

VARIATION IN EARLY GROWTH AND SURVIVAL  
OF YELLOW BIRCH PROVENANCES

Knud E. Clausen<sup>1</sup>

A range-wide study of variation in yellow birch (Betula alleghaniensis Britt.), initiated by the Institute of Forest Genetics, Rhinelander, Wisconsin, in 1963, includes 55 provenances (Fig. 1). Nursery observations showed that variation in shoot growth initiation and cessation of the provenances was clinal (Clausen 1968, Clausen 1973b). Similarly, the degree of winter injury to the provenances was related to their origin (Clausen and Garrett 1969). The seedlings also varied greatly in height and diameter, but variation in these characteristics showed no clear geographic pattern (Clausen 1973b). The provenances were subsequently outplanted at 11 locations in the U. S. and Canada and their survival and growth after 5 years in the field are discussed in this paper.

METHODS

Details of provenance origins, seed collection procedures, and handling of the material in the nursery at Rhinelander have been described previously (Clausen 1968). One-year-old seedlings of 30-36 provenances sent to four cooperators in the spring of 1966 were later field-planted as 1-2 plants. In the spring of 1968, when the seedlings grown at Rhinelander were 3 years old, the Institute established 5 plantations containing all 55 provenances in Minnesota, Wisconsin, and Michigan. Two additional plantations were planted by the Canadian Forestry Service. The Institute plantings were arranged as randomized blocks with 10 or 15 replications and 4-tree plots at 8 x 8 ft. spacing. Most of the cooperators also used 4-tree plots and 8-ft. spacing, but the number of replications varied.

The plantations were checked for survival after 1, 2, and 5 years in the field. Replacements were made in some plantations 1 and 2 years after planting. Height of the surviving plants in the successful plantations was measured at the end of the fifth growing season.

RESULTS AND DISCUSSION

Early survival of many provenances was poor and kept declining in several plantations due to severe competition from weeds and woody vegetation. Consequently, six of the eleven plantations -- two in Minnesota, one in Wisconsin, two in Michigan, and one in Ontario -- had to be abandoned. Useable data were only obtained from the remaining 5 plantations (Table 1). Plantations 3, 4, and 5 were established by Michigan State University, the State University of New York at Syracuse, and the Canadian Forestry Service, respectively.

Principal Plant Geneticist, USDA Forest Service, North Central Forest Experiment Station, Institute of Forest Genetics, Rhinelander, Wisconsin 54501



Figure 1.--Approximate natural range of yellow birch and geographic origins of 55 provenances included in the test.

Table 1.--Location of yellow birch test plantings and number of provenances and replications in each.

Plantation number	State or Province	County	Lat. N	Long. W	No. of provenances	No. of replications
1	Wisconsin	Sawyer	45.9	91.0	55	15
2	Michigan	Gogebic	46.3	89.4	55	10
3	Michigan	Kalamazoo	42.3	85.3	36	5-10
4	New York	Onondaga	42.8	76.1	36	2
5	New Brunswick	Queens	45.8	66.0	45	10

Survival in the two plantations (1 and 2) containing all 55 provenances averaged 32.1 and 33.5 percent, respectively (Table 2). Average survival in the Lower Michigan (3) and New York (4) plantations, each containing only 36 provenances, was much better, and the 45 provenance New Brunswick plantation (5) had the best survival, 82.6 percent. The very low survival percentage in plantations 1 and 2 was partly due to competition, but the trees also suffered severe attacks by two canker diseases, Diaporthe alleghaniensis and Gnomonia setacea. Since the seedlings used in plantations 1, 2, and 5 were all grown in the Rhinelander nursery and those in plantation 5 were not attacked by disease, infection of the trees in plantations 1 and 2 probably took place after they were moved into the field.

Because the provenances had such poor survival in plantations 1 and 2 and were only replicated twice in plantation 4, statistical analyses of survival and height in these plantations were based on completely randomized plots, instead of on randomized complete blocks. The provenances differed significantly in survival at the three northern test locations but not in the two more southerly plantations (Table 3). Calculation of variance components showed that the variation in survival due to provenances amounted to 5 percent in plantation 1, 11 percent in plantation 2, and 12 percent in plantation 5.

As expected, there was considerable variation within a plantation in the survival of the various provenances (Table 2). Northern provenances survived better than southern provenances in Wisconsin and Upper Michigan (Fig. 2) but in New Brunswick the correlation between survival and latitude of provenance origins, though significant ( $r = .4085$ ), was poor. Survival in the Lower Michigan and New York plantations was not related to the origin of the provenances;  $r = .3024$  and  $.0811$ , respectively. The trees from Tennessee, Kentucky, and Ohio were not hardy in the Wisconsin and Upper Michigan plantations but survived reasonably well at other locations. The "local" provenance or the one originating closest to the plantation location was not the best survivor in any of the plantations, but usually had about average survival (Table 2).

