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Tree and Shrub Species for the Northern Great Plains

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Division of Fruit and Nut Crops and Diseases

Bureau of Plant Industry, Soils, and Agricultural Engineering

Agricultural Research Administration

UNITED STATES DEPARTMENT OF AGRICULTURE

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Planting of trees and shrubs for protection purposes on farm and range lands of the northern Great Plains is an important factor in the establishment of comfortable and attractive homes in that area. The plantings give much needed protection in winter to farm buildings, livestock, and feed lots against cold winds and drifting snow, and in summer against strong, hot drying winds that damage orchard, garden, and other farm crops. The trees and shrubs attract birds, which destroy many injurious insects. Such plantings also increase the value of farm property.

On the northern Great Plains, limited rainfall, occasional periods of severe drought, extremes of temperature, a high rate of evaporation, and strong drying winds during the growing season present difficulties in tree and shrub growing that are unknown in the higher rainfall and irrigated areas of the United States.

Testing of species to find those that will prove hardy under the prevailing climatic conditions is requisite in any planting program for the area. Such a testing program was started by the United States Department of Agriculture at the Northern Great Plains Field Station, Mandan, N. Dak., in 1913 and was extended with the co-

operation of farmers on the northern Great Plains in 1916. The testing of species is only one of the lines of work with trees and shrubs that has been carried on by that station. This publication gives the results of the testing program at Mandan and on farms during the period 1913-50.

CLIMATE

The climate of the northern Great Plains is classed as semiarid. The amount and distribution of the seasonal and annual precipitation, however, vary from year to year.

The monthly, growing-season (April-September), and annual precipitation at the Mandan station for the years 1914-50 are given in table 1. Precipitation during the growing season ranged from 2.96 inches to 21.36 inches, with a mean of 12.34 for the 37-year period. This mean is about 78 percent of the average annual precipitation of 15.91 inches. The annual precipitation ranged from 6.43 inches to 24.06 inches. The years 1934 and 1936 were severe drought years; precipitation was 8.13 inches in 1934 and 6.43 inches in 1936.

The trees and shrubs used up all available moisture in the area occupied by their roots during the growing season of almost every year. The average precipitation of 3.57 inches, or 22 percent of the total annual precipitation, which fell during October through March, was not sufficient to replenish the water supply exhausted by the trees and shrubs during the preceding growing season (April-September). After a few years of growth, therefore, the trees and shrubs had to rely largely on current precipitation, although in some plantings at least water was available in the soil immediately below that occupied by roots. Soil moisture determinations made in old tree and shrub plantings in 1936 showed that the available moisture at depths of 8 to 10 feet was identical to that found in 1917, 1918, and 1919.

The mean monthly and the maximum and minimum daily temperatures; the mean, high, and low monthly evaporation from a free water surface during the growing season; and the mean monthly wind velocity for the years 1914-50 at the Mandan station are given in table 2. Yearly temperatures show a range of 161° F. Rate of evaporation during the growing season was nearly three times the total precipitation during the same period.

The average frost-free period for the years 1914-50 was 137 days. The longest period was 172 days and the shortest was 115 days. Dates of the last killing frost in the spring ranged from April 19 to May 29, and of the first killing frost in the fall from September 9 to October 8.

Climatic data ¹ for the northern Great Plains show temperature extremes ranging from -63° F. to 121°, frost-free periods ranging from 89 days to 161 days, and annual precipitation ranging from 9.39 inches to 24.20 inches.

¹ From the USDA Yearbook for 1941, Climate and Man.

SOIL TYPE

Tree and shrub species at the Mandan station were tested on Cheyenne fine sandy loam soil. Fine gravel, encountered in the fourth to fifth foot, grades into fine sand in the seventh to beyond the tenth foot. Water penetrates the soil readily, but the holding capacity of the soil is low from the fourth foot through at least the tenth foot. A high percentage of the water held was available to plants. Most of the tree roots fed from the surface 3 or 4 feet. On farms testing was on a wide range of soils that varied from sand to clay. Only in rare cases were farm plantings made on sites that had a water table sufficiently close to the surface that it could be penetrated by tree or shrub roots.

METHODS OF TESTING

Species tested were received either as seed or seedlings from the following sources: Division of Plant Exploration and Introduction of the United States Department of Agriculture, commercial nurseries, or local collection. Testing to determine hardiness, usefulness, and general adaptability of the various species for windbreak purposes was done in one or more of the following ways: (1) In nursery rows; (2) in arboretum plantings of 1 to 10 plants; (3) in block plantings of pure stand of approximately 100 plants each, spaced 4 by 4 feet, or of 49 plants each, spaced 6 by 6 feet; and (4) in cooperative farm windbreak plantings where the species were planted in rows, usually between or adjacent to other species. Small numbers of plants were always tested in the nursery or arboretum rather than in the block plantings. Some species were tested in the arboretum, in blocks of pure stand, and in the farm windbreak plantings.

A few seedlings of some species were planted on the station grounds as ornamentals at the same time that the test-block or arboretum plantings were set out. The ornamentals received a limited amount of irrigation after 1920. Their growth and survival was compared with that of trees or shrubs of the same species growing under dry-land conditions.

All species at the Mandan station received clean cultivation each year to control weed growth and to keep the soil in suitable condition for absorbing rainfall. Annual notes on growth, survival, winter and other types of injury, and setting of terminal buds were taken at the end of each growing season for all station plantings except the ornamental ones, and every 5 years for the cooperative farm windbreaks.

The scientific and common names and the origin of all species that were tested during the 1913-50 period to determine their suitability for windbreak purposes are given in table 3. Those species which carry a Plant Introduction (P. I.) number were introduced from foreign countries by the Division of Plant Exploration and Introduction of the United States Department of Agriculture. Nearly all lots of seed and seedlings were given an accession number for identification when they were received at the Mandan station.

TABLE 1.—Monthly, growing-season, and annual precipitation at the Northern Great Plains Field Station, Mandan, N. Dak., 1914-50

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Apr.- Sept. ¹	Annual
	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>
1914	0.07	0.05	1.89	1.55	3.57	10.68	1.35	1.89	1.24	0.90	0.31	0.37	20.28	23.87
1915	.07	(²)	.30	1.11	4.98	6.32	6.48	.63	1.84	1.85	.34	.14	21.36	24.06
1916	.28	.09	1.88	.93	1.69	2.25	3.55	2.04	.92	.27	.07	1.10	11.38	15.07
1917	.28	.19	.35	1.87	.35	2.56	1.58	.89	1.97	.05	.03	.19	9.22	10.31
1918	.20	.11	.45	2.61	2.45	.68	2.47	2.03	.63	.27	.45	1.02	10.87	13.37
1919	.08	.80	.83	1.72	3.95	1.12	.85	1.22	.49	.98	1.19	.25	9.35	13.48
1920	.52	.20	1.21	.58	1.72	1.85	2.68	1.81	1.29	.25	.37	.21	9.93	12.69
1921	.18	.09	.79	2.59	3.05	.82	3.38	.25	1.58	1.39	.87	.24	11.67	15.23
1922	.28	1.55	.52	.66	2.05	3.43	3.17	.32	2.31	.64	1.60	.82	11.94	17.35
1923	.36	.38	.16	1.85	1.18	1.94	4.12	1.15	2.31	.54	.28	.14	12.55	14.41
1924	.03	.25	.28	1.68	.41	5.56	2.07	2.35	1.34	1.94	.06	.28	13.41	16.25
1925	.28	.03	.44	.94	1.18	7.34	.33	1.31	.99	.69	.15	.38	12.09	14.08
1926	.71	.22	.04	.13	2.41	1.20	2.19	1.31	2.38	.18	.30	.44	9.62	11.51
1927	.18	.14	1.17	1.37	6.65	2.00	2.37	3.16	.49	.44	1.56	.77	16.04	20.30
1928	.20	.07	.23	.99	.55	6.32	4.94	2.24	.89	.19	.06	.17	15.93	16.85
1929	.80	.31	1.47	1.75	2.68	.99	1.20	.81	1.56	1.81	.14	.70	8.99	14.22
1930	.19	1.68	(²)	1.71	2.23	1.50	2.40	2.00	2.56	1.85	1.13	.13	12.40	17.38
1931	.05	.44	1.62	.43	2.14	1.65	4.32	1.01	3.11	1.46	.47	.74	12.66	17.44
1932	.44	.19	1.00	1.99	3.48	3.33	1.90	.70	.24	2.12	.19	.18	11.64	15.76
1933	1.23	.34	1.02	.86	1.83	2.18	1.80	.41	.27	.55	.90	.52	7.35	11.91
1934	.06	.05	.58	.63	.17	3.78	1.10	.25	.47	.73	.17	.14	6.40	8.13
1935	.13	.36	1.13	3.09	2.63	2.85	4.71	1.34	.22	(²)	.96	.88	14.84	18.30
1936	.61	.72	1.12	.48	.04	.43	0	.55	1.46	.17	.61	.24	2.96	6.43
1937	.86	.49	.48	1.38	1.29	5.65	1.83	1.34	1.37	.43	.34	.63	12.86	16.09
1938	.54	1.06	.64	.97	2.42	3.11	2.90	.72	1.25	.21	1.04	.18	11.37	15.04
1939	.67	.62	.44	.74	1.93	4.65	1.69	2.19	.17	.54	(²)	.31	11.37	13.95
1940	.03	.45	.93	4.24	1.20	1.95	2.73	.25	1.28	1.69	.98	.41	11.65	16.14

1941	.31	.22	1.00	1.57	1.95	5.72	1.10	2.36	4.16	.90	.27	.16	16.86	19.72
1942	.47	.47	.79	3.15	2.30	2.44	3.10	1.30	2.33	.69	.04	.46	14.62	17.07
1943	1.17	.55	1.67	.87	1.95	7.67	1.56	3.20	.16	1.56	.60	.19	15.41	21.15
1944	.26	.49	.27	1.22	3.13	5.54	.67	3.19	1.17	.07	3.44	.01	14.92	19.46
1945	.60	.25	1.01	1.02	1.54	1.78	1.94	3.48	1.85	.04	.53	.61	11.61	14.65
1946	.04	.63	1.36	1.28	1.81	3.14	1.25	1.28	2.36	2.56	.24	.82	11.12	16.77
1947	.52	.15	.32	1.90	.73	7.72	3.21	1.17	1.77	2.15	1.08	.39	16.50	21.11
1948	.47	.95	.41	3.21	.80	2.32	2.28	1.08	.01	1.34	.53	.31	9.70	13.71
1949	.75	.41	.33	2.54	1.93	1.62	4.53	1.22	.60	2.04	.14	.18	12.44	16.29
1950	.75	.40	2.82	2.03	3.13	2.67	1.42	2.35	1.65	.58	.36	1.14	13.25	19.30
Average	.38	.42	.84	1.56	2.09	3.43	2.41	1.48	1.37	.92	.59	.43	12.34	15.91

¹ Growing season.² Trace.

TABLE 2.—Mean monthly and maximum and minimum daily temperatures; mean, high, and low monthly evaporation from a free water surface during the growing season; and mean monthly wind velocity at the Northern Great Plains Field Station, Mandan, N. Dak., 1914-50

TEMPERATURE													
Classification	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual or seasonal
	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
Mean	9	13	26	43	55	64	72	69	58	45	28	14	41
Maximum	57	65	81	89	102	108	115	109	104	91	71	66	115
Minimum	-43	-46	-28	0	17	32	38	32	16	14	19	40	-46
EVAPORATION													
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
Mean				3.6	5.3	6.0	7.3	6.6	4.4				33.2
High				4.9	8.4	9.2	12.6	8.5	5.8				49.4
Low				2.0	3.1	4.1	5.4	5.1	3.1				22.8
WIND VELOCITY													
	M, p, h.	M, p, h.	M, p, h.	M, p, h.	M, p, h.	M, p, h.	M, p, h.	M, p, h.	M, p, h.	M, p, h.	M, p, h.	M, p, h.	M, p, h.
Mean	5.5	5.8	6.5	7.1	6.8	5.6	4.5	4.7	5.1	5.3	5.6	5.1	5.6

TABLE 3.—Scientific and common names and origin of tree and shrub species tested for windbreak purposes at the Northern Great Plains Field Station, Mandan, N. Dak., 1913-50

Scientific name and authority	Plant Intro- duction No.	Mandan acces- sion No.	Common name	Received as—	Origin and year
<i>Abies balsamea</i> (L.) Mill. ¹		2687	Balsam fir	Seed	Commercial, 1915.
Do. ¹		8308	do.	Seedlings	Minnesota, 1922.
<i>Abies concolor</i> (Gord. & Glend.) Hoopes ¹		8306	White fir	do.	Commercial, 1922.
<i>Abies holophylla</i> Maxim. ²	90649	10067	Needle fir	do.	Manchuria, 1930.
Do.	90649	10337	do.	do.	Do.
<i>Abies koreana</i> Wils. ¹		7552	Korean fir	do.	Arnold Arboretum, 1921.
<i>Abies nephrolepis</i> (Trautv.) Maxim. ³	90650	10285	Khingan fir	do.	Manchuria, 1930.
<i>Acer barbinerve</i> Maxim. ¹	65909	8490	Maple	Seed	Manchuria, 1926.
Do. ¹	68404	8717	do.	do.	Do.
<i>Acer buergerianum</i> Miq. ¹	42821	7318	Trident maple	Seedlings	China, 1916.
Do. ³	42821	7430	do.	do.	Do.
<i>Acer campestre</i> L. ²		3786	Hedge maple	do.	Commercial, 1916.
<i>Acer carpiniifolium</i> Sieb. & Zucc. ³	95540	9929	Hornbeam maple	do.	Japan, 1931.
<i>Acer caudatum</i> var. <i>ukurunduense</i> (Trautv. & Meyer) Rehd. ¹	69880	8716	Maple	Seed	Manchuria, 1926.
<i>Acer cissifolium</i> (Sieb. & Zucc.) K. Koch ³	102739	10068	do.	Seedlings	Manchuria, 1933.
<i>Acer ginnata</i> Maxim.	69112	1891	Amur maple	do.	Commercial, 1914.
Do.	69878	8680	do.	Seed	Manchuria, 1926.
Do.	34784	8713	do.	do.	Do.
<i>Acer ginnata</i> var. <i>semenovii</i> (Regel & Herd.) Pax. ¹		463	Maple	Seedlings	Russia, 1913.
<i>Acer glabrum</i> Torr. ²		9365	Dwarf maple	Seed	Montana, 1931.
<i>Acer mandshuricum</i> Maxim. ¹	68405	8672	Manchurian maple	do.	Manchuria, 1926.
Do. ²	69879	8715	do.	do.	Do.
Do.	91241	9422	do.	Seedlings	Japan, 1931.
Do. ²	91241	9579	do.	do.	Do.
<i>Acer negundo</i> L.		8	Boxelder	Seed	North Dakota, 1913.

