USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Plant Guide

FREMONT'S COTTONWOOD

Populus fremontii S. Wats.

Plant Symbol = POFR2

Contributed by: USDA NRCS National Plant Data Center & New Mexico Plant Materials Center

Charles Webber

Alternate Names
Poplar, Alamo cottonwood

Uses
Ethnobotanic: The sweet and starchy sap can be consumed raw or cooked. The bark is bitter, but edible. It can be scraped off and eaten, cooked in strips like soup noodles, or dried and powdered as a flour substitute. The inner bark of cottonwoods and aspens were used for man and horse in hard times. Some Indians preferred it because of its sweetness.

The active biochemical constituents are salicin and populin, the precursors of aspirin that are useful wherever a fever needs reducing or an anti-inflammatory is appropriate (Moore 1979). The bark is the most effective part for tea but is rather bitter; for this reason the leaves are often preferred. Leaf buds make an excellent ointment for burns and skin irritations. A wash of the bark is applied externally for cuts, bruises, abrasions, burns and fetid perspiration, as well as healing chafing sores on horses. A poultice can be used for sprains, muscle pain, and swollen joints. A salve can be made that cleanses and conditions the skin when used regularly. Taken internally, it is an anti-inflammatory agent, reduces fever, indigestion, aids coughs from colds, expels worms and intestinal parasites, is effective against scurvy, heart troubles, back pain, excessive menses, urinary tract infections, is a diuretic, and is used to prevent premature birth.

The Hopi Indians of Arizona consider the cottonwood tree sacred and carve Kachina dolls from the roots of the tree. They believe the rustle of the wind through the quaking leaves to be the gods speaking to people (Strike 1994).

Several California tribes used *Populus* roots to make loosely twined baskets. The Hupa, from Northern California, use cottonwood roots to begin making twined baskets. The Maidu and Yokuts Indians use cottonwood twigs in their basketry (Strike 1994).

Chumash skirts were made of fibers of *Populus* inner bark. Cordage, made from the inner bark of cottonwood or milkweed, held the rest of the fibers hanging freely. Sometimes small teardrop-shaped pieces of asphaltum, shell beads or Pinus seeds were used as weights to make the fibers hang properly. Wintun also used *Populus* fibers for skirts and for padding baby cradles.

Other Uses: Ecological diversity, bank and sediment stabilization, maintenance of channel morphology, water quality improvement, ground-water recharge, flood abatement, fish and wildlife habitat.

Riparian Ecosystem Services and Functions: The riparian zone essentially encompasses those alluvial sediment deposits where river and alluvial ground water supplement that available from local precipitation. High-to-low elevations, north-south and east-west gradients, and steep-to-shallow terrain all influence the relationship between geomorphic and fluvial processes and vegetation community

structure. Riparian ecosystem functions include the following:

- Ecological diversity.
- Riparian vegetation stabilizes sediment, thus preventing excessive soil erosion.
- Water quality is improved through filtration and trapping of sediment, nutrients and pollutants.
- Riparian vegetation tends to prevent the river from down-cutting or cutting a straight path (channeling), thus promoting a sinuous course, ground-water recharge, and maintenance of an elevated water table.
- Structurally complex riparian vegetation communities provide many different habitats and support a diverse array of animal species. Different groups of animals occupy or use the different layers of vegetation, and this multi-story arrangement is often present nowhere else in the arid landscapes.
- Canopies of plants growing on streambanks provide shade, cooling stream water, while roots stabilize and create overhanging banks, providing habitat for fish and other aquatic organisms

Riparian habitat provides living conditions for a greater variety of wildlife than any other habitat type found in California. Use of riparian areas by wildlife species is affected by diversity and volume of foliage, presence of water, availability of "edge" habitat, and high levels of insect populations. Valley-foothill riparian habitats provide food, water migration and dispersal corridors, and escape, nesting and thermal cover for an abundance of wildlife. About 25 percent of the 502 California native land mammal species and subspecies are largely dependent on riparian ecosystems. Additionally, 55 species of mammals are known to use California's Central Valley riparian communities (Trapp et al. 1985). At least 21 mammal species or subspecies have been identified as being particularly vulnerable to loss of riparian habitat (Williams and Kilburn 1984). At least 50 amphibians and reptiles occur in lowland riparian systems (Brode and Bury 1985).

