***Salix exigua* Nutt.** coyote willow
SALICACEAE

Synonyms: *S. interior* Rowlee

General Description.—Coyote willow is also known as sandbar willow, basket willow, narrowleaf willow, slender willow, riverbank willow, acequia willow, long-leaved willow, and gray willow (Elmore 1976). It generally ranges in height from 0.5 to 3 m, is occasionally a small tree to 6 m and trunk diameter to 13 cm, with one author (Dorn 1998) reporting up to 17 m in height. Coyote willow is a clonal species that spreads by creeping rootstocks that generate new shoots forming multistemmed dense thickets. Coyote willow is one of few willow species that reproduce this way. As with other willows the species is dioecious. The bark is greenish to reddish on young twigs and ashy gray to grayish brown on older stems. Lenticels are elliptic and raised. The buds are reddish brown. The leaves are alternate, simple, long and narrow, linear to lanceolate in shape, tapering at both ends, generally six or more times longer than wide, 2 to 16 cm long, 4 to 15 mm wide, the margins are smooth or irregularly toothed, with one to five teeth per cm, and the petioles are short, 2 to 7 mm long (Argus 1986, Britton and Brown 1913, Carter 1997, Gleason and Cronquist 1963, Great Plains Flora Association 1986, Martin and Hutchins 1980-81, Newsholme 1992). Upon emergence the young twigs and leaves are densely silvery hairy, but with time and aging, the upper leaf surface reduces to a moderately gray hairy or smooth surface, sometimes slightly shiny. Plants in moist sites at higher elevations in the mountains may be noticeably less hairy (Mozingo 1987). The lower leaf surface generally remains whitish and much hairier. Coyote willow is one of few willow species with stomata on both leaf surfaces (Argus 1986). Stipules are small and sometimes absent. The chromosome number is 2n = 38 (Dorn 1998).

Taxonomy.—Coyote willow has a complicated taxonomy. It is a member of *Salix* section *Longifoliae*. Several botanists now consider *S. interior* as a much less hairier to smooth form of *S. exigua* that occurs in the Great Plains and Eastern United States, while variety *exigua* is the hairier Western form (Argus 1986, Carter 1988, Dorn 1998, Gleason and Cronquist 1963, Great Plains Flora Association 1986, Weber and Wittman 2001a, b). The Eastern *interior* is more distinctly toothed, leaf veins are more prominent, and the fruits (capsules) slightly longer. But characteristics are highly variable across the entire range of this plant. Under this taxonomic organization and using the Dorn (1998) treatment, there would be two subspecies: *S. exigua* subsp. *exigua* (coyote willow) and *S. exigua* subsp. *interior* (Rowlee) Cronq. (sandbar willow). The Western subspecies is divided into four varieties: var. *exigua*, var. *hindsiana* (Benth.) Dorn, var. *sessilifolia* (Nutt.) Dorn, and var. *columbiana* Dorn. The Eastern subspecies, *interior*, contains no varieties under Dorn's treatment. There are various synonyms (Argus 1986, Britton and Brown 1913, Dorn 1998, Gleason and Cronquist 1963, Great Plains Flora Association 1986, Kearney and others 1951, Newsholme 1992). A close to complete list of 34 synonyms can be found in Kartesz (1994). Hybridization is likely an important factor complicating the taxonomy for this species, the

entire section, likely a syngameon undergoing geographic speciation (Brunsfield and others 1992).

Range.—This is a widely distributed species of plains and lower elevations to lower montane habitats in the Western United States, as well as throughout Eastern deciduous forests if *S. interior* is considered a subspecies. The Western form (*exigua*) occurs from Saskatchewan to Eastern British Columbia in Canada, south through the United States to Eastern and Southern California, Arizona, New Mexico, and into Northern Mexico and the Western Great Plains. The Eastern form or subspecies (*interior*) occurs from New Brunswick in Eastern Canada, westward throughout the Great Plains, as far west as Idaho, north to Alaska, south to Eastern New Mexico, and extends into the Southeast along a line from Northern Virginia to Tennessee and Louisiana. The two subspecies overlap in the Western Great Plains. In the Western mountains, coyote willow can be found as high as 2,900 m in elevation.

Ecology.—Coyote willow commonly forms thickets along streams and rivers and is an important riparian species stabilizing streambanks. It will commonly colonize sand bars along rivers, hence the frequently used alternate common name sandbar willow. It also occurs in ditches, and on the edges of swamps, lakeshores, and other wetland habitats. This species will grow anywhere groundwater is close to the surface. This includes sites where human activities result in surface water availability on a reasonably regular and reliable basis (exclusive of saline conditions). Coyote willow is also one of the few willow species that can be found in lower elevation, hot desert areas in the Western United States. But because if its wide elevational range it is both a floodplain-plains and montane riparian species (Dick-Peddie 1993). Due to the extensive rootstock and clonal nature of the species, cut stands of coyote willow will regenerate relatively quickly. The presence of an aerenchyma-containing wetland plant, *Typha latifolia* L., may facilitate a nonaerenchyma bearing species like coyote willow to survive in low oxygen wetland soils (Callaway and King 1996). Leaf water potentials as low as -2.7 MPa have been measured for high elevation populations in Wyoming (Foster and Smith 1991). Coyote willow leaves within the Colorado River (Arizona) decomposed substantially more slowly than those of *Populus fremontii* S. Watson and salt cedar (*Tamarix ramosissima* Ledebour), with 52 percent of the leaf mass remaining after 142 days (Pomeroy and others 2000). A number of insects attack coyote willow, including leaf mining beetles, lepidopterans, sawflies (*Euura* spp.), and galling insects. A bud galling midge (*Rabdophaga* sp.) affects both terminal and lateral shoots, arresting growth of the immediate shoot (Declerck and Price 1994). Coyote willow responds by producing new lateral buds and shoots, but many do not survive.

Reproduction.—The male flowers are in densely flowered catkins from 1 to 6 cm in length, each flower with two stamens, the filaments hairy. The female catkins are loosely flowered, from 2 to 10 cm long, the ovaries are smooth to slightly silky with a short or almost nonexistent style. Each ovary bears nine to 15 ovules (Argus 1986). Catkin scales are yellow and deciduous. The catkins appear with the leaves or shortly after the leaves in spring (March to May) on short leafy stalks. The flowers are bee pollinated. There may even be a second blooming period from June to August (Argus 1986). The fruits are smooth capsules from 4 to 8 mm long, green, turning yellow to reddish brown upon ripening. The fruits open by two valves releasing tiny seeds (22,000/g [Brinkman 1974]) with long hairs that aid in wind dispersal. The seeds are short-lived, do not require stratification, must fall on a moist substrate, and can germinate within 12 to 24 hours under proper conditions (Young and Young 1992). Successful germination is reported at 22 EC for the Western subspecies *exigua* (Brinkman 1974) and 5 to 25 EC for the Eastern subspecies *interior* (Densmore and Zasada 1983, Baskin and Baskin 2001). Flower-and-fruit-bearing shoots have been observed to sprout new leafy shoots and become new side branches (Argus 1986).

Growth and Management.—Along the Rio Grande in New Mexico, clearing riparian areas of the invasive, nonnative salt cedar prior to peak river flows in the spring can facilitate the reestablishment of natives such as coyote willow (Taylor and others 1999). In Alberta, Canada, successful seedling establishment of several riparian species, including coyote willow, occurred best on deposits 80 to 120 cm above the late summer stream flow (Rood and Mahoney 2000). In Manitoba, Canada, average annual height increases were 30 cm, stem diameter increases were 2.6 mm, flowering began in 2 to 3 year old stems, stem mortality was greatest in 3 to 6 year old clones, entire plant senescence first occurred at 12 years, and the oldest plant recorded was 31

years on a point bar in the Assiniboine River (Ottenbreit and Staniforth 1992).

Benefits.—Because coyote willow forms dense thickets and spreads clonally, it is an important stabilizer of streambanks. It is frequently and successfully used in riparian and wetland revegetation and restoration. It is an important food for wildlife such as deer and beaver. It is considered good browse for sheep and fair for cattle, but cattle generally find it more palatable later in the growing season (Mozingo 1987, Stubbendieck and others 1997, USDA 1937). Coyote willow is used in intensive culture coppice plantations (Aravanopoulos and others 1999), was one of 32 woody plants tested for biomass gasification, and was one of three species that exceeded 0.30 liter methane per gram of volatile solids (Turick and others 1991). Coyote willow has been successfully grown in tissue culture with roots developing from shoots longer than 1 cm (Stoehr and others 1989). Native Americans have used the slender stems in making baskets and have made a tea from the bark to treat fever and headache. Willow bark, as with most willows, is bitter and acts as an astringent for diarrhea, has been used for fevers, pain, arthritis, rheumatism, and a poultice for cuts, ulcers, and rashes. Salicylic acid, commonly used in asperin as acetylsalicylic acid, was originally derived from salicin contained in the bark of willows (Foster and Duke 1990). Salicin is a member of the chemical class of phenols and affords some protection against browsing mammals such as rabbits. It tends to attain a greater concentration in low growing willows but becomes lost in larger, taller willows (Harborne 1988). Oestriol (an oestrogen), a human sex hormone, has also been found in willow flowers.

References

Aravanopoulos, F.A., K.H. Kim, and L. Zsuffa. 1999. Genetic diversity of superior *Salix* clones selected for intensive forestry plantations. Biomass and Bioenergy 16(4): 249-255.

Argus, G.W. 1986. The Genus *Salix* (Salicaceae) in the Southeastern United States. Systematic Botany Monographs, Vol. 9. The American Society of Plant Taxonomists, USA. 170 p.

Baskin, C.C. and J.M. Baskin. 2001. Seeds: Ecology, Biogeography, and Evolution of Dormancy, and Germination. Academic Press, San Diego, CA. 666 p.

Brinkman, K.A. 1974. *Salix* L. Willow. In: C.S. Schopmeyer, tech. coord. Seeds of Woody Plants in the United States. U.S. Department of Agriculture Forest Service, Handbook 450. Washington, DC. p. 746-750.

Britton, N.L. and A. Brown. 1913 (1970 Dover edition). An Illustrated Flora of the Northern U.S. and Canada, Vol. 1. Dover Publications Inc., New York. 680 p.

Brunsfield, S.J., D.E. Soltis, and P.S. Soltis. 1992. Evolutionary patterns and processes in *Salix*: evidence from chloroplast DNA. Systematic Botany 17(2): 239-256.

Callaway, R.M. and L. King. 1996. Temperature driven variation in substrate oxygenation and the balance of competition and facilitation. Ecology 77(4): 1,189-1,195.

Carter, J.L. 1988. Trees and Shrubs of Colorado. Johnson Books, Boulder, CO. 165 p.

Carter, J.L. 1997. Trees and Shrubs of New Mexico. Johnson Books, Boulder, CO. 534 p.

Declerck, F.R. and P.W. Price. 1994. Impact of a bud-galling midge on bud populations of *Salix exigua*. Oikos 70(2): 253-260.

Densmore, R. and J.C. Zasada. 1983. Seed dispersal and dormancy patterns in northern willows: ecological and evolutionary significance. Canadian Journal of Botany 61: 3,207-3,216.

Dick-Peddie, W.A. 1993. New Mexico Vegetation: Past, Present and Future. University of New Mexico Press, Albuquerque, NM. 244 p.

Dorn, R.D. 1998. A taxonomic study of *Salix* section Longifoliae (Salicaceae). Brittonia 50(2): 193-210.

Elmore, F.H. 1976. Shrubs and Trees of the Southwest Uplands. Southwest Parks and Monuments Association, Tucson, AZ. 214 p.