See footnotes at end of table.

Scientific name and authority	Plant Intro- duction No.	Mandan acces- sion No.	Common name	Received as—	Origin and year
<i>Acer platanoides</i> L. ¹		2476	Norway maple	Seedlings	Commercial, 1915.
Do. ²		8303	do	do	Commercial, 1922.
<i>Acer saccharinum</i> L.		489	Silver maple	Seed	Commercial, 1913.
<i>Acer saccharum</i> Marsh. ²		1415	Sugar maple	Seedlings	Commercial, 1914.
Do. ²		1422	do	do	Do.
Do. ²		1934	do	do	Commercial, 1915.
<i>Acer tataricum</i> L.		1893	Tatarian maple	do	Commercial, 1914.
<i>Acer tegmentosum</i> Maxim. ²	69401	8684	Manchustripe maple	Seed	Manchuria, 1926.
<i>Acer triflorum</i> Komar. ²	82472	9423	Threelower maple	Seedlings	Korea, 1929.
Do. ¹	90655	9747	do	do	Manchuria, 1930.
Do. ¹	90655	10284	do	do	Do.
<i>Acer truncatum</i> Bunge ¹	18578	5259	Purplebloss maple	do	China, 1906.
<i>Acer sp.</i>		7550	Maple	do	Arnold Arboretum, 1921.
<i>Aesculus hippocastanum</i> L. ¹		3787	Common horsechestnut	do	Commercial, 1916.
<i>Alnus hirsuta</i> var. <i>sibirica</i> (Spach) C. Schneid. ²	82473	9424	Manchurian alder	do	Korea, 1929.
Do. ¹	90787	9581	do	do	Korea, 1930.
<i>Alnus japonica</i> (Thunb.) Steud. ³	90786	9582	Japanese alder	do	Do.
<i>Amelanchier stolonifera</i> Wieg.		4040	Running serviceberry	do	Commercial, 1916.
<i>Aralia elata</i> (Miq.) Seem. ¹		3993	Chinese angelica tree	Seed	Russia, 1916.
<i>Betula daurica</i> Pall. ³	78400	9349	Daburian birch	Seedlings	Korea, 1928.
<i>Betula fruticosa</i> Pall. ³	65917	8493	Altai birch	Seed	Manchuria, 1926.
Do. ³	65917	9029	do	Seedlings	Do.
<i>Betula hetera</i> Michx. ¹		3793	Yellow birch	do	Commercial, 1916.
<i>Betula mandshurica</i> var. <i>japonica</i> (Miq.) Rehd. ¹	64444	9030	Japanese white birch	do	Manchuria, 1925.
Do. ³	65062	9031	do	do	Do.
Do. ²	75415	9203	do	do	Japan, 1927.
Do. ³	76735	9204	do	do	Manchuria, 1928.
Do. ³	75445	9350	do	do	Japan, 1927.
Do. ³	82066	9554	do	do	Korea, 1929.

<i>Betula papyrifera</i> Marsh	3794	Paper birch	do	Commercial, 1916.
<i>Betula platyphylla</i> Sukatchev ¹	8492	Asian white birch	Seed	Manchuria, 1926.
Do. ¹	9032	do	Seedlings	Do.
<i>Betula populifolia</i> Marsh	1890	Gray birch	do	Commercial, 1914.
Do	3792	do	do	Commercial, 1916.
<i>Betula</i> sp.	1594	Birch	Seed	North Dakota, 1914.
Do. ¹	1595	do	do	Do.
<i>Caragana arborescens</i> Lam.	35234	do	do	Canada, 1913.
Do	64769	Siberian pea-tree	do	Manchuria, 1925.
<i>Caragana aurantiaca</i> Koehne ²	40157	Dwarf pea-tree	Seedlings	England, 1915.
<i>Caragana chamlagu</i> Lam. ³	22981	Pea-tree	do	China, 1908.
<i>Caragana decorticans</i> Hemsl. ¹	34989	Afghanistan pea-tree	do	England, 1913.
<i>Caragana frutex</i> (L.) K. Koch ¹	40158	Russian pea-tree	do	England, 1915.
Do	10885	do	do	Commercial, 1945.
<i>Caragana microphylla</i> var. <i>mandshurica</i> Kom	107663	Littleleaf pea-tree	do	Manchuria, 1934.
<i>Caragana pygmaea</i> DC.	21967	Pygmy pea-tree	do	Commercial, 1936.
<i>Caragana sinica</i> (Buc'hoz) Rehd. ²	30655	Chinese pea-tree	Seed	China, 1908.
<i>Caragana</i> sp. ³	36746	Pea-tree	Seedlings	Chinese Turkestan, 1910.
Do. ¹	38824	do	do	China, 1913.
Do. ²	40711	do	do	Do.
Do. ¹	7320	do	do	China, 1914.
Do	9722	do	Seed	U. S. S. R., 1934.
Do	9723	do	do	Do.
Do	9726	do	do	Manchuria, 1934.
<i>Carpinus turczaninovi</i> Hance ¹	9584	Hornbeam	Seedlings	China, 1930.
<i>Carya ovata</i> (Mill.) K. Koch ¹	4039	Shagbark hickory	do	Commercial, 1916.
<i>Castanea mollissima</i> Blume ²	8745	Chinese chestnut	do	China, 1924.
<i>Catalpa bignonioides</i> Walt.	8312	Common catalpa	Seed	Minnesota, 1921.
<i>Catalpa spectosa</i> Warder ²	1319	Western catalpa	Seedlings	Commercial, 1913.
Do	8311	do	Seed	Minnesota, 1921.
<i>Celtis koraiensis</i> Nakai. ³	9585	Korean hackberry	Seedlings	China, 1931.
<i>Celtis morifolia</i> Planch. ¹	2366	Hackberry	do	Brazil, 1914.
<i>Celtis occidentalis</i> L.	4022	do	do	Commercial, 1916.
<i>Celtis sinensis</i> Pers. ³	7410	Chinese hackberry	do	China, 1918.
Do. ²	9407	do	do	Japan, 1929.
<i>Chilopsis linearis</i> (Cav.) DC. ¹	7891	Desert willow	do	Oklahoma, 1923.
<i>Corylus heterophylla</i> Fisch.	8695	Siberian filbert	Seed	Manchuria, 1926.
<i>Cotinus coccigera</i> Scop. ²	3830	Common smoke-tree	Seedlings	Commercial, 1916.

See footnotes at end of table.

TABLE 3.—Scientific and common names and origin of tree and shrub species tested for windbreak purposes at the Northern Great Plains Field Station, Mandan, N. Dak., 1913-50—Continued

Scientific name and authority	Plant Intro- duction No.	Mandan acces- sion No.	Common name	Received as—	Origin and year
<i>Elaeagnus angustifolia</i> L.					
Do. ²	26594	529	Russian-olive	Seed	Colorado, 1913.
Do. ¹	28806	3504	do	Seedlings	Turkey, 1910.
Do. ¹	29225	3505	do	do	Russia, 1910.
Do. ¹	29415	3506	do	do	Russian Turkestan, 1910.
Do. ¹	30063	3507	do	do	Turkey, 1911.
Do. ¹	30412	3508	do	do	Nevada, 1911.
Do. ¹	30633	3509	do	do	Chinese Turkestan, 1911.
Do. ¹	31822	3510	do	do	Do.
Do. ²	12926	5199	do	do	Chinese Turkestan, 1910.
Do. ²	12926	5131	do	do	North Africa, 1905.
Do. ²	42680	5746	do	Seed	Do.
Do.	58528	8365	do	Seedlings	Russia, 1916.
<i>Elaeagnus multiflora</i> Thunb. ¹					
Do. ¹		3729	Cherry elaeagnus	do	China, 1924.
Do. ¹		3810	do	do	Commercial, 1916.
Do. ¹		3860	do	do	Do.
Do. ¹		4446	do	do	Do.
<i>Elaeagnus umbellata</i> Thunb.		8214	Autumn elaeagnus	do	Do.
Do. ²		10437	do	do	Horticultural Office, Washington, D. C., 1924. Soil Conservation Service, 1940.
<i>Elaeagnus</i> sp.		7551	Russian-olive	do	Arnold Arboretum, 1921.
Do. ¹	116928	10228	do	do	China, 1936.
<i>Fagus grandifolia</i> Ehrh. ¹		8302	American beech	do	Commercial, 1922.
<i>Fraxinus americana</i> L. ²		3813	White ash	do	Commercial, 1916.
Do		8313	do	do	Commercial, 1921.
<i>Fraxinus holotricha</i> Koelne ³		9931	Ash	Seed	Rumania, 1935.
Do		112093	do	Seedlings	Arnold Arboretum, 1935.
<i>Fraxinus mandshurica</i> Rupr.		71390	Manchurian ash	do	Manchuria, 1927.
Do		82479	do	Seedlings	Korea, 1929.

<i>Fraxinus nigra</i> Marsh.	42838	Black ash	do	Minnesota, 1921.
<i>Fraxinus oxycarpa</i> Willd. ²	7315	Ash	do	Russia, 1916.
<i>Fraxinus pennsylvanica</i> var. <i>lancoolata</i> (Borkh.) Sarg.	9	Green ash	Seed	North Dakota, 1913.
<i>Fraxinus potanophila</i> Herd. ³	44133	Turkestan ash	Seedlings	Chinese Turkestan, 1917.
<i>Fraxinus</i> sp.	65866	Ash	do	Manchuria, 1926.
<i>Gleditsia sinensis</i> Lam. ³	39978	Chinese honeylocust	do	China, 1915.
Do. ³	38801	do	do	China, 1913.
Do.	10435	do	do	Oklahoma, 1940.
<i>Gleditsia triacanthos</i> L. ²	2568	Honeylocust	do	Nebraska, 1915.
Do. ²	5872	do	do	South Dakota, 1918.
Do.	9870	do	Seed	South Dakota, 1933.
Do.	10813	do	do	North Dakota, 1940.
<i>Halimodendron halodendron</i> (Pall.) C. Schneid.	8495	Salt-tree	Seedlings	Russia, 1924.
<i>Hemiptelea davidii</i> (Hance) Planch. ¹	9433	Hemiptelea	do	Japan, 1931.
<i>Juglans cinerea</i> L.	4032	Butternut	do	Commercial, 1916.
<i>Juglans mandshurica</i> Maxim.	7319	Manchurian walnut	do	China, 1916.
Do.	8683	do	Seed	Manchuria, 1926.
<i>Juglans nigra</i> L. ²	4018	Black walnut	Seedlings	Commercial, 1916.
Do. ²	5873	do	do	South Dakota, 1918.
Do.	7435	do	Seed	North Dakota, 1921.
<i>Juglans regia</i> L. ¹	3818	Persian walnut	Seedlings	Commercial, 1916.
<i>Juniperus ashei</i> Buchholz ¹	10290	Ozark white cedar	do	Maryland, 1937.
Do. ²	10303	do	do	Soil Conservation Service, 1936.
Do. ¹	10440	do	do	Soil Conservation Service, 1940.
Do. ³	10441	do	do	Soil Conservation Service, 1936.
<i>Juniperus chinensis</i> L. ³	18577	Pyramid Chinese juniper.	do	China, 1906.
<i>Juniperus communis</i> L.	2682	Common juniper	do	Montana, 1915.
<i>Juniperus monosperma</i> (Engelm.) Sarg.	9637	One-seed juniper	Seed	New Mexico, 1933.
Do. ³	10431	do	Seedlings	Soil Conservation Service, 1940.
<i>Juniperus pachyphloea</i> Torr. ³	10432	Alligator juniper	do	Do.
<i>Juniperus scopulorum</i> Sarg.	9630	Rocky Mountain juniper.	Seed	Wyoming, 1933.

See footnotes at end of table.

