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Field Guide for Managing Saltcedar in the Southwest

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Southwestern Region

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Cover Photos

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Saltcedar (*Tamarix* spp.)

Tamarisk family (Tamaricaceae)

Saltcedar is an invasive plant common to southwestern states and has been listed in New Mexico as a noxious weed. This field guide serves as the U.S. Forest Service's recommendations for management of saltcedar in forests, woodlands, rangelands, and riparian areas associated with its Southwestern Region. The Southwestern Region covers Arizona and New Mexico, which together have 11 national forests. The Region also includes four national grasslands located in northeastern New Mexico, western Oklahoma, and the Texas panhandle.

Description

Saltcedar (synonyms: salt cedar, salt-cedar, tamarix, tamarisk) is an invasive plant in the Tamaricaceae, which has 4 genera with 54 species worldwide. Saltcedar taxonomy is somewhat disputed, and scientific writers can use nomenclatures that are different from each other. The common names of saltcedar and tamarix have been applied to many species of the *Tamarix* genus; however, these terms usually refer to *T. chinensis* or *T. ramosissima* in the southwestern United States. Although these species can hybridize, many taxonomists consider them to be the same species since they are indistinguishable from one another; in which case, *T. chinensis* is the more appropriate taxonomic name.

Growth Characteristics

- Perennial, deciduous, small shrub or tree, 5 to 25 feet tall.
- Small, scaly, bluish-green, flat leaves resemble evergreen "needles."
- Reddish-brown branches; smooth, slender, and flexible but snap off easily; bark furrowed and ridged with age.
- Rooting system with shallow, lateral rhizomes and deep roots that penetrate to a depth of 30 feet or more.
- Flowers March through October; many tiny, pink-to-white flowers with five petals.
- Extremely small, short-lived seeds resembling pepper; seed tips with tufts of hair that aid in wind and animal dispersal.
- Reproduces by seed and sprouting which commonly occurs from disturbed root crowns or from stems or roots lying near the soil surface.
- Shade intolerant.

Ecology

Impacts/threats

Saltcedar alters the ecology and hydrology of native riparian systems and generally diminishes habitat quality; however, saltcedar can provide nesting sites for birds and may be an important pollen source for honeybees. Leaf drop from saltcedar increases soil salinity and lessens microbial activity. Evapotranspiration rates for saltcedar are higher than native riparian species which may reduce streamflows. Soils become drier under dense saltcedar stands.

Location

Saltcedar is found throughout most of the United States except for parts of New England, Middle Atlantic States, and the Midwest. It is common along disturbed and undisturbed streams, riverbanks, desert springs, flood plains, drainages, and irrigation waterways.

Spread

Rapid colonization and expansion of saltcedar most commonly occurs with flood events or water inundation. Seeds float on water and require damp soil moisture for germination and seedling survival.

Invasive Features

Saltcedar can reproduce by both seed and sprouting. The saltcedar root system is dominated by a root crown that lies 12 to 18 inches below the soil surface. Buds on the root crown and shallow lateral roots will sprout new stems rapidly when aerial portions of the plant are removed.

Management

Control and restoration of saltcedar infested areas over the long term requires an integrated management approach that involves more than one control method. These methods are based either on individual plant treatment (IPT) or stand treatment. Control methods that target and destroy the root system are the only techniques that provide complete control of saltcedar. Methods that damage or remove aboveground growth without destroying the root crown will suppress saltcedar but will not kill the plant. Aboveground control methods include fire, mowing, grazing with goats or other livestock, defoliating herbicides, etc.

Table 1. Management options*

Site	Site Factor	Physical Control	Cultural Control	Biological Control	Chemical Control
Streambanks or narrow riparian corridors	Accessibility may be limited.	Excavation, grubbing	NA	Grazing with goats. Tamarisk beetles *(Diorhabda carinulata)* are currently restricted as biological control agents for saltcedar (see "Biological Control" section).	Cut stump method, individual plant treatment (IPT) foliage spray, aerial application of herbicide by helicopter.
Flood plains, valley bottoms, or other flat areas	Emergent saltcedar seedlings on tillable land.	Shallow disking	Prolonged flooding	Tamarisk beetles *(Diorhabda carinulata)* are currently restricted as biological control agents for saltcedar (see "Biological Control" section).	Low volume broadcast spray.
	Sparse to moderate stands of young saltcedar or regrowth.	Excavation, grubbing	NA	Grazing with goats. Tamarisk beetles *(Diorhabda carinulata)* are currently restricted as biological control agents for saltcedar (see "Biological Control" section).	IPT or broadcast foliage spray.
	Open saltcedar stands; goal is to suppress.	Mowing, shredding, mulching, scraping, prescribed burning.	NA	Same as above.	Sublethal herbicide application that defoliates but does not kill the tree. To prevent developing herbicide resistance, avoid repeated applications with the same herbicide.
	Open saltcedar stands; goal is to eradicate or provide high mortality.	Excavation, grubbing, root plowing/raking.	NA	Same as above.	Targeted application with a lethal herbicide. Methods include cut-stump, foliage spray, and aerial herbicide application.
	Old saltcedar growth in dense, uniform stands.	Large-scale clearing with root plowing/raking.	NA	Same as above.	Aerial herbicide application by helicopter or fixed-wing aircraft.
Wilderness and other natural or protected areas	Use of mechanical equipment may be restricted.	Hand removal or selective mechanical removal if allowed.	NA	Same as above.	Cut stump method, IPT foliage spray, aerial herbicide application if allowed.

* Choice of a particular management option must be in compliance with existing regulations for land resource.

Choice of an effective control method depends on specific stand and site characteristics. Land use and current site conditions (accessibility, terrain, climate, other flora and fauna present, etc.) must be considered. Other important considerations include treatment effectiveness, overall cost, and the number of years needed to achieve control. Table 1 summarizes management options for some common situations involving saltcedar. More than one control method may be needed for a particular site.

Since saltcedar is difficult to eradicate completely, saltcedar control programs should be based on the degree of control necessary to achieve management objectives. The following actions should be considered when planning an overall management approach:

- Maintain healthy plant communities to prevent or limit saltcedar infestations. This may involve using improved grazing management to prevent excessive grazing and reseeding areas with desirable grasses and forbs after disturbance.
- Detect, report, and map known infestations. Keep annual records of reported infestations.
- Eradicate new populations of saltcedar as early as possible.
- Combine mechanical, cultural, biological, and chemical methods for most effective saltcedar control.
- Implement a monitoring and followup treatment plan for missed plants and seedlings.

Assessing revegetation potential is a critical first step before proceeding with saltcedar control. Costs for saltcedar control and revegetation are expensive, and careful selection of areas with a high potential for reestablishment is necessary to provide sustainable saltcedar control in the long term. In some situations, a treated area will recover naturally after aerial spraying without revegetation. In other situations, artificial plantings or seeding may be necessary. Sites that have dense saltcedar stands, poor hydrologic integrity, elevated salinity, or related conditions may have limited revegetation potential. A soil survey may be used to determine the soil texture, ground water depth, salinity levels, and other related soil factors that can ultimately influence replacement of the vegetation community.

Special Considerations

Saltcedar potentially serves as nesting habitat for the endangered southwestern willow flycatcher (*Empidonax traillii extimus*) which is protected under the Endangered Species Act of 1973. To avoid harm to this species, information should be obtained from the U.S. Fish and Wildlife Service (Arizona, phone (602) 242-0210; New Mexico, phone (505) 248-6920) before implementing treatment of saltcedar stands of 0.25 acre or more in riparian or wetland areas within Arizona or New Mexico. A formal survey for flycatcher nesting habitat by a surveyor with a scientific permit may be required for a saltcedar site prior to treatment if the nesting status of the site is undetermined. Within occupied or suitable flycatcher habitat, saltcedar treatment operations (including ground or aerial herbicide spraying) should not occur during the flycatcher nesting period of April 15 to August 30. When nesting habitat of the southwestern willow flycatcher is present, a no-treatment buffer of 0.25 mile is necessary around the nest(s). Migratory birds other than the flycatcher may also nest in saltcedar from April through August, and saltcedar treatment during this period should be avoided if possible.

Physical Control

Manual Methods

Digging or hoeing can be used to target individual plants in relatively small areas. Some commercially available hand implements are practical for uprooting small saltcedar plants; however, a shovel or hoe is most commonly used. The root crown and associated layered roots must be entirely removed from the soil. Uprooted material should be stacked into piles and dried before burning or mulching.

Mechanical Methods

Mechanical methods to treat saltcedar range in scale from individual plant excavation (from hand-operated equipment

to excavators) to broadscale clearing (from tillers to bulldozers). Clearing saltcedar stands with a mechanical method often requires repeated applications.

Grubbing with a tractor-mounted implement is particularly useful for control of scattered individual trees. A grubbing tool mounted on a tractor's hydraulic system drives a blade into the soil to sever roots below the root crown and force the root crown onto the surface. To prevent rerooting, grubbed saltcedar should be piled, dried, and then burned or mulched rather than left on the surface.

Excavating can be used to remove individual trees selectively. Operators of excavating equipment must be skilled in placing the extracting bucket beneath the root crown of the target plant and grasping the tree with an opposing hydraulic arm so that it can be pulled directly upward in a vertical motion. Extracting the tree vertically rather than sideways minimizes excessive breakage of the root material at or near the ground surface.

Mulching and excavating can be used in combination by first eliminating top growth of saltcedar quickly through mulching and then using excavation to destroy the remaining root system. Mulching by itself may be used to reduce fuel loading for fires by clearing significant acreage of saltcedar in a relatively short period of time. Mulching requires mobile, high horsepower machinery to operate a high speed rotating drum equipped with cutting teeth. The mulching equipment shreds saltcedar top growth to ground level and simultaneously grinds it into fine segments. Mulching operations leave the roots intact; therefore, saltcedar will resprout when growth conditions become favorable. The sprouts will typically reach 2 to 5 feet in height within the first or second season after mulching. A track-mounted excavator may be used to remove the remaining live root crowns and layered roots as indicated by the resprouting.

Root plowing and raking is a combined mechanical treatment designed to clear large, mature saltcedar stands on relatively level areas. A two-phase approach is generally followed. In the first phase, aerial trunks and stems are cut at the soil surface and piled using a D-7 or D-8 class bulldozer equipped with a front mounted brush blade. An articulated loader equipped with a brush rake working in tandem with a bulldozer may be used to facilitate piling. Piles should be allowed to dry for a month or longer prior to burning. The work may be accomplished during winter months to avoid overheating of equipment and summer nesting of birds. The second phase of control should occur during hot and dry summer months (usually May and June) when root material will dry out after removal from the soil. A 12-foot-wide root plow pulled by a bulldozer (e.g., D-7 class) can be used to sever the root crown from the remaining root system about 12 to 18 inches below the soil surface depending on the maturity of the saltcedar stand. Root material near the soil surface can then be raked by a bulldozer (e.g., D-8 class) equipped with a 21-foot-wide hydraulic root rake containing teeth that are 4 feet in length and are spaced 15 inches apart. The material can then be windrowed and piled using an articulated loader. The piles are subsequently burned.

Prescribed Fire

Prescribed fire as a single control method is not recommended for long-term saltcedar management since saltcedar is fire adapted and regrows rapidly. Natural or prescribed fires in mature or decadent stands of saltcedar are hazardous as flame lengths in these fires can be extremely high and crown fires can be difficult to stop with standard firefighting methods. However, burning may be useful or necessary to remove brush piles or any dead saltcedar left standing after herbicide spraying.

Cultural Control

Education and monitoring can be important components to saltcedar control. Some nurseries still stock saltcedar as a decorative plant which could serve as sources of escaped stock in noninvaded areas.

Biological Control

Grazing

Livestock will browse saltcedar, but the foliage has little nutritional value and is usually not preferred. Grazing with

goats may be used to suppress resprouting after other treatments have been made.

Classical Biological Control

Saltcedar is typically damaged by a number of organisms in its native Mediterranean and Asian habitat. The northern tamarisk beetle *(Diorhabda carinulata)* and allied *Diorhabda* species are host-specific species that have been used as biological control agents for saltcedar (see table 2). Both adult beetles and larvae consume the foliage of saltcedar which can kill the plant over a period of several years. Different species of the *Diorhabda* beetle with specific biotic requirements for climate and day length were released in the United States according to their corresponding needs. Four other insect species feed on saltcedar (including the cicadellid leafhopper, *Opsius stactogalus*), but these insects have not been observed to cause anything more than marginal damage.

Table 2. Biological control agents

Species	Type of Agent	Site of Attack	Impact on Host	Use/Considerations for Release
Diorhabda carinulata and allied species	beetle	Larvae and adults feed on foliage.	Varies by *Diorhabda* species	Has been released in Nevada, Utah, Colorado, California, and Texas. These particular beetle species should not be released as biological control agents since they can potentially impact saltcedar habitat of the endangered southwestern willow flycatcher.

Expansion of tamarisk beetles from original release sites threatens to impact the endangered southwestern willow flycatcher *(Empidonax traillii extimus)* which nests in saltcedar dominated areas that have replaced the original native willow communities. The beetle has moved into Arizona and New Mexico from outlying states, and this advancing migration could damage critical nesting habitat used by the flycatcher. The USDA Animal and Plant Health Inspection Service (APHIS) has suspended further releases of *Diorhabda* beetles pending review by the U.S. Fish and Wildlife Service. A permit must be obtained from APHIS before biological control agents can be transported across state boundaries. Regulations and permit applications (PPQ 526 permit forms) pertaining to interstate shipment of biological control agents can be found at http://www.aphis.usda.gov/ppq/permits/.

Chemical Control

Herbicides are a primary method of saltcedar control and can be applied by a number of ways including fixed-wing aircraft, helicopter, tractor, truck or ATV-mounted boom sprayers, power sprayers, backpack sprayers, and carpet rollers. Treatment success depends on care taken during herbicide application. Most compounds available for saltcedar control have postemergence activity and provide limited preemergence control (see herbicide recommendations in table 3).

Herbicide Control Methods

IPT basal bark treatment can be made on individual saltcedar plants by using herbicide mixed with oil in a backpack sprayer that is fitted with an adjustable nozzle (X0 to X1 orifice size) to deliver a mist spray from the base of the stem up to 6 inches above the ground. Triclopyr ester herbicide mixed with crop oil in a 50:50 v/v (volume to volume) ratio is an effective mixture. Imazapyr with crop oil may also be used for this application. Although basal bark treatment provides fair control, it is very tedious and time consuming, especially when the saltcedar is multistemmed. Applications on older stems with thick, furrowed bark should be avoided since success may be limited. Basal bark treatments are more easily made in winter when foliage is shed; however, summer treatment is recommended in Texas.

IPT cut stump treatment is often used in areas where mechanical treatments or foliar applied herbicide spraying are restricted due to logistical considerations or when there is a need to be highly selective and protect nontarget vegetation. The treatment involves hand cutting or chain

sawing the saltcedar trunk or stems as close to the ground surface as reasonable, and then applying herbicide to the cut stump surface by paintbrush, hand-held spray bottle, or backpack sprayer. The cut surface should be horizontal to the ground to minimize runoff, and any residual sawdust over the cut surface should be removed prior to herbicide application. A solution of triclopyr ester or imazapyr mixed with bark or crop oil must be immediately applied within 15 minutes. The herbicide:oil mixture ratio can vary from 33:67 to 50:50 v/v depending on the number and size of plants to be treated and the application technique used. Lower ratios (e.g., 33:67) are typically used when applications are made with a low volume backpack sprayer or hand-held spray bottle, whereas higher ratios (e.g., 50:50) are used when the solution is brushed directly onto the cut stump. Cut surfaces of plants with less than 4 inches diameter must be thoroughly wetted with herbicide to kill the roots; however, the herbicide should be applied to the cambial layer just inside the bark ring if the diameter of the saltcedar stump exceeds 4 inches. A blue indicator dye should be added to the spray mixture to show prior treatment of stumps. Disposal of trunks, limbs, and other top growth should follow acceptable practices (e.g., stack piles or chips).

Mortality rates from cut-stump treatments are directly related to care taken when treating cut surfaces. Control can be 60 to 80 percent under optimal conditions, but plant kills may be less than 40 percent due to difficulties associated with this method. Therefore, followup treatment using ground-based foliar applications should be anticipated.

IPT foliar spray may be used to control small saltcedar plants that are less than 5 feet in height and are relatively small in acreage. Saltcedar foliage should be completely covered, and the terminal ends of all branches (including blooms) should be wetted without allowing dripping to occur. The interior of the plant should then be laced with the spray solution to complete treatment. Ground application of 1 percent imazapyr solution by volume to saltcedar foliage can be made with a variety of spraying equipment such as hand-held pump-up or backpack sprayers, tractor-towed tank sprayers, or ATV-mounted low and high powered sprayer systems. An adjustable cone nozzle (X6 to X8 orifice size) can be used to deliver a coarse spray (large droplets). A nonionic surfactant (0.25 percent by volume) and a blue indicator spray dye should be added to the mixture. Since absorption of herbicide into the foliage is relatively slow, chemical penetration into the plant should be increased by spraying during weather conditions of low wind, high relative humidity, and low air temperature. After treatment, the top growth should remain undisturbed for at least 2 years. Although plants may appear dead (i.e., completely defoliated) in the first growing season after spraying, they will still try to grow. If top growth is removed too early after spraying, saltcedar will shift stored carbohydrate reserves toward apical root buds and will resprout.

Airplane or helicopter applications can be used to spray saltcedar successfully if the aircraft is equipped with the proper spray system. Helicopters can spray difficult, "tight" areas that require precision application such as edges of meandering rivers or saltcedar stands interspersed with nontarget vegetation. Fixed-wing aircraft are better for spraying large, monotypic blocks of saltcedar where an overlapping spray pattern can be delivered at a lower operational cost than by a helicopter. Aircraft should be equipped with a satellite guidance system, a variable rate flow meter, and an onboard GIS display system for spraying in wildland situations. Areas to be sprayed should be premapped, and the onboard computer spray system should be preprogrammed to apply herbicide only on defined treatment areas. Swaths should be overlapped to prevent streaking whereby plants are left untreated or slightly damaged.

For aerial applications, the spray volume should be sufficiently high to insure maximum spray coverage. Spray nozzles should be fitted to deliver moderate to large-sized droplets ranging from 450 to 1,200 μm. As indicated in table 3, a spray mixture may include 2 quarts of imazapyr or a 1.5 quarts imazapyr plus 1.5 quarts glyphosate mixture applied in water. A nonionic surfactant (0.25 percent by volume) and a drift control agent (0.07 percent by

Table 3. Herbicide recommendations

Common Chemical Name	Product Example[1]	Product Example Rate per Acre	Individual Plant Treatment (IPT)	Time of Application	Remarks
Triclopyr ester	Garlon 4, Remedy, Ultra, Others	NA	50:50 mixture of triclopyr and crop oil with a blue indicator dye.	Anytime	For cut stump treatment, apply to fresh cut stump within 15 minutes of cutting.
Imazapyr	Arsenal, Habitat, Others	2 quarts	1 percent mixture for foliage spray (1 gallon per 100 gallons of water with 0.25 percent surfactant and a blue indicator dye).	Late summer to early fall when plants are taking up nutrients; plants should be healthy and not stressed.	For IPT, spray to wet all foliage especially the terminal ends of branches. For aerial broadcast spraying, add 0.25 percent nonionic surfactant. Use a high spray volume; 15 gallons per acre total solution when applied by helicopter. Allow two full growing seasons before followup treatment. In addition to overspray, death or injury may occur from transfer of imazapyr between intertwined root systems.
Imazapyr + glyphosate	Arsenal + Rodeo	1.5 quarts + 1.5 quarts	1/2 to 1 gallon + 1/2 to 1 gallon (1–2 pounds + 2–4 pounds per 100 gallons of water with 0.25 percent surfactant and a blue indicator dye).	Same as imazapyr.	Same as imazapyr.

[1] Trade names for products are provided for example purposes only, and other products with the same active ingredient(s) may be available. Individual product labels should be examined for specific information and appropriate use with saltcedar.

volume) should be added to the mixture. For optimum plant control, an aerial application should leave the entire saltcedar canopy glistening with spray liquid long after spraying has occurred. This can partially be accomplished by equipping the aircraft with the correct spray system and by spraying under optimal environmental conditions. Moderate temperatures (60 to 80 °F), high relative humidity (65 to 90 percent), and light winds (3 to 7 m.p.h.) are ideal to maximize herbicide activity. Late summer (August–September) is usually the best time to spray saltcedar by aircraft. Plants to be sprayed should be in a healthy state with full foliage that has not been stressed by drought, damaged by hail, or is beginning to turn yellow late in the season.

Control Strategies

Saltcedar may be managed to enhance downstream waterflow, recreation, fire prevention, grazing, flood control, and aesthetics. Strategies to control saltcedar often vary depending on specific management objectives and location within a watershed. For example, an eradication strategy in headwater areas may be used to prevent the downstream spread of saltcedar along waterways. In transitional zones, such as river edges or riparian areas, saltcedar may be removed to enhance waterflow and channel characteristics. In depositional or flood plain areas, goals for saltcedar control can vary widely and may include enhancing wildlife habitat, minimizing potential fire hazard, regenerating native riparian communities, or meeting other multiple use needs.

Numerous research and practical integrated approaches have been developed to manage saltcedar. Successful long-term management programs (typically more than 5 years) usually include a combination of mechanical, fire, and chemical control methods. A combination of methods is particularly necessary if the primary objective is to achieve long-term native plant stability. The **herbicide–burn–mechanical** control program, for example, has emerged as a practical strategy for controlling saltcedar in large, monotypic tracts on valley bottoms and flood plains. The initial intervention step is to apply herbicide aerially which typically provides 70 to 90 percent saltcedar mortality. After 2 years, prescribed burning is used to remove dead aerial trunks and stems. When prescribed burning cannot be done, mechanical treatments such as chaining, cabling, bulldozing, or roller chopping may be used to drop standing dead debris. Surviving saltcedar plants can then be removed in the fourth or fifth year after spraying with an excavator, grubber, or root plow and raking. In some instances, IPT foliage spraying may be needed to control saltcedar resprouting.

Once saltcedar has been removed, aggressive revegetation is often required. Managers should understand the revegetation requirements of a site after saltcedar treatment and include restoration as part of a control strategy. Without special planning and care, treated areas may be rapidly reinvaded by saltcedar or other invasive species. In such instances, sustainable control over the long term is best accomplished by planting competitive native plants that have a high exclusionary ability. Native riparian woody species such as cottonwood (*Populus deltoides*), Goodings willow (*Salix gooddingii*), and coyote willow (*S. exigua*) have a rapid growth potential under conditions of low environmental stress and are good candidate species for plantings.

Adaptive Management

A persistent commitment over many years is required for successful control of saltcedar. Consideration should be given to the ongoing expansion of *Diorhabda* beetles before implementing saltcedar control projects in Arizona or New Mexico. Realistic goals and objectives should also be established to manage saltcedar infestations occurring extensively throughout a given landscape before undertaking a project. If saltcedar control is still necessary, consider using an adaptive management strategy with the overall goal of restoring desirable plant communities. The stepwise process for adaptive management involves:

1. Assessment of the overall weed problem,
2. Establishing management goals and objectives,
3. Implementation of control strategies,
4. Monitoring the effectiveness of management actions,
5. Evaluating actual outcomes in relation to expected results, and
6. Adjusting practices as necessary.

Steps of this process should be repeated in sequence as part of a continuous learning cycle that improves management planning and strategy by learning from the outcomes of previous management actions. In general, an adaptive management strategy may be considered to be successful if:

1. Stakeholders are actively involved and remain committed to the process,
2. Monitoring and assessment are used to adjust and improve management decisions, and
3. Management goals and/or objectives are being achieved for the resource.

References and Further Information

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Suggested Web Sites

For information on invasive species:

http://www.invasivespeciesinfo.gov/

http://www.invasive.org/weedus/index.html

For information about calibrating spray equipment:

NMSU Cooperative Extension Service Guide #A-613 Sprayer Calibration at http://aces.nmsu.edu/pubs/_a/A-613.pdf

Herbicide labels online:

http://www.cdms.net/LabelsMsds/LMDefault.aspx

For more information or other field guides, contact:

USDA Forest Service
Southwestern Region
Forest Health
333 Broadway Blvd., SE
Albuquerque, NM 87102

Or visit:

http://www.fs.usda.gov/main/r3/forest-grasslandhealth/invasivespecies