GROWTH OF SOME SELECTED EXOTIC FIRS (Abies spp.) OVER THREE GROWING SEASONS IN WOLCOTT, VERMONT

M, L. McCormack, Jr.[1]

ABSTRACT

In the spring, 1972, several fir transplants (including Abies alba, A. x bornmulleriana, A, cephalonica, A. concolor, A. firma, A. fraseri, A. grandis, A, homolepis, A. lasiocarpa, A. procera, A. sachalinensis, and A, veitchii) were outplanted for evaluation as Christmas trees to be produced in northern New England. Differences in survival, growth, and development have been observed. Differences in preference by mice and deer have been expressed.

INTRODUCTION

As part of the University of Vermont research program on production of improved Christmas trees, a group of available exotic fir transplants were outplanted in May 1972. The site is a typical northern Vermont old farm field on a westerly slope exposed to winter weather conditions on the Wolcott Research Forest (44°35'N 72°30'W, Elev. 390 m.). The soils are shallow loams with some exposed rock ledges.

The growing season is restricted by possible last spring frosts in the first week of June and first fall frosts possible in early September. Maximum summer temperatures are usually of short duration, but may be as high as 33°C, Minimum winter temperatures are frequently as low as -30 C. Average annual precipitation usually ranges from 890 to 1015 mm. and is well distributed throughout the year.

The planting stock was four to six year old transplants. They were hand planted in 12-inch auger holes which allowed for careful distribution of the roots. In addition to periodic mowing between the rows, weeds have been continuously suppressed with band applications of simazine (2-chloro-4,6-bis (ethylamino)-s-triazine). The spacing was 1.5 m x 1.5 m. with the exotic species arranged in plots of five trees within rows. Outside buffer rows and alternate rows between single rows of test plots were planted with known sources of balsam fir (Abies balsamea (L.) Mill.) for comparison.

This limited planting is intended as a preliminary screening of the species available in order to gain information on:

1. Growth and development of branches and foliage,
2. Winter hardiness,
3. Frost resistance, and
4. Susceptibility to animal pests.

[1] Associate Professor, Department of Forestry, University of Vermont, Burlington.

SPECIES OBSERVED

Thirteen exotic firs are included in this planting.

From western North America:[2]

White fir (Abies concolor (Gord. & Glend. (Lindl.)
Grand fir (A, gran'dis (Dougl,) Lindl,)
Subalpine fir TA, lasiocarpa (Hook.) Nutt, var. lasiocarpa)
Corkbark fir (A, lasiocarpa var. arizonica (Merriam) Lemm.)
Noble fir (A, procera Rehd.)

From the southern Appalachian Mountains:

Fraser fir (A. fraseri (Pursh) Poir.)

From Europe and Asia Minor:[3]

European silver fir (A. alba Mill.)
Bornmueller fir (A. x bornmuelleriana) Mattf.)
Greek fir (A. cepTalonica loud.)

From Japan:

Momi fir (A, firma Sieb, et Zucc.)
Nikko fir TA, homolepis Sieb. and Zucc.)
Sakhalin fir (A, sachalinensis (Fr. Schm.) Mast.)
Veitch fir (A. veitchii Lindl.)

Of the firs observed two have been eliminated from evaluation. Noble fir has failed to develop beyond the transplant stage though it has remained alive. The single plot of Momi fir did not survive. A third, Greek fir, has failed to develop and numbers are slowly decreasing because of natural mortality and a decided preference for bark of this speices by small rodents, The planting site is located in an area where bark stripping of native species by rodents during winter has been a common problem in recent years. Greek fir is the only species in this planting which has been girdled by rodents.

OBSERVATIONS TO DATE

Table 1 summarizes the height growth of two seasons after allowing one year for establishment; average needle lengths are also listed. Table 2 ranks the first observed in order of decreasing height growth and needle length.

[2] Scientific names of North American firs are from Little, E. L., Jr., 1953. Checklist of native and naturalized trees of the United States. Agricultural Handbook No, 41, U.S. Forest Service, Washington, D.C.

[3] Scientific names of non-North American firs are from Liu, Tang-shui. 1971. A monograph of the genus Abies. Department of Forestry, College of Agriculture, National Taiwan University, Taipei, Taiwan, China.

Table 1.--Summary of growth data for some selected exotic fir species growing at the Wolcott Research Forest.

