A PROVENANCE TEST OF GREEN ASH[1]

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ABSTRACT.--This paper describes the origin, establishment, and objectives of a test of 60 provenances of green ash planted in ten northern states. Survival and growth through the sixth year are briefly summarized.

Green ash (Fraxinus pennsylvanica Marsh.) occurs naturally under as wide a variety of environmental and biotic conditions as nearly any native American tree species. Between the extremities of the species' natural range, mean annual precipitation varies from 36 to 160 cm, mean annual minimum temperature from below -40°C to above -7°C, and the frost-free season from 100 to 280 days. The species typically occurs on seasonally wet soils of floodplains or near pond margins in association with such species as sugarberry, red maple, American elm, sweetgum, and eastern cottonwood. But green ash is also capable of invading and growing rapidly in moist, upland fields in association with white ash. In the western portion of its distribution, green ash grows in ravines and along small streams, and in Wyoming it may be found growing near water courses in close association with grass, cacti, and ponderosa pine.

The ability of green ash to grow in a wide range of environments is reflected in the uses to which the species is put. It is one of the principal street and shade trees of the East and Midwest, and one of the most

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frequently planted tree species in shelterbelts in the prairie regions of the U.S. and Canada. Green ash has been used for several decades in reclaiming strip-mined lands in the Midwest. The species has not been widely used in forest plantations in the U.S., although its use is increasing especially in the South.

The ecological distribution of green ash suggests considerable genetic variability and potential for improvement through selection. The fact that it is planted probably more frequently in non-native than native habitats, even within its natural range, makes provenance selection a particularly appropriate method of genetic improvement in this species (Nienstaedt 1979). Several studies have compared provenances in portions of the species' range (Meuli and Shirley 1937, Woessner and Hicks 1975, Wright 1944, Ying and Bagley 1976). This paper describes the establishment and progress in a provenance/progeny experiment designed primarily to supply information on genetic variation applicable to the northeastern quadrant of the U.S., where green ash is especially important as a street tree.

SEED COLLECTION

The seeds for this study were collected in fall 1975 from 216 female trees representing 60 provenance locations scattered throughout much of the range of green ash (Table 1 and Figure 1). Each provenance was represented by seed from two to four trees separated from one another by a minimum distance of 90 m but all growing within a locality of no more than 26 km . In all but three cases„ the trees representing a provenance were believed to be native to their sites.

About 10 percent of the parents were chosen for superior form; the remainder were considered average compared to other trees in each stand. Although seed collections were treated primarily as provenance collections, the separate identity of most single-tree progenies has been maintained throughout the study.

NURSERY PRACTICE

In November 1975, the seedlots were sown in random arrangement by family in nursery beds at two locations in central Pennsylvania. In April 1977, after one year of growth, the seedlings from both nurseries were transplaned to a single location at a maximum density of 34/m . Seedlings in the transplant bed were randomized by provenance with family sub-plots and two replicate

TABLE *1.* -- Geographic origins of population samples represented in the study.

