PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN. NO. 51. SALICACEAE. THE GENUS *SALIX* — THE WILLOWS*

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The species of *Salix* occurring in Wisconsin have been treated in several regional floras and floras of nearby states, as well as in a preliminary report on the Salicaceae of Wisconsin by D. F. Costello (1935). The purpose of the present study is to elaborate on, to augment, and in some instances, to correct these former treatments by providing more detailed descriptions than can be presented in a flora; discussing some problems in variation; discussing some nomenclatural problems; and pointing out species relationships and the diagnostic features of closely related species. It is hoped that this study will make the species of *Salix* in Wisconsin more understandable, and encourage some much needed field study, especially of population variation and ecological modification.

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This study is based on specimens in the herbaria of the University of Wisconsin (WIS), University of Wisconsin–Milwaukee (WISM), University of Minnesota (MIN), Milwaukee Public Museum (MIL), State University of Iowa (IA) and the W. P. Fraser Herbarium, University of Saskatchewan (SASK). About 3,500 specimens were studied. Descriptions of the species are based primarily on specimens from Wisconsin. However, several species are not sufficiently represented from this area, and in these cases type descriptions and descriptions in floras were referred to in writing the descriptions. At the end of each description the number of specimens on which the description was based is noted. The species are arranged in a phylogenetic order. Only the important synonymy is given for each species, followed by a description, a brief sketch of its ecology, and pertinent discussions of variation, nomenclature, related species, etc.

Illustrations of leaves and, for some species, pistillate aments are included. The leaf and ament prints were prepared by Mr. F. Glenn Goff, all other drawings and graphs were prepared by the author. Range maps are provided for each species with dots indicating the exact location of each collection and triangles indicating the presence in that particular county. Generalized phenological data are included in the lower left hand corner of each map (cf. discussions of phenology).

Three keys to the species are provided, one to each of the following groups of specimens: staminate, pistillate, and vegetative. Characteristics which are usually present in specimens in each of these categories have been used wherever possible. In some instances reproductive characteristics alone are insufficient to separate species or groups of species and in these cases vegetative characteristics are used as well. The keys must be regarded as guides and cannot replace a careful comparison of the unknown with descriptions and herbarium specimens. The best way to gain an understanding of the willows of a particular region is to study a series of representative, correctly identified specimens and to coordinate this with field study, including the tagging and successive collection of individuals. The variation in some species of *Salix* is so great that only field study can finally clarify the taxonomic units.

Although much of the variation in *Salix* is often attributed to hybridization, it is very difficult and highly subjective to identify hybrids on the basis of herbarium material alone. An understanding of the degree and importance of hybridization in North American *Salix* will only come through experimentation and not by the indiscriminate labeling of herbarium specimens as hybrids on the basis of their supposed morphological intermediacy. Very few of

the specimens that I have examined in the course of this study could be unequivocally named as hybrids. Because of our insufficient knowledge concerning the total variation of many species it is often impossible to determine whether a particular variant is simply part of the total species variability or a hybrid. For this reason I have placed "intermediate" specimens with the species they most closely resemble rather than in hybrid categories. Those hybrids which have been recognized are discussed under the primary parent. The determination of which species can and do hybridize and the morphology and fertility of the offspring are among the most important unsolved problems in North American *Salix*.

The phenology of *Salix* in Wisconsin, with particular reference to time of flowering, is an important consideration in any study of natural hybridization. For this reason, and as an aid to collectors, the flowering time of the indigenous species was recorded (Fig. 1). The distribution maps may be consulted for additional phenological data. The staminate specimens recorded to be in "anthesis" were actively shedding pollen, and the pistillate specimens recorded as "flowering" had stigmas that were apparently receptive. The species are arranged according to their approximate order of flowering with *Salix discolor* flowering the earliest and *S. syrticola* latest. Due to variation in sample size and the influence of habitat on flowering time such a sequence of species can be only approximate. However, it does indicate that there is a sequence of flowering in *Salix* and that some species flower earlier or later than others. The genus as a whole is in full flower during the period from 6–19 May, with the season extending from 8 April to 21 July.

WILLOW TERMINOLOGY

HEIGHT OF SPECIES. Although the height of woody plants should always be noted on herbarium specimens this is rarely done. As a result the heights given for the species in this treatment are based in part on the literature and in part on my field experience with the same species in other parts of their range.

BRANCHLETS. The branchlets are the current years shoot growth. Their color and pubescence vary with stage of development and the color may change markedly in drying. In this treatment the color of branchlets applies to dry herbarium specimens.

LEAF MEASUREMENTS. Leaf length, width, and length/width are based on the largest mature leaf on a branchlet. The total variation was based on measurements of one leaf per individual from all or most of the individuals bearing mature foliage. This was done in order to have comparable measurements from leaves in the same

	April				May				June				July		
	8	15	22	29	6	13	20	27	3	10	17	24	1	8	15
Discolor	2	3	3	2	2	1	—	—							
	1	4	4	6	9	7	—	1							
Humilis		2	3	2	2	2	—	—	—						
		2	2	5	9	2	—	—	1						
Glaucophylloides		1	1	1	1	1									
		1	4	1	3	—									
Amygdaloides	1	—	2	2	3	—									
	—	—	—	—	5	2									
Rigida	—	1	—	2	—	—	—								
	1	1	1	2	9	1	1								
Candida		—	—	1	1	—	—	—							
		1	2	1	4	4	—	1							
Sericea					—										
					1										
Petiolaris		—	1	3	1	—	—	—							
		2	3	4	7	11	5	5							
Pedicellaris		1	—	1	—	2	—	1	—	—	—				
		1	—	1	3	4	—	1	5	—	2				
Bebbiana	—	—	3	5	7	6	—	1	—	—	—	—			
	1	1	1	9	12	17	7	4	4	2	2	2			
Lucida	1	—	—	—	—	7	3	2	—	—	1				
	—	—	—	—	2	2	2	—	4	—	—				
Nigra					1	2	—	—	—	1	—				
					—	4	—	3	1	1	1				
Pyrifolia					—	—	—	—	1	—	1				
					1	2	3	4	2	1	—				
Interior	1	—	—	2	3	6	4	2	3	2	—	5	1	—	2
	—	—	—	1	1	5	2	3	—	2	3	1	—	—	—
Serissima							2	2							
							—	1							
Syrticola							1	—	—	—	—				
							1	—	—	—	1				

FIGURE 1. Flowering time of *Salix* native to Wisconsin based on herbarium specimens. The species are arranged in an approximate order of flowering. The top line indicates the number of staminate specimens in anthesis and the bottom line the number of pistillate specimens in flower. The dash (—) indicates no data.

general stage of development and in the same position on the shoot. Leaves of different size or shape than given for the species can be found on almost any specimen, but the most prominent leaves, at least, will be as described (cf. Figs. 3 and 9). Petiole and stipule length are based on the same leaf.

GLAUCOUS. Leaves with a waxy bloom occurring on the under surface are termed glaucous. In some species the bloom, which can be rubbed off, is absent but the leaf is whitish beneath. This condition is apparently caused by the presence of subepidermal chambers in *Salix lucida* and its relatives, and is termed "pale".

PETIOLE GLANDULAR. In some species glands occur at the distal end of the petiole (near the base of the lamina) and on the adaxial (inner) surface. These glands may be prominent and stalked or similar to those on the leaf margin. In some species they are inconspicuous, e.g. *Salix alba,* but they can be observed under adequate magnification.

PRECOCIOUS. The aments appear before the leaves in precocious species.

COETANEOUS. The aments and leaves appear at the same time in coetaneous species.

SEROTINOUS. The aments appear after the leaves in serotinous species.

AMENT LENGTH. The length of pistillate aments is based on material in early fruit, before the seeds are shed.

REPRODUCTIVE BRANCHLET. The stalk of the inflorescence from the lowermost flower to the branch is the reproductive branchlet (Figs. 4 and 6). This structure is usually termed the "peduncle" in the literature. I have avoided the use of the term because of its inaccurate application (to be discussed in a later paper) for what appears to be not a peduncle but a branch terminated by an ament. In some species (e.g. *Salix discolor*) the reproductive branchlet is very short or absent and the ament is then described as sessile (Fig. 11).

BRACTS. The foliar structure subtending each flower is a bract (scale in some literature). The foliar structures on the reproductive branchlet are leaves although they may sometimes be bract-like.

ABAXIAL AND ADAXIAL. Dorsal and ventral. If a single gland (nectary) is present in a pistillate flower it is located adaxially, between the pedicel and the rachis. If two glands are present the second is located abaxially, between the pedicel and the bract.

COLLECTING WILLOWS

For identification purposes the ideal collection of *Salix* should include a branch bearing leaves and pistillate aments. Most species are best understood in their pistillate form and the most definitive keys are to such specimens. However, it is not always possible to collect pistillate material, nor is it always desirable. In the case of an ecologist who may be required to collect sterile material during the course of a study, it is advisable to select "typical" shoots. Adequate notes are essential if the material represents sprout shoots or if the plant is growing under extreme conditions. In general, the more the specimen diverges from the "ideal" the more copious the notes should be. In most species the staminate morphology is insufficiently known, and descriptions are based on few specimens. This general lack of staminate specimens may account, in part at least, for their limited use in keys. The most valuable staminate collections are successive collections, but material bearing leafy branchlets is often adequate.

Valuable and critical information may be obtained through successive collections. Such collections are made over a period of time (usually a single growing season) from tagged plants. Each collection in the series represents a different stage in the annual development of the individual. Successive collections are especially important in the sampling of precocious species (e.g. *Salix discolor* and *S. humilis*) which often drop their aments before the leaves are produced. Most species of *Salix* show a high degree of local population variation and an adequate description of the annual local population dynamics can only be obtained through successive local population collections. This would require the tagging and repeated collections of a large number of plants in the same population. To my knowledge, work of this type has not yet been published, although it could theoretically yield significant information.

A. KEY TO STAMINATE SPECIMENS

1. Stamens 3 or more.
   2. Staminate aments slender and loosely flowered; flowers tufted and more or less whorled along the rachis.
      3. Immature leaves narrowly lanceolate, green beneath; stipules prominent. ----------1. *S. nigra.*
      3. Immature leaves lanceolate, glaucous beneath; usually exstipulate. ----------2. *S. amygdaloides.*
   2. Staminate aments thickish and densely flowered; flowers spirally arranged.
      4. Immature leaves bearing caducous ferruginous trichomes; stipules prominently glandular. ----------3. *S. lucida.*

      4. Immature leaves glabrous; stipules minute or absent.
         5. Staminate aments 3–3.5 cm long; indigenous species. ----------4. *S. serissima.*
         5. Staminate aments 2–6 cm long; introduced species. ----------5. *S. pentandra.*
1. Stamens 2.
   6. Staminate aments precocious.
      7. Staminate aments and leaves opposite or subopposite; filaments and anthers coalescent. ----------22. *S. purpurea.*
      7. Staminate aments and leaves alternate; filaments and anthers distinct.
         8. Leaves finely to densely sericeous beneath, margin entire or serrate; rare species in Wisconsin.
            9. Leaf margin serrulate; blade finely sericeous, at least beneath; filaments pubescent at base; indigenous species. ----------18. *S. sericea.*
            9. Leaf margin entire, revolute; blade densely sericeous beneath; filaments glabrous; introduced species. ----------21. *S. viminalis.*
         8. Leaves pubescent when immature, but not sericeous; common species in Wisconsin.
            10. Staminate aments 0.7–1.5 cm long. --19. *S. humilis.*
            10. Staminate aments 2–3.5 cm long. ---20. *S. discolor.*
   6. Staminate aments coetaneous or some subprecocious.
      11. Filaments pubescent.
         12. Petiole glandular at distal end; introduced trees.
            13. Branchlets tenacious and flexible. ----8. *S. alba.*
            13. Branchlets brittle at base.
               14. Leaves sericeous, margin finely serrulate; branchlets pendulous; staminate aments 3–3.5 cm long. ----------6. *S. babylonica.*
               14. Leaves glabrous or glabrate, margin coarsely serrate; branchlets not pendulous; staminate aments 3–6 cm long. ----------7. *S. fragilis.*
         12. Petiole not glandular at distal end; indigenous shrubs.
            15. Bracts black ----------17. *S. petiolaris.*
            15. Bracts yellow or yellow-green.
               16. Reproductive branchlets 0.8–8 cm long; staminate aments often branched; leaves linear; margin remotely denticulate. ----------9. *S. interior.*
               16. Reproductive branchlets 0.3–0.6 cm long; staminate aments unbranched; leaves not linear, margin entire to crenate.-15. *S. bebbiana.*

11. Filaments glabrous.
    17. Immature leaves and branchlets dull tomentose. ---- ----------14. *S. candida*
    17. Immature leaves and branchlets pubescent or glabrous
        18. Immature leaves thin and translucent; plants with balsam-like fragrance. ----13. *S. pyrifolia*
        18. Leaves or plants not as above.
            19. Staminate aments few flowered, 0.5–2 cm long; bracts yellowish; leaf margin entire, revolute. ----------16. *S. pedicellaris*
            19. Staminate aments many flowered, 1.2–4 cm long; bracts dark brown to black; leaf margin serrate.
                20. Inner bud scale persistent at base of aments and vegetative shoots.
                    21. Immature leaves glabrous, reddish. ---- ----------12. *S. glaucophylloides*
                    21. Immature leaves pubescent, sometimes reddish.
                        22. Branchlets glabrate or velutious; immature leaves pubescent, reddish, margin serrate, not prominently glandular. --10. *S. rigida*
                        22. Branchlets grayish tomentose; immature leaves densely sericeous, margin prominently glandular; on Lake Michigan dunes, rare. ----------11. *S. syrticola*
                20. Inner bud scale not persistent. -------- ----------17. *S. petiolaris*

B. KEY TO PISTILLATE SPECIMENS

1. Pistils and capsules pubescent.
    2. Pistillate aments precocious.
        3. Leaves and aments opposite or subopposite. ---------- ----------22. *S. purpurea*
        3. Leaves and aments alternate.
            4. Capsules subsessile, pedicels less than 1 mm long; introduced tree. ----------21. *S. viminalis*
            4. Capsules pedicellate, pedicels 1–2.5 mm long; indigenous species.

                5. Pistils and capsules blunt; aments 1–2.5 cm long; reproductive branchlets 2–10 mm long; leaves silvery sericeous beneath; rare in Wisconsin. -18. *S. sericea.*
                5. Pistils and capsules long beaked; aments 1.5–7 cm long; reproductive branchlets absent or very short; leaves not as above; common in Wisconsin.
                    6. Pistillate aments 1.5–4 cm long in fruit; styles 0.2–0.4 mm long; capsules 4–7 mm long. -------- ----------19. *S. humilis.*
                    6. Pistillate aments 4–7 cm long in fruit; styles 0.5–0.8 mm long; capsules 6–11 mm long. ---------- ----------20. *S. discolor.*
    2. Pistillate aments coetaneous or serotinous.
        7. Pistils and capsules dull white-tomentose. --14. *S. candida.*
        7. Pistils and capsules finely sericeous or glabrescent.
            8. Reproductive branchlets 3–6.5–12.5 cm long; bracts deciduous after flowering; capsules deciduous after dehiscence. ----------9. *S. interior.*
            8. Reproductive branchlets 0.3–1 cm long; bracts and capsules persistent.
                9. Bracts brown, oblong; pistillate aments 1.5–3.5 cm long in fruit; leaves linear-lanceolate, serrate to serrulate, sometimes with ferruginous pubescence. ---- ----------17. *S. petiolaris.*
                9. Bracts yellowish to tawny, lanceolate; pistillate aments 3.5–6 cm long in fruit; leaves elliptic, elliptic-ovate to oblanceolate, entire or crenate, lacking ferruginous pubescence. ----------15. *S. bebbiana.*
1. Pistils and capsules glabrous.
    10. Bracts deciduous after flowering, yellowish.
        11. Leaves green or pale beneath.
            12. Leaves linear to linear-lanceolate, remotely denticulate to serrulate; upper surface of blade dull.
                13. Leaves linear, remotely denticulate; stipules small or absent; pistillate aments often branched; capsules slender, 4.5–7 mm long. -- ----------9. *S. interior.*
                13. Leaves linear-lanceolate, often falcate, serrulate; stipules large and prominent; pistillate aments unbranched; capsules 3–4 mm long. -1 *S. nigra*
            12. Leaves lanceolate or broader, serrulate; upper surface of blade glossy, often coriaceous or subcoriaceous.

14. Immature leaves bearing caducous ferruginous trichomes; stipules prominently glandular. ---3. *S. lucida.*
14. Immature leaves glabrous; stipules minute or absent.
15. Pistillate aments stout, 2–4.5 cm long; capsules 7–10 mm long; indigenous species. ---4. *S. serissima.*
15. Pistillate aments slender, 3.5–6 cm long; capsules 1–5 mm long; introduced species. ---5. *S. pentandra.*

11. Leaves glaucous beneath.
16. Pistillate aments short and stout, 2–4.5 cm long; capsules 7–10 mm long; seeds shed late in season.---4. *S. serissima.*
16. Pistillate aments short or long, but slender, 2–3.5 or 4–8 cm long; capsules 1–5 mm long.
17. Pistillate aments loosely flowered; pedicels long, 1.5–2.5 mm long; indigenous species; leaves lanceolate to ovate-lanceolate; stipules absent or minute. ---2. *S. amygdaloides.*
17. Pistillate aments not as loosely flowered; pedicels short to sessile, 0.0–0.5–0.75 mm long; introduced species; leaves linear-lanceolate to lanceolate; stipules usually small and caducous.
18. Twigs slender and pendulous, not fragile. ---6. *S. babylonica.*
18. Twigs stout, not pendulous, fragile.
19. Leaves sericeous, margin serrulate. ---8. *S. alba.*
19. Leaves glabrous, margin coarsely serrate. ---7. *S. fragilis.*

10. Bracts persistent, yellow to brown.
20. Leaf margin entire, revolute; bracts sparsely pubescent. ---16. *S. pedicellaris.*
20. Leaf margin serrate to crenate; bracts pubescent to densely villous.
21. Immature leaves translucent, glabrous or glabrescent; plant with balsam-like fragrance; pistillate aments loosely flowered; pedicels 2.5–3.5 mm long. ---13. *S. pyrifolia.*
21. Immature leaves opaque, glabrous to pubescent; plants lack balsam-like fragrance; pistillate aments densely flowered; pedicels 0.5–2–(2.5) mm long.