Species	1973 Ht Basis[1] (plots)	Grth (cm)	1974 Ht Basis (plots)	Grth (cm)	Needle Basis (trees)	Lgth[2] (cm)
A. alba	9	3.9	10	7.5	53	2.5
A. bornmuelleriana	6	6.0	6	9.0	34	3.2
A. cephalonica	5	3.9	6	6.6	30	1.8
A. concolor	4	11.3	4	17.1	15	5.4
A. fraseri	4	12.6	4	39.0	19	2.0
A. grandis	5	10.9	5	14.4	31	3.2
A. homolepis	7	10.7	7	19.8	47	2.4
A. lasiocarpa v. sasio.	1	3.5	2	6.5	9	2.8
A. lasiocarpa v. ariz.	1	5.4	1	22.6	5	3.5
A. sachalinensis	2	16.8	2	42.3	10	3.8
A. veitchii	8	12.9	8	33.2	54	2.5

[1] Each plot is a separate grouping of five trees.

[2] Three separate, random measurements of 1973 needles from each tree.

Table 2.--Ranking of selected firs according to height growth and needle length.

1973 Height Growth	1974 Height Growth	Needle Length
1. A. sachalinensis	1. A. sachalinensis	1. A. concolor
2. A. veitchii	2. A. fraseri	2. A. sachalinensis
3. A. fraseri	3. A. veitchii	3. A. bornmuelleriana A. grandis
4. A. concolor	4. A. homolepis	4. A. alba A. veitchii
5. A. grandis	5. A. concolor	5. A. homolepis
6. A. homolepis	6. A. grandis	6. A. fraseri
7. A. bornmuelleriana	7. A. bornmuelleriana	7. A. cephalonica
8. A. alba A. cephalinica	8. A. alba	
	9. A. cephalonica	

Longer needles contribute to the desirable characteristic of foliage density, Needle length does not provide a strong basis for choosing any of the firs studied as outstanding Christmas trees. White fir was the only species with needles which were unusually long with some examples up to eight centimeters. Greek fir exhibited needles which were unusually short. Most others suppported needles within the range of lengths found on balsam firs.

There was a wide variation in height growth. Sakhalin fir consistently produced the longest leaders, but had extremely poor branch development with abnormal secondary growths along the upper portion of the terminals. Veitch and Fraser fir were also outstanding for good height growth. Fraser fir tends to have poor internodal branch development, but other studies indicate this defect can be reduced by careful selection of seed source. The good height growth of Veitch fir is partly neutralized by deer (Odocoileus virginianus borealis Miller) browsing and bark stripping. In an area where deer damage is an extremely serious problem, this was the only species to be damaged in this planting. The first which rated low for height growth (European silver, Bornmueller, Grand) exhibited winter injury and winter burning of foliage above the spring snow line.

Foliage characterisitcs of the trees with satisfactory height growth and branch development were adequate for Christmas tree production. Subalpine fir, and especially Corkbark fir, produce foliage which is superior to any observed to date on the Wolcott Research Forest. Color evaluations using Munsell color charts were made for old growth foliage. Balsam, Greek, and Fraser firs were rated as 7.5 GY 3/2 to 4/4. European silver, Bornmueller, Grand, Nikko, Sakhalin, and Veitch firs all rated within 5 GY. Subalpine fir foliage was 7.5 GY 5/6 and the new growth of Corkbark fir, which was outstanding, rated as 7.5 G 6/2.

Phenology of bud break is important as it relates closely to susceptibility to spring frost injury and insect pests. There are wide variations in time of bud break within and between species. Because late flushing is a consistent and very beneficial characteristic, it is significant to note that Fraser fir can be as much as two to three weeks later than average native balsam firs. There are balsam firs which are as late, or later, in flushing as Fraser. Veitch fir appears to be comparable to Fraser. Nikko fir is the latest, with bud break as much as two to three weeks after Fraser and Veitch. Under Wolcott Research Forest growing conditions Nikko fir can be as much as six weeks later than average native balsams.

DISCUSSION

Animal pest problems and winter injury appear to be limiting factors. On this basis it seems realistic to disregard Greek, Momi, and Noble firs as possible Christmas trees in northern New England. Poor height growth of species like Subalpine fir apparently can be counteracted by providing partial overstory protection, Other outplantings on the Wolcott Research

[4] Munsell Book of Color.1963. Color charts for plant tissues. Munsell Color Company, Baltimore, Maryland.