Wildlife: California's riparian forests support a high diversity of breeding birds (Miller 1951). In one study conducted on the Sacramento River, 147 bird species were recorded as nesters or winter visitants (Laymon 1985). The percentage of breeding individuals, which are migratory, is very high in the cottonwood-willow habitat. Humid conditions in the cottonwood-willow forest may promote more lush plant growth, higher invertebrate populations and; therefore, more available food for flycatchers, warblers and other migratory, insectivorous birds. Riparian areas support up to 10.6 times the density of migrant birds per hectare as adjacent non-riparian areas (Stevens et al. 1977). Most of these migratory birds belong to the foliage insect (47%) or air insect (34%) foraging guilds.

Grouse, quail, and other birds eat cottonwood buds and catkins (Martin et al. 1951). Bark, twigs, and leaves are eaten by ungulates and rabbits, while beavers and porcupines relish the bark and wood.

Since European settlement, the nesting riparian forest avifauna has changed significantly. Double-crested cormorants, great blue heron, great egret, Cooper's hawk, bald eagle, yellow-billed cuckoo, willow flycatcher, bell's vireo, warbling vireo, yellow warbler, and common yellow throat have been severely negatively impacted. Parasitism by brown-headed cowbirds has significantly negatively impacted willow flycatcher, Bell's vireo, warbling vireo, yellow warbler and common yellow throat. They burden other species with the task of incubating their eggs and raising their young.

Fremont's cottonwood is one of several species which constitutes the majority of the diet of beavers (*Castor canadensis*) (Stromberg 1993). Beavers, once a dominant aquatic mammal in riparian systems, have been significantly reduced in many riparian areas through trapping, shooting, in-stream flow reductions, and other factors.

Recreation: Recreational use of the riparian zone is many times that of other habitats. People are drawn to the cool, shady environment along flowing streams for camping, picnicking, hiking, birding, photography, hunting, and fishing. These areas contain water, interesting plants and animals, shade, and numerous other enjoyable features in the otherwise arid and semiarid environments.

The impact of recreational use on wildlife varies with the season and with the type, intensity and duration of use. Construction of trails, picnic tables, and docks encourages recreational use and increases conflict with wildlife. Recreational use may also reduce water quality because of proliferation of human wastes.

Livestock: Riparian ecosystems offer water, shade, and food for domestic livestock. Cattle and sheep congregate in riparian areas, particularly during hot or dry periods. Overgrazing of domestic livestock in riparian areas destroys riparian ground cover, disrupts the reproductive cycle of cottonwood trees, destabilizes streambanks, and thus increases sediment

loads to streams. At periods in the year when the soil is not too wet, the leafage, twigs and shoots of Fremont cottonwood are browsed by all domestic grazing animals and deer. The twigs are cropped especially close by sheep, goats, and deer. The browse rating for cottonwood is good to fair for goats; fair to poor for sheep and deer; poor for cattle; and useless for horses (Sampson et al. 1981).

Restoration Concerns: Many land uses in arid watersheds significantly decrease or destroy cottonwood riparian forests. Timber harvest often adversely affects flood flows, which often become larger and flashier and carry increased sediment. Buffer strips can help reduce sedimentation rates and flood velocities.

Stream diversion for irrigation may reduce surface flows to a level insufficient to maintain cottonwood vegetation. Ground water pumping lowers local and regional water tables and reduces stream flow, which can eliminate or weaken riparian vegetation.

Runoff from hardened urban watersheds is immediate and intense, and sometimes actually lowers nearby riparian water tables as it causes rapid erosion and down-cutting in stream channels.

Two introduced weedy riparian species that continue to be recommended and distributed by commercial plant nurseries are Russian olive (*Eleagnus angustifolia*) and tamarisk or salt cedar (*Tamarix chinensis*). Intensive or poorly timed livestock grazing and dam-induced changes in flood timing and magnitude often favor the survival of these introduced species and allow them to displace native species. These species are very difficult to remove from human-impacted landscapes and are more competitive than cottonwood.

Status
Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status, such as, state noxious status and wetland indicator values.

Description
Willow Family (Salicaceae). Fremont's cottonwood is a native tree growing in riparian areas near streams, rivers and wetlands in the American Southwest. Fremont's cottonwood trees range from 12 to 35 meters in height, and trunk diameter ranges from 0.30 to 1.5 meters. The bark is smooth in younger trees, becoming deeply furrowed with whitish cracked bark with age. The leaves are cordate (heart-shaped) with white veins and coarse crenate-serrate teeth on the margins. The leaves have petioles 1/2 to equal the blade length, laterally compressed near the blade which causes the leaves to flutter in the wind. These trees are dioecious, with flowers in drooping catkins, which are 4 to 14 cm long. Cottonwoods bloom from March-April. The fruit is an achene, which is attached to a silky hair, en masse looking like patches of cotton hanging from the limbs, thus the name cottonwood. The seeds are wind dispersed.

Distribution
For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site. *Populus fremontii is* distributed throughout the Southwest, extending from California eastward to Nevada, Colorado, Arizona, Texas, New Mexico, and southward into Mexico. This species occurs throughout California and is most abundant in the San Joaquin and Sacramento Valleys. According to Hickman (1993), cottonwood occurs in alluvial bottomlands and streamsides at elevations less than 2000 m.

Establishment
Adaptation: Cottonwoods dominate the riparian forests of lower terrace deposits and stabilized gravel bars. Cottonwoods are found near water. They require a bare gravel or sand substrate with adequate moisture for germination and development. Cottonwoods grow very rapidly when their roots are in contact with the permanent water table; they can grow as much as 12 to 18 feet in 3 years.

In California, common associates are valley oak (*Quercus lobata*), interior live oak (*Quercus wislizenii*), California walnut (*Juglans hindsii*), and California sycamore (*Platanus racemosa*). Box elder (*Acer negundo*), Oregon ash (*Fraxinus latifolia*), alder (*Alnus rhombifolia*), and willow (*Salix gooddingii, S. exigua, S. lasiandra, and S. laevigata*) are particularly prevalent in the subcanopy. Understory species are mostly shrubs, including elderberry (*Sambucus mexicana),* buttonbush (*Cephalanthus occidentalis),* blackberry (*Rubus* spp), and California rose (*Rosa californica*). Lianas such as poison oak (*Rhus diversiloba*) and California grape (*Vitis californica* are) are a dominant feature. Herbaceous vegetation is 1% cover except in openings where tall forbs may occur.

Typically, in California, cottonwoods and willows predominate on the immediate stream banks, whereas valley oaks are spread irregularly over the natural levees farther away from the river. In other parts of the American west, temporal gradients occur within a

location in the riparian zone. Early pioneer communities such as cottonwood/willow give way to late successional communities such as mesquite or sagebrush, often a consequence of sediment accumulation (Patten 1998). Many similarities among western riparian ecosystems exist because several dominant genera (e.g. *Populus* and *Salix* spp.) are common throughout the West, and many geomorphic and hydrologic processes that influence riparian establishment are similar.

Western riparian ecosystems have been greatly altered by human activity. Riparian forests have been reduced to fragmented, discontinuous patches because of human intervention. For example, estimates are that 70 - 90 percent of the natural riparian ecosystems in the U.S. have been lost to human activities (Warner 1979). Regional losses in these ecosystems have been estimated to exceed 98% in the Sacramento Valley in California (Smith 1977) and 95% in Arizona (Warner 1979). Many factors have contributed to these resource losses, including the following: natural resource use; urbanization; alteration of stream flows through dam construction and ground-water withdrawal; modification of biotic conditions through grazing, agriculture, and introduction of non-native species; and alteration within watersheds (Patten 1998).

Restoration: Use of an ecosystem model of riparian restoration has been used to create a functioning and self-sustaining habitat. The long term objective is to create a framework within which natural selective forces can operate to create a self-sustaining, functioning riparian habitat that not only provides habitat for a complete assemblage of riparian species, but which is also capable of long-term regeneration and recovery following natural disturbances (Baird 1989). Careful design, monitoring, and adaptive management are key components to successful restoration. The structure and dynamics of the plant community as well as species composition are designed and monitored, as well as landscape position.

