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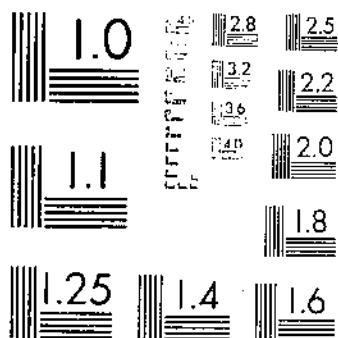
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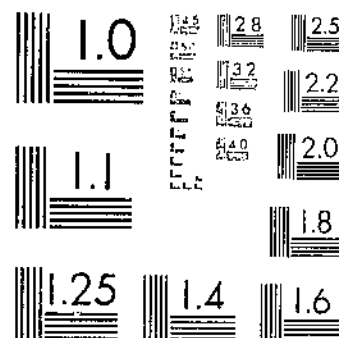
USDA TECHNICAL BULLETINS
TREE WILLOWS AND WALNUTS OF THE ROCKY MOUNTAIN REGION

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**POPLARS
PRINCIPAL TREE WILLOWS
AND WALNUTS OF THE
ROCKY MOUNTAIN
REGION**

By

GEORGE B. SUDWORTH

Late Dendrologist, Branch of Research, Forest Service



UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D.C.

George B. Sudworth (1864-1927) was at the time of his death dean of the profession of forestry in this country. He had the distinction of having been the first person in the history of American forestry to receive official appointment as dendrologist, and was the oldest member of the Forest Service in point of service. His appointment in the Department of Agriculture on August 31, 1886, during the infancy of organized Federal forestry in this country, made his 41 years of official service, through the successive stages of Division of Forestry, Bureau of Forestry, and finally Forest Service, practically coextensive with American forestry development and progress. Mr. Sudworth's contributions to the advance of forest research in those years were extensive and varied, including much field study and exploration as a dendrologist, the discovery and naming of a large number of new tree species and varieties, and the collection of many valuable type specimens, as well as studies in nursery practice, wood identification, and horticulture. He was one of the framers of the so-called American code of botanical nomenclature. For 15 years he was an active member of the Federal Horticultural Board. Of his many publications on forestry, among the most important are his reports on early forest reserves and his Check List of the Forest Trees of the United States, Their Names and Ranges, a completely revised edition of which was issued only a few weeks before his death and which represented the fruit of painstaking study and solicitous attention during the four decades of his public service.

The present bulletin is sixth in a series of works by Mr. Sudworth on the systematic dendrology of western trees, of which the predecessors are Forest Trees of the Pacific Slope (1908), Cypress and Juniper Trees of the Rocky Mountain Region (1915), Spruce and Balsam Fir Trees of the Rocky Mountain Region (1916), Pine Trees of the Rocky Mountain Region (1917), and Miscellaneous Conifers of the Rocky Mountain Region (1918).



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AND WALNUTS OF THE ROCKY
MOUNTAIN REGION

By GEORGE B. SUDWORTH¹

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CONTENTS

	Page		Page
Introduction.....	1	Generic characteristics of the willows.....	48
Family characteristics of poplars and willows.....	3	Key to the willows described in this bulletin.....	50
Generic characteristics of poplars.....	4	Black willow (<i>Salix nigra</i> Marsh.).....	53
Key to Rocky Mountain poplars.....	6	Dudley willow (<i>Salix goodingii</i> Ball).....	56
Aspen (<i>Populus tremuloides</i> Michx. and <i>P. tremuloides aurea</i> (Pit. & Dan.).....	7	Peachleaf willow (<i>Salix amygdaloides</i> Anders.).....	59
Balsam poplar (<i>Populus balsamifera</i> L.).....	11	Red willow (<i>Salix lasioigata</i> Bebb).....	63
Balm-of-Gilead poplar (<i>Populus balsamifera canadensis</i> (Mill.) A. Gray).....	14	Toumey willow (<i>Salix bonplandiana</i> Toumey) (Britt) Schn.).....	66
Northern black cottonwood (<i>Populus trichocarpa</i> hastata (Dode) Henry).....	17	Western black willow (<i>Salix lasiandra</i> Benth.).....	69
Lanceleaf cottonwood (<i>Populus acuminata</i> Rydb.).....	20	Sandbar willows.....	74
<i>Populus acuminata rehderi</i> Sarg.....	22	<i>Salix interior</i> Rowles.....	76
<i>X Populus andrewsii</i> Sarg.....	23	<i>Salix ericua</i> Nutt.....	78
Narrowleaf cottonwood (<i>Populus angustifolia</i> James).....	23	Yewleaf willow (<i>Salix taxifolia</i> H. B. K.).....	81
Arizona cottonwood (<i>Populus arizonica</i> Sarg.).....	28	White willow (<i>Salix lasiolepis</i> Benth.).....	84
Cottonwood (<i>Populus</i> spp.).....	29	Mackenzie willow (<i>Salix mackenzieana</i> Barr.).....	87
<i>Populus sargentii</i> Dode.....	29	Bebb willow (<i>Salix bebbiana</i> Sarg.).....	90
<i>Populus fremontii</i> S. Wats.....	32	Scouler willow (<i>Salix scouleriana</i> Barr.).....	93
<i>Populus texana</i> Sarg.....	35	Family relationships and generic characteristics of walnuts.....	97
<i>Populus wislizeni</i> (S. Wats.) Sarg.....	39	Key to Rocky Mountain walnuts.....	98
Southern cottonwood (<i>Populus deltoides</i> virginiana (Castigl.) Sudw.).....	41	Little walnut (<i>Juglans rupestris</i> Engelm.).....	98
MacDougal cottonwood (<i>Populus macdougalii</i> Rose).....	45	Nogal (<i>Juglans rupestris major</i> Torr.).....	102
		Literature cited.....	105

INTRODUCTION

In a series of four preceding monographs (86, 87, 88, 89)² the author has covered the coniferous trees of the Rocky Mountain region. In the present publication he discusses certain of the hardwoods of that region.

¹ Review and some revision of this posthumous manuscript has been made by Perkins Coville. It was the intention of the author to prepare keys for the identification of the species covered in this bulletin, but up to the time of his death (May 10, 1927) such keys had not been compiled. Those published herewith have been prepared by William A. Dayton, who has also enlarged and rearranged the bibliography and added certain footnote notations. In his original draft of the manuscript the author took pains to express his hearty appreciation of the unflinching assistance given by members of the Forest Service, particularly officers of the national forests, who responded to many special requests for specimens and information on range. Indebtedness was expressed to the late Mrs. A. E. Hoyle for fully half of the botanical drawings which illustrate the text; also to Mrs. N. B. Brentner of the Forest Service; and to J. Marion Shull and Frank Bond, formerly of the Forest Service but now, respectively, of the Bureau of Plant Industry and chairman of the U.S. Geographic Board, for their share of the illustrative work.

² Italic figures in parentheses refer to Literature Cited, p. 105.

As defined in this bulletin, the Rocky Mountain region includes Montana, Idaho, Wyoming, Colorado, Utah, Nevada, Arizona, New Mexico, and the western part of North Dakota, South Dakota, Nebraska, Oklahoma, and Texas. The Dakotas, western Nebraska, western Oklahoma, and western Texas are included because their topographic and climatic conditions are more or less similar to those of the Rocky Mountain States and because many of the tree species are the same. For example, the Rocky Mountain form of ponderosa pine (western yellow pine) grows abundantly in the Black Hills of South Dakota and in western Nebraska, and limber pine (*Pinus flexilis*), Arizona cypress (*Cupressus arizonica*), alligator juniper (*Juniperus pachyphloea*), and other species occur in the mountains of western Texas. A number of Rocky Mountain species grow naturally also in adjacent Canadian and Mexican territory. It was necessary, in defining the range of such trees, to include this territory.

The geographic distribution of the different species is shown by photographic reductions of large folio maps on which the range data were originally plotted. It is comparatively easy to describe the range of trees in some such words as "from Maine to Florida and westward to Minnesota, Missouri, and Texas", but when the attempt is made to express such very general information satisfactorily on a map many difficulties are encountered. The statement does not indicate whether the boundary reaches the nearer or farther State line or lies somewhere within the State. Also there may be and usually are large and small interruptions or gaps within a generally described range from north to south or from east to west. In mountainous regions it is important to know also the altitudinal range of a tree. In spite of these difficulties, these reduced maps present a much more accurate outline of the distribution than would be believed possible from their small size.

In mapping the range of trees it is often necessary, for want of detailed information, to represent the range area as solid or continuous. A map so constructed is apt to give the impression that the tree concerned grows in all places throughout an area thus indicated; in reality, all it means in the majority of cases is that the tree is found within the limits of the area. In a few instances available information has been sufficient to allow the range to be indicated more accurately by a disconnected plotting.

Although the geographic distribution of a good many of the better known trees is now thoroughly delimited, further painstaking field explorations are necessary before knowledge of the range of many of the others can be completed. The extreme points actually reached in the range of these trees are yet to be discovered, and it is only through the combined efforts of students of trees that this highly desirable information can be obtained.

The information used in compiling the maps accompanying this bulletin was derived from all available published and unpublished material, including field notes and reports of Forest Service officers who in the exploration and administration of the national forests have unusual opportunities for gathering such data.

Text descriptions are put, so far as has seemed feasible to the author, in simple language. Some technical phrases, however, have seemed unavoidable, especially in the keys. For definition of those terms the reader is referred to the glossary of botanical terms issued by the Forest Service (24). Effort has been made to supplement the text descriptions as fully and accurately as possible by keys and illustrations. The nomenclature is that established as official for the Forest Service, as presented in the Check List of the Forest Trees of the United States (90). It is admitted that this usage varies considerably from that given in many botanical publications.

FAMILY CHARACTERISTICS OF POPLARS AND WILLOWS

Salix and *Populus*, the two genera constituting the whole family Salicaceae, comprise a very large group of trees and shrubs. The bark of these plants is characteristically bitter,³ particularly that of the willows, and their juices are bitter and watery. The leaves, shed in early autumn, are borne alternately on the branches, never in pairs. In willows they are short-stalked but are long-stalked in aspens and most cottonwoods and poplars. As a rule, the staminate and pistillate flowers of poplars and willows are produced on different trees,⁴ and seed is therefore borne only by female trees, the flowers of which are fertilized by wind and by insects (largely bees).

Buds of both genera are scaly. In poplars all the staminate and most of the pistillate catkins droop. They come forth on twigs of the previous year's growth and appear considerably in advance of the leaves. The aments of poplar flowers differ from those of the willows in producing no leaves at their bases. The staminate flowers bear at their base a small fringed or toothed scale. In most species the pistillate flowers have a similar scale.

The fruits of poplars and willows ripen in late spring about the time the leaves reach full size. They are single-celled thin capsules (figs. 29 and 32) which split open soon after maturity into 2 or 4 sections, liberating the minute seeds. The numerous long, exceedingly fine, silky hairs on the seeds enable the wind to carry them easily for very long distances.

With some exceptions the poplars and willows are moisture-loving plants. This accounts for their prevalence along streams and in moist bottom lands. A remarkable characteristic is their ability to grow readily from root or branch cuttings and to sprout vigorously and persistently from cut stumps of almost any age and from various points on their long, shallow roots, often at great distances from the stump.

A key to the Salicaceae is presented as follows:

Flores in cuplike, often oblique disks; floral bracts fimbriate or incised; stamens numerous (6 to 80); stigmas 2-4, entire or 4-lobed; buds resinous, covered by several scales. Trees; leaves mostly broad, typically of an ovate type (occasionally narrower), mostly rather long-stalked; aments usually pendulous.-----*Populus*

³The bark and fresh aments in willows and the bark of poplars yield the exceedingly bitter glycoside known in medicine as salicin.

⁴Sometimes one tree may produce clusters of male and female flowers, or even clusters combining both male and female flowers, but this is exceptional.

Flowers not in cuplike disks, subtended by 1 or 2 small glands; floral bracts entire (or at most with small teeth); stamens mostly 2 (varying from 1-10); stigmas 2, short, entire, or 2-cleft; buds covered by a single scale. Shrubs, trees, or subalpine-alpine undershrubs; leaves mostly of a narrow (often lanceolate) type, sessile or short-stalked; aments usually erect or spreading, sometimes pendulous.----- *Salix*

GENERIC CHARACTERISTICS OF POPLARS

This large group includes the trees popularly known as aspens, poplars⁵ or "popples", and cottonwoods. Several of them are very large forest trees, with rough, deeply furrowed, grayish bark (cottonwoods), or smooth, little broken, brownish green, pale green, whitish, or ashy bark (aspens). In outline, many of the leaves are broadly triangular (deltoid) or ovate; in a very few species, however, the leaves are lanceolate and willowlike. The leaf edges are occasionally uncut (entire) but more often bear fine teeth like a small saw or large and coarse or hooked teeth. When mature, the leaves are most often hairless (glabrous) on both surfaces, but in some species the hairy or woolly covering is persistent. The leaf stalks (petioles) of the aspen group of this genus are flattened at right angles to the leaf blade, and this causes the leaves to tremble in the slightest breeze. After turning yellow in autumn the leaves fall from the trees, leaving prominent leaf scars which give the twigs a knotty appearance.

The scaly buds of many species are characterized by a covering of pungent sticky resin,⁶ which appears to act as a winter protection. Male and female flowers are borne on separate trees; only the female trees produce seed. Trees of the two sexes are unevenly distributed—frequently only one seed tree to many staminate or sterile trees; sometimes male and female trees are very widely separated.

The wood of the poplars is light, soft, and straight grained. The grain is sometimes fine, but is more often coarse as a result of the rapid diameter growth characteristic of these trees. The wood ranges in color from whitish to light or yellowish brown. The wood of most species is brittle, susceptible to heat and moisture changes, not durable, and formerly had no economic value; but that of a number of species is now rapidly coming into wide use and great commercial value, both for pulpwood and as lumber to take the place of other lightweight woods, the supply of which is decreasing. One of the last-mentioned is yellow poplar (tuliptree), which the wood of some of the poplars resembles in grain and in the ease with which it can be worked.

The poplars are important to the forester. They produce a forest cover and useful timber in 25 to 50 years and, like the willows, can easily and conveniently be grown from root and branch cuttings and from cut stumps, even from stakes set in damp soil. Thus artificial propagation is very simple. Maturity is reached in not more than 100 to 150 years, usually well within a century. After

⁵ *Larix dendron tulipifera* L., native of the eastern part of the United States, and known as yellow poplar, is a member of the magnolia family and is not closely related to the true poplars. This species is also known as "tuliptree."

⁶ Cottonwood buds are one of the chief sources from which bees derive propolis, the so-called "bee glue" with which honeybees cement cracks in their hives and fasten the combs in hives or in the hollows of trees. When hard it is very strong.

maturity the poplars ordinarily begin to show signs of arrested growth, but on account of their great vitality and recuperative power some species may continue to grow for a much longer time.

Poplars now recognized in the United States and adjacent areas in Mexico and Canada include 17 different native and naturalized species, 13 varieties, and 4 hybrids. Eleven botanical species (embracing 11 varieties) and 1 hybrid grow within the Rocky Mountain region.

The poplars are of very ancient origin. Remains show that they existed among the earliest tree forms of the Lower Cretaceous period in Greenland, and that many different species inhabited the central portion of this continent in the same epoch. They existed also in the Tertiary and Miocene periods in this country and Europe. (14; 43; 50; 51; 52; 73; 76, v. 9; 105.)

KEY TO ROCKY MOUNTAIN POPLARS⁷

Leaves lanceolate to ovate-lanceolate; petioles short (one third as long as the blades or shorter). Leaves crenulate, with blunt teeth, 5-15 cm long, 2-4 cm wide, rounded or narrowed at the base, much paler beneath; stamens 12-20; stigmas dilated; capsules ovate, rugulose; Transition and Upper Sonoran Zones.....*Populus angustifolia*

Leaves not lanceolate (rarely ovate-lanceolate), of a broader type; petioles more than one third as long as the blades (mostly about as long as the blades or even longer).

Petioles terete, though sometimes channeled above.

Leaves rhombic-lanceolate to ovate, green on both sides, acuminate, crenulate.

Twigs and winter buds more or less resinous but not woolly pubescent. Leaves 6-10 cm long, 3-5 cm broad, abruptly long-acuminate, crenulate to rather coarsely crenate, the lower surface often somewhat paler and duller than the upper; petioles one half to three fourths as long as the blades; Upper Sonoran Zone, Saskatchewan to Texas and Arizona.....*P. acuminata*

Twigs and winter buds woolly-pubescent. Leaves larger and longer-petioled than in typical *acuminata*; stream banks of southeastern New Mexico.....*P. acuminata rehderi*

Leaves not at all rhombic.

Leaves usually yellow-green, not conspicuously reticulated, glabrous, oblong-ovate, finely crenate-serrate, rounded or cuneate at the base, 9-10 cm long. Petioles nearly terete; twigs light orange-brown; Colorado hybrid of *P. sargentii* x *P. acuminata*.

Leaves dark green above, conspicuously reticulated, much paler, and often more or less puberulent beneath.

Leaves ovate-lanceolate to cordate-ovate, about one half to three fifths as wide as long, the margins somewhat thickened and revolute; petioles usually glabrous; stamens 20-30, short, with pink anthers; stigmas 2; capsules ovoid-oblong, two-valved. Leaves minutely ciliate but otherwise glabrous except sometimes on midrib beneath, silvery whitish or pale brownish beneath, 7-12 cm long, acute or short-acuminate, rounded or occasionally cordate or truncate, rarely broadly cuneate at the base; buds highly fragrant-resinous.

*P. balsamifera*⁸

Leaves broadly ovate to ovate, about two thirds as broad as long or broader.

⁷ Key prepared by W. A. Dayton, based largely on the work of Britton and Shaffer (19), Standley (89), Sargent (79), Tidestrom (92), and Rydberg (77). Mr. Sudworth's nomenclature has, however, of course been followed. The key was also orally discussed with Mr. Tidestrom, who has a monograph of *Populus* in preparation and has contributed many excellent suggestions.

⁸ This has been confused by some American authors with *P. tacamahacca* Mill.

Leaves typically cordate (rarely truncate) at the base; petioles pubescent. Leaves of a broadly ovate-deltoid type, acuminate, coarsely crenate-serrate, ciliate, usually 12-16 cm long and about 10 cm broad, slightly pubescent above, whitish and sparingly pubescent beneath, but densely so on the veins; twigs brown. Common in cultivation; the balm-of-Gilead poplar. Sargent states that only the pistillate tree is known.

P. balsamifera candidans (= *P. candidans*)

Leaves not typically cordate; stamens 40-60, elongated, with purple anthers; stigmas 3; fruit usually subglobose, three-valved. Leaves usually rounded at base, ovate or short-acuminate. ----- *P. trichocarpa*⁹

Petioles laterally compressed, mostly elongated. Aspens and allied "cottonwoods."

Leaves suborbicular, 2-6 cm long (those of rootshoots ovate), finely serrate; stigmas 2, filiform. Bark thin, smooth, pale, grayish or greenish; winter buds glabrous but somewhat resinous; the common western aspen, a Canadian Zone tree.

P. tremuloides aurea (= *P. aurea*)

Leaves not suborbicular; stigmas mostly 3 or 4, usually dilated.

Leaves oblong-ovate, 9-10 cm long, finely crenate-serrate, rounded or cuneate at base. Petioles nearly terete, only slightly flattened laterally; Colorado hybrid of *P. sargentii* x *P. acuminata*.

x *P. andrewsii*

Leaves of a distinctly deltoid or ovate type, acuminate, thick or thickish, usually coarsely toothed. Largely southern species (except *P. sargentii*).

Pedicels as long as and usually longer than the capsules;¹⁰ leaves lustrous above, thick. Fruit three- or four-valved; large trees.

Leaves glabrous, not ciliate, usually broader than long, yellow-green, not pale beneath, abruptly short-pointed, coarsely and irregularly crenate-serrate but the tip often entire. Glands absent at base of leaf blade;¹¹ capsules 10-13 mm long; southwestern tree, Lower and Upper Sonoran Zones. ----- *P. wislizeni*

Leaves ciliate but glabrous on both faces, deltoid or cordate-deltoid, about as long as broad or somewhat longer, crenately serrate with incurved glandular teeth. Buds glabrous, not resinous; floral bracts deciduous. Typically eastern tree, river bottoms and lowlands.

P. deltoides virginiana (= *P. virginiana*)¹²

Pedicels shorter than the capsules.¹⁰

Twigs slender; capsules not over 6 mm long.¹³ Leaves truncate or broadly cuneate at the base, long-acuminate,

⁹ Dode (87) has separated out a form of this under the name of *P. hastata* Dode, which Mr. Sudworth here recognizes as *P. trichocarpa hastata* (Dode) Henry. Dode distinguished it by its larger catkins, larger, more acuminate, and less conspicuously nerved leaves, and glabrescent capsules. It seems to be a feebly separable form at best and Tidestrom rejects it altogether. Rydberg (71) separates it from *trichocarpa* on the following key (N. B.—Dode states that the petioles of *trichocarpa* are pubescent, and those of *hastata* pubescent when young):

Petioles usually more or less pubescent; ovary and capsule subglobose, densely pubescent. ----- *P. trichocarpa*

Petioles glabrous; ovary and capsule ovoid, glabrous. ----- *P. hastata*
Tidestrom regards the above characters as entirely too variable in this species to hold; it will be noted that he recognizes *trichocarpa* but makes no mention of *hastata* in his Flora of Utah and Nevada (93). Rydberg (71) admits typical *trichocarpa* to Montana and presumably to Idaho also. Sudworth, in this bulletin, does not admit any but the form *P. trichocarpa hastata* to the Rocky Mountains. The type locality of both *trichocarpa* and *hastata* seems to be California.

¹⁰ Some botanists believe this character is too variable to hold.

¹¹ Willdenow first made use of this character, but later botanists (except Rehder) have largely discarded it as uncertain.

¹² Tidestrom questions western range (except under cultivation) of this typically eastern species or variety.

¹³ Tidestrom is inclined to regard *arizonica* as a synonym of *P. fremontii*. It is supposed to have the smallest fruits among American cottonwoods (Sargent), but this raises questions of dwarfing and improper fertilization.

coarsely serrate, 3.5-5 cm long; disk cup shaped,¹⁴ bark light gray and ridged or, on young trees, smooth. Good-sized tree, southwestern California to southern Arizona and northern Mexico.-----*P. arizonica*²¹

Twigs stout; capsules 8 mm long or more. Leaves truncate, subcordate or reniform at base.

Disk of pistillate flowers and capsules minute.¹⁴ Leaves deltoid to broadly ovate, long-acuminate, truncate at base, coarsely serrate, 4-6 cm long; fruiting capsules 8 mm long, their pedicels 1.5-3 mm long; twigs glabrous.-----*P. texana*

Disk larger, cup shaped, 5-8 mm broad.¹⁴ Leaves subcordate or reniform at base, varying to truncate.

Leaves usually about as broad as long or broader than long, coarsely serrate, short-acuminate, pubescent when young; glands absent from juncture of petiole and leaf blade.¹⁵ Disk well developed, 6-8 mm broad,¹⁴ capsules 8-11 mm long.-----*P. fremontii*²²

Leaves usually longer than broad, long-slender-acuminate, coarsely crenate-dentate, glabrous, lustrous, thick, often varying to ovate; glands present at juncture of petiole and leaf blade.¹⁶

Disk small, about 5 mm broad;¹⁴ capsules about 10 mm long, on pedicels 2.5-3 mm long; winter buds puberulent; twigs light yellow.-----*P. sargentii*

ASPEN (*POPULUS TREMULOIDES* MICHX. AND *P. TREMULOIDES AUREA* (TID.) DAN.)

COMMON NAME AND EARLY HISTORY

In 1911 the American aspen, previously known solely as *Populus tremuloides* Michx., was definitely separated by Tidestrom (92) into an eastern and a western species. The eastern form retains the designation *P. tremuloides* Michx. and the western form is known as *P. tremuloides aurea* (Tid.) Dan. (23). Without reference to these systematic changes, both forms appear to be most widely known simply as aspen and less commonly under a variety of names, such as quaking asp, American aspen, poplar, trembling poplar, popple, and trembling aspen.

American aspen does not appear to have been distinguished from European aspen (*P. tremula* L.) until 1803, when the French botanist, André Michaux (58) described it as *P. tremuloides*.¹⁷ It was

¹⁴ Most botanists use disk characters in describing and separating poplars, but Tidestrom thinks it is very variable within the same species.

¹⁵ Some botanists recognize these glands as good characters; others do not.

¹⁶ Here belong Sargent's 4 varieties (recognized by Sudworth), viz: *macrodiaca* (with long disks nearly enclosing fruit); *pubescens* (with pubescent twigs; typical forms of *fremontii* have glabrous twigs); *thornberi* (with shorter pedicels, smaller disks, narrower capsules, and more numerous marginal teeth on the leaves), and *towneyi* (with large disks and long-pointed leaves shallowly cordate at base). The *Populus macdougalii* of this bulletin seems to key at once to *P. fremontii*. The pubescence of foliage and twigs in *P. macdougalii* is very variable and it tends to be glabrescent. While Standley recognizes it as a species (83), he says it is "probably not specifically distinct" from *P. fremontii*. Sargent (79) separates it from *P. fremontii* chiefly on the development of the disk, a factor which Tidestrom states is extremely variable. Tidestrom regards *P. macdougalii* as coalescent with *P. fremontii*, and has thus treated *macdougalii* as a synonym in the manuscript of his Flora of Arizona. Abrams (2) states that the characters used to distinguish *macdougalii* from *fremontii* "are not constant" and feels that "it is doubtful if the species is distinct."

¹⁷ House (42, p. 260) has this interesting nomenclatorial note on *Populus tremuloides* Michx.: "This tree was quite fully described long before Michaux's publication, by C. F. Ludwig (Neue Wilde Baumz. 35, 1783). In Darmstadt, Germany, I was able to consult this rare publication, and it appears that the plants described were sent to Germany from the German colony at Athens on the Hudson river, in this State, and the species was designated as *Populus althensis*. The date of the publication is uncertain, but is supposed to be about 1783." W.A.D.

then known to occur abundantly in lower Canada and the Northern States. Eighteen years before this, in 1785, Humphrey Marshall (57) described this species as *P. tremula*, American aspen tree, showing that he believed it to be the same as the European aspen.¹⁸

P. tremuloides represents a somewhat variable species of extremely wide range, which in the 100 years and more since it became known to science has been traced from Labrador and Hudson Bay to Alaska, southward through Canada and over most of the United States (excepting the South Atlantic and Gulf States), and even into northern Mexico. To the ordinary observer, the characteristics now relied upon to separate the eastern and western forms of aspen will not be appreciated, because they are relatively trivial, relating chiefly to minor differences in the size and shape of the leaves and to differences in autumnal coloration. Silviculturally, a rational treatment would seem to be to consider both forms as one species, comprising two geographic forms.

As now understood, our American aspen is botanically separated into the following closely related forms: (1) *P. tremuloides* Michx. (in its typical form) and (2) *P. tremuloides reniformis* Tid., both mainly eastern forms; (3) *P. tremuloides aurea* (Tid.) Dan., a widely distributed western form; (4) *P. tremuloides cercidiphylla* (Britt.) Sudw. (90), a locally restricted form of western Wyoming (upper basin of the Hoback River); and (5) *P. tremuloides vancouveriana* (Trel.) Sarg., a form confined to the locality of Vancouver Island.

The fourth form was originally described (19, p. 180) in 1908 as a species, but its varietal relationship to the type species seems so obvious that it is here designated as *P. tremuloides cercidiphylla* (Britt.) Sudw. Two of these forms, *P. tremuloides aurea* and *P. tremuloides cercidiphylla*, occur within the Rocky Mountain region.

DISTINGUISHING CHARACTERISTICS

The western form of the aspen attains a height ranging from 25 to 80 or 90 feet and a diameter from 6 to 30 or more inches. The smaller trees are common on the poor, thin, rocky soils of ridges and high mountain slopes, while the larger sizes are characteristic of the lower elevations in the richer soils of mountain coves and benches. In very high exposed places the growth is greatly stunted and characterized by bent or almost prostrate stems. In pure dense stands the large trees have straight trunks clear of branches for two thirds of their length. The short, slender, irregularly bent limbs stand out straight from the stems in a narrow domelike crown which is much shorter in dense than in open stands. The smooth firm trunk bark is conspicuously grayish white, brownish green, pale green, or varied with greenish or yellowish areas. It is irregularly furrowed and ridged only at the base of the trunk, where in larger

¹⁸ The American aspen is said to have been first introduced into cultivation in England in 1779 by the Duke of Northumberland. The likeness of this tree to the European *P. tremula*, frequent in gardens, is probably the reason why the American aspen is so little seen abroad.

trees it is blackish and may be from 1 to nearly 2 inches thick. Many black rounded protuberances and curved scarlike marks are scattered over the smoother portions of the trunks.

The leaves (fig. 1), which are smooth at maturity on both surfaces, are somewhat shiny and deep yellow-green above and dull and much paler beneath.¹⁹ The leaf stems are yellow and flattened near the leaf blade and range in length from about $1\frac{1}{4}$ to nearly 3 inches. In autumn the leaves become a clear golden yellow, sometimes orange or nearly red. Mature twigs are smooth and shiny, and are a clear reddish brown in autumn of the first year, later becoming pale reddish gray, and finally dull gray. For several years the twigs are



FIGURE 1.—Foliage of *Populus tremuloides aurca*. $\times \frac{1}{2}$.

rough with old leaf scars. The conical, smooth, shiny winter buds are reddish brown and thinly resinous.

The silvery white sapwood forms a large proportion of the stem. The small core of heartwood is pale brown. In general, the wood is rather fine grained, very soft, and brittle. It decays rapidly in contact with the ground. As it is practically odorless, the seasoned wood of fire-killed trees is much used for food containers, excelsior, pulp, and many other purposes. (74, 101.) On account of their lightness, aspen logs, cut and peeled in the spring and air-dried for a season, have long been a favorite material for log houses.

¹⁹ *P. tremuloides cerclidiphylla* (Britt.) Sudw. differs from the form under discussion in its shorter leafstalks, and its small, thick, redbudlike, slightly heart-shaped leaves, the margins of which are entire or inconspicuously wavy, and in which the lowest pair of veins are almost as long and as stout as the midvein. In addition, a peculiarly distinctive mark of this tree is a pair of minute, oblong, brownish, concave glands situated on the under side of the leaf at the base. This form was discovered by C. C. Curtis in August 1900.

OCCURRENCE AND HABITS

Aspen grows at widely varying altitudes over its extensive range (fig. 2). At the north it ranges from 1,000 up to 5,800 feet, and southward in the great mountain systems it may ascend to elevations ranging from 6,000 to 11,000 and occasionally 12,000 feet. As a rule, it is of small size at elevations above about 7,000 feet, and it becomes

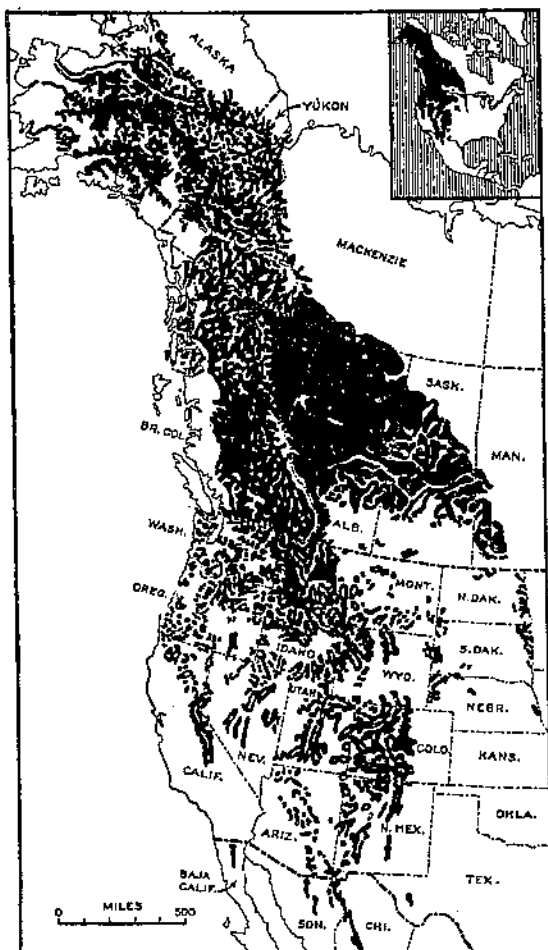


FIGURE 2.—Geographic distribution of western forms of aspen.

more and more stunted as it reaches the wind-swept rocky slopes and ridges of upper levels. The largest and most perfect growth occurs on protected benches and lower slopes of mountains at elevations between about 3,000 and 6,000 feet or occasionally higher.

Aspen is naturally a forest-forming species and often covers immense areas with a dense pure stand. It is commonly the first tree to establish itself on fire-denuded lands. If seed trees of the original forest of pine, spruce, or fir have been completely killed off

over extensive areas, thick stands of aspen may continue to hold the ground for many years. But wherever seed trees of the original conifer forest survive, a scattered growth of pines, spruces, and firs soon invades the nearby thickets of aspen and ultimately crowds them out. Aspen is usually considered to represent a very transient type of forest which, because of its superabundant seed production and the ease with which the seed is carried long distances by wind, always comes in over large denuded areas. As scattered small areas of pure growth, it is often found in mixture with the longer-lived conifers of the region.

LONGEVITY

Height and diameter growth of aspen are most rapid during the period from 35 to 50 years of age. Merchantable size is attained at 50 years. Some trees maintain a vigorous condition up to as much as 120 years, after which they decline more or less rapidly, only occasional trees retaining their vigor to a maximum of 200 years. The average age limit is probably less than 150 years. Trees from 100 to 150 years old are from 11 to 15 inches in diameter and from 70 to 80 feet in height.

BALSAM POPLAR (*POPULUS BALSAMIFERA* L.)

COMMON NAME AND EARLY HISTORY

Balsam poplar, sometimes also called balsam and incorrectly balm-of-Gilead—a name properly belonging to a variety of this species (*P. balsamifera candicans* (Ait.) A. Gray)—is distinguished in general appearance by its lustrous, very dark green leaves which, as they tremble and turn in the breeze, show glinting flashes of their pale-green and bright rust-brown under surfaces.

Balsam poplar has been for a great many years technically known as *P. balsamifera* L., which was established in 1753 (54, v. 2). Quite recently, however, some authors have come to believe that it is the "*P. balsamifera*" described by Du Roi (29, v. 2) in 1772, and not the *P. balsamifera* of Linnaeus that applies to the balsam poplar; they believe that *P. balsamifera* L. applies to the eastern form of cottonwood, variously designated as *P. monilifera* Ait. (3, v. 3, p. 406), *P. angulata* Ait. (3, v. 3, p. 407) and *P. deltoides* Marsh. (57). If this view is tenable, balsam poplar would be designated as *P. tacamahacca* Mill. (59), the next oldest name (1768) in its list of synonyms. However, the decision that the name *P. balsamifera* L. does not apply to the balsam poplar would seem to be an error, as proved by the fact that Linnaeus cites under his name Gmelin's description "*POPULUS foliis ovatis, acutis serratis*" in volume 1 of the latter's *Flora Sibirica*, page 152, plate 33, 1747 (32, v. 1). Gmelin's plate 33, cited by Linnaeus, clearly represents the foliage of our balsam poplar and in no way the deltoid foliage of our eastern cottonwood (*P. deltoides* Marsh. and *P. deltoides virginiana* (Castigl.) Sudw.). The writer is, therefore, here retaining *P. balsamifera* L. for the balsam poplar.

During the nearly 200 years that balsam poplar has been known to science, 3 or 4 varieties, mainly garden forms, have been segregated. Only one of these, *Populus balsamifera candicans* (Ait.) A.

Gray, described later, is of importance in this connection. Elwes (30, p. 1833) credits Aiton with the statement that balsam poplar was cultivated at Hampton Court in 1692, and was again introduced in 1731, when a tree was planted in the Chelsea Botanic Garden. He also gives Walker (1812) as authority for the first introduction of this species into Scotland, by seed from Canada, in 1768. Loudon's testimony (56, v. 3, p. 1673) on the first point is very similar. Aiton (3, v. 3, p. 406), however, gives the year of introduction into England as 1731 alone. At the present time the tree is said to be rarely cultivated in England, where it appears to have been almost entirely replaced by *P. balsamifera canadensis*, the form usually grown now by English nurserymen.²⁰

DISTINGUISHING CHARACTERISTICS

Balsam poplar, one of the largest and most characteristic deciduous trees of the great northern forest regions is, at its best, from 80 to 100 feet in height and from 3 to sometimes 6 or more feet in diameter. Commonly, it is from 60 to 70 feet in height, and the trunk is from 30 to 40 inches through. Stems straight and clear of branches for 30 to 50 feet are not uncommon; the large thick limbs trend upward strongly and form a rather long, narrow, and irregular open crown. The bark of large trunks is slightly reddish gray and has regular deep furrows and wide ridges; that of the large limbs and of young trees is brownish gray, sometimes with a greenish shade, and smooth or more or less roughened by blackish protuberances. Year-old twigs are clear, shiny, and reddish brown, with conspicuously large chestnut-brown, pointed buds (fig. 3) which are from five eighths to nearly an inch in length. The bud scales are thickly coated with a yellowish, pungently fragrant balsam, with which the young leaves are also coated and from which the tree derived its common name. Mature leaves are slightly leathery, smooth, dark green, and shiny on the upper surface, and light green, whitish, or rust colored and very veiny on the under surface. They are usually about 3½ to 5 inches in length and about 2 to 3 inches in width. Leaf stems are round, smooth, and very slender, and are about 1¾ to 2 inches long.

Balsam poplar wood is light in weight, soft, rather narrow-ringed, and has a thick layer of nearly white sapwood. The heartwood is pale brown. In general appearance the wood of this poplar closely resembles that of other timber poplars and cottonwoods. The large trunks give clear wide lumber which is suitable for light packing boxes, slack-cooperage stock, and paper pulp.

OCCURRENCE AND HABITS

Balsam poplar (fig. 4) forms small pure stands and is also more or less mixed in its northern reaches with black and white spruce, alpine and balsam fir, birch, alder, willow, aspen, and black cottonwood. It inhabits cool humid climates with short growing seasons and very low temperatures in winter, but rarely ascends to an

²⁰ The largest balsam poplar tree observed in Great Britain by Elwes (30, p. 1833) was 72 feet high and 7 feet 10 inches in circumference in 1905. Balsam poplar has been introduced into Norway, where it is said to thrive as far north as latitude 69°40'.

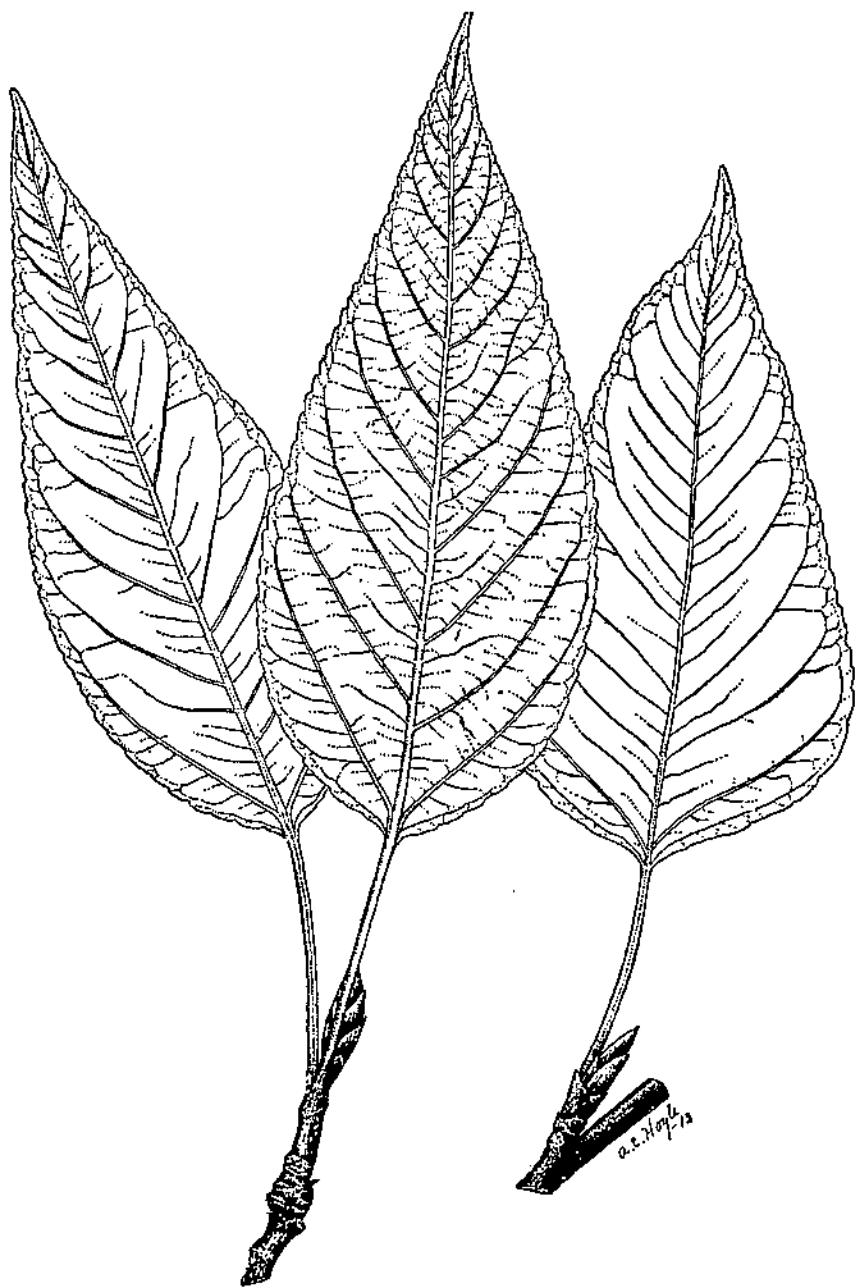


FIGURE 3.—Leaves and buds of *Populus balsamifera*. X1.

elevation of more than 5,500 feet above sea level in the Rocky Mountain region. It grows naturally in alluvial stream bottoms, on flats, on moist benches which are often deep and rich, or on the borders of lakes and swamps in moist sandy and gravelly soils. In youth the balsam poplar is only moderately tolerant of shade; with age it becomes very intolerant. It sometimes reproduces itself in dense stands beneath the shade of old trees, but the young trees die out during the pole stage or earlier unless they receive full top light.

LONGEVITY

Balsam poplar grows very rapidly in height and diameter during the first 40 or 50 years of its life. It is not a long-lived tree, the

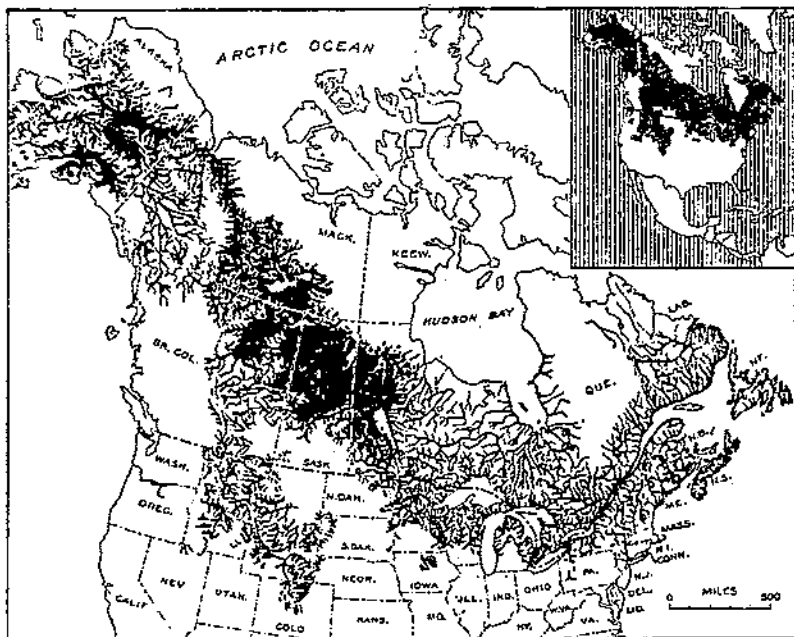


FIGURE 4.—Geographic distribution of balsam poplar (*Populus balsamifera*).

maximum age of full development being about 160 years. However, individual trees may remain alive to approximately 200 years.

BALM-OF-GILEAD POPLAR (*POPULUS BALSAMIFERA CANDICANS* (AIT.) A. GRAY)

COMMON NAME AND EARLY HISTORY

Balm-of-Gilead poplar is often called balsam poplar, but the historically proper name for this variety seems to be the one here given.

There has long been doubt as to the natural range of this tree, a question which is not yet satisfactorily cleared up. From time to

time it was believed to be indigenous in the northeastern part of the United States and in eastern Canada. It is now thought to have been established in that region from cultivated trees, the origin of which is in doubt. As now known, the balm-of-Gilead poplar extends from Newfoundland to North Carolina and westward to Michigan, and possibly occurs, as some authors believe, even in South Dakota, Colorado, Alberta, and Alaska (fig 5).

The balm-of-Gilead poplar first became known to science in 1789, when it was technically described as a distinct species, *P. candicans* Ait. (3). It was possibly first described (in part) in 1768, some 21

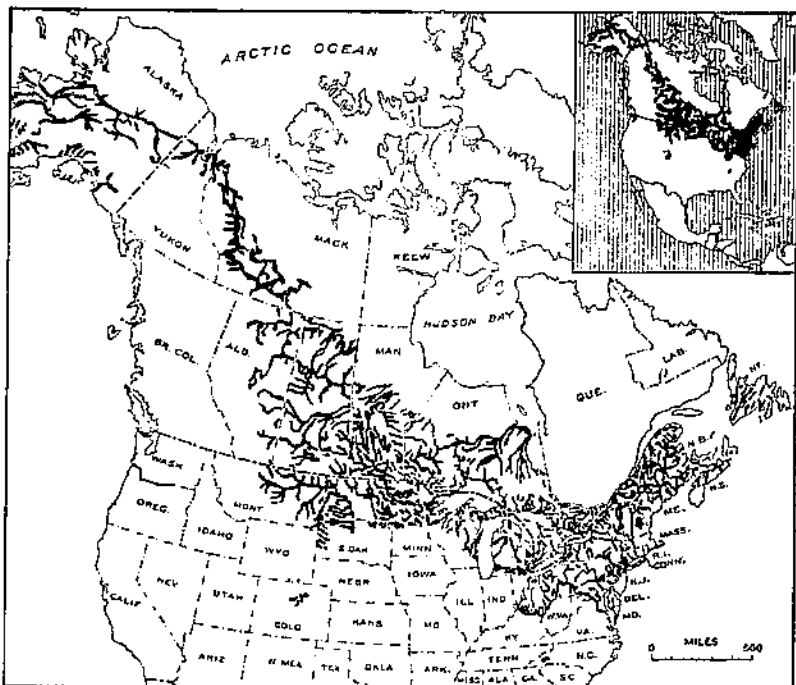


FIGURE 5.—Geographic distribution of balm-of-Gilead poplar (*Populus balsamifera candicans*).

years earlier, as *P. tacamahacca* Mill. (59). Miller's description, however, seems to include also the balsam poplar. Still held to be a distinct species, the balm-of-Gilead poplar was 40 years later, in 1829, described as *P. macrophylla* Lindl. (in Loudon, 55, p. 840) and as *P. ontariensis* Desf.²¹ Lastly, in 1856, this poplar was held to be

²¹ *Populus ontariensis* is not mentioned in Sargent's *Silva* (76, v. 2, p. 15), in Miss Day's card index, or in Dode's monograph (27). The Index Kewensis (44, v. 3, p. 696) cites "*Populus ontariensis* Lodd. ex Loud. Arboret. 3. 1670." In Loudon's work referred to, however, *P. ontariensis* is given (56, v. 3, p. 2675) as a synonym of *P. candicans* Ait., Desfontaines as the author, and Hort. Par. as the place of publication. Furthermore, Elwes and Henry (39, v. 7, p. 2834) give the citation "*Populus ontariensis*, Desfontaines, Cat. Hort. Paris (1829)." I am unable to locate that name, however, in the U.S. Department of Agriculture Library copy of the work referred to (26). Alice C. Atwood states she has examined the second edition of this work of Desfontaines' and has not been able to find the name there.—W. A. D.

a variety of the balsam poplar and designated as *P. balsamifera canadensis* (Ait.) A. Gray (33, p. 419), which, the writer believes, correctly expresses the identity of this tree. However, it is possible that future evidence may show that the balm-of-Gilead poplar is specifically distinct from the balsam poplar.

At the present time there is a confusion of judgment among authors as to whether both male and female trees exist in this country. The author has seen only the male trees here. Sargent (76, v. 9, p. 126) says only the pistillate tree is known. Dame and Brooks (22, p. 37) state that trees of both sexes have been found in New Hampshire and Vermont but that male trees are rarely if ever seen in southern New England.

Balm-of-Gilead poplar is said to have been introduced into England about 1772, where it has since been generally propagated for ornament (3, 56). It is preferred to balsam poplar because it can more readily be grown from cuttings. Only female trees appear to be used for this purpose.²²

DISTINGUISHING CHARACTERISTICS

Balm-of-Gilead poplar, comparable in height and diameter to balsam poplar, is characterized by a broader and more open crown and more spreading branches. It is generally distinguishable also by larger, broader, more ovate-cordate leaves, which are 5 or 6 inches long and about 4 inches wide at the base, by its pubescent leafstalks (petioles), and perhaps by a stronger fringe of minute hairs on the leaf margins and on the smaller veins on the lower surfaces of the blades.

The wood is very similar in general appearance to that of balsam poplar but is somewhat heavier. No special use is made of the wood, although it would be suitable for the same purposes as balsam poplar.

OCCURRENCE AND HABITS

Balm-of-Gilead poplar is apparently very like balsam poplar in its habitat. It occurs in moist soils, either as single individuals or in small groups interspersed with native trees.

LONGEVITY

Balm-of-Gilead poplar grows very rapidly in height and diameter during the first 35 or 40 years. It attains maximum development in about 50 years but continues to live long afterward. Little is known of its age limits, but the greatest age probably does not exceed 150 to 175 years.

²² According to Elwes (39, p. 3635) nearly all the balsam poplar trees in England are of this variety. The largest specimen seen by him was at Syon and at that time (1906) was 85 feet high and nearly 3 feet in diameter. Numerous other specimens growing in England, observed in 1910, averaged not more than 70 feet in height and about 2 feet in diameter. Henry (39, p. 3634) reports an unnamed form of this poplar, apparently of garden origin, having the leaves blotched with yellow, specimens of which may be seen at Woburn, and in the Glasnevin and Edinburgh Botanic Gardens.

NORTHERN BLACK COTTONWOOD (*POPULUS TRICHOCARPA HASTATA* (DODE) HENRY)

COMMON NAME AND EARLY HISTORY

Northern black cottonwood, sometimes also called balsam cottonwood and black balsam poplar, extends over a wide range from Alaska through British Columbia to southern California and eastward into the Rocky Mountain region. *P. trichocarpa* (black cottonwood) was first described by Torrey and Gray (ex Hooker, (40))²³ in 1852, based on specimens collected by C. C. Parry in 1850 on the Santa Clara River, near Buena Ventura, Calif. Although generally it has been clearly understood, some forms have been somewhat confused with its near relative the balsam poplar, which it closely resembles. In 1905 a form of northern black cottonwood with large pointed leaves with rounded or heart-shaped bases was described as *P. hastata* Dode (27); this is clearly not specifically distinct but is properly to be considered a variety of *P. trichocarpa hastata* (Dode) Henry (30, p. 1837). This form of the northern black cottonwood is the typical form of the species in the Rocky Mountain region.

The earliest record of the northern black cottonwood is found in the narrative of the Lewis and Clark Expedition (53), where mention is made of the occurrence of this tree near the mouth of the Columbia River, in all probability the *P. trichocarpa hastata* (Dode) Henry of the Rockies. What is probably the same variety was introduced into cultivation in continental Europe in 1889 from seed obtained in British Columbia, and into England in 1892.²⁴

DISTINGUISHING CHARACTERISTICS

In the Puget Sound country, the region of the greatest development of northern black cottonwood in North America, this tree attains a maximum height of 200 feet and a diameter of 6 or 8 feet. Within the Rocky Mountain region its greatest size is considerably less. Its straight or sometimes slightly bent trunk is commonly clear of branches to a height of 60 to 80 or more feet. The pale gray trunk bark is regularly, deeply, and sharply furrowed and is from 1 to 2½ inches thick. Trees grown from the first in the open have broad oval-shaped crowns, but the crown of forest-grown trees is open, short, and wide. Twigs when young are indistinctly angled; later they become rounded, shiny, and reddish yellow or brownish, and finally grayish, when they are much roughened by the thickening leaf scars. The reddish or orange-brown winter buds, which are from five eighths to three fourths of an inch long, are curved, as if bent above the middle. They are covered with a yellowish-brown fragrant gum similar to that found on the balsam poplar; the presence of this gum has led to frequent confusion of the two trees. Mature leaves (fig. 6) are thick, leathery, and smooth, deep shiny

²³ The Check List (30, p. 63) cites Hooker as the author of *Populus trichocarpa*, but Hooker himself (40) cites Torrey and Gray as the authors of the species.—W. A. D.

²⁴ According to Elwes (30, p. 1837), the oldest tree known was planted in the Edinburgh Botanic Garden in 1892. In 1906 this tree was 39 feet in height and nearly 10 inches in diameter. The largest tree at the Kew Botanic Gardens, obtained from Späth in 1896, was, in 1911, 55 feet high and a little less than 15 inches in diameter.

green on the upper surface and on the lower surface very veiny and silvery white, or whitish with rusty areas. On the under side of the leaf the midveins and their branches are minutely hairy—rarely smooth. Distinguishing characteristics of the leaves of this varietal form, as contrasted with those of the species, are their greater thick-

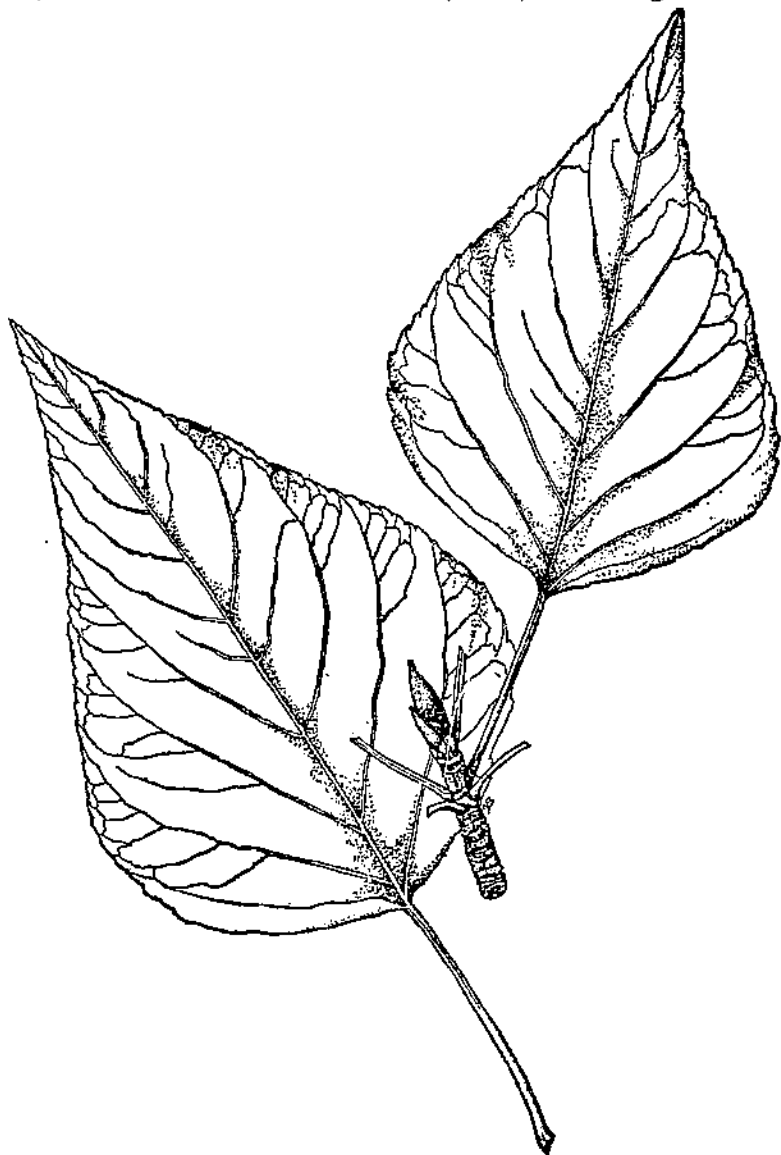


FIGURE 6.—Foliage and portion of twig of *Populus trichocarpa hastata*. $\times 1$.

ness, more leathery texture, larger size (often from 5 to 6 inches in length and 3 to 4 inches in width), rounded or rarely heart-shaped bases, and long points (leaves of the species are commonly very short pointed). The slender, rounded leafstalks and very young

twigs are mostly hairless, whereas in the typical forms of the species those parts are usually more or less hairy.

Trees grown in a dense stand have narrow-ringed wood with a relatively thin layer of whitish sapwood and dull grayish-brown heartwood. Large logs obtainable from the best-grown trees give wide, clear lumber. The wood when thoroughly seasoned is soft, straight grained, and odorless and is suitable for food containers,



FIGURE 7.—Geographic distribution of black cottonwood (*Populus trichocarpa*) and northern black cottonwood (*P. trichocarpa hastata*), the more common variety appearing outside of the heavy line. *

excelsior, cheap lumber, and tight cooperage. Large quantities have been used in Oregon and Washington for apple and sugar barrels. The wood has already been used to a considerable extent for paper pulp.

OCCURRENCE AND HABITS

Northern black cottonwood (fig. 7) grows most extensively at low elevations in river bottoms, on sand bars, and along watercourses in sandy, rich, humus soils. In the last-named locations it reaches

its largest size. It is less abundant and smaller at higher elevations, where it grows in canyon bottoms and gulches in moist sandy or gravelly soils, and in drier atmospheres where there is much less soil moisture. The climate in the region of its best growth is marked by great humidity, abundant precipitation, and moderate temperatures. Under the best conditions this variety forms broad belts and smaller areas of pure growth and in some places also occurs in mixture with other broad-leaved trees and conifers of its range. It is very intolerant of shade throughout life. Rapid height growth during the first 40 or 50 years enables it to hold its own in mixture with much more shade-tolerant conifers, among which its small crown is carried high into full light.

LONGEVITY

The age limit of northern black cottonwood has not been fully determined. It is, however, comparatively short-lived, like its near relatives. Probably the largest trees (the sort now mostly cut for lumber) are between 150 and 200 years old, possibly more. Trees from 2 to 3 feet in diameter are from 85 to 110 years old; one tree measuring 43½ inches in diameter was 112 years old.

LANCELEAF COTTONWOOD (*POPULUS ACUMINATA* RYDB.)

COMMON NAME AND EARLY HISTORY

The lanceleaf cottonwood, also called cottonwood, Rydberg's cottonwood, and smoothbark cottonwood, was for a long time not distinguished from the narrowleaf cottonwood (*P. angustifolia* James), which it somewhat resembles in general appearance. It was first described in 1893 by Rydberg (68, p. 46), who in 1891 discovered a grove of over 100 trees in Carter Canyon, Scotts Bluff County, northwestern Nebraska. Sargent, however, states (76, vol. 4) that he has seen in Engelmann's herbarium a specimen of this cottonwood collected by Hayden on the Reynolds expedition to the headwaters of the Missouri and Yellowstone Rivers in 1859-60. He further states that Engelmann collected it in 1874 at Denver, Colo., and that he himself found it in 1880 in Colorado Springs.

DISTINGUISHING CHARACTERISTICS

Lanceleaf cottonwood, which grows from 35 to 40 feet high and from 10 to 20 inches in diameter, has a dense rounded crown made up of robust branches, the lower of which are spreading whereas the upper trend upward rather sharply. Bark of larger trunks, approximately one half an inch thick, is light grayish brown and broken into narrow furrows and wide flat ridges. Bark of young trees and of the large limbs of old trees is smooth and whitish. The smooth, slender, rounded or somewhat quadrangular twigs are pale yellow-brown and marked for several years by the old leaf scars. Mature terminal buds, approximately one half of an inch long, are shiny, cinnamon brown, and more or less gummy; lateral buds are smaller and flattened against the twig. Mature leaves (fig. 8), 2 to 4 inches in length and from three fourths of an inch to as much as 2 inches in width, are pendulous (being borne on slender, nearly

round stems) and thickish and leathery. They are of a deep glossy green on the upper surface and dull green on the under surface; the slender midvein and its branches are light yellow. The slender drooping fruiting catkins are from 4 to 5 inches long, and the smooth rather short-stalked capsules are about one third of an inch long.

Wood of the lanceleaf cottonwood is very similar in its light weight and soft texture to that of *Populus angustifolia* James; the



FIGURE 8.—Spray of *Populus acuminata*. X1.

thin layer of sapwood (showing 12 to 28 annual rings) is grayish white, and the heartwood is pale yellowish brown. Because of the small size of the tree only occasional use is made of the wood, viz, for temporary fence posts and corral poles.

OCCURRENCE AND HABITS

Lanceleaf cottonwood (fig. 9) grows rather sparingly along streams, in moist, poor, sandy and rocky soils, usually in small groups or as scattered individuals. In general, its habitat is rather arid regions. It is very intolerant of shade, apparently in all stages of growth.

LONGEVITY

Lanceleaf cottonwood appears to be short-lived but of rather rapid growth. A log cut in northwestern Nebraska and measuring

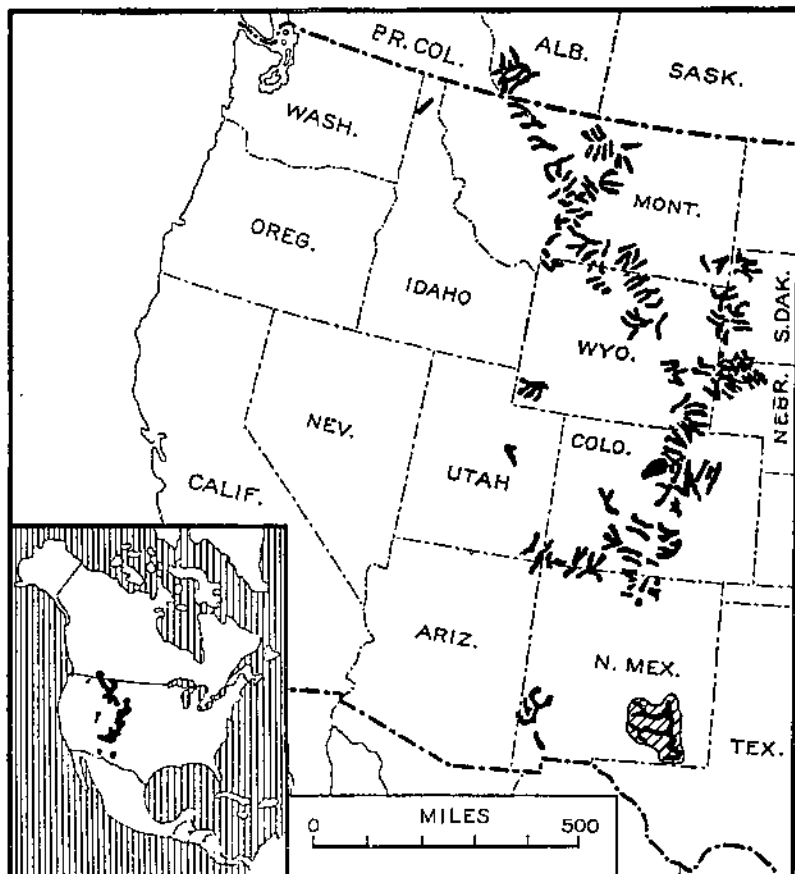


FIGURE 9.—Geographic distribution of lanceleaf cottonwood (*Populus acuminata*).

about 13 inches in diameter is from a tree but 28 years old (76, v. 14, p. 69). This diameter growth probably represented a height of 35 to 40 feet.

POPULUS ACUMINATA REHDERI SARG.

This variety of the lanceleaf cottonwood differs from the species in its larger leaves, longer leafstalks, and hairy twigs and mature buds. So far as is now known it is confined to southeastern New

Mexico, where it occurs along watercourses. (See area covered by grille, fig. 9.)

X *POPULUS ANDREWSII* SARG.

This is supposed to be a natural hybrid between *P. acuminata* Rydb. and *P. sargentii* Dode, and in it the characteristics of both these trees appear to be more or less combined. It grows in a wild state in the vicinity of Boulder and Walsenburg, Colo. (see solid black area, fig. 9), and is planted in the streets of Montrose, Colo. (79, p. 129).

NARROWLEAF COTTONWOOD (*POPULUS ANGSTIFOLIA* JAMES)

COMMON NAME AND EARLY HISTORY

Narrowleaf cottonwood, also called black cottonwood, willow cottonwood, willow-leaved cottonwood, and bitter cottonwood, first became known to science in 1823 under the technical name *P. angustifolia* James (45). Edwin James, the author of this name, discovered the tree in Colorado. Record of what is doubtless the original discovery of this cottonwood is to be found in the narrative of the expedition made across the continent in 1804-6, under the command of Captains Lewis and Clark.²⁵ (53, v. I, pp. 330-338.)

During the upwards of 100 years since this cottonwood became known to science, its distinctly willowlike leaves have prevented its confusion with any other cottonwood of the West, except, perhaps, *P. acuminata*. Rafinesque, evidently not knowing it had been described, named it *Populus salicifolia* in 1838 (62). Thirty years later (1868) it was designated as *P. canadensis*, γ *angustifolia* Wesmael (102), and again in 1871, as *P. balsamifera*, var. *angustifolia* S. Wats. (98).

DISTINGUISHING CHARACTERISTICS

Narrowleaf cottonwood attains a height ranging from 40 to 60 feet and a diameter ranging from 12 to about 18 inches. In general appearance it is fairly distinct from other American cottonwoods, except the lanceleaf cottonwood, on account of its narrow willowlike leaves which give the crown a comparatively thin-foliaged aspect. The crown is narrowly pyramidal in outline, being composed of slender branches which trend sharply upward. The bark is usually about 1 inch thick; that of the larger trunks, most of which are straight and free from branches for one fourth to one half their length, is light grayish brown and broken into shallow grooves and wide, flat-faced ridges at the base of the stem. Higher up on younger portions of old trees and also on young trees the bark is smooth, unbroken, and pale grayish green tinged with yellow. The slender twigs of a season's growth are smooth or very rarely hairy.

²⁵On June 9, 1805, the expedition while traveling along the Tansy River, now known as the Teton River, tributary to the Upper Missouri River, came upon "a species of cottonwood, with a leaf like that of the wild cherry." Later, on June 12, members of the expedition observed that "with the broad-leaved cottonwood, which has formed the principal timber of the Missouri, is here mixed another species differing from the first only in the narrowness of its leaf and the greater thickness of its bark. The leaf is long, oval, acutely pointed, about two and a half or three inches long and from three quarters of an inch to an inch in width; it is smooth and thick, sometimes slightly grooved or channeled, with the margin a little serrate, the upper disk of a common, the lower of a whitish green. This species seems to be preferred by the beaver to the broad-leaved, probably because the former affords a deeper and softer bark."

At first they are pale yellowish green, but later they turn dark brownish red or orange; during the second season they become light yellow, and finally pale gray. The rounded, long-pointed terminal buds are from about one fourth to one half an inch long and are made up of resinous scales, strongly balsamic in odor and externally



FIGURE 10.—Sprays of *Populus angustifolia*. $\times 1$.

chestnut brown in color. The lateral buds, which are from one eighth to one fourth of an inch long, are flattened on the side next to the twigs. Mature leaves (fig. 10) are rather thin but firm in texture. They are smooth and yellowish green on the upper surface, and smooth (or rarely hairy) and pale yellow green on the under surface. The margins are somewhat thickened and slightly turned

downward. The leaves range in length from about $1\frac{3}{4}$ to 6 inches and in width from about three fourths of an inch to $1\frac{1}{2}$ inches. The leaves on young shoots are often 6 inches long or perhaps even longer and about $1\frac{1}{2}$ inches wide. The leaf stems are short, slender, and slightly flattened on the upper side. The midrib is broad and yellowish, as are its main branches. The smooth pendulous fruiting catkins are about $2\frac{1}{2}$ to 4 inches in length, their two-valved capsules being broadly ovate and suddenly contracted at the apex.

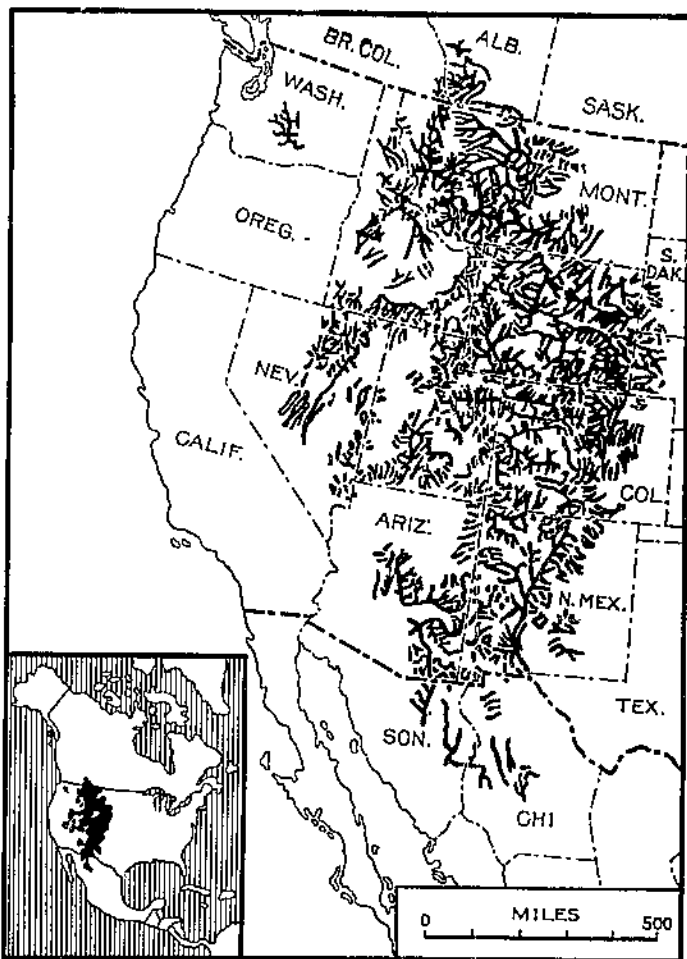


FIGURE 11.—Geographic distribution of narrowleaf cottonwood (*Populus angustifolia*).

Thoroughly seasoned wood weighs approximately 24 pounds a cubic foot. It is soft and brittle; the thin layer of sapwood (containing from 12 to 30 annual rings) is whitish and the heartwood pale brown. It is very similar in texture to the wood of lanceleaf cottonwood. Sometimes it is used locally for temporary fence posts or corral poles and occasionally for fuel.

OCCURRENCE AND HABITS

Narrowleaf cottonwood (fig. 11) grows singly or in groups scattered along the moist borders of mountain streams or flats at elevations ranging from 4,800 to 9,000 feet or more above sea level. It is rather more abundant in the central Rocky Mountain region than elsewhere in its range. The largest trees are usually found at elevations between 5,000 and 8,000 feet, sometimes in association with willows, mountain alder, scattered alpine fir, Engelmann spruce, and blue spruce. Narrowleaf cottonwood is decidedly intolerant of shade. It grows rather rapidly during the first 40 or 50 years.

Because it is native to the Rocky Mountain region and adapted to local climatic conditions, and on account of its attractive form and foliage and rather rapid growth, narrowleaf cottonwood has become a favorite for street and roadside planting in many parts of that area. However, at least at the lower elevations where rainfall is rather scanty, more or less irrigation is usually necessary for the tree to develop satisfactorily.²⁶

LONGEVITY

Narrowleaf cottonwood is a relatively short-lived tree. It reaches its maximum height and diameter growth probably within 50 or 60 years, but it may remain in a sound condition, growing slowly, for 100 to 150 years or more. An authentic record of a tree cut on the Humboldt National Forest, Nev., showed it to be 130 years old.

ARIZONA COTTONWOOD (*POPULUS ARIZONICA* SARG.)

COMMON NAME AND EARLY HISTORY

P. arizonica has no popularly established common name, being known locally simply as "cottonwood." The name Arizona cottonwood here applied is coined from the botanical name of the tree. Until recently, the Arizona cottonwood had not been satisfactorily classified. Prior to 1902 (76, v. 14) and subsequent to 1875 (99) Arizona cottonwood was confused with *P. fremontii* S. Wats.; for the next 17 years it was believed to be *P. mexicana* Wesm., a cottonwood of northern Mexico, described in 1868 (102), from which our cottonwood is now believed to be distinct. The status of Arizona cottonwood was, in the writer's opinion, satisfactorily settled in 1919 by Sargent, who characterized it as *Populus arizonica* (78, pt. 4, p. 210). Its main range in the United States, as now known, is in central and southern Arizona. On account of the long confusion of Arizona cottonwood with other closely related species of the Southwest it is difficult to determine just when and where it was discovered, but it is believed that Jean Luis Berlandier first found the tree in northern Mexico.²⁷

²⁶ According to Henry (32, p. 1832) this species scarcely attains more than shrub size in England, where, in Kew Gardens, it forms a small, irregularly spreading tree. He quotes Spith's Catalogue (Berlin 1803-94) to the effect that Spith introduced young Colorado plants of this species into Germany in 1803, but no information is given regarding their behavior.

²⁷ A variety of the Arizona cottonwood, *P. arizonica jonesii* Sarg., occurs in northern Mexico.

DISTINGUISHING CHARACTERISTICS

Arizona cottonwood ordinarily ranges in height from 35 to 50 feet but sometimes attains a height of 65 to 70 feet. The diameter is from 20 to 30 inches. The bark of larger trunks, from 1 to nearly

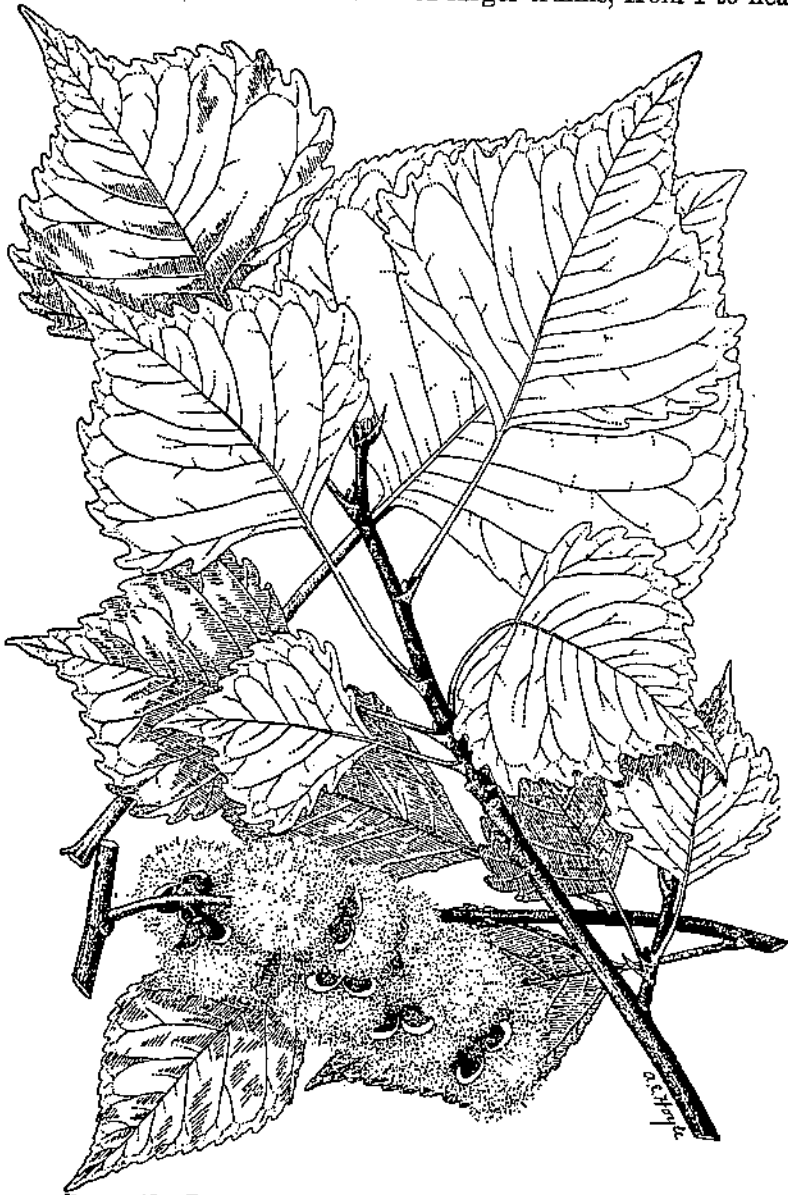


FIGURE 12.—Foliage and seed capsules of *Populus arizonica*. $\times \frac{1}{2}$.

$1\frac{1}{2}$ inches thick, is light ash-gray or sometimes whitish in color, and is broken into deep furrows and wide flat ridges. The bark of large limbs and young trunks is usually unbroken, smooth, and of an

ash-gray color. This is a rather short-trunked tree, with a broad, rounded crown of wide-spreading large branches. Most of the branches of young trees have an upward trend, whereas in old trees the large lower-crown branches (owing to their weight) are more spreading in their habit, though the upper-crown branches preserve a more upward trend. The slender twigs, smooth and pale yellow at the end of a season's growth, are more or less drooping. Terminal buds, which are approximately one fourth of an inch long, are pale reddish yellow or orange-brown, pointed, smooth, and slightly hairy near the base; the flattened lateral buds are very much smaller. Mature leaves (fig. 12), somewhat leathery in texture, are yellowish

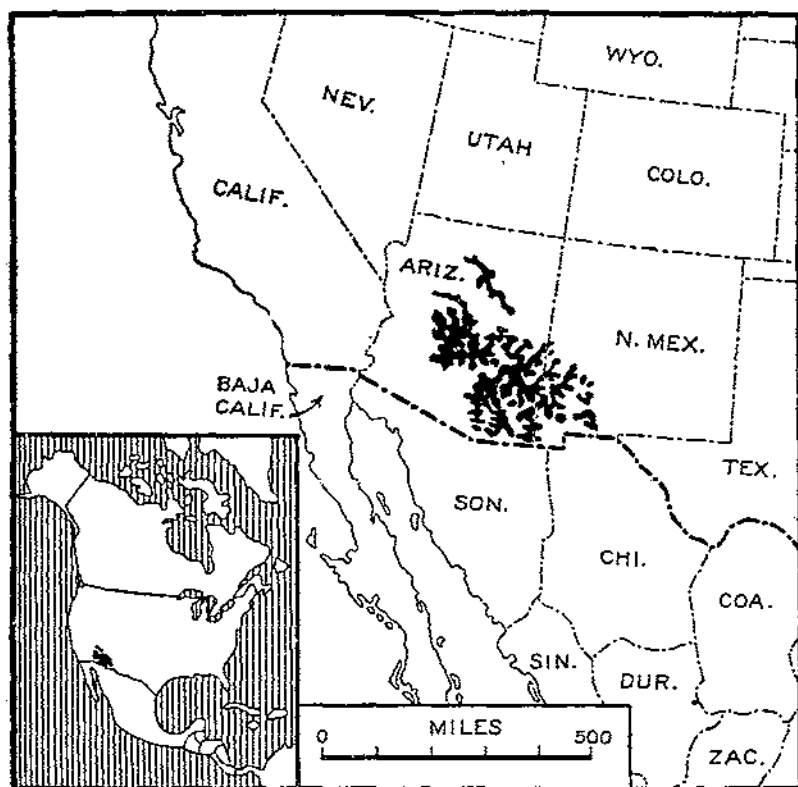


FIGURE 13.—Geographic distribution of Arizona cottonwood (*Populus arizonica*).

green in color (very glossy on the upper surface and slightly paler beneath) and are from about $1\frac{1}{2}$ to 2 inches in length. They have slender yellow midveins. The leaf stems, which are from $3\frac{1}{2}$ to 4 inches in length, are smooth and laterally flattened; the leaves, which are borne by vigorous shoots, are often 2 inches long and nearly 3 inches wide. Mature clusters of seed capsules (fig. 12) are about 3 inches long. The thin-walled capsules are about one fourth of an inch long, pale yellow-brown, deeply marked with pits, and on elevated pedicels of about the same length.

Thoroughly seasoned wood of this cottonwood weighs approximately 28 pounds a cubic foot. The thin layer of sapwood is nearly white, and the heartwood is pale brown. Locally the wood is sometimes used for corral poles, posts, fence posts, roof timbers of adobe houses, and fuel.

OCCURRENCE AND HABITS

Arizona cottonwood (fig. 13) grows scatteringly along the borders of mountain streams in moist rocky or gravelly soils where the water flow is constant, and sometimes on the borders of dry stream beds which carry torrential waters at certain periods of the year, leaving the substrata continually moist. The trees occur singly, in a thin bordering line, or sometimes in scattered small and large groups; rarely is the growth of any considerable extent. This species gives evidence of being considerably more tolerant of shade than other cottonwoods of the Southwest, especially during its early stages of development.

LONGEVITY

This species grows rather rapidly up to an age of 30 or 40 years; thereafter growth is slower as is evidenced by the narrow annual rings in the sapwood. The maximum age is possibly between 100 and 150 years. Several trees freshly cut by beavers along Salt River, in Arizona, showed very rapid early growth, trunks from 12 to 20 inches in diameter being only from 16 to 27 years old.

COTTONWOOD (POPULUS SPP.)

Under the common name of cottonwood are grouped four species and several varieties that have no other definite, well-recognized common name. These are *P. sargentii* Dode, *P. fremontii* S. Wats., *P. texana* Sarg., and *P. wislizeni* (S. Wats.) Sarg. *P. deltoides virginiana* (Castigl.) Sudw. and *P. macdougalii* Rose are generally known simply as cottonwood, but are described in the following pages under the common names of southern and MacDougal cottonwood.

POPULUS SARGENTII DODE

COMMON NAME AND EARLY HISTORY

This species has not acquired a distinctive common name; several coined or book names have been applied to it, such as "Sargent cottonwood", "western cottonwood", and "river cottonwood." The first name is coined from the present technical name of the tree, and the second is similarly derived from the third term of another of its scientific names, *P. deltoides occidentalis* Rydb.

Because of the early confusion of this species with several other cottonwoods growing within the region east of the Rocky Mountains, it is impossible now to find any very early authentic record of where or when the tree was discovered. It was first definitely characterized in 1900 as *P. deltoides* var. *occidentalis* Rydb. (69), and in 1905 it was designated as *P. sargentii* Dode (27); a year later (1906) it was renamed *P. occidentalis* (Rydb.) Britt. (94). Although this name is based on the oldest technical name applied to the tree, it must give way, according to the rule of nomenclature, to the oldest binomial applied, *P. sargentii* Dode.

DISTINGUISHING CHARACTERISTICS

In general appearance *P. sargentii* closely resembles *P. deltoides virginiana* (Foug.) Sudw. (p. 41), with which, among other eastern cottonwoods, it was long confused. As a rule it is a somewhat smaller tree, ordinarily ranging in height from 50 to 75 feet

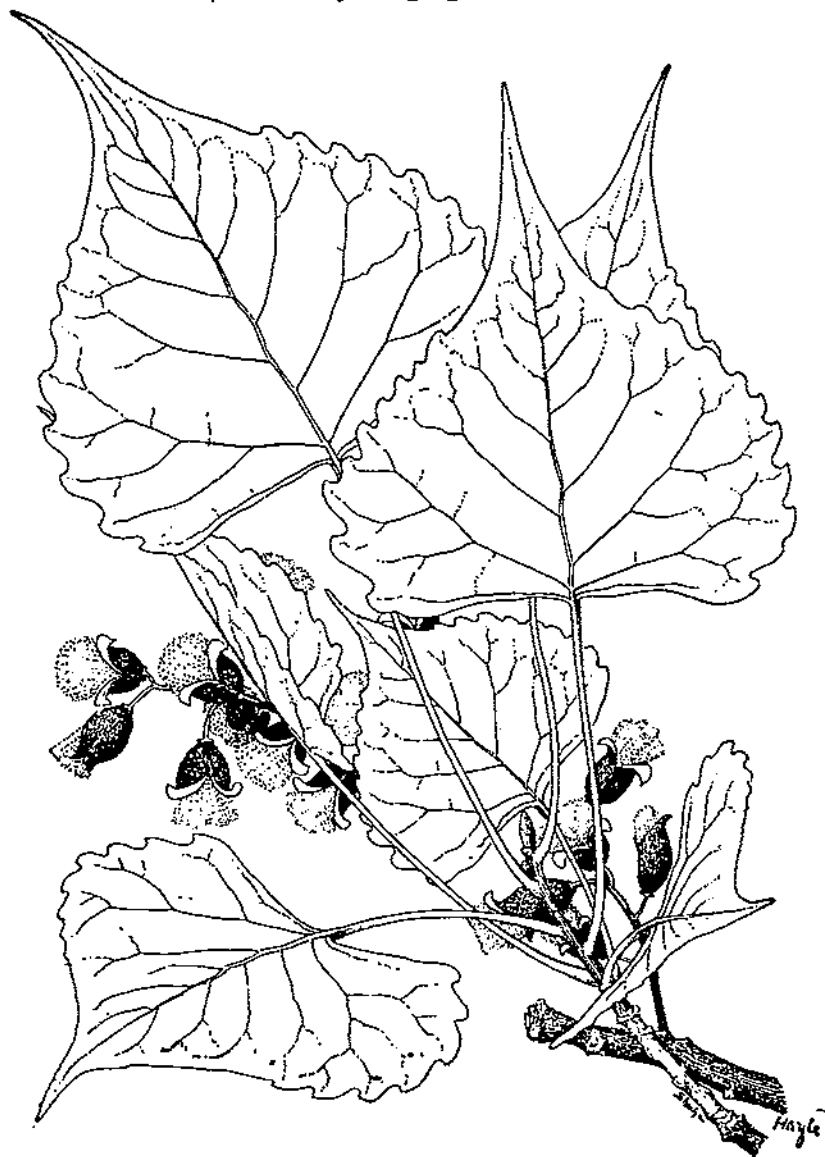


FIGURE 14.—Foliage and seed capsules of *Populus sargentii*. $\times \frac{1}{2}$.

but less commonly reaching heights of 80 or 90 feet. Diameters range from 2 or 3 feet to from 4 to 6 feet. The trunk bark of fairly large trees is thick, externally gray, deeply furrowed, and ridged. On large branches and young trunks the bark is smooth or only

shallowly furrowed and is grayish. The straw-colored twigs are rounded or slightly angled and rough, with enlarged leaf scars. The pointed terminal buds are brownish yellow and slightly hairy. The pointed terminal buds are brownish yellow and slightly hairy. Mature leaves (fig. 14) are firm, smooth, light yellow-green and shiny on the upper surface and pale green on the lower surface. They are from $1\frac{1}{2}$ to $3\frac{1}{2}$ inches long and from $1\frac{3}{4}$ to 4 inches wide. The midrib and leaf stem are slender. The leaf stem is flattened and



FIGURE 15.--Geographic distribution of cottonwood (*Populus sargentii*).

from $2\frac{1}{4}$ to $3\frac{1}{2}$ inches long; often two small glands are at its juncture with the leaf blade. The staminate flowers are borne in catkins from $1\frac{3}{4}$ to $2\frac{3}{4}$ inches long; pistillate flowers, borne in similar clusters, are from $3\frac{1}{2}$ to $7\frac{1}{2}$ inches long. The bluntly pointed smooth seed capsules, about two fifths of an inch long, are borne on tiny short pedicels, which are much shorter than the capsules (fig. 14).

Little is known now of the distinguishing characteristics of the wood. The heartwood is dark yellowish brown and the thick sap-

wood is nearly white. Locally the wood is sometimes used for temporary fence posts and corral poles and for fuel. In recent years it has been used rather extensively in Colorado for making veneer baskets for fruits and vegetables.

OCCURRENCE AND HABITS

P. sargentii (fig. 15) grows naturally in low moist ground in the vicinity of streams, where it may form a thin fringe, or in broad river bottoms in scattered pure stands. It is intolerant of shade during all stages of its growth. It is frequently planted as a shade tree in the streets of small towns within its natural range. It is essentially a stream-bank tree and is seldom found above an altitude of 7,000 feet.

LONGEVITY

This is a short-lived tree, usually attaining its maximum height and diameter growth within about 50 years, although under favorable circumstances it may remain in a vigorous condition for 80 to 90 years. During the first 25 or 30 years it grows rather rapidly to a height of some 40 or 50 feet and a diameter of 16 to 20 inches.

POPULUS FREMONTII S. WATS.

COMMON NAME AND EARLY HISTORY

It is the writer's opinion that typical *P. fremontii* (99, p. 350) occurs solely within California and Baja California, and that it is replaced in the southern part of the Rocky Mountain region by four rather distinct varieties. For many years what is now known as *P. sargentii* was confused with *P. fremontii*, and it was supposed that the now clearly distinguishable *P. wislizeni* of western Texas, New Mexico, the Rio Grande region, and adjacent Mexico was vari- etally related. A careful study of the flowers and fruits of these poplars has disclosed distinctive characteristics. Although *P. fremontii* has been allowed no distinctive common name in the Check List, the name of Frémont cottonwood has been applied to it by several writers.

DISTINGUISHING CHARACTERISTICS

P. fremontii (fig. 16) ranges in height from 50 to occasionally 100 feet and in diameter from 1½ to sometimes 4 feet. The trunk, free from branches for about half its length, is rarely straight, but is more or less bowed and leaning. The thick branches and their drooping twigs form a wide, round-topped, open crown. The rough, thick, deeply furrowed bark is dark grayish brown without and clear red within; the wide distinctly cut main ridges are connected irregularly by smaller lateral ridges. Bark of large limbs and of young trunks is only slightly seamed and of a pale ashy brown color. Twigs of one season's growth are smooth and pale yellow; they become yellowish gray as they grow older. The shiny winter buds are greenish, the terminal ones, about one half of an inch long, being much larger than the lateral buds. Mature leaves are smooth throughout, rather thick and leathery, clear yellow-green and shiny, with flattened yel-

low stems. The leaves vary in length from about 2 to $2\frac{3}{4}$ inches and in width from $2\frac{1}{4}$ to about 3 inches; the leaf stems are from $1\frac{1}{2}$ to sometimes 3 inches long. In the fall the leaves become a bright lemon yellow. The staminate flowers are borne thickly on a smooth



FIGURE 16.—Leafy twigs and fruit of *Populus fremontii*. $\times\frac{1}{2}$.

stem $1\frac{1}{2}$ to $2\frac{3}{4}$ inches long, and the thinly flowered pistillate clusters are often from $3\frac{1}{2}$ to 5 inches long by the time the seed capsules mature; the blunt or pointed seed capsules, about one half of an inch long, are sparingly pitted and borne on thick pedicels.

The wood of *P. fremontii* is pale dull brown, with a thin layer of whitish sapwood. It is considerably heavier than that of other cottonwoods and is rather coarse grained, soft, and brittle. It is not durable and is specially liable to crack in seasoning. It is not used commercially, but locally some use is made of it for fuel, temporary fence posts, and log buildings.

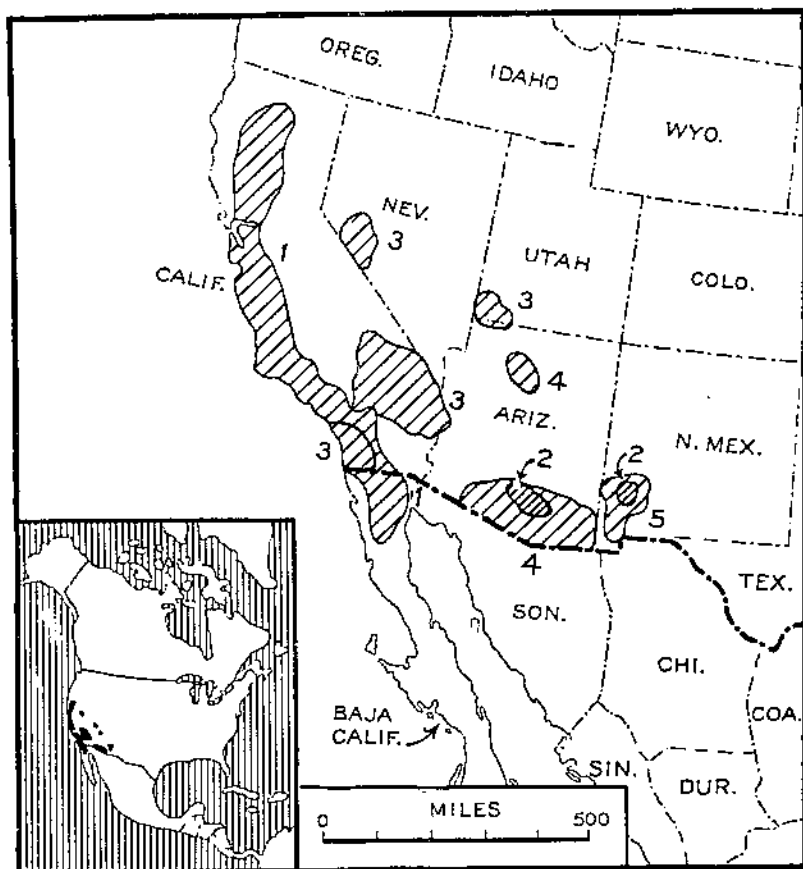


FIGURE 17.—Geographic distribution of cottonwood: 1, *Populus fremontii*; 2, *P. fremontii thornberii*; 3, *P. fremontii pubescens*; 4, *P. fremontii tonmei*; 5, *P. fremontii macrodactylu*.

OCCURRENCE AND HABITS

P. fremontii (fig. 17) occurs exclusively in stream bottoms and along their borders, in moist, sandy, gravelly humus soils. It grows in a climate of high temperatures and low precipitation, where the air is generally dry except where rendered humid through the proximity and influence of the sea. The tree forms strips and small bodies of pure growth along the borders of streams or occurs in mixture with Arizona sycamore, willows, and alders. It is very intolerant of shade through life. It reproduces itself abundantly

from seed lodged in open moist soil or in sand and gravel. Sometimes it is planted along streets for shade. More recently it has been used in erosion-control operations.

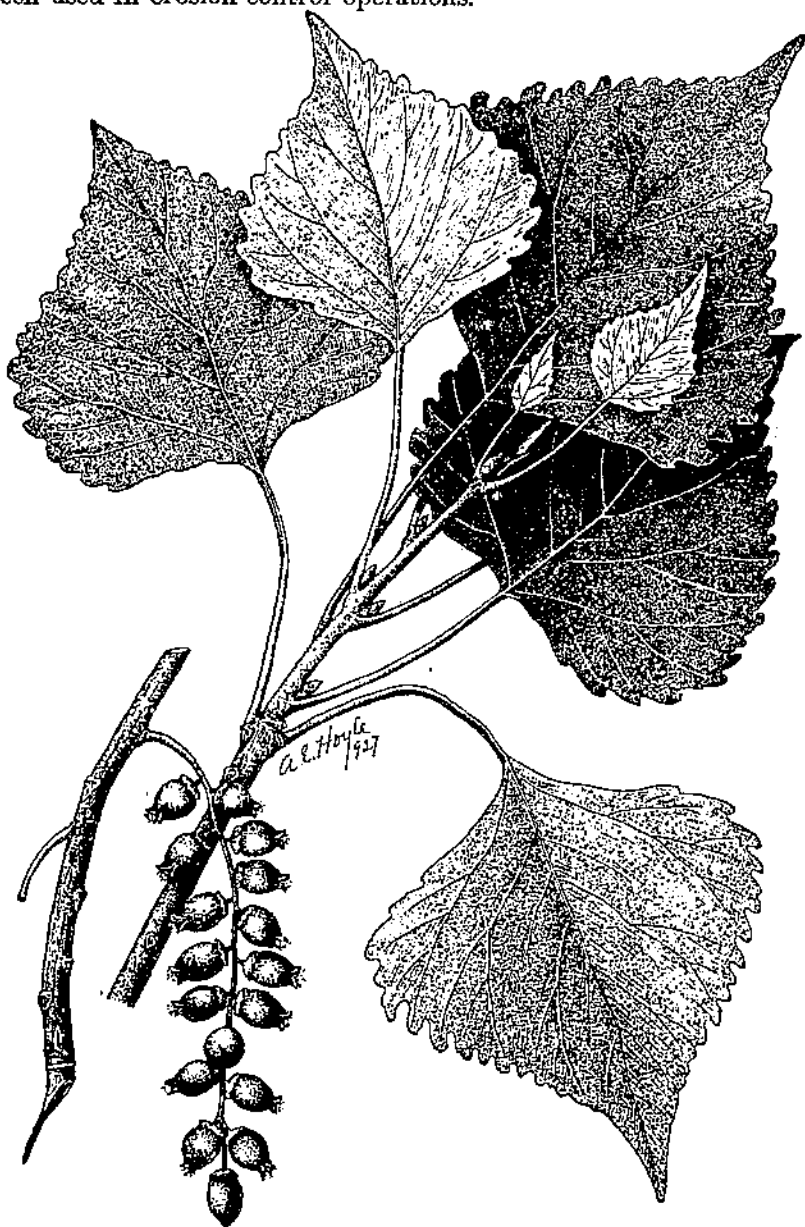


FIGURE 18.—Leafy twig and fruit of *Populus fremontii* Torr. & G. $\times \frac{1}{2}$

LONGEVITY

P. fremontii appears to be short-lived. It grows rapidly to maturity, which it probably attains within about 50 years although

it may remain vigorous for a much longer time. One tree $36\frac{1}{4}$ inches in diameter (inside the bark) showed an age of only 29 years.

The following distinct varieties of *P. fremontii* occur within the Rocky Mountain region:

P. fremontii thornberi Sarg. (78, pt. 4, p. 213) is distinguished by the much more numerous teeth on the borders of the leaves and the elliptical shape of the seed capsules, which also have a smaller basal cup and shorter pedicels than the species whose capsules are rather distinctly ovate, with larger cup-shaped bases, and are borne on longer pedicels.

P. fremontii pubescens Sarg. (78, pt. 4, p. 213) is distinguished from the species by its hairy twigs.

P. fremontii toumeyii Sarg. (78, pt. 4, p. 214) (fig. 18) is distinguished from the species by the shallowly heart-shaped bases of the leaves, which are narrowed and wedge-shaped toward the attachment of the leaf stems. The leaves also are long pointed, whereas those of the species are rather squarely cut off at the base and short pointed. The seed capsules of this variety have large basal cups.

P. fremontii maorodisca Sarg. (78, pt. 5, p. 62) is distinguished from the species by the very large basal cups which nearly enclose the elliptical-shaped seed capsules.

POPULUS TEXANA SARG.

COMMON NAME AND EARLY HISTORY

Little is known of *P. texana* Sarg., but it is included here because it occurs within a territory that is climatically closely related to the Rocky Mountain region. It was first satisfactorily distinguished in March 1919 (78, pt. 4, p. 211), the earliest authentic specimens having been collected in July 1917. Until 1919 *P. texana* was apparently confused with *P. wislizeni*, which it closely resembles in the shape and texture of its leaves, size and color of its twigs, and in its smooth buds. It is, however, readily distinguished from *P. wislizeni* by its much smaller seed capsules, which are borne on shorter pedicels. The ranges of the two species are also different.

DISTINGUISHING CHARACTERISTICS

P. texana is from 30 to 60 feet in height and from 12 to 30 inches in diameter. The bark on the lower part of the trunk is of a dull ash-gray color and is distinctly cut into narrow ridges and furrows; bark of the large limbs and of young trunks is grayish and smooth or little broken. The tree has a rounded, rather broad open crown of large drooping branches and stout twigs, which are smooth and of a light yellow-brown. The sharp-pointed winter buds are also smooth. Young trees are straight and symmetrical, but large specimens have more or less crooked trunks and unsymmetrical crowns. Mature leaves (fig. 19) are smooth and thin and vary in length from $2\frac{3}{4}$ to about 3 inches and in width from 2 to $2\frac{1}{2}$ inches; the flattened slender leaf stems are from $1\frac{1}{4}$ to $2\frac{1}{2}$ inches long. The flowers have not been collected. The longish, ovate, sharp-pointed



FIGURE 19.—Foliage, twigs, and fruit of *Populus texana*. X%.

seed capsules are borne on a slender, smooth stem about $2\frac{1}{2}$ or 3 inches long and are deeply pitted and thin walled. They divide into three sections.

The wood has not been studied; it is probably similar to that of *P. sargentii* and *P. wislizeni*.

OCCURRENCE AND HABITS

P. texana (fig. 20) grows along the moist sandy and gravelly borders of streams in canyons, where it forms narrow strips and

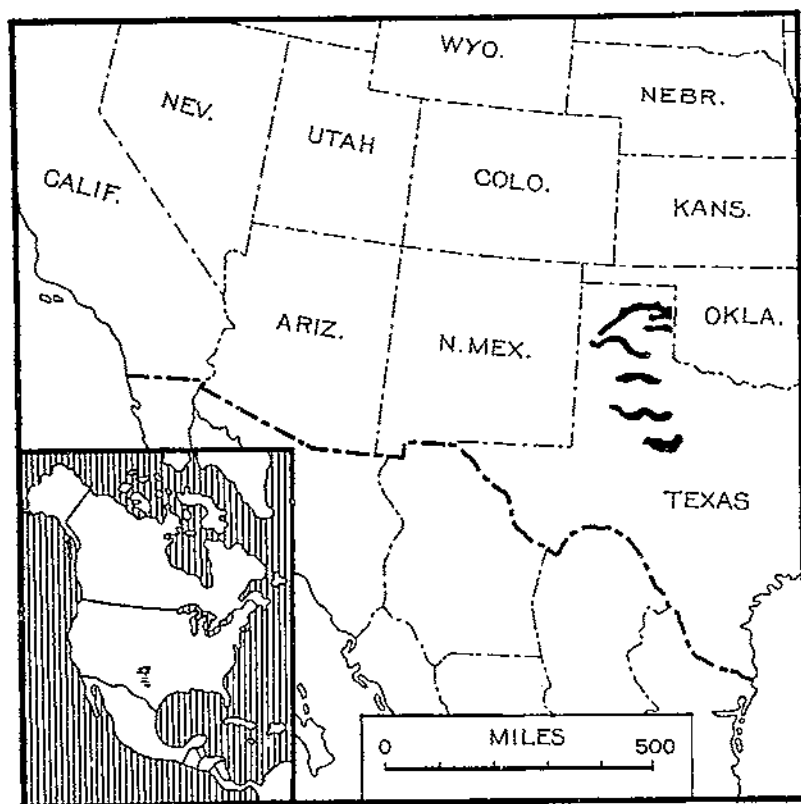


FIGURE 20.—Geographic distribution of cottonwood (*Populus texana*).

scattered small areas of pure growth. It is intolerant of shade in all stages of growth. In northwestern Texas it is practically the only cottonwood to be seen.

LONGEVITY

Nothing is known now of the age limits of this cottonwood, which is apparently short-lived and of rather rapid growth in early life.

POPULUS WISLIZENI (S. WATS.) SARG.²⁸

COMMON NAME AND EARLY HISTORY

P. wislizeni in some of the books is designated as "Wislizenus' cottonwood." Wislizenus discovered it in July 1846, along the Rio



FIGURE 21.—Foliage, fruit, and flowers of *Populus wislizeni*: A, fruiting spray; B, staminate catkins. $\times \frac{2}{3}$.

Grande in northern Mexico. In 1854 and 1859 Torrey (95, p. 172; 97, p. 204) refers to this cottonwood under the name *Populus moni-*

²⁸ The Check List form (90, p. 67) of this name, possibly through a typographical error, is *Populus wislizenii*. Sereno Watson's original spelling (100, p. 136) is *P. fremontii wislizenii* and Sargent (76, v. 14, p. 71), in raising the variety to specific rank, follows the original orthography.—W. A. D.

lifera Ait. (3, v. 3). In 1878 Sereno Watson (100) distinguished the tree as "*P. Fremontii* var. (?) *Wislizeni*." There long was question, however, as to its varietal relationship to *P. fremontii* S. Wats., a question which was not satisfactorily answered until 1902, when Sargent (76, v. 14) published the combination *P. wislizeni* (S. Wats.) Sarg., based on *P. Fremontii* var. (?) *Wislizeni* S. Wats.

DISTINGUISHING CHARACTERISTICS

P. wislizeni attains a height ranging from 40 to sometimes nearly 100 feet and a diameter from about 2 to 4 or more feet. The crown

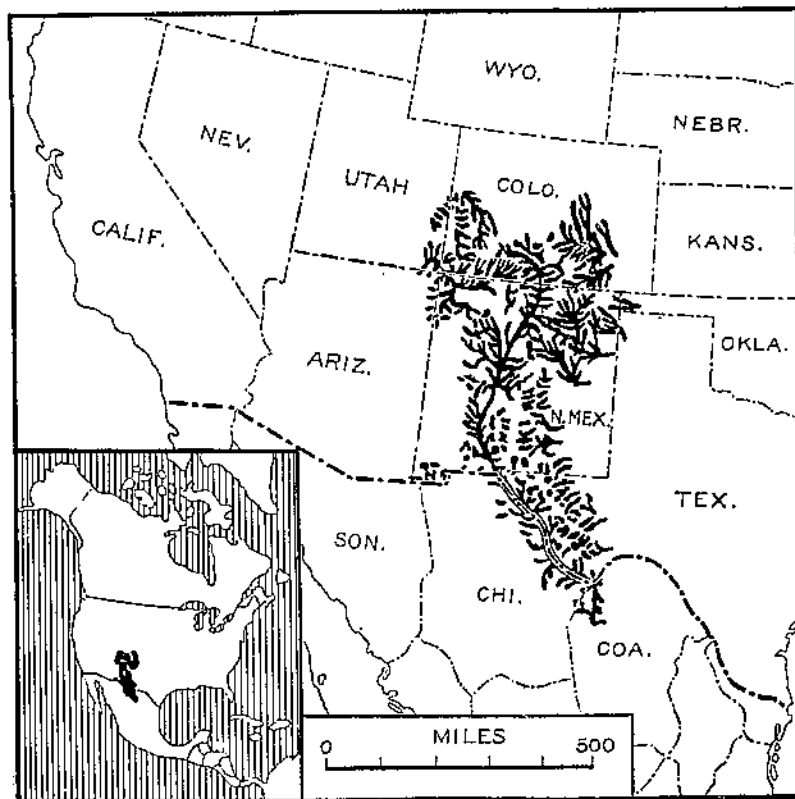


FIGURE 22.—Geographic distribution of cottonwood (*Populus wislizeni*).

is broad and rather flat in old trees and is composed of large wide-spreading branches. The large smooth twigs, rough with old leaf scars, are of pale orange-brown color and the winter buds are rather sharp pointed and shiny. The thick, firm trunk is light grayish brown and is deeply and distinctly cut into wide flattish ridges. The main ridges are laterally connected by smaller ones. Mature leaves (fig. 21) are thick and leathery in texture, smooth, yellowish green

and shiny on the upper surface, paler beneath, and from 2 to 2½ inches long and from 2¾ to about 3 inches wide. They are borne on rather slender, smooth, flattened leaf stems. The leaves of vigorous shoots are very much larger. In the fall the leaves become a bright lemon-yellow. The seed capsules, about one quarter of an inch long, are borne loosely on smooth stems from 3½ to 5 inches long and on pedicels from one half to three fourths of an inch long. The heartwood is pale yellowish brown, and the thin layer of sapwood is whitish. In general the wood is soft, brittle, and light in weight when seasoned. In drying it warps and checks badly. Locally it is often used for fuel, for temporary fence posts, and for timbering the roofs of adobe houses.

OCCURRENCE AND HABITS

This cottonwood (fig. 22) grows extensively in the sandy soils of broad river bottoms and along the borders of streams, usually in pure stands of considerable extent in the Rio Grande Valley where it is common. During the first 20 or 30 years it grows rapidly in an evenly moist situation and very slowly in situations that are intermittently dry and moist. It is widely planted for shade in western Texas and in New Mexico. Cuttings are used in erosion-control operations.

LONGEVITY

This tree is relatively short-lived and, according to present observation, attains maximum growth in about 50 years and in some instances reaches an age of 80 or 100 years.

SOUTHERN COTTONWOOD (*POPULUS DELTOIDES VIRGINIANA* (FOUG.) SUDW.)²³

COMMON NAME AND EARLY HISTORY

This cottonwood is an inhabitant mainly of the eastern part of the United States and adjacent sections of eastern Canada, but it extends also into the Dakotas and west-central Texas. It is not strictly a Rocky Mountain tree, but because of its occurrence in the Dakotas, where a number of Rocky Mountain species are found, it is deemed advisable to include it in the Rocky Mountain tree flora.

Forty years or more ago this was one of 3 or 4 cottonwoods ranging throughout the region east of the Rockies, and all were more or less confused under the name *P. monilifera* Ait. As recently

²³ In the author's manuscript, as in the Check List (30), the authorities are given as "Castigl. (Sudw.)", but this combination is in error in giving the parenthesized authority as Castiglioni. Castiglioni himself (21) attributes the authorship of the name *Populus virginiana* (whereon the combination *P. deltoides virginiana* is based) to Fougereux (31). In this connection it will be noticed that Tidestrom (91, p. 16), in publishing the combination *Algeiros virginiana* (Foug.) Tid. for this same cottonwood, also attributes the specific name to Fougereux. The distinctive nomenclatural history of this cottonwood is indicated in the following chronological statement: *Populus virginiana* Foug., Mém. Agr. Paris 1786: 87. 1787; *Populus nigra* β *virginiana* Castigl., Viag. Negli Stati Uniti 2: 334. 1790; *Populus deltoides virginiana* Sudw., Check List of the Forest Trees of the United States, Their Names and Ranges: 65, 1927.—W. A. D.

as 1905 these cottonwoods were assembled under the oldest name, *P. deltoides* Marsh. (some authors preferring *deltoides*), with one varietal or specific form (*P. deltoides* var. *occidentalis* Rydb., or *P. occidentalis* (Rydb.) Britt.) inhabiting the western part of this extensive range. The different cottonwoods so long confused are very difficult to distinguish, so closely do they resemble each other in the general appearance of their foliage. It is only by an extremely careful study of their flowers, fruit, and adult leaves that a satisfactory definition of the different forms can be worked out.

What is here treated as *P. deltoides virginiana* was described by Duhamel du Monceau (28, v. 2, pp. 178-180) under the vernacular name *peuplier noir de Virginie*. He wrote of it as having been already successfully introduced into cultivation in France. This form appears to be the one first introduced into English gardens, probably at a much earlier date than available records now show. According to Elwes and Henry (30, p 1808) the only specimens in Great Britain were a tree in Oxfordshire, England, which in 1910 was 91 feet high and 35 inches in diameter, and another in Glamorganshire, Wales, about 80 feet high and 52 inches in diameter.

DISTINGUISHING CHARACTERISTICS

Within its more eastern range this is one of the largest cottonwoods, but western representatives are smaller. The western tree ranges in height from 75 to (occasionally) 100 feet and in diameter from about 30 inches to 4 or 5 feet, or in a few individuals to 7 or 8 feet. In more or less dense stands the trunk is clear of branches for 30 to 50 feet or more, and the crown, composed of a few large spreading branches, is broad and open. Trees grown in the open with plenty of sunlight have relatively short, clear trunks, the massive branches occurring at 15 or 20 feet from the ground and producing a very broad crown, sometimes 80 or 90 feet wide. In young trees only the lower-crown branches are strongly spreading, while the upper-crown branches are upright, forming a broad pyramidal crown. The trunk bark of large trees is from 1½ to 2 inches thick (much thinner on young trees), dull gray, and sharply and deeply cut into rather wide furrows and ridges. Bark of very young trees and of branches of old trees is smooth and pale yellow with a slight tinge of green. The thickish twigs are round, but during their second season, particularly on young trees, they are marked by three rather conspicuous wing angles, one running downward from each of the two sides and the base of the three-parted old leaf scars. The resin-covered terminal buds, of a dark chestnut color, are shiny and pointed, and about one half inch long; the lateral buds are much smaller and are flattened. Mature leaves (fig. 23), which are from 3 to 4 inches long, are thickish and leathery. The upper side is smooth, yellowish green, and shiny; the under side is pale; and the midrib is yellow. The slender leaf stems, which range in length from 2 to 3 inches, are flattened laterally and are yellow or often reddish at the lower end. The clusters of seed capsules are from 7 to about 11 inches long; the capsules, somewhat elliptical in outline and pointed, are about one third of an inch long and are borne on pedicels about one fourth inch in length.

The wood is rather soft and narrow-ringed. When thoroughly seasoned it weighs approximately 24 pounds to the cubic foot. The

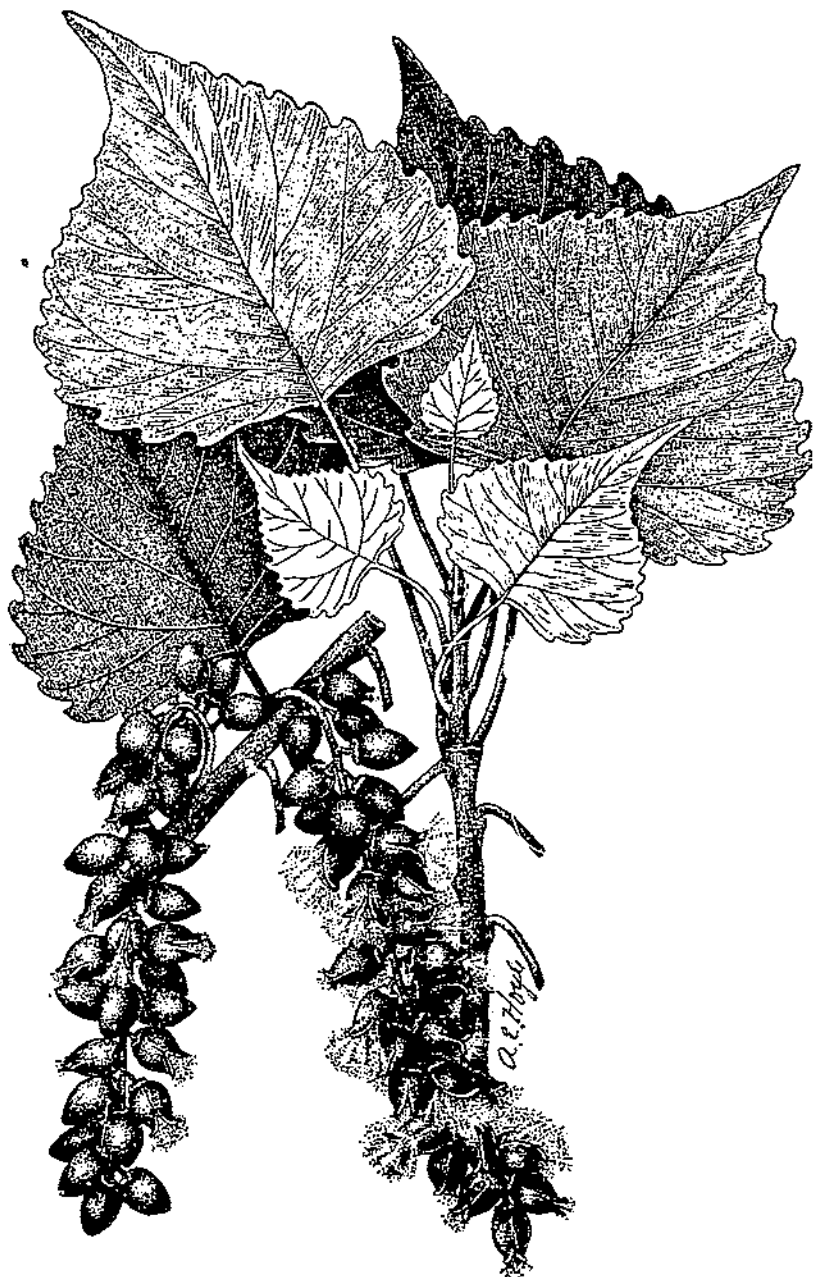


FIGURE 23.—Leafy and fruiting sprays of *Populus deltoides virginiana*. $\times\frac{1}{2}$.

thick layer of sapwood is almost white, and the color of the heartwood varies greatly in different trees, ranging from light to dark

brown. Twenty-five or thirty years ago the large logs were rather extensively cut into inch boards and dimension lumber to furnish cheap building material. The wood is now used for paper pulp, slack cooperage, packing boxes, and, in the western part of the tree's range, for poles, temporary fence posts, and fuel.

OCCURRENCE AND HABITS

This cottonwood (fig. 24) grows along streams and in river bottoms in moist, rich, alluvial soils, often in situations inundated for a part of the year. It occurs in scattered groups and thin lines

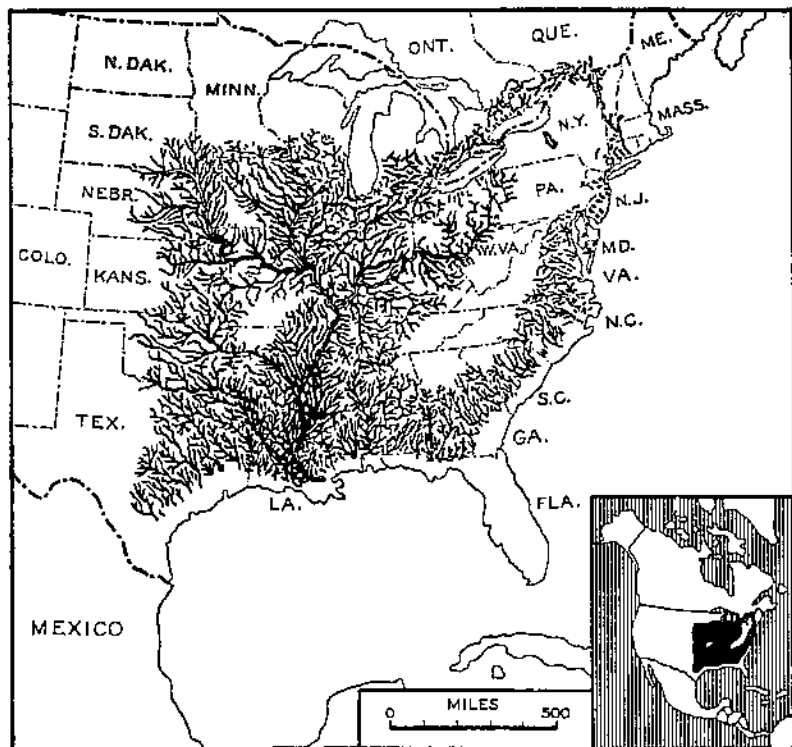


FIGURE 24.—Geographic distribution of southern cottonwood (*Populus deltoides virginiana*).

bordering slow-flowing streams and inland lakes and ponds, but in broad river bottoms it often forms open or rather dense pure stands. It is intolerant of shade during all stages of its growth.

LONGEVITY

This is a relatively short-lived tree. It attains its maximum height and diameter growth in from 50 to 60 years, growing rapidly (in rich well-drained soils) during the first 35 or 40 years of its life. After reaching maturity it grows very slowly, but it may remain in sound and vigorous condition up to 100 or 125 years, or possibly more.

MACDOUGAL COTTONWOOD (*POPULUS MACDOUGALII* ROSE)

COMMON NAME AND EARLY HISTORY

MacDougal cottonwood was first discovered by D. T. MacDougal at Colonia Lerdo,⁹⁹ Sonora, Mexico, in February 1904. Specimens and excellent photographs of the tree were at the time obtained by

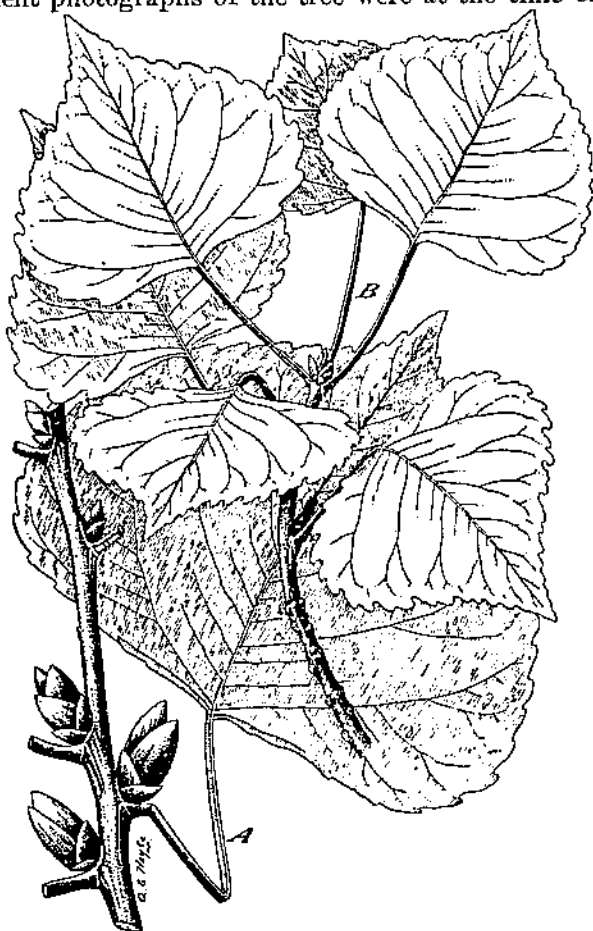


FIGURE 25.—Foliage and buds of *Populus macdougalii*: A, Staminate catkin buds and adult form of large, vigorously grown leaf; B, form of foliage on large trees (upper crown). $\times \frac{1}{2}$.

MacDougal, who apparently suspected it to be an undescribed species, for he referred this material to Rose, who considered it new. However, the latter did not publish an account of it until September

⁹⁹ In a letter from Dr. MacDougal, dated Jun. 3, 1925, he writes as follows concerning the location of this Mexican town: "Colonia Lerdo was at the extreme head of tide-water on the Colorado River about 80 miles south of the point at which the international boundary strikes the river from the Arizona side. . . . I consider all of the *Populus* in the delta to be of this one kind. Specimens were taken at this place in 1904, and I believe that other material was taken near Yuma in 1905."

3, 1913 (66), just previous to which S. B. Parish supplied the following further information about the tree:

I am sending you under another cover specimens of a *Populus* which does not well agree with any species of which I have a description. It belongs in the delta lands of the Colorado River, at least to Yuma, where it is abundant in the bottom lands on both sides of the river. It also comes into the Salton Sink, along the Alamo and New Rivers. In the settled part of the Sink it is very generally cultivated but is not indigenous. The Indio and Mecca specimens are from cultivated trees.



FIGURE 26.—Foliage and seed capsules of *Populus macdougalii*. $\times 46$. A, A seed, natural size.

DISTINGUISHING CHARACTERISTICS

P. macdougalii is usually from 30 to 60 feet in height and from 12 to 18 inches in diameter; exceptionally large trees are 80 or 90 feet high and 25 or 30 inches through. A striking characteristic of this cottonwood when grown in a dense stand is its large branches, sharply ascending from a short clear trunk. The crowns

of trees grown in the open are made up of 6 to 10 sharply ascending large branches, the length of even the lowest of which often nearly equals that of the central upper branches. Altogether these produce a flat-topped crown broadest near the top. Young trees in the open have a rather narrow columnar-shaped crown until they become 5 or 6 inches in diameter, when the lower branches develop rapidly until they nearly equal or sometimes exceed the height of the upper branches. The trunk and large branches are clothed with slender twigs. Bark of large trunks is grayish and furrowed and ridged only near the ground; higher up and on the large branches it is smooth and unbroken and is of a light ash-gray color which often

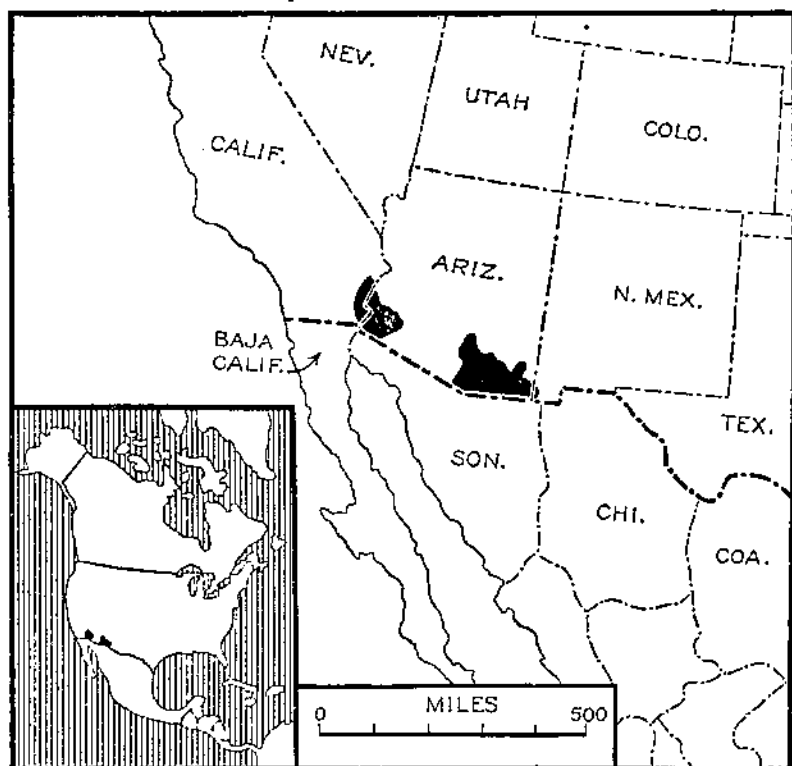


FIGURE 27.—Geographic distribution of MacDougal cottonwood (*Populus macdougalii*) in the United States.

appears nearly white. The round twigs of the first season's growth are light gray and usually more or less hairy; during the second season they are commonly smooth, but occasionally are somewhat hairy. Mature leaves of adult trees (fig. 25, A), which are from $1\frac{1}{2}$ to 3 inches long and of the same or of greater width, are smooth and blue-green; the slender, flattened leaf stems are smooth, or sometimes scantily hairy, and are from $1\frac{1}{2}$ to $2\frac{1}{4}$ inches long. Leaves of juvenile trees are commonly wedge-shaped at the base, especially those of seedlings. The clusters of seed capsules are smooth and are from $1\frac{3}{4}$ to 2 inches long; seed capsules, thickly set on the stems and

borne on pedicels about one fifth of an inch long, are ovate and pointed, slightly pitted, and when ripe split into three parts (fig. 26). Nothing is known now regarding the characteristics of the wood, which is much used locally for fuel, corral poles, and temporary fence posts.

OCCURRENCE AND HABITS

P. macdougalii (fig. 27) inhabits moist, rich alluvial river bottoms, often forming dense pure stands of considerable extent, particularly on both sides of the Colorado River in the vicinity of Yuma. Because of constant changes in the stream bed, numbers of trees growing along the river in the unstable silt and sand are frequently undermined by the water and washed away. The seedlings are reproduced in dense thickets along the borders of the river on moist silt and sand. The tree is intolerant of shade at all ages. It grows naturally in a region of high temperatures and low atmospheric humidity.

P. macdougalii is often planted along streets in towns near and within its natural range and is the only tree planted at many stations along the line of the Southern Pacific Railroad in and near the Salton Sink.

LONGEVITY

Nothing is known definitely regarding the age limits of this tree. It appears to grow rapidly during the early years of its life, but like related species it is probably short-lived, not attaining an age greater than 70 or possibly 100 years.

GENERIC CHARACTERISTICS OF THE WILLOWS

The deciduous leaves, variable in form, of most of the willows are long and narrowly pointed, smooth, or coated with fine silky hairs on the under surfaces. The margins may be entire (uncut) or variously toothed. The leaves are characterized by a pair of earlike minute or large bracts, or stipules, at the base of the leaf stem. The bracts are larger and more conspicuous on vigorous new shoots, on which they may remain until they fall with the leaves; on other twigs they are present only during the early growth of the leaves. The foliage may be shed in the autumn without much change of color, or it may turn lemon yellow before falling. Leaf scars are marked by three minute dots of fibro-vascular bundles. Sterile flowers are mostly in pairs, with distinct or united stamens. Stigmas are short. Catkins appear with the leaves or a little before. Buds are covered with a single scale, in contrast with the several scales of poplar buds.

The minute and sometimes slightly fragrant flowers of the willows appear before the leaves expand or at the same time. They are arranged more or less thickly on a central drooping or erect stem (rachis) and altogether form a cylindrical or elliptical-shaped cluster ranging in length, according to the species, from one half inch to 2 or 3 inches and in diameter from about one fourth to three

fourths of an inch. As a rule, the staminate aments are bright yellow, but sometimes they are a dull yellow, yellowish green, or pale rose. The clusters of pistillate flowers are much less conspicuous, usually being greenish. The little aments spring from lateral or side buds borne on twigs of the previous year's growth. In some cases these bear only the flowers, but in others a few small leaves occur just beneath the flowers. Each flower has a minute, usually entire-margined scale or bract at its base. The twigs of willows are for the most part tough and withy, but usually they are readily broken off where they join the branch.

Annual stump sprouts of willows are exceedingly strong and withy, but twigs from the crown are often very brittle, especially where they are joined to a branch. Many of the willows produce several trunks from a single greatly extended rootstock, but some species regularly produce single isolated trunks. Such species are readily admitted to be trees; those forming clusters of large trunks sometimes have been denied this rank, even though the trunks were otherwise treelike. For all practical purposes, however, they are trees and should be so considered.

The willows have remarkable vitality and grow persistently from cut stumps and easily from cuttings or pieces of branches or roots. This vitality and readiness of growth have been exploited in some foreign willows, which for centuries have been pollarded to cause them to produce long slender rods used in the manufacture of crates and coarse baskets, for fuel, and for other purposes.

The pistillate trees of practically all the arborescent willows produce an abundance of seed which is widely distributed by wind and water. The seed germinates and seedlings develop quickly in moist sand, muck, or other moist soils, and dense thickets are often produced.

As a group, the willows are intolerant of dense shade, their best development being attained in full sunlight. They are usually but not universally swamp or moist-ground plants, finding their habitat from sea level to an elevation of 10,000 or more feet.

Some of the tree willows produce moderately large, clear trunks which would yield lumber, but as a rule their boles are poorly formed for sawing. Except in generally forestless regions, where willows and their associates, the cottonwoods, become useful because no other trees are available, these trees have little to commend them in comparison with many other trees of demonstrated value. Willow wood is soft, light, usually brittle, but firm; commonly pale brown tinged with red. The wood of some species is very durable when exposed to water or earth. Willow wood has various economic uses, especially for baseball and cricket bats and for gunpowder and charcoal, but the greatest commercial use of willows appears to be that of shoots in the manufacture of baskets and furniture.

Willows are distinctly important to the forester because of their effectiveness in binding shifting sands and holding the banks of streams in soft bottoms where extensive ruin of agricultural lands may result from the erosion of unprotected banks. Willow cuttings are used in controlling gullies.

Tree willows attain maturity in 50 to 150 years; after maturity the trunks usually become hollow and may gradually show other signs of decay. They are then easily broken by storms. The vitality of the tree, however, allows it to remain alive for centuries, new stem or root sprouts repairing or replacing broken trunks.

Over 100 species of willow occur on this continent, and of these about 35, perhaps more, attain tree size.

The willows are of very ancient origin. Their geological history has been described by Berry (14) and others (49; 50; 51; 52; 73; 76, v. 9; 105). They make their appearance in the geological record during the Cretaceous period, when at least a score of species were in existence in North America, Europe, and probably in Asia. The genus undoubtedly originated in the holarctic region. Upwards of 100 species are known from Tertiary deposits, at which time the willows appear to have been widespread throughout the Northern Hemisphere, penetrating as far north as Greenland. During the glacial period the Arctic willows of the tundras extend their ranges southward, and their remains are found as far south as New York in the United States and Switzerland and Galicia in Europe. Many of the existing species were already present in the Pleistocene.

With few exceptions the various species of willow are difficult to identify, especially before they become trees. As a class, however, nearly everyone will recognize them as willows. But many even of the most important ones can be distinguished only by a careful study of their mature leaves, bark, twigs, and habits of growth. Individual trees are likely to be found that can only be identified through a close examination of the minute characters of the male and female flowers and the tiny seed capsules.

KEY TO THE WILLOWS DESCRIBED IN THIS BULLETIN¹¹

Stamens 2. (Section *Diandrae*):

Stipe (i. e., stalklike base) of ovary and capsule longer than the subtending bractlet. Bractlets¹² persistent; filaments free and glabrous; capsules beaked.

Ovaries and capsules glabrous; leaves usually broadest towards the base; bractlets dark brown, hairy at base only. Twigs sometimes yellowish but mostly dark brown; leaves mostly of a lanceolate type, distinctly petioled, crenately serrulate, pale below, thin but firm.-----*Salix mackenziana*

Ovaries and capsules finely villous or pubescent with silky white hairs; leaves mostly broadest towards the apex; bractlets usually pale but sometimes lawny and usually rose colored at apex, villous-hairy throughout, of a narrow (lance-oblong) type. Leaves firm, pubescent or glabrate, elliptic-lanceolate to obovate, mostly acute, sometimes entire but usually entire below and irregularly and remotely toothed from about the middle upwards; pistillate aments slender, lax.-----*S. bebbiana*

¹¹ Key prepared by W. A. Dayton, based largely on the treatment of Ball ex Abrams (2), Wootton and Standley (164), Standley (83), Rydberg (72), and Sargent (79). The nomenclature, however, is of course that of Mr. Sudworth.

¹² I. e., the small bracts, called "scales" by many authors, in the axils of one of which each of the mucutaceous flowers of *Salicaceae* is borne.

Stipe of ovary and capsule conspicuously shorter than the subtending bractlet.

Filaments united below the middle, glabrous; bractlets persistent, dark tawny, rounded, villous with long crisp white hairs, blunt or truncate at tip. Leaves typically oblanceolate, sometimes lanceolate or narrowly elliptic, 6-15 cm long, mostly acute, strongly reticulate, minutely denticulate or entire, short-villous when young, in age glabrous and shining above, and glaucous and usually more or less villous beneath; aments appearing before the leaves, sessile or nearly so, dense, the staminate about 12 mm thick, nearly twice as thick as the pistillate aments; ovaries and capsules glabrous; style evident (0.5 to 1 mm long); stigmas short-----*S. lasiolepis*

Filaments free.

Bractlets deciduous, pale yellowish; filaments more or less hairy.

Leaves very small (1 to 3 cm long), usually not over three fourths inch (18 mm) long, linear-lanceolate, almost yew-like, entire or nearly so, finely pubescent. Southwestern species; season's twigs woolly; aments very short, the staminate 5-13 mm long and the pistillate in fruit, 12-20 mm long; bractlets woolly on outer surface; filaments hairy below the middle; anthers globose or nearly so; ovaries and capsules pubescent-----*S. taxifolia*

Leaves larger (more than 3 cm long), not at all yewlike; aments much larger (1-3 cm long). Bractlets villous; filaments slightly hairy at the base; stigmas sessile (no style).

Leaves sericeous-canescens below when mature, 5-8 cm long, mostly not over 8 mm wide, sessile or very short-petioled, linear to linear-oblong, yellowish green, those of the flowering twigs entire or nearly so; stipules minute or wanting; staminate flowers with 2 glands; capsules sessile or nearly so, usually glabrous-----*S. exigua*

Leaves glabrous or nearly so below and bright green and glabrate above when mature, linear-lanceolate, 5-15 cm long, those of the flowering twigs denticulate; stipules ovate-lanceolate, deciduous, about 6 cm long; capsules 7 mm long, usually somewhat pubescent when young but glabrate in age-----*S. longifolia*²³ (= *S. interior* and "*S. fluvialis*" of some authors)

Bractlets persistent, dark fuscous to blackish, hairy; filaments glabrous. Leaves mostly of an obovate type but varying to oblanceolate or oblong-elliptic, usually cuneate at the base and obtuse or acutish at apex, 3-12 cm long, usually entire but varying to crenulate-serrulate, thickish, dull green or slightly shiny and glabrate above, variable beneath (silvery, rusty pubescent, glabrous, or glaucous-reticulate); aments dense, stout; styles very short (not over 0.3 mm long); stigmas long and slender; capsules reddish brown, pubescent, 8 mm long. The commonest willow of the Pacific region, often invading burns; bark reddish brown with (like the young leaves) a disagreeable odor-----*S. scouleriana*²⁴

Stamens more than 2 (usually about 5). Bractlets deciduous, pale yellowish; filaments free, hairy at the base. (Section *Pleandrac*.)

Leaves green on both sides. Twigs brittle (i.e., easily separable, as if articulated); petioles without glands at junction of blade.

Ovaries and capsules glabrous; twigs (often reddish or purplish) brown. Leaves lanceolate, long-acuminate, short-petioled; aments long and lax; bractlets pale hairy within; stigmas nearly sessile; capsule stipe or pedicel much shorter than the body of the capsule.

S. nigra

²³ This name is a homonym and untenable under either botanical code (p. 74). To this species belong the two varieties mentioned by Mr. Sudworth, *S. longifolia angustissima* (with sericeous ovaries and absence of glands in the male flowers) and *S. longifolia pedunculata* (with longstalked fruit, glabrous ovaries, and narrower, linear leaves).

²⁴ Mr. Sudworth follows Sargent (29) here in separating off a Rocky Mountain-Sierra variety, *S. scouleriana flavescens*, having yellowish-green twigs and yellowish-green, obovate-rounded leaves.

Ovaries and capsules woolly-hairy; twigs yellowish, slender. Leaves lanceolate or elliptic-lanceolate; no stipules; bractlets woolly; capsules 3-4 mm long, the stipe or pedicel nearly equal to the capsule body; stigmas sessile-----*S. gooddingii*
 Leaves not of the same hue on both faces, paler and usually more or less bluish (glaucous) beneath, at least when mature. Ovaries and capsules glabrous.

Petioles glandular; twigs "brittle", i. e., easily separable, brown, and shining. Leaves lanceolate to ovate-lanceolate, acuminate, about 8-12 cm long, dark green and shining above; aments elliptic-oblong; bractlets (especially of staminate aments) toothed (in typical forms to the base)-----*S. lasianдра*²⁵

Petioles without glands.

Bractlets untoothed (entire). Twigs "brittle", i. e., easily separable.²⁶

Twigs dark orange to red brown, shining, occasionally somewhat hairy (pilose); stipe or pedicel of capsule about two thirds as long as bractlet. Leaves acuminate, thin, broadly lanceolate, on slender petioles (leafstalks) 6-15 mm long; stamens about 5-9; style evident though short; bractlets sparsely villous-hairy on the outside, densely villous inside.
S. amygdaloides (in typical form)

Twigs bright yellow or yellowish brown, hairless (glabrous); stipe or pedicel of capsule about as long as the bractlet. Leaves stomata-bearing on the upper surface, short-acuminate, usually broadest at or above the middle; aments short, thick, and dense; stamens 5 or 6; bractlets villous-hairy on the back. A southwestern form (western Texas-New Mexico-northern Mexico).

S. amygdaloides wrightii (= *S. wrightii*)

Bractlets rather irregularly toothed, villous-hairy at least on the outside. Twigs rigid—not easily separable.

Twigs glabrous, i. e., hairless (yellowish, brownish, reddish, or purplish);²⁷ leaves silvery white below, narrow, finely toothed, more or less persistent through the winter; stamens usually three; capsules 4-5 mm long, with a cuplike glandular disk, their stipes or pedicels not more than one half as long as the capsule body; stigmas nearly sessile. Southwestern tree-----*S. bonplandiana toumeyii* (= *S. toumeyii*)

Twigs pubescent when young, yellowish or reddish brown; leaves dark green and glossy above, glaucous (bluish) beneath and often with rather long yellowish hairs beneath, at least when young, 7-15 cm long, lanceolate or lance-oblong (at least when mature), long-acuminate; aments of a narrow type (linear) 5-10 cm long; stamens 4-6; capsules about 6 mm long, without a cuplike disk at the base, their stipes or pedicels about two thirds as long as the capsule body; stigmas minute. California-Nevada-western Arizona species-----*S. laevigata*

²⁵ Mr. Sudworth recognizes two varieties of *S. lasianдра*, viz. *S. lasianдра caudata* and *S. lasianдра lanifolia*, which may be keyed as follows:

Leaves green on both faces though darker above; twigs not hairy, or at least not conspicuously so. Twigs yellowish; leaves rather thick and leathery, about 2-4 inches (5-10 cm) long, wedge-like (tenuate) at base, the tips often falciform caudate (i. e., with a curving, tail-like acumination); staminate aments thick and dense; buds hairy; bractlets toothed toward apex only; shrub or small tree-----*S. lasianдра caudata* (= *S. caudata*, *S. pentandra caudata*, *S. lasianдра fendlerian* and "*S. fendleriana*," at least in part)

Leaves grayish or rusty pubescent on the lower surface; twigs grayish or rusty pubescent. A Pacific, especially North Pacific, (hardly Rocky Mountain) form.

S. lasianдра lanifolia

S. amygdaloides; field observations on this point appear to be needed.

²⁷ Authorities seem not to be agreed as to twig color in *S. bonplandiana toumeyii*; field observations are evidently needed.

BLACK WILLOW (*SALIX NIGRA* MARSH.)

COMMON NAME AND EARLY HISTORY

S. nigra, perhaps the best known of our tree willows, is very generally known as black willow, a common name doubtless sug-



FIGURE 28.—Flowering and fruiting sprays of *Salix nigra*. X1.

gested by the blackish trunk bark. In some parts of its range this willow is occasionally called swamp willow, because it grows in wet bottom lands,

The black willow first became known to science in 1785. Humphrey Marshall, a resident of Chester County, Pa., described it at that time and named it *Salix nigra* in his now famous work on American trees and shrubs (57), a publication which has the distinction of being the first book on plants written by an American. While the history of this willow is generally free from confusion insofar as American authors are concerned, European writers applied 6 or 7 other specific names to it from 1788 to 1829, and 9 or 10 sub-specific, varietal, and subvarietal forms of the tree were described and named during the succeeding 30 years. These segregated forms are, however, properly held to be phases only of one variable species of an exceedingly wide range.³⁸

Schneider (81) in 1918 renamed a variety of the black willow *S. nigra* Marsh., var. *landheimeri* Schn., which Andersson described in 1868 (8, p. 199) as *S. humboldtiana* γ *oxyphylla* (H.B.K.) Anders., a varietal name that under present rules of nomenclature cannot be used. Schneider gives its range as—

eastern and southern Texas (perhaps also in southern Oklahoma), from about 34° N. latitude and between 100° and 95° W. longitude southward into Mexico to southeastern Coahuila, Nuevo Leon, and to Tamaulipas (and probably also Hidalgo).

Since Andersson originally described this willow it has been variously held to be either a form of *S. humboldtiana* or of *S. nigra*. Schneider (81) further states that this seems to be the most southern form of *S. nigra*, from typical forms of which it differs in usually having narrower leaves (at least more attenuated at the base) with comparatively much longer leafstalks. The young twigs and leafstalks are hairless or rapidly become so, whereas in typical *S. nigra* they are for a considerable time distinctly downy or hairy. Moreover, the stipules of this variety are described as having minute yellowish glands on the inner surface, which are absent in the stipules of typical *S. nigra*. The seed capsules also are slightly larger (about $\frac{1}{4}$ inch long) than those in typical forms of the black willow (about $\frac{1}{8}$ inch long).

Bebb (12, pt. 3) has described a hybrid of which this willow was one of the parents.

S. nigra altissima Sarg., a variety differentiated in 1913 (77, v. 2, p. 216), occurs abundantly in Louisiana, southern Arkansas, and eastern Texas. It is distinguished from the typical form of *S. nigra* by its greater height growth (it occasionally attains more than 120 feet), more pubescent twigs, more pubescent and narrower-based blades, more pubescent and larger leafstalks (petioles), and by its habit of flowering 2 to 3 weeks later than ordinary black willows.

DISTINGUISHING CHARACTERISTICS

Black willow is the largest and most widely known of the native willow trees, but it is much less abundantly represented in western United States than in the Eastern States. It is more distinctly a tree throughout its range than almost any other arborescent willow

³⁸ Elwes and Henry (30) do not mention the black willow as a cultivated tree in English gardens, and probably it is not represented there at the present time. However, Loudon (36, v. 3, p. 1529) says that *Salix nigra* was introduced into cultivation in England in 1811, adding that (in 1838) "There are plants in the Hackney and Goldworth arboretums, and at Woburn Abbey."

and for this reason is probably the one most commonly recognized. Occasionally it forms a single trunk, but usually several trunks grow from the same root. Very commonly it is from 25 to 50 feet in height and from 10 to 20 inches in diameter. Trees from 60 to 80 or more feet in height and from 2 to 3 feet in diameter are of rather rare occurrence. The trunks are nearly always somewhat bowed and leaning. In scattered, open stands the trunks are clear of branches for one third or one half of their length and in close stands for two thirds of their length. The branches trend upward some-

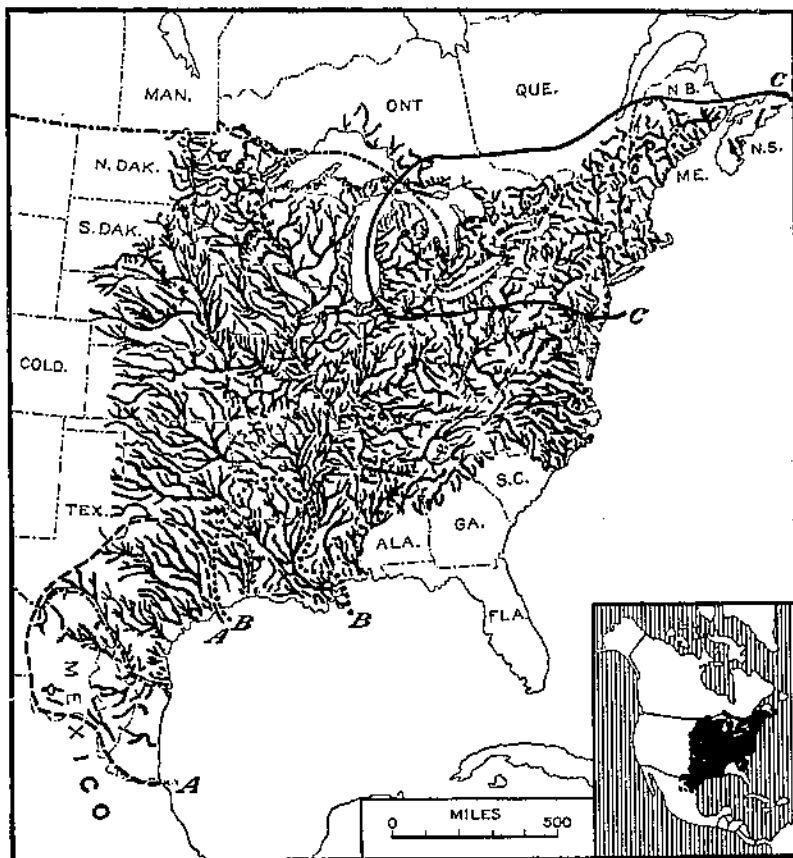


FIGURE 29.—Geographic distribution of black willow: A-A, *Salix nigra fulcata*; B-B, *S. nigra altissima*; C-C, *S. nigra lindheimeri*.

what, forming a wide, round-topped, open crown. Rough, furrowed, blackish-brown bark with wide, thick-scaled ridges and narrower connecting ridges is a marked characteristic of this tree, as is also the brittleness of the slender, drooping branchlets at their bases. The pale yellow-green leaves range in size and shape from fairly straight or slightly curved to strongly curved or scythe-shaped (fig. 28) and are from $2\frac{1}{2}$ to 5 or 6 inches long. They are smooth and somewhat shiny on the upper surface and smooth beneath, where

the veins are sometimes minutely hairy. The margins of the leaves are finely toothed.

Heartwood of the black willow is pale reddish brown, soft but firm, and rather fine-grained. A cubic foot of thoroughly seasoned wood weighs about 26 to 28 pounds (48, p. 91).

For a long time the wood of this species was used locally, chiefly for fuel and charcoal and occasionally for ball bats. At present it is also used extensively for packing cases, berry boxes, artificial limbs, woodenware, excelsior, boat scoops, and bucket handles, and as a substitute for yellow poplar for the backing and other unseen parts of furniture.

OCCURRENCE AND HABITS

S. nigra (fig. 29) grows naturally on the borders of streams and on low flats, in humus-covered wet or moist gravelly and sandy soils and is found commonly along the lower levels of watercourses in New Mexico. It forms strips and occasionally small patches of pure growth and is in some places mixed with other willows, cottonwoods, and alder. The largest trees are found in the valleys of the Mississippi, Ohio, Wabash, and White Rivers, in some parts of which black willow forms the principal tree growth over considerable areas. The regions of its best development are marked by moderate temperatures; this does not, however, properly account for the comparative rarity of this willow in the Pacific region. Black willow is decidedly intolerant of shade throughout life. It produces an abundance of seed, which is widely distributed by the wind and by streams. Reproduction takes place most frequently and abundantly on wet humus and sand.

LONGEVITY

Not much is known of the extreme age limits attained by the black willow. It is, however, essentially a short-lived tree, although the rootstock may continue to produce new sprouts for a great many years. Trees from 10 to 18 inches in diameter are from 35 to 60 years old. Occasional large trees from 2 to 3½ feet in diameter are estimated to be from 125 to 150 years old.

DUDLEY WILLOW (*SALIX GOODINGII* BALL)²⁸

COMMON NAME AND EARLY HISTORY

S. goodingii is a little-known willow which for a number of years was not distinguished from southwestern forms of the black willow. Commonly it is known only as willow, although its two book names are Dudley willow and Goodding willow.

The botanical history of this willow dates from 1904, when it was technically described (1) from southern California specimens as a variety of the black willow (*S. nigra* var. *vallicola* Dudl.); in 1908 it was termed a species, *S. vallicola* (Dudl.) Britt. (19). The former

²⁸The Check List (20) uses the spelling *gooddingii*, but Ball's original description (9, p. 376) used the form *gooddingi*.—W. A. D.



FIGURE 30.—*Salix gooddingii*: A, Fruiting spray; B, staminate spray. $\times 5\%$.

name is the oldest one applied to this tree, but owing to a rule of nomenclature it cannot be maintained. Accordingly, Ball (9, p. 376) renamed the species *S. gooddingii*. The oldest specimen now preserved of *S. gooddingii* was collected in 1845 by Frémont himself in his expedition to California, but definite record was not made of the locality, which was either in Utah or Arizona (10, p. 231).

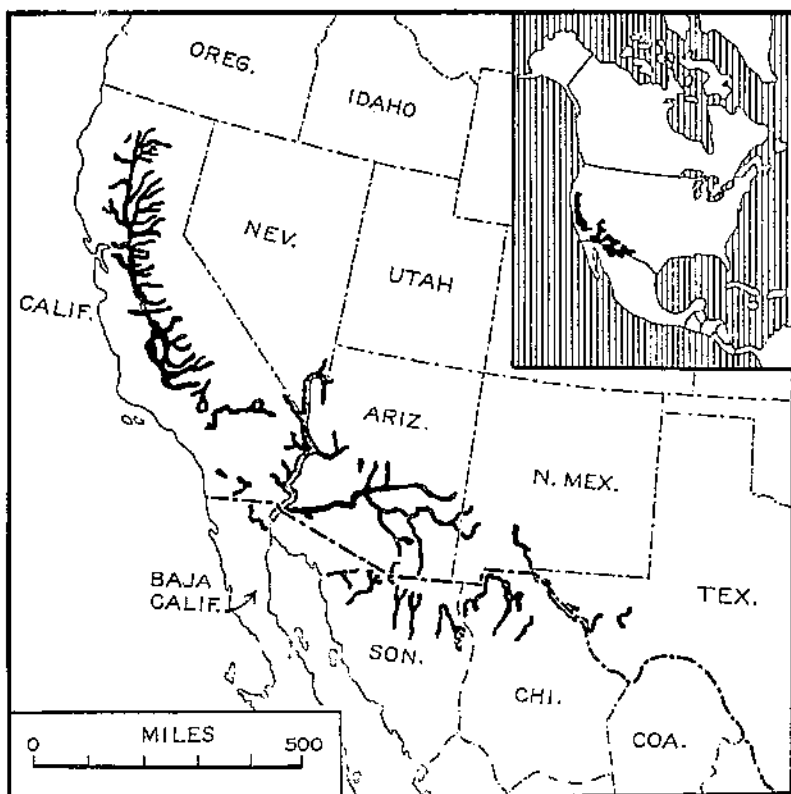


FIGURE 31.—Geographic distribution of Dudley willow (*Salix gooddingii*).

Other early records show that it was found on the Piute River in 1861, and in Lake County, Calif., in 1863.

DISTINGUISHING CHARACTERISTICS

S. gooddingii, although sometimes shrubby, is ordinarily a tree from 20 to 45 feet in height and from 10 to 30 inches in diameter. Widely scattered as the tree usually grows, it produces a broad rounded crown and a very short clear trunk. Occasionally in crowded stands it has a tall slender stem and a narrow columnar crown of short branches. Often the crown is composed of several large trunklike stems rising from near the ground. The thick, firm, gray or blackish trunk bark is cut with deep furrows and narrow ridges. The slender, easily detached twigs are straight, yellowish, more or

less shining, and often slightly hairy. Twigs of a season's growth are usually densely woolly.

Mature leaves are dull green and smooth and are from $1\frac{1}{2}$ to about 3 inches in length and from about one fourth to one half of an inch in width (fig. 30). They vary in form from narrowly to broadly lance-shaped and are commonly slightly curved above the middle; the apex is gradually or sometimes abruptly narrowed to a sharp point. The base of the leaves is wedge-shaped and attached to the twigs by a stem about one fourth of an inch long or less. At first the leaf stems are woolly, but later they become smooth. Margins of the leaves are finely cut with shallow glandular teeth. The beaked, red-brown seed capsules, borne on threadlike pedicels, are at first woolly but usually become smooth at maturity.

OCURRENCE AND HABITS

As now known, *S. gooddingii* (fig. 31) grows naturally in moist ground along watercourses and about springs from western Texas (El Paso and Jeff Davis Counties) through southern New Mexico to central and southern Arizona and southeastern Nevada (Lincoln County). Thence it extends into northern Baja California and northward in the interior of California to the northern part of the State (Shasta and Tehama Counties). It also occurs in northern Mexico.

LONGEVITY

Nothing is known now regarding the age attained by *S. gooddingii*. Apparently, however, it is likely to be similar in this respect to *S. nigra*, which attains maturity in from 50 to 75 years, although trees may remain in vigorous condition much longer.

PEACHLEAF WILLOW (*SALIX AMYGDALOIDES* ANDERSS.)

COMMON NAME AND EARLY HISTORY

S. amygdaloides is rarely if ever recognized by laymen as distinct from other tree willows, and for this reason it is usually called simply willow or common willow throughout its Rocky Mountain range. The most common names of this willow are peach (leaf) willow and almond (leaf) willow, both of which names obviously reflect the resemblance of the leaves of this American willow to the foliage of the cultivated peach and almond (*Amygdalus* spp.). These resemblances, and the relationship to the European species *S. amygdalina* L., doubtless suggested the technical name *S. amygdaloides*.

The peachleaf willow became known to science in 1858, when the Swedish botanist Andersson described it as *S. amygdaloides* from specimens which appear to have been collected in Missouri (5). Ten years later, apparently believing it to be a form of the black willow (*S. nigra* Marsh.) he named it *S. nigra* var. β *amygdaloides* (8). As we now know this willow, it is generally held to be distinct from the black willow.

DISTINGUISHING CHARACTERISTICS

The peachleaf willow produces one straight or leaning trunk or very rarely several clustered stems, like the black willow. Its upright branches are peculiarly straight, forming a rather compact,



FIGURE 32.—Leafy sprays of *Salix amygdaloides*. $\times \frac{1}{2}$.

round head. Ordinarily, the tree is from 20 to 30 feet high and from 8 to 12 inches in diameter, but occasional trees are from 40 to 50 feet in height and from 16 to 18 inches in diameter. The very pale reddish-brown trunk bark is about half an inch thick and is

rather deeply furrowed, the wide ridges being thick-scaled and connected by narrower lateral ridges. The twigs are straight, slender but rather tough, shiny, and red to orange-brown. Mature leaves (fig. 32) are thin, smooth, shiny, and light yellow-green above and pale or whitish (glaucous) on their under surfaces. The



FIGURE 33.—*Salix amygdaloides* (wrightii), syn. *S. wrightii*: A, Staminate spray; B, pistillate (fruiting) spray. $\times \frac{1}{2}$.

borders of the leaves have minute teeth with glandlike points. The prominent midveins range in color from a conspicuous light yellow to dark yellow. The leaves vary in length from about $2\frac{3}{4}$ to 4 inches and in width from about three fourths of an inch to $1\frac{1}{4}$ inches.

Staminate and pistillate flower clusters, which are usually found at the ends of short leafy twigs, are narrowly cylindrical, more or less woolly, and from about 2 to 3 inches long. The stamens vary in number from 5 to 9 and are distinct from each other. The flask-shaped seed capsules are smooth, deep orange-yellow, and about one fourth of an inch long. They are borne on rather long pedicels.

Wood of this species is pale yellow-brown, soft, brittle, and narrow-ringed, weighing about 28 pounds to the cubic foot. So far as is known the wood has no commercial uses, but it is cut locally for fuel and fence posts. It appears that the annual shoots of this willow have been tested in basket making, for which use they would

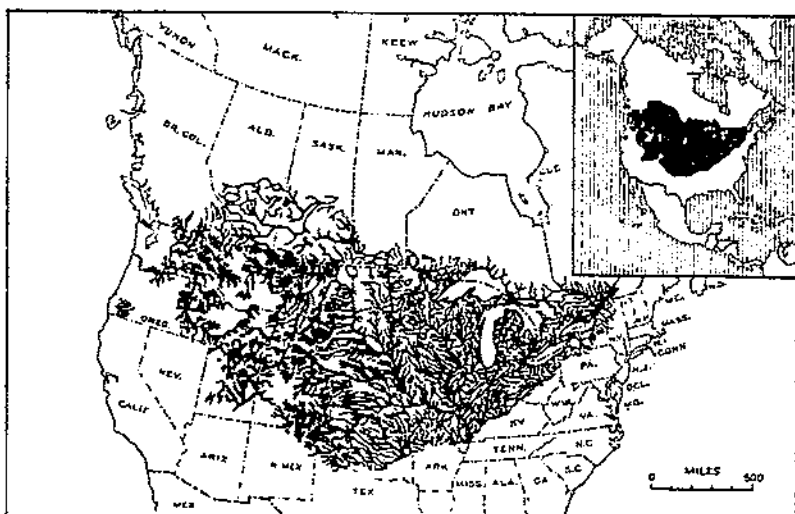


FIGURE 34.—Geographic distribution of peachleaf willow (*Salix amygdaloides*).

seem to be adapted. They are straight, slender, and tough, resembling those of the almond willow (*S. amygdalina*) of Europe, which is one of the standard willows cultivated for basket rods.

OCCURRENCE AND HABITS

Peachleaf willow (fig. 34) grows naturally along the borders of perpetual and intermittent streams, in moist rocky or gravelly soils, where it forms interrupted lines and small groups. Reproduction occurs rather sparingly and only along the moist open borders of streams and about springs and water holes, in sand, gravel, or silt.

LONGEVITY

Little is known of the age attained by the peachleaf willow. It grows rapidly in height and diameter during the first 25 or 30 years. Trees from 7 to 10 inches in diameter are from 25 to 40 years old; those from 18 to 24 inches in diameter are probably from 75 to 100 years old.

In 1918 Schneider (81, p. 14) designated *S. amygdaloides* var. *wrightii* as a varietal form of the peachleaf willow, ranging from

western Texas to southern New Mexico and south into northern Chihuahua. This varietal name is based on *S. wrightii* Anderss. (1858) (5), of which *S. nigra wrightii* Anderss. (1868) is a synonym (8). Ball (fide Schneider) (81, p. 14) regards this form as a distinct species, as do also Britton and Shafer (19, p. 185) and Rydberg (71, p. 191). In Schneider's opinion, however, it is a variety only, differing from typical *S. amygdaloides* chiefly in its more distinctly yellowish branchlets and its more lanceolate and more often acute (rather than long-acuminate) leaves, all of which have numerous stomata in the upper surface, and are mostly broadest at or above the middle.

The characters indicated do not appeal to the writer as of specific weight, and, for the present at least, he is inclined to accept Schneider's view and maintain this phase of peachleaf willow as a variety, *S. amygdaloides wrightii* (Anderss.) C. Schn. (fig. 33). From its general resemblance to *S. nigra* it is sometimes called black willow, and the book name Wright('s) willow is also applied to it.

RED WILLOW (*SALIX LAEVIGATA* BEBB)

COMMON NAME AND EARLY HISTORY

S. laevigata is commonly known as red willow, in allusion to the dark orange or bright red-brown twigs. It is also called black willow and California black willow, probably because the trunk bark of older trees is dark or blackish brown. Other names applied are smoothleaf willow and polished willow, because of the smooth, shiny upper surface of the leaves. Occasionally it is called Bebb willow, in honor of the eminent salicologist who described it.

This willow in typical form became known to science in 1874, when it was described under its present technical name (11). It was long supposed to be an inhabitant only of western California, where it was discovered. The first collection of red willow seems to have been at Santa Cruz, Calif., about 1852, by Andersson. However, Bebb not only had Andersson's specimen before him when he wrote his original description of the species but also specimens from Alameda and Mendocino Counties, Calif. The earliest statement that this willow ranges outside of California appears to have been made in 1908 by Britton and Shafer (19, p. 187) when they defined its range as extending eastward into Nevada and Utah.

DISTINGUISHING CHARACTERISTICS

The red willow is a straight-trunked tree ranging in height from 25 to 40 feet (occasionally 50 feet) and in diameter from 12 to 24 inches. The dark or blackish-brown trunk bark of large trees, sometimes faintly tinged with dull red, is about an inch thick and is deeply cut by furrows and ridges irregularly connected by narrow lateral ridges. Bark of young trunks and large limbs is much thinner and only shallowly furrowed. The crown, made up of rather slender, more or less spreading branches, varies from elongated in young trees to round-topped in old trees. Mature leaves, from 3 to 7 inches long and three fourths of an inch to 1½ inches wide, are smooth through-

out, shiny and dark green on the upper surface, and bluish (glaucous) on the under surface, with very finely toothed margins turned slightly under (fig. 35). The wide, grooved leaf stems are minutely hairy and up to about half an inch long, the wide yellowish midvein being conspicuous on the upper surface of the leaf and indistinctly visible on the under surface. The cylindrical staminate and pistillate flower clusters, 2 to 4 inches in length and occurring on $\frac{1}{4}$ - or $\frac{1}{2}$ -



FIGURE 35.—Leafy sprays of *Salix laevigata*: A, Fruiting (pistillate) spray; B, staminate flowering spray. $\times \frac{1}{2}$.

inch stems, are borne singly at the ends of short small-leaved twigs and, as a rule, are slightly drooping. The stamens, commonly 5 or 6 in number and having separated filaments hairy at the base, are accompanied by a small, pale, minutely hairy, thin scale, delicately toothed at the apex. A similar, but narrower scale accompanies the pistillate flower. The elongated conical seed capsules, on rather long pedicels, measure scarcely one fourth of an inch. Wood of the red

willow is narrow-ringed and brittle, the thick layer of sapwood being whitish and the heartwood pale reddish brown. A cubic foot of seasoned wood weighs slightly less than 30 pounds. None but very occasional local use is made of the wood.

OCCURRENCE AND HABITS

The red willow (fig. 36) grows only in moist sand and gravel along the borders of streams in the mountains and at lower elevations. It occurs singly or in small clumps and patches and is some-



FIGURE 36.—Geographic distribution of red willow (*Salix lucuigata*).

times associated with other willows and occasionally with alders. It grows at elevations ranging from about 1,900 to 3,000 feet in its California range, but in the central and southern Rocky Mountain region at somewhat higher levels.

LONGEVITY

The age limits of this willow have not been fully determined. It grows rapidly during the first 10 or 15 years and slowly thereafter and appears to be short-lived. Trees from 10 to 14 inches in diameter are from 28 to 40 years old.

TOUMEY WILLOW (*SALIX BONPLANDIANA TOUMEYI* (BRITT.)
C. SCHN.)

COMMON NAME AND EARLY HISTORY

Toumey willow is a little-known variety to which the book name of Toumey's willow was first applied by Britton and Shafer in 1908 (19). Until that time this willow was confused with the Bonpland willow (*S. bonplandiana* H. B. K.), the range of which is in central and southern Mexico. Considering this variety to be specifically distinct from the Bonpland willow, Britton (19, p. 187) described it in 1908 as *S. toumeyi* Britt. In 1918 C. Schneider (81, p. 20) designated it as *S. bonplandiana* var. *toumeyi* (Britt.) C. Schn. While further investigation may possibly show it to be specifically distinct from *S. bonplandiana*, the writer believes that it should be maintained as a variety.

The discovery of *S. bonplandiana toumeyi* within the United States was on September 11, 1893, when Mearns collected a specimen of it in a canyon on the east side of the San Luis Mountains in Hidalgo County, southwestern New Mexico. The second collection within the United States was by W. M. Canby, J. W. Toumey, and C. S. Sargent who found it in February 1894 in Sabino Canyon, Santa Catalina Mountains, Pima County, Ariz., and described it as a tree 25 to 30 feet high. (12, pt. 1, p. 364; 76, v. 9, p. 120.)

DISTINGUISHING CHARACTERISTICS

S. bonplandiana toumeyi attains a height of 20 to sometimes 50 feet and a diameter of 8 to 16 inches. It has a rather broad, rounded crown of slender branches and twigs, which trend sharply upward but are more or less drooping at their ends. The blackish-brown trunk bark, about three fourths of an inch thick, is irregularly broken by deep narrow furrows and rather wide, flat, scaly ridges. At first the smooth young twigs are pale yellow; they become yellowish or reddish brown and shining at the end of the first season and deep yellow-brown during the second summer.⁴⁰ The reddish-brown pointed, shiny winter buds, almost one fourth of an inch long, are somewhat curved toward the twig.

The leaves (fig. 37), thickish when full grown, are yellow-green, shiny above, bright silvery white beneath, and smooth on both surfaces, with conspicuously wide yellow midveins and large red-brown leaf stems. They vary in length from about 3¾ to 6 inches and in width from about one half to seven eighths of an inch. When the leaves appear they are accompanied by small, rounded, leaflike stipules at the base of the stem, which commonly disappear before the leaves are fully grown, but on vigorous shoots often persist until late summer. Among all of the tropical willows that occur in the United States, *S. bonplandiana toumeyi* is peculiar in its habit of not shedding its foliage in autumn. Most of the leaves fall irregularly

⁴⁰This twig description evidently follows that of Sargent's *Silva* (76, v. 9, p. 120) for *Salix bonplandiana*, which reads as follows: "The branchlets are x glabrous, x light yellow at first, light or dark red-brown and lustrous at the end of their first season, and paler and orange-brown in their second year." Schneider (81, p. 2), a foremost present-day salicologist, keys out *bonplandiana* partly under the caption "ramuli annuati blanesque rubescentes vel purpurascetes." Field observations on this point appear to be needed.—W. A. D.

during the winter, but some may remain on the trees as late as February.

The short-stemmed staminate and pistillate flower clusters, borne in the axils of leafy twigs, are cylindrical in form, erect, and from about $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in length. Many of the staminate clusters are slightly longer than the pistillate. The male flowers usually bear 3 but occasionally 4 stamens, whose slender filaments, slightly hairy



FIGURE 37.—Foliage, flowers, and seed capsules of *Salix bonplandiana* Loumey. $\times \frac{1}{2}$.

at their bases, are entirely separate from each other. The rounded, thin, yellowish basal scales of both male and female flowers are minutely hairy on the outer surface and smooth on the inner surface or have only a few delicate hairs on the upper half. The rather long-stalked seed capsule is smooth, pale orange-yellow, and about one fifth of an inch long.

Nothing is now known regarding the characteristics of the wood.

OCCURRENCE AND HABITS

So far as is now known (fig. 38) *S. bonplandiana toumeyii* extends into the United States only as far as southern Arizona and south-

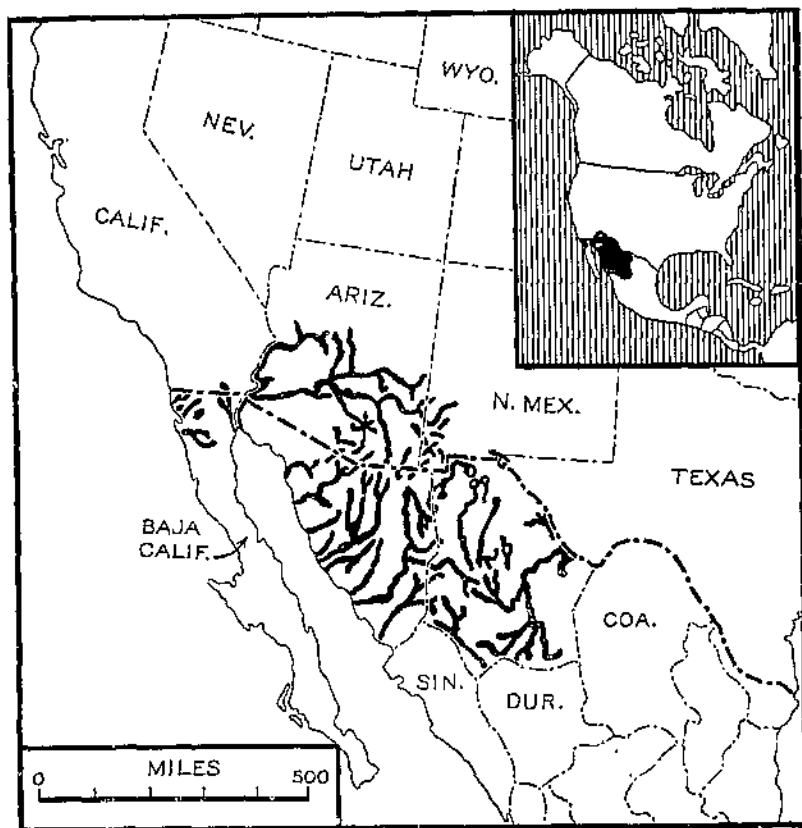


FIGURE 38.—Geographic distribution of Toumey willow (*Salix bonplandiana toumeyii*).

western New Mexico. There it grows in gravelly, rocky soils along the borders of mountain streams at elevations of about 2,500 feet.

LONGEVITY

Nothing is known definitely regarding the age attained by this willow.

WESTERN BLACK WILLOW (*SALIX LASIANDRA* BENTH.)

COMMON NAME AND EARLY HISTORY

S. lasiandra is frequently known throughout its range as black willow, evidently because of the very dark-brown or blackish trunk bark. But since the name black willow has been so long and properly applied to *S. nigra*, the writer has preferred to call this species western black willow, a name which was first taken up in 1908 (19, p. 190; 85, p. 219). In California, *S. lasiandra* is called yellow willow and waxy willow (47, p. 175), because the "one-winter-old" twigs are yellowish. But as the color of the twigs may vary from yellowish to dark purple, these names appear to be inappropriate.

In the first published account (41, p. 159) of the western black willow, the name *S. hoffmanniana* Smith was given it, on the supposition that this American willow was a form of the European *S. hoffmanniana* J. E. Smith, published in 1817. The specimens forming the basis for this designation were stated to have been collected at San Francisco, and a few at Monterey Bay, in 1827.

Specimens from which Bentham (13, p. 335) described and named this tree *S. lasiandra* in 1857 were collected by Hartweg along the Sacramento River in California, at a point, according to Jepson (47, p. 176), between Sacramento and Marysville. In 1842 Nuttall (61, v. 1, p. 58) described and named a large-leaved form *S. speciosa* (neither *S. speciosa* Host nor Hook. & Arn.). In 1859 Lyall found this large-leaved form of *S. lasiandra* on Vancouver Island (7, p. 34) and Andersson named it *S. lancifolia* (not *S. lancifolia* Doell). In 1868 Andersson (8, p. 205) named the same form *S. lucida* β *macrophylla* (not *S. macrophylla* Kerner). When, in 1895, it was discovered that all these specific and varietal designations were pre-occupied for other willows at the time that they were applied to this large-leaved form of *S. lasiandra*, Sargent (76, v. 9) named it *S. lasiandra* var. *lyallii* in honor of Dr. Lyall, who at that time was supposed to have discovered the form. It would seem, however, that credit for having first recorded the existence of this variety belongs to Nuttall, whose observations and definite account of the tree in Oregon under *S. speciosa* preceded Lyall's discovery of it by 25 or more years.

A varietal form of the western black willow, found mainly in the Rocky Mountain region, is *S. lasiandra* β *caudata* (Nutt.) Sudw. (84, p. 43; see also 12, pt. 2, p. 372). This form was first described (61, v. 1, p. 61), under the name *S. pentandra caudata* Nutt., the author supposing it to be an American form of the Old World *S. pentandra*. In 1858 Andersson (5, p. 115) named this form *S. fendleriana*.

Authors differ greatly in their judgment as to what constitutes the species *S. lasiandra* Benth. and the three varietal forms *S. lasiandra caudata* (Nutt.) Sudw., *S. lasiandra lancifolia* Bebb, and *S. lasiandra lyallii* Sarg. In his various writings, Sargent maintained the species and the first two varieties.

In 1898 Heller (35, p. 580) designated *S. lasiandra* var. *lyallii* Sarg. as *Salix lyallii* (Sarg.) Hell. and 2 years later (1900) he maintained *S. lasiandra caudata* (Nutt.) Sudw. (36, p. 19). In 1908 Britton and Shafer (19, p. 190) held *S. lasiandra* Benth. to include *S. pentandra caudata* Nutt. and *S. fendleriana* Anderss.,

and accepted Heller's promotion of *S. lasiandra* var. *lyallii* Sarg. to specific rank as *S. lyallii* (Sarg.) Hell. Recently also Rydberg (71, p. 191) accepted the latter designation but held *S. lasiandra caudata* (Nutt.) Sudw. to be a synonym of *S. fendleriana* Anderss. Under the present rules of nomenclature the latter name, which is the oldest applicable binomial, must be applied to this plant if it be considered a species. In the second edition of his manual, Sargent appears to have absorbed *S. lasiandra* var. *lyallii* Sarg. under *S. lasiandra*. Ball concurs in this disposition of the Lyall willow, the extremely wide and long leaves of which appear to be connected with the typical form of *S. lasiandra* by many intermediate leaf forms. Moreover, no floral or fruit characters found separate this supposed variety from the species.

In the writer's opinion it is advisable to follow Sargent (79) and maintain with *S. lasiandra* its two distinct varieties *S. lasiandra caudata* and *S. lasiandra lancifolia*.

DISTINGUISHING CHARACTERISTICS

In parts of its range *S. lasiandra* is hardly more than a shrub, but elsewhere it sometimes reaches heights of 40 or 60 feet and a diameter of 24 to 30 inches. Ordinarily, however, it is about 25 or 30 feet in height and 12 to 14 inches in diameter.

The bark of medium- and large-sized trunks is about three fourths of an inch thick and very dark brown, with a pale-reddish tinge that is most marked in the little-exposed shallow fissures. The wide flat ridges of the bark are distinctly cut by cross seams into plates longer than they are wide. The short, rarely straight trunk bears long, straight, upright branches which form a narrow, open, unsymmetrical crown. Mature twigs are rather large and vary in color from clear reddish brown to yellow-brown; when very young the twigs are more or less hairy and are often covered with a whitish bloom. The ovate, pointed winter buds, about one fourth inch long, are a shiny chocolate-brown.

The long-pointed leaves of *S. lasiandra* (fig. 39) range in length from about 2 to $4\frac{3}{4}$ inches and in width from about one half to three fourths of an inch. The largest leaves usually are produced at the ends of vigorous shoots. In occasional trees leaves throughout the crown are from 7 to 12 inches long and 2 inches wide. When the leaves are mature the upper surface is deep yellow-green and shiny, and the lower surface is pale bluish green. The margins of the leaves are finely cut into very small gland-tipped teeth. The yellowish smooth or hairy leaf stems are from one fourth of an inch to 1 inch long and are provided with several rather conspicuous blackish glands at the point where they are joined to the base of the leaf.

A pair of minutely toothed, leaflike, half-moon-shaped stipules are produced at the base of each leaf stem. These are much larger on vigorous shoots, where they often remain with the leaves much of the summer, whereas the smaller stipules found elsewhere usually fall from the plant earlier. Staminate and pistillate flower clusters, borne on somewhat hairy, leafy twigs, are from about $1\frac{1}{2}$ to 3 inches long, and the staminate clusters are almost twice as thick as the pistillate clusters. Staminate flowers bear 5 to 9 stamens on slender filaments which are minutely hairy at their bases. The ripe

seed capsules, borne on short pedicels, are from one fifth to one fourth of an inch long, smooth, and pale reddish yellow.

The varietal form *S. lasiandra caudata* (Nutt.) Sudw. (western black willow) is distinguished by its thicker, more leathery, some-



FIGURE 33.—*Salix lasiandra*: A, Pistillate spray; B, fertile twig with ripe ament, the seed about to disseminate. $\times \frac{1}{2}$.

what smaller leaves which are conspicuously "tailed" at the tip, more or less slightly scythe-shaped, and usually green on both sides or

only slightly paler beneath. The twigs of this variety are yellow and the winter buds are large and sometimes hairy on the lower part. The male catkins are relatively shorter and thicker than in typical *S. lasiandra*, and the scale at the base of each flower is usually toothed only at the top. As a rule also this variety is a smaller tree than is the typical *S. lasiandra*.

S. lasiandra lancifolia Bebb differs from *S. lasiandra* in the brownish or grayish hairiness on the twigs during the first season

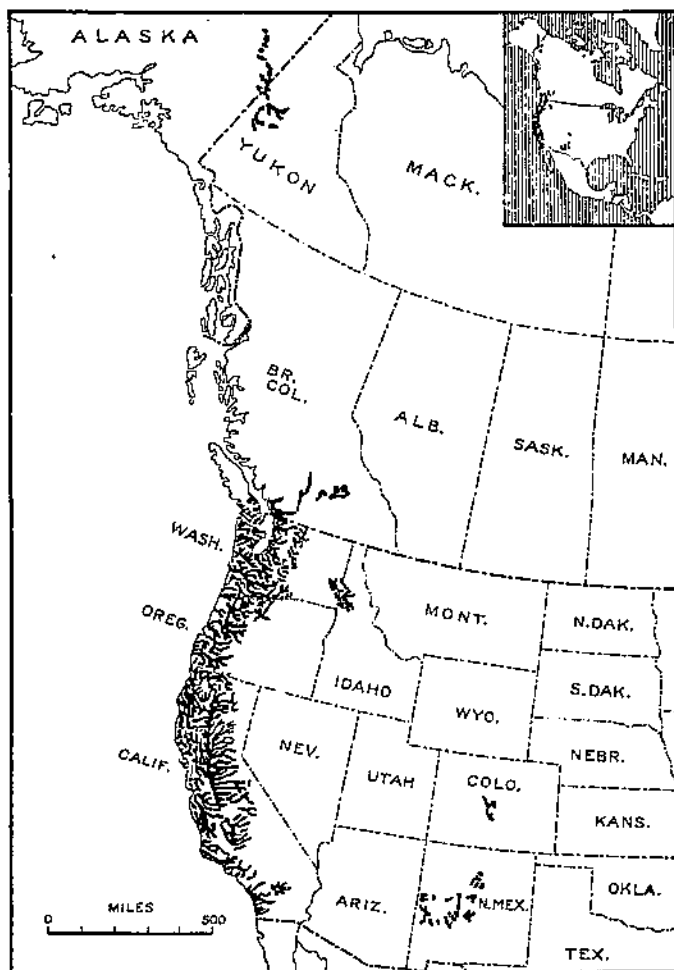


FIGURE 40.—Geographical distribution of western black willow (*Salix lasiandra*).

(sometimes also during the second season) and on the lower side of immature leaves.

The heartwood of *S. lasiandra* and its varieties is pale brown, and the thick layer of sapwood is nearly white. When thoroughly seasoned a cubic foot of the wood weighs from 28 to 30 pounds (15). The wood has a characteristic soft, brittle texture. Locally it is sometimes used for fuel and for charcoal. The long slender annual

shoots, particularly those from the pollarded trunks, are tough and suitable for coarse grades of baskets. It is related (*47, p. 176*) that in the days of Alta California the trees of Spanish saddles were made from selected pieces of western black willow and red willow.

OCOUERENCE AND HABITS

S. lasiandra and its varieties have a range extending roughly from the valley of the Yukon River southward through the coast region and mountain ranges to southern California and southward from

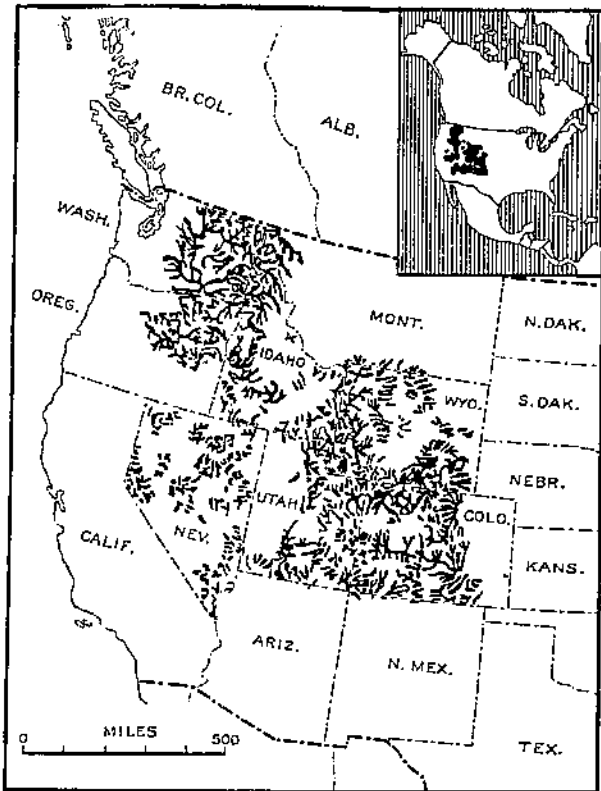


FIGURE 41.—Geographical distribution of the Rocky Mountain variety of western black willow (*Salix lasiandra caudata*).

Washington to the central Rockies and into New Mexico (figs. 40 and 41).

They occur on the borders of streams, water holes, and lakes, in moist sandy and gravelly soils, growing singly or forming small, scattered groups. The vertical range is extensive, from about 50 feet above sea level in the California coast region to 4,500 feet in the northern Sierras and 8,500 feet in the southern Sierras; but everywhere abundant soil moisture is a requisite. The largest trees occur at the lower elevations. All bear seed abundantly, but reproduction is always rather scattered.

LONGEVITY

Very little is known at present regarding the age limits of *S. lasiandra* and its varieties. It is probable, however, that maturity is reached within about 50 years. Trees from 12 to 18 inches in diameter are from 30 to 47 years old.

SANDBAR WILLOWS

As originally defined, several similar forms of very narrow-leaved willows were included under *S. longifolia* Muhl., published in 1803 (60), and this name served from 1803 to 1895 to designate what was considered a variable species of wide geographic range. The common names applied to *S. longifolia* were sandbar willow and longleaf willow. In 1895, however, Sargent (74, p. 463) showed *S. longifolia* Muhl. to be preoccupied, Lamarck having published the name *S. longifolia* in 1778 for a European willow perhaps identical with *S. viminalis* L. Sargent believed at that time (1895) that Nuttall's name *S. fluviatilis*, published in 1842 (61, p. 73), was the next oldest name for these willows and should be adopted. Nuttall's common name for them is river willow, in allusion to their common habit of growing along streams.

In 1900 Rowlee proposed a revision of western willows, in which all the forms previously referred to *S. longifolia*, and later to *S. fluviatilis*, were segregated as four distinct species, as follows: *S. fluviatilis* Nutt., *S. interior* Rowlee (67, p. 253), *S. exigua* Nutt., and *S. argophylla* Nutt. The characteristics relied upon to distinguish these species are not such as to be easily appreciated nor, in the writer's opinion, are they so fully dependable for the purpose of identification as could be desired. In point of stature these segregates are characterized respectively as "tree or large shrub" (*S. argophylla*); "a low shrub to a small tree" (*S. interior*); "low slender shrub to a small tree" (*S. fluviatilis*, *S. exigua*). The silvical habits of all appear to be rather similar.

The next event in the botanical history of what are here called the sandbar willows occurred in 1901 when Rydberg (in Britton, 17, p. 316) maintained *S. fluviatilis* Nutt., to which were added as new species *S. luteosericea* Rydb. and *S. linearifolia* Rydb. The first of these two species was described in 1842 by Nuttall as *S. exigua*, and later (1896) designated by Sargent as *S. fluviatilis exigua* (76, v. 9, p. 124). The latter is a form of *S. interior* Rowlee published in 1900. In 1908, Britton and Shafer (19, pp. 193-195) took up *S. interior* Rowlee, citing as a synonym of it *S. fluviatilis* Sarg. (not Nutt.), and adding that—

Salix fluviatilis Nuttall, to which this plant has been referred by some authors, described originally from Oregon or Washington, appears to be distinct from it and is not known to us to become a tree.

Britton and Shafer also took up *S. exigua* Nutt. and cited *S. fluviatilis exigua* Sarg. and *S. luteosericea* Rydb. as synonyms. They likewise maintained *S. sessilifolia* as distinct from other forms of the sandbar willow of Nuttall, and considered *S. argophylla* Nutt. and *S. fluviatilis argophylla* (Nutt.) Sarg. as synonyms. More recently (1913) Britton and Brown (18, pp. 594-595) continued the maintenance of *S. exigua* Nutt. and *S. interior* Rowlee, as the senior author did in 1908.

The next disposition of the variable forms originally referred to *S. longifolia* and later to *S. fluviatilis* Nutt. is by Rydberg (71, p. 192) who distinguishes five species—*S. exigua* Nutt., *S. stenophylla* Rydb. (70, p. 271), *S. interior* Rowlee, *S. linearifolia* Rydb., and *S. argophylla* Nutt.

In the writer's present judgment the arborescent narrow-leaved willows, heretofore called sandbar willows and occurring within the Rocky Mountain region, are held to constitute two distinct species, as discussed below under the headings *S. interior* Rowlee and *S. exigua* Nutt.

SALIX INTERIOR ROWLEE "

COMMON NAME AND EARLY HISTORY

S. interior is commonly called sandbar willow, longleaf willow, narrowleaf willow, and river-bank willow.

It is difficult to trace the early history of this willow. In his original description of it as *S. longifolia*, Muhlenberg (60, pp. 238-239) gives "Habitat ad Susquehannam," showing that the type specimen came from the East, presumably prior to 1803. It seems probable that Nuttall first found it in the Missouri and Mississippi River bottoms some time previous to 1842, for he says (61, v. 1, p. 73) in speaking of *S. fluviatilis*: "We believe this is also the same Willow that we mistook for the Long-leaved species of Pursh and Muhlenberg (*Salix longifolia*), which so commonly lines the banks of the Missouri and Mississippi. . . ."

DISTINGUISHING CHARACTERISTICS

This willow is very commonly a slender-stemmed shrub from 4 to 8 feet in height. Less frequently it becomes a small tree from 15 to 20 feet high and from 2 to 6 inches in diameter. Exceptional trees are sometimes from 40 to 60 feet high and 1 or 2 feet through. The trunk bark, dull brown and sometimes slightly reddish, is comparatively smooth with small, irregular close scales. The slender twigs are smooth and during the first season are yellowish or sometimes dull reddish yellow. The mature, very narrow leaves (fig. 42) are finely and distinctly toothed; they are from about 2 to 5½ inches long, or slightly longer, and vary in width from about three sixteenths to one third of an inch. They are smooth on both surfaces and are pale yellowish green, which is of a lighter shade on the lower surface. The channeled leafstalks are from about one eighth to one fourth of an inch long. The cylindrical staminate and pistillate flower clusters are finely hairy and are borne on leafy twigs, the staminate flowers at the end of the twig or in the axils of leaves, and the pistillate flowers terminating the twig. The staminate clusters are approximately 1 inch long and one third of an inch in diameter, and the pistillate clusters vary from 1½ to 3 inches in length

"This name is substituted for *S. longifolia* Muhl., which the author in his uncompleted manuscript had designated for "sandbar willow", following the precedent of the Check List (90, p. 71). Since Mr. Sudworth has just pointed out in the above text that *S. longifolia* is a homonym (preempted by the 25-year-older *S. longifolia* Lam. of Europe) and is therefore absolutely untenable botanically, it seems unwise to perpetuate here an error that the author himself, given full opportunity for the revision of his manuscript, would doubtless have corrected. The name *S. interior* Rowlee is now generally adopted by botanists to replace *S. longifolia* Muhl.—W. A. D.

and are about one fourth of an inch thick. The mature pale-brown smooth or woolly seed capsules are nearly one fourth of an inch long.



FIGURE 42.—Fructing spray of *Salix interior*. $\times 1$.

The sapwood is thin and is pale grayish white, and the heartwood is pale reddish brown. In texture the wood is rather firm; when thoroughly seasoned a cubic foot of it weighs about 30 pounds. It is rarely used for any purpose.

OCCURRENCE AND HABITS

S. interior (fig. 43) grows almost entirely on the periodically overflowed sand banks and mud banks of ditches, streams, ponds, and lakes, where, according to the space available, it forms large or small dense thickets of pure growth. It is one of the first woody plants to establish itself on the shifting sand and mud bars. These growths are rapidly extended by shoots from running rootstocks, which increase the density of the seeded stand. In some instances these thickets are almost impenetrable. The effects of their sand- and mud-binding qualities are often seen in broad, low river bottoms where the thickets effectively retain the shifting sand and silt bordering the water channel and form strips of permanent land. The density of the growth usually excludes all other plants. *S. interior* is very intolerant of shade, rarely growing in the imme-

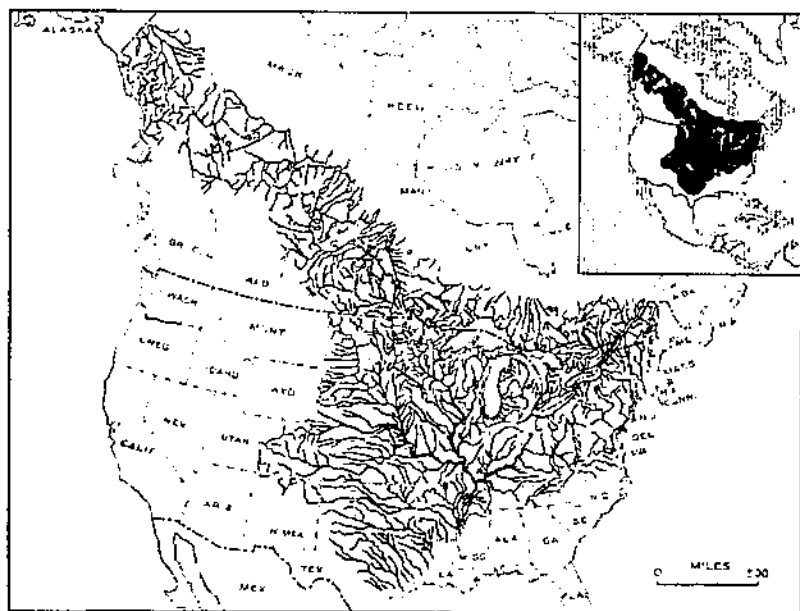


FIGURE 43.—Geographic distribution of sandbar willow (*Salix interior*).

diately shade of other willows and cottonwoods and commonly producing a long, clean, canelike trunk surmounted by a narrow little-branched crown.

LONGEVITY

Little is known now regarding the age limits of this willow. Its shrubby form is rather short-lived, especially where it stabilizes the land, allowing the growth there of cottonwoods and large willows which soon crowd it out. Trees from 2 to 3 inches in diameter are from about 10 to 14 years old. The largest trees doubtless attain their maximum growth in 40 to 50 years.

The following varietal forms of *Salix interior* Rowlee are distinguished:

S. longifolia angustissima Anderss. (7),⁴² which ranges from northwestern Texas through northeastern and southern New Mexico, is distinguished from the species by the absence of a dorsal gland in the staminate flower and by the silky hairiness of the young ovary.

S. interior pedicellata (Anderss.) Ball⁴³ occurs from western South Dakota and northwestern Wyoming into eastern Montana, Saskatchewan, and Alberta to the Yukon River (vicinity of Dawson). It is distinguished from the species by its extremely narrow leaves, smooth ovaries, and longer pedicels of the seed capsules.

SALIX EXIGUA NUTT.

COMMON NAME AND EARLY HISTORY

This species, termed here narrowleaf willow, is probably not popularly distinguished from *S. interior*, which it resembles in general appearance. Nuttall called it slender willow, first describing it in 1842 under its present name, *S. exigua* (61). Later it was made a variety of "*S. longifolia*", being designated in 1880 as *S. longifolia* var. *exigua* Bebb (in Brewer, Watson, and Gray, 16, v. 2, p. 85) and in 1896 as *S. fluviatilis* var. *exigua* Sarg. (79).

S. exigua Nutt. was probably first discovered by Nuttall (61, v. 1, p. 75), for he says of it:

This species is also a native of the territory of Oregon and grew with the preceding [i.e., *S. fluviatilis*], which it strongly resembles. * * * The male plant I have not seen.

DISTINGUISHING CHARACTERISTICS

S. exigua is for the most part a very slender reedlike shrub from 4 to 6 feet high, but in eastern Washington on the borders of the Palouse and other streams it becomes a small slender-stemmed tree 18 to 20 feet in height and 3 to 6 inches in diameter. The form found in the Rocky Mountain region is at best only a tall shrub. The trunk bark is dull grayish brown and nearly smooth or only slightly furrowed on the larger trunks. The crown, composed of a few slender branches, is similar to that of *S. interior*. The delicate twigs are smooth and brownish, tinged with red. The narrowly lance-shaped mature leaves, tapering at both ends, vary in length from 2 to 3 inches and in width from one eighth to one fourth of an inch (fig. 44). They are bluish green, smooth on the upper surface and coated with white silky hairs on the lower surface, and the borders of the leaves are minutely toothed, mostly above the middle. The staminate and pistillate flowers, which are usually terminal on smooth leafy twigs but are sometimes borne also in the axils of the upper leaves, are from about 1 to 2 inches long and are narrowly cylindrical. Scales of the flowers are white

⁴² Although this varietal name is unfortunately untenable, because of the homonymity of the specific name already explained, the logically consistent combination would appear to be *S. interior angustissima* (Anderss.). As given above, this name follows the form in the Check List (90, p. 71). Strictly speaking, however, Andersson's name (7, p. 55) is *Salix longifolia* Muhl. * * * *argyrophylla* (Nutt.) Anderss. — *angustissima* Anderss., indicating this form as a variety of the subspecies, and hence a quadrinomial.—W. A. D.

⁴³ In the author's manuscript this appears as *S. longifolia pedunculata*, which accords with the Check List (90, p. 71). However, since I have been unable to locate this name, I have assumed that it is a slip for *S. longifolia pedicellata* Anderss. (7, 8).—W. A. D.

and woolly and the filaments of the two stamens are hairy on the lower half. The pointed, stemless seed capsules are smooth.

Wood of *S. exigua* is indistinguishable from that of *S. interior*.

OCCURRENCE AND HABITS

The range of *S. exigua* is a western complement of that of *S. interior* (fig. 45). For botanical reasons these two species must be



FIGURE 44.—Foliage and fertile catkins of *Salix exigua*. $\times \frac{1}{2}$.

held distinct, but in the writer's opinion they are so similar in their silvical habits that they could as well be treated as one. *S. exigua*, seeding abundantly and also readily establishing itself from root-stocks, comes up in a crowded mass of seedlings that are the first woody growth to occupy wet sand bars and muddy shores of streams, ponds, and lakes. Its preference is for moist or wet sand and gravel, often overlain with silt. In such soil the network of running roots forms an excellent binder, holding these favorable but too easily

erodible bars and banks in place until, more slowly, cottonwoods and other valuable lowland trees can become established. Often these pure, dense thickets of narrowleaf willow grow up into strikingly even-aged stands characterized by small crowns and long,

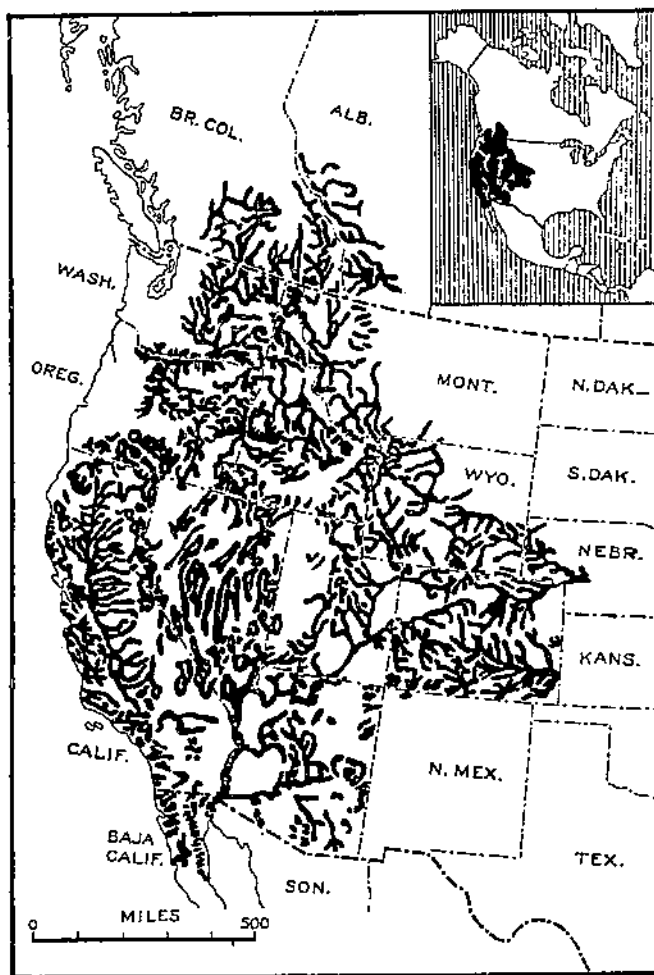


FIGURE 45.—Geographic distribution of narrowleaf willow (*Salix exigua*).

reedlike, clear stems. Despite its crowded character of growth, this willow is intolerant of overhead shade in all stages.

LONGEVITY

S. exigua is probably short-lived. Stems from 2 to 3 inches in diameter are from 9 to 14 years old; the largest are probably 50 years old, at least.

YEWLEAF WILLOW (*SALIX TAXIFOLIA* H.B.K.)

COMMON NAME AND EARLY HISTORY

S. taxifolia, though little known to many, is perhaps one of the most distinctly marked of all native tree willows because of its small, very narrow leaves. Settlers know it only as "a variety of willow." The name yewleaf willow, here adopted, is a book name coined from the tree's specific name, *taxifolia*, in allusion to its yewlike leaves.

The yewleaf willow appears to have become known to travelers first through plants growing in Mexican gardens, as Humboldt, Bonpland, and Kunth indicate (45, p. 22) in their note: "Colitur in hortis Mexici, Queretari, Zelayae, alt. 900-1,200 hex."

Specimens of *S. taxifolia* were first collected in the United States near El Paso, Tex., in 1849 (76, v. 9, p. 129) by Wright, and later, in 1888, Pringle found it in the vicinity of Tucson, Ariz., and again in canyons of the Santa Catalina Mountains in Arizona. Sargent (76, v. 9) further reports that Toumey found it in 1894 in similar situations in the Santa Rita and Swissholm Mountains of Arizona. In 1924 the author found it in the Davis Mountains in Texas. In 1817 it was first technically described and named *S. taxifolia* by Humboldt, Bonpland, and Kunth (43, v. 2, p. 22), and this name has been generally maintained to the present time. In 1831 Schlechtendal and Chamisso (30, p. 354) described and named what the writer regards as a form of *S. taxifolia* under the specific name *Salix microphylla* Schlecht. and Cham., which Schneider in 1918 (81, p. 24) designated as *S. taxifolia* var. *microphylla* (Schlecht. and Cham.) C. Schn., stating that its range is from central Mexico to Guatemala and Puerto Rico. In 1867 Andersson (7, p. 57) distinguished two varietal forms as *S. taxifolia* var. a *sericocarpa* and *S. taxifolia* var. b *lejocarpa*, but these forms have not been satisfactorily identified and are not now recognized by American botanists.

DISTINGUISHING CHARACTERISTICS

S. taxifolia ordinarily attains a height of 30 to 40 feet and sometimes 50 feet, and a diameter ranging from 12 to 18 inches. It has a rather widespreading, round, open crown, and the mid-crown and lower-crown branches are conspicuously long and weeping. The trunks are more or less crooked and are clear of branches for one third to one half of their length. The rough, pale brownish-gray bark is about an inch thick and is broken by rather deep, narrow furrows and wide flattish ridges which have very small, closely attached scales. The main ridges are connected by diagonally disposed smaller ones. During most of the first season the very slender twigs are covered with grayish woolly hairs, which are usually shed toward the close of the season, exposing the pale red-brown bark. The mature pointed buds are also covered with fine hairs. Fully mature leaves are a pale gray-green. Young leaves are covered on both sides with fine, soft, whitish hairs, which as the leaves become full grown disappear almost entirely from the upper surface but never completely from the lower side. The borders of the

leaves are mostly entire, only occasionally having very small indistinct teeth. Foliage of this willow is conspicuously smaller than that of any other native arborescent species (fig. 46). Both kinds of flower clusters are borne at the ends of short, slender, leafy twigs



FIGURE 46.—Foliage, flowers, and seed capsules of *Salix taxifolia*. $\times \frac{1}{4}$.

(fig. 46). The twigs bearing the staminate clusters grow from the axils of large leaves on the main stems. Male flowers bear two stamens, the slender filaments being hairy toward their lower ends. The mature, rather long-pointed, reddish-brown seed capsules are hairy and are borne on very short pedicels.

The color, weight, and structural characteristics of the wood are at present unknown. The branches are used for brooms, and, very occasionally, the wood for fuel.

OCURRENCE AND HABITS

In its rather limited range (fig. 47) in southwestern United States, *S. taxifolia* occurs scattered sparingly in some sections and abun-



FIGURE 47.—Geographic distribution of yewleaf willow (*Salix taxifolia*).

dantly in others in the narrow bottoms and near the borders of mountain streams, at elevations ranging from about 3,200 feet to approximately 5,000 feet. Instances are recorded in northern Mexico of this tree reaching an altitude of 6,500 feet. The soil in which it grows is often a mixture of washed sand and gravel, which is sometimes overlain by rich adobe silt.

S. taxifolia produces an abundance of seed which is widely distributed by the wind and in some cases by flood waters. Many capsules with partly escaped seeds adhere to the trees as late as November. Reproduction is generally rather sparse but in some instances is exceedingly abundant, producing dense growths of seedlings, similar to those of sandbar and narrowleaf willows. More or less common associates of yewleaf willow at the upper limits of its vertical range are *Platanus wrightii* and *Juglans rupestris*.

S. taxifolia is very intolerant of shade during all stages of its growth.

LONGEVITY

Little is known now regarding the age limits of this willow. It is possible, however, that the largest trees are 80 to 125 years old.

WHITE WILLOW (*SALIX LASIOLEPIS* BENTH.)

COMMON NAME AND EARLY HISTORY

S. lasiolepis is commonly called white willow,⁴⁴ probably because of the whitish (glaucous) undersurface of the leaves. The common name California white willow has also been proposed (19, p. 198) for this tree, but as its range is not wholly within California this name does not seem to be entirely appropriate. The name arroyo willow, in use by Jepson (46), Sargent (79), and Ball and Abrams (2) refers to a characteristic habitat of the species.

S. lasiolepis was discovered by the German gardener and collector of plants, Theodor Hartweg, along the Salinas and Carmel Rivers, near Monterey, Calif., in 1846 or 1847 (13, pp. 294, 335). Bigelow found it next near San Francisco, Calif., in 1854. It first became known to science in February 1857, when Bentham named it *S. lasiolepis* (13, p. 335). Three varieties, proposed by Bebb (in Brewer, Watson, and Gray, 16, v. 2, p. 86) and Ball (9a, pp. 436-437), distinguished mainly by differences in the form and size of the leaves, have not generally been maintained by botanists. Jepson (46, p. 340) and Ball (in Abrams, 2, p. 497) have, however, taken up *S. lasiolepis* var. *bigelovii* Bebb, which is the form Bigelow found near San Francisco in 1854. This form was originally named "*S. bigelovii*" by Torrey (96, p. 139).⁴⁵ This is the only other binomial that has been applied to this willow since it has been known to science.

DISTINGUISHING CHARACTERISTICS

At high elevations white willow forms a cluster of low shoots; at low elevations it is a tree 15 to 25 feet in height and 6 to 10 inches

⁴⁴This name is in conflict with that in general use (4) for the original white willow (*Salix alba* L.) of Europe, now widely naturalized in the eastern United States through long cultivation and named in the Check List (90) "European White Willow."—W. A. D.

⁴⁵Inasmuch as the Pacific Railroad report in which *S. bigelovii* Torr. was first published bears the title-page date 1856, it would at first appear that *S. bigelovii* is older by 1 year than *S. lasiolepis* Benth., published in 1857, and that it should replace the latter. As a matter of fact, however, Torrey's introduction to his part of the report bears the date January 12, 1857, and in describing other willows in this report Torrey refers to Bentham's *Plantae Hartwegianae*, published in 1857, in which *S. lasiolepis* Benth. was first published. It is clear, therefore, that the latter name is really the older.

in diameter. Exceptionally large trees are 30 to 40 feet high and 14 inches or more in diameter. The slender branches trend upward strongly, forming a rather narrow, irregular, open crown. The pale-brown or gray-tinged bark of larger trunks is less than half an inch thick and is shallowly seamed, the wide flat ridges being connected here and there by smaller lateral ridges. Occasionally light ashy

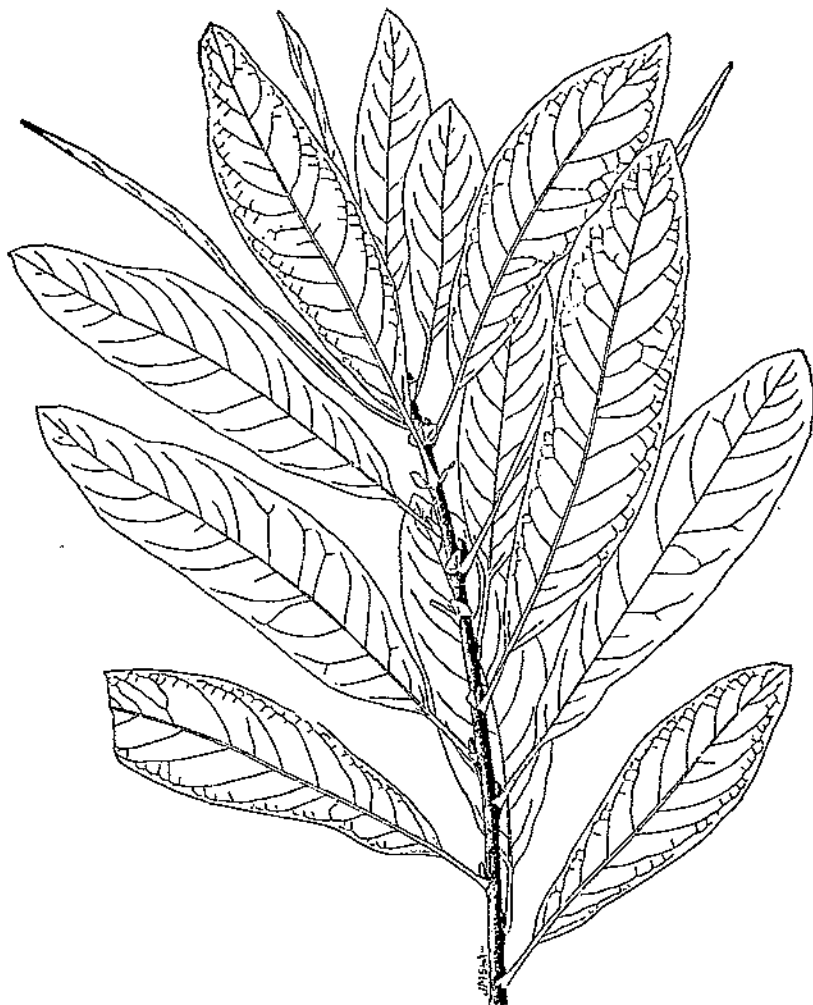


FIGURE 48.—Leafy spray of *Salix lasiolepis*. $\times \frac{3}{8}$.

gray areas also appear on the ridges. The smooth, unbroken bark of the large branches and of young trunks is pale gray. The mature, rather thick twigs of the season are deep red-brown, tinged with yellow toward their extremities, where they are sometimes very minutely downy, though elsewhere smooth. Young twigs are covered with a fine velvety down. Mature leaves (fig. 48) which are

2½ to about 5½ inches long and one half to 1 inch wide, are somewhat thick and leathery. They have yellow stems and midveins, and are dark yellow-green and smooth on the upper sides and very pale green or sometimes conspicuously silvery white beneath. They are more or less downy, particularly on the midveins and the lower surface of the less mature terminal leaves. The margins of the leaves are wavy and entire, but occasionally bear minute widely spaced teeth. The erect flower clusters, both male and female, are cylindrical in form and are from 1¼ to 1½ inches long. They are densely flowered and are borne on very short hairy twigs, most of which

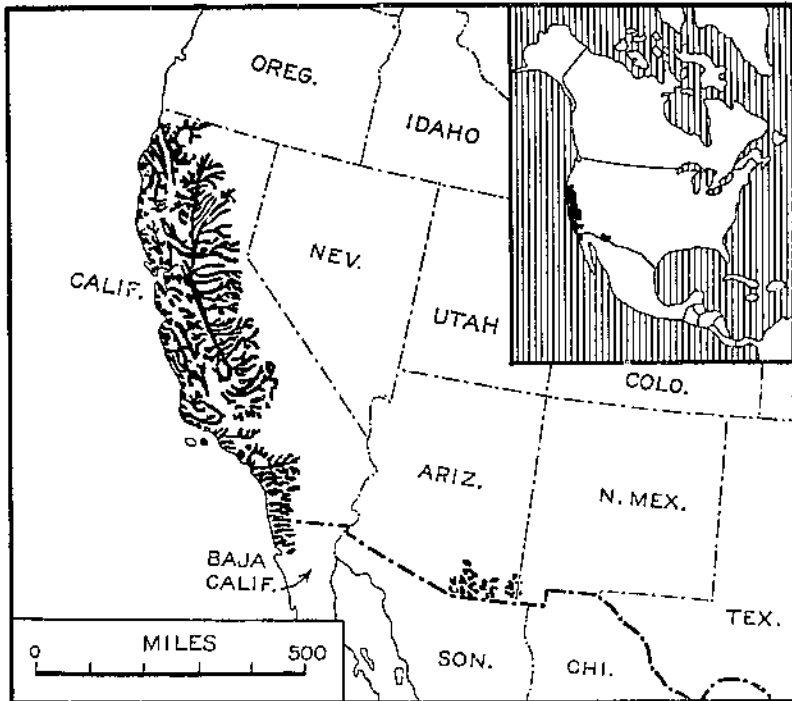


FIGURE 49.—Geographic distribution of white willow (*Salix lasiolepis*).

bear from 1 to 3 small leaves or early deciduous scales. The staminate flower clusters are about half an inch in diameter, the pistillate about one fourth inch. Each staminate flower bears two stamens, the smooth filaments being united below the middle. Mature seed capsules are pale reddish brown and about one fifth of an inch long, the catkins bearing them being about 2½ to 2¾ inches long.

The wood of white willow is narrow-ringed, soft in texture, rather brittle, and when dry weighs about 35¼ pounds per cubic foot. The whitish sapwood forms a much larger proportion of the bole of the tree than the brownish heartwood. In the southern part of its range, where fuel timber is scarce, the wood of this willow is used for fuel.

OCCURRENCE AND HABITS

S. lasiolepis (fig. 49) grows in moist sandy and gravelly soils, scattered individuals or small groups occurring on the borders of lowland streams and in adjacent bottoms, in springy places, and on streams of lower mountain slopes. Tree forms occur most commonly at lower elevations in the Pacific slope portion of the tree's range, shrubby forms being found only at higher elevations (3,000 to 4,000 feet). Little is known now regarding the silvical habits of this willow. In the southwestern part of the Rocky Mountain region it is often associated with *Alnus oblongifolia* and *Platanus wrightii*.

LONGEVITY

The age attained by *S. lasiolepis* has not been fully determined. Stems from 5 to 9 inches in diameter are from 12 to 22 years old. The largest trees are probably from 75 to 80 years old.

MACKENZIE WILLOW (*SALIX MACKENZIEANA* BARR.)

COMMON NAME AND EARLY HISTORY

S. mackenzieana is probably not distinguished by laymen from other willows in its range. The book name of Mackenzie willow is known chiefly to botanists. Rydberg (71) has recently applied the common name diamond willow to it.

Information is lacking as to the exact locality where this willow was discovered. Richardson first found it in Canadian territory at the "Great Slave Lake and the Mackenzie River" (39, v. 2, p. 149) some time previous to 1833. It first became known to science in 1839, when Hooker published Barratt's manuscript name *Salix mackenzieana*⁴⁶ and his own variant of that, *S. cordata* γ *mackenzieana*. In 1858 Andersson (5, p. 125) described it as a hybrid, *S. cordata* \times *vagans*, and 2 years later confirmed it (6, p. 65) as *S. cordata* \times *vagans* (= *rostrata*), while in 1867 (7, p. 160) he questionably treated it as a valid species, *S. mackenzieana*, though still intimating its possible hybrid nature. In 1895 Bebb (12, pt. 4, p. 473) designated it as *S. cordata mackenzieana* Hook., as did also Sargent (76, v. 14) as late as 1902. In 1908 Britton and Shafer (19, p. 193) treated this willow as a distinct species, *S. mackenzieana* Barr., and this disposition was followed also by Rydberg (71, p. 193).

While *S. mackenzieana* is a little-known willow, possibly to be considered a variety of the widely distributed shrubby heartleaf willow (*S. cordata* Muhl.), it is here maintained as a distinct species. The extreme type of *S. mackenzieana* is apparently specifically distinct from *S. cordata* in the form of its leaves; nevertheless, if strict account is taken of the common intermediate forms that clearly connect *S. mackenzieana* with *S. cordata*, the maintenance of *S. mackenzieana* as a varietal form may appear advisable.

⁴⁶ Hooker's spelling (39, v. 2, p. 149) is *mackenziana* in the trinomial *Salix cordata mackenziana*, which subsequent authors changed to *mackenzieana*. The manuscript name *Salix mackenzieana* Barr. and that of *S. cordata mackenzieana* Hook. were published simultaneously (39), the latter having place priority in the line. Some botanists prefer to write the authority as "(Hook.) Barr.," but Mr. Sudworth's citation of Barratt as sole authority for *S. mackenzieana* is justifiable, as it seems more probable that Hooker changed Barratt's name than vice versa.—W. A. D.

DISTINGUISHING CHARACTERISTICS

S. mackenziana is a slender, straight tree from 15 to 18 feet high and from 3 to 5 inches in diameter, with thin, smooth, unbroken ash-

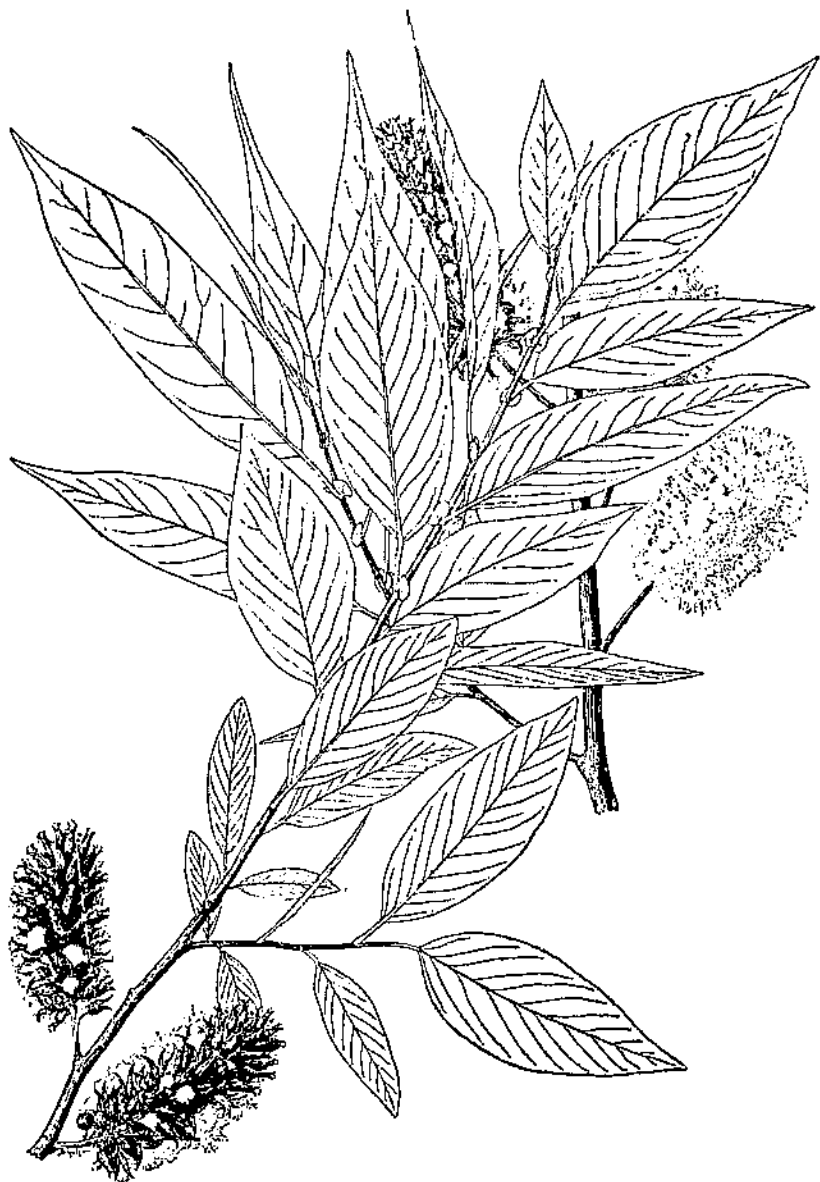


FIGURE 50.—Foliage and seed capsules of *Salix mackenziana*. $\times \frac{1}{2}$.

gray bark and a narrow, rather compact crown of thin branches which grow upward. The winter buds, which are about one eighth of an inch long, are bright reddish yellow. Mature twigs of the year are stiff, rather slender, and shiny yellow; during the second season they become greenish. When young the reddish twigs are

sometimes slightly hairy, particularly near the base. Mature leaves (fig. 50) are $1\frac{3}{4}$ to $3\frac{1}{4}$ inches long, smooth on both surfaces, and a deep yellow-green (paler beneath). The scythe shape of occasional leaves is a notable characteristic. The leaf margins usually show fine, although sometimes obscure, teeth, but are occasionally entire. Midveins and stems of the leaves are yellow. Kidney-shaped, veiny

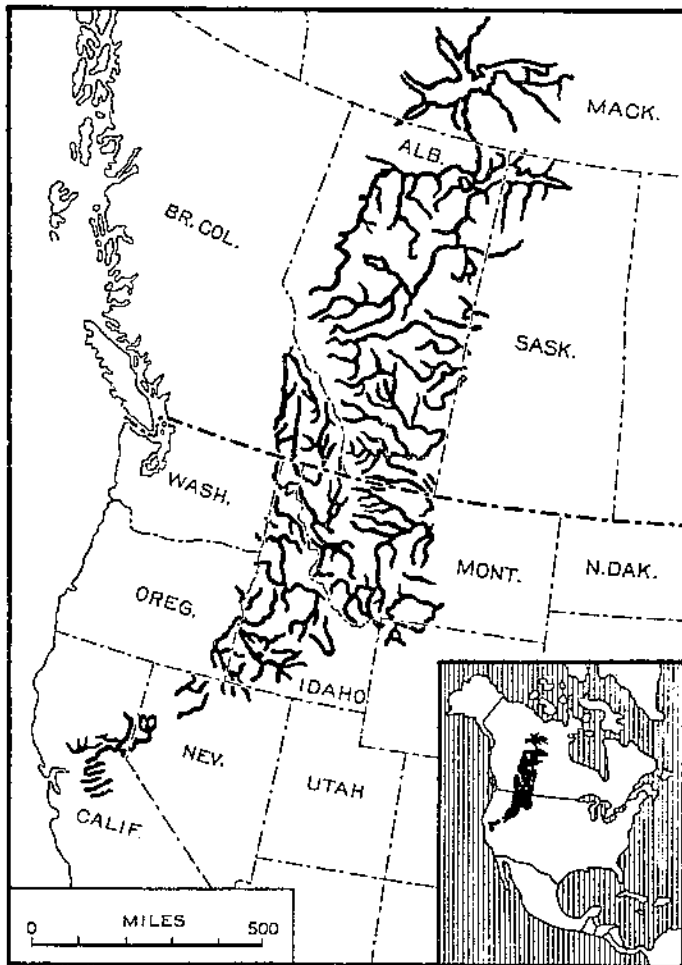


FIGURE 51.—Geographic distribution of Mackenzie willow (*Salix mackenziana*).

stipules are usually present during the first season. Staminate flowers bear two stamens on rather long, slender, smooth filaments. The smooth seed capsules are about one fourth inch long, pale reddish brown, and borne on rather long stems when mature. The structural and other characteristics of the wood are unknown.

OCCURRENCE AND HABITS

S. mackenziana (fig. 51) grows naturally along the borders of mountain streams in moist rocky and gravelly soils. Little is now

known regarding its silvical habits and associates, except that it is found with *S. monochroma* and *S. lutea*. Its climatic requirements and seeding habits and the conditions under which reproduction takes place most readily are also little known. Like other willows, it is doubtless intolerant of shade during all periods of its life.⁴⁷

LONGEVITY

Nothing is known of the age of the largest trees. Small trees from 3 to 5 inches in diameter are from 13 to 22 years old.

BEBB WILLOW (*SALIX BEBBIANA* SARG.)

COMMON NAME AND EARLY HISTORY

S. bebbiana is a common and widely distributed willow. Another book name for this species is beak willow, derived from the botanical *S. rostrata* Richards., formerly applied to this tree in allusion to the slender beaklike apex of the seed capsules. However, this technical name cannot be retained now, because at a still earlier date it was applied to another willow.

The botanical history of *S. bebbiana* began in 1823, when Richardson (64, p. 753) named and described this willow as *S. rostrata*, not knowing that in 1799 Thuillier had applied that name to an Eurasian willow which also had been previously named *S. repens* by Linnaeus. In 1868 Gray (34, p. 464) described and named *S. bebbiana* "*S. livida*, Wahl., var. *occidentalis*", under which name it was known to botanists for nearly 30 years. In 1895 Sargent (74, p. 463) called attention to the fact that *S. livida occidentalis* A. Gray was preoccupied by the West Indian willow, *S. occidentalis* Koch (published in 1828), leaving the species under discussion without a technical name. He therefore named it *Salix bebbiana*.

Exactly when, where, and by whom the Bebb willow was discovered appears to be unknown. The English captain, John Franklin, who headed the Franklin Expedition (66), in the course of whose explorations the tree was found, conducted his work during the years from 1819 to 1822, and this is the general date of discovery, for which credit probably belongs to Richardson, surgeon-naturalist of the expedition, the discovery probably taking place in the region of the species' greatest abundance, west of Hudson Bay.

DISTINGUISHING CHARACTERISTICS

S. bebbiana is commonly a shrub or small shrublike tree 8 or 10 feet high, but occasionally it becomes a tree 18 to 25 feet high and 4 to 8 inches in diameter. The clear trunk is short and the broad, rounded, dense crown is made up of slender branches which ascend sharply. The thin trunk bark is scaly and of a dull gray-green or reddish green. The bark of the twigs, which varies in color from

⁴⁷Jepson has taken up in his *Silva of California* (37, p. 180) *S. cordata* var. *scottsonii* Bebb, which he says occurs at elevations of 6,000 to 9,000 feet in "San Jacinto Mountain, northern Sierra Nevada, and eastward to Utah." The variety is characterized by smooth, polished yellow branches; smaller (1 to 3 inches long), oblong, short-acuminate, serrulate or subentire leaves; small or no stipules, and crowded catkins 1 inch long.

purple to reddish brown, is at first very hairy but becomes smooth during the first winter.

Mature leaves (fig. 52, C) are thick. On the upper surface they are dull green, veiny, and usually smooth but occasionally minutely hairy; on the under surface they are whitish or pale green, coated with minute hairs, and conspicuously net-veined. When old, some of the leaves may be nearly or entirely smooth on both sides. The



FIGURE 52.—Foliage, flowers, and seed capsules of *Salix bebbiana*: A, Fruiting spray, with capsules; B, staminate twig; C, twig with mature leaves; D, young shoot with leaves. $\times \frac{1}{2}$.

hairiness is particularly pronounced along the midribs and veins, and late in the season the hairs may become pale yellowish brown. The leaf margins are usually somewhat wavy and beset irregularly with mostly distant, often incurved teeth; frequently only the terminal portion of the leaf is toothed, and occasional leaves are entire. The leaves range in length from about $1\frac{1}{2}$ to 3 inches and in width from about one half to 1 inch. The reddish, hairy leaf stems are

from one fourth to one half of an inch long. On vigorous shoots (fig. 52, *D*) the half-heart-shaped, leaflike stipules at the base of the leaf stems are sometimes almost one half of an inch long and have gland-tipped teeth on their margins.

The catkins come forth with the leaves and are then from about three fourths to 1 inch in length. Two stamens are borne by the staminate flowers, the filaments of the stamens having no hairs. Flowers of both sexes bear a tiny minutely hairy scale at each flower base; in the pistillate flowers this scale persists until the seed capsules are ripe. Mature seed capsules (fig. 52, *A*) are borne in loose



FIGURE 53.—Geographic distribution of Bebb willow (*Salix bebbiana*).

clusters and have long, beaklike points and slender pedicels often about one half of an inch long.

Nothing is known now regarding the characteristics of the wood.

OCCURRENCE AND HABITS

S. bebbiana (fig. 53) grows in moist sandy or gravelly soils rich in humus. It occurs near streams, lakes, and ponds, and frequently in the vicinity of perpetual springs. It is very abundant throughout the Northern States, and especially so in its far-northern range in Canada. Richardson, the probable discoverer of this willow, mentions it (65, p. 313) as one of the two commonest willows in Rupert's Land and in the far north, stretching in all directions in great, impenetrable thickets 20 or more feet in height. Richardson also states that he traced this species "from Lake Superior to the Arctic Circle, or beyond it." Bebb willow is less abundant and more or

less widely scattered in the Rocky Mountain region where, as a slender, many-stemmed shrub, it reaches elevations of 8,500 to 10,000 feet. In its range it descends to within a few hundred feet of sea level.

S. bebbiana bears seed abundantly. It reproduces itself both by seed and root sprouts. When growing in dense thickets the production of long, slender stems with small crowns indicates that it is not tolerant of shade.

LONGEVITY

Nothing is known regarding the age attained by this willow. It is probable, however, that mature trees are produced within 50 or 60 years.

SCOULER WILLOW (*SALIX SCOULERIANA* BARR.)

COMMON NAME AND EARLY HISTORY

S. scouleriana is usually called simply willow, black willow, or occasionally mountain willow, because it grows at rather high elevations. Another name in frequent use is fire willow, because of its invasion of burned-off areas. The earliest book name for this species is "blunt-leaved willow", applied to it in 1842 by Nuttall (61). For the most part, however, it has been known to botanists during the last 20 years as Nuttall willow, this name having been coined from the technical name *S. nuttallii* Sarg., which was applied to the species in 1895 (74). Scouler willow first became known to botanists in 1839 when Hooker published Barratt's original diagnosis of *S. scouleriana* (39, v. 2, p. 145). Apparently American writers did not, until quite recently, recognize this as the first technical name applied to the plant, for it was long and widely known as *S. flavescens* (61). In 1895 Sargent (74, p. 463) showed that Nuttall's *S. flavescens* is antedated by *S. flavescens* Host, published in 1828, which is now held to be a synonym of Linnaeus' *S. arbuscula*, published in 1753. Not being aware of its true name and assuming that the tree had had no tenable technical name for more than 50 years, Sargent renamed it *S. nuttallii*. The true connection of the name *S. scouleriana* Barr. with this willow appears to have been fully understood only somewhat later.

In 1896 the Pacific slope form of Scouler willow was segregated as a variety, *S. nuttallii* var. *brachystachys* (Benth.) Serg. (76, v. 2, p. 142), based on *S. brachystachys* Benth. (13, p. 336), to which the author referred as a synonym *S. scouleriana* Barr. (in part). Jackson (44, pp. 780, 785) has accepted *S. brachystachys* Benth., published in 1857, for this willow.

Scouler willow, as found throughout its wide range in the Pacific slope and Rocky Mountain regions, is exceedingly variable in the size and shape of its leaves. Although fairly dependable characters allow the distinguishing of two varieties, a central and southern California form and a Sierra and Rocky Mountain form, it might be best not to consider this distinction and to regard the whole as one variable species. Without considering possible varietal distinctions, there is a peculiarly close general resemblance in the habit of the trees and in their leaves as found from the Pacific slope to the Rocky Mountains.

In his treatment of Scouler willow (47, p. 180) Jepson states that he is unable to distinguish, even varietyally, the California coast region form from the one found in the Sierras. Likewise, Ball (in Abrams, 2, p. 505) terms this willow "an immensely variable species especially as to foliage. To attempt to distinguish varieties



FIGURE 54.—Leafy spray of *Salix scouleriana*. $\times \frac{1}{2}$.

here would add to confusion." Sargent (79, p. 161) distinguished two varieties, *S. scouleriana* var. *erassifolia* Anderss.⁴⁸ (syn. *S. brachystachys* Benth.), which occurs from central California to San Bernardino County, and *S. scouleriana* var. *flavescens* C. Schn. (see footnote 50, page 96) which occur from the Sierras to the Rocky Mountains of Colorado and northern New Mexico, northern Wyoming, and the Black Hills of South Dakota.

⁴⁸The Check List (50, p. 73) cites Andersson as the authority for this variety. However, Andersson's name (8, p. 225) was *Salix brachystachys* Benth. (subsp.) β *scouleriana* (Barr.) Anderss. var. *erassifolia* Anderss. The correct citation is *S. scouleriana* (var.) *erassifolia* (Anderss.) C. Schn. (82, pt. 2, p. 12).—W. A. D.

The central and southern California form of Scouler willow, first described in 1857 as *S. brachystachys* Benth. was, according to Benth. (13, p. 294) first collected by Hartweg in 1846-47 in woods near Monterey, Calif. The northern Pacific slope form, first described in 1839 as *S. scouleriana* Barr., appears to have been col-



FIGURE 55.—Geographic distribution of Scouler willow (*Salix scouleriana*).

lected first by Scouler in "North West America, on the Columbia", probably about 1836 or 1837.

Scouler willow appears not to have been introduced into English and European gardens. On the Pacific coast, particularly in Oregon and Washington, it is occasionally cultivated as a shade and ornamental tree in lawns and public parks. It serves excellently for these purposes, because of its handsome varied foliage and symmetrical crown.

TB 420 (1934)

USDA TECHNICAL BULLETINS

UPDATA

POPULARS PRINCIPAL TREE WILLOWS AND WALNUTS OF THE ROCKY MOUNTAIN REGION

SUDHORTH, G. B.

2 OF 2

DISTINGUISHING CHARACTERISTICS

The trunk of the typical tree form of Scouler willow is single and usually straight and upright, but sometimes crooked or variously bent. When grown in the open the long, slender, somewhat drooping branches form a rather close, elongated crown which is shortest in trees growing in dense stands. The clear trunk is very short. The usual height of the tree form is about 20 to 30 feet, and the diameter 6 to 10 inches. At high altitudes it is only a shrub. The thin bark of large trunks is irregularly broken into wide ridges at the base of the trunk and is dark brown, with a faint tinge of red, which is present also on smoother parts of the trunk.⁴⁹ Twigs of 1 or 2 seasons' growth are stout and clear reddish yellow, becoming deep mahogany brown with age.

The shape and texture of the leaves (fig. 54) serve generally to distinguish Scouler willow from other willows associated with it. When mature the leaves are from about 1½ to 4 inches in length, firm, thickish, and somewhat shiny and smooth. They are deep yellow-green on the upper surface, and pale or whitish and sometimes very minutely hairy beneath. The prominent yellow midveins, as well as the leaf stems, are finely hairy. The margins of most leaves are entire and are thickened and slightly curled toward the under surface, but some leaves are remotely and very shallowly cut into round-pointed teeth. The early matured leaves are accompanied by glandular-toothed leaflike stipules at the base of each leaf-stalk, are crescent-shaped, about one fourth of an inch long, and usually fall in late summer, except those on vigorous new shoots, which may remain much longer.

The flower clusters, which appear before the leaves, are erect and on very short pedicels. The staminate clusters are about 1 inch long and one half of an inch thick and the pistillate clusters about 1½ inches long and nearly an inch thick. The staminate flowers are subtended by a small, minutely hairy scale, and bear two stamens on smooth slender filaments. The clusters of mature seed capsules are erect and about 2½ to 3 inches long; the long-pointed, hairy seed capsules are pale brown, about one third of an inch long, and are borne on very short pedicels.⁵⁰

Wood of the Rocky Mountain form of Scouler willow is pale reddish brown and of somewhat lighter weight than that of the Pacific slope tree, which is slightly more reddish. The whitish sapwood of both forms is very thick, and the wood of both is narrow-ringed. When dry the wood of the Rocky Mountain tree weighs about 31 pounds per cubic foot. The wood is not commercially

⁴⁹ The varietal form of this willow, *S. scouleriana crassijulis* Andrews. (= *S. brachystachys* Benth.), found in central California and southward, is generally a larger tree than the Rocky Mountain form and has a longer clear trunk and ashen-gray bark with whitish areas, which when broken shows clear red-brown.

⁵⁰ *S. scouleriana flavescens* C. Schn., a varietal form which occurs from the California Sierras to the central Rockies and the Black Hills of South Dakota, is characterized by its yellowish-green twigs and yellowish-green obovate-rounded leaves. The Check List (90, p. 73) cites Schneider as sole authority for this variety. The correct citation is *Salix scouleriana flavescens* (Nutt.) J. K. Henry (38, p. 98), based on *S. flavescens* Nutt. (61, p. 65). Schneider, however, seriously questions whether Henry's plant is the same as Nuttall's (82, pt. 9) and, therefore, proposes for Henry's form first the varietal name *S. scouleriana poikila* C. Schn. (82, pt. 9, p. 12) and later the formal name *S. scouleriana f. poikila* C. Schn. (82, pt. 12, p. 76).—W. A. D.

used. Scouler willow is, however, an important browse species for range livestock (25, 72).

OCCURRENCE AND HABITS

Scouler willow (fig. 55) is frequently a shrub growing about the headwaters of high mountain streams at elevations of 7,000 to 10,000 feet. The highest elevations are reached in the Pacific slope range. At lower elevations along the middle courses of mountain streams and on moist benches, in depressions, and on gentle slopes, this willow more usually appears as a small tree. It attains its greatest size in moist bottom lands on the Pacific slope, where it nearly reaches sea level. Abundant soil moisture and well-drained situations are essential for the best growth. Scouler willow occurs singly and in small groups. In the Pacific slope range it is in many places associated with red alder and bigleaf maple. Unlike other willows Scouler willow is fairly tolerant of shade for a number of years, its height growth not being materially retarded. Ultimately, however, it requires full top light for its best growth. It bears an abundance of seed, and seedlings are numerous but usually are much scattered.

LONGEVITY

The extreme age attained by this willow is not known. Trees from 6 to 10 inches in diameter are from 25 to 50 years old. The largest trees are probably from 100 to 125 or more years old.

FAMILY RELATIONSHIPS AND GENERIC CHARACTERISTICS OF WALNUTS

Walnuts (*Juglans*) are one of the two genera in the United States that represent the aromatic family Juglandaceae. The other representatives are the hickories (*Hicoria*). Juglandaceae, which occur generally in tree form, and rarely as shrubs, are characterized by odd-pinnate leaves and flowers in naked or bracteate catkins, the pistillate flowers being solitary or few-clustered, mostly with a four-toothed calyx and an inferior ovary. The fruit is a nut or, more precisely, a dry modified drupe, either with a firm pulpy covering which does not break off of its own accord (walnuts) or a firm woody covering which at maturity separates into four nearly distinct or partly connected rindlike valves or divisions (hickories). The deciduous, compound leaves occur singly and more or less distant from each other. The North American representatives of this family are commercially important timber trees, and many are also prized for their edible nuts.

Of the 5 species, 1 subspecies, and 3 natural hybrids of walnut indigenous to the United States, only 1 species and a single subspecies occur in the Rocky Mountain region. These are found in the southern Rockies and adjacent Mexican territory. Other representatives of the genus are distributed over many parts of the world.

The walnuts are of ancient origin. Remains of numerous ancient species, once common in Europe but now extinct, have been found in the Cretaceous and Tertiary formations. In the northern Pacific

coast region signs of ancient walnuts have been obtained from the Eocene formation and in the California Sierras from gold-bearing gravel beds. No living representatives are found in these regions now, although two native walnuts occur in California, one near the coast and the other (possibly introduced by the Indians) in the central portion of the State (20; 49; 50; 51; 52; 76, v. 7; 105).

A pungent aromatic odor is characteristic of the twigs, leaves, and other green parts of the walnut when bruised. The heartwood is of a rich dark-brown color. Other distinctive characteristics are the triangular leaf scars on the twigs, with three groups of minute dots, and the partitionlike structure of the pith (best seen by slicing a twig longitudinally). The pinnately compound leaves are made up of a single central stem from which grow some 5 to 11 pairs of leaflets, in addition to the terminal leaflet, each appearing like a small simple leaf and usually pointed. By the suppression of one of the terminal pair of leaflets, the number of leaflets may be odd. The flowers appear after the leaves. Staminate or pollen-bearing flowers are long, flexible, pendent catkins, borne singly or in pairs from buds on branches produced the previous season; pistillate flowers, which develop into fruit, have four small petals and are budlike bodies borne in small spikes at the ends of the new green shoots of the season, usually on the same branch as that which bears the staminate flowers. The fruit is a sculptured or rugose nut (spherical in the case of Rocky Mountain walnuts), matured by autumn of the first season. Its firm, more or less pulpy husk breaks up after maturity but with no regular divisions. The heavy fruits are dependent for their distribution upon rodents, which bury many of them for their winter food, and upon flood waters, which often carry them long distances.

KEY TO ROCKY MOUNTAIN WALNUTS ⁵¹

- Leaflets 17-23 (occasionally 13 or 15), lanceolate (mostly narrowly so), about 1 cm broad, long-acuminate, usually falcate, finely serrate or nearly entire; fruit 15-20 mm thick. Stamens about 20; much-branched, round-headed shrub or small tree, ranging from Texas to western Oklahoma and southeastern New Mexico.-----*Juglans rupestris*
- Leaflets 9-13 (occasionally 15; rarely 17 or 19), oblong-lanceolate to ovate, about 2 cm broad, acuminate, coarsely serrate; fruit 20-35 mm thick. Stamens about 30-40; medium-sized tree, occasionally 50-60 feet high, with well-defined trunk and narrow crown, ranging from central and southern New Mexico to Arizona.-----*J. rupestris major* (= *J. major*)

LITTLE WALNUT (*JUGLANS RUPESTRIS* ENGELM.)

COMMON NAME AND EARLY HISTORY

Juglans rupestris is a species well known within its natural range, but through a misunderstanding of its relationship to nogal (*J. rupestris major*), it has been long considered an eastern form of the latter tree. On account of the smaller stature of *J. rupestris*, its

⁵¹ Key prepared by W. A. Dayton, based largely on the treatments of Britton and Shafer (19), Rehder (63), Sargent (79), and Standley (83). It is worthy of note that all four of these authors regard *major* as a species, as does Standardized Plant Names (4), and as will Thicketron in his Flora of Arizona now in course of preparation.

smaller leaves, and especially its diminutive fruit, it seemed desirable to apply to it the name little walnut.⁶²

This walnut was first discovered in west-central Texas in 1835 by the Belgian botanist, Jean Luis Berlandier. Sargent (76, v. 7, p. 126) cites the existence of a specimen, "No. 2459, Rio de Medina, Texas, June, 1834" in support of this statement. It was first described as a distinct species by Engelmann (95) in 1854 under the name *J. rupestris*.⁶³

Torrey states that he read a paper about this walnut before the American Scientific Association in August 1851 (see also Dr. Woodhouse's statement (95, p. 37) in which he referred to this walnut as *Juglans whippleana*, naming it (at the request of Dr. Bigelow, who sent him the material) in compliment to Lieutenant Whipple, of the Mexican Boundary Commission, but that he afterwards ascertained that Dr. Engelmann had obtained this walnut before him and had already named (but not published) it as *J. rupestris*.

DISTINGUISHING CHARACTERISTICS

Little walnut is typically a bushy tree, generally 8 to 15 feet high and 6 to 18 inches in diameter, but sometimes 18 to 30 feet in height and correspondingly thicker. The trunk is usually more or less crooked and leaning. The crown is broad and rounded, and the lower branches very often come out close to the ground. The trunk bark is very like that of the nogal. In dry, poor soils the little walnut is often a low shrub with several or many slender stems from 2 to 4 feet high, growing from a common rootstock. The slender reddish-yellow twigs are at first covered with a light-colored short down, which remains during 2 or 3 seasons; finally the twigs become smooth and ashy. The leaves are about 8 to 13 inches long and usually have from 17 to 23 (rarely as few as 13) very narrow, scythe-shaped, long-pointed, leaflets finely toothed, except that the margin of the incurved portion is often entire or nearly so. These leaflets are often practically sessile or else borne on extremely short stalklets (petioles), and range in length roughly from 2 to 3 inches and in width from one half to two thirds of an inch. The main stem (rachis) of the leaf and that of the leaflets is usually slightly hairy, as is also the lower surface of the leaflets along the midvein; otherwise, the leaflets are smooth. The border of the leaflets is often slightly turned under (fig. 56). The fruit, generally borne in great abundance, is spherical or nearly so (sometimes slightly flattened at the basal end) and is covered with a very thin, brownish, minutely rusty-velvety husk. It is from five eighths to three fourths of an inch in diameter, and is reputed to be the smallest known in the genus. The thick-shelled nut, from about one half to five eighths of an inch in diameter, is somewhat pointed at

⁶² The name Texas walnut has been adopted for the species in Standardized Plant Names (4) and, since this name is suggestive of the principal range of the species, may be considered by many as preferable. Other local names include desert walnut and western walnut.

⁶³ *J. rupestris* appears to have been first introduced in Europe at the botanic garden of Berlin, Germany, where, according to a note attached to a specimen in Engelmann's herbarium, it was established as early as 1808 (76, v. 7, p. 126). Its next introduction into cultivation was in the Arnold Arboretum, near Boston, Mass., where seeds from western Texas were planted in 1879, and it is said to be perfectly hardy in that part of New England where, as a shrubby form, it had matured fruit as early as 1905.

the apex, its body marked with longitudinal, often interrupted or branched grooves; the scanty meat is sweet, with a black-walnut flavor.

OCCURRENCE AND HABITS

Little walnut is very scattered in its distribution (fig. 57), occurring singly and in small groups on and near the borders of perpetual watercourses and along periodically watered tributary stream beds in desert mountain regions, especially in limestone formations. It inhabits a region of very scanty rainfall and grows in rocky, grav-



FIGURE 53.—Foliage and fruit of *Juglans rupestris*. $\times \frac{1}{2}$.

elly soils into which its roots descend to great depths to obtain water. In a few places, widely scattered single trees or small groups, sometimes the only arborescent vegetation, appear along dry washes in rolling hill country. Though the fruit is commonly produced in great abundance every 2 or 3 years, reproduction is rather rare, owing to the fact that the nuts fall on dry ground or among bare rocks where there are few chances of germination. Wide dissemination of the nuts can be accomplished only by flood waters, and the only nuts to germinate are those which have been accidentally covered with soil or have been buried by rodents and left uneaten. Seedling plants of this walnut, like those of the nogal, produce

a deep-growing taproot during the first 2 or 3 years; the aerial portion of the stem develops very little during that period. The plant is intolerant of shade, growing only in full sunlight.

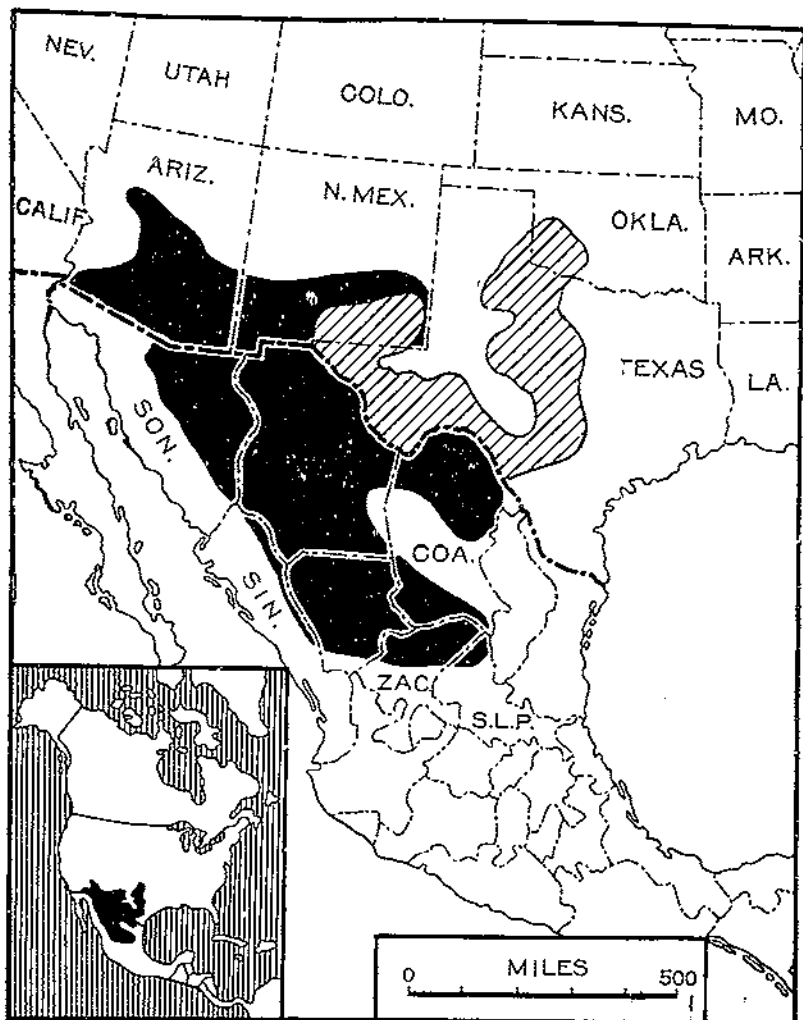


FIGURE 57.—Geographic distribution of the little walnut (*Juglans rupestris*) (hatched area) and nogal (*J. rupestris major*) (solid black area).

LONGEVITY

Little is known regarding the age limits of this walnut; the age of the largest trees has never been determined and may be anywhere from 85 to 150 years, or possibly much more. Two trees, 6 and 12½ inches in diameter, respectively, were 58 and 114 years old. After

the first 4 or 5 years, if conditions are not too severe, the tree grows rather rapidly.

NOGAL (JUGLANS RUPESTRIS MAJOR TORR.)

COMMON NAME AND EARLY HISTORY

J. rupestris major is known throughout its range simply as walnut or as nogal.⁵⁴ Settlers familiar with the eastern black walnut (*J. nigra*) sometimes distinguish this southwestern species as western walnut. The name Mexican walnut was once arbitrarily applied to this tree under the impression that it was essentially of Mexican origin.

The first authentic record we have of the collection of nogal is that by J. M. Bigelow, botanist of the Mexican Boundary Commission, at Copper Mines (i.e., Santa Rita), Grant County, N. Mex., about 1850, and by S. W. Woodhouse, surgeon-naturalist of the Sitgreaves Expedition down the Zuni and Colorado Rivers in "western New Mexico" (i.e., what is now Arizona) in 1851. In 1854 it was first published under the name *J. rupestris* var. *major* Torr. The publication in the same year of the similar but smaller-fruited *J. rupestris* Engelm. discovered in Texas appears to have led botanists to regard these two distinct forms as geographic phases of one species, and for more than 40 years both were designated as *J. rupestris* Engelm. In 1904, however, Heller (37), considering these walnuts specifically distinct, took up for the more western, larger-fruited tree the name *J. major* (Torr.) Heller, based on *J. rupestris major* Torr. In 1908 Britton and Shafer (19) adopted this view, as have also Wootton and Standley in 1915 (104), Standley in 1920 (33), Rehder in 1927 (63), Sargent (79) in the second edition of his Manual of the Trees of North America, and the American Joint Committee on Horticultural Nomenclature (4). After a long and careful study of these two walnuts the writer is convinced that the larger-fruited western one, here designated as *J. rupestris major* Torr.,⁵⁵ is a variety of the typically smaller-fruited, more eastern tree (*J. rupestris* Engelm.).

DISTINGUISHING CHARACTERISTICS

The nogal ordinarily ranges from 15 to 40 feet in height and from 4 to 15 inches in diameter. Exceptionally large trees are 45 to 50 feet in height and 3 to 4 feet in diameter, and the smallest form of this variety is a 3- or 4-foot shrub having several or many stems. The clear length of bole is usually only 6 to 12 feet; the bole above this height divides into a number of large erect or spreading limbs

⁵⁴ Nogal is applied by Mexicans to all species of *Juglans*, and hence is indistinctive, without modification, as a specific or varietal name. Clarence A. Reed, in charge of nut culture investigations of the Division of Horticultural Crops and Diseases, Bureau of Plant Industry, suggests adoption of the name Arizona walnut for this walnut.—W. A. D.

⁵⁵ According to Elwes and Henry (30, p. 276) this walnut was first introduced into cultivation in England in 1804, seeds obtained from the vicinity of Fort Huachuca, Ariz., having been planted at that time in the Royal Gardens at Kew. One tree grown from this seed attained a height in 11 years of about 12 feet. Other single trees planted in England at Tortworth, Coleborne, and Mount Edgcumbe, near Plymouth, reached nearly the same height within from 10 to 12 years.

and smaller branches forming, according to the growing space, a narrow or broad and domelike crown. In some instances the main body of the trunk appears to be greatly suppressed and gives off several spreading trunklike stems from a point at or very near the ground. The bark of young trees and of the branches on old trees is very thin, unbroken, and a light gray that is sometimes almost white. The trunk bark of old trees is from three-fourths to 1 inch thick, grayish brown, and distinctly furrowed and ridged, the surface of the ridges being irregularly divided into thin, firmly attached scales. Twigs of one season's growth are reddish brown. They are more or less downy for two or three seasons, but later be-

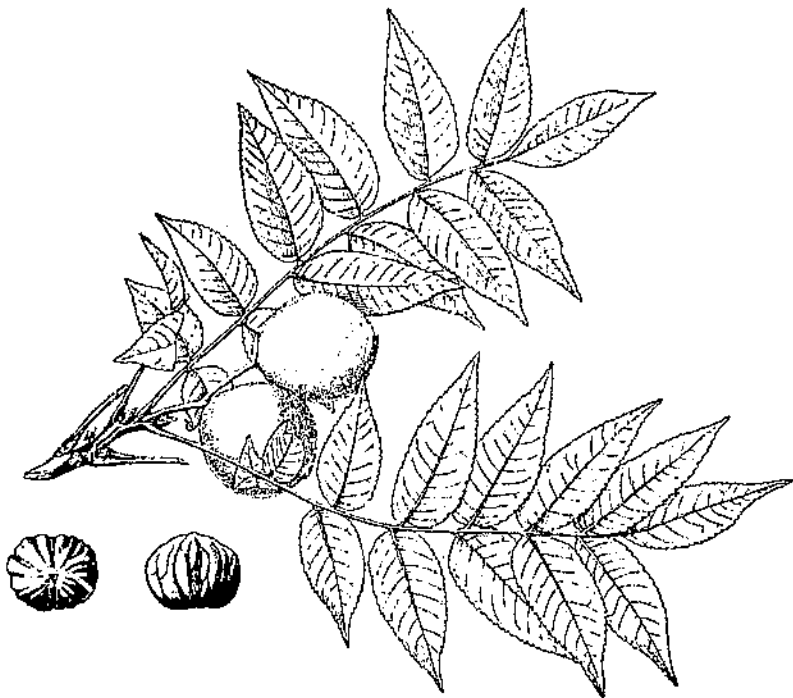


FIGURE 58.—Foliage and fruit of *Juglans rupestris major*. $\times \frac{1}{4}$.

come smooth and grayish or nearly white. The terminal mature buds are about one-half inch long, are slightly flattened, and are covered with tawny fine down; the slightly flattened lateral buds are about one eighth of an inch long and are similar in color to the terminal buds.

The compound leaves are 7 to about 14 inches long and are usually made up of 9 to 13 leaflets of a lanceolate or ovate-lanceolate type, all but the terminal or odd leaflet being arranged in opposite or nearly opposite pairs (fig. 58). The main leaf stems are finely hairy, as are, sparingly, the under sides of the leaflets along the midveins; the largest pairs of leaflets range from 3 to 4 inches in length and from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in width, and the smallest leaflets are about

2 inches long. The leaflets are thinish and yellowish green, occasionally somewhat sickle-shaped or falcate, at first scurfy and downy-haired, later hairless (glabrous) on the upper surface, but usually somewhat downy, especially at the midrib, below. The more or less spherical and slightly flattened fruit ranges in diameter from about seven eighths of an inch to $1\frac{1}{4}$ inches; exceptionally large fruit sometimes is $1\frac{1}{2}$ inches through. The nut is covered with a very thin husk, which is densely coated with light rust-colored down. The thick-shelled, dark-brown or blackish nut is smoother than that of the eastern black walnut, but conspicuously lined with narrow, deep, parallel and branched, wrinklelike furrows. In flavor the kernel is very like that of the common eastern black walnut.

During the first few years the stems of a seedling grow very slowly, while the little-branched taproot grows extensively, descending to a great depth.

The heartwood of *J. rupestris major* is a deep chocolate-brown, and the sapwood is almost white. Young trees have a thick layer of sapwood, but in old trees the layer is often very thin. The wood is heavier than that of any other native walnut, a cubic foot of it when dry weighing nearly 43 pounds. The rich-brown color and attractive figure of the heartwood render it suitable for furniture and cabinet work. The general appearance of the finished wood is very similar to that of eastern black walnut. Occurrence of the tree in small numbers and in rough inaccessible localities, however, probably will prevent any but local use of the wood for lumber. As in the eastern black walnut, the heartwood is very durable in contact with the soil and is often used locally for fence posts.

OCCURRENCE AND HABITS

Nogal (fig. 57) grows in rough, rocky, or gravelly soils in the bottoms and on the sides of canyons, usually near or on the edges of perpetual or intermittently watered stream beds or adobe-gravel washes and about rocky springs. Its vertical range is from an altitude of about 1,400 to 7,000 feet above sea level. Wooton (103, p. 49) states that the altitudinal range of this walnut in New Mexico is from 1,500 to 2,000 feet higher than that of typical *J. rupestris*.

Although where soil moisture is present this tree appears to be indifferent to the quality of the soil, as is shown by its persistent growth even in the poorest rocky, gravelly sites, the largest trees are produced in canyon bottoms where the soil is deep and fertile and moisture is abundant. The largest specimens are found in the central and western parts of the tree's range in New Mexico and Arizona, and the smallest trees in the eastern part of its range.

Nogal grows only as scattered individuals or in groups of a few trees. In general it is associated more or less with *Platanus wrightii*, *Alnus oblongifolia*, cottonwoods, and willows. In southwestern New Mexico it is in some places associated with *Morus microphylla*, the western form of *Quercus muhlenbergii*, *Q. emoryi*, and *Fraxinus pennsylvanica lanceolata*.

This walnut is very intolerant of shade and grows for the most part in the open where direct sunlight or strong diffused light is abundant. Trees growing in the bottoms of narrow canyons where

light is restricted show the influence of this deficiency in their comparatively tall slender trunks, sparse branches, and thin foliage.

Nogal bears fruit abundantly at irregular periods of 2 to 3 years, smaller quantities being produced every other year or so. Notwithstanding the large periodic production of seed, reproduction is relatively sparse, only scattered seedlings coming up where flood waters or some other accidental agency have covered the nuts with soil. In situations where such agencies are rarely if ever helpful, the entire crop of nuts may fail of germination. The germination of the nuts varies greatly from year to year, but the percentage is usually 30 to 50. Squirrels and other rodents consume considerable quantities of the nuts, particularly where the trees grow in wooded canyons at high elevations.

LONGEVITY

Under the most favorable soil conditions this walnut grows rapidly during the first 25 or 30 years of its life, after which time its increase in height and diameter, and especially in height, is slow. It is long-lived, attaining an age of 300 to 380 or possibly 400 years.

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⁸⁰ Completely revised, corrected, and enlarged by W. A. Dayton.

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