Forest indicate this is possible. This approach has been followed with a high level of success in Denmark for producing high quality Christmas trees of Noble fir and Nordmann fir (Abies nordmanniana (Stev.) Spach). Firs which developed to a minimum acceptable level of quality at the Wolcott Research Forest possibly could be produced under a protective overstory; perhaps that of a longer rotation, high quality sawtimber crop. Of the first observed in this study, those considered as potential Christmas tree crops in northern New England grown under conditions suitable for balsam firs would be rated as follows:

1. Balsam fir
2. Fraser fir
3. Veitch fir
   Nikko for
4. White fir
5 Subalpine fir
   Corkbark fir

Modified cultural methods during production, better matching of site to seed source, and other exotic species are presently under consideration and study. However, variation within the indigenous species, balsam fir, is almost as great as that between the exotic firs that have been available for study.

DISCUSSION

Cech - Dick would it be feasible to list your "alias numbers" on that form so someone looking down the form could see who else has the particular scions?

Miller - This would require another ADP Program. We haven't reached the point in time when we would need this additional program. It's just as easy to keep a cuff record. If several cooperators were interested in this, it might be desirable to create another program that would list the alias numbers.

Cech - As I recall early discussions about this in the North Carolina State program and other programs there was-some question about scions being sent from secondary sources rather than the primary sources. There was some question about whether a company would want anybody to control distribution of scions from select trees they had located. I think perhaps you might get better cooperation if the "alias" or the originator of the clone were known.

Miller - I would assume that a tree being used in several improvement programs would be listed by each cooperator with his own tree number and accession number. In light of what you have just said Frank, I should modify the ADP Program to include a place for identifying the cooperator who made the initial selection. Then, if someone wanted to obtain material from a particular tree, he could contact the originator even though he saw the tree listed under another cooperator's program.

Ledig - Dick, are you looking just for select trees with desirable characteristics or any trees that have contributed progeny to testing programs and for which there is data?

Miller - We are looking for any trees that have been included in a tree improvement program. Actually, this would help the individual cooperators keep better track of their own materials. If a tree has been included in your improvement program, I think you would want it on the list.

Ledig - We don't really have an improvement program at Yale, but every year we make collections for the Mississippi State Sycamore Program, for Calvin Bey's ash program, our own pitch pine research, etc. All of these trees are under test and we have data on them. Would these trees be of any interest?

Miller - In our tree improvement program, every tree we select is put on this list. Twenty years from now someone is going to wonder where a clone or a seed source originated. They will be able to go to this list and find out.

Fechner - Does this program or something similar to it get input from other Regions or agencies? It comes to my mind that George Howe has a similar program.

Miller - Yes. All of the National Forest Regions are familiar with these programs. Dick Cunningham in Denver is using this same system throughout his area.

Steiner - Dick, can you handle stand collections with that system or is it limited to single tree selections?

Miller - The system is designed for single tree selections; however, I believe there is enough flexibility in the coding system to permit the identification of a stand collection.

Steiner - One other thing, do you have a system for handling growth data that is taken in these tests?

Miller - We have developed 15 ADP Programs to handle the data generated by our tree improvement program. Three programs provide up-to-date records of the material included in the improvement program; nine programs summarize and map data collected in seed orchards and evaluation plantations, and three other programs are used for statistical analysis. We use another program developed by G. R. Stairs to design our clonal seed orchards.

Schreiner - Cedric, when you speak of a swamp site, I assume you are not speaking of standing water. Moving water is essential to the oxygenation of most plants in water. We do have one swamp cottonwood, Populus heterophylla, that gets about as far north as New York and it really grows in standing water all year, but your swamps do dry out occasionally.

Larsson - That is correct. Our swamps are flooded for about seven months and then they generally dry out for the rest of the year.

Hunt - We were talking yesterday about some spin-off from Miller's listings if indeed someone did want to look at all of the white pine in the Northeast that had been selected by various states and screened them for non-crystallizing resin acids. It might be an easy way to just ask each state for material from their seed orchards and within a year you could probably run every tree through a program like that - superimpose another selection on top of the one you already have might help.

Sayward - Is there some way to get our hands on the original sheets submitted to you with exact locations, if we want to go to the trees? The forms you have described only list the county or origin.

Miller - If, for example, you want to know where the white spruce selections are in the Northeast, you can check the printouts, and then it would be up to you to contact the cooperator who selected the tree. He would be able to tell you where the tree is located. We will not keep a file of maps showing on-the-ground locations of individual tree selections.

van Kraayenoord - Larsson mentioned that P. jackii had fewer attacks by mice and deer. He also mentioned that it had a smooth bark and we found that rough bark trees are less attacked. Could it be that a chemical is involved that would make the P. jackii less attractive?

Larsson - We think that may be the case. We think it is probably inherited from the Populus balsamifera parent and that this character must be dominant as it appears to show up in most of the progeny. We have planted both clones and progeny in areas of high mouse, rabbit, and deer populations and have had no damage as compared to Populus deltoides clones which are always severely injured, They might nibble the bark to see what it tastes like, but they do not continue to feed.

Palpant - I just wanted to suggest that as time goes on, records have more and more value. We may eliminate a tree from a breeding program because of susceptibility to aphids or something like that, but it may have superior characteristics for other traits that we may want to include later on. At Penn State our philosophy is that old records become more valuable as memories fade and people move in and out of the program.

Hunt - I think that the weak link is how good the record is even before it is submitted. We have some without maps and from the descriptions on the sheets, we have been unable to find them. We also have some that are passed from state to state without a firm record being passed along with them. You might have height and diameter or some other characteristics for its neighbors, but the tree itself may have been cut.

McCormack - We still have some Abies lasiocarpa var. lasiocarpa alive and growing after 26 years. Dr. Adams who was in our Botany Department had these at the Jerico Research Forest for many years before I arrived at the University. About 8 or 9 years ago we dug them up and moved them up to our research forest at Wolcott. We may have stumbled onto something that is very interesting relative to light requirements and we are now ready to get height growth data on these trees.

Carlaw - Have you had any infestation of the budworm at all?

McCormack - Spruce budworm is a real concern to us up that way now. I have to confess that I was scared and more concerned about the survival of some other test trees in the area than I was in evaluating these for resistance. We did spray this spring, and I think we were successful in reducing the budworm population. I would like to expose these particular trees to the insect, but I didn't know how to expose only these and protect the other material in the same area. I don't think the Christmas tree growers can afford to spray, but I was chicken and we did.

Carlaw - But you do believe there is an infestation in the area?

McCormack - No. This question is a good one, and I wanted to mention this. The Abies homolepis sample that I showed you had not broken bud until mid-June, and it had already caught up in terms of its height growth, branch development, and any increase in size of the stem. It just grows faster during a shorter period. It has not been a problem in any of the trees we observed, and this late flushing has been observed for many. It seems to be a very consistent growth pattern.

Fechner - Ellie, is there any information on the carotenes of some of these species? It seems like 3-carene is totally lacking - almost like it was under single gene control.

Reddington - There has been a fair bit of work done though not in the firs. Hanover has looked at monoterpenes in pines and concluded that they are probably controlled by relatively few genes and that 3-carene may be controlled by a single gene. There has also been some work in Finland. Control of 3-carene is probably unlike that of the other monoterpenes.

Carlaw - How do you eliminate the fact of trees being under stress and hence perhaps more resins? Is that a factor rather than genetic differences? In other words, you are showing more terpenes in the mountain-top trees which are under stress; and, therefore, perhaps more resin - are you in danger of equating a local environmental situation into genetic differences?

Reddington - I think not, but this is why I have tested trees on more than one site. Trees grown from a mountain seed source, but growing at the research forest at Wolcott, sort of monoterpene profile as those growing on the mountain.

Jaynes - What about differences within a clone - I think you looked at grafts. More particularly, what about differences between the juvenile stage trees and mature trees with cones on them?

Reddington - I haven't really compared young seedlings with mature trees. In another experiment I used the smallest trees I could find as well as older trees. Here again, I found that high and low altitude trees were quite different, and even the real small seedlings already had the expected ratios of alpha- to beta-pinene. As far as the grafts are concerned, I don't have a lot of information. I did test grafts from one particular tree. These grafts were on half-sib root stocks from the parent tree. There was no correlation between root stocks and scions, but the differences between the grafts, both those growing in the greenhouse and those at Wolcott, were just about the same as you would expect if you took one twig from one area of a tree and another twig from another area of the same tree. There is a fair amount of within tree variability.