TABLE 3.—Scientific and common names and origin of tree and shrub species tested for windbreak purposes at the Northern Great Plains Field Station, Mandan, N. Dak., 1913-50—Continued

Scientific name and authority	Plant Intro- duction No.	Mandan acces- sion No.	Common name	Received as—	Origin and year
<i>Juniperus squamata</i> var. <i>meyeri</i> Rehd. ³	23023	7428	Meyer singleseed juniper	Seedlings	China, 1908.
<i>Juniperus utahensis</i> (Engelm.) Lemmon ³		10433	Utah juniper	do	Soil Conservation Service, 1940.
<i>Juniperus virginiana</i> L.		1097	Eastern redcedar	do	Commercial, 1914.
<i>Larix decidua</i> Mill.		4033	European larch	do	Commercial, 1916.
<i>Larix gmelini</i> (Rupr.) Kuzeneva ³	33319	3440	Dahurian larch	do	Russia, 1912.
Do. ³	78403	9351	do	do	Korea, 1928.
Do. ³	97946	9655	do	do	Japan, 1932.
Do. ²	90663	9750	do	do	Manchuria, 1930.
<i>Larix gmelini</i> var. <i>principis-rupprechtii</i> (Mayr) Pilger ¹	71123	8694	Prince Rupprecht dahurian larch.	Seed	Japan, 1927.
<i>Larix laricina</i> (DuRoi) K. Koch.		4034	Tamarack	Seedlings	Commercial, 1916.
<i>Larix sibirica</i> Ledeb.	36163	497	Siberian larch	Seed	Russia, 1913.
Do. ²	87382	9275	do	do	U. S. S. R., 1930.
<i>Maackia amurensis</i> Rupr.		7852	Amur mackia	Seedlings	
Do.	65939	8494	do	Seed	Manchuria, 1926.
Do.	90665	9434	do	Seed	Manchuria, 1930.
<i>Malus baccata</i> Borkh.		5557	Siberian crabapple	do	Commercial, 1918.
<i>Ostrya virginiana</i> (Mill.) K. Koch ²	4031	4031	Eastern hophornbeam	do	Commercial, 1916.
<i>Phellodendron amurense</i> Rupr.		3991	Amur corktree	Seed	Russia, 1916.
Do.	65638	8697	do	do	Manchuria, 1925.
Do. ³	65638	9036	do	Seedlings	Do.
<i>Picea abies</i> (L.) Karst. ²		1180	Norway spruce	do	Commercial, 1914.
<i>Picea engelmanni</i> (Parry) Engelm.		8305	Engelmann spruce	do	Commercial, 1922.
<i>Picea glauca</i> (Moench) Voss.		1170	White spruce	do	Commercial, 1914.
<i>Picea glauca</i> var. <i>densata</i> Bailey		1172	Black Hills spruce	do	Do.
<i>Picea glehnii</i> (Fr. Schmidt) Mast. ²	78179	9436	Sakhalin spruce	do	Japan, 1928.
<i>Picea koyamai</i> Shiras	97948	10295	Koyama spruce	do	Japan, 1932.
<i>Picea mariana</i> (Mill.) B. S. P.		9018	Black spruce	do	Minnesota, 1928.

<i>Picea pungens</i> Engelm.	1171	Blue spruce	do	Commercial, 1914.
Do.	10875	do	Seed	North Dakota, 1940.
<i>Pinus banksiana</i> Lamb.	1041	Jack pine	Seedlings	Commercial, 1914.
<i>Pinus bungeana</i> Zucc. ³	7399	Lacebark pine	do	China, 1916.
Do. ³	7426	do	do	Do.
Do. ¹	9656	do	do	Manchuria, 1931.
Do. ²	89604	do	do	China, 1930.
Do. ¹	9752	do	do	Manchuria, 1931.
Do. ¹	9753	do	do	Do.
Do. ²	9934	do	do	China, 1930.
Do. ²	10079	do	do	China, 1932.
Do. ¹	10080	do	do	U. S. Forest Service, 1918.
<i>Pinus contorta</i> var. <i>latifolia</i> Engelm.	7477	Lodgepole pine	Seed	Wyoming, 1933.
<i>Pinus edulis</i> Engelm.	9633	Pinyon	do	Wyoming, 1932.
<i>Pinus flexilis</i> James	9869	Limber pine	do	North Dakota, 1933.
<i>Pinus nigra</i> Arnold	9636	Austrian pine	Seedlings	Commercial, 1914.
<i>Pinus ponderosa</i> Laws		Ponderosa pine	do	Do.
Do.	1173	do	do	Minnesota, 1920.
<i>Pinus resinosa</i> Ait.	7400	Red pine	do	Commercial, 1914.
<i>Pinus sylvestris</i> L.	1174	Scotch pine	do	Russia, 1926.
Do.	9208	do	do	Korea, 1928.
<i>Pinus tabulaeformis</i> Carr.	9353	Chinese pine	do	Do.
Do. ³	9437	do	do	Korea, 1929.
Do. ¹	9438	do	do	Korea, 1930.
Do. ¹	9439	do	do	Japan, 1932.
Do. ¹	97949	do	do	Korea, 1930.
Do. ³	9657	do	do	China, 1930.
Do. ³	9658	do	do	Montana, 1919.
<i>Pinus yunnanensis</i> Franch. ³	9440	Yunnan pine	do	Russia, 1913.
<i>Populus acuminata</i> Rydb.	7396	Lanceleaf poplar	do	Chinese Turkestan, 1910.
<i>Populus alba</i> L. ¹	477	White poplar	do	Commercial, 1918.
Do. ¹	1262	do	do	Chinese Turkestan, 1910.
<i>Populus alba</i> var. <i>nivea</i> Wesm.	5874	Snowy poplar	do	Montana, 1918.
<i>Populus alba</i> var. <i>pyramidalis</i> Bunge ²	1246	Bolleana poplar	do	Russia, 1913.
<i>Populus angustifolia</i> James	7395	Narrowleaf poplar	do	Commercial, 1916.
<i>Populus balsamifera</i> L.	460	Balsam poplar	do	Russia, 1913.
Do.	4042	do	do	Russia, 1910.
<i>Populus berolinensis</i> Dippel	478	Berlin poplar	do	Alberta, 1921.
Do. ²	1131	do	do	
Do.	7431	do	do	
Do.	26614	do	do	
Do.	34792	do	do	
Do.	26614	do	do	

See footnotes at end of table.

TABLE 3.—Scientific and common names and origin of tree and shrub species tested for windbreak purposes at the Northern Great Plains Field Station, Mandan, N. Dak., 1913-1950—Continued

Scientific name and authority	Plant Intro- duction No.	Mandan acces- sion No.	Common name	Received as	Origin and year
<i>Populus canadensis</i> var. <i>engelmii</i> (Schelle) Rehd. Do. ²	62110	2564	Carolina poplar	Seedlings	U. S. Forest Service, 1915.
<i>Populus canadensis</i> Ait.	34794	8747	do	do	England, 1924.
<i>Populus deltoides</i> Marsh.	34790	479	Balm-of-Gilead poplar	do	Russia, 1913.
Do.	34793	472	Eastern cottonwood	do	Do.
<i>Populus generosa</i> Henry ²	62111	480	do	do	Do.
Do. ²	58646	8750	Poplar	do	England, 1924.
Do.	62111	8943	do	do	Ireland, 1924.
Do.	62111	9742	do	do	England, 1924.
Do.	62111	10984	do	do	Do.
<i>Populus laurifolia</i> Ledeb. ²	34797	459	Laurel poplar	do	Russia, 1913.
<i>Populus maritima</i> Henry ²	51877	8088	Japanese poplar	do	New York, 1920.
Do. ²	51877	8367	do	do	Do.
Do. ²	51877	8748	do	do	Do.
Do. ¹	68170	9743	do	do	Arnold Arboretum, 1922.
<i>Populus nigra</i> L.	34795	461	Black poplar	do	Russia, 1913.
Do.	34796	476	do	do	Do.
<i>Populus nigra</i> var. <i>betulifolia</i> (Pursh) Torr. ²	33206	575	Birchleaf black poplar	do	Spain, 1912.
Do.	92522	9744	do	do	Spain, 1931.
<i>Populus nigra</i> var. <i>italica</i> DuRoi ²	30147	570	Lombardy poplar	do	Chinese Turkestan, 1910.
Do. ²	26812	1103	do	do	Russia, 1910.
Do. ²	29148	1990	do	do	Chinese Turkestan, 1910.
Do.	4044	475	do	do	Commercial, 1916.
Do. ²	38232	5750	do	do	China, 1914.
<i>Populus petrowskiana</i> (Regel) C. Schneid	34801	475	Petrowsky poplar	do	Russia, 1913.
Do.	34801	1977	do	do	Canada, 1915.
<i>Populus sargentii</i> Dodge	34798	5978	Plains cottonwood	do	North Dakota, 1918.
<i>Populus simonii</i> Carr. ³	58484	458	Simon poplar	do	Russia, 1913.
Do. ²	58484	8942	do	do	Manchuria, 1924.
Do. ³	58484	9587	do	do	Do.
Do.	58484	9745	do	do	Do.

<i>Populus suaveolens</i> Fisch. ¹	34799	471	Mongolian poplar	do	Russia, 1913.
Do. ²	22447	1037	do	do	China, 1908.
Do. ³	34799	1263	do	do	Russia, 1913.
Do. ³	22363	5747	do	do	China, 1908.
Do. ³	22861	5749	do	do	Do.
Do. ²	22363	7425	do	do	Do.
<i>Populus tremula</i> L. ¹	34800	474	European aspen	do	Russia, 1913.
<i>Populus tremuloides</i> Michx		4045	Quaking aspen	do	Commercial, 1916
<i>Populus</i> sp.		1	Poplar	do	North Dakota, 1913.
Do.		1881	Northwest poplar	do	Commercial, 1914.
Do.		1882	Poplar	do	Do.
Do.		2353	do	do	U. S. Forest Service, 1915.
Do.		4043	do	do	Commercial, 1916.
Do.		5517	do	do	Commercial, 1918
Do. ²		7437	do	do	Commercial, 1921.
<i>Prunus americana</i> Marsh		4016	American plum	do	Commercial, 1916.
<i>Prunus pensylvanica</i> L. f.		5544	Pincherry	do	Commercial, 1918.
<i>Prunus serotina</i> Ehrh		4026	Black cherry	do	Commercial, 1916.
<i>Prunus virginiana</i> var. <i>melanocarpa</i> (A. Nels.) Sarg.			Western chokecherry	do	North Dakota, 1917.
<i>Pseudotsuga taxifolia</i> (Poir.) Britton		5553	Douglas-fir	do	Commercial, 1918.
<i>Quercus acutissima</i> Carr. ²	89698	9441	Bristletooth oak	do	China, 1930.
<i>Quercus alba</i> L. ²		5878	White oak	do	Commercial, 1918.
<i>Quercus coccinea</i> Muenchh. ²		4025	Scarlet oak	do	Commercial, 1916.
<i>Quercus dentata</i> Thunb. ¹	78659	9355	Daimyo oak	do	Japan, 1929.
Do. ²	89605	9442	do	do	China, 1930.
Do. ²	89696	9443	do	do	Do.
Do. ³	89697	9444	do	do	Do.
Do. ¹	89605	9588	do	do	Do.
Do. ³	89696	9590	do	do	Do.
Do. ¹	89697	9627	do	do	Do.
<i>Quercus macrocarpa</i> Michx. ¹		494	Bur oak	Seed	North Dakota, 1913.
Do. ¹		5876	do	Seedlings	Commercial, 1918.
Do. ¹		8309	do	Seed	North Dakota, 1921.
Do.		10330	do	Seedlings	North Dakota, 1934.
<i>Quercus palustris</i> L. ³		4023	Pin oak	do	Commercial, 1916.
<i>Quercus rubra</i> L. ²		4044	Southern red oak	do	Do.
<i>Quercus variabilis</i> Blume ¹		9445	Oriental oak	do	China, 1930.
<i>Rhamnus cathartica</i> L.	89606	1409	Common buckthorn	do	Commercial, 1914.

See footnotes at end of table.

TABLE 3.—Scientific and common names and origin of tree and shrub species tested for windbreak purposes at the Northern Great Plains Field Station, Mandan, N. Dak., 1913-50—Continued

Scientific name and authority	Plant introduction No.	Mandan accession No.	Common name	Received as—	Origin and year
<i>Rhamnus davurica</i> Pall	69889	8704	Dahurian buckthorn	Seed	Manchuria, 1926.
Do	62230	8865	do	Seedlings	China, 1924.
<i>Rhamnus parvifolia</i> Bunge ³	36735	1986	Littleleaf buckthorn	do	China, 1913.
Do ³	36735	3495	do	do	Do.
Do ¹	69890	8703	do	Seed	Manchuria, 1926.
<i>Rhamnus rupestris</i> Scop. ¹	107640	9908	Cliff buckthorn	Seedlings	Arnold Arboretum, 1934.
<i>Rhamnus saratilis</i> Jacq	107641	9909	Rock buckthorn	do	Do.
<i>Rhamnus</i> sp.	65773	8996	Buckthorn	do	France, 1926.
<i>Rhus glabra</i> f. <i>laciniata</i> (Carr.) Rehd. ²		2474	Cutleaf smooth sumac	do	Commercial, 1915.
<i>Rhus trilobata</i> Nutt		5402	Skunkbush sumac	do	North Dakota, 1917.
<i>Rhus typhina</i> L.		5552	Slaghorn sumac	do	Commercial, 1918.
<i>Robinia pseudoacacia</i> L. ³		1322	Black locust	do	Commercial, 1913.
Do ³		2896	do	do	Commercial, 1915.
Do ¹		4046	do	do	Commercial, 1916.
Do ¹		9764	do	do	Commercial, 1935.
<i>Rosa multiflora</i> Thunb.		11261	Japanese rose	do	Soil Conservation Service, 1949.
<i>Salix alba</i> var. <i>italica</i> (L.) Stokes ²	26671	1104	Yellowstem white willow.	do	Russia, 1910.
<i>Salix babylonica</i> L. ²	24418	1264	Babylon weeping willow.	do	China, 1907.
<i>Salix daphnoides</i> Vill		1976	Daphne willow	do	Canada, 1915.
Do		2352	do	do	U. S. Forest Service, 1915.
<i>Salix elaeagnus</i> Scop. ¹		3840	Elaeagnus willow	do	Commercial, 1916.
<i>Salix fragilis</i> L.		4	Brittle willow	do	North Dakota, 1913.
Do		1372	do	do	Commercial, 1913.
Do		1978	do	do	Canada, 1915.
Do		2765	do	do	Commercial, 1915.
Do		3701	do	do	Commercial, 1916.

