

Ecology and Management of Saltcedar (*Tamarix ramosissima*, *T. chinensis* and *T. ramosissima* x *T. chinensis* hybrids)

By

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Figure 1. A large-scale infestation of saltcedar (middle-ground of photo) with fall foliage on Hell Creek in the draw-down zone on Fort Peck Reservoir.

Abstract

Saltcedar, also known by the common name tamarisk (*Tamarix* spp; Tamaricaceae taxonomic family), is a long-lived, invasive deciduous shrub or small tree intentionally introduced to North America from Eurasia for ornamental, wind break, and erosion mitigating purposes in the early 1800s. The spread of this species, both vegetatively from submerged stems and root sprouts, and sexually by seed, is optimized in riparian habitats. Saltcedar escaped controlled cultivation by the late 1800s with weedy populations reported in Montana since the 1960s. Until recent discoveries of saltcedar populations in North Dakota, Montana infestations represented the northern-most Great Plains distribution of this species in North America. Recent surveys indicate that in Montana, saltcedar has established on the Yellowstone River east of Big Timber; on the Bighorn River from Wyoming to the Yellowstone River; on the Powder River from Wyoming to the Yellowstone

River; along the shoreline of Fort Peck reservoir (see Figure 1), and on the Musselshell River from Ryegate to Fort Peck Reservoir (Pearce and Smith 2003). It is also found outside riparian settings, including along irrigation ditches, stock ponds, reservoirs, and roadside borrow pits and establishes opportunistically on available moist, bare soil. Saltcedar has been planted as an ornamental throughout Montana, with known specimens or stands reported from Missoula, Kalispell, Polson, near Canyon Ferry Reservoir, Marias, Malta, and Glasgow. Unintentional introductions and existing, intentional horticultural plantings position this weed to potentially invade much of Montana's water resources.

Basal bark treatment using 30% triclopyr (Garlon 4® or Remedy®) in an oil carrier is, to date, the most effective herbicidal control of saltcedar plants in Montana. To be effective, the entire circumference of each stem, from ground level to a height of 18 inches needs to be evenly coated with the spray solution. It may take one to two seasons for the shrub to die using a single application. Individual plants can also be treated by severing the stem and applying triclopyr or glyphosate (Roundup®) within one hour of cutting to the remaining stump. Cut stems should be burned, chipped for fuel, or disposed of to prevent sprouting. Extensive, solid canopy infestations of saltcedar with little or no native vegetation present can be treated with an aerially-applied imazapyr (Habitat®) or imazapyr/glyphosate mix foliar spray. Although releases of the biological control leaf beetle *Diorhabda elongata* have been successful in defoliating saltcedar and reducing populations on the Big Horn River, the beetles have not yet established to any significant degree along Fort Peck Reservoir.

Biology and Identification

There are no known native North American species in the four total genera, including *Tamarix*, belonging to the Tamaricaceae family. The name *Tamarix* is derived from the Tamaris River in Spain. *Tamarix ramosissima*, *T. chinensis*, and their hybrids are the most common saltcedar shrubs invading Montana riverways and lakeshores of the 8 to 12 *Tamarix* species known to have established in the United States. These species and hybrids originated in cold deserts from eastern Turkey to Korea, where winters are severe and frost-free growing seasons range from 60 to 120 days. Saltcedar's tolerance of climatic extremes suggests that its expansion throughout Montana will not be limited by our characteristic cold winters, short growing seasons, and periodic droughts. Other *Tamarix* species used for horticultural planting may not be invasive. A recent DNA study of 32 ornamental specimens and 182 saltcedar plants that had escaped cultivation (or 'wild' plants/populations) in Montana found that wild saltcedar populations originated from other wild plants and not from ornamentals. The results also suggest that ornamental plants can contribute genetic material to an invasion or re-establishment of wild populations after wild plants are removed.

Seeds. Saltcedar will produce seeds throughout the growing season when soil moisture is sufficient to maintain active plant metabolism. Plants generally reach reproductive maturity in three years; large saltcedars produce several hundred thousand seeds annually. The extremely small seeds (0.17 mm diameter, 0.45 mm long) are contained within capsules. Each seed has an apical pappus, a tuft of hairs on the tip of the seed coat, which aids in wind and water dispersal (see Figure 2). Saltcedar seeds typically germinate at very high rates (up to 100%), but due to their extreme susceptibility to desiccation, remain viable only up to 45 days under ideal summer conditions and 130 days under ideal winter seedbank conditions. Seeds have been kept viable in laboratory storage for over 40 weeks. Once they come into contact with sufficient moisture, the seeds quickly germinate and where abundant produce extensive seedling carpets of over 800

seedlings/m². Seedling survival of the first year is less than 10 percent. Seedlings can withstand total inundation by water for up to four weeks.

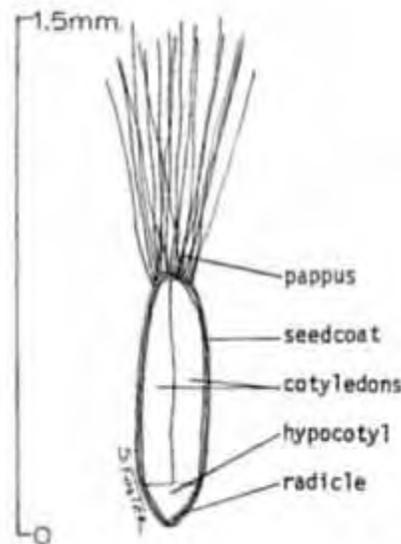


Figure 2. Anatomy of a *Tamarix chinensis* seed.

Stems. Saltcedar stems are slender and often re-curved or arching (see Figure 3). The bark of young branches is smooth, reddish-brown, and after leaves fall, is distinctively marked with light-colored leaf scars. Older branches and stems become brownish-purple, ridged, and furrowed. Stems can grow up to 20 feet (4.5 m) tall. In Montana, stems often die back to the ground over winter and re-sprout from root crowns forming multiple stemmed plants that are generally less than 10 feet (3 m) tall. Saltcedar stems are capable of rapid growth and can grow up to 10 to 13 feet (3-4 m) in one season. Mature plants and root crowns can survive 70 and 98 days of flooding, respectively. Plants are short-lived relative to other shrubs and trees, and are said to have a total life expectancy of 20 years.



Figure 3. Flowering saltcedar in October near Fort Peck Reservoir showing the pink colored flowers, re-curved red stems, and grey-green foliage.

Leaves. The leaves of saltcedar are scale-like, small (about 1/16-inch or 1.5 mm long) and overlap each other along the stem, with an appearance similar to cedar or juniper leaves. They are grey-green in the summer and turn golden in the fall (see Figure 3). Buds break in early spring. Saltcedar species in Montana are deciduous, dropping their leaves in October. Salt-secreting glands are located on the underside of the leaves. On saline sites, leaves can become glazed with salt crystals secreted by the plant from water taken up through the roots to compensate for salty growing conditions. Salt that leaches from leaf litter can build up in the upper 2 inches (5 cm) of the soil profile and prevent the establishment of other plant species. Saltcedar prefers full sun and does not tolerate shade from overtopping cottonwood and willow species.



Figure 4. *Tamarix chinensis* flowers.

Flowers. The flowers of saltcedar are pink to white, small (3-5 mm across), with five distinct sepals and five distinct petals. They are clustered in showy compound catkin-like racemes (see Figure 4). Saltcedar typically blooms from May to September, although flowers have been observed blooming into October. Plants can flower in the first year after establishment, although viable seed is not produced until the third year of growth. Fruits mature to form capsules that contain thousands of seeds.

Roots. Saltcedar grows an extensive root system with a strong, deep taproot that enables access to groundwater. Root morphology is adaptable depending on water table and soil conditions. Adventitious roots that grow from near the vascular cambium of stems and branches allow severed stems to sprout and form separate plants. Stems can grow from roots and root crowns. Root growth is rapid. In one year, lateral roots can grow up to 20 feet (6 m) and the primary root can grow 11 feet (3.5 m) long.