Little - Tom Ledig's remarks earlier in this meeting may have left you with a wrong impression, possibly similar to recent articles in National Geographic and the New Yorker magazines that implied that the Plains stands were more or less of an enigma as far as present knowledge is concerned. Actually, there have been many studies in that region and several false hypotheses have been responsible for the wrong impressions. John Harshberger, a botanist at the University of Pennsylvania, publised a book in which he put forth several false hypotheses. Harold Lutz in a Yale Forestry School bulletin disproved Harshberger's hypotheses. Jacob S. Joffe, a soil chemist from Rutgers, had the idea that soluble aluminum was a factor. John Andresen wrote his Ph.D. thesis, published in Ecological Monographs, mostly on soluble-aluminum effects. He disproved it as a factor, showing that soluble aluminum was associated with the amount of clay, and the more clay the more growth. The age of the Plains areas goes back to pre-settlement days, but Lutz showed that the location of Plains areas has changed through the years - through finding old charcoal pits in present-day Plains areas and through talking to a man who helped cut merchantable timber in parts of these areas. The primary factor is wildfire at fairly short internvals. Gifford Pinchot in about 1899 was the first to mention this fact. Lutz gave 8 years as the interval between killing fires in the Plains areas. John Andresen had the same conclusions. One important secondary factor is the age of the stools. The last sprouts started when the stools were 40 to 60 years old, and naturally on such stools you don't get the growth that you would expect for seedling sprouts. Competition is another factor. You can have 100 to 200 sprouts on a single stool of pitch pine in the Plains a year after a killing fire, and then there is the competition between stools. In areas that have escaped fire for 20 years, we have counted 16,000 stems per acre. Another secondary factor is "pine bailers" - the local "pineys" who collect cones year-round for the florist trade - cones used for decorations. They cut branches and tops to obtain cones. Insects and possibly air pollutants are perhaps factors, but very little is known about their effects. Soil is apparently not a factor. The original soil surveyor found all types of Pine Barren soil in Plains areas, and soil drainage varies from excessively drained to at least poorly drained. White pines we planted in one Plains areas 15 years ago show a possible site index of 80 feet in 50 years. I do agree with Tom that recent results do indicate that genetics may be a factor. I hadn't thought that was a possibility because the areas are surrounded by normal pitch pine. However, our recent results to indicate that seedlings from local Plains seed in the same study area are developing a flat top, an indication of early maturity

so perhaps there has been some selection for special races as a result of the fire history.

Ledig - I might mention one thing in this regard, John Fryer's dissertation was a comparison of Pine Plains and other populations in the greenhouse. He used electrophoretic techniques to investigate isozyme differences. The Pine Plains' seedlings were distinct from any other population that he looked at, including a couple from less than 10 miles away in the surrounding Pine Barrens, The Pine Plains definitely are genetically distinct. How they will behave in terms of growth rate at advanced ages is still to be seen.

Steiner - I wonder if those small genetic differences between the Plains pitch pine and other nearby provenances are any larger than you would expect between any two sources that far apart.

Ledig - No. They are very small differences, We compared the Pine Plains (2 provenances) with 10 populations from the surrounding Pine Barrens. Each of the 10 had mean height greater than the mean height of the two Pine Plains' populations, but the difference was only 4 centimeters in two years; nothing to get excited about yet.

Sayward - Do you think there is a difference in height or elevation in light intensity in collecting the trees at the mountain tops, or dormant trees as opposed to shady trees, or trees on lower slopes in terms of their variation?

Reddington - That is one thing that I probably should have mentioned. The trees that I sampled on the mountain were for the most part on the western or exposed slope I did take some trees for another study from 3600 feet on the east or lee side of the mountain. These looked like lower altitude trees, so I think that precipitation or wind drainage pattern may have something to do with it.

RESOLUTIONS

The Conference unanimously adopted the following resolutions submitted by the Resolutions Committee, David Canavera and Henry Gerhold, Chairmen:

WHEREAS the members of the 23rd Northeastern Forest Tree Improvement Conference enjoyed the outstanding program arrangements, and the fine facilities of the Continuing Education Center of Rutgers University,

THEREFORE be it resolved that we express our appreciation

to Dick West for the excellent overall arrangements;

to Dean Grant Walden for his warm, personal welcome;

to Elwin Orton and Dick West for their most interesting and refreshing overview of breeding and research in hollies, dogwoods, Christmas trees, and other species;

to Bill Flemer III for the privilege of seeing the extensive plantings of Princeton Nurseries;

and to Si Little and Tom Ledig for guiding us through experiments with pitch pine and its hybrids with loblolly pine.

ATTENDANCE

CAMERON, E. Alan – The Pennsylvania State University, Department of Entomology, 106 Patterson Building, University Park, PA 16802
CANAVERA, David - School of Forest Resources, University of Maine, Orono, ME 04473
CARLAW, James - Woodlands International Paper Company, P.O. Box 1500, South Glens Falls, NY 12801
CECH, Franklin – West Virginia University, Route 7, Box 155, Morgantown, WV 26506
CONNOLA, Donald P. - New York State Museum and Science Service, Rm. 985, State Education Bldg. Annex, Albany, NY 12224
DAVIDSON, Walter H. - USDA Forest Service, P.O. Box 1151, Kingston, PA 18704
DEMERITT, M. E. Jr. – USDA Forest Service, P.O. Box 640, Durham, NH 03824

FECHNER, Gilbert H. - Colorado State University, Fort Collins, CO 80523

FERET, Peter – Dept. of Forestry & Forest Products, Virginia Polytechnic Institute, Blacksburg, VA 24060

GENYS, John B. - Natural Resources Institute, University of Maryland, College Park, MD 20742
HICKS, Ray R. - Stephen F. Austin State University, School of Forestry, Nacogdoches, TX 75961
HOCKER, Harold W. - Inst. Nat. & Environ. Resources, James Hall, University of New Hampshire, Durham, NH 03824
HOLMES, Francis - Shade Tree Laboratories, University of Massachusetts, Amherst, MA 01002
HUNT, Clyde - USDA Forest Service, 6816 Market Street, Upper Darby, PA 19082
HUTCHINSON, Fred - Maine Agricultural Experiment Station, University of Maine, Orono, ME 04473
JAYNES, Richard A. - The Connecticut Agricultural Experiment Station, Box 1106, New Haven, CT 06504
KARNOSKY, David - The Cary Arboretum, Box AB, Millbrook, NY 12545

KEYS, Roy - Forestry Department, West Virginia University, Morgantown, WV 26506
LARSSON, H. Cedric - Ministry of Natural Resources, Forestry Research Branch, Maple, Ontario, Canada
LEDIG, F. Thomas - Yale University, School of Forestry, 370 Prospect Street, New Haven, CT 06511
LITTLE, Silas - USDA Forest Service, P.O. Box 115, Pennington, NJ 08534

McCORMACK, M. L. - The University of Vermont, Department of Forestry, Hills Science Bldg., Burlington, VT 05401
MILLER, Richard G. - USDA Forest Service, 633 West Wisconsin Avenue, Milwaukee, WI 53203
PALPANT, Edgar H. - The University of Pennsylvania, Forestry Research Laboratory, University Park, PA 16802
POST, Boyd - USDA, Cooperative State Research Service, Washington, DC 20250

REDDINGTON, Eleanor - Dept. of Botany, University of Vermont, Burlington, VT 05401
SAMMAN, Safiya - Department of Forestry, The University of Tennessee, Knoxville, TN 37901
SANTAMOUR, Frank S. Jr. - U.S. National Arboretum, Washington, DC 20002

SAYWARD, William R. - Georgia-Pacific Corporation, Woodland, ME 04694

Schmitt, Daniel M. - USDA Forest Service, P.O. Box 640, Durham, NH 03824

SCHREINER, E. J. - Bagdad Road, Route 1, Durham, NH 03824

STEINER, Kim - The University of Pennsylvania, 108 Ferguson Bldg., University Park, PA 16802
TREW, I. F. - Westvaco Corporation, Box 46, Ivy, VA 22945

VAN KRAAYENOORD, C. W. - National Plant Materials Centre, Ministry of Works & Development, Private Bag, Palmerston North, New Zealand

VERRIER, Philip - Division of Resources Development, State of New Hampshire, State House Annex, Concord, NH 03301
WARGO, Philip M. - USDA Forest Service, 151 Sanford Street, Hamden, CT 06514

WEST, Richard - Department of Horticulture and Forestry, Cook College, P.O. Box 231, Rutgers University, New Brunswick, NJ 08903
WESTFALL, Robert - SERM, Dept. of Silviculture, SUNY College of Forestry, Syracuse, NY 13210