22. Immature leaves white-pubescent or densely sericeous, green beneath or thinly glaucous in some plants.
23. Leaves oblong-lanceolate, apex gradually acuminate or attenuate, margin serrulate; immature leaves reddish-purple; capsules 4–5 mm long. ---10. *S. rigida.*
23. Leaves oblong-ovate, apex acute or acuminate, margin glandular serrate, teeth often prolonged; capsules 5–7 mm long. ---11. *S. syrticola.*
22. Immature leaves glabrous, sometimes with caducous ferruginous trichomes, blade thickly glaucous beneath, often drying black. ---12. *S. glaucophylloides.*

C. KEY TO SPECIMENS WITH MATURE FOLIAGE

1. Leaves opposite or subopposite. ---22. *S. purpurea.*
1. Leaves alternate.
2. Leaves glabrous or glabrate on both sides, midrib and petiole at times pubescent.
3. Petiole glandular at distal end.
4. Leaves glaucous or whitish beneath.
5. Immature leaves thin and translucent, glabrate and green on both sides; mature leaves subcoriaceous, base cordate to rounded; plants with balsam-like fragrance. ---13. *S. pyrifolia.*
5. Leaves and plants not as above.
6. Leaves coriaceous or subcoriaceous, margin serrulate, apex acuminate. ---4. *S. serissima.*
6. Leaves not coriaceous, margin finely to coarsely serrate.
7. Branchlets brittle at base; leaves often linear-lanceolate to oblong-lanceolate; introduced trees.
8. Leaves coarsely serrate; branchlets not pendulous; leaves lanceolate to oblong-lanceolate. ---7. *S. fragilis.*
8. Leaves serrulate; branchlets pendulous; leaves linear-lanceolate. ---6. *S. babylonica.*
7. Branchlets tenacious and flexible; leaves often ovate-lanceolate; indigenous trees or shrubs. ---2. *S. amygdaloides.*

4. Leaves green beneath, sometimes pale but not glaucou
   9. Leaves linear to linear-lanceolate, often falcate, n coriaceous, dull above; stipules prominent. ---- ----1. *S. nigr*
   9. Leaves lanceolate or elliptic-lanceolate, -ovate, o -oblong, coriaceous to subcoriaceous, glossy above stipules prominent or absent.
      10. Stipules present, persistent, and prominentl glandular on margin; immature leaves pubescen ----3. *S. lucid*
      10. Stipules absent or minute and early deciduous immature leaves glabrous.
         11. Indigenous species; aments broad; capsule 7–10 mm long. ----4. *S. serissim*
         11. Introduced species; aments slender; capsule 5–6 mm long. ----5. *S. pentandr*

3. Petiole not glandular at distal end.
   12. Leaves green beneath.
      13. Leaves linear to linear-lanceolate, margin remotel denticulate; immature leaves sericeous. ---- ----9. *S. interio*
      13. Leaves oblong-lanceolate, margin serrate to serru late; immature leaves reddish-purple, densel pubescent. ----10. *S. rigid*
   12. Leaves glaucous beneath.
      14. Leaf margin entire or crenate, not serrate.
         15. Low bog shrubs, 20–70 cm tall; leaf margin e tire, revolute; exstipulate. --16. *S. pedicellari*
         15. Tall shrubs or trees, 1.5–6 m tall; leaf marg commonly crenate; stipulate.
            16. Immature leaves with caducous ferrug nous trichomes; mature leaves broadly e liptic, oblanceolate or lanceolate; stipul small, often persistent. ---20. *S. discolo*
            16. Immature leaves pilose to sericeous-tomen tose; mature leaves elliptic, elliptic-ovat or oblanceolate; stipules small, deciduou ----15. *S. bebbian*
      14. Leaf margin serrate, at least on immature leave
         17. Leaf base rounded to subcordate; stipules larg and prominent, or sometimes absent.

         18. Stipules small or absent; immature leaves thin and translucent; mature leaves lanceolate to narrowly ovate, L/W 1.6–2.5. --- ----13. *S. pyrifolia.*
         18. Stipules prominent; immature leaves thick.
            19. Leaves narrow, 1.2–2 cm wide, L/W 3.7–5–6.2, apex acuminate to attenuate, thinly glaucous beneath. ---- ----10. *S. rigida.*
            19. Leaves broader, 2.4–3.5–4.6 cm wide, L/W 1.9–3–4.4, apex acute to sometimes acuminate, thickly glaucous beneath. ---12. *S. glaucophylloides.*
      17. Leaf base tapering; stipules usually small or absent.
         20. Leaves linear to lanceolate, if broader then with an attenuate apex and serrulate margin.
            21. Branchlets pendulous, brittle; introduced trees. ----6. *S. babylonica.*
            21. Branchlets erect, tenacious; indigenous trees or shrubs.
               22. Immature leaves mostly glabrous, reddish; leaf blades lanceolate to ovate-lanceolate, L/W 4.2–5.7, apex attenuate; petioles 10–16 mm long, glabrous. ---- ----2. *S. amygdaloides.*
               22. Immature leaves velutinous sericeous, green; leaf blades linear to lanceolate, L/W 5–7, apex acute; petioles 3–10 mm long, pubescent. ----17. *S. petiolaris.*
         20. Leaves broader, elliptic to broadly lanceolate or oblanceolate, apex acute to subacuminate, margin entire to crenate or sometimes serrate.
            23. Immature leaves often bearing caducous ferruginous trichomes; mature leaves broadly elliptic, oblanceolate to lanceolate; stipules small, often persistent. ----20. *S. discolor.*

23. Immature leaves pilose or sericeous-tomentose; mature leaves elliptic, elliptic-ovate to oblanceolate; stipules small, deciduous. ____15. *S. bebbiana.*

2. Leaves pubescent, at least beneath.
24. Petioles glandular at distal end.
25. Leaves glaucous beneath, not coriaceous; stipules small and deciduous; introduced trees. ____8. *S. alba.*
25. Leaves green or pale beneath, coriaceous or subcoriaceous; stipules 1–6 mm long, persistent; indigenous shrubs. _____3. *S. lucida,* variety.
24. Petioles not glandular.
26. Young branchlets and underside of leaves dull white tomentose, flocculent above, margin entire and undulate, revolute. _____14. *S. candida.*
26. Young branchlets and underside of leaves not as above, margin entire, crenate or serrate.
27. Leaves linear to linear-lanceolate, margin entire or remotely denticulate.
28. Leaves densely sericeous beneath, margin entire, revolute; introduced species. _____21. *S. viminalis.*
28. Leaves mostly glabrescent, sericeous when immature or after insect damage.
29. Leaves green beneath, linear, margin remotely denticulate. _____9. *S. interior.*
29. Leaves glaucous beneath, sometimes drying black, linear-lanceolate, margin serrate to subentire. _____17. *S. petiolaris.*
27. Leaves lanceolate or broader.
30. Leaf margin entire, crenate or sometimes irregularly serrate.
31. Leaves sometimes bearing ferruginous trichomes, L/W 3–5, apex acute to acuminate, bright green or gray green above; aments precocious.
32. Margin revolute, leaves gray-green above, pubescence beneath persistent, often drying black. ___19. *S. humilis.*
32. Margin not revolute, leaves bright green above, usually glabrate in age; immature leaves commonly bearing ferruginous trichomes. _____20. *S. discolor.*

31. Leaves lacking ferruginous trichomes, rugose beneath, L/W 2–3.8, apex abruptly acute, leaves dull green above; aments coetaneous. _____15. *S. bebbiana.*
30. Leaf margin definitely and uniformly serrate.
33. Leaves green on both sides; stipules prominent.
34. Leaves oblong-lanceolate, apex acuminate to attenuate, base rounded to acute, becoming glabrescent, midrib often remaining velutinous. _____10. *S. rigida.*
34. Leaves oblong-ovate, apex acute or short acuminate, base cordate or rounded, densely sericeous. _____11. *S. syrticola.*
33. Leaves glaucous beneath; stipules small or lacking.
35. Introduced trees; leaves sericeous, especially beneath. _____8. *S. alba.*
35. Indigenous shrubs; leaves finely sericeous to glabrescent beneath.
36. Leaves finely sericeous beneath. _____18. *S. sericea.*
36. Leaves usually glabrescent, if sericeous the trichomes are longer and less regularly distributed than in the above species. _____17. *S. petiolaris.*

TAXONOMIC TREATMENT

SALIX L. Sp. Pl. 1051. 1753.

Creeping alpine shrubs, erect shrubs or trees. Buds with a single outer bud scale fused into a cap or with overlapping margins. Leaves alternate, simple, and usually stipulate. Flowers unisexual, borne in spikelike aments, dioecious. The aments sessile on branches of the previous year or borne on short vegetative shoots (reproductive branchlets) on these branches. Each flower subtended by a bract (scale) and one to several glands (nectaries). The staminate flowers contain 1-several stamens, usually two. The pistillate flowers contain a single pedicellate (stipitate), bicarpellate, unilocular pistil, with 2 stigmas. The fruit a bivalved capsule releasing seeds surrounded by an apillate coma.

THE SPECIES OF SALIX IN WISCONSIN

1. S. nigra
2. S. amygdaloides
3. S. lucida
4. S. serissima
5. S. pentandra
6. S. babylonica
7. S. fragilis
8. S. alba
9. S. interior
10. S. rigida
11. S. syrticola
12. S. glaucophylloides
13. S. pyrifolia
14. S. candida
15. S. bebbiana
16. S. pedicellaris
17. S. petiolaris
18. S. sericea
19. S. humilis
20. S. discolor
21. S. viminalis
22. S. purpurea

Sect. NIGRAE Loudon

1. SALIX NIGRA Marsh. Arbust. Am. 139. 1785.
Black Willow — Map 1, Fig. 2.

Shrubs or trees 3–20 m tall, often with several boles; branchlets brownish to sometimes yellowish, slender, often pubescent and becoming puberulent or glabrate, brittle at base. Leaf blade linear to linear-lanceolate, often falcate, 5–10.5 cm long, 0.8–1.5 cm wide, length/width 5.5–12, apex attenuate to a narrow tip, base acute to rounded, margin serrulate, immature leaves often densely pubescent, sometimes glabrous, mature leaves glabrescent or glabrous, dark green on both sides, puberulent on midrib beneath; petiole pubescent to puberulent, 3–8 mm long, glandular at distal end; stipules prominent, up to 10 mm long, glandular and subpersistent. Aments coetaneous, borne on reproductive branchlets. Staminate aments slender 3.5–10 cm long; reproductive branchlets 1–2 cm long; stamens 3–6, filaments pilose near base, distinct; bracts obovate, pale yellow, pubescent, not deciduous in staminate inflorescence; glands 2 to several surrounding filaments; flowers appear to be whorled along rachis. Pistillate aments loosely flowered, 4–6 cm long, slender; reproductive branchlets 1–3.5 cm long; capsules ovoid, glabrous, 3–4 mm long, often deciduous after dehiscence; styles and stigmas short; pedicel 0.5–0.75 mm long; bracts oblong, pale yellow, 2–3 mm long, pubescent, deciduous after anthesis; glands adaxial, about 0.25 mm long. Based on 14 staminate, 29 pistillate, and 48 vegetative specimens.

Salix nigra is a very important component of the southern lowland forests where it may occupy pioneer sites along sand bars, mud flats, and other areas of disturbance in association with *Populus deltoides* (Curtis, 1959). It has been collected in bottomland woods

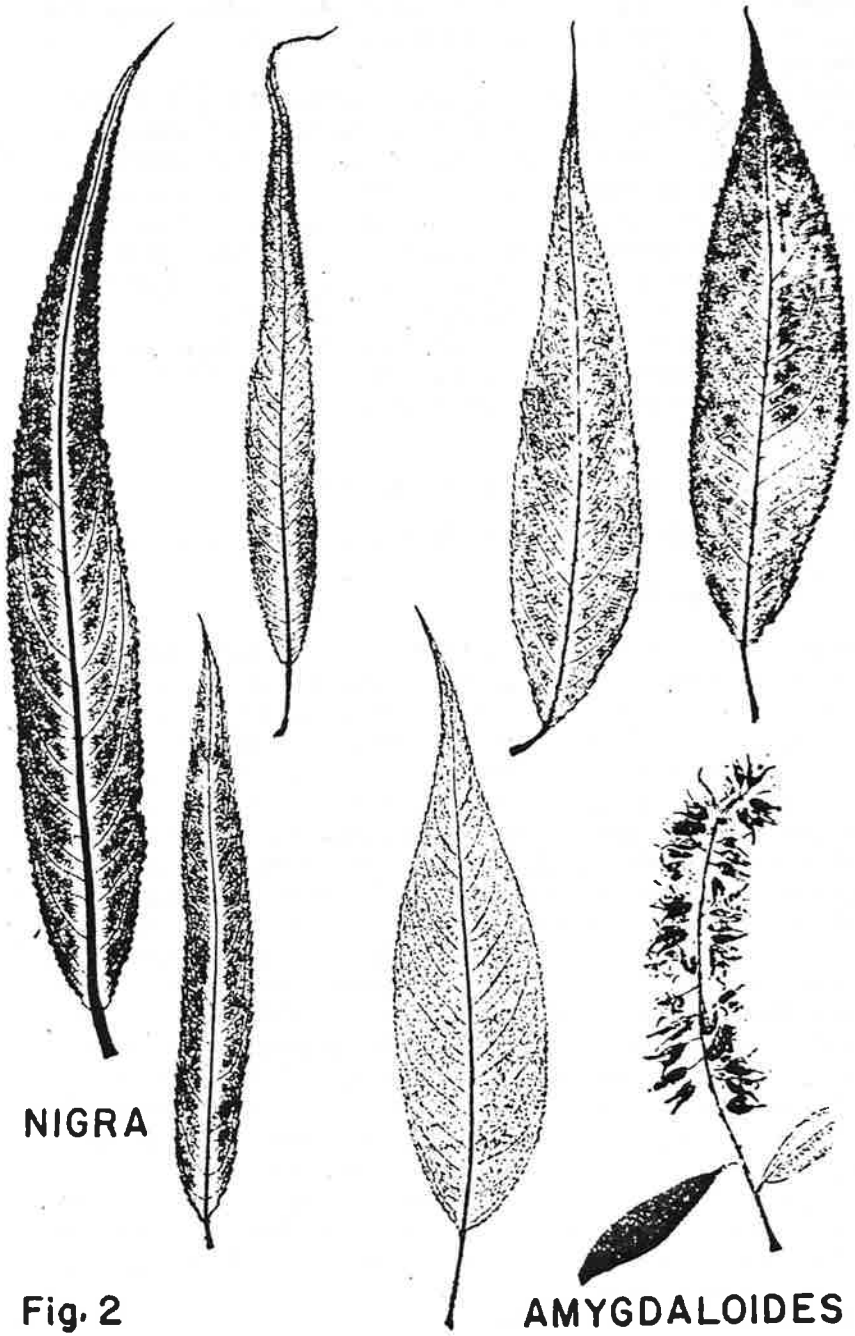


Fig. 2

FIGURE 2. Leaves of *S. nigra* and *S. amygdaloides*. Pistillate anent of *S. amygdaloides* in fruit.

associated with *Quercus bicolor, Fraxinus, Acer saccharinum,* and *Betula nigra,* in wet mixed savanna, sedge meadows, and in the northern hardwoods.

Sterile specimens of *Salix nigra* are often difficult to distinguish from *S. rigida.* Characteristics which are sometimes diagnostic include: leaves green on both sides in *S. nigra* vs. leaves mostly glaucous beneath in *S. rigida*; leaves narrower, more attenuate, and often falcate in *S. nigra* vs. broader and less attenuate in *S. rigida;* petiole glandular at the apex in *S. nigra* vs. petiole not glandular in *S. rigida*; and trees in *S. nigra* vs. shrubs in *S. rigida.* Some of these characteristics such as leaf glaucescence and shape are subject to wide variation and are not always definitive in themselves.

The floral morphology of *Salix nigra* is very similar to that in *S. amygdaloides*; see discussion under that species.

Sect. AMYGDALOIDES Kimura

2. SALIX AMYGDALOIDES Anderss. Öfvers. Vet-akad. Förh. 15:114. 1858.

Peach-leaved Willow — Map 2, Fig. 2.

Shrubs or trees 3–20 m tall, often with several boles; branchlets yellow or brownish, slender, glabrous, and tenacious. Leaf blade lanceolate to ovate-lanceolate, 8–11 cm long, 0.8–1.6 cm wide, length/width 4.2–5.7, apex attenuate, base acute or sometimes obtuse, margin serrulate, immature leaves mostly glabrous, sometimes puberulent and becoming glabrescent, reddish, mature leaves dark green and glabrous above, glaucous and glabrous beneath; petiole 10–16 mm long, yellow, glabrous, sometimes with small glands at distal end; stipules none or minute, rarely up to 1 cm long on vigorous shoots. Aments coetaneous, borne on reproductive branchets. Staminate aments slender, 3–6.5 cm long, sometimes pendulous; reproductive branchlets 1–3 cm long; stamens 3–5, filaments pilose at base, distinct; bracts pale yellow, glabrate abaxially, pubescent adaxially (inner side), not deciduous in staminate inflorescence; glands 2; flowers appear to be whorled along axis. Pistillate aments loosely flowered and often lax, 4.5–8 cm long; reproductive branchlets 1.5–3 cm long; pistils and capsules glabrous, ovoid, short beaked, 3–4 mm long; styles less than 0.5 mm long; stigmas short; pedicels 1.5–2.5 mm long, slender; bracts oblong, pale yellow, glabrescent at outer tip, pubescent at base and adaxially, deciduous after anthesis; glands adaxial, reddish. Based on 19 staminate, 26 pistillate, and 18 vegetative specimens.

Salix amygdaloides occurs along the edges of rivers, in alluvial woods, and margins of swamps, lakes, and streams. It is relatively important in wet southern lowland forests and is absent from the white pine-hemlock northern hardwoods.

This species is closely related to *Salix nigra* and, although *S. amygdaloides* does have longer more slender pedicels and generally longer aments, they are virtually identical in their floral morphology. Fortunately they are distinctive vegetatively (Fig. 2) and leaves are present even on early flowering specimens. The leaves of *S. amygdaloides* are broader, glaucous beneath, and rarely as pubescent, when young, as the narrowly lanceolate, non-glaucous leaves of *S. nigra.* Stipules, which are prominent in *S. nigra,* are very small or absent in *S. amygdaloides.* See *S. nigra.*

Sect. PENTANDRAE Dumortier

3. SALIX LUCIDA Muhl. Neue Schr. Ges. Naturf. Fr. Berlin 4:139. 1803.

Shining Willow — Map 3, Figs. 3 and 4.