Foster, S.A. and J.A. Duke. 1990. A Field Guide to Medicinal Plants (Eastern/Central). Peterson Field Guide Series, Houghton Mifflin Co., Boston, MA. 366 p.

Foster, J.R. and W.K. Smith. 1991. Stomatal conductance patterns and environment in high elevation phreatophytes of Wyoming, USA. Canadian Journal of Botany 69(3): 647-655.

Gleason, H.A. and A.R. Cronquist. 1963. Manual of the Vascular Plants of Northeastern U.S. and Adjacent Canada. D. Van Nostrand Co., New York. 810 p.

Great Plains Flora Association. 1986. Flora of the Great Plains. University Press of Kansas, KS. 1,392 p.

Harborne, J.B. 1988. Introduction to Ecological Biochemistry, 3rd Ed. Academic Press, London. 356 p.

Kartesz, J.T. 1994. A Synonymized Checklist of the Vascular Flora of the United States, Canada, and Greenland, Vol. 1, 2nd Edition. Biota of North America Program of the North Carolina Botanical Garden. Timber Press, Portland, OR. 622 p.

Kearney, T.H., R. Peebles, and Collaborators. 1951 with 1960 supplement. Arizona Flora. University of California Press, Berkeley, CA. 1,085 p.

Martin, W.C. and C.E. Hutchins. 1980-1981 (reprinted 2001). A Flora of New Mexico, Vol. 1. Bishen Singh Mahendra Pal Singh (India) and Koeltz Scientific Books (Germany). 1,276 p.

Mozingo, H.N. 1987. Shrubs of the Great Basin: A Natural History. University of Nevada Press, Reno, NV. 342 p.

Newsholme, C. 1992. Willows: The Genus *Salix*. Timber Press, Portland, OR. 224 p.

Ottenbreit, K.A. and R.J. Staniforth. 1992. Life cycle and age structure of ramets in an expanding population of *Salix exigua* (sandbar willow). Canadian Journal of Botany 70(6): 1,141-1,146.

Pomeroy, K.E., J.P. Shannon, and D.W. Blinn. 2000. Leaf breakdown in a regulated desert river: Colorado River, Arizona, U.S.A. Hydrobiologia 434: 193-199.

Rood, S.B. and J.M. Mahoney. 2000. Revised instream flow regulation enables cottonwood recruitment along the St. Mary River, Alberta, Canada. Rivers 7(2): 109-125.

Stoehr, M.U., M. Cai, and L. Zsuffa. 1989. In-vitro plant regeneration via callus culture of mature *Salix exigua*. Canadian Journal of Forest Research 19(12): 1,634-1,638.

Stubbendieck, J., S.L. Hatch, and C.H. Butterfield. 1997. North American Range Plants, 5th Edition. University of Nebraska Press, Lincoln, NE. 501 p.

Taylor, J.P., D.B. Wester, and L.M. Smith. 1999. Soil disturbance, flood management, and riparian woody plant establishment in the Rio Grande floodplain. Wetlands 19(2): 372-382.

Turick, C.E., M.W. Peck, D.P. Chynoweth, D.E. Jerger, E.H. White, L. Zsuffa, and W.A. Kenney. 1991. Methane fermentation of woody biomass. Bioresource Technology 37(2): 141-147.

U.S. Department of Agriculture Forest Service. 1937 (1988 Dover edition). Range Plant Handbook. Dover Publications Inc., New York. 816 p.

Weber, W.A. and R.C. Wittman. 2001a. Colorado Flora: Eastern Slope. University Press of Colorado, Boulder CO. 521 p.

Weber, W.A. and R.C. Wittman. 2001b. Colorado Flora: Western Slope. University Press of Colorado, Boulder CO. 488 p.

Young, J.A. and C.G. Young. 1992. Seeds of Woody Plants in North America. Dioscorides Press, Portland, Oregon. 407 p.

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