Number (75KS---P)	Female parents	North latitude	West longitude	Elevation (meters)	County	State or province
045	?	-- cultivated --			Centre	PA
046	2	38°36'	75°58'	6	Dorchester	MD
073	4	43°18'	103°42'	1097	Fall River	SD
093	4	49°50'	97°06'	381	--	Man.
138	3	39°26'	86°49'	?	Owen	IN
141	2	39°22'	84°30'	?	Butler	OH
145	3	35°55'	87°47'	?	Humphreys	TN
153	2	37°53'	87°34'	?	Henderson	KY
155	2	38°33'	82°45'	?	Lawrence	OH
161	4	40°30'	90°00'	?	Mason	
165	4	39°58'	91°25'	?	Adams	IL
169	4	39°00'	90°30'	?	Jersey	IL
173	4	38°12'	88°55'	?	Jefferson	IL
177	4	36°40'	89°13'	?	Mississippi	MO
185	4	36°18'	84°13'	?	Cambell	TN
189	4	37°45'	84°15'	?	Madison	KY
193	4	37°45'	80°50'	?	Summers	WV
197	4	45°48'	103°30'	1020	Harding	SD
201	4	41°50'	73°33'	?	Dutchess	NY
205	4	42°02'	73°37'	?	Columbia	NY
211	2	43°01'	80°25'	251	Brant	Ont.
214	2	-- cultivated --			--	Alb.
217	4	44°22'	73°10'	108	Chittenden	VT
225	4	47°13'	95°11'	454	Clearwater	MN
233	4	36°58'	91°00'	146	Carter	MO
237	4	34°05'	82°17'	122	Greenwood	SC
249	4	39°55'	82°25'	283	Licking	OH
253	4	42°20'	85°20'	265	Kalamazoo	MI
265	4	-- cultivated --			Centre	PA
269	4	43°39'	103°02'	914	Custer	SD
273	4	43°28'	103°21'	1006	Fall River	SD
277	4	40°33'	77°09'	?	Perry	PA
293	4	43°33'	86°07'	?	Oceana	MI
305	4	44°10'	76°48'	84	--	Oat.
309	4	36°10'	84°04'	266	Anderson	TN
317	4	40°58'	97°13'	?	Seward	NE
321	4	42°40'	103°10'	1280	Dawes	NE
337	4	46°41'	71°55'	?	Portneuf	Que.
345	4	37°43'	89°30'	122	Jackson	IL
373	4	43°03'	76°04'	138	Onondaga	NY
393	4	37°17'	78°24'	?	Prince Edward	VA
397	4	37°31'	80°06'	389	Craig	VA
405	4	42°00'	97°05'	?	Stanton	NE
409	4	42°01'	97°25'	?	Madison	NE
413	4	42059'	103°34'	1158	Sioux	NE
417	2	43°55'	102°21'	876	Pennington	SD
425	4	42°02'	93°38'	274	Story	IA
429	4	40°26'	86°57'	183	Tippecanoe	IN
437	4	47°10'	103°22'	823	McKenzie	ND
441	4	41°53'	100°19'	853	Thomas	NE
450	2	39°22'	75°39'	14	Newcastle	DE
453	4	34037'	93°37'	177	Montgomery	AR
469	4	38°33'	90°15'	139	St. Louis	MO
477	4	37°10'	89°22'	104	Alexander	IL
505	4	45°47'	77°04'	130	Renfrew	Ont.
509	3	50°27'	95°25'	305	--	Man.
513	4	50°40'	99°30'	396	--	Man.
529	3	43°29'	79°59'	?	--	Ont.
533	4	44°32'	104°05'	1090	Crook	WY
541	3	50042'	103°38'	482	--	Sas.

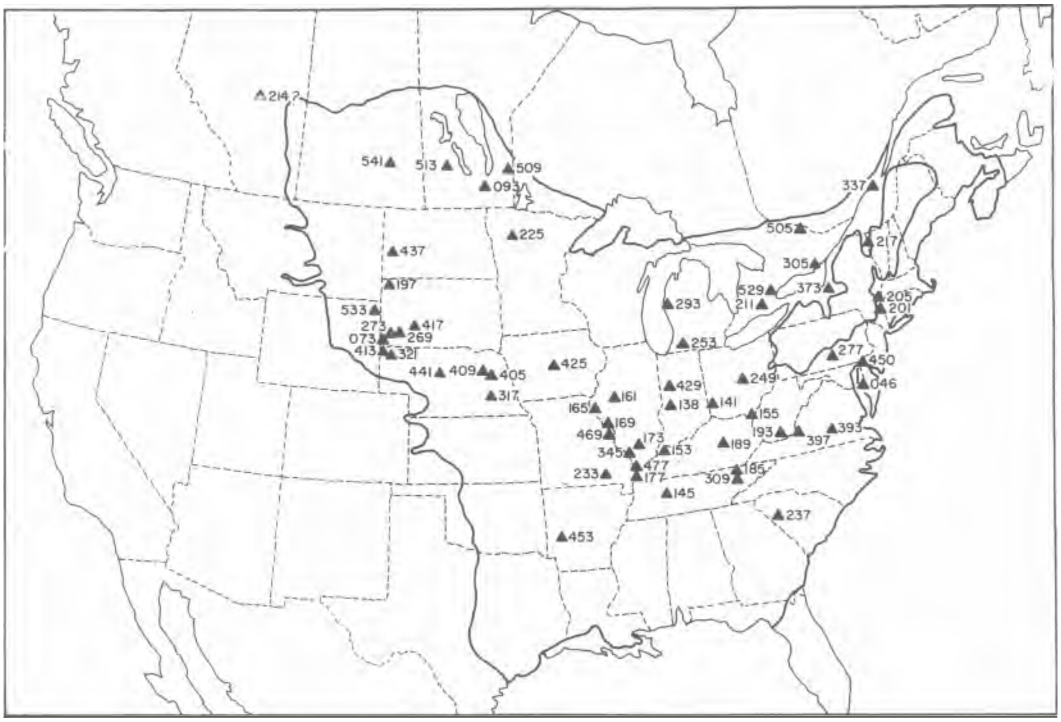

Figure 1.--Natural range of green ash showing the locations of populations sampled in the study.

blocks, one from each of the two nurseries.