Live Plant Collections: Fremont's cottonwood is a pioneer or colonizing species and a prolific seed producer (Stromberg 1993). Fremont's cottonwood propagates primarily from seed rather than asexually. Cottonwood can also sprout shoots from lateral buds when the apical meristem is prostrated by floodwaters, snapped off in high winds, or pruned by beaver, deer, or other wildlife.

Flooding is the primary disturbance in Fremont's cottonwood forests. Seed germination and tree establishment coincides with flood events. Fremont's cottonwood seed germinates only during spring and early summer. This seasonal restriction is due to: 1) early spring seed dispersal; 2) short periods (1 to 5 weeks) of seed viability; and 3) rapid seed germination (Shafroth et al. 1998). These traits help synchronize germination with high stream flows in spring. Moist soil is necessary for both germination and establishment of Fremont's cottonwood.

During this century most of the major rivers in the West were dammed. The presence of these dams changed riparian habits in ways unfavorable to cottonwood regeneration. In particular, the dams altered the timing and volume of water flowing through riparian areas. The dams reduce floodplain inundation during spring, and spring flooding is necessary for cottonwood regeneration.

Spring over-bank flows or capillary wetting of the soil surface in areas with shallow water tables, moistens the soil which is necessary for Fremont's cottonwood establishment. A number of studies have related components of the reproductive cycle of *Populus* species to floodplain site conditions produced by stream flow and associated fluvial processes. In particular, components of the annual pattern of stream flow, or annual hydrograph, are associated with specific stages of *Populus* seedling emergence and growth. These include the following: 1) flood flows that precede *Populus* seed dispersal produce suitable germination sites; 2) flow recessions following a peak expose germination sites and promote seedling root elongation; and 3) base flows supply soil moisture to meet summer and winter seedling water demand (Shafroth et al. 1998; Mahoney et al. 1998). The combination of root growth and capillary fringe defines the successful recruitment band for seedling establishment, which is usually from about 0.6 to 2 m in elevation above the late summer stream stage (Mahoney et al. 1998). The rate of stream stage decline is also critical for seedling survival and should not exceed 2.5 cm per day .

Cottonwoods grow rapidly and can reach medium/large tree height in about 20 to 25 years. Cottonwood forests could occur as rapidly as 25 - 30 year (Grenfell 1988). Shrubby riparian willow thickets may last 15 to 20 years before being overtopped and shaded out by cottonwoods. Cottonwood or willow tree habitats close to river channels that receive a good silt infusion, without major disruptive flows, tend to be self- perpetuating.

Cottonwood is susceptible to mistletoe. In certain instances cottonwood can be invasive. Its shallow root system can disrupt sidewalks or pavement.

Artificial Establishment: Fremont's cottonwood establishment from seed is difficult and seldom used. Fremont's cottonwood propagation is possible from hardwood, root cuttings and through tissue culture (Pope et al. 1990). Fremont's cottonwood establishment from transplanted containerized saplings is costly and risky unless the saplings are irrigated. The NRCS Los Lunas Plant Materials Center, in cooperation with the U.S. Fish and Wildlife Service, developed a pole planting technique for establishing Fremont's cottonwood (USDA, NRCSa). We reprint this procedure below.

"Trial planting on well adapted sites indicate more that 80% survival of cottonwood and willow poles when dormant poles are cut and planted between November and February.

It is essential to monitor the water tables at proposed planting sites for at least one year before planting. Poles planted where the water table fluctuates widely will have lower survival rates than those planted where water table is relatively stable. If groundwater monitoring shows the water level will drop more than 3 feet during the growing season (May-October), another site should be selected. Monitoring of observation wells for at least one calendar year before planting will allow better planting depth to ensure establishment.

Salt cedar (*Tamarix chinensis*) and *Arundo donax* will need to be controlled before poles are planted. However, young cottonwoods and willows can grow successfully in quite small openings in stands of salt cedar. Study of natural stands suggest they will eventually shade out the salt cedar."

In six riparian restoration projects carried out in California, competition from exotic weed species was a key factor in mortality and site failure (Baird 1989). With the addition of water, weeds grew so vigorously that plants smaller than a 5-gallon pot was out-competed. One way to avoid this was to remove the surface soil, although this has the disadvantage of removing nutrients, mycorrhizal fungi, bacteria, and insect and invertebrate populations critical to a healthy habitat. They also used a cover crop of native wildflowers, hand-broadcast over the site to aid in weed control. On wetter, heavier soils this does not seem to provide effective weed control.