<i>Salix matsudana</i> Koidz. ²	Do.	4041	do.	do.	Do.
Do. ²		1094	Hankow willow	do.	China, 1908.
Do.		8749	do.	do.	England, 1924.
<i>Salix matsudana</i> f. <i>umbraculifera</i> Rehd. ²	Do.	9659	do.	do.	France, 1928.
Do. ²		7422	do.	do.	China, 1906.
Do. ²		8995	do.	do.	Do.
Do.		17737	do.	do.	Do.
Do.		17737	do.	do.	Do.
<i>Salix missouriensis</i> Bebb	Do.	10297	do.	do.	Do.
<i>Salix pentandra</i> L.		524	Diamond willow	do.	North Dakota, 1913.
<i>Salix viminalis</i> L. ²		1373	Laurel willow	do.	Commercial, 1913.
<i>Salix sp.</i> ³		1265	Basket willow	do.	Madeira, 1907.
Do. ²		30144	Willow	do.	Chinese Turkestan, 1910.
Do. ²		30052	do.	do.	Do.
Do. ²		30051	do.	do.	Do.
Do. ²		61852	do.	do.	China, 1924.
<i>Shepherdia argentea</i> Nutt.		1324	Silver buffaloberry	do.	Commercial, 1913.
<i>Sophora davidi</i> (Franch.) Skeels ¹	Do. ¹	9872	Sophora	do.	China, 1907.
<i>Sorbus americana</i> Marsh	Do.	9735	do.	do.	Do.
		5871	American mountain-ash	do.	Commercial, 1918.
		1935	do.	do.	Commercial, 1914.
<i>Sorbus aucuparia</i> L.		1895	European mountain ash	do.	Do.
<i>Syringa amurensis</i> Rupr		10876	Amur lilac	Seed	North Dakota, 1942.
<i>Thuja occidentalis</i> L.	Do.	1179	Eastern arborvitae	Seedlings	Commercial, 1914.
		7448	do.	do.	Minnesota, 1921.
<i>Thuja orientalis</i> L. ²	Do. ²	3456	Oriental arborvitae	do.	China, 1914.
Do. ²		3457	do.	do.	Do.
Do. ²		38798	do.	do.	Do.
Do. ²		38831	do.	do.	Do.
<i>Tilia americana</i> L.		1369	American linden	do.	Commercial, 1913.
<i>Tilia europaea</i> L.		1937	European linden	do.	Commercial, 1914.
<i>Tilia mandshurica</i> Rupr. & Maxim. ¹	Do. ²	3989	Manchurian linden	Seed	Russia, 1916.
		9755	do.	Seedlings	Manchuria, 1931.
<i>Ulmus americana</i> L.		2764	American elm	do.	Commercial, 1915.
<i>Ulmus campestris</i> L.		8301	English elm	do.	Commercial, 1924.
<i>Ulmus carpinifolia</i> Gleditsch ²		10879	Smoothleaf elm	do.	Maryland, 1945.
<i>Ulmus carpinifolia</i> var. <i>suberosa</i> (Moench) Rehd. ²		473	do.	do.	Russia, 1913.

See footnotes at end of table.

TABLE 3.—Scientific and common names and origin of tree and shrub species tested for windbreak purposes at the Northern Great Plains Field Station, Mandan, N. Dak., 1913-50—Continued

Scientific name and authority	Plant Intro- duction No.	Mandan acces- sion No.	Common name	Received as—	Origin and year
<i>Ulmus carpinifolia</i> var. <i>umbraculifera</i> (Trautv.) Rehd. ²	32830	1987	Smoothleaf elm	Seedlings	Russian Turkestan, 1911.
Do. ²	32829	3520	do	do	Do.
Do. ²	32830	3521	do	do	Do.
Do. ²	32831	3523	do	do	Do.
Do.	32830	5370	do	do	Do.
<i>Ulmus fulva</i> Michx.		4030	Slippery elm	do	Commercial, 1916.
<i>Ulmus japonica</i> (Rehd.) Sarg.	64466	9046	Japanese elm	do	Manchuria, 1925.
<i>Ulmus parvifolia</i> Jacq. ²	37810	2369	Chinese elm	do	China, 1914.
Do. ²	37810	3460	do	do	Do.
Do. ²		8686	do	do	Oklahoma, 1927.
Do.		10434	do	do	Oklahoma, 1940.
<i>Ulmus pumila</i> L. ²	34063	1127	Siberian elm	do	Nevada, 1912.
Do. ²	34063	1988	do	do	Do.
Do. ²	22975	3522	do	do	China, 1908.
Do. ²	34063	3524	do	do	Nevada, 1912.
Do.	40898	5263	do	do	China, 1915.
Do.	22975	8787	do	do	China, 1908.
<i>Ulmus pumila</i> var. <i>pilosa</i> Rehd. ²	112116	9939	do	do	China, 1934.
<i>Ulmus</i> hybrids		10329	do	do	Soil Conservation Service, 1938.
<i>Vitex negundo</i> var. <i>heterophylla</i> (Franch.) Rehd. ¹	63649	8963	Cutleaf elaste-tree	do	China, 1925.
Do. ²	63649	9220	do	do	Do.
<i>Zelkova serrata</i> (Thunb.) Makino	82353	9596	Sawleaf zelkova	do	Korea, 1929.
<i>Zelkova sinica</i> C. Schneid	22985	8862	Chinese zelkova	do	China, 1908.

¹ Became established but did not survive the first winter.² Survived for more than 1 but less than 10 years.³ Did not become established.

PRESENTATION OF DATA

A total of 373 tree and shrub plantings, composed of 215 species, were tested. Of this total, 146 plantings survived for 10 years or more. Eight additional plantings, which were alive in 1950, had not been growing for a period as long as 10 years. Of these 8 plantings, 3 were duplicates of species that had been tested for 10 or more years, and 5 of them were of species that had not been tested previously. The 219 plantings that did not survive for 10 years are identified by footnotes in table 3. These footnotes show: (1) Plantings that failed to become established—which includes failure of seed to germinate; (2) those which became established for the first season but did not survive the following winter; and (3) those which lived 1 year or more but did not survive for 10 years.

Those species that survived for 10 years or more are listed in table 4. The table also includes survival data at the first, fifth, and tenth years and in 1950, and height at the tenth year and in 1950. The ability of the respective species to survive under the prevailing climatic and other conditions can be judged by comparing the survival in 1950 with that at 5 years of age. Losses that occurred during the first 2 or 3 years may more accurately be attributed to difficulty of establishment than to inability of the species to survive the prevailing conditions. The survival data at 10 years of age give an indication of when the losses, if any, took place.

Additional data that follow on these species include also that from other plantings at the Mandan station and from plantings on cooperative farms and elsewhere in the area.

Based on results of tests by the Mandan station, a listing of tree and shrub species recommended for planting on the northern Great Plains is presented in table 5. An index showing suitability of the respective species for windbreak, wildlife-cover, and ornamental purposes is also given, as well as an index showing the response to dry-land conditions and irrigation.

TREE AND SHRUB SPECIES NOTES

Abies holophylla.—Testing of this species was confined to the Mandan station. The absence of any appreciable amount of winter injury indicates that the species may have some promise for use in the area.

Acer ginnala.—The four test plantings of this species at the station suffered heavy winter injury following the 1936 drought. Winter injury was not severe in any other year. Test plantings were made on cooperating farms in 1917 and later years. A high percentage of these plantings lived for only a few years and killed back repeatedly during the period they were alive. Several shrubs planted as ornamentals on the station grounds in 1916 received a limited amount of irrigation. These gave a much better showing in growth and survival. The foliage of this tall shrub is highly colored in the fall, which makes it an attractive ornamental. It is not recommended for dry-land planting but is suitable under irrigation for either windbreak or ornamental purposes.

TABLE 4.—Tree and shrub species that survived 10 years or longer in test plantings at the Northern Great Plains Field Station, Mandan, N. Dak., 1913-50

Scientific name	Man- dan acces- sion No.	Year planted	Num- ber planted	Survival—				Height—		Index to set- ting of termi- nal buds ¹	Index to ex- tent of win- ter in- jury ²
				At 1 year of age	At 5 years of age	At 10 years of age	In 1950	At 10 years of age	In 1950		
				Percent	Percent	Percent	Percent	Feet	Feet		
<i>Abies holophylla</i>	10337	1939	2	50	50	50	50	4.2	5.5	1	1
<i>Acer glabratum</i>	8680	1929	5	100	100	100	40	5.2	12.3	1	2
Do	8680	1929	49	91	94	72	72	5.3	14.5	1	2
Do	8713	1929	3	100	100	100	67	7.3	16.2	1	2
Do	1891	1915	100	95	92	91	54	6.0	11.4	1	2
<i>Acer mandshuricum</i>	9422	1933	5	100	60	60	60	10.2	14.4	1	1
<i>Acer negundo</i>	8	1915	100	99	99	97	66	14.0	17.8	1	2
<i>Acer saccharinum</i>	489	1915	110	98	98	98	0	15.3	—	2	3
<i>Acer tataricum</i>	1893	1915	100	93	92	90	29	10.1	14.0	2	2
<i>Acer</i> sp.	7550	1921	1	100	100	100	0	1.5	—	2	3
<i>Amelanchier stolonifera</i>	4040	1916	100	53	49	49	46	4.0	5.7	1	1
<i>Betula papyrifera</i>	3794	1916	100	88	69	61	0	12.1	—	2	3
<i>Betula populifolia</i>	1890	1915	100	77	39	21	0	14.3	—	2	2
Do	3792	1916	100	70	26	22	0	12.6	—	2	2
<i>Betula</i> sp.	1594	1917	100	87	80	71	0	10.1	—	1	2
<i>Caragana arborescens</i>	351	1915	100	97	97	96	62	7.4	12.9	1	1
Do	8941	1928	3	100	33	33	33	8.7	17.0	1	1
<i>Caragana microphylla</i> var. <i>mandshurica</i>	9727	1937	33	100	100	100	97	6.9	8.9	1	1
Do	9727	1937	5	100	100	100	100	7.1	9.8	1	1
<i>Caragana pygmaea</i>	10302	1936	5	100	100	100	100	1.9	3.7	1	1
<i>Caragana</i> sp.	9722	1938	2	100	100	100	100	3.0	4.2	1	1
Do	9723	1938	6	50	50	50	50	3.7	4.3	1	1
Do	9726	1937	49	100	100	100	100	2.8	3.1	1	1
Do	9726	1937	5	40	40	40	40	2.7	3.6	1	1
<i>Catalpa bignonioides</i>	8312	1923	49	96	52	48	18	7.4	7.7	3	3
<i>Catalpa speciosa</i>	8311	1923	49	100	38	34	18	8.0	8.3	3	3

<i>Celtis occidentalis</i>	4022	1916	100	97	88	87	54	10.8	25.4	2
<i>Corylus heterophylla</i>	8695	1932	49	100	50	16	12	2.9	5.4	1
<i>Elaeagnus angustifolia</i>	529	1916	100	100	97	96	51	12.8	16.0	2
Do.....	8365	1925	1	100	100	100	0	12.0	3.8	2
<i>Elaeagnus umbellata</i>	8214	1926	5	100	100	40	20	4.7	3.8	3
<i>Elaeagnus</i> sp.....	7551	1922	1	100	100	100	0	4.0	18.1	3
<i>Frazinus americana</i>	8313	1924	49	96	96	96	56	12.3	2.5	1
<i>Frazinus holotricha</i>	10073	1938	2	100	100	100	50	2.0	10.8	1
<i>Frazinus mandshurica</i>	8692	1932	49	100	72	39	37	7.5	10.8	1
Do.....	8692	1932	8	100	100	100	100	5.6	11.4	1
Do.....	9431	1932	6	100	100	100	100	3.0	10.0	1
<i>Frazinus nigra</i>	7449	1921	100	96	86	86	62	7.8	13.0	1
<i>Frazinus pennsylvanica</i> var. <i>lanceolata</i>	9	1915	100	97	97	97	65	12.6	16.9	1
<i>Gleditsia triacanthos</i>	8940	1928	3	100	100	100	100	2.0	2.7	1
<i>Halmiodendron halodendron</i>	9870	1935	49	100	92	64	58	2.8	8.9	2
<i>Juglans cinerea</i>	8495	1926	5	80	80	80	60	5.0	6.7	1
<i>Juglans mandshurica</i>	4032	1916	100	99	96	96	0	8.2	6.7	1
Do.....	7319	1919	2	100	100	100	0	4.0	2.9	1
<i>Juglans nigra</i>	8683	1932	5	100	80	40	40	2.2	18.4	1
<i>Juniperus communis</i>	7435	1921	100	30	30	16	15	6.8	4.8	1
<i>Juniperus monosperma</i>	2682	1921	3	100	100	100	33	2.0	1.4	3
<i>Juniperus scopulorum</i>	9637	1938	49	76	32	22	16	2.2	8.2	3
<i>Juniperus virginiana</i>	9630	1938	49	100	100	100	100	6.8	22.5	3
<i>Larix decidua</i>	1097	1916	100	83	81	80	68	8.9	13.4	1
<i>Larix laricina</i>	4033	1916	100	86	54	51	0	13.9	27.5	1
<i>Larix sibirica</i>	4034	1916	100	65	62	58	0	16.0	14.5	1
<i>Maackia amurensis</i>	497	1924	4	100	100	100	100	5.2	12.8	1
Do.....	7852	1923	4	100	100	100	100	3.5	10.2	1
Do.....	8494	1930	5	80	80	80	80	9.7	9.0	1
<i>Malus baccata</i>	9434	1932	1	100	100	100	0	8.5	21.4	1
<i>Phellodendron amurense</i>	5557	1918	100	55	33	30	0	5.8	4.7	1
Do.....	3991	1921	11	100	91	91	0	3.1	3.8	1
<i>Picea engelmanni</i>	8697	1932	5	100	100	100	100	6.6	19.2	1
<i>Picea glauca</i>	8305	1922	100	40	11	11	10	7.2	25.2	1
<i>Picea glauca</i> var. <i>densata</i>	1170	1916	100	73	73	68	0	3.8	19.2	1
<i>Picea koyamai</i>	1172	1916	100	84	57	57	0	6.3	25.2	1
<i>Picea mariana</i>	10295	1938	1	100	100	100	0	7.2	25.2	1
<i>Picea pungens</i>	9018	1928	49	70	40	14	12	6.3	19.2	1
.....	1171	1916	100	90	88	88	58	7.2	25.2	1

See footnotes at end of table.

