

THE SALT CEDAR MANAGEMENT WORKSHOP

PROCEEDINGS OF THE
SALT CEDAR MANAGEMENT WORKSHOP
JUNE 12, 1996
MARRIOTT'S RANCHO LAS PALMAS RESORT
RANCHO MIRAGE, CALIFORNIA

SPONSORED BY

UNIVERSITY OF CALIFORNIA &
COOPERATIVE EXTENSION,
IMPERIAL COUNTY AND UC DAVIS



CALIFORNIA
EXOTIC
PEST PLANT
COUNCIL

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PREFACE

The Saltcedar Management Workshop was a huge success, attracting more than 150 people from 10 western states. Nine federal agencies were represented, along with four Native American tribes, four state agencies from California and Arizona, numerous local government entities, private consultants, pest control advisors, landscape and nursery businesses, three NGO's (nongovernmental organizations), and three Universities. The extent and severity of the saltcedar problem in the western US is apparent by the interest shown in this workshop.

The Saltcedar Management Workshop happened because of the hard work and thoughtful input by the organizing committee. These people came together one day last March, and in two hours, had outlined the whole workshop and suggested most of the speakers. The members of the organizing committee are listed on the following page. Most of these individuals were also speakers at the workshop. The papers included in this Proceedings should serve as an excellent reference both for workshop attendees and to those who could not join us in Rancho Mirage.

Additional copies of the proceedings are available; to order, send a check payable to the Ag Extension Trust Fund for \$10.00 per copy to Carl E. Bell, Cooperative Extension, 1050 E. Holton Rd., Holtville, CA 92250. Proceedings Editors are Joe DiTomaso and Carl E. Bell

SALT CEDAR MANAGEMENT WORKSHOP

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ORIGIN, HISTORY AND CURRENT RANGE OF SALT CEDAR IN THE U.S.

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I. ORIGIN/TAXONOMY

The genus *Tamarix* (common name "tamarisk") contains many species (as many as 54 are formally recognized) originating from widely dispersed areas located in arid and semi-arid regions of the Old World (Baum, 1967; DeLoach, 1989). Examples are *Tamarix pentandra* from the Middle East, *T. articulata* and *T. tetragyna* from Israel, *T. articulata-africana* from the Libyan Sahara, *T. aphylla*, *T. ericoides* and *T. dioica* from India and Pakistan, *T. chinensis*, *T. parviflora* and *T. ramosissima* from southwestern Asia, *T. taklamakanensis* from the Sinkiang, *T. gallica* from Sicily and Morocco and *T. gallica canariensis* from the Canary Islands (DeLoach, 1989). There are no species of tamarisk native to the New World (DeLoach, 1989).

II. HISTORY/IMPORT INTO THE U.S.

Eight tamarisk species were introduced in the U.S. in the early 1800's, mostly from Asia (DeLoach, 1989). Some were introduced for their ornamental values (e.g., *T. chinensis* and *T. ramosissima*), others for planting in wind breaks (e.g., *T. aphylla*) or to stabilize eroding stream banks (Neill, 1985).

III. PRESENT DISTRIBUTION IN THE U.S.

While *T. aphylla* (a large evergreen tree often planted along railroad tracks and referred to as "athel") has invaded some riverain ecosystems in Australia (Griffin et. al., 1989), it has not acquired weedy habits in North America. This is not the case for *T. chinensis*, *T. parviflora* and *T. ramosissima* (small deciduous trees or shrubs often called "salt cedar") which are invasive weeds throughout the southwestern United States (Kerpez and Smith, 1987; Kunzmann et al., 1989). They have successfully invaded nearly every drainage system in arid and semi-arid areas, occupying over 607,050 hectares (Brotherson and Field, 1987), including approximately 6,475 hectares in California (Johnson, 1987). Today, salt cedar occupies suitable habitat west of the Great Plains, north into Montana and south into northwestern Mexico (DeLoach, 1989).

A4

A3
A3
A first phase of the spread of salt cedar in the southwestern U.S. affected the floodplains of major drainages. By the 1940s, saltcedar had spread through extensive areas along the Gila, Salt, Pecos and Colorado River, as well as the Rio Grande (Horton, 1977). Less severe and seasonally altered flooding regimes brought about by the dams and flood control structures constructed along these rivers provided ideal conditions for the establishment, reproduction and spread of salt cedar (DeLoach, 1989; Kerpez and Smith, 1987). It is estimated that 1400 square miles of floodplain land in the western U.S. was occupied by salt cedar by 1961 (Neill, 1985). Large intermittent desert streams, such as the Mojave River near Barstow, California, have seen their original riparian vegetation of willows and cottonwoods replaced by salt cedar, but disturbances other than flood control may have favored that process. In Afton Canyon, 70% of the original native vegetation has been replaced by salt cedar, mostly since the 1960s. Reduced river flows, off-road vehicle disturbance, year-round grazing and native tree cutting are hypothesized to have contributed to that vegetation type conversion (Lovich et al., 1994).

More recently, salt cedar has expended its range into interior desert riparian habitats that are otherwise unaffected by human activities. This invasion of desert riparian areas by salt cedar has occurred fairly recently, during the last couple of decades (Lovich et al., 1994). In the Colorado Desert of southern California, *Tamarix ramosissima* can now be found in many of the springs (e.g., Buzzard Spring in the Eagle Mountains), streams (e.g., Palm Canyon in the Santa Rosa Mountains), and in some of the more mesic desert washes (e.g., Thousand Palm Canyon in the Coachella Valley, prior to eradication).

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IDENTIFICATION, BIOLOGY AND ECOLOGY OF SALT CEDAR

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Taxonomy

Tamarix (salt cedar) is one of four genera of Tamaricaceae and is represented by 90 species worldwide. The genus was named after the Tamaris River in Spain and consists of halophytic shrubs and small trees native to Western Europe, the Mediterranean, North Africa, and northeast China and India (Baum 1967). Eight species of *Tamarix* have been introduced into the United States, primarily as ornamentals or for wind breaks and shade. Of these species, five are present in California. Most species are weedy, particularly *T. parviflora*, previously known as *T. tetrandra*, and *T. ramosissima*, previously known as *T. pentandra*. One species which is less weedy is the large evergreen tree, athel (*T. aphylla*). Table 1 compares the morphology, distribution and abundance of the salt cedar species found in California.

Table 1. Comparison of the naturalized five California *Tamarix* species.

Species	Height	Leaves	Flowers	Range	Abundance
<i>T. aphylla</i>	tree <12 m	not overlapping, strongly clasping	5-parted, nectar disk lobes wider than long, stamens alternate disk lobes	San Joaquin valley to desert	escaped populations uncommon, often cultivated
<i>T. chinensis</i>	tree <10 m	overlapping, oblong to narrowly lanceolate	5-parted, nectar disk lobes wider than long, stamens alternate disk lobes	Southern California, primarily desert	uncommon
<i>T. gallica</i>	shrub or tree <8 m	overlapping, linear to narrowly lanceolate	5-parted, nectar disk lobes longer than wide, stamens together with disk lobes	primarily in Southern California, as far north as San Francisco Bay	uncommon
<i>T. parviflora</i>	shrub or tree 1.5-5 m	overlapping, linear	4-parted, nectar disk lobes longer than wide, stamens together with disk lobes	throughout Northern and Southern California	common, serious weed problem
<i>T. ramosissima</i>	shrub or tree <8 m	overlapping, ovate	5-parted, nectar disk lobes wider than long, stamens alternate disk lobes	San Joaquin valley to desert, uncommon in Northern California	common, serious weed problem

Biology

Salt cedar species are phreatophytes (deep-rooted to reach water table) that depend on groundwater for their water supply. However, under some conditions salt cedar can grow where no groundwater is accessible. Thus, it is classified as a facultative rather than obligate phreatophyte (Kerpez and Smith 1987).

Shoot Growth. Weedy salt cedars can grow to heights of 3 to 4 m in a single growing season under favorable conditions (Sisneros 1991). Furthermore, mature salt cedar is remarkably tolerant to a variety of stress conditions, including heat, cold, drought, flood, and high concentrations of dissolved solids. By dropping its leaves and halting growth, salt cedar can withstand lengthy periods of drought. In contrast, mature plants can also survive complete submergence for as long as 70 days (Kerpez and Smith 1987).

Root Growth. The root system of salt cedar is extensive, and is largely responsible for its competitiveness and survival under stress. