quercus bicolor
Quercus palustris
Quercus phellos
Quercus rubra
Sophora japonica
Sorbus alnifolia
Syringa reticulata
Taxus cuspidata
Ulmus parvifolia
Zelkova serrata

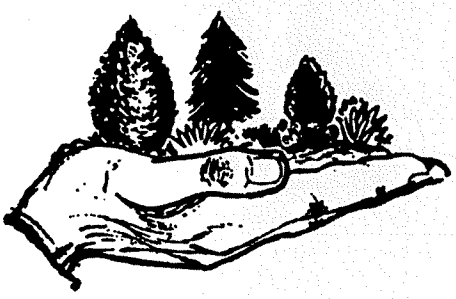
APPENDIX 2: (continued)

BEST PLANTED IN SPRING

Acer griseum
Acer rubrum
Betula nigra
Carpinus betulus
Carpinus caroliniana
Cercidiphyllum japonicum
Cladrastis lutea
Cornus racemosa
Fagus sylvatica
Halesia carolina
Ilex crenata
Ilex glabra
Ilex pedunculosa
Ilex verticillata
Ilex x meserveae hybrids
Kalmia angustifolia
Kalmia latifolia
Koelreuteria paniculata
Magnolia acuminata
Magnolia kobus
Magnolia stellata
Magnolia virginiana
Magnolia x loebneri
Magnolia x soulangiana
Malus species
Nyssa sylvatica
Parrotia persica
Pyrus calleryana cultivars
Quercus acutissima
Quercus alba
Quercus bicolor
Quercus phellos
Quercus rubra
Rhododendron species & cultivars
Stewartia koreana
Zelkova serrata

USDA PLANT HARDINESS ZONE





The Rhode Island Nurserymen's Learning Landscape has been created on the University of Rhode Island campus through the generosity of the Rhode Island Nurserymen's Association. The Learning Landscape and Sustainable Landscape are located adjacent to the Cooperative Extension Center and Plant Science Greenhouses, just west of Upper College Road at the north end of campus. The public is welcome at all times, and the gardens may be reserved for special events by prior arrangement with the Cooperative Extension Center (401-792-2900).

Directions to the Rhode Island Nurserymen's Learning Landscape:

From the North:

Travel south on I-95 to exit 9, Rt. 4 south. Travel south on Rt. 4, onto Rt. 1 south and turn right on 138 west. Travel 3.5 miles to Kingston and turn right at the second light, onto Upper College Road, and travel 3/4 miles to Alumni Avenue and the Learning Landscape on your left, across from the Fine Art Building.

From the East:

On I-195 from the Cape and southeastern Massachusetts travel to I-95 south and follow directions from the north, above. On Rt. 24 from eastern Rhode Island travel west to Rt. 138 and follow over the bridges to Rt. 1 south. Continue west on 138 to Kingston and follow the directions below.

From the South and West:

Travel north on I-95 from Connecticut to Exit 3 in Rhode Island. Exit onto 138 east and travel 14 miles to Kingston. Turn left at the first light in Kingston, onto Upper College Road, and travel 3/4 miles to Alumni Avenue and the Learning Landscape on your left, across from the Fine Art Building.

URI

Cooperative Extension
U.S. Department of Agriculture
The University of Rhode Island
Kingston, RI 02881-0804

Address Correction Requested

Official Business
PENALTY FOR PRIVATE USE, $300