The average plant height after 5 years in the field ranged from a low of 126.4 cm in the New York plantation to a high of 333.6 cm in the Lower Michigan plantation (Table 2). The very low value in plantation 4 is not due to a poor site or poor performance of the provenances but rather to the fact that the trees were severely girdled by rodents during the winter of 1970-71. Thus, the height measurements taken in the fall of 1972 mostly represented sprout growth and are not a good measure of the potential performance of the provenances at this location.

Differences in height among provenances were highly significant in all but plantation 2 where the difference was only significant at the .05 level (Table 3). The provenance component accounted for about 7 percent of the variation in plantations 1 and 2, for about 13 percent in plantations 4 and 5, and for 22 percent in plantation 3. Thus, the greatest differentiation among the provenances was in the plantation that also had the greatest height.

Table 2.--Average survival and height of yellow birch provenances after 5 years in the field.<sup>a</sup>

Provenance No.	Origin	Survival (percent)						Height <sup>b</sup>					
		Plantation					Mean	Plantation					Mean
		1	2	3	4	5	Mean	1	2	3	4	5	Mean
3243	NF	43	42	-	-	78	54.3	96	119	-	-	93	102.7
3244	"	32	55	-	-	98	61.7	98	96	-	-	110	101.3
3241	NS	40	58	63	61	85	61.4	84	102	97	111	88	96.4
3065	"	47	58	67	92	85	70.0	93	93	111	101	97	99.0
3242	"	28	22	67	86	78	56.2	94	81	121	116	101	102.6
3063	"	33	45	69	-	88	56.8	98	102	104	-	93	99.2
3068	NB	22	22	53	61	82	48.0	87	82	106	100	106	96.2
3066	"	40	49	56	82	72	59.8	86	96	77	93	88	88.0
3067	"	28	35	-	-	-	31.5	75	94	-	-	-	84.5
3001	PQ	52	48	60	50	78	57.6	111	77	85	81	95	89.8
2998	"	40	35	-	-	90	55.0	85	97	-	-	105	95.7
2997	"	38	40	58	79	75	69.0	103	94	105	82	100	96.8
2999	"	50	45	80	90	90	71.0	101	92	102	104	92	98.2
3000	"	37	32	64	69	90	58.9	102	86	90	101	105	96.8
3002	ON	40	22	68	0	92	70.1	111	117	132	-	106	116.5
3003	"	33	70	-	-	77	60.0	121	99	-	-	93	104.3
3004	"	53	58	-	63	92	66.5	109	109	-	99	94	102.8
3311	"	22	25	-	-	-	23.5	110	89	-	-	-	99.5
3309	"	40	50	62	56	80	57.6	90	104	90	88	95	93.4
2977	ME	53	38	58	53	-	50.5	110	94	113	111	-	107.0
2956	"	18	18	59	62	92	49.8	94	69	109	91	106	93.8
2985	NH	30	28	58	44	-	40.0	94	107	99	91	-	97.8
2986	"	27	15	75	-	88	51.2	92	103	84	-	108	96.8
2982	VT	27	18	62	36	80	44.6	88	102	87	75	103	91.0
2971	MA	40	22	70	100	78	62.0	108	115	92	102	104	104.2
2980	NY	40	45	-	-	90	58.3	96	111	-	-	101	102.7
2996	"	25	22	72	50	79	49.6	99	112	109	119	108	109.4
2976	"	43	18	-	76	82	54.8	104	107	-	90	103	101.0
2979	PA	15	32	-	86	73	51.5	126	92	-	120	99	109.2
3312	"	30	28	69	60	-	46.8	102	119	108	81	-	102.5
2969	WV	20	15	-	-	90	41.7	92	117	-	-	102	103.7
3299	VA	17	22	50	89	70	49.6	92	125	96	106	94	102.6
2959	NC	18	12	60	81	87	51.6	109	128	106	105	100	109.6
2973	GA	23	15	-	-	82	40.0	85	87	-	-	91	87.7
2953	TN	2	0	47	28	-	19.2	127	-	88	70	-	95.0

Table 2.--cont.