In November 1977, following their second growing season, the seedlings were lifted and their roots and shoots trimmed back to lengths of about 30 cm to facilitate handling (Woessner and Hicks 1973). The seedlings were then packed for cold storage according to plot, replicate, and plantation destination. For most plantations, a plot consisted of four trees representing as many as possible of the two to four families in a provenance, and each provenance was represented by one plot in a replicate. For the West Virginia and New York plantations, a plot consisted respectively of two and four trees all of the same family, and each provenance was represented in a replicate by four family plots. For the most part, each replicate for a plantation was put together from seedlings in one or the other of the nursery blocks.

PLANTATION ESTABLISHMENT

The seedlings were shipped to cooperators in late April 1978, and all plantations were established shortly after receipt of the seedlings. All plantations were arranged in randomized complete block designs. Other information for each is as follows:

Iowa -- 3 blocks of 38 provenances; latitude 41°55', longitude 93°15'; planting site a former pasture on the flood plain of a small stream, prepared by scalping planting spots; soil a Nodaway silt loam; spacing 3.7 x 3.7 m; post-planting weed control by mowing and spot sprays of glyphosate; cooperator: R. B. Hall.

Maine -- 4 blocks of 32 provenances; latitude 44°18', longitude 69°45'; planting site a former agricultural field planted to vegetable crops and hay in previous years, prepared by spraying planting spots with simazine; soil a Buxton silt loam; spacing 3.7 x 3.7 m; post-planting weed control by applications of glyphosate in May 1978 and mowing in subsequent years; cooperator: K. K. Carter.

Maryland -- 2 blocks of 42 provenances; latitude 39°00', longitude 76°51'; planting site a poorly drained old field abandoned several decades previously and mowed occasionally, prepared by plowing and disking, planting spots fertilized; soil a Christiana silt loam; spacing 3.0 x 3.0 m; post-planting weed control by annual mowings; cooperator: F. S. Santamour.

Michigan - Kellogg Forest -- 5 blocks of 39 provenances; latitude 42°22, longitude 85°21'; planting site a moderately sloping upland field, prepared by spraying strips with paraquat; soil an Oshtemo sandy loam; spacing 2.4 x 2.4 m; post-planting weed control by applications of simazine in first three years and frequent mowings; cooperator: W. A. Lemmien.

Michigan - Russ Forest -- 5 blocks of 39 provenances; latitude 42°06', longitude 85°50'; planting site a level field planted to soybeans or corn up to 1978, prepared by plowing and disking; soil a Kalamazoo sandy loam; spacing 2.1 x 2.4 m; post-planting weed control identical to Kellogg Forest; cooperator: G. Kowalewski.

Nebraska -- 4 blocks of 18 provenances; latitude 40°30', longitude 98°18'; planting site a level upland field with a perennial grass cover, sprayed with dalapon prior to planting; soil a silt loam; spacing 3.7 x 3.7 m; post-planting weed control by occasional mowings and applications of simazine and glyphosate; cooperator: W. T. Bagley.

New Hampshire -- 4 blocks of 32 provenances;

latitude 43°08', longitude 70°56'; planting site a moist abandoned hay field with grasses and scattered aspen, birch, and alder, prepared by spraying with simazine; soil a loam and clay loam; spacing 1.8 x 2.4 m; post-planting weed control by occasional mowing; cooperator: R. T. Eckert.

New York -- 3 blocks of 17 provenances; latitude 41°46', longitude 73°35'; planting site a well-drained but intermittently flooded old field located along a stream; soil a Copake gravelly loam; spacing 3.7 x 3.7 m; post-planting weed control by annual mowings and directed applications of glyphosate during first two years; cooperator: D. F. Karnosky.