There is considerable evidence that fertilizing a restoration site in southern California favors exotic weeds over native plants (Grime and Hunt 1975; Grime 1978; t. John 1987 and 1988). Inoculation with mycorrhizal fungi enabled seedlings of some species to better utilize limited supplies of both water and nutrients. Baird (1989) achieved inoculation through large (1.2 m deep by 2.8 m wide) root balls of mature trees brought in from riparian sites. Smaller, more economical soil plugs scattered throughout the site serve the same purpose. The number of soil plugs needed to ensure the establishment of soil flora is directly related to the distance of the restoration site from a similar, mature community.

Management

Howe and Knopf (1991) conclude that to ensure the survival of cottonwood riparian communities along the Rio Grande, resource managers need to implement strategies to enhance cottonwood regeneration and survival, and control the spread of exotic species.

Decadent age structures in cottonwood forest consist of stands composed of large old trees but few saplings or small trees. Several studies have implicated unregulated livestock grazing as an important cause of decadent age structures in cottonwood forests (Brotherson et al. 1983; Fenner et al. 1984; Rucks 1984; Shanfield 1984). Glinski (1977) showed a negative correlation between grazing levels and Fremont's cottonwood recruitment. Several studies showed fewer cottonwood seedlings in grazed than in non-grazed areas (Crouch 1979; Reichenbacher 1984).

Livestock grazing has widely been identified as a leading factor causing or contributing to degradation of riparian habitats in the western United States (U.S. General Accounting Office 1988; Chaney et al. 1990, Fleischner 1994, Ohmart 1996). Livestock grazing can alter vegetative structure and composition of riparian habitat. Overgrazing, especially by livestock and big game, frequently changes plant species composition and growth form, density of stands, vigor, seed production of plants, and insect production. Bull and Slovlin (1982) attributed to livestock grazing the paucity of deciduous woody vegetation that was required by some bird species along Oregon streams.

Schulz and Leininger (1991) found that bird species are differentially affected by cattle grazing in riparian areas. Livestock grazing causes the replacement of bird and mammal species requiring the vertical

vegetation structure of riparian habitat to species, which are ubiquitous in their habitat preferences. Previous heavy cattle grazing changed the bird and small mammal community composition through reduction of shrub and herbaceous cover.

Riparian zones can be managed for non-game species richness by maintaining high structural diversity of vegetation. Species that are sensitive to grazing pressure should be monitored as indicators of habitat change. Johnson (1985) pointed out the need to coordinate range and wildlife habitat management to ensure the existence of sensitive wildlife species that are negatively impacted by livestock grazing. Woody plant species increase rapidly when riparian areas are protected from livestock grazing. The woody structural component of the vegetation is essential for wildlife species that are obligate inhabitants of riparian habitat, and in providing hiding cover and stabilizing streambanks for fish habitat.

Slovlin (1984) recommended a 5-year rest from cattle grazing to re-establish healthy stands of riparian vegetation such as cottonwood and willows. Siekert et al. (1985) reported that spring grazing showed no significant changes in channel morphology, whereas summer and fall grazing did. However, even with limited seasonal grazing, all tree seedling would be eliminated. Marlow and Pogacnik (1985) recommended fencing riparian habitat, rest-rotation, light grazing (<20% forage removal), and grazing after streambanks have dried to 10% moisture.

Cultivars, Improved and Selected Materials (and area of origin)

Containerized Fremont's cottonwood samplings are available from most nurseries in the areas where adapted. We recommend using plants from the same region, elevation, climate, soil type, moisture or hydrologic regime as you are replanting.

Contact your local Natural Resources Conservation Service (formerly Soil Conservation Service) office for more information. Look in the phone book under "United States Government." The Natural Resources Conservation Service will be listed under the subheading "Department of Agriculture."

References

Auble, G.T. & M.L. Scott 1998. *Fluvial disturbance patches and cottonwood recruitment along the upper Missouri River, Montana*. Wetland 18(4):546-556.