Provenance No. Origin	Survival (percent)							Height <sup>b</sup>										
	Plantation							Plantation										
	1	2	3	4	5	Mean	1	2	3	4	5	Mean						
2954 TN	2	0	64	67	-	32.2	95	-	112	67	-	91.3						
3294 KY	5	5	-	-	58	22.7	78	116	-	-	73	89.0						
2955 OH	7	2	-	-	-	4.5	102	44	-	-	-	73.0						
2958 IN	13	20	45	71	62	42.2	72	83	111	111	94	94.2						
2983 IL	28	22	70	100	-	55.0	104	109	110	128	-	112.8						
3295 IA	17	35	-	-	80	44.0	120	101	-	-	112	111.0						
2961 MI	42	35	-	-	82	53.0	126	93	-	-	102	107.0						
2960 "	25	42	53	86	80	57.2	98	108	109	99	106	104.0						
2978 "	42	65	-	-	82	63.0	102	76	-	-	96	91.3						
2987 "	33	<u>50</u>	61	72	-	54.0	102	<u>90</u>	98	94	-	96.0						
2968 WI	<u>33</u>	22	72	80	90	59.4	<u>95</u>	87	84	98	102	93.2						
3298 "	<u>32</u>	40	56	80	82	58.0	<u>100</u>	106	108	112	103	105.8						
3297 "	38	38	55	-	80	52.8	109	119	85	-	109	105.5						
2962 "	22	20	-	64	82	47.0	98	108	-	136	109	112.8						
2963 "	45	40	<u>61</u>	62	90	59.6	133	118	<u>94</u>	131	104	116.0						
2964 MN	30	37	69	78	68	56.4	84	107	92	97	106	97.2						
2965 "	48	45	-	-	87	60.0	103	115	-	-	100	106.0						
2966 "	55	55	70	83	85	69.6	96	96	96	115	108	102.2						
2967 "	32	32	62	86	98	62.0	91	96	105	95	98	97.0						
2957 IR	43	60	67	67	95	66.4	93	93	81	84	100	90.2						
Mean	32.1	33.5	63.0	70.4	82.6	-	Mean height (cm)						220.7	215.0	333.6	126.4	226.6	-

<sup>a</sup> Values for provenances closest to plantation location are underlined.

<sup>b</sup> Expressed as percent of the plantation mean.



Table 3.--Results of analysis of variance for differences among provenances.<sup>a</sup>

Characteristic	Significance of F <sup>b</sup>				
	Plantation				
	1	2	3	4	5
Survival	**	**	NS	NS	**
Height	**	*	**	**	**

<sup>a</sup> Analysis based on completely randomized plots in plantations 1, 2, and 4, and on randomized blocks in plantations 3 and 5.

<sup>b</sup> \*\* = significant at .01 level  
 \* = significant at .05 level  
 NS = not significant