Pennsylvania -- 8 blocks of 60 provenances; latitude 40°48', longitude 77°52'; planting site a moderately sloped and well-drained upland field formerly in pasture, prepared by spraying strips with paraquat; soil a Hagerstown silty clay loam shallowly underlain by fragmented limestone; spacing 3.7 x 3.7 m; post-planting weed control by directed applications of glyphosate in first two years and frequent mowings; cooperator: K. C. Steiner.

Vermont -- 4 blocks of 27 provenances; latitude 44°29', longitude 73°12'; planting site an upland gently sloping field formerly planted to vegetables, prepared by rototilling; soil a Vergennes clay; spacing 2.3 x 3.7 m; post-planting weed control by frequent mowings and spot applications of simazine plus amitrole; cooperator: D. H. DeHayes.

West Virginia -- 4 blocks of 15 provenances; latitude 39°39', longitude 79°48'; planting site gently sloping, in a stand of red oak, black cherry, yellow-poplar, and red maple clearcut the previous year, prepared by spraying spots with simazine; soil a DeKalb channery sandy loam; spacing 3.7 x 3.7 m; post-planting weed control by hand-weeding and directed sprays of 2,4-D; cooperator: F. C. Cech.

PROGRESS

Careful handling and good stock resulted in uniformly high survival rates after the first growing season. Most mortality occurred subsequently, but after four growing seasons all but three plantations (Nebraska, New York, and West Virginia) still have overall survival rates of about 90 percent or more. At most plantations, all provenances have survived well, indicating no real differences in mortality among provenances. At others, relatively heavy mortality has occurred in some provenances from the northern Great Plains and from the southern part of the range.

Height growth ranges from disappointing to excellent after four years in the various plantations. Their growth tends to underline the importance of good site preparation, weed control, and fertility when growing this species in plantations. The best growth by a considerable margin has been achieved in the Michigan-Russ plantation   = 2.6 m), which had been in soybeans the year before planting and which has had excellent weed control. The Pennsylvania plantation, second-tallest at x = 1.7 m, is on a shallow, somewhat impoverished soil and appears as though it would benefit from an application of nitrogen. The Iowa plantation (x = 1.5 m) is on a fairly fertile site, but the trees suffered severely from rodent gnawing in the first winter. The shortest plantation, West Virginia (x - 0.5 m), has similarly been suppressed by deer browsing on all but about 5 percent of the trees. Growth in the remaining plantations lies between these extremes and appears to reflect differences in site quality and cultural practices.

Provenances vary considerably in mean height at all locations. In every case, the fastest growing provenance is at least 20 percent taller than the plantation mean, and usually it is over 30 percent taller. Although it is too early to make conclusive recommendations, the tallest provenances to date appear to originate almost exclusively from an oval-shaped region from west-central Illinois to eastern Nebraska (Figure 1). Some southern Ontario provenances are also relatively tall at most locations. Provenances more-or-less local to the plantation sites are generally growing little better than average, and provenances from the northeastern U.S. are generally below-average.

The superiority of provenances in the west-central portion of the range was entirely unexpected, especially for the Northeast plantations, and it will be interesting to watch the performance of these provenances as the plantations get older. Most of the same provenances are also flowering precociously at some locations, and it is possible that early sexual maturity will change their relative height advantage.

Green ash and white ash may be considered alternative choices for fuelwood plantations and in some cases timber plantations. To get some idea of the relative growth of the two species, five provenances of white ash had been included as an integral part of the study. One or more of these were represented in all but the New York plantation, permitting comparisons to be made with green ash of similar geographic origin. Considering only similar provenances, green ash shows a height advantage that averages 12 percent, even in the upland plantations. This is obviously an inconclusive comparison, but it supports a previous observation (Taylor 1972) that green ash has the faster juvenile growth of the two species. I suspect, with admittedly little evidence, that green ash is somewhat more flexible than white ash in its site requirements.

Each cooperator has his own objectives for his plantation, but the major goal for the study at present is to refine our understanding of the limits of provenance adaptability and performance. This information will especially benefit urban foresters and landscape nurserymen because of the extent to which green ash is used in "off-site" amenity plantings with virtual disregard of provenance. The information may be useful also for plantation forestry. Reports that are now in preparation will examine growth rate interactions across plantations and provenance cold tolerances. Future studies will look at family variation in growth rate and provenance variation in form.

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