TABLE 4.—Tree and shrub species that survived 10 years or longer in test plantings at the Northern Great Plains Field Station, Mandan, N. Dak., 1913-50—Continued

Scientific name	Man- dan acces- sion No.	Year planted	Num- ber planted	Survival—				Height—		Index to set- ting of termi- nal buds ¹	Index to ex- tent of win- ter in- jury ²
				At 1 year of age	At 5 years of age	At 10 years of age	In 1950	At 10 years of age	In 1950		
				Percent	Percent	Percent	Percent	Feet	Feet		
<i>Pinus banksiana</i> -----	1041	1916	100	94	93	91	0	13.5		1	2
<i>Pinus contorta</i> var. <i>latifolia</i> -----	7477	1921	100	91	76	37	35	6.0	20.7	1	1
<i>Pinus edulis</i> -----	9633	1939	49	84	74	74	74	1.6	1.5	1	2
<i>Pinus flexilis</i> -----	9869	1935	49	96	94	94	94	3.7	9.0	1	1
<i>Pinus nigra</i> -----	9636	1933	49	96	96	94	92	6.4	15.0	1	2
<i>Pinus ponderosa</i> -----		1918	100	72	65	64	50	8.6	29.3	1	1
Do-----	1173	1916	100	70	56	55	45	7.4	28.0	1	1
<i>Pinus resinosa</i> -----	7400	1920	100	64	42	15	1	6.0	5.0	1	3
<i>Pinus sylvestris</i> -----	1174	1916	100	94	94	93	0	10.9		1	3
Do-----	9208	1930	4	100	75	75	75	12.5	28.5	1	1
<i>Pinus tabulaeformis</i> -----	9353	1931	2	100	100	50	50	4.7	12.5	1	1
<i>Populus acuminata</i> -----	7396	1924	8	100	100	35	0	20.3		1	2
<i>Populus alba</i> var. <i>nivea</i> -----	5874	1918	100	71	56	47	0	18.6		1	3
<i>Populus angustifolia</i> -----	7395	1924	9	100	100	22	0	14.0		1	2
<i>Populus balsamifera</i> -----		1916	100	72	63	51	0	21.3		1	3
Do-----	460	1916	100	84	28	12	0	11.3		1	2
<i>Populus berolinensis</i> -----	4042	1916	100	70	14	13	0	20.7		2	3
Do-----	478	1916	100	70	60	50	0	3.0		1	2
<i>Populus canadensis</i> var. <i>eugenei</i> -----	7431	1924	8	100	87	49	0	19.6		1	3
<i>Populus canadensis</i> var. <i>eugenei</i> -----	2564	1916	100	91	87	49	0	11.6		1	2
<i>Populus candicans</i> -----	479	1916	100	70	22	7	0	17.5		1	3
<i>Populus deltoides</i> -----	472	1916	100	36	35	34	0	16.7		1	3
Do-----	480	1916	100	36	35	35	0	26.5	28.5	1	1
<i>Populus generosa</i> -----	9742	1935	2	100	100	100	100	23.7	43.0	1	1
<i>Populus nigra</i> -----	461	1916	100	21	21	20	11	16.4		1	3
Do-----	476	1916	100	29	28	27	0	10.2	13.3	1	3
<i>Populus nigra</i> var. <i>betulifolia</i> -----	9744	1935	3	100	100	100	100			1	3

<i>Populus nigra</i> var. <i>italica</i>	4044	1916	100	98	59	40	0	12.7	2	3
<i>Populus petrowskiana</i>	475	1916	100	73	59	49	0	23.9	1	3
Do	1977	1916	100	97	89	50	0	21.3	1	2
<i>Populus sargentii</i>	5978	1918	100	64	62	50	0	19.8	1	2
<i>Populus simonii</i>	9745	1935	2	100	100	100	100	8.3	1	3
<i>Populus tremuloides</i>	4045	1916	100	28	25	27	0	16.1	1	2
<i>Populus</i> sp.	1	1915	100	94	90	64	0	21.3	1	3
Do	1881	1915	100	100	96	79	0	22.0	1	2
Do	1882	1915	100	98	94	45	0	17.5	2	2
Do	2353	1915	100	98	88	58	0	17.9	1	3
Do	4043	1916	100	74	66	40	0	16.9	1	2
Do	5517	1915	100	21	20	16	0	18.8	1	1
<i>Prunus americana</i>	4016	1916	100	93	87	83	0	8.6	1	2
<i>Prunus pensylvanica</i>	5544	1918	100	72	72	50	0	14.1	1	2
<i>Prunus serotina</i>	4026	1916	100	86	32	31	17	12.1	1	2
<i>Prunus virginiana</i> var. <i>melanocarpa</i>	5553	1918	100	100	97	97	49	8.6	1	2
<i>Pseudotsuga taxifolia</i>	10330	1938	49	74	74	74	74	5.6	1	2
<i>Quercus macrocarpa</i>	1409	1918	100	92	54	54	16	18.1	1	2
<i>Rhamnus cathartica</i>	8704	1929	39	100	100	100	98	10.5	1	1
<i>Rhamnus davurica</i>	8865	1927	3	100	100	100	33	7.4	1	1
Do	9909	1936	1	100	100	100	67	11.2	1	1
<i>Rhamnus saratilis</i>	8996	1928	3	33	33	33	33	7.8	1	1
<i>Rhamnus</i> sp. (P. I. 65773)	5402	1921	1	100	100	100	100	5.4	1	1
<i>Rhus trilobata</i>	5552	1918	100	77	71	70	0	8.8	2	3
<i>Rhus typhina</i>	1976	1916	100	85	84	74	0	18.5	1	3
<i>Salix daphnoides</i>	2352	1921	49	100	60	16	0	13.3	1	2
<i>Salix fragilis</i>	4	1915	100	100	100	96	0	13.7	1	2
Do	1372	1915	100	98	96	83	0	14.1	1	2
Do	1978	1916	110	94	94	91	0	13.6	1	2
Do	2765	1916	100	88	82	81	0	17.3	1	3
Do	3701	1916	100	100	98	69	0	18.5	1	2
Do	4041	1916	100	99	96	71	0	14.5	1	3
<i>Salix matsudana</i>	9659	1934	5	100	60	60	60	7.0	2	3
<i>Salix matsudana</i> f. <i>umbraculifera</i>	10297	1938	1	100	100	100	100	8.0	2	3
<i>Salix missouriensis</i>	524	1915	100	97	95	87	23	9.6	1	3
<i>Salix pentandra</i>	1373	1915	100	97	94	77	0	10.1	1	3
<i>Shepherdia argentea</i>	1324	1918	100	99	97	92	33	10.0	1	2

See footnotes at end of table.

TABLE 4.—Tree and shrub species that survived 10 years or longer in test plantings at the Northern Great Plains Field Station, Mandan, N. Dak., 1913-50—Continued

Scientific name	Man- dan acces- sion No.	Year planted	Num- ber planted	Survival—				Height—		Index to set- ting of termi- nal buds ¹	Index to ex- tent of win- ter in- jury ²
				At 1 year of age	At 5 years of age	At 10 years of age	In 1950	At 10 years of age	In 1950		
				Percent	Percent	Percent	Percent	Feet	Feet		
<i>Sorbus americana</i> -----	1935	1915	100	100	85	63	0	10.5	---	2	2
Do -----	5871	1918	100	73	9	8	0	12.2	---	2	2
<i>Sorbus aucuparia</i> -----	1895	1915	100	79	73	66	0	10.5	---	2	2
<i>Thuja occidentalis</i> -----	1179	1916	100	80	40	39	0	3.5	---	2	3
Do -----	7448	1921	100	95	88	88	0	4.0	---	2	3
<i>Tilia americana</i> -----	1369	1918	100	78	77	77	69	10.0	16.2	2	2
<i>Tilia europaea</i> -----	1937	1915	100	91	86	79	0	8.2	---	1	3
<i>Ulmus americana</i> -----	2764	1915	100	95	85	84	32	13.6	28.4	1	2
<i>Ulmus campestris</i> -----	8301	1924	49	88	68	62	20	7.3	19.2	1	2
<i>Ulmus carpinifolia</i> var. <i>umbraculifera</i>	5370	1917	1	100	100	100	0	18.0	---	2	2
<i>Ulmus fulva</i> -----	4030	1916	100	97	90	87	26	12.2	26.0	1	2
<i>Ulmus japonica</i> -----	9046	1929	2	50	50	50	50	12.0	24.0	1	1
<i>Ulmus parvifolia</i> -----	10434	1941	10	60	40	40	40	4.7	4.7	3	3
<i>Ulmus pumila</i> -----	5263	1917	110	94	91	91	43	19.8	31.6	2	2
Do -----	8787	1927	4	100	100	75	75	18.5	25.6	2	2
<i>Ulmus</i> hybrids -----	10329	1938	49	100	100	94	90	18.8	21.7	2	1
<i>Zelkova serrata</i> -----	9596	1933	2	100	100	100	100	10.5	13.8	1	2
<i>Zelkova sinica</i> -----	8862	1927	2	100	100	100	100	16.0	24.0	1	2

¹ In relation to time of first killing frost in fall: 1—Always before; 2—variable; 3—always after.² 1—None or minor; 2—variable; 3—severe.

Acer mandshuricum.—This species was tested at the Mandan station only. Loss was suffered after the 1936 drought. Growth habits of this species would class it as a tall shrub. Data indicate that it has promise for dry-land windbreak or ornamental planting.

Acer negundo.—This species was widely tested over the northern Great Plains. It was highly subject to winter injury, the extent of which varied from year to year, depending on moisture conditions. The trees in most dry-land plantings were killed to the ground by such injury following the droughts of 1934 and 1936. This species makes a rapid recovery when moisture conditions are favorable (fig. 1). The trees have a wide-spreading habit of growth, which

FIGURE 1.—These 23-year-old trees of *Acer negundo* growing under dry-land conditions made an excellent recovery in 1938 following their killing to the ground in the fall of 1934. Annual precipitation was approximately normal or above in 1935, 1937, and 1938. The most severe drought of the 1914-50 period occurred in 1936.

may cause suppression of species in adjacent rows. Trees of *A. negundo* are useful for windbreaks on sites that have favorable moisture conditions.

Acer saccharinum.—This species has been planted to some extent for both dry-land windbreak and ornamental purposes in the area. The trees suffered winter injury in most years. Such injury was severe in the winter following the drought of 1934. The species did quite well as an ornamental under irrigation. It is highly recommended for both windbreak and ornamental plantings under irrigation.

Acer tataricum.—This species has been planted to a very limited extent in the area. It closely resembles *A. ginnala* in growth habits and in the fall coloring of foliage. Losses were heavy in the late

summer of 1936 and in the following year as a result of the severe drought conditions. Shrubs planted on the station grounds and under irrigation remained free of winter injury and progressed quite well. *A. tataricum* is recommended for both windbreak and ornamental planting under irrigation.

Acer sp. (7550²).—This species, originally from northern China, lived for 13 years, although new growth was killed back each year. It cannot be recommended for planting in the area.

Amelanchier stolonifera.—This species has been used to some extent in home-orchard plantings throughout the area. It is hardy but has a very dwarf habit of growth and suckers profusely under cultivation. Heavy crops of fruit useful for pie and sauce were produced in most years. The species is more suitable for planting in the home orchard than as a windbreak tree.

Betula papyrifera.—Data on this species are confined to plantings at the Mandan station. Winter injury was very heavy after 1925. The last trees died in 1934. It has no value as a dry-land windbreak tree.

Betula populifolia.—Data on this species are confined to plantings at the Mandan station. Trees suffered varying degrees of killing back in most years. The last trees of one test block died in 1934 and those of the other one in 1935. A few trees planted on the station grounds in 1916, and which were irrigated since 1920, did much better. Winter injury to these trees was minor and none died. The species has value as an ornamental only under irrigation.

FIGURE 2.—Trees of *Betula* sp. severely injured by drought, as they appeared in June 1934, at Mandan, N. Dak.

² Mandan accession number.

Betula sp. (1594).—This species, native to the Killdeer Mountains of North Dakota, suffered periodic injury prior to the drought of 1934 and severe injury that year (fig. 2). All trees were dead in the spring of 1935. The species is not recommended for planting in this area.