Habitat. Saltcedar is an early seral species with specific adaptations to flood and drought conditions. Although it requires moist, barren soil for germination, mature plants are facultative phreatophytes capable of drawing adequate water supplies, as circumstances demand, from either surface soil moisture or groundwater. Mature stands of saltcedar consume vast amounts of groundwater; neighboring obligate phreatophyte species such as cottonwoods and willows cannot survive when the groundwater level drops below that of their roots for any sustained period. These adaptations allow saltcedar to successfully colonize, establish and dominate along rivers; streams, lakes, irrigation ditches and reservoirs (see Figure 1). Also, in mixed stands of native willow and saltcedar or cottonwood and saltcedar, beaver select native species over saltcedar by a ratio of 10:1, giving saltcedar a further competitive advantage over the native species. Older plants are generally found along the high water mark (see Figure 5) while flooding zones are more likely to be populated by seedling plants (see Figure 6). This distribution reflects seasonal extremes in surface water levels, and is likely due to saltcedar's inability to survive inundation for a period of three months or longer. Mechanical disturbances such as riverbank scouring that accompany natural river flooding cycles are thought to inhibit the buildup of saltcedar populations (see Figures 5 and 6). Saltcedar has also been reported in roadside borrow pits where bare soil and standing water from roadbed drainage provides suitable conditions for establishment.



Figure 5. A saltcedar bush with fall foliage established above the disturbance zone on the Musselshell River. Seedling saltcedar plants can be seen in the disturbance zone in the background.

Although saltcedar ecology is similar to that of cottonwood, it has a longer seed production and dispersal period. This allows it to take advantage of floods or flow releases of dammed river systems that occur throughout the summer. Saltcedar is also more deeply rooted than native species and more tolerant of salinity.



Figure 6. Saltcedar seedlings (rust color) in the fall lining the water edge along the Musselshell River. Cottonwood seedlings (yellow leaves) are higher up on the bank.

Economic importance. Impacts associated with saltcedar include reduced native plant and small mammal diversity, altered avian composition in riparian communities, increased evapotranspiration-mediated water loss from riparian systems (although research suggests losses similar to native species use), and altered stream hydrology. Nationwide, millions of dollars are spent each year to control saltcedar and restore native plants to riparian areas where large scale saltcedar populations have been removed.

Spread. The highly invasive nature of saltcedar is thought to be due to its high regenerative capability through crown and root sprouts, profuse seed production, and high rates of seedling establishment. Short- and long-distance dispersal mechanisms include wind and waterways. It is believed that seeds from horticultural plantings in yards can be carried by wind to nearby waterways. On the Musselshell River, saltcedar has spread at estimated rates of 12 and 1.25 miles per year downstream and upstream, respectively. Saltcedar is also spread when seeds on boats, in water ballast, on boat trailers, and on fishermen's waders are transported from one body of water to another.

Management Alternatives

Herbicide^{1/}

Basal bark treatment. For scattered individual shrubs (see Figure 7), a single low volume basal bark treatment using a 30% solution of triclopyr (Garlon 4® or Remedy®) mixed with a commercially available basal bark oil, number one or two diesel fuel, or kerosene is highly effective and practical. Spray until thoroughly wet, but not to the point of runoff, the entire

^{1/}Any mention of products in this publication does not constitute a recommendation by the NRCS. It is a violation of Federal law to use herbicides in a manner inconsistent with their labeling.

circumference of all stems including the root collar area from the ground up to 18 inches. This treatment can be applied anytime including winter, except when the bark is frozen, when snow or water prevent spraying to the ground line, or when the stems are submerged in water. It may take one or two years for the herbicide to move throughout the plant, especially the roots, and for plants to die. Triclopyr is labeled for non-irrigation ditch banks, seasonally dry wetlands, and transitional areas between uplands and lowlands where surface water is not present except in uneven isolated pockets. It cannot be sprayed on open water or irrigation ditch banks currently used to carry irrigation water. Read and follow all label instructions.



Figure 7. Basal bark herbicide treatment is the most practical control for multiple stem saltcedar plants such as these established along the high water mark on Fort Peck Reservoir.

Cut stump treatment. Where it is practical to cut saltcedar stems using a saw or loppers, applying triclopyr (Garlon 4®, Garlon 3®, or Remedy®) or glyphosate (Roundup®) directly to the cut stem up to an hour after cutting will prevent re-sprouting. Herbicide should be applied undiluted to wet the wood and surrounding cambium around the entire circumference of the cut stump. Cut stump treatments can be applied any time of year except when stems are frozen or when plants are under water stress during late summer. To prevent regeneration from sprouting, cut, and then dispose of stems and branches by burning or chipping for fuel.

Foliar application. Foliar herbicide application to control saltcedar is most practical where there is a dense stand of saltcedar with a solid canopy or where basal bark or cut stem treatments are not practical. Imazapyr (Habitat®) at a rate of 2 quarts product per acre or imazapyr plus glyphosate (1 qt. + 1 qt./acre) are the most effective foliar sprays for controlling saltcedar. A non-ionic surfactant in the spray solution at 0.25% by volume is needed when using imazapyr. The best control is obtained when applied in late summer or early fall (August and September). For spot treatment, a 1% solution of imazapyr with surfactant can be used. Imazapyr is labeled

for riparian use and can be sprayed directly in water. However, there are many restrictions for water applications and the label instructions should be carefully followed.

Table 1. Chemical and product name, recommended application rate, soil residual half life, and eco-toxicity of herbicides commonly used to control saltcedar.

Chemical name	Product name	Rate	Half life-days	Eco-toxicity (LC ₅₀ /EC ₅₀) for aquatic organisms
imazapyr	Habitat®, Arsenal®	1.5% v/v with 1% MSO in oil carrier.	31-233	>100 mg/L
tryclopyr	Garlon 4®, Remedy®	25-33% v/v in oil carrier.	14-180	0.1 - 1 mg/L
glyphosate	Rodeo®, Roundup Original®	2% v/v with ½% non-ionic surfactant.	47	3 - 11 mg/L

Grazing. Cattle, sheep and goats will graze saltcedar, but it is considered nutritionally poor. Cattle only eat young sprouts early in the spring. However, livestock tend to select cottonwood and willow over saltcedar. Aggressive grazing by confined sheep or goats may provide some control, but suckering may increase the density of the canopy. Boer goats have been used to graze saltcedar. In one field study conducted in Utah, goats grazing along a shoreline four times throughout the summer reduced the biomass of saltcedar. This type of intensive grazing has been recommended as a treatment to reduce the amount of foliar herbicide applied. Herbicide effectiveness increased when herbicides were applied after the grazing treatment.

Biological Control. Investigations to determine the efficacy and feasibility of saltcedar biological control were initiated in 1987 by USDA-ARS researchers in Temple, Texas. Biological control of saltcedar (like other noxious weeds) is appealing because it represents a highly selective, low cost, sustainable management approach when effective agents successfully establish, proliferate, and efficiently reduce target populations. However, the release of saltcedar bio-control agents remains somewhat restricted due to the perceived threat posed to indigenous wildlife, specifically the nesting resources of a threatened southwestern sub-species of the willow flycatcher (*Empidonax traillii extimus*). The willow flycatcher became habituated to nesting in saltcedar in locations where cottonwood, the flycatcher's conventional nesting tree, had become locally extinct. Biological control is a desirable control strategy for saltcedar because target removal is more gradual and highly selective than other methods - this approach is thought to be a good way to facilitate the re-establishment and availability of non-saltcedar alternatives for wildlife food and shelter resources.

The saltcedar leaf feeding beetle, *Diorhabda elongata* Brullé subspecies *deserticola* Chen (Coleoptera: Chrysomelidae), originates from northwestern China and eastern Kazakhstan. Larval and adult stages of the beetle feed primarily on saltcedar leaves; occasional feeding on the epidermis of twigs and first-year shoots will also cause the tip of the twig/shoot and associated foliage to desiccate and fall off. The beetles prefer to feed on young foliage over mature leaves.

Diorhabda is reported to have successfully established and controlled saltcedar in Lovelock, NV. Preliminary results suggest that *Diorhabda* can defoliate up to 162 ha of saltcedar three years after initial release under ideal conditions. However, successful establishment and control of saltcedar in Montana has been complicated by a number of factors. Early indications suggest that either biotic interference (predation) or environmental incompatibility (drought or springtime flooding) may be the primary factors impeding Montana releases of this agent, especially on saltcedar infestations along the Fort Peck shoreline.

This agent is not yet widely available for release in Montana. Current efforts are underway to establish insectaries throughout saltcedar-affected areas for the purpose of fostering the rapid growth of *Diarhabda* populations so that surplus agents can be collected for local re-distribution. Currently, any non-research releases of this agent in Montana must be made and annually monitored according to protocols developed by USDA-APHIS-PPQ.

Mechanical. Mechanical treatments including plowing, mowing, cutting, chaining and burning are not effective when applied alone because saltcedar readily re-sprouts from roots, root crowns, and stems after treatment. Follow-up treatments are needed to remove root crowns and new growth.