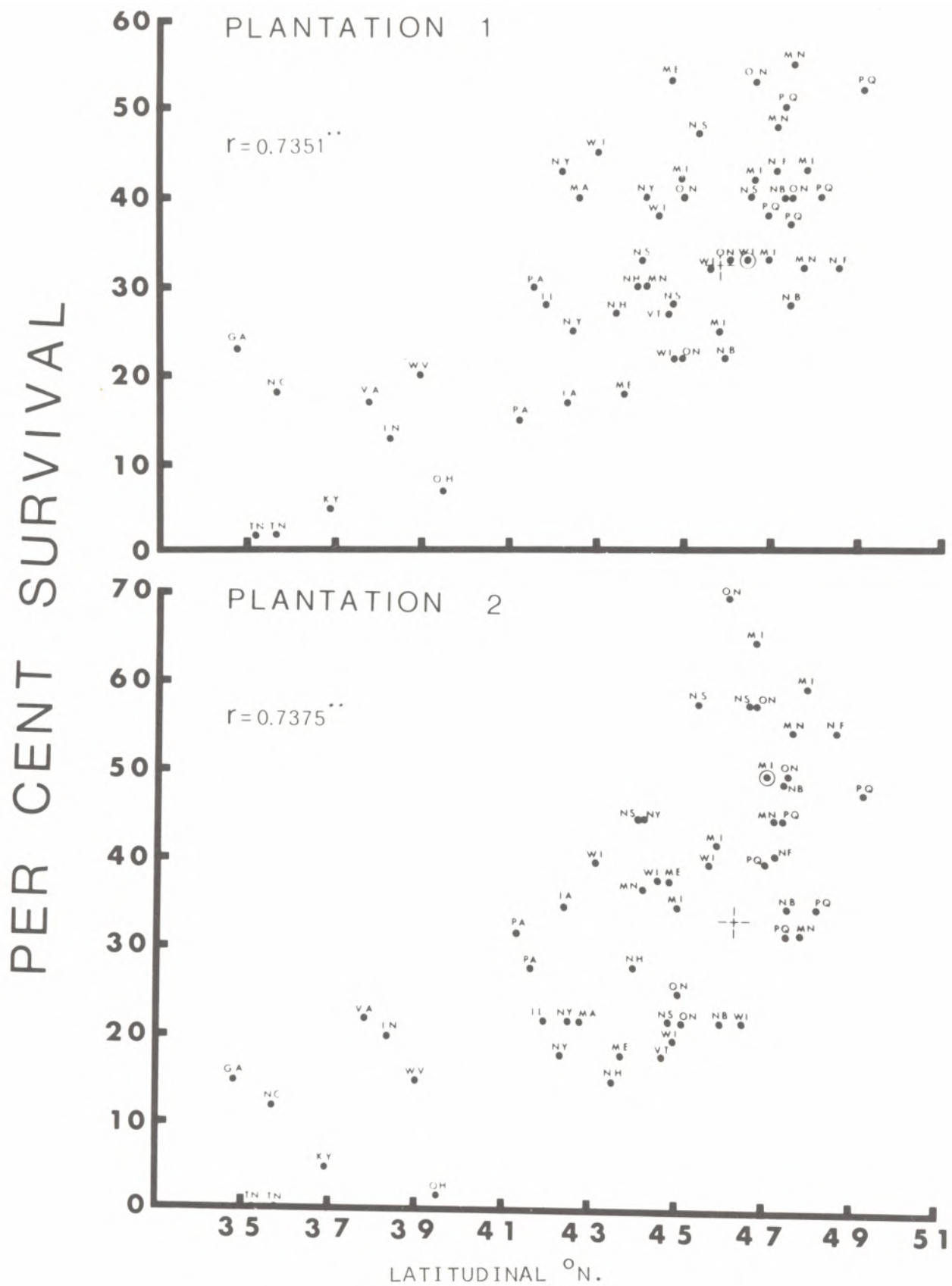


Figure 2.--Survival and seed origin of 55 yellow birch provenances planted in Wisconsin (upper) and Upper Michigan (lower).  
 + = average survival and latitude of plantation.  
 · = provenance originating nearest to plantation location.  
 \*\* = significant at the .01 level.

Height of the individual provenances varied greatly within a plantation. It ranged from 44 to 128 percent of the plantation mean in plantation 2, but only from 73 to 112 of the mean in plantation 5 (Table 2). Height of the provenances was, however, not correlated with their origin in any plantation. The provenance closest to the plantation had below average height in all but the New Brunswick plantation, where it was 6 percent above average (Table 2). Thus, there were always several provenances taller than the "local" provenance.

Due to the rodent damage in the New York plantation, provenance heights have very little meaning in this plantation and will not be discussed further. Because growth of the individual provenances was highly variable in the other 4 plantations, it is difficult to discuss their performance. Instead, the provenances were arranged in 12 somewhat arbitrary regional groups and average heights and ranks calculated for each group.

On a grouped basis (Table 4), the provenances from Massachusetts, New York, and Pennsylvania emerge as generally good performers. This group ranked among the best four in all 4 plantations. The four provenances from southeastern Ontario performed very well in the Lake States but rather poorly in New Brunswick. The 4 provenances from Illinois, Iowa, southern Wisconsin and southern Minnesota, and the 3 provenances from northwestern Wisconsin reacted similarly in being among the best in Wisconsin, Upper Michigan and New Brunswick and among the poorest in Lower Michigan. The provenances originating close to Lake Michigan and western Lake Superior (3309, 2960, 2961, 2962) had average or above average performance at all 4 locations. The 5 New England provenances as a group did very well in New Brunswick, but poorly in the Lake States. The provenances from West Virginia, Virginia, Ohio, and Indiana had generally poor growth except in Lower Michigan. The Quebec provenances and those from northern Minnesota, Isle Royale, and western Upper Michigan had average or below average performance at all locations. The provenances from New Brunswick and the Gaspé were uniformly poor, even in New Brunswick (Table 4).

#### CONCLUSION

The results reported in this paper demonstrate that yellow birch provenances differ greatly in their performance when planted at different locations. Whereas the same material showed no clear geographic variation pattern in height and diameter growth when in the nursery (Clausen 1973b), some regional trends or groups of provenances now seem to be emerging.