Shrubs or small trees 4–6 m tall; branchlets reddish brown or yellowish, glabrous and highly glossy, immature branchlets sometimes pubescent (remaining so in var. *intonsa*). Leaf blade lanceolate, broadly lanceolate to sometimes elliptic-ovate, 4–14 cm long (excluding apex), 1.4–3.3(–4.5) cm wide, length/width (excluding apex) (1.8–)2.2–3.5(–4.7), apex long-attenuate 2–4.9 cm long on later leaves, acute to acuminate on earlier leaves, base acute to rounded, margin serrate, teeth with large glands at the tip, immature leaves reddish, glabrous or with caducous, ferruginous and colorless trichomes (sometimes persistent in var. *intonsa*) mature leaves glabrous and dark green above (except in var. *intonsa*) and glabrous or pale beneath; petiole 5–13 mm long, glabrous or pubescent on adaxial side, glandular at distal end; stipules reniform to semicircular, 1–6 mm long, margin glandular. Aments coetaneous, borne on reproductive branchlets. Staminate aments 1.7–4 cm long; reproductive branchlets 1–2.5 cm long, often pubescent; stamens 3–6, filaments pilose near the base, distinct; bracts oblong 2–3 mm long, pale yellow, pubescent on both sides or becoming glabrate at abaxial side of apex, not deciduous in staminate inflorescence; glands 2, more or less cuplike. Pistillate aments 1.8–2.5–5 cm long; reproductive branchlets 1.3–2.5 cm long; pistils greenish or brown, glabrous, capsules light brown, 5–7 mm long, dehiscent between 7 June and 10 July, often deciduous after dehiscence; styles 0.5–0.75 mm long; stigmas short; pedicels 0.5–1–1.5 mm long; bracts oblong-oblanceolate, 1.5–3 mm long, pale yellow, pubescent both sides or glabrate toward abaxial side of apex, deciduous after anthesis; glands small, less than 0.25 mm long, somewhat cuplike, lobed

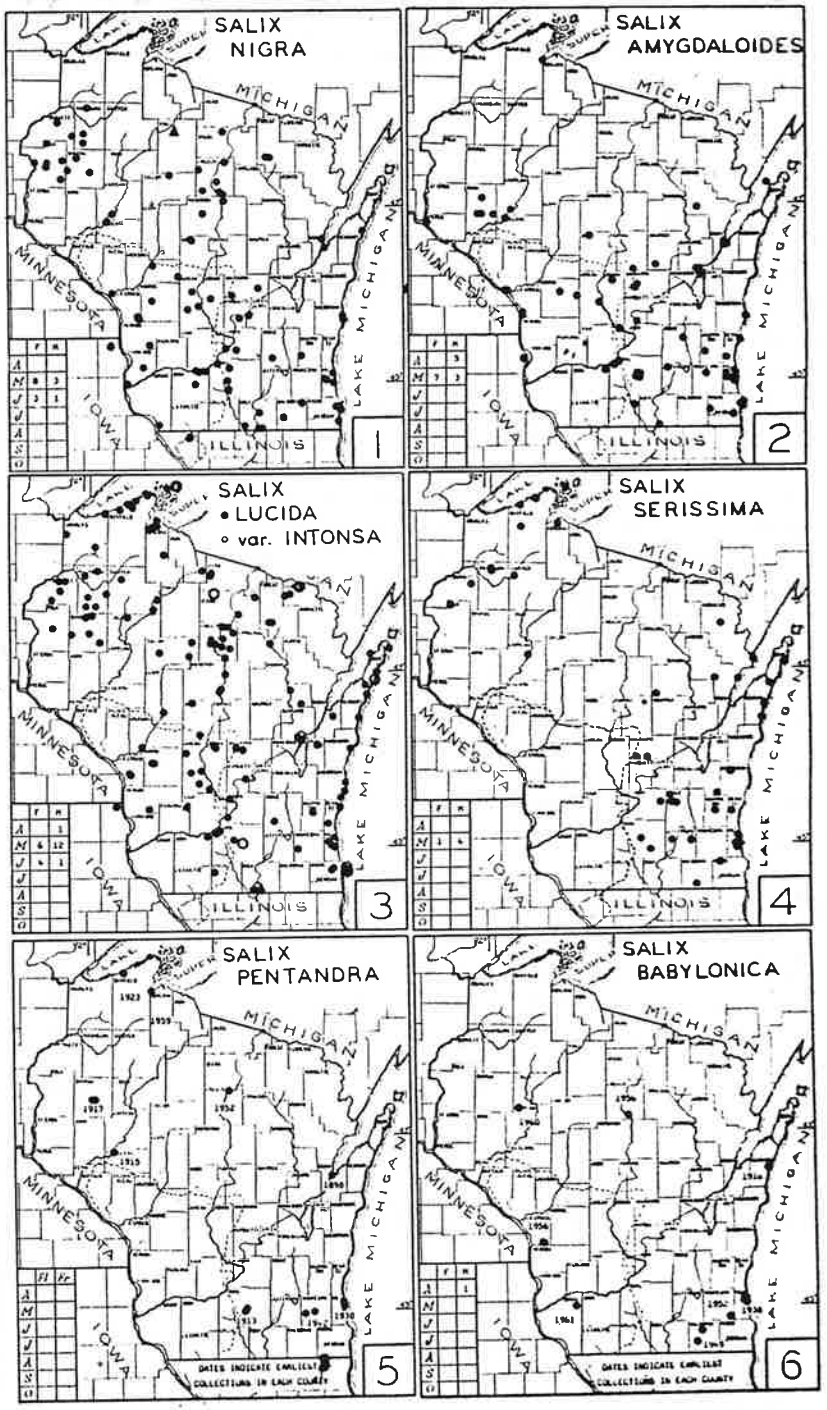
adaxially and abaxially. $2n = 76$ (Darlington and Wylie, 1955). Based on 39 staminate, 38 pistillate, and 59 vegetative specimens.

Salix lucida commonly occurs in wet situations including swamps, low wet meadows, spruce bogs, mudflats along lake edges, lake dunes, and river banks. It may also occur along roadsides.

A group of closely related species in Wisconsin includes *Salix lucida*, an eastern American element, *S. serissima*, a western American element (Raup, 1959), and *S. pentandra*, an introduced European species. *Salix lucida* and *S. serissima*, although distinct species, have often been confused. The confusion seems to stem from the lack of a clear understanding of the characteristics ordinarily used to distinguish them, i.e. leaf glaucescence and leaf shape. In reference to leaf glaucescence *S. lucida* is usually considered to have leaves non-glaucous beneath, but sometimes pale, and *S. serissima* to have leaves glaucous beneath. It is difficult to apply this criterion to herbarium specimens for although the leaves of *S. serissima* are glaucous beneath in life, the glaucescence is very thin and is rapidly lost in drying. Only about 2% of the Wisconsin herbarium specimens examined retained this waxy bloom. For purposes of herbarium identification it is desirable to describe the leaves of *S. serissima* as whitish or subglaucous beneath and those of *S. lucida* as pale green beneath. With this refinement of the definition the characteristic becomes more useful.

The use of leaf shape places primary emphasis on the apex, for the shape of the body of the blade is only quantitatively different (Fig. 4) and for diagnostic purposes is essentially the same in both species (Fig. 3). *Salix lucida* has a long-attenuate apex in contrast to the acute or acuminate apex of *S. serissima*. However, there is not only intergradation in apex length between species but even in the same individual. On a single branchlet of *S. lucida* the lowermost (proximal) leaves have acute apices, the next higher acuminate, and only the distal leaves have the characteristic long-attenuate apex of the species (Fig. 3). This characteristic is useful as a diagnostic feature if intra-individual variation and intergradation are kept in mind.

Fernald (1950) reports hybridization between *Salix lucida* and *S. serissima* in northeastern United States and Canada. I have been unable to recognize this hybrid in the Wisconsin flora. The reason for this may be sought in the possible ecological or seasonal isolation of these species in Wisconsin. The taxa are at least partially isolated ecologically, with *S. lucida* occurring mainly on the margins of meadows, lakes, and streams, and *S. serissima* occurring in marshes and bogs. They may also be isolated seasonally but the available phenological data are still inconclusive. *Salix serissima*



does shed its seeds later than *S. lucida* but they both seem to flower at about the same time.

The species in question are distinct and may be distinguished on the basis of the following characteristics (Figs. 3 and 4).

SALIX LUCIDA: Stipules 1–6 mm long, always with prominent glands on the margin. Immature leaves and branchlets usually bearing caducous ferruginous trichomes. Leaf apex usually long-attenuate. Pistillate aments narrow. Capsules 5–7 mm long and dehiscing between 7 June and 10 July.

SALIX SERISSIMA: Stipules minute, 1 mm long or less, or absent. Immature leaves and branchlets always glabrous. Leaf apex acute to attenuate. Pistillate aments broad. Capsules 7–10 mm long and dehiscing between 9 July and 23 August.

SALIX PENTANDRA combines some of the characteristics of each of the native species. It has narrow (but usually longer) pistillate aments and short capsules as in *S. lucida* and it is often exstipulate with the glabrous, acute to acuminate leaves characteristic of *S. serissima*. It rarely occurs as an escape in Wisconsin and is unlikely to be confused with either of the native species.

A variant of *Salix lucida* which has been recognized in this study is *S. lucida* var. *intonsa* Fern. (Rhodora 6:2. 1904). It is characterized by persistently hispid-pubescent branchlets and the persistence of pubescence on mature leaves. This variety is very common eastward, especially in northern New England and the Gulf of St. Lawrence region. Because of its possible geographic significance, I have recognized it in the Wisconsin flora.

4. SALIX SERISSIMA Fern. Rhodora 6:6. 1904.
Autumn Willow — Map 4, Figs. 3 and 4.

Shrubs 1–4 m tall; branchlets yellowish to reddish brown, glabrous, highly glossy. Leaf blade broadly or narrowly lanceolate to elliptic-lanceolate, 5.4–9.5(–11.2) cm long (excluding apex), 0.9–2.5 cm wide, length/width (excluding apex) (2.7–3–)3.5–5(–6), apex acuminate on later leaves, base acute to obtuse, margin glandular serrulate, immature leaves glabrous, reddish, mature leaves dark green above, thinly glaucous beneath becoming whitish or subglaucous, subcoriaceous; petiole 4–10 mm long, glandular at distal end; stipules minute, often reduced to a single gland or absent. Aments coetaneous or subserotinous, borne on reproductive branchlets. Staminate aments 3–3.5 cm long; reproductive branchlets 1.5–3.5 cm long; stamens 4–7, filaments pilose below middle, distinct; bracts pale yellow, oblong, 2–3 mm long, pubescent, not deciduous in staminate inflorescence; glands 2. Pistillate aments 2–4.5 cm long; reproductive branchlets 1.7–5 cm long; ovaries reddish, glab-

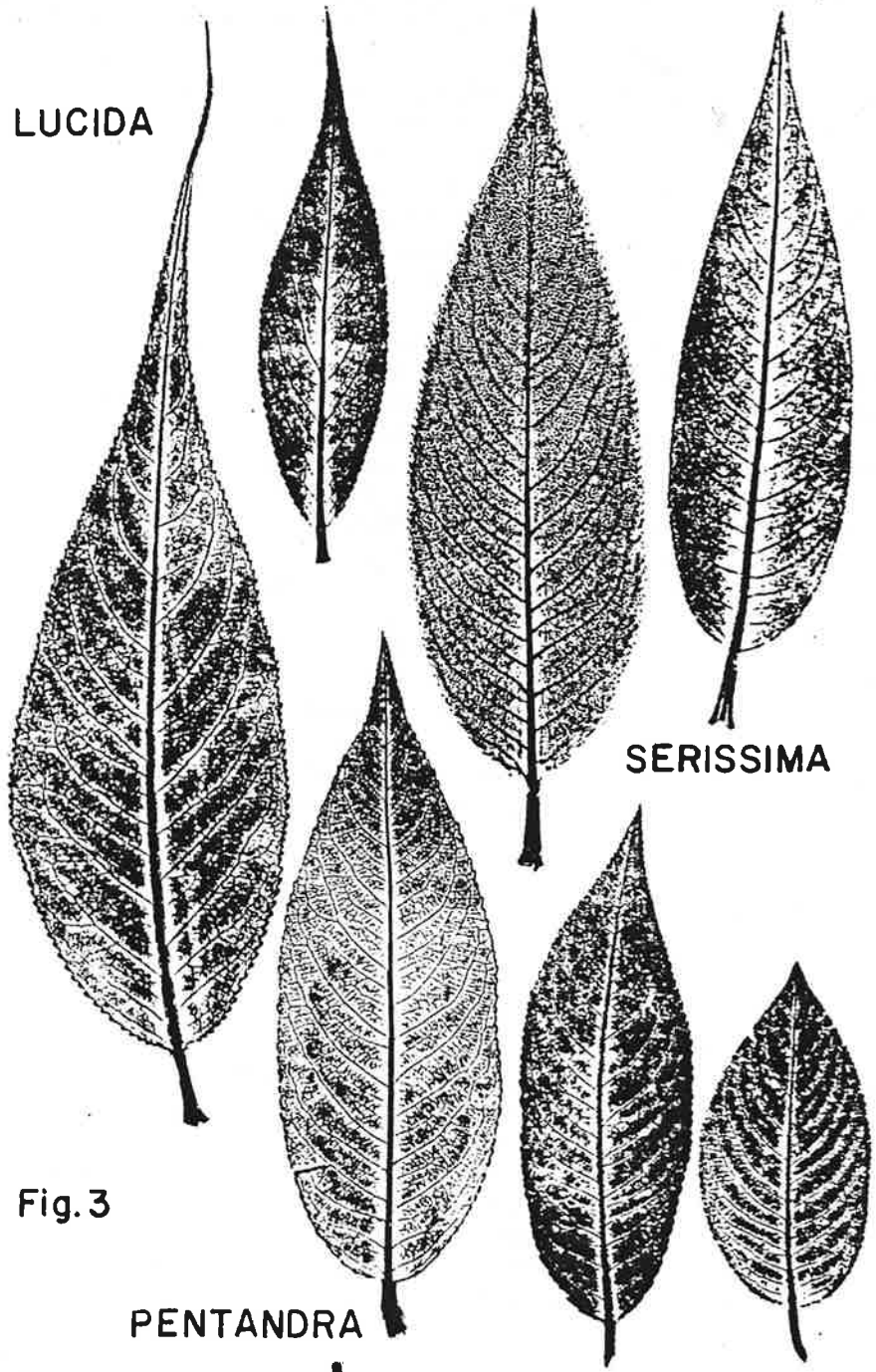


Fig. 3

FIGURE 3. Leaves of *S. lucida*, *S.. serissima*, and *S. pentandra*.

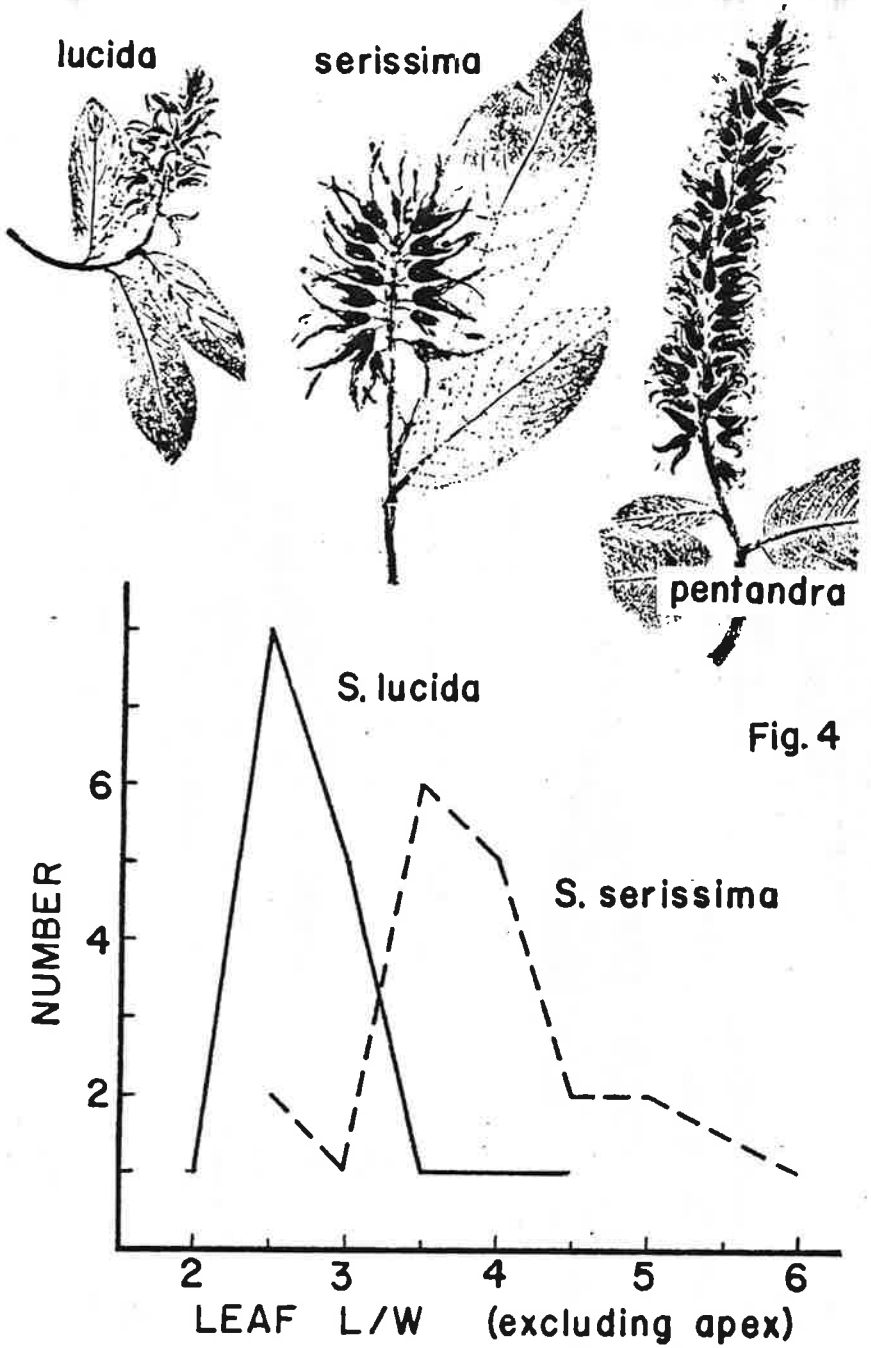


Fig. 4

FIGURE 4. (Top) Pistillate eaments of *S. lucida*, *S. serissima* and *S. pentandra* in fruit. (Bottom) A comparison of the shape of the leaf blades (length-width ratio, excluding apex) of *S. lucida* and *S. serissima*.

rous, capsules light brown, 7–10 mm long, dehiscent between 9 July and 23 August, deciduous after dehiscence; styles up to 1 mm long; stigmas short; pedicels 0.75–2 mm long; bracts as in staminate but deciduous after anthesis; glands adaxial, about half as long as pedicel. Based on 7 staminate, 28 pistillate, and 13 vegetative specimens.