Flooding. Where water levels can be controlled in reservoirs and stock ponds, prolonged inundation for over three months may reduce saltcedar populations. Cottonwoods and other native vegetation are also killed by prolonged flooding and re-vegetation of desirable plants may be needed to prevent re-establishment of saltcedar or other weeds after flooding. Natural flooding cycles on free-flowing waterways are believed to reduce saltcedar establishment by scouring establishment sites free of seedlings, washing away deposits of accumulated salts, and clearing large accumulations of the highly saline leaf litter. Manipulating dam releases to restore natural flows on controlled waterways may favor native riparian plant establishment over establishment or re-establishment of saltcedar. Saltcedar seedlings five weeks old or younger are more susceptible to summer flooding than older saltcedar plants.

Re-vegetation. Re-vegetation of riparian sites can be used to prevent saltcedar establishment and to reduce re-establishment after control procedures are applied because saltcedar is not shade tolerant. To prevent saltcedar invasion, native perennial plants adapted to site hydrologic conditions should be established to minimize exposed bare soil during periods of moisture availability. To reduce re-establishment of saltcedar from root sprouts, trees, shrubs, and herbaceous plants should be used to provide an inhospitable shading canopy. Guidance on seeding and planting techniques can be found in the NRCS Field Office Technical Guide (FOTG), Section IV, Practice Standards and Specifications:

Riparian Forest Buffer (Code 391) and Riparian Herbaceous Cover (Code 390)

State and area resource specialists can help determine the most appropriate, site-specific species mix, timing of seeding or planting, and seeding or planting methods. Where herbicides have been applied, chemical carryover should be assessed prior to planting permanent vegetation.

Integrated Pest Management

Integrated pest management uses a combination of [cultural](#), [mechanical or physical](#), [biological](#), and [chemical](#) pest control methods selected to optimize control efficacy while minimizing associated risks to human health, property, and the environment. Statewide, saltcedar can be considered in the early phase of invasion in Montana. Management strategies most appropriate for early phase invasions are prevention, early detection and rapid response, and containment, and should be applied according to local saltcedar population characteristics.

Detection and Monitoring. In riparian areas not infested with saltcedar, regular surveys (every three years) for new saltcedar populations should be planned. Intensive surveys should be conducted within 25 miles of known individuals and populations. An early inspection should be made before or at flowering, to identify mature plants and initiate control before seeds set and have an opportunity to disperse. Additional inspections made later in the growing season will identify seedlings that have developed from seed set in the current year. Individual seedlings should be considered high-priority targets for fall eradication programs, while areas with concentrated seedling populations should be conscientiously monitored to ensure that a significant long-term infestation does not develop. Records of plant densities by age stage and GPS location should be maintained and updated at each inspection. In addition, horticultural saltcedar plantings should be tested for potential invasiveness.

Prioritizing Control Efforts. Individual plants and populations detected along irrigation ditch banks should be prioritized for eradication using basal bark or cut stem treatments (follow label instructions regarding restrictions for herbicide application on active irrigation ditches). Cut stem treatments integrate mechanical and chemical control, and have been proven to be highly effective under many common saltcedar infestation scenarios. Saltcedar populations growing on stock pond banks should also be prioritized for control. Basal bark or cut stem treatment should be used on older, reproductive plants. Prolonged flooding followed by re-vegetation with flood-tolerant species is most effective on the seedling demographic in the drawdown zone. On free-flowing waterways with natural flood cycles, control should target reproductive individuals and populations using basal bark or cut stem treatments. The seedling demographic within the flood zone should be monitored for potential natural control by the scouring action of floods (see Figure 8). Large-scale populations should be contained by early detection of satellite infestations within a 25 mile radius of the parent population and rapid response using herbicidal control. As they become more widely available, *Diorhabda* beetles should be released within large-scale saltcedar infestations because the beetles function as a chronic drain on the weed's fitness and invasiveness. Large-scale infestations populated by plants with large diameter stems could be managed using the cut-stem treatment; stems should be chipped and used as a fuel source for heating or otherwise safely disposed of.



Figure 8. Saltcedar seedlings on a gravel bar in the Yellowstone River. Seedling populations are susceptible to destruction by flood scouring. Reproductive plants are mixed with willows and cottonwoods above the flood zone.

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