Baird, Kathryn 1989. *High quality restoration of riparian ecosystems*. Restoration and Management Notes 7(2):60-64.

Beier, P., & R.H. Barret 1987. *Beaver habitat use and impact in the Truckee River Basin, California USA*. J. Wildlife Management 51:794-799.

Brode, J. & R.B. Bury 1984. *The importance of riparian systems to amphibians and reptiles.* Pages 30 – 35, IN R.E. Warner and K. Hendrix, eds. California riparian systems; ecology, conservation, and productive management. University of California Press, Berkeley, California.

Brotherson, J.D., S.R. Rushford, W.E. Evenson, & C. Morden 1983. *Population dynamics and age relationships of eight trees in Navajo National Monument, Arizona*. J. Range Management 36: 250-256.

Bull, E.L. & J.N. Slovlen 1982. *Relationships between avifauna and streamside vegetation*. Trans. North. Am. Wildl. Nat. Resour. Conf. 47: 496-506.

Cemments, C. 1991. *Beavers and riparian systems*. Rangelands 13:277-279.

Chaney, E., W. Elmore, & W.S. Platts 1990. *Livestock grazing on western riparian areas*. U.S. Environmental Protection Agency, Region 8, Denver, Colorado.

Conard, S.G., R.L. MacDonald & R.F. Holland. 1977. *Riparian begetation and flora of the Sacramento Valley*. pp. 47-56 IN: Anne Sand (ed.). Riparian Forests in California. Their Ecology and Conservation.

Crouch, G.L. 1979. *Long-term changes in cottonwoods on a grazed and ungrazed plains bottomland in Northeastern Colorado*. USDA, Forest Service Research Note RM 370: 1-4.

Ellis, L.M. 1994. *Bird use of salt cedar and cottonwoods on a grazed and ungrazed plains bottomland in northeastern Colorado*. USDA, Forest Service Research Note RM-370:1-4.

Farley, G.H., L.M. Ellis, J.N. Stuart, & N.J. Scott, Jr. 1994. *Avian species richness in different-aged stands of riparian forest along the middle Rio Grande, New Mexico*. Conservation Biology 8:1098-1108.

Fenner, P.W., W.W. Brady, & D.R. Patton 1984. *Observations on seed and seedlings of Fremont's cottonwood*. Desert Plants 6:55-58.

Fleishner, T.L. 1994. *Ecological costs of livestock grazing in western North America*. Conservation Biology 8:629-644.

Gaines, D. 1977. *The valley riparian forests of California: Their importance to bird populations.* pp. 57-86 IN: Anne Sand (ed.). Riparian Forests in California. Their Ecology and Conservation.

Glinski, R.L. 1977. *Regeneration and distribution of sycamore and cottonwood trees along Sonoita Creek, Santa Cruz County, Arizona*. USDA, Forest Service General Technical Report RM-43:116-123.

Grenfell, W.E., Jr. 1988. *Valley foothill riparian.* IN: Kenneth A. Mayer and William F. Laudenslayer, Jr., *A guide To wildlife habitats of California*. USDA, Pacific SW Forest and Range Experiment Station, California Dept. of Fish and Game, PG and E, and USDA Forest Service Region 5. Page 86 - 87.

Grime, J.P. 1978. *Interpretation of small-scale patterns in the distribution of plant species in space and time*. IN: A.J.H. Freysen and J.W. Woldendorp (eds.) Structure and Functioning of Plant Populations. Elsevier, North-Holland, Amsterdam, New York. pp. 101-104.

Grime, J.P. and R. Hunt 1975. *Relative growth rate: its range and adaptive significance in a local flora*. J. Ecology 63: 393-422.

Hickman, J.C. (ed.) 1993. *The Jepson manual. Higher plants of California*. University of California Press. 1400 pp.

Howe, W.H. & R.L. Knopf 1991. *On the imminent decline of Rio Grande cottonwoods in central New Mexico*. The Southwestern Naturalist 36:28-224.

Johnson, R.R. & C.W. Lowe 1985. *On the development of riparian ecology*. Pp 112-116 IN: R.R. Johnson, C.D. Ziebell, D.R. Patten, P.F. Folliot, and R.H. Hamre, technical coordinators. Riparian ecosystems and their management: Reconciling conflicting uses. General Technical Report RM-120. U.S. Forest Service, Fort Collins, Colorado.