Salix serissima is a shrub of marshes and bogs. It has been collected from *Chamaedaphne calyculata-Sphagnum* bogs, *Larix* bogs, lake shores, and in willow scrub along creek margins and roadsides.

For discussion of *Salix serissima* and related species, see *S. lucida*.

5. SALIX PENTANDRA L. Sp. Pl. 1016. 1753.
Bay-leaved Willow — Map 5, Figs. 3 and 4.

Introduced shrubs or small trees up to 7 m tall; branchlets brown to reddish brown, glabrous and glossy, immature ones drying blackish. Leaf blade broadly lanceolate to elliptic-oblong, (3.5–)7–8.5(–11) cm long (excluding apex), (1.5–)2.5–3(–4.3) cm wide, length/width (excluding apex) 2.3–2.9, apex acuminate on later leaves, 7–12 mm long, base rounded, margin glandular-serrulate, immature leaves reddish, glabrous, mature leaves dark green above, green or pale beneath, coriaceous; petiole 4–10 mm long, glandular at distal end; stipules minute, up to 2–4 mm long in some specimens, deciduous. Aments coetaneous, borne on reproductive branchlets. Staminate aments 2–6 cm long; stamens 5, filaments pilose below middle, distinct. Pistillate aments 3. 5–6 cm long; reproductive branchlets 1.5–4 cm long; capsules 5–6 cm long, glabrous, dehiscent between 20 June and 6 Sept.; styles about 1 mm long; stigmas short; pedicels 0.5–1 mm long; bracts pale yellow. oblong, 2–3 mm long, glabrate adaxially and pubescent at base abaxially, deciduous after anthesis; glands cuplike with lobes adaxially and abaxially, sometimes laterally, about half as long as the pedicel. $2n = 76$ (Darlington and Wylie, 1955). Based on 15 pistillate specimens and the literature.

Salix pentandra is a species introduced from Europe and is cultivated in Wisconsin. It rarely occurs as an escape.

See *Salix lucida* for a discussion of related species.

Sect. FRAGILES W. D. J. Koch

6. SALIX BABYLONICA L. Sp. Pl. 1017. 1753.
Weeping Willow — Map 6, Fig. 5.

Introduced trees up to 12 m tall; branchlets slender, pendulous (in our area), yellowish to brown, glabrous. Leaf blade linear-lanceolate, 8–12 cm long, 0.5–1.5 cm wide, base acute, apex long-

acuminate, margin serrulate, immature leaves sericeous, mature leaves glabrate, yellowish-green above, glaucous beneath; petiole with glands at distal end; stipules lanceolate, 2–7 mm long, or mostly wanting. Aments coetaneous, borne on reproductive branchlets. Staminate aments up to 4 cm long, slender; reproductive branchlets 0.5–1.5 cm long; stamens 2, occasionally 3–5 or more, filaments distinct, pubescent at base; bracts (in both sexes) pale yellow, pubescent, caducous. Pistillate aments 2–3.5 cm long, slender; reproductive branchlets present; capsules narrowly ovoid, 1–2 mm long, glabrous, nearly sessile; styles about 0.5 mm long; stigmas short; glands adaxial. $2n = 76$ (Darlington and Wylie, 1955). Based on 1 staminate, 3 pistillate, 6 vegetative specimens, and the literature.

Salix babylonica is a widely cultivated tree native to Asia and apparently introduced to North America from Europe. It escapes sparingly in Wisconsin and then may occur along roadsides and river banks.

7. SALIX FRAGILIS L. Sp. Pl. 1017. 1753.
Crack Willow Map 7, Fig. 5.

Introduced trees up to 20–30 m tall; branchlets slender, yellowish to brown, glabrous to pubescent, very brittle at the base. Leaf blade lanceolate to oblong-lanceolate, 9–14(–16) cm long, 1.5–2.2(–3) cm wide, apex long-acuminate, base acute, margin coarsely serrate (4–5 serrations per 1 cm), glabrous above, glaucous or glaucescent and glabrous beneath; petiole 8–10(–18) mm long with prominent stalked glands at the distal end; stipules small, caducous. Aments coetaneous, borne on reproductive branchlets. Staminate aments 3–6 cm long, slender; stamens 2, occasionally 3–4, filaments pubescent at the base, distinct; bracts (in both sexes) pale yellow, sparsely pubescent, caducous; glands 2. Pistillate aments 5–7 cm long; reproductive branchlets 1.5–2.5 cm long; capsules narrowly conic, 4–5 mm long, glabrous; styles 0.5–1 mm long; stigmas short; pedicels about twice as long as the adaxial gland; glands 2, the abaxial small and inconspicuous. $2n = 76, 114$ (Darlington and Wylie, 1955). Based on 8 staminate, 29 pistillate, and 20 vegetative specimens.

Salix fragilis is a cultivated tree introduced to North America from Europe. It frequently escapes from cultivation and then may occur in low areas along the edges of rivers and lakes, and along roadsides.

In the keys I have used the characteristic pendulous branches of *Salix babylonica* to distinguish it from *S. fragilis*. However, this character is not invariable. I have seen collections of *S. fragilis*

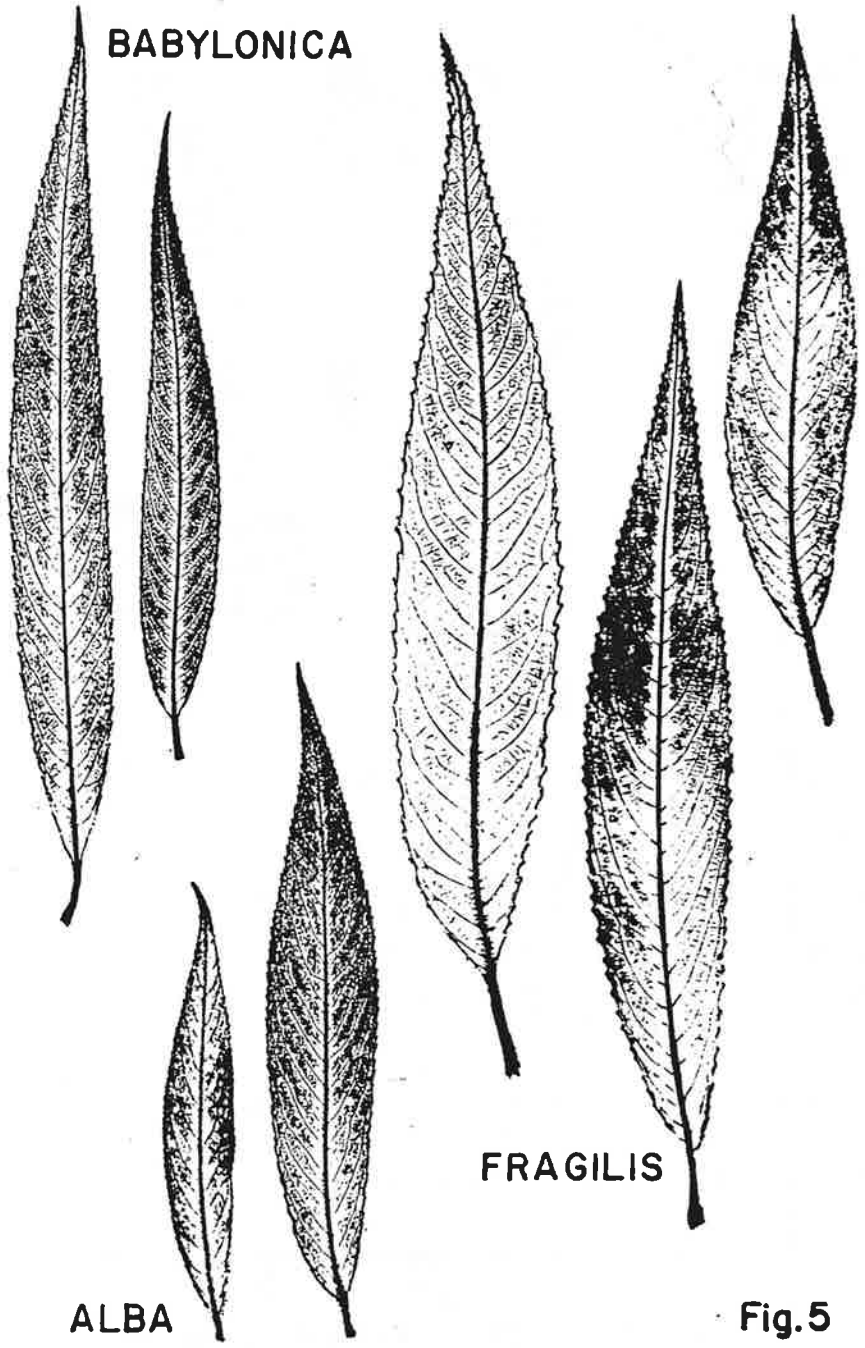


FIGURE 5. Leaves of *S. babylonica*, *S. fragilis*, and *S. alba*.

cultivated in Illinois with pendulous branches. Furthermore, Otto von Seemen in his "Mitteleuropäische Wieden" (1911) describes the branches of *S. fragilis* as often long, thin, and pendent. The Illinois specimens of *S. fragilis* were collected by Professor G. N. Jones and I am grateful to him for calling them to my attention.

This species is sometimes difficult to distinguish from *Salix alba*, but its leaves are more coarsely serrate and glabrous, or only sparsely pubescent at maturity. The hybrid *S. alba* × *S. fragilis* is recognized in Wisconsin (see *S. alba*).

Sect. ALBAE Borrer

8. SALIX ALBA L. Sp. Pl. 1021. 1753.
White Willow — Map 8, Fig. 5.

Introduced trees up to 20 m tall; branchlets greenish or yellowish brown, pubescent, not brittle. Leaf blade lanceolate to narrowly lanceolate, 4–8(–10) cm long, 1–2.5 cm wide, margin serrulate (about 9 serrations per 1 cm), immature leaves white-sericeous, mature leaves sericeous (especially beneath), glaucous beneath; petiole glandular at distal end; stipules small and deciduous. Aments coetaneous, borne or reproductive branchlets. Staminate aments 3–3.5 cm long; reproductive branchlets about 1 cm long; stamens 2, occasionally 3, filaments distinct, pubescent at base; bracts (in both sexes) pale yellow, sparsely pubescent and caducous. Pistillate aments 4–6 cm long; reproductive branchlets 1.5–2 cm long; capsules ovoid-conic, 3–4.5 mm long, glabrous, sessile or subsessile; styles small; stigmas minute; gland adaxial. $2n = 76$ (Darlington and Wylie, 1955). Based on 4 staminate, 12 pistillate, 5 vegetative specimens, and the literature.

Salix alba is an introduced tree which is occasionally found as an escape along rivers, especially in southeastern Wisconsin.

Hybrids between *Salix alba* and *S. fragilis* seem to be relatively common in Wisconsin and seven specimens representing this putative hybrid have been segregated out of the material studied. The difficulty encountered in distinguishing between *S. alba* and *S. fragilis* may be due in part to this hybridization; but our inadequate representation of these European taxa, and the frequent introduction of "unusual specimens" (sports, hybrids, etc.) contributes to the difficulties.

Specimens with sericeous, finely serrate leaves and sessile to subsessile capsules have been named *Salix alba*. Those with glabrous or sparsely pubescent, coarsely serrate leaves and capsules on distinct pedicels have been named *S. fragilis* (Fig. 5). There are numerous intermediate specimens in Wisconsin some of which have received

varietal names. For our purposes it seems best not to attempt to distinguish any of these proposed varietal names but rather to consider *S. alba* in a broad sense.

Sect. LONGIFOLIAE Andersson

9. SALIX INTERIOR Rowlee, Bull. Torrey Bot. Club 27:253. 1900.
Sand Bar Willow — Map 9, Fig. 6

S. longifolia Muhl.
S. interior var. *pedicellata* (Anderss.) Ball.
S. interior f. *wheeleri* (Rowlee) Rouleau.

Shrubs 1.5–2(–5) m tall, colonial, shoots originating from roots; branches numerous, grayish; branchlets brown to reddish-brown, sericeous or thinly so, becoming glabrescent. Leaf blade linear to linear-lanceolate, up to 6.5–10.5 cm long, 0.5–0.9 cm wide, length/width 9.4–15, sometimes broader on vigorous shoots, apex and base acuminate, margin distantly denticulate with glandular, often prolonged teeth 5–10 per 2 cm, immature leaves sericeous, sometimes glabrate, mature leaves glabrescent, sometimes sparsely pubescent or densely sericeous, green on both sides; petiole 2–7 mm long; stipules absent or minute, or up to 3 mm long, caducous. Aments coetaneous, borne on reproductive branchlets. Staminate aments 2–3 cm long, lateral secondary aments present in 60% of Wisconsin specimens; reproductive branchlets 0.8–8 cm long; stamens 2, filaments pubescent on lower half, distinct; bracts yellow or yellow-green, curly pubescent, becoming glabrescent. Pistillate aments loosely flowered, 2–5.5 cm long, lateral secondary aments present in 22% of Wisconsin specimens; reproductive branchlets 3–6.5 (–12.5) cm long; pistils glabrescent, glabrous or thinly sericeous, green or reddish, capsules glabrescent-glabrous, slender, 4.5–7 mm long, deciduous after dehiscence; styles obsolete; stigmas short; pedicels 0.5–1 mm long; bracts oblong to linear, 3 mm long, yellowish (green when young), pubescent adaxially, glabrescent abaxially, deciduous after anthesis (in pistillate inflorescence only), rachis pubescent; gland adaxial, half as long as the pedicel. Based on 72 staminate, 81 pistillate, and 61 vegetative specimens.

Salix interior is a pioneer woody plant in primary succession (Lindsey, *et al.*, 1961). It occurs widely in sandy habitats including sandy lake and river margins, sand and gravel bars, the foot of sandstone cliffs, sand dunes, edges of cultivated fields, railroad rights-of-way, and along roadsides. Although it has been collected in bottomland woods and bogs, it seems to be most abundant in moist, sandy situations.

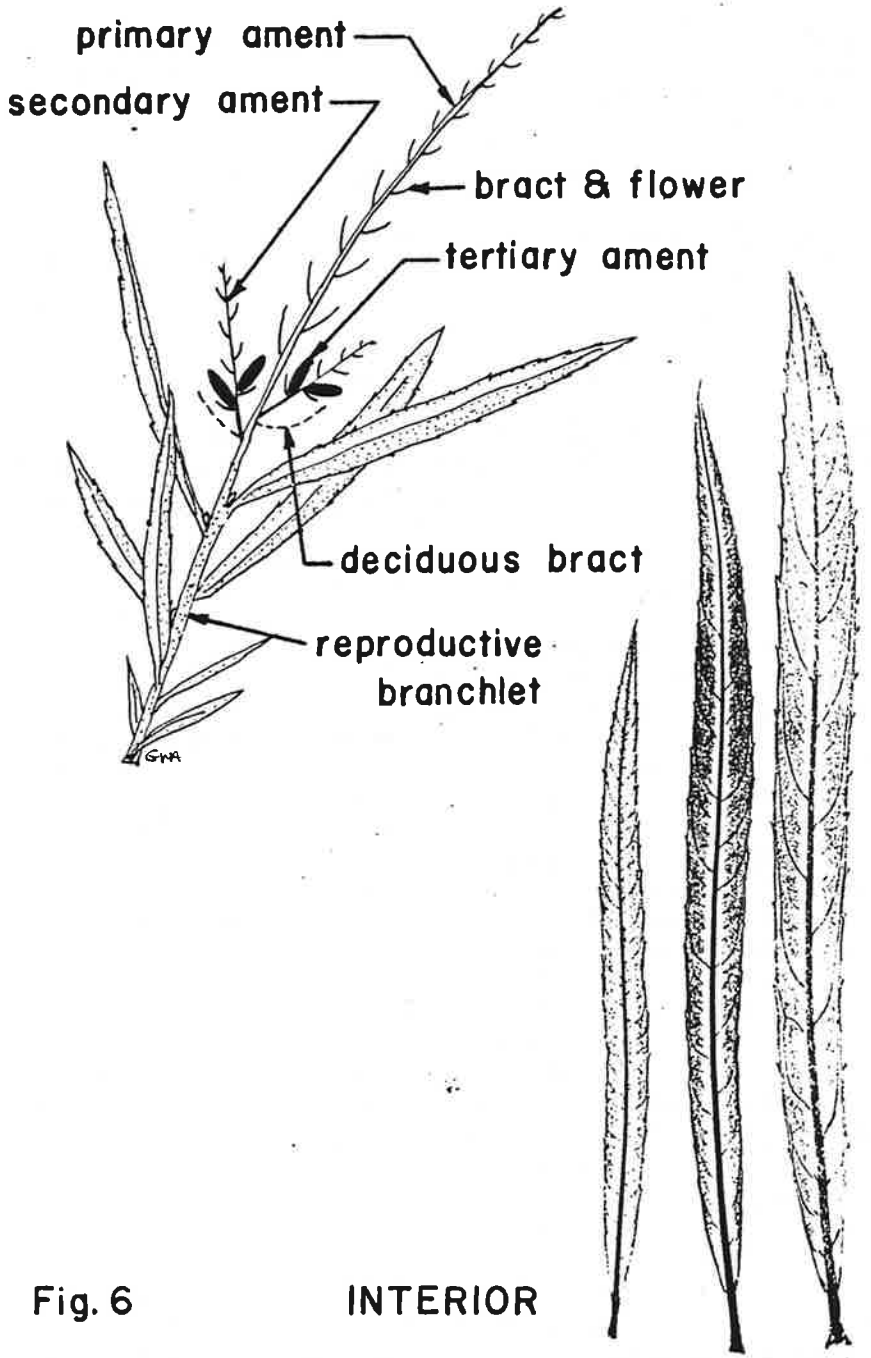
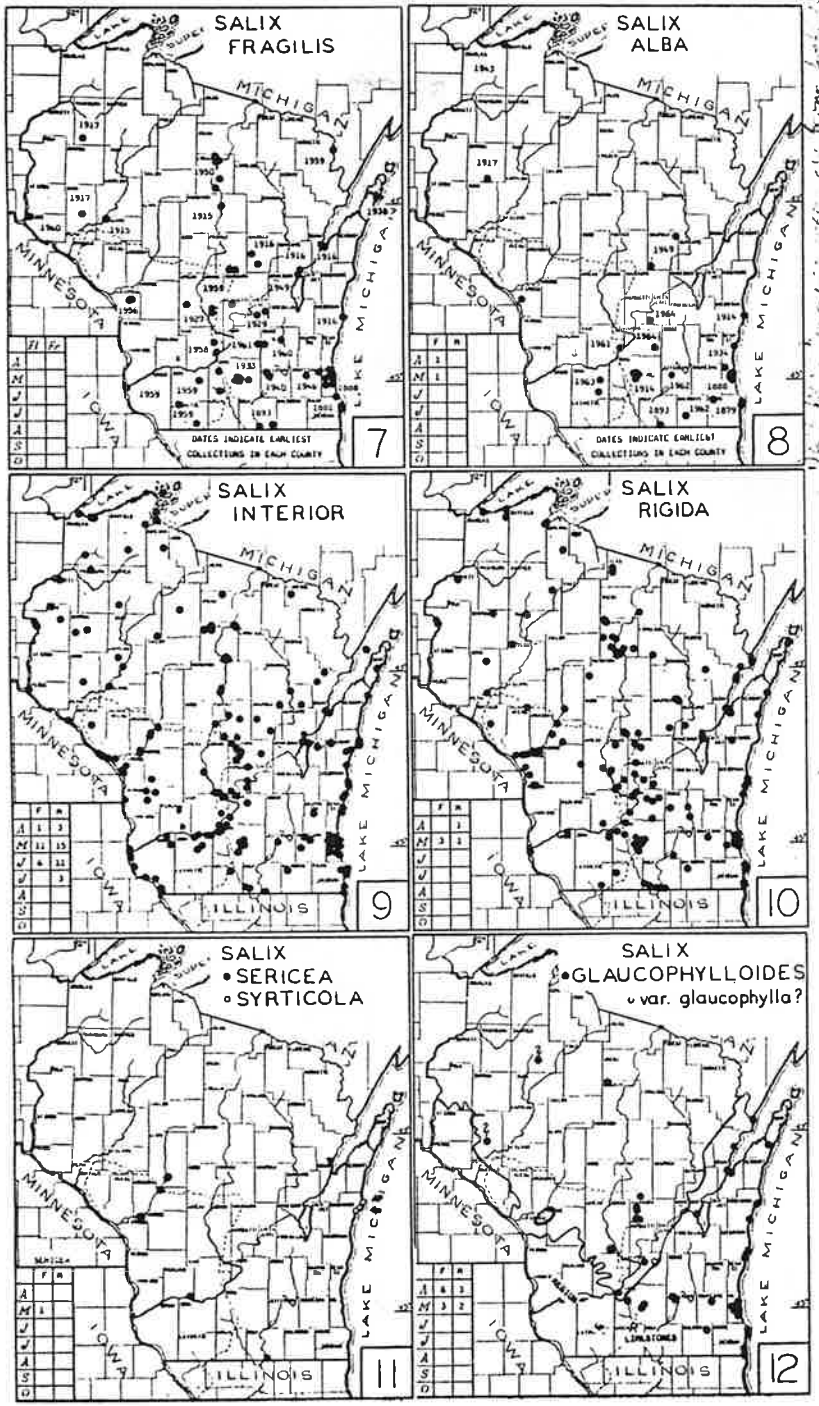