Caragana arborescens.—This species has been widely planted for windbreak purposes on the northern Great Plains. It is both cold- and drought-hardy but will not survive in low areas that remain wet for long periods. The species does not thrive as well on very sandy soils as it does on the heavier types of soils. It has proved to be one of the best shrubs for planting in outside rows of windbreaks. Insects frequently defoliate branches and injure terminal growth. This makes the species unsightly. Another unfavorable feature is that leaves drop early in very dry seasons. Despite these objectionable features, the species is highly recommended for windbreak planting except on wet or very sandy sites.

Caragana frutex.—This species was under test at the station for only 6 years, but it had been grown to some extent in the area for a longer period. It proved to be hardy, but lack of height makes it more suitable for ornamental than for windbreak purposes.

Caragana microphylla var. *mandshurica*.—This species was tested at Mandan only. It proved to be hardy and appears to be satisfactory for planting in the area.

Caragana pygmaea.—This species has been used to some extent for ornamental purposes throughout the area. It proved to be quite hardy, but it lacks suitable height for windbreak purposes.

Caragana sp. (P. I. 107664³).—This species proved to be hardy. It is more resistant to defoliation by insects than are the other species of this genus. Its growth habit is semiprostrate. The species has no value for windbreak planting but would be suitable as an ornamental or for wildlife cover.

Caragana sp. (P. I. 108051).—This species, dwarf in growth habit, proved hardy. The slow growth of the species makes it of no value as a windbreak shrub. The sharp spines developed are excellent for wildlife cover but limit its use for ornamental purposes.

Caragana sp. (P. I. 108332).—This species proved hardy but its dwarf and spiny growth characteristics limit its use to ornamental or wildlife cover purposes. Some of the trees developed a spread of 10 feet.

Catalpa bignonioides.—This species has been used to some extent in the southern part of the area. The wood of the trees in the test planting failed to mature in the fall and killing back, usually to the ground, resulted. The trees sprouted prolifically from the base each spring and grew 7 or 8 feet during the season. It is not recommended for planting in the area.

Catalpa speciosa.—Behavior of this species was similar to *C. bignonioides*. It is not recommended for planting in the area.

Celtis occidentalis.—This species is native to the eastern half of both North and South Dakota and has been used to a limited extent in windbreaks throughout the northern Great Plains. There was considerable killing back and losses in stand in windbreak plantings.

³ Plant Introduction number. See p. 3.

Certain strains were found which had a high degree of resistance to winter injury. In the test planting at the Mandan station, many of the trees in inside rows were suppressed by trees in the outside rows. Some trees in outside rows were 50 to 60 feet high. This suppression was responsible for some of the losses in stand. The species responded very favorably to irrigation. It is recommended for windbreak and ornamental purposes under irrigation and on dry-land sites where the moisture supply is favorable.

Corylus heterophylla.—This species was tested at the Mandan station only. It made a dense, bushy type of growth, which killed back severely during the drought years of 1934 and 1936. It does not bear much fruit. On the favorable side, it does not have the objectionable suckering habit common to some species of *Corylus*. It has no value for dry-land windbreak planting.

Elaeagnus angustifolia.—This species has been extensively planted for windbreak and to a lesser extent for ornamental purposes throughout the area. It showed considerable variability in winter hardiness, depending largely upon soil moisture conditions in the fall. Winter injury usually was heaviest following a wet autumn. Retention of leaves late in the fall makes the trees subject to breakage by sleet. Also, as the wood is somewhat brittle, large trunks are sometimes broken by gusty winds or drifted snow. *E. angustifolia* does not thrive in shade. Suppression by shade caused much of the injury and loss in the test block. The species is recommended for both dry-land and irrigated windbreaks. The species should not be irrigated during late August or in September, as maturing of the wood and setting of terminal buds would tend to be delayed.

Elaeagnus umbellata.—Testing of this species was confined to the Mandan station. Winter injury was severe each year, particularly after 1940 when fall soil moisture was higher than average. Heavy losses occurred during the severe drought years of 1934 and 1936. The species has no value for planting in the area.

Elaeagnus sp. (7551).—This species, originally from northern China, survived for 11 years but killed back heavily each winter. It is not suitable for planting in the area.

Fraxinus americana.—This species was tested at the Mandan station only. It suffered heavy injury and loss during the severe drought years of 1934 and 1936. Several trees were badly infested with the carpenterworm, *Prionoxystus robiniae* (Peck). The species is not recommended for dry-land planting but is believed to be suitable for planting under irrigation.

Fraxinus holotricha.—Testing of this species was confined to the Mandan station. The trees suffered heavy killing back each year. The species is not recommended for planting in the area.

Fraxinus mandshurica.—This species was tested at the Mandan station only. Killing back was severe after 1947. The species has a very erect form of growth and has a narrow crown (fig. 3). This growth form makes it a desirable type for ornamental purposes if supplemental water is available. It has no value as a dry-land windbreak tree. Leaves are dropped early in the fall.

Fraxinus nigra.—This species was tested at the Mandan station only. The trees were killed back severely during the drought years of 1934 and 1936 and to a lesser extent in other years. Many of the

FIGURE 3.—Trees of *Fraxinus mandshurica* have a very erect form of growth and have narrow crowns. These factors make the species desirable as an ornamental if supplemental water is available.

killed-back trees became suppressed. The species has an erect form of growth and a narrow crown, which makes it desirable for ornamental purposes if irrigation water is available. It is not suitable for dry-land planting.

Fraxinus pennsylvanica var. *lanceolata*.—This species is native to the area and has been widely planted for windbreak and ornamental purposes. The trees suffered heavy winter injury during the severe drought years of 1934 and 1936 only. The species does not thrive in shade; trees suppressed by shade frequently kill back. Weakened trees are susceptible to borer infestation throughout much of the area. This species is one of the best for windbreak purposes both under dry-land conditions and under irrigation.

Fraxinus sp. (P. I. 65866).—This species was tested at the Mandan station only. The trees were killed back frequently and they showed no promise of being suitable for dry-land planting in the area.

Gleditsia sinensis.—This species was tested at the Mandan station only. Severe winter injury occurred each year prior to 1947. It was less severe afterward. Failure of the species to set terminal buds in the fall makes its value for use in the area doubtful.

Gleditsia triacanthos.—This species has been planted to a limited extent throughout the area. Ordinarily, the trees are subject to killing back during the winter months. However, a few were found which have been entirely cold-hardy to date. The species will not be recommended for general planting until favorable results are obtained in further tests.

Halimodendron halodendron.—This species was tested at the Mandan station only. Winter injury was never severe. *H. halodendron*

is shrubby in growth habit and develops a crown spread approximately equal to its height. The species suckers profusely under cultivation. It appears to be a desirable species for erosion control and wildlife-cover purposes.

Juglans cinerea.—This species has been planted to a very limited extent in the area. Trees were killed back in varying degree each year, primarily as a result of insufficient moisture. In the test block survival dropped to 11 percent by the time the trees were 15 years old. The species is not recommended for planting in the area.

Juglans mandshurica.—This species was tested at the Mandan station only. The trees suffered severe winter killing each year. The species is not recommended for planting in the area.

Juglans nigra.—This species was tested throughout the area. Killing back and losses were heavy in dry-land plantings during the severe drought years of 1934 and 1936. The species is difficult to transplant. It has no value as a dry-land windbreak tree but is suitable for windbreaks under irrigation. A light crop of nuts was produced most years in the Mandan test block.

Juniperus communis.—This species, native to the area, has been used extensively for ornamental purposes. It is frequently found growing in the shade of other species. When planted in the open the foliage is subject to "burning" during the winter months. This burning was responsible for the loss in the test block. The species has no value for windbreak purposes but is a desirable ornamental. It is quite drought-resistant and can develop considerable spread.

Juniperus monosperma.—This species, native to the Wyoming section of the northern Great Plains, killed back repeatedly. It is recommended only for its native habitat.

Juniperus scopulorum.⁴—This species, native to the western two-thirds of the northern Great Plains, is hardy except for the "burning" of foliage on trees exposed to northwest winds during the winter. It is highly recommended for dry-land windbreak and ornamental planting in the area. Among conifers, *J. scopulorum* is one of the easiest to establish.

Juniperus virginiana.⁴—This species is native to the eastern edge of the area and has been planted fairly extensively in windbreaks. It is quite hardy and is highly recommended for both windbreak and ornamental plantings (fig. 4). The foliage occasionally suffers from "burning" during the winter. The species transplants fairly readily.

Larix decidua.—Testing of this species was confined to the Mandan station. It did well until the drought of 1934, when survival dropped to 4 percent. The species is not recommended for dry-land planting but is believed to be suitable for planting under irrigation.

Larix laricina.—Testing of this species was confined to the Mandan station. The behavior of the trees was similar to that of *L. decidua*. It can be recommended for planting under irrigation only.

Larix sibirica.—Testing of this species was confined to the Mandan station, where it was free of winter injury. It is recommended for dry-land and irrigated windbreak planting in the area.

⁴ This species is an alternate host of cedar rust of apples, a disease injurious to apple trees.

FIGURE 4.—*Juniperus virginiana* is quite hardy and is excellent for windbreak plantings.

Maackia amurensis.—Testing of this species was confined to the Mandan station. The trees proved to be cold-hardy and drought-resistant. The species has an upright growth form and a spreading crown. The data indicate that it is highly satisfactory for planting in the area, either as a windbreak or an ornamental tree.

Malus baccata.—This species has been extensively planted in the area as rootstocks for apple and crab trees and to a limited extent for windbreak purposes. The trees in the test block did well until the drought of 1934, when a high percentage died. They did not suffer severe winter injury at any time. The species gave highly satisfactory results in some farm windbreak plantings. It is recommended for such planting on the more favorable moisture sites.

Phellodendron amurense.—Testing of this species was confined to the Mandan station. Results were variable. One introduction (3991), which originated at Kiev, Russia, was killed out by the drought of 1934. The other introduction (P. I. 65638), brought in from Manchuria, proved to be more hardy. The data indicate that the species is worthy of trial for windbreak and ornamental purposes in the area.

Picea engelmanni.—This species is native to the higher altitudes of the western part of the area. The trees suffered no winter injury but lost most of their needles during the severe drought years of 1934 and 1936. Only 11 percent of the trees became established. They made a very dense growth, which is highly desirable for windbreak purposes.

Picea glauca.—This species has been planted to a limited extent in the area. Heavy winter injury and losses occurred during the severe drought years of 1934 and 1936. The species is recommended for

FIGURE 5.—Trees of *Picea glauca* var. *densata* suffered heavy killing back and losses during the drought year of 1934. The species should be planted only under irrigation or on sites of favorable moisture supply.

planting only on the more favorable moisture sites and under irrigation.

Picea glauca var. *densata*.—This species has been extensively planted for windbreak and ornamental purposes. Behavior of the trees (fig. 5) was similar to that of *P. glauca*, and the recommendations are the same. The species is difficult to establish in dry seasons.

Picea koyamai.—Testing of this species, consisting of only one tree, was confined to the Mandan station. The tree suffered severe killing back during the first 4 years and little or no injury during the remaining 7 years of its life. It is not recommended for planting in the area.

Picea mariana.—Testing of this species was confined to the Mandan station. Heavy killing back and losses occurred during the severe drought years of 1934 and 1936. It cannot be recommended for dry-land planting, but might be satisfactory under irrigation.

Picea pungens.—This species has been extensively planted for windbreak and ornamental purposes. Severe winter injury and heavy losses occurred during severe drought periods only. Tops of occasional trees planted on very dry sites have been killed back in some other years. *P. pungens* is a very desirable windbreak and ornamental tree, but it should be planted only on the more favorable moisture sites or on those receiving irrigation. The species is difficult to establish in dry seasons.

Pinus banksiana.—This species was planted fairly extensively in windbreaks prior to the first severe drought year (1934). Some killing back and losses, resulting from the lack of sufficient moisture, took place in most years. The injury and losses became heavy during the severe drought years of 1934 and 1936. The species is recom-

FIGURE 6.—Trees of *Pinus edulis* (foreground) made little progress in height in 11 years. Terminal growth killed back each year. The species is not recommended for planting in the area.

mended for planting only on sandy soils that have a high water table or on soils that can be irrigated.

Pinus contorta var. *latifolia*.—This species is native to the western part of the area. It has been used to a very limited extent for windbreak planting. Only minor winter injury has ever occurred. The data indicate that the species has promise for windbreak planting in the area.

Pinus edulis.—Testing of this species was confined to the Mandan station. Terminal growth was killed back each year and the trees made small progress in height (fig. 6). *P. edulis* is not recommended for planting in the area.

Pinus flexilis.—Testing of this species was confined to the Mandan station. It is native to the higher elevations in the western part of the area. A small stand of native trees was discovered in southwestern North Dakota in 1942 by Richard Williams. Although the trees in the test block made little growth during the first 8 years, good progress was made after that. The trees suffered no winter injury. Data indicate that the species is satisfactory for windbreak planting in the area.

Pinus nigra.—A small number of plantings of this species has been made in the area. The trees suffered minor killing back in some years and severe killing back in a few—as in 1942, when the temperature suddenly dropped to 16° F. in mid-September. The species should be planted only on the more favorable moisture sites or under irrigation. It is best adapted to the southern part of the area.

Pinus ponderosa.—This species, native to the western two-thirds of the area, has been planted extensively in windbreaks. Winter injury was of a minor nature except in suppressed trees, which frequently suffered severe injury. The species will not thrive in shade. The

FIGURE 7.—These trees of *Pinus ponderosa* are 33 years old. Although the species frequently is difficult to establish, it is excellent for windbreaks either under irrigation or in dry-land conditions.

trees lost most of their needles during the severe drought years of 1934 and 1936. The species makes an excellent dry-land or irrigated windbreak tree (fig. 7), but is frequently difficult to establish.