Knopf, F.I. and F.B. Samson 1994. *Scale perspectives on avian diversity in western riparian ecosystems*. Conservation Biology 8(3):669-676.

Laymon, S.A. 1984. *Riparian bird community structure and dynamics: Dog Island, Red Bluff, California*. Pages 587-597 IN: R.E. Warner and K. Hendrix, eds. *California riparian systems; ecology, conservation, and productive management.* Univ. of California Press, Berkeley, California.

Mahoney, J.M. & S.B. Rood 1998. *Streamflow requirements for cottonwood seedling recruitment - an integrative model*. Wetlands 18(4): 634-645.

Marlow, C.B. & T.M. Pogacnik 1985. *Time of grazing and cattle-induced damage to streambanks*. Pages 279-284. IN: Johnson, R.R., C.D. Ziebell, D.R. Patton, P.F. Ffolliott, and R.H. Hamre (Tech. Coords.) *Riparian ecosystems and their management: Reconciling conflicting uses.* Proc. First North Am. Riparian Conf. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-120. 523 pp..

Martin, A.C., H.S. Zim, & A.L. Nelson 1951. *American wildlife and plants: A guide to wildlife food habits*. Dover Publications, Inc. New York. 500 pp.

McGinley, M.A. & T.G. Whitham 1985. *Central place foraging by beavers (Castor canadensis): A test of foraging predictions and the impact of selective feeding on the growth form of cottonwoods (Populus fremontii)*. Oecologia 66: 558-562.

Michny, F.J., D. Boos & F. Wernette 1974. *Riparian habitats and avian densities along the Sacramento River, California*. State of California Dept. of Fish and Game. 23 pp.

Moore, M. 1979. *Medicinal plants of the Mountain West*. Museum of New Mexico Press. 200 pp.

Ohmart, R.D. 1996. *Historical and present impacts of livestock grazing on fish and wildlife resources in western riparian habitats*. pp. 245-279. IN: P.R. Karausman (ed.) Rangeland Wildlife. Society for Range Management, Denver, Colorado.

Ohmart, R.D. & B.W. Anderson 1986. *Riparian habitat. In inventory and monitoring of wildlife habitat*. Bureau of Land Management. pp 169-199.

Patten, D.T. 1998. *Riparian ecosystems of semi-arid North America: diversity and human impacts*. Wetland 18(4): 498-512.

Pope, D.P., J.H. Brock, and R.A. Backhaus 1990. *Vegetative propagation of key Southwestern woody riparian species*. Desert Plants 10: 91-95.

Reichenbacher, F.W. 1984. *Ecology and evolution of Southwestern riparian plant communities*. Desert Plants 6:15-22.

Roberts, W.G, J.G. Howe & J. Major 1977. *A survey of riparian forest flora and fauna in California*. Pages 3-20. IN: Anne Sand (ed.). *Riparian forests in California*. Their Ecology and Conservation.

Robichaux, Robert 1977. *Geologic history of the riparian forests of California*. Pages 21-34. IN: Anne Sand (ed.). Riparian Forests in California. Their Ecology and Conservation..

Rucks, M.G. 1984. *Composition and trend of riparian vegetation on five perennial streams in southeastern Arizona*. pp 97-107. IN: R.E. Warner and K.M. Hendrix (eds.). *California riparian systems: Ecology, conservation, andpProductive management*. University of California Press, Berkeley, California

St. John, T.V. 1987. *Mineral acquisition in native plants*. Pages 529-536. IN: Elias, Thomas S. (ed.) *Conservation and management of rare and endangered plants*. California Native Plant Society, Sacramento, California.

St. John, T.V. 1988. *Soil disturbance and the mineral nutrient of native plants*. Pages 34-39. IN: Rieger J.P. and B.K. Williams (eds.) *Proceedings of the second native plant revegetation symposium*. San Diego, California.

Sampson, A.W. & B.S. Jespersen 1981. *California range brushlands and browse plants*. Division of Agricultural Sciences, University of California.

Schulz, T.T. & W.C. Leininger 1991. *Nongame wildlife communities in grazed and ungrazed montane riparian sites*. Great Basin Naturalist 51(3):286-292.