Provenance origin seemed to be important for survival in the three northern plantations (1, 2, and 5). Northern provenances generally survived better than southern provenances in the Wisconsin and Upper Michigan plantations which are in the most severe climate. The trend was less pronounced in the New Brunswick plantation which is at about the same latitude as plantation 1 but in a much milder climate. In contrast, survival did not appear related to latitude of origin in the more southerly plantations (3 and 4). Apparently, there is greater differentiation among the provenances at the northern test locations where they are under greater climatic stress than at the southern locations.



Table 4.--Average height and rank of groups of yellow birch provenances in 4 plantations.

Provenance Group	Plantation								
	No.	1		2		3		4	
Origin	Prov.	Ht.	Rank	Ht.	Rank	Ht.	Rank	Ht.	Rank
NF, NS	6	207	10	213	6	361	2	220	9
NB. and 3001	4	198	11	188	11	298	12	218	11
PQ (less 3001)	4	215	8	198	9.5	330	7	228	6
Southeastern ON	4	249	1	223	4	442	1	221	8
ME, NH, VT	5	210	9	204	7	329	9	239	2
MA, NY, PA	6	234	3	236	1	344	4	233	4
WV, VA, OH, IN	4	197	12	198	9.5	346	3	219	10
KY, NC, TN, GA	5	218	6	181	12	340	5	200	12
IL, IA, 2963, 2964	4	244	2	235	2	330	8	243	1
3309, 2960, 2961, 2962	4	228	4	222	5	333	6	233	5
Northwestern WI	3	224	5	224	3	309	11	237	3
MN, MI, 2957	6	216	7	203	8	317	10	227	7

Although variation in shoot growth initiation and cessation of these provenances has been shown to be clinal (Clausen 1968, Clausen 1973b), height growth of the provenances showed no comparable direct relationship to their origin. However, certain regional groups of provenances appear to show some consistency in their performance. Thus, provenances from Massachusetts, New York, and Pennsylvania grew well when moved west and north to Wisconsin and Michigan, and also when moved north and east to New Brunswick. On the other hand, provenances from Illinois, Iowa, southern Wisconsin and southern Minnesota performed well when moved to northern Wisconsin and Upper Michigan and north and east to New Brunswick, but rather poorly when moved to southern Lower Michigan. Similarly, a group of provenances from southeastern Ontario grew well when moved west and south to Wisconsin and Michigan, but not as well when moved east to New Brunswick. At the other extreme, provenances from New Brunswick and the Gaspe Peninsula of Quebec had poor performance at all test locations.

Few individual provenances had consistently good performance at all locations. Of the provenances present in all 5 plantations, one Quebec provenance (2999) had the best overall survival and a southeastern Wisconsin provenance (2963) had the greatest average height. Ontario provenance 3002 had the best average survival and height among the provenances tested in 4 plantations only. A high-elevation North Carolina provenance had surprisingly good growth at these northern test locations with average or above average height in all 5 plantation.

As demonstrated previously, there is much within-provenance variation in yellow birch (Clausen 1973a). This was also apparent in this material and often resulted in large differences among the trees in a 4-tree plot. The heights reached after 5 years in the field by individual trees planted as 30-80 cm tall seedlings are an indication of the growth potential of yellow birch. Height of the tallest tree was 525 cm in plantations 1 and 3, 455 cm in plantation 2, 365 cm in plantation 5, and 305 in plantation 4. These are excellent growth rates for northern hardwood trees. The fact that the 36 provenances tested in plantation 3 averaged 3.34 m (10.9 ft.) in height also shows that yellow birch is capable of very good growth when it is planted on a reasonably good site and receives proper care. Very likely the species can produce even better growth if it is more intensively managed.

These early results indicate that considerable improvement in growth rate of yellow birch can be achieved through the use of good provenances. They also show that the best provenances may be found outside the local region.

#### ACKNOWLEDGEMENT

The help of various cooperators in establishing the test plantings and in the collection of data is greatly appreciated.

#### LITERATURE CITED

- Clausen, Knud E. 1968. Variation in height growth and growth cessation of 55 yellow birch seed sources. Proc. 8th Lake States Forest Tree Improv. Conf., Madison, Wis., Sept. 12-13, 1967, p. 1-4.
- Clausen, Knud E. 1973a. Within-provenance variation in yellow birch Proc. 20th Northeastern Forest Tree Improv. Conf., Durham, N.H., July 31-Aug. 2, 1972, p. 90-98.
- Clausen, Knud E. 1973b. Genetics of yellow birch. USDA For. Serv. Res. Pap. W0-18, 28 p.
- Clausen, Knud E. and Peter W. Garrett. 1969. Progress in birch genetics and tree improvement. In Birch Symp. Proc.: 86-94. USDA For. Serv., Northeast. For. Exp. Sta., Upper Darby, Pa.