Pinus resinosa.—This species was tested throughout the area. The trees killed back severely and losses were heavy during the severe drought years of 1934 and 1936. The species is not recommended for dry-land planting.

Pinus sylvestris (1174).—This species was tested throughout the region. Heavy killing back and losses in stand occurred during the severe drought years of 1934 and 1936. P. I. 65796, tested at the Mandan station only, appears to be much more hardy. The species can be recommended only for planting on the more favorable moisture sites and under irrigation.

Pinus tabulaeformis.—Testing of this species was confined to the Mandan station. Of six plantings made during the drought years, only one tree became established. This tree made fair progress. The species may have some promise for planting in the area.

Populus acuminata.—This species is native to the western part of the area. The trees suffered variable winter injury each year. Sixty percent of the trees died by the sixth season and all were dead at the end of the eleventh season. *P. acuminata* is not suitable for dry-land planting, but is recommended for planting under irrigation.

Populus alba var. *nivea*.—This species has been planted for ornamental and windbreak purposes on many dry-land and irrigated farms throughout the area. It is not satisfactory under dry-land

conditions but is highly successful under irrigation. Root suckers, which frequently come up at long distances from the trees, are objectionable if the trees are near gardens or lawns.

Populus angustifolia.—This species, native to the western part of the area, suffered heavy winter injury and loss during the severe drought years. It is recommended for planting under irrigation only.

Populus balsamifera.—This species has been planted to a limited extent in the area. It suffered frequent killing back and heavy losses before the severe drought years. It is not recommended for dry-land sites but would be satisfactory where there is a plentiful supply of water for irrigation.

Populus berolinensis.—This species was tested at the Mandan station only. Winter injury, while not severe, was variable from year to year. Most of the trees died prior to the first severe drought year (1934). The last ones died that year.

Populus canadensis var. *eugenei*.—This species was extensively planted in the area during the early years of settlement. It was not satisfactory on dry-land sites but gave good response under irrigation. The species is susceptible to canker and leaf-rust infection.

Populus candicans.—This species, tested only at the Mandan station, suffered such heavy winter injury, canker infection, and loss during its early years that it is not recommended for planting in the area.

Populus deltoides.—Testing of this species was confined to an introduction that suffered heavy winter injury and loss during its early years. Many of the trees were badly infected with canker. It cannot be recommended for planting in the area.

Populus generosa.—Testing of this species was confined to the Mandan station. The trees made quite satisfactory progress and appear to have promise for planting in the area.

Populus nigra.—The two introductions of this species tested showed considerable variation. Introduction P. I. 34795 remained free of appreciable winter injury. It is recommended for either dry-land or irrigated windbreak planting. The other introduction, P. I. 34796, suffered heavy killing back and losses before the severe drought years and cannot be recommended for planting in the area.

Populus nigra var. *betulifolia*.—This species was tested at the Mandan station only. Winter injury was present each year. Further testing is needed before recommendations can be made for this species.

Populus nigra var. *italica*.—This species has been planted to a limited extent in the area. Winter injury occurred most years and losses began early in life. The species is recommended only for planting where there is a plentiful supply of irrigation water.

Populus petrowskiana.—Testing of this species was confined to the Mandan station. Severe killing back and heavy losses did not occur until the severe drought year of 1934, when a high percentage of the trees died. The remaining trees died in 1935. All trees were badly infected with canker at the time of their death. The species is not recommended for planting in the area.

Populus sargentii.—This species is native along streams and other moist places throughout much of the area. The trees killed back periodically and heavy losses occurred early in life. The species is recommended for planting under irrigation only.

Populus simonii.—This species was tested at the Mandan station only. Winter injury, varying from light to severe, was present each year. Despite the fact that no loss has occurred in stand, the killing back which has taken place in years of above-normal rainfall prevents the species from being recommended for planting in the area.

Populus tremuloides.—This species is native to the entire area. The trees are found in ravines, in depressions on the open prairie, and on sites where there is a good supply of moisture. The data indicate that it is not suitable for dry-land windbreak planting, but that it will give satisfactory results when planted under irrigation.

Populus spp.—These species include the so-called Canadian, Norway, and Northwest poplars, the first two of which were extensively planted in the area during the early years of settlement. The last one was widely planted in the area during the period 1922–34. With exception of the Northwest poplar, all species were highly subject to killing back and loss of stand, even before the severe drought years. Leaf rust was present in most years. Trees weakened by any cause became susceptible to borer infestation and canker infection. The Northwest poplar, native to North Dakota, and usually considered a cross between *P. sargentii* and *P. tacamahaca*, appeared to be the most drought-resistant species in years of normal rainfall. All of these species are suitable for windbreak planting under irrigation.

Prunus americana.—This species is native to the entire area. It grows in thickets on some of the more favorable moisture sites. Plantings on dry land suffered heavy injury and loss during the severe drought years of 1934 and 1936. The species suckers profusely under cultivation. These suckers give good cover even though the original trees die out. The species is recommended for windbreaks and for wildlife-cover plantings on the more favorable moisture sites and under irrigation.

Prunus pensylvanica.—This species is native to the extreme eastern edge of the area. It has been tested only at Mandan. The trees suffered heavy winter injury and loss during the severe drought years of 1934 and 1936. The species is recommended only for planting under irrigation.

Prunus serotina.—This species was tested at the Mandan station only. Some winter injury occurred each year. The trees usually produce an abundance of fruit, which is readily eaten by birds. The species is recommended for wildlife-cover planting under irrigation or on the more favorable moisture sites.

Prunus virginiana var. *melanocarpa*.—This species is native throughout the area. The shrubs suffered no appreciable amount of winter injury but became infected with X-disease in the last few years of the test. This infection resulted in the killing back or death of a number of shrubs (fig. 8). As X-disease spreads from chokecherry to domestic stone fruits, it is recommended that this useful hardy windbreak species not be planted close to stone-fruit orchards.

Pseudotsuga taxifolia.—This species has been planted in very limited quantities as an ornamental. It also is native to some parts of the Plains area of eastern Montana. Winter injury was severe during the drought years of 1934 and 1936 only. Heavy losses in stand occurred in 1936 and 1937. The species is a highly desirable windbreak or ornamental tree, but plantings should be confined to

FIGURE 8.—Shrubs of *Prunus virginiana* var. *melanocarpa* badly infected with X-disease. This hardy windbreak species should not be planted near stone-fruit trees, as it is the host for the X-disease.

irrigated sites or those with very favorable moisture conditions.

Quercus macrocarpa.—This species is native to most of the area. The trees are both cold- and drought-hardy but have a reputation of being slow growers. Trees grown under clean cultivation on dry land and free of other competition averaged about 1 foot of growth per year. Seedlings are usually difficult to transplant because of their taproot habit of growth. The wood is highly valued for fence posts. The species is recommended for windbreak and wood-lot plantings, both on dry land and under irrigation.

Rhamnus cathartica.⁵—This species (fig. 9) has been planted to some extent for hedge purposes. It is extremely cold- and drought-hardy and has a shrubby, dense habit of growth. *R. cathartica* is a highly desirable shrub for windbreak purposes.

Rhamnus davurica.⁵—This species was extensively planted in the area after the mid-1930's. It has proved to be both cold- and drought-hardy. The shrubs make a dense growth and can develop a crown spread that equals or exceeds their height. As the wood is very brittle, stems and branches are easily broken by drifted snow. The shrubs are prolific seed bearers. The seed ripens in late October and remains on the shrubs throughout the winter unless eaten by birds. The species is highly recommended for windbreak, ornamental, and wildlife-cover purposes.

Rhamnus saxatilis.⁵—This species was tested at the Mandan station only. The plantings suffered no winter injury, and the data indicate that the shrub may be very suitable for windbreak planting.

⁵ Species of *Rhamnus*, with the possible exception of *R. frangula*, which was not tested, are alternate hosts of crown rust of oats. They should not be planted in areas where oats are grown to much extent.

FIGURE 9.—These shrubs of *Rhamnus cathartica* were planted on this steep south slope in 1918. By 1950 only 2 percent of them had died. The species is highly desirable for windbreak purposes.

Rhamnus sp. (P. I. 65773).⁵—This species was tested at the Mandan station only. It proved to be both cold- and drought-hardy. The data indicate that it is suitable for windbreak planting.

Rhus trilobata.—This species is native to the area, where it grows in bottoms, ravines, and on hillsides. It seldom exceeds a height of 2 to 3 feet on dry sites but can reach heights of 10 to 12 feet on the more favorable sites of moisture supply. The species is quite hardy, but the low growth habit on dry sites limits its use in those locations to wildlife-cover purposes.

Rhus typhina.—This species has been used to some extent for ornamental and wildlife-cover purposes in the area. Winter injury and losses occurred in occasional years prior to 1934 and became heavy in that and the following year. The shrubs are attractive ornamentals in the fall, when the foliage becomes highly colored. However, the suckering habit of the species is objectionable in lawns. *R. typhina* is recommended only for ornamental and wildlife-cover plantings under irrigation.

Rosa multiflora.—This species was not tested long enough to permit definite recommendations. However, the data to date indicate that it has no promise for planting in the area. The shrubs were killed to the ground or to the snow line each winter. A rank growth sometimes 8 feet long was made each season. This semi-prostrate growth provided excellent cover for wildlife during the summer months.

Salix daphnoides.—This species was tested at the Mandan station only. Winter injury and losses in stand were heavy before the severe drought year of 1934. The species is not recommended for dry-land planting but presumably would be satisfactory under irrigation.

⁵ Species of *Rhamnus*, with the 'possible exception' of *R. frangula*, which was not tested, are alternate hosts of crown rust of oats. They should not be planted in areas where oats are grown to much extent.

Salix fragilis.—This species has been extensively planted in the area under several common names. Winter injury and loss varied from light to severe, largely dependent upon soil moisture conditions in the fall. The species has been used to a considerable extent for ornamental purposes, but has been objectionable because of the continual dropping of twigs and small branches. Another unfavorable feature is the usually heavy aphid infestation, which is objectionable on trees close to houses. The species is recommended for windbreak planting only on favorable moisture sites or on those receiving irrigation.

Salix matsudana.—This species was tested at the Mandan station only, where it suffered severe winter injury almost every year. The species has no possibilities for dry-land planting, but under irrigation it may have some value as an ornamental because of its crooked shoot growth.

Salix matsudana f. *umbraculifera*.—This species was tested at the Mandan station only. The tree suffered some winter injury each year. The species does not appear to have any promise for dry-land planting.

Salix missouriensis.—This species is native to the area, where it grows on bottoms that usually are flooded each year. The trees killed back repeatedly under dry-land conditions. Suckers that grew profusely from the roots of these trees seldom lived for more than 5 or 6 years. Behavior of the species on the bottom lands was somewhat similar to that under dry-land conditions except that the stems of the trees lived longer and grew to a greater height. These stems make excellent fence posts that find a ready market. The species is recommended for planting only for wood-lot purposes on sites that are wet or which usually are flooded each year.

Salix pentandra.—This species was tested in windbreaks and to a limited extent as an ornamental. Winter killing and losses in stand occurred most years. The species is highly desirable for windbreak plantings under irrigation. It is also the most desirable willow species for ornamental purposes.

Shepherdia argentea.—This species is native throughout the area. The shrubs grow along streams, in ravines, and on the north slopes of hills. The species suffered heavy killing back during the severe drought years of 1934 and 1936. It is highly susceptible to heart rot infection caused by *Fomes fraxinophilis* (Pk.) Sacc. forma *ellisianus* (F. W. Anders) Baxter. Breakage by wind and snow frequently occurs as a result of this disease and brittleness of the wood. Wind frequently uproots cultivated trees or twists them off at the ground line. Because of this the species is not recommended for windbreaks. However, it can provide good cover for wildlife throughout the year.

Sorbus americana.—This species has been planted on a very limited scale for ornamental purposes in the area. Winter injury and losses occurred in most years. Stems were very susceptible to sunscald. The species is of no value for planting on dry land but is a desirable ornamental under irrigation.

Sorbus aucuparia.—This species was tested at the Mandan station only. It behaved similarly to *S. americana*, and is therefore of no value for dry-land planting. It is a desirable ornamental under irrigation.

Syringia amurensis.—This species has been planted to some extent

in the area for hedge or ornamental purposes. It was tested as an ornamental at the Mandan station since 1916. The species suffered winter injury during the winter of 1949-50 only. It does not sucker under cultivation as do some other lilac species. The data indicate it to be very suitable either as a windbreak shrub or as an ornamental—in either group or trimmed-hedge form.

Thuja occidentalis.—This species has been planted to a very limited extent in the area. Some winter injury occurred each year, and losses were very heavy during the severe drought years. The species is not recommended for dry-land planting but is fairly satisfactory for ornamental purposes under irrigation.

Tilia americana.—This species is native to the eastern edge of the area and has been planted in some other parts of the northern Great Plains as an ornamental. The trees in the test block suffered winter injury each year. This resulted in a many-stemmed, shrubby type of growth (fig. 10). Trees planted nearby under irrigation escaped winter injury and developed a tree form of growth. The species is highly recommended for planting under irrigation.

Tilia europaea.—This species was tested only at the Mandan station. The heavy winter killing and losses in stand which took place during the severe drought years prevent the species from being recommended for dry-land planting. It may possibly be satisfactory for planting under irrigation.