Schulz, T.T. & W.C. Leininger 1990. *Differences in riparian vegetation structure between grazed areas and exclosures*. Journal of Range Management 43(4): 295-299.

Shafroth, P.B., G.T. Auble, J.C. Stromberg, & D.T. Patten 1998. *Establishment of woody riparian vegetation in relation to annual patterns of streamflow, Bill Williams River, Arizona*. Wetlands (18)4: 577-590.

Shanefield, A.N. 1984. *Alder, cottonwood, and sycamore distribution and regeneration along the Nacimiento River, California*. pp 196-201. IN: R.E. Warner and K.M. Hendrix (eds.). *California riparian systems: Ecology, conservation, and productive management*. University of California Press, Berkeley.

Siekert, R.E., Q.D. Skinner, M.A. Skinner, M.A. Smith, J.L. Dodd, & J.D. Rodgers 1985. *Channel response of an ephemeral stream in Wyoming to selected grazing treatments*. Pages 276-278. IN: Johnson, R.R., C.D. Ziebell, D.R. Patton, P.F. Folliott, and R.H. Hamre (Tech. coords.). *Riparian ecosystems and their management: Reconciling conflicting uses*. Proc. First North Am. Riparian Conf. USDA, For. Serv. Gen. Tech. Rep. RM-120. 523 pp.

Slovlin, J.M. 1984. *Impact of grazing on wetlands and riparian habitat: a review of our knowledge*. pp. 1001-1104. IN: *Developing strategies for rangeland management*. Nat. Res. Counc. Natl. Acad. Sci. Westview Press, Boulder, Colorado.

Stromberg, J.C. 1998. *Functional equivalency of saltcedar (Tamarix chinensis) and Fremont cottonwood (Populus fremontii) along a free-flowing river*. Wetlands 18(4): 675-686.

Smith, F. 1977. *A short review of the status of riparian forests in California*. Pp. 1-2. IN: Anne Sand (ed.). Riparian Forests in California. Their Ecology and Conservation.

Stevens, L.E., B.T. Brown, J.M. Simpson, & R.R. Johnson 1977. *The importance of riparian habitat to migrating birds*. pp. 156-164. IN: Johnson, R.R. and D.A. Jones (tech. coords.). *Importance, preservation and management of riparian habitat: a symposium*. USDA Forest Service Gen. Tech. Report RM-43. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 217 pp.

Strike, S.S. 1994. *Ethnobotany of the California Indians. Volume 2. Aboriginal Uses of California's Indigenous Plants*. Koelz Scientific Books, USA/Germany. 210 pp.

Stromberg, J.C. 1993. *Fremont cottonwood-goodding willow riparian forest: a review of their ecology, threats, and recovery potential*. J. Arizona-Nevada Acad. Sci. 27:97-110.

Thompson, K. 1977. *Riparian forests of the Sacramento Valley, California*. Pp. 35-38. IN: Anne Sand (ed.). *Riparian forests in California*. Their Ecology and Conservation.

Trapp, G.R., G.L. Linck & E.D. Whisler 1984. *The status of ecological research on the mammal fauna of*

California's central valley riparian communities. Pages 942-949. IN: R.E. Warner and K. Hendrix, eds. California riparian systems; ecology, conservation, and productive management. University of California Press, Berkeley, California.

USDA, NRCS 1999. *The PLANTS database*. National Plant Data Center, Baton Rouge, Louisiana. <http://plants.usda.gov>. Version: 05APR1999.

U. S. General Accounting Office 1988. *Public rangelands: some riparian areas restored but widespread improvement will be slow*. GAO/RCED-88-01, Washington, D.C.

Warner, R.E. & K.M. Hendrix 1979. *California riparian systems: Ecology, conservation, and productive management*. University of California Press, Berkeley, California.

Williams, D.F. & K.S. Kilburn 1984. *Sensitive, threatened, and endangered mammals of riparian and other wetland communities in California*. pp. 950-956. IN: Warner, R.E., and K.E. Hendrix (eds.), *California riparian systems: ecology, conservation, and productive management*. University of California Press, Berkeley, California. 1035 pp.

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Edited: 05dec00 jsp; 29may03 ahv; 060808 jsp

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