FIGURE 6. (Top) A generalized diagram of an ament (♂ or ♀) of *S. interior* illustrating the mode of branching (cf. text for discussion). (Bottom, right) Leaves of *S. interior*.

Vegetative propagation is highly developed in this species and large clones are commonly produced by vegetative shoots originating from roots and from prostrate branches. Although this mode of reproduction (vegetative buds originating on roots) has been suspected in other *Salix*, I have not seen it demonstrated for species outside of Section Longifoliae *(S. interior, S. exigua, et al.)*. Propagation is not wholly vegetative. I have seen several collections of seedlings from Wisconsin *(N. C. Fassett 12914, 12915*, shores of the Mississippi, near Dubuque and Potosi, 8 Sept. 1930 (WIS)). The leaves of seedlings of *S. interior*, including those cited, have an unusual lobed blade. This lobed leaf form has been reported by Lindsey, *et al.* (1961) in seedlings which assumed a rosette-form during their first year of growth in open exposed habitats, and I have collected similar seedlings from a sand bar on the South Saskatchewan River *(Argus 91–62*, Batoche, Sask.). It is probable that the lobed leaf is the juvenile leaf shape, however, it may also be related to the rosette habit produced under certain environmental conditions. This problem requires further study.

Two variants, one based on leaf width and the other on leaf pubescence, have been recognized by authors in Wisconsin. The first (var. *pedicellaris)* is thought to be characterized by leaves shorter and narrower (6 mm wide) than "typical". This is a highly variable characteristic even on a single plant. In some cases short, narrow leaves can be related to second growth during the same year. The second variant (forma *wheeleri)* is distinguished by its densely and permanently sericeous leaves. As has been noted by Costello (1935) and others, sericeous leaves are often related to insect attack; and in virtually no instance have I seen densely sericeous specimens of *Salix interior* which did not show some sign of insect damage, or in which the sericeous leaved shoots were not initiated during the year of their development (see *Salix bebbiana* for discussion of a similar situation). It is very doubtful whether either of these taxa merit formal taxonomic recognition.

The inflorescences of *Salix interior* are often branched, having one or more lateral secondary and even tertiary aments borne at the base of the primary ament (Fig. 6). Branched inflorescences are common in staminate individuals (occurring in 66% of Wisconsin specimens), and somewhat less common in pistillate individuals (occurring in about 22%). A superficial examination of the branching shows that a lateral (secondary) inflorescence is sometimes located in the axil of the first, second, or rarely the third bract near the base of the primary inflorescence. The secondary inflorescence(s) may have a tertiary inflorescence located in the axil of one of its lower bracts. The bract subtending the secondary inflorescence is usually deciduous soon after the secondary inflorescence



begins to elongate. Not uncommonly, one or two secondary inflorescences may reach anthesis, however, tertiary inflorescences have not been observed to reach this stage of development. A detailed anatomical study of branched aments in *Salix interior* would contribute important information concerning the nature of the *Salix* inflorescence and the relationship between the ament and the reproductive branchlet.

A situation which may be confused with the development of lateral inflorescences occurs when the bud in the axil of the distal leaf on a reproductive branchlet develops during the same year in which it was initiated. If this happens, two or more aments may be produced on a single reproductive branchlet. The second ament in this case can be distinguished from the above by noting that it is borne on its own reproductive branchlet. However, if buds on the reproductive branchlet develop during the year of their initiation they are usually vegetative.

Sect. CORDATAE Barratt

10. (SALIX RIGIDA Muhl.) Neue Schr. Ges. Nat. Fr. Berlin 4:236. 1803. *S. cordata* Muhl. Map 10, Fig. 7.

Shrubs 0.3–3 m tall, sometimes taller; branchlets reddish brown to yellow-green, glabrate, or often remaining velutinous for two years. Leaf blade oblong-lanceolate, 6–10.5 cm long, 1.2–2.1 cm wide, length/width 3.7–5–6.2, apex gradually acuminate or attenuate, base rounded to acute or rarely subcordate, margin serrulate, immature leaves reddish-purple, thin, densely white pubescent, mature leaves glabrate, midrib often remaining velutinous, green above and glabrate or finely pubescent, light green and becoming thinly glaucous beneath; petiole 8–17 mm long, velutinous on inner surface; stipules 5–9(–20) mm long, lanceolate to ovate semicordate, margin serrate; buds velutinous to glabrate, inner bud scale separating from the outer and often clinging to the base of the shoot. Aments coetaneous or subprecocious, borne on reproductive branchlets. Staminate aments 1.5–2.5 cm long; reproductive branchlets 2–5 mm long; stamens 2, filaments glabrous, coalescent at base; bracts tawny to dark brown, pilose, 1–1.5 mm long; gland adaxial. Pistillate aments 3–5 cm long; reproductive branchlets 3–13 mm long; ovaries slender, reddish or greenish and glabrous, capsules greenish becoming brown, 4–5 mm long; styles 0.5–0.75 mm long; stigmas small; pedicels 1–2 mm long, glabrous; bracts narrow, light brown to blackish, long pilose, about 2 mm long, apex reflexed in fruit; glands adaxial 0.2–0.5 mm long. Based on 14 staminate, 29 pistillate, and 48 vegetative specimens.

Salix rigida occurs in a variety of habitats from river banks, creek bottoms, and willow swamps to sedge flats, seepage bogs, *Acer rubrum* second growth woods, lake dunes, and waste places such as ditches and railroad rights-of-way.

The nomenclatural problems surrounding *Salix rigida* and the closely related *S. cordata* Michx. have been discussed by Fernald (1946). I am following his treatment in using the name *S. rigida* and in regarding *S. cordata* Muhl. as synonymous with it. The entire complex surrounding these species is confusing to me and is in need of a thorough study. However, *S. rigida* in Wisconsin seems to be a relatively homogeneous species and to represent a single taxon.

Species closely related to *Salix rigida* in Wisconsin include *S. syrticola* and *S. glaucophylloides*. *Salix rigida* can be distinguished from the very rare *S. syrticola* by immature leaves pubescent and reddish colored vs. densely sericeous and green, mature leaves oblong-lanceolate vs. oblong-ovate, leaf margins serrulate vs. glandular serrate, pistillate aments 3–5 cm long vs. 6–8 cm long, and capsules 4–5 mm long vs. 5–7 mm long. From *S. glaucophylloides* it may be distinguished as discussed under that species. Vegetatively *S. rigida* resembles *S. nigra;* see that species for distinguishing characteristics.

The pistillate aments of *Salix rigida* are very distinctive during flowering and early fruit. At this time the glabrous ovaries project beyond the bracts and contrast sharply with the long pilose bracts. The distinctive aspect is lost during the late fruiting stage as the apex of the bracts becomes reflexed and some of the bracts are abscissed.

11. SALIX SYRTICOLA Fern. Rhodora 9:225. 1907.
Sand Dune Willow — Map 11, Fig. 7.

Spreading shrubs 1–3 m tall; branchlets grayish tomentose, becoming glabrate. Leaf blade oblong-ovate, 3.5–9.5 cm long, 2–6 cm wide, apex acute or abruptly short acuminate, base cordate or broadly rounded, margin glandular serrate, teeth often prolonged, immature leaves densely sericeous, mature leaves pubescent or becoming glabrate, green on both sides; petiole 2–6(–10) mm long, pubescent; stipules prominent, 6–15 mm long, semicordate to subovate. Aments coetaneous, subsessile or borne on short reproductive branchlets. Staminate aments 2.5–4.5 cm long, subsessile and subtended by several bracts; stamens 2, filaments glabrous; bracts (in both sexes) oblong, pale brown, villous. Pistillate aments 6–8 cm long; reproductive branchlets about 10 mm long; capsules glabrous, 5–7 mm long; styles 0.7–1 mm long; stigmas small; pedicels

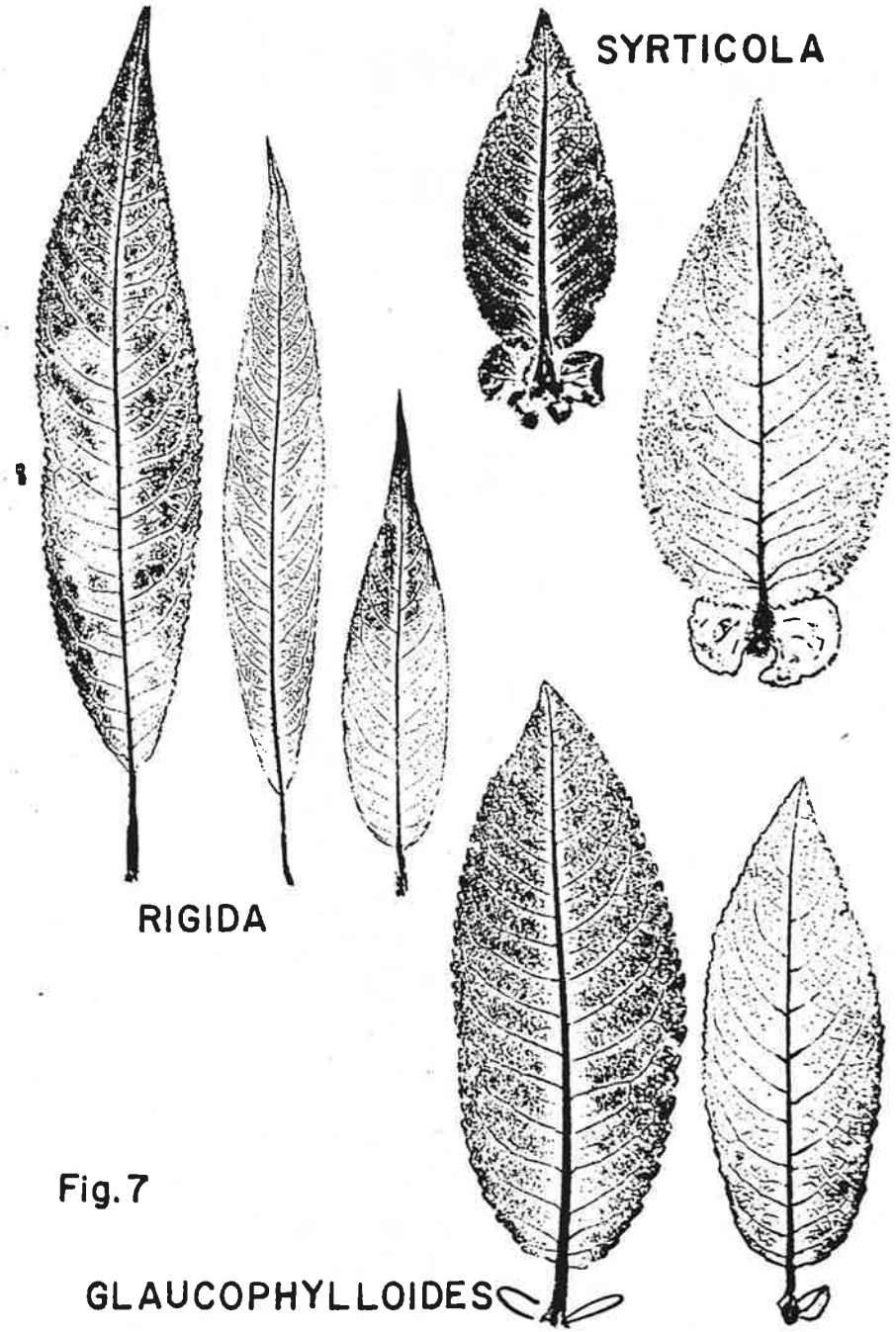


FIGURE 7. Leaves of *S. rigida*, *S. syrticola* (including stipules), *and S. glaucophylloides.*

0.5–1 mm long, glabrous; glands adaxial, small. Based on 1 staminate, 3 pistillate, 3 vegetative specimens, and the literature (especially Fernald, 1907, 1946, and 1950).

Salix syrticola apparently is a Great Lakes endemic occurring on sand dunes and beaches. It is known from only one locality in Wisconsin, namely Two Rivers, Manitowoc Co. I have also seen material from the southern end of Lake Michigan at Chicago, Illinois; the Indiana Dunes State Park and vicinity, Indiana; and New Buffalo, Michigan; and from Big Bay, Bruce Peninsula, Ontario.

In using this specific name I am following Fernald (1946) who regarded it as distinct from *Salix cordata* Michx. *(S. adenophylla)*. Whether or not the populations occurring on sand dunes in the Great Lakes region represent a species different from the closely related and wider ranging *S. cordata* Michx. is open to question. However, this problem cannot be resolved without considering the entire complex surrounding *S. rigida* and *S. cordata*. The determination of the true nature and relationships of *S. syrticola* awaits a thorough study of this complex (see *S. rigida)*.

12. SALIX GLAUCOPHYLLOIDES Fern. Rhodora 16:173. 1914.
Blue-leaved Willow Map 12. Fig. 7.

S. cordata var. *glaucophylla* Bebb.
S. glaucophylla (Bebb) Bebb.
S. glaucophylloides Fern. var. *glaucophylla* (Bebb) Schneider.

Shrubs 1–2.5 m tall; branchlets brown to yellowish, glabrous or gray pubescent, glossy. Leaf blade elliptic, broadly elliptic, oblong or obovate, 6.5–8.5–11.4 cm long, 2.4–3.5–4.6 cm wide, length/width 1.9–3 (–4.4), apex acute or abruptly short acuminate, base obtuse, rounded or rarely cordate, margin serrate or serrate-crenate, immature leaves often reddish, usually glabrous or with caducous ferruginous trichomes (the petiole and young branchlet may be white velutinous), mature leaves glabrate or with persistent pubescence on midrib, green above, strongly glaucous beneath with thick layer of wax, often drying black; petiole 4–10(–14) mm long, pubescent, dilated at base; stipules prominent, about 10 mm long, ovate, glandular toothed margin, glaucous beneath; buds glabrous or pubescent, inner bud scale sometimes clinging to the base of the branchlet. Aments coetaneous or subprecocious, subsessile or on short reproductive branchlets. Staminate aments 2–4 cm long, subsessile or reproductive branchlets 2–6 mm long; stamens 2, filaments glabrous, distinct or rarely coalescent at the base; bracts (in both sexes) dark brown to black, 1–2 mm long, densely villous. Pistillate aments loosely flowered in fruit, 3.5–6.5 cm long; reproductive branchlets 5–14 mm long; capsules glabrous 4.5–7 mm long; styles 1–1.25 mm long; stigmas small; pedicels 1.5–2.5 mm long; glands adaxial. Based on 17 staminate, 40 pistillate, and 35 vegetative specimens.

Salix glaucophylloides occurs on sand dunes, sandy flats, and in thickets along Lake Michigan. It is also known from wet prairies, stream banks, and along railroad rights-of-way.

This species has been considered by Raup (1959) to be the eastern segregate of a continuous population whose western segregate is named *Salix padophylla* Rydb. The approximate area of overlap between these two taxa, which may have been isolated during the Pleistocene glaciation in "eastern" and "western" refugia, is in northern Ontario with Wisconsin probably lying within or near the southern edge of the zone of overlap. If this interpretation is correct it may account for the description of the species in Wisconsin under the variety *glaucophylla,* a taxon somewhat intermediate between *S. padophylla* and *S. glaucophylloides*. A critical study of these two taxa and their relatives is required for an understanding of the problem.

A closely related species in Wisconsin is *Salix rigida* Muhl. From this species *S. glaucophylloides* is distinguished vegetatively by broader leaves, less acuminate at the apex, the margin serrate to crenate, not serrulate, and immature leaves less pubescent and becoming glabrescent earlier. The undersides of the leaves are coated with a thick layer of wax and the blade often dries black. Reproductively *S. glaucophylloides* is distinguished by more villous bracts, especially in the staminate inflorescence, generally longer pistillate inflorescence, and longer capsules and styles.

A small leaved form of the species (var. *brevifolia* (Bebb) Ball, Ohio Jour. Sci. 50:187. 1950) has been collected along the shores of Lake Michigan at Two Rivers and Oostburg (*J. J. Davis*, Two Rivers, Manitowoc Co., 25 July 1917 (WIS); *W. Finger*, Two Rivers, 18 Aug. 1902 (MIL); and *T. F. Grittinger*, Oostburg, Sheboygan Co. 6 July 1961 (WIS)). Although the leaves on these specimens are small (3.8–5.8 cm long and 1.6–2 cm wide) this feature seems to be of doubtful taxonomic importance. It should be observed in the field and its possible ecological significance studied.

Sect. BALSAMIFERAE Schneider

13. SALIX PYRIFOLIA Anderss. Sv. Vet-akad. Handl. 6:162. 1867.
Balsam Willow Map. 13, Fig. 8.

S. balsamifera Barratt ex Anderss.

Shrubs 3 m tall; reported to have a strong balsam-like fragrance; branchlets glabrous, shiny, dark reddish-brown, rarely greenish, drying black. Leaf blade lanceolate, narrowly ovate, ovate or broadly so, to oblong-lanceolate, 4–6(–8.5) cm long, 2–3.5(–4) cm

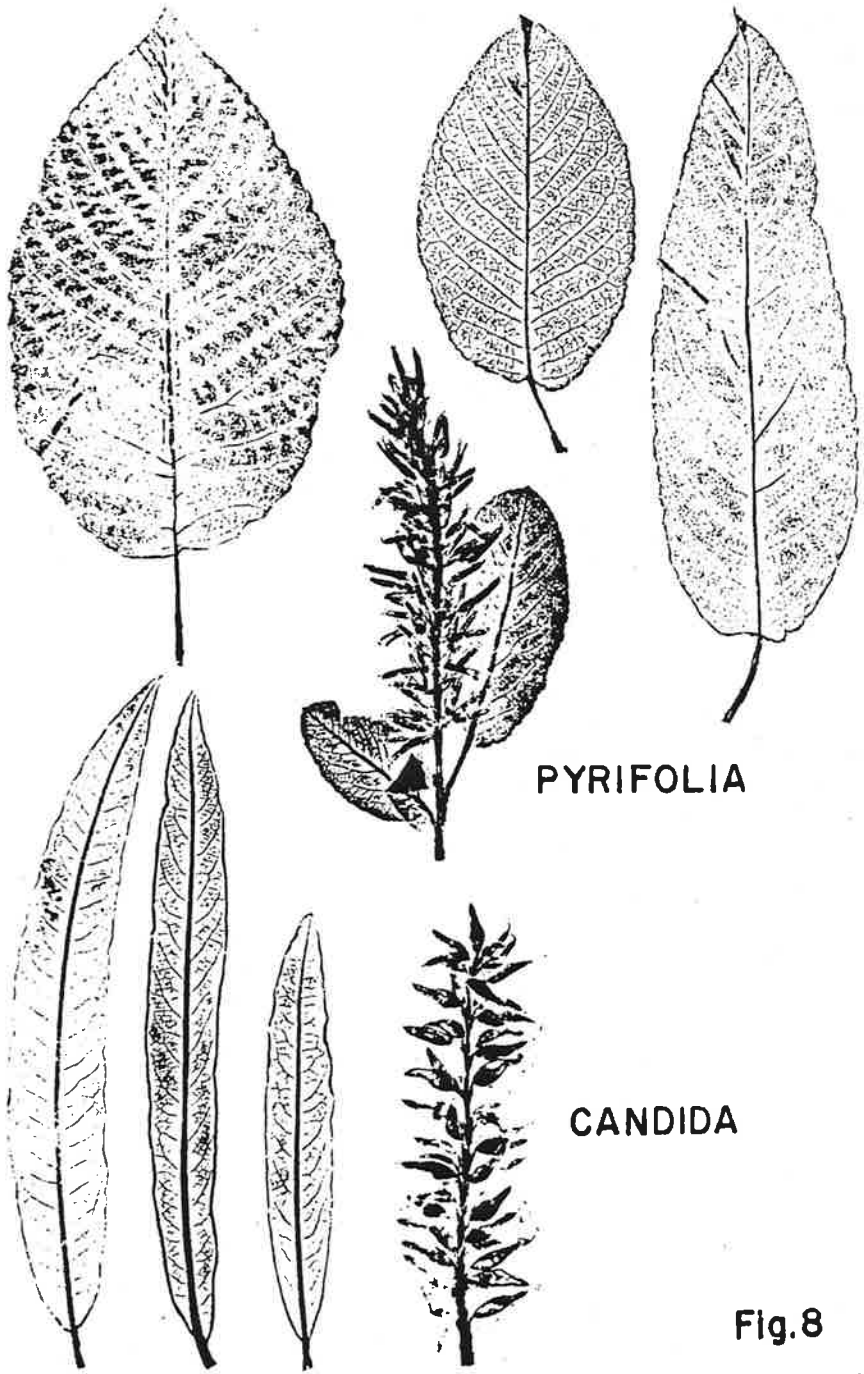


FIGURE 8. Leaves and pistillate aments (in early fruit) of *S. pyrifolia* and *S. candida*.

wide, length/width 1.6–2.5, apex acute, base cordate to rounded, margin glandular serrulate on immature leaves, becoming coarsely serrate or crenate in age, immature leaves thin and translucent, thinly pubescent or glabrescent, green on both sides or faintly glaucous beneath, mature leaves subcoriaceous, opaque, reticulate veined and glaucous beneath; petiole 7–15 mm long, pubescent, sometimes glandular at the distal end; stipules small, caducous. Aments coetaneous, borne on reproductive branchlets. Staminate aments 2.5–5 cm long; reproductive branchlets 5–7 mm long; stamens 2, filaments glabrous or pubescent at base; bracts (in both sexes) oblong, tawny, pilose. Pistillate aments loosely flowered, 2.5–6 cm long; reproductive branchlets 0.5–2 cm long, leaves of reproductive branchlets broad, apex obtuse to rounded; pistils and capsules glabrous, up to 5–6 mm long; styles 0.5–1 mm long; pedicels divergent, 2.5–3.5 mm long; glands adaxial. Based on 7 staminate, 26 pistillate, and 22 vegetative specimens.

Salix pyrifolia generally occurs in wet places and is most commonly encountered in *Chamaedaphne calyculata-Sphagnum* or *Larix-Picea bogs*. It has been collected along wet shores and marshes bordering lakes, in swamps, in the mixed northern hardwoods, and in waste places such as railroad rights-of-way and ditches.

Sect. CANDIDAE Schneider

14. SALIX CANDIDA Flügge in Willd. Sp. Pl. 4:708. 1805.
Sage-leaved Willow Map 14, Fig. 8.

Shrubs 0.5–3.5 m tall; branchlets yellowish to brownish, and tomentose to floccose when immature, becoming reddish-brown and glabrescent in age. Leaf blade linear to oblong, sometimes appearing to be narrowly lanceolate due to revolute margins near the base, 4.7–10.3 cm long, 0.5–2 cm wide, length/width (5–)7.8–12, apex acute, base attenuate, margin revolute, entire, undulate, often distantly glandular, dull white-tomentose beneath persistent in age, floccose to pubescent above becoming glabrate, drying dark green to brown above, midrib prominent and yellowish beneath, veins impressed above; petiole 3–5–10 mm long; stipules lanceolate, tomentose. Aments coetaneous, borne on short reproductive branchlets. Staminate aments 1–1.5 cm long, subsessile, stamens 2, filaments glabrous, bracts (in both sexes) pale to dark brown, bearded. Pistillate aments 2.2–5.2 cm long, cylindrical or narrowly so, densely to loosely flowered; reproductive branchlets 0–15 mm long; pistils dull white-tomentose, 4–6 mm long, styles about 1 mm long, red when fresh; pedicels 1 mm long or less; glands adaxial, red when fresh. Based on 5 staminate, 40 pistillate, and 37 vegetative specimens.

Salix candida is a shrub of alkaline *Carex-Eriophorum* meadows, sloughs, limestone shores, *Larix* bogs, and floating *Carex-Typha* mats. It commonly occurs in wet calcareous habitats, but it is not restricted to them.

The distribution of *Salix candida* in Wisconsin (Map 14) is similar to that of other calciphilous species including *Solidago patula* and *S. ridellii* (Salamun, 1963), *Lysimachia quadriflora* (Iltis and Shaughnessy, 1960), and *Gentiana procera* (Iltis, pers. comm.). *Salix candida* principally occurs in eastern Wisconsin, with rare extensions into northwestern Wisconsin. Its occurrence in Trempealeau Co., well within the "Driftless Area", parallels that of *Lysimachia quadriflora* (cf. Iltis and Shaughnessy, 1960).

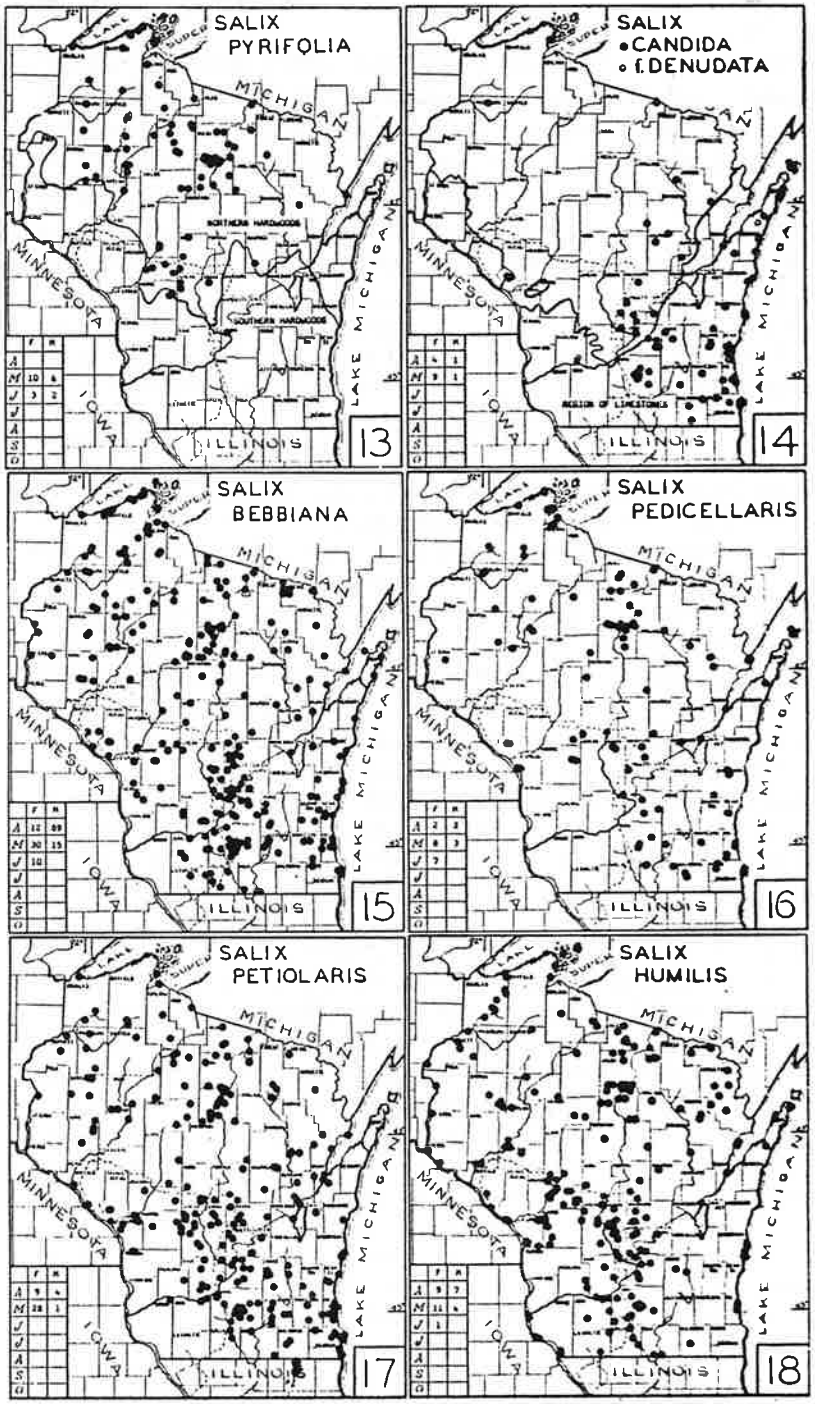
A glabrate variant of this characteristically tomentose species has been named *Salix candida* f. *denudata* (Anderss.) Rouleau (Nat. Canada. 71:266. 1944). Two specimens of this variant from Wisconsin have been seen (*A. M. Fuller 2371*, Cedarburg swamp, Ozaukee Co., Wis., 9 June 1928 (MIL); *H. Iltis 17532*, ½ mi. North of Maplewood, edge of old *Larix* bog, Door Co., Wis., 9 June 1961 (WIS)). Its glabrous or glabrescent leaves, branchlets and capsules are in marked contrast with the typically tomentose species. Specimens of typical *S. candida* as well as the putative hybrid *S. candida* X *S. petiolaris* have also been collected at the Cedarburg swamp (bog), and it is possible that forma *denudata* is of hybrid origin. Other habitats in which *S. candida* and *S. petiolaris* occur together should be searched for glabrescent hybrids which resemble f. *denudata*.

Sect. FULVAE Barratt

15. SALIX BEBBIANA Sarg., Gard. and For. 8:463. 1895.
Long-beaked Willow, Bebb's Willow Map 15, Fig. 9.

S. rostrata Richards.
S. perrostrata Rydb.
S. bebbiana var. *perrostrata* (Rydb.) Schneid.

Shrubs or small trees 1.5–6 m tall; branchlets divaricate, reddish brown, becoming darker in age, gray pubescent, sometimes glabrescent, pubescence commonly persistent for several years. Leaf blade elliptic, elliptic-obovate, oblanceolate or rarely broadly elliptic, 3–7.5 cm long, 1.3–3.3 cm wide, length/width 2–3.8, apex abruptly acute, rarely obtuse or sometimes tapering, base acute to obtuse, margin entire to crenate or irregularly glandular toothed, immature leaves pilose and ciliate or sericeous-tomentose, mature leaves pubescent, sericeous-tomentose or glabrate, dull green above, glaucous and often rugose-veiny beneath; petiole (3–)5–7(–10) mm



long, pubescent; stipules small, usually less than 2 mm long, deciduous. Aments coetaneous or subprecocious, borne on reproductive branchlets. Staminate aments 1.5–2.5 cm long; reproductive branchlets 3–6 mm long; stamens 2, filaments pilose at base, distinct or partly coalescent; bracts (in both sexes) lanceolate, yellowish to tawny, thinly pilose to long pubescent, 2 mm long. Pistillate aments loosely flowered, often lax, 3.5–6 cm long, reproductive branchlets 3–10 mm long; pistils lanceolate, long beaked, gray sericeous, capsules pubescent, 3–7 mm long; styles obsolete; stigmas short; pedicels 2–3.5 mm long; glands adaxial, half as long as the bract. Based on 44 staminate, 141 pistillate, and 112 vegetative specimens.

Salix bebbiana is a very common shrub in Wisconsin and occurs in a wide variety of habitats. In northern Wisconsin it is known from *Larix-Picea mariana* forests on the edge of open bogs, thickets of *Abies balsamea, Thuja occidentalis,* and *Picea glauca;* in the central portion from rich deciduous woods, *Quercus* scrub, swamps, alkaline sedge meadows, and *Larix* bogs; and in the south from bogs, willow swamps, and virgin prairie where it may be associated with *Andropogon gerardi, Carex, Cornus racemosa, Corylus americana* and scattered *Quercus macrocarpa.* Throughout the state it is commonly encountered in old fields and along roadsides.

The variation in *Salix bebbiana* is highly complex. Its extremes of variation in leaf pubescence and rugosity have been typified by var. *bebbiana* which has pubescent and rugose leaves, and var. *perrostrata* which has glabrescent and plane leaves. These characteristics seem to be influenced by the time of initiation and development of the leaves, the stage of leaf development, and the external environment. Leaves which develop later in the season, especially on vigorous or sprout shoots, are more rugose and pubescent than those which developed earlier. Presumably these leaves were initiated and developed during the same season. Many of the specimens identified as var. *perrostrata* are immature and may become more rugose in age. Individual shrubs, or even branches, growing under shade conditions often produce leaves which are less pubescent, thinner, and more plane than usual, and this may account for some of the leaves of the *perrostrata* type in *S. bebbiana.* Insect attack may stimulate the host to produce densely pubescent shoots and leaves (see: *Cheney 7473,* LaChapelle to mouth of Brule R., Wis., 17 July 1897, (WIS, MIL)). This condition is also known to occur in *S. interior.* Most Wisconsin material represents some stage of intermediacy between the extremes of leaf pubescence and rugosity and the recognition of intraspecific taxa on the basis of this variation is of doubtful validity. I agree with Raup (1959) and others in placing *S. bebbiana* var. *perrostrata* in synonymy.

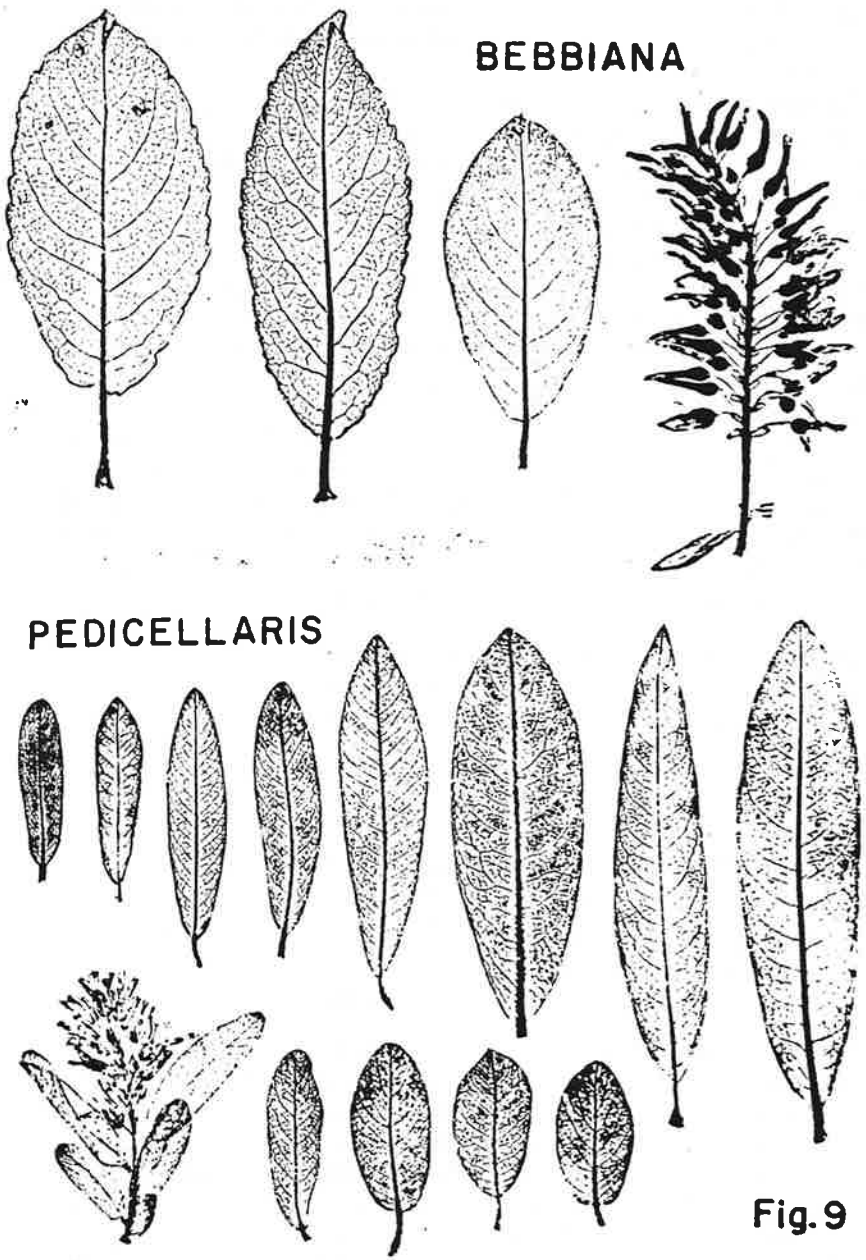


FIGURE 9. Leaves and pistillate aments (in fruit) of *S. bebbiana* and *S. pedicellaris.*

The leaf margins vary from entire to crenate or irregularly toothed. This variation, similar to that discussed above, seems to be correlated with the time of leaf development, or perhaps initiation. The proximal (lowermost) leaves on almost all shoots have entire margins, and the distal leaves have margins crenate to toothed. It is possible that the distal, toothed leaves are not only developed later in the season but initiated during the season of their development. Evidence supporting this hypothesis is found in the observation that all the leaves are often toothed on sprout shoots and shoots located in the axil of the same year's leaf. For example see *F. C. Seymour 14389*, Lincoln Co., Wis., Tomahawk, 10 July 1952, (WIS); and *12184*, Lincoln Co., Wis., Pine R., 27 Aug. 1950, (WIS). This possible correlation of variation with seasonal development and/or initiation emphasizes the need for thorough developmental and autecological studies of *Salix bebbiana*.

Sect. ROSEAE Andersson

16. SALIX PEDICELLARIS Pursh Fl. Am. Sept. 2:611. 1814.
Bog Willow — Map 16, Fig. 9.

S. pedicellaris var. *hypoglauca* Fern.

Low shrubs 20–70 cm tall, rarely to 2.5 m, loosely branched or simple, often partly decumbent and rooting along the branches; branchlets glabrous, yellowish, becoming reddish brown and grayish in age. Leaf blade oblong, elliptic-oblong, narrowly oblanceolate, obovate, or oblanceolate, (1.9–)2.5–4.7(–6.9) cm long, 0.6–1.3 (–2.2) cm wide, length/width (1.9–)2.5–4(–4.9), apex obtuse to rounded or acute, base narrowed, obtuse to acute, margin entire, revolute, mature leaves subcoriaceous, dark green, glabrous, and with fine but prominent veination above, glaucous and with prominent midrib beneath; petiole (2–)3–5(–6) mm long; exstipulate. Aments coetaneous, borne on reproductive branchlets. Staminate aments 0.5–2 cm long; reproductive branchlets 0.5–1 cm long; stamens 2, filaments glabrous, distinct or partly coalescent, bracts (in both sexes) tawny, sparsely pubescent on adaxial surface, glabrous abaxially. Pistillate aments loosely flowered, broad, 1.5–3 cm long; reproductive branchlets 1–1.5 or up to 5 cm long; pistils glabrous, dark red or yellow, capsules becoming yellow to brown, 4–6 (–8) mm long; styles very short or obsolete; pedicels 2–3 mm long. Based on 7 staminate, 58 pistillate, and 31 vegetative specimens.

Salix pedicellaris is a bog species found in open *Sphagnum-Chamaedaphne* bogs, *Larix-Sphagnum* bogs, *Larix, Picea, Pinus strobus* and *P. resinosa* bogs, and floating bogs. It also occurs along lake shores and in moist to wet *Acer rubrum-Pinus strobus* northern hardwoods.

In 1909 Fernald proposed names for three variations of *Salix pedicellaris*. The commonest variant (var. *hypoglauca)* had leaves obovate-oblong and glaucous beneath. The second variant (var. *pedicellaris)* was uncommon and although similar to the first had leaves which were green on both sides. The third variant (var. *tenuescens)* was narrow leaved and similar in other respects to var. *hypoglauca*. The two names which are most important in Wisconsin are var. *hypoglauca* and var. *pedicellaris*. Evidence obtained from Wisconsin specimens suggests that the grounds for distinguishing between these names, i.e. the absence of leaf glaucescence, in one variety is simply an artifact and not of taxonomic importance. It is well known that leaf glaucescence may be driven off in drying specimens over excessive heat. I have seen 4 Wisconsin specimens of *S. pedicellaris* with leaves green on both sides. In one of these *(H. Iltis 13688*, Oconto Co., Wis., Island Lake, 11 July 1959, WIS) a duplicate specimen (in Argus collection) had leaves which were partly and irregularly glaucous beneath giving every indication that it had been dried over excessive heat which drove off some of the waxy bloom. The other three specimens may have been similarly affected.

The material that Fernald cites in his description of var. *hypoglauca* has been noted by Schneider (1920) to have leaves ". . . with at least a partly more or less glaucescent undersurface." In the light of the knowledge that leaf glaucescence is, at best, a fickle characteristic I am not recognizing the name *Salix pedicellaris* var. *hypoglauca* in Wisconsin. A complete study of this species should be undertaken to finally settle the status of the proposed intraspecific taxa.

Sect. GRISEAE Borrer

17. SALIX PETIOLARIS J. E. Smith, Trans. Linn. Soc. 6:122. 1802.
Slender Willow — Map 17, Fig. 10.

S. gracilis Anderss.

Shrubs 1–3 m tall; branches slender, dark brown, drying blackish and glabrate, rarely pruinose; branchlets yellow-green to brown, pubescent. Leaf blade linear to lanceolate, 3.8–11 cm long, 0.6–1.9 cm wide on flowering specimens, 3.8–6.8 cm long, 0.8–1 cm wide on fruiting specimens, length/width 5–7(–9), apex acuminate, base acute, margin serrate with sharp sometimes prolonged teeth, to irregularly and distantly serrate or subentire, immature leaves velutinous-sericeous, often with ferruginous trichomes, mature leaves glabrate or remaining more or less sericeous, green and glabrate above, midrib pubescent, glaucous and glabrate to thinly ser-

iceous beneath, often drying black; petiole 3–10 mm long, yellow and pubescent; stipules absent or minute and caducous. Aments coetaneous, sessile or on reproductive branchlets. Staminate aments 1.2–2 cm long, sessile or reproductive branchlets 1–2 mm long; anthers 2, filaments glabrous or pubescent at base, distinct; bracts (in both sexes) oblong, 1–2 mm long, brown, pubescent. Pistillate aments broad and sometimes lax in fruit, 1.5–3–3.5 cm long; reproductive branchlets 3–7 mm long; pistils densely sericeous, capsules finely sericeous, lanceolate, slender beaked, 5–8 mm long; styles obsolete; stigmas short; pedicels sericeous, 1.5–4 mm long; glands adaxial, small. Based on 20 staminate, 98 pistillate, and 102 vegetative specimens.

Salix petiolaris is a common shrub occurring in a variety of habitats from sandy or peaty low prairie (with *Sorghastrum, Castilleja coccinea, Viola sagittata,* and *V. lanceolata),* sand prairies (with *Artemisia caudata, Viola adunca,* and *Antennaria),* sandy lakeshores and thickets (including dunes); to damp, low, rich deciduous woods (with *Ulmus, Tilia, Acer, Betula,* and *Quercus macrocarpa),* and northern hardwoods (with *Acer rubrum* and *Pinus strobus,* or *Abies, Picea, Tsuga,* and *Acer);* to lake edge communities including *Juncus-Carex* meadows; and peat bogs (with *Picea, Larix,* and *Sphagnum*). It also occurs in waste places along roadsides and railroad rights-of-way.

There has been considerable discussion in the literature concerning the correct name for this species (see: Schneider, 1920:16–19; Fernald, 1946:46–48; Ball, 1948; and Raup, 1959:84–85). One view is that *Salix petiolaris* is an English "tree" and has nothing to do with the North American taxon whose correct name is *S. gracilis* (Fernald, 1946); the other view is that the type of *S. petiolaris* was a specimen introduced from eastern North America into an English garden and described in a more or less atypical form (Ball, 1948). Although there is a large measure of subjectivity in both arguments, Ball's argument is the most convincing, and it seems most likely that *S. petiolaris* was based on material of American origin. For the time being I will continue to recognize *S. petiolaris* as the name applicable to the North American taxon.

This nomenclatural dispute has brought to light the east-west geographic variation which occurs in this species. A species concept based on *S. petiolaris,* whose type is presumably of eastern American origin, has large leaves (4–10 cm long, 2 cm wide) with prominently serrate margins. A concept based on *S. gracilis,* described from material from Cumberland House, Saskatchewan, has leaves somewhat smaller (2.5–7 cm long, 3–11 mm wide) and margins often subentire. Most of the material from Wisconsin is of the eastern type (Fig. 12) although there is considerable variation in leaf size. This variation seems to be correlated with either the stage of ontogenetic development or a difference in leaf size on vegetative and reproductive branches. Specimens with subentire leaves are rare in Wisconsin. A study of population and geographic variation in this taxon would contribute to an understanding of the intraspecific variation which may be related to postglacial plant migrations.

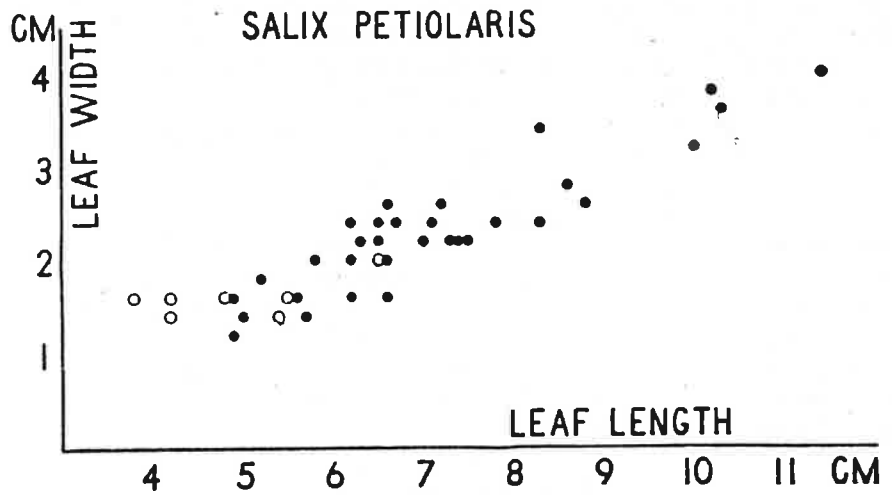


FIGURE 12. Leaf length and width of *Salix petiolaris* in Wisconsin. The scatter diagram compares leaf length and leaf width of fruiting (open circles) and vegetative (closed circles) specimens. See text for discussion.

A close relationship seems to exist between *Salix petiolaris* and *S. sericea.* However, on the basis of the available material of *S. sericea* the relationship cannot be fully explained. These species can be distinguished by the narrow beaked ovaries, coetaneous aments, longer reproductive branchlets, and generally glabrate mature leaves of *S. petiolaris* contrasted with the blunt ovaries, apparently precocious aments, very short or absent reproductive branchlets, and finely sericeous undersurface of leaves in *S. sericea.*

Specimens of *Salix petiolaris* with permanently sericeous leaves do occur in Wisconsin, and they have generally been named *S. sericea,* although they are clearly of the *S. petiolaris* type. These specimens may fit the concept of *S.* × *subsericea* (Anderss.) Schneid. Ill. Handb. Laubholzk. 1:65, 1904, a hybridogenous taxon supposedly representing *S. petiolaris* × *S. sericea.* I am reluctant

to regard those specimens with coarsely sericeous leaves as *S. sericea* or as the above hybrid. The reasons are two, (1) a more or less continuous variation in leaf pubescence can be observed in *Salix petiolaris*, and (2) typical *S. sericea* is extremely rare in the state and unknown from the localities in which the sericeous form of *S. petiolaris* occurs.

Specimens which represent the sericeous form of *Salix petiolaris* in Wisconsin include: *Heyns, Laferriere, Meyer,* and *Nichols,* Columbia Co., 29 Apr., 14 May, and 31 May 1960 (a successive collection); *M. Johnson 29,* Wood Co., 20 May 1960; *F. Seymour 15743,* Lincoln Co., Pine R., 8 July 1954; *H. Gale,* et al., Oconto Co., Lena, 25 June 1958; *H. Iltis 15132,* Waushara Co., Wautoma, 1 Sept. 1959; *15237,* Portage Co., Rosholt, 2 Sept. 1959; *K. White 708,* Columbia Co., Portage, 30 Aug. 1960; *293,* Dane Co., Stoughton, 15 June 1960; *415,* Dodge Co., Horicon, 7 July 1960 (WIS).

18. SALIX SERICEA Marsh. Arbust. Am. 140. 1785.

Map 11, Fig. 10.

Shrubs 1–3 m tall; branchlets glabrate, light brown to dark brown. Leaf blade narrowly lanceolate, 4–10 cm long, 1–2.5 cm wide, apex acuminate, base acute, margin serrulate, immature leaves sericeous on both surfaces, mature leaves puberulent to glabrescent above, silvery sericeous beneath, blackening in drying; petiole 5–10 mm long; stipules on sprout shoots lanceolate, deciduous. Aments apparently precocious, sessile or borne on short reproductive branchlets. Staminate aments (unknown from Wisconsin) 1–2.5 cm long; stamens 2, filaments distinct, pubescent at base; bracts (in both sexes) dark brown to blackish. Pistillate aments 1–2.5 cm long; reproductive branchlets 2–10 mm long; capsules blunt, sericeous, 3–5 mm long; styles obsolete; stigmas short; pedicels 1–2 mm long. Based on 3 pistillate, 4 vegetative specimens, and the literature.

Salix sericea occurs in Wisconsin in wet, boggy soils and sand terraces along rivers and on ledges above rivers.

This species is rare in Wisconsin and unequivocal specimens are known from only the following: Clark Co.: Neillsville, 1915, *Goessl s.n.* (WIS); Jackson Co.: Ledges along Black River, near Hatfield, *Fassett & Schmidt 15495* (WIS); shrub, moist acid meadow near the Black River, sect. 36, Melrose Township, *Hartley & Hartley 3136a* (WIS); Richland Co.: sand terraces of the Wisconsin River, 1 mi. south of Gotham, *Hartley 5234* (IU). A fourth specimen may have been collected at Beloit, but it is on a sheet with specimens from New York and the locality is in doubt. *Salix sericea* is closely

related to *S. petiolaris* (see that species). Pistillate Wisconsin specimens have a very low level of seed formation suggesting that they may be hybrids.

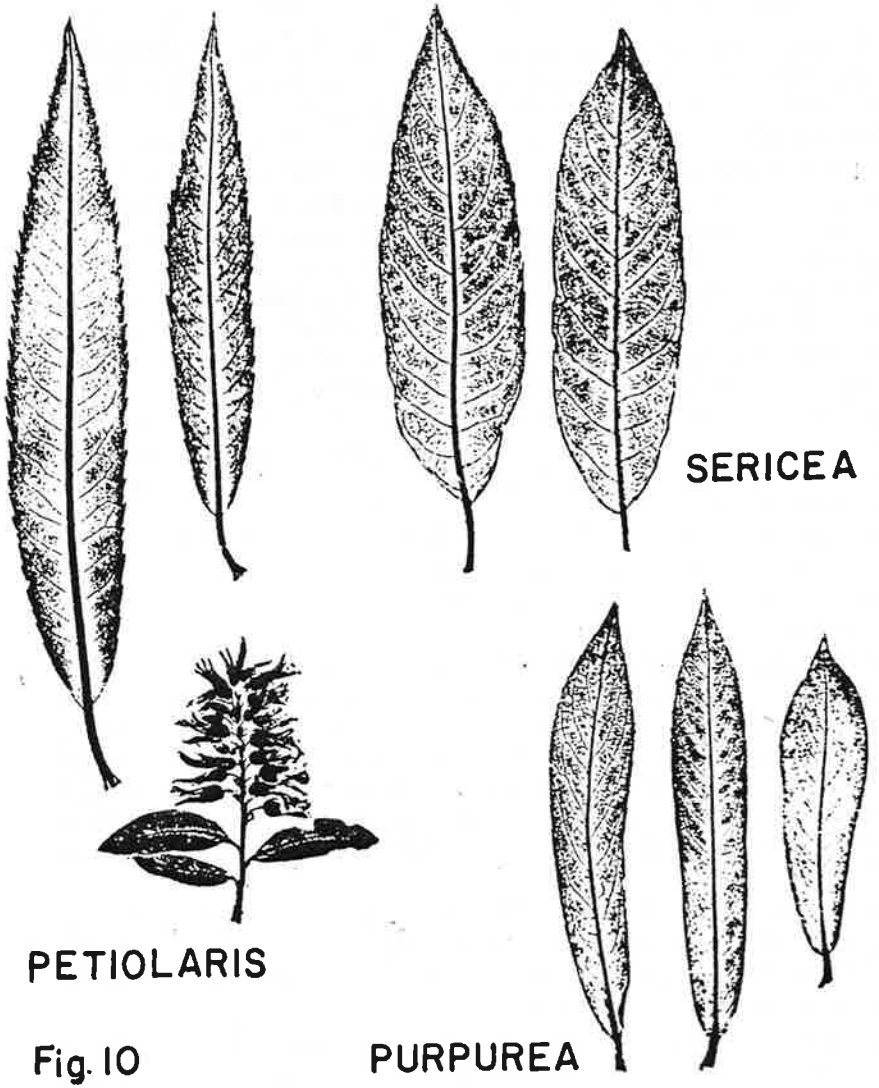


FIGURE 10. Leaves of *S. petiolaris, S. sericea,* and *S. purpurea.* Pistillate ament of *S. petiolaris* in fruit.

Sect. CAPREAE Bluff and Fingerhuth

19. SALIX HUMILIS Marsh. Arbust. Am. 140. 1785.
Upland Willow, Prairie Willow Map 18, Fig. 11.

S. tristis Ait.
S. humilis var. *microphylla* (Anderss.) Fern.

Shrubs 1–3 m tall; branchlets yellow to brown, densely pubescent to glabrate, dull, drying dark. Leaf blade narrowly to broadly oblanceolate, sometimes obovate, 4–10 cm long, 0.8–1.9(–2.7) cm wide, length/width 3.2–5(–6.3), apex acute to short acuminate, base acute, margin subentire, undulate or crenate, revolute, immature leaves tomentose, sometimes with ferruginous trichomes, mature leaves pubescent to glabrate, gray-green above, rugose, pubescent-tomentose to glabrate and glaucous beneath; petiole (2–)5–10 (–15) mm long, yellow, pubescent; stipules narrow, deciduous, 3–11 mm long. Aments precocious, sessile. Staminate aments 7–15 mm long, sessile, usually subtended by several light colored, sterile bracts; stamens 2, anthers often reddish (drying purple), filaments glabrous, distinct; bracts (in both sexes) 1.5–2 mm long, brown to black, or often bicolored, long villous. Pistillate aments (0.6–1–) 1.3–4(–5) cm long, subsessile often on short reproductive branchlets with several sterile, light colored or greenish bracts; pistils gray sericeous, capsules long beaked, 4–7 mm long, thinly pubescent; styles short; stigmas short; pedicels 1–2.5 mm long; gland adaxial. Based on 25 staminate, 76 pistillate, and 131 vegetative specimens.

Salix humilis commonly occurs in wet or wet-mesic prairie where it has been collected in association with *Andropogon gerardi, Carex, Cornus racemosa* and *Corylus americana*. It also occurs on sandy uplands in pine barrens with *Pinus banksiana* and *Quercus*, in oak barrens associated with *Quercus velutina* and *Q. alba*, and around the base of sandstone bluffs. It has also been collected in willow thickets grading into *Carex-Typha* "swinging" mats, and *Sphagnum* bogs.

Salix humilis and the related *S. discolor* are the earliest flowering species in Wisconsin and, as a result, they are the most conspicuous willows in the early spring. These species have precocious aments and flower in April and early May.

Salix humilis is a variable species which intergrades in one direction with *S. discolor* and in another with *S. scouleriana* Barratt. The glabrate leaved form (var. *hyporhysa* Fern. Rhodora 48:45. 1946) probably represents intergradation with *S. discolor* (see discussion under that species), and the tomentose leaved form (var. *keweenawensis* Farwell, Rep. Mich. Acad. Sci. 6:206. 1904) repre-

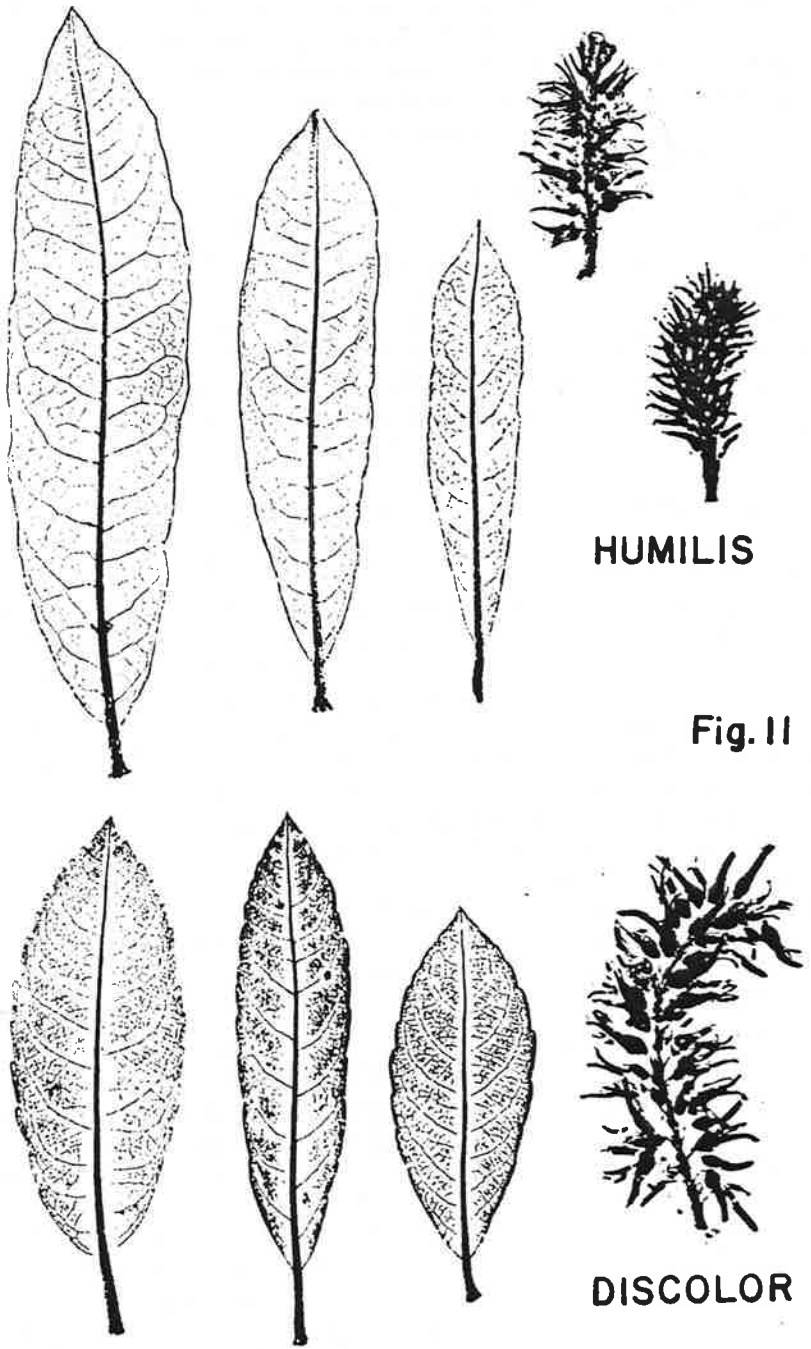


Fig. 11

FIGURE 11. Leaves of *S. humilis* and *S. discolor*. Pistillate aments of *S. humilis* (upper in fruit, lower in flower) and *S. discolor* (in fruit).

sents intergradation with *S. scouleriana*. The problems in identification which are posed by this variation are of considerable importance, especially to ecologists who may be identifying sterile specimens. The intergradation with *S. scouleriana* is not of particular importance in Wisconsin but it becomes an acute problem in southern Ontario and Manitoba. It may be that this intergradation is due to hybridization, but this is speculation in the absence of experimental evidence. The total variation based on population studies is not yet available for these three species (*S. discolor, S. humilis,* and *S. scouleriana*) and this poses an obstacle to the understanding of any of these taxa.

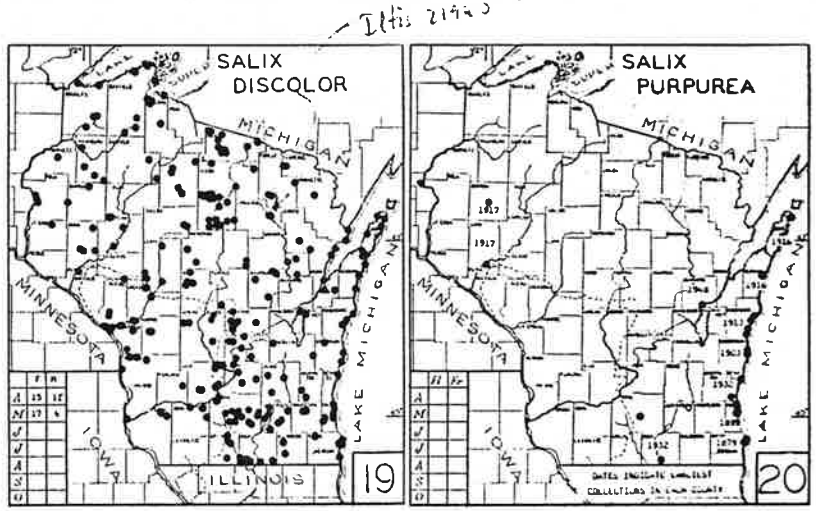
A diminutive form of *Salix humilis* which occurs in Wisconsin has been named *S. tristis* Ait., or *S. humilis* var. *microphylla* Fern. It is distinguished from the species on the basis of the small size of all its organs and may represent a prairie ecotoype or perhaps an ecophene (a reversible ecological modification). Whether or not this is so remains to be studied.

None of the forementioned varieties have been distinguished in this study.

20. SALIX DISCOLOR Muhl. Neue Schr. Ges. Nat. Fr. Berlin 4:234. 1803.

Pussy Willow — Map 19, Fig. 11.

Shrubs or small trees 2–3(–6) m tall; branchlets reddish to dark brown, pubescent, usually becoming glabrate the same year but sometimes remaining pubescent; branches glabrous and sometimes pruinose. Leaf blade narrowly to broadly elliptic, oblanceolate or lanceolate, 3.7–8(–11) cm long, 1.2–3 cm wide, length/width (2.3–)3–3.5(–4.5), apex acute to subacuminate, base obtuse to acute, margin crenate to serrate, immature leaves mostly thinly pubescent composed in part of caducous ferruginous trichomes, sometimes densely pubescent, blade usually thin and commonly reddish, mature leaves glabrate and dark green above, glabrate to puberulent, and glaucous beneath; petiole 7–17 mm long, often pubescent; stipules present, prominent on sprout shoots. Aments precocious, sessile or subsessile. Staminate aments sessile usually with several sterile, yellowish or greenish bracts at the base, 2–3.5 cm long; stamens 2, filaments glabrous or puberulent at the base, distinct; bracts black, brown or bicolored, 1.5–2.5 mm long, acute to rounded at apex, long villous. Pistillate aments densely flowered, sometimes becoming loosely flowered in fruit (2.5–3.5–)4–7 cm long, up to 9.5 cm in fruit; sessile or subsessile with several sterile, light colored bracts at the base, rarely borne on a reproductive branchlet (see discussion); pistils densely sericeous, capsules



long beaked, pubescent to puberulent, 6–11 mm long; styles 0.5–0.8 mm long; stigmas as long or longer than the styles, up to 1 mm long; pedicels 2–2.5 mm long, bracts black to brown, broad, 1.5–2 mm long, sometimes oblong and up to 3 mm long, long villous to pubescent; glands adaxial, 0.5–0.8 mm long. Based on 24 staminate, 97 pistillate, and 127 vegetative specimens.

Salix discolor commonly occurs in willow thickets along rivers, wet margins of lakes (in *Juncus-Carex* or *Carex*-grass meadows), and in *Chamaedaphne-Sphagnum* bogs. It also occurs in *Acer rubrum-Betula* northern hardwoods, *Quercus bicolor-Fraxinus-Acer saccharinum-Betula nigra* bottomland woods, pine barrens, dry sandy beaches, and prairies. It is a component of the shrub carr in association with other willows including *S. bebbiana, S. interior* and *S. petiolaris.*

This species is highly variable; however, the factors which influence the variation are poorly understood. Two of the many varieties and forms of *Salix discolor* which have been described are often found in modern literature. The typical variety of *S. discolor* is characterized by glabrous branchlets, or, if pilose, soon becoming glabrate, and leaves early glabrate. The var. *latifolia* Anderss. (Sv. Vet-akad. Handl. 6:84. 1867) is characterized by pubescent branchlets which remain puberulent in the second year, and leaves puberulent beneath and often retaining ferruginous trichomes. This variation in pubescence is not extraordinary in *Salix* and has been described in *S. bebbiana, S. humilis, S. interior,* et al. The pubescent form of *S. discolor* (var. *latifolia*) intergrades with *S. humilis* (see that species) and raises the problem of identification of some vegetative specimens and the question of hybridization between *S. dis-*

color and *S. humilis*. Hybridization may be more common than is suggested by the present circumscription of these taxa and it may be that specimens referrable to var. *latifolia* are of hybrid origin. A parallel situation may exist in relation to the glabrate form of *S. humilis* (var. *hyporhysa*) which is discussed under that species. The possibility of hybridization between these two common species deserves careful field study and experimental hybridization. I have not attempted to formally recognize *S. discolor* var. *latifolia* in my annotations of Wisconsin specimens.

The aments of *Salix discolor* are usually sessile or subsessile. However, there are several specimens which have aments borne on reproductive branchlets 8–25 mm long, and represent exceptions to this statement. The specimens are: *W. Finger,* Milwaukee Co., 21 May 1908 (MIL), 20–25 mm long; *W. Derr, K. Rabideau, B. Smith 27,* Iowa Co., Lone Rock, 14 May 1961 (WIS), 8–10 mm long; and *P. Wise,* Sauk Co., Leland, 19 May 1961 (WIS), 8–10 mm long.

The formulation of a clear concept of *Salix discolor* has been handicapped by its precocious nature and the manner in which collections are made. This species flowers early and the aments are deciduous before the leaves mature. Therefore, most herbarium collections represent either fertile or vegetative material, but rarely both. This problem can be largely eliminated by applying the technique of successive collection. Such collections would enable the student to relate fertile and vegetative material and permit a more meaningful evaluation of putative hybrids or ecological modifications.

I have examined several vegetative specimens which have been determined as *Salix planifolia* Pursh. Their leaves are smaller than usual for *S. discolor,* but they are similar to that species in all other respects. In the absence of flowering or fruiting specimens of *S. planifolia* I cannot recognize that species in Wisconsin and I have referred material so identified to *S. discolor*.

Sect. VIMINALIS Bluff and Fingerhuth

21. SALIX VIMINALIS L. Sp. Pl. 1021. 1753. Osier

Introduced shrubs or small trees; branchlets yellowish to reddish brown, puberulent and becoming glabrous. Leaf blade linear to linear-lanceolate, 12–17(–25) cm long, 0.5–1 cm wide, apex long acuminate, base acute, margin entire, revolute, mature leaves dull green and puberulent above, densely sericeous beneath, midrib yellow; petiole slender, up to 1 cm long; stipules narrow, caducous. Aments precocious, sessile. Staminate aments 2–3 cm long, sessile; stamens 2, filaments slender, glabrous, distinct; bracts (in both sexes) acutish, black, long villous. Pistillate aments up to 4–6 cm long, sessile; capsules 4–6 mm long, subsessile, densely sericeous; styles 0.7–1.2 mm long; stigmas short. $2n = 38$ (Darlington and Wylie, 1955). Based on 2 staminate, 2 vegative specimens (all possible hybrids), and the literature.

Salix viminalis is a species introduced from Europe. It is not known to occur as an escape in Wisconsin.

All of the specimens I have seen from Wisconsin are possible hybrids. The typical form of the species is unknown in Wisconsin.

SALIX INCANA Schrank, Baier. Fl. I: 230. 1789

A specimen which may represent this species was seen in the W. P. Fraser Herbarium (*L. H. Shinners,* Milwaukee, 10 Aug. 1940 (SASK). It is an introduced, cultivated species very similar to *Salix viminalis*. From that species it differs in being a lower shrub with shorter acute leaves, pistillate aments shorter in fruit (1–2 cm vs. 4–6 cm long) and pedicellate capsules (Fernald, 1950). This species is of doubtful occurrence in Wisconsin and is not included in the keys.

Sect. HELIX Dumortier

22. SALIX PURPUREA L. Sp. Pl. 1017. 1753.
Purple Osier Map 20, Fig. 10.

Introduced shrubs 1–2.5 m tall; branchlets slender, glabrous, yellow, green to brown, sometimes purplish on immature branchlets. Leaf blade spatulate to linear, 3.4–6.8 cm long, 0.8–1 cm wide, apex acute to acuminate, base obtuse, margin entire on basal portion, irregularly serrulate above, glabrous, glaucous beneath, subopposite; petiole 2–6 mm long; exstipulate. Aments precocious, sessile or subsessile. Staminate aments 2–3 cm long, narrow, sessile or subsessile, subtended by several yellowish or green bracts, aments usually in subopposite pairs; stamens 2, filaments pubescent on lower half, filaments and anthers often coalescent; bracts (in both sexes) obovate, bicolor or black, pubescent, often reflexed in anthesis. Pistillate aments 2–3 cm long, narrow, subsessile and bracteate; pistils densely pubescent, capsules pubescent, ovoid, 3 mm long, sessile; styles and stigmas minute. $2n = 38$ (Darlington and Wylie, 1955). Based on 10 staminate, 2 pistillate, 14 vegetative specimens, and the literature.

Salix purpurea was introduced into North America from Europe during colonial times. It is found widely as an apparent escape and may occur along river banks, lake shores (especially Lake Michigan), wooded ravines, sandy beaches, or along roadsides and in waste places.

This species is characterized by its subopposite leaves and aments, its coalescent filaments and anthers, and its prominently bicolored bracts.

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