Ulmus americana.—This species is native to much of the area. It grows in bottoms and other favorable moisture sites. The trees have

FIGURE 10.—As the result of killing back each year, these trees of *Tilia americana* growing under dry-land conditions developed multiple stems and a shrubby type of growth. Under irrigation, for which it is highly recommended, the species develops a tree form of growth.

been used extensively in windbreaks and for ornamental planting. Killing back frequently occurred during dry periods. Bark beetles infested weakened trees during the severe drought periods and made the trees more susceptible to killing back or loss of stand. The species gave an excellent response under irrigation. Under dry-land conditions the species gives the best response on the lighter soils. More frequent killing back takes place on the heavier soils.

Ulmus campestris.—Testing of this species was confined to the Mandan station. Most of the trees suffered frequent winter injury. Such injury was severe during the drought years of 1934 and 1936 (fig. 11). The species has no value as a dry-land windbreak tree but may have limited worth under irrigation. A shrubby type of growth makes the species less desirable than *U. americana*.

Ulmus carpinifolia var. *umbraculifera*.—This species was tested at the Mandan station only. Several of the introductions lived for only 2 or 3 years. The species is not recommended for planting in the area.

Ulmus fulva.—This species is native to the eastern edge of the area. It has not been planted to any appreciable extent in windbreaks. Winter injury was severe during the drought years of 1934 and 1936. Some injury during those years was caused also by a heavy infestation of bark beetles. Most of the losses occurred during that time. The species is recommended for planting under irrigation and also on lighter soils under dry-land conditions.

Ulmus japonica.—Testing of this species was confined to the Mandan station. Winter injury was minor, only tip injury being

FIGURE 11.—Some trees of *Ulmus campestris* were killed to the ground by the middle of summer during the severe drought of 1934. Trees that remained free of winter and drought injury that year killed back severely during the drought year of 1936. The species is recommended for planting under irrigation only.

recorded during the severe drought years. The species has a good form of growth and the data indicate that it is highly satisfactory for windbreak planting.

Ulmus parvifolia.—Testing of this species was confined to the Mandan station. The trees suffered severe winter injury almost every year. During the period this species was under test, it showed no promise for planting in the area.

Ulmus pumila.—This species has been extensively planted on the northern Great Plains for both windbreak and ornamental purposes. Its behavior has been somewhat erratic in that very heavy killing back and losses occur in some years for no apparent reason. Severe freezing temperatures early in the fall, such as occurred in 1942, resulted in heavy killing back and loss. Heavy losses that occurred in some years cannot be traced to any climatic factor. The species seldom sets terminal buds before late in the fall. The late retention of leaves and brittleness of the wood makes exposed trees subject to wind and sleet breakage. Young trees are quite susceptible to damage by rabbits. Despite the unfavorable factors, the species is recommended for windbreak planting on all except wet sites. Trees should not be irrigated in late August or in September and they should always be planted among other species. *U. pumila* was introduced from China in 1908 as Chinese elm. It is now generally known as Siberian elm.

Ulmus hybrids.—These trees are natural hybrids. *U. pumila* is one parent and *U. fulva* is possibly the other. The hybrids were selected from a nursery field of the Soil Conservation Service at Vermillion, S. Dak. In the test block, four of the trees lacked vigor and suffered repeated winter injury before dying between the fifth and eleventh years. The other trees suffered no injury and maintained a vigorous condition. A high percentage of these trees have an excellent growth form (fig. 12) that is free of the heavy branching and sharp crotches so characteristic of *U. pumila*. Most of the trees drop their leaves and set terminal buds before the advent of cold weather. Hybrid trees with *U. pumila* as one parent are believed to have considerable promise for windbreak and ornamental purposes in the area.

Zelkova serrata.—Testing of this species was confined to the Mandan station. Some winter injury occurred each year but was severe in the drought years of 1934 and 1936 only. Young trees of the species are highly susceptible to rabbit injury. The species has some promise for windbreak planting in the area.

Zelkova sinica.—Testing of this species was confined to the Mandan station. Some winter injury occurred in most years and was severe following a heavy freeze in September 1942. The data indicate that the species is suitable for planting in the area.

RECOMMENDED SPECIES

Tree and shrub species recommended for planting on the northern Great Plains must be highly resistant to long periods of freezing weather, during which time the temperature may sometimes drop to as low as -63° F. A very limited amount of moisture is usually available to species in dry-land plantings. In some years the total

FIGURE 12.—A high percentage of *Ulmus* hybrids with *U. pumila* as one parent have an excellent growth form. It is believed that the hybrids hold considerable promise for windbreak and ornamental purposes in the area.

rainfall may not exceed 6 or 7 inches. Also, the evaporation rate during the growing season is generally very high.

Not all of the species listed in table 4 can be recommended for planting in the area. Some died shortly after passing the 10-year mark; others survived for much longer periods but exhibited unfavorable characteristics. A few species were tested for only a short time.

Most of the data are based on trees grown under dry-land conditions. However, observations were made of a number of species (not in test plots but corresponding to test species) that were under irrigation or were growing under favorable moisture conditions. These observations as well as the test data have been drawn upon in making up the recommended list of trees and shrubs and their suggested uses that are presented in table 5.

Many species that killed back repeatedly or failed under dry-land conditions were found to be hardy and of long life when given supplemental water. Examples of such species are those of *Populus* and *Salix*, which under dry-land conditions killed out at comparatively early ages and suffered heavy winter injury during the period they were alive. Identical species planted a short distance away at approximately the same time, and under irrigation, did very well in their 35 to 40 years of growth.

The application of irrigation water at the proper seasons of the year was highly beneficial to most trees and shrubs; its use is highly recommended. Irrigation early in the fall may sometimes prove harmful to species of indeterminate growth habits in that it tends to

TABLE 5.—Tree and shrub species recommended for planting on the northern Great Plains, based on observations by the field station at Mandan, N. Dak., 1913-50

Scientific name	Type of growth	Height ¹	Crown spread ²	Num-ber of years tested	Index to suitability ³ —			Index to growth response under ⁴ —	
					In wind-breaks	For wild-life cover	As ornamentals	Dry-land conditions	Irrigation
<i>Acer ginnala</i>	Shrub.....	T.....	M.....	36.....	G.....	F.....	G.....	P.....	G.....
<i>Acer mandshuricum</i>	do.....	T.....	M.....	18.....	G.....	F.....	G.....	G.....	G.....
<i>Acer negundo</i>	Tree.....	M.....	W.....	36.....	G.....	F.....	F.....	P.....	G.....
<i>Acer saccharinum</i>	do.....	T.....	W.....	36.....	G.....	F.....	G.....	F.....	G.....
<i>Acer tataricum</i>	Shrub.....	T.....	M.....	36.....	G.....	F.....	G.....	P.....	G.....
<i>Amelanchier stolonifera</i>	do.....	L.....	N.....	35.....	U.....	G.....	F.....	G.....	G.....
<i>Betula populifolia</i>	Tree.....	M.....	M.....	35.....	U.....	F.....	F.....	F.....	G.....
<i>Caragana arborecens</i>	Shrub.....	M.....	M.....	36.....	U.....	G.....	F.....	G.....	G.....
<i>Caragana frutex</i>	do.....	L.....	N.....	6.....	U.....	F.....	G.....	G.....	G.....
<i>Caragana microphylla</i> var. <i>mandshurica</i>	do.....	M.....	M.....	14.....	G.....	F.....	G.....	G.....	U.....
<i>Caragana pygmaea</i>	do.....	L.....	N.....	15.....	U.....	F.....	F.....	G.....	G.....
<i>Caragana</i> sp. (P. I. 107664).....	do.....	L.....	M.....	14.....	U.....	F.....	G.....	G.....	G.....
<i>Caragana</i> sp. (P. I. 108051).....	do.....	L.....	N.....	13.....	U.....	G.....	F.....	G.....	U.....
<i>Caragana</i> sp. (P. I. 108332).....	do.....	L.....	W.....	13.....	U.....	G.....	F.....	G.....	U.....
<i>Celtis occidentalis</i>	Tree.....	T.....	M.....	35.....	G.....	F.....	G.....	P.....	G.....
<i>Elaeagnus angustifolia</i>	Shrub.....	T.....	W.....	35.....	G.....	G.....	F.....	V.....	G.....
<i>Fraxinus americana</i>	Tree.....	T.....	M.....	27.....	G.....	F.....	G.....	P.....	G.....
<i>Fraxinus mandshurica</i>	do.....	M.....	N.....	19.....	F.....	F.....	G.....	P.....	G.....
<i>Fraxinus nigra</i>	do.....	M.....	N.....	30.....	G.....	F.....	G.....	P.....	G.....
<i>Fraxinus pennsylvanica</i> var. <i>lanceolata</i>	do.....	T.....	M.....	36.....	G.....	F.....	G.....	G.....	U.....
<i>Halimodendron halodendron</i>	Shrub.....	M.....	M.....	25.....	G.....	G.....	F.....	G.....	G.....
<i>Juniperus communis</i>	do.....	L.....	W.....	30.....	F.....	G.....	G.....	G.....	G.....
<i>Juniperus scopulorum</i>	do.....	M.....	M.....	13.....	G.....	G.....	G.....	G.....	G.....
<i>Juniperus virginiana</i>	do.....	M.....	M.....	35.....	G.....	G.....	G.....	G.....	G.....
<i>Larix sibirica</i>	do.....	M.....	M.....	27.....	G.....	F.....	F.....	G.....	G.....
<i>Maackia amurensis</i>	do.....	L.....	M.....	28.....	G.....	F.....	G.....	G.....	U.....
<i>Malus baccata</i>	Shrub.....	T.....	W.....	30.....	G.....	F.....	F.....	V.....	G.....
<i>Phellodendron amurense</i>	Tree.....	L.....	M.....	19.....	G.....	F.....	G.....	G.....	U.....

<i>Picea engelmanni</i>	do	M	29	G	G
<i>Picea glauca</i>	do	M	30	G	G
<i>Picea glauca</i> var. <i>densata</i>	do	T	35	G	G
<i>Picea pungens</i>	do	T	35	G	G
<i>Pinus contorta</i> var. <i>latifolia</i>	do	T	30	G	G
<i>Pinus flexilis</i>	do	T	16	G	G
<i>Pinus nigra</i>	do	M	18	G	G
<i>Pinus ponderosa</i>	do	M	35	G	G
<i>Pinus sylvestris</i>	do	T	35	G	G
<i>Populus acuminata</i>	do	T	35	G	F
<i>Populus alba</i> var. <i>nivea</i>	do	T	36	G	F
<i>Populus generosa</i>	do	T	16	G	F
<i>Populus nigra</i>	do	T	35	G	F
<i>Populus sargentii</i>	do	T	35	G	F
<i>Populus</i> sp. (Northwest).....	do	T	36	G	F
<i>Prunus americana</i>	Shrub	M	35	G	F
<i>Prunus serotina</i>	do	M	35	G	F
<i>Prunus virginiana</i> var. <i>melanocarpa</i>	do	M	33	G	F
<i>Pseudotsuga taxifolia</i>	Tree	T	13	G	F
<i>Quercus macrocarpa</i>	do	M	33	G	G
<i>Rhamnus cathartica</i>	Shrub	M	23	G	G
<i>Rhamnus davurica</i>	do	M	15	G	G
<i>Rhamnus saxatilis</i>	do	M	23	G	G
<i>Rhamnus</i> sp. (P. I. 65773).....	do	M	35	F	G
<i>Rhus trilobata</i>	do	L	36	G	F
<i>Salix fragilis</i>	Tree	M	36	G	F
<i>Salix pentandra</i>	do	M	36	G	F
<i>Shepherdia argentea</i>	Shrub	L	33	F	G
<i>Sorbus americana</i>	do	M	35	F	G
<i>Syringia amurensis</i>	do	M	7	G	G
<i>Tilia americana</i>	Tree	L	33	G	G
<i>Ulmus americana</i>	do	T	36	G	F
<i>Ulmus fulva</i>	do	W	35	G	F
<i>Ulmus japonica</i>	do	M	22	G	F
<i>Ulmus pumila</i>	do	T	34	G	F
<i>Zelkova serrata</i>	do	M	18	F	F
<i>Zelkova sinica</i>	do	T	24	F	F

¹ L—Low; M—medium; T—tall.

² N—Narrow; M—medium; W—wide.

³ G—Good; F—fair; U—unsuited.

⁴ G—Good; P—poor; V—variable; F—failure; U—unknown.

delay maturity of the wood and setting of terminal buds. Most research workers agree that irrigation in late summer and early fall reduces the resistance of plants to frost injury.⁶ Fall irrigation of immature trees should be delayed until they are dormant.

The form of growth and the comparative height and crown spread given in table 5 for each of the recommended species are the normal ones. Long dry periods or unfavorable soil types may prevent some of the species that normally have a tree form of growth from ever becoming more than medium or tall shrubs. Close planting such as that often practiced in landscape groups may prevent full development of the crown. Such planting frequently results also in either weak, suppressed trees or forced height growth at the expense of trunk diameter and crown-spread growth. Proper planting arrangement and maintenance of the best possible growing conditions will do much to assure the most satisfactory development of the trees. Information on growing trees for windbreak and other purposes on the northern Great Plains may be obtained by writing the County Agricultural Agents or Extension Service Foresters of the respective States; the Northern Great Plains Field Station, Mandan, N. Dak.; or the Office of Information, United States Department of Agriculture, Washington, D. C.

⁶ LEVITT, J. FROST KILLING AND HARDINESS OF PLANTS. A CRITICAL REVIEW. Pp. 56-58. Univ. Minn. 1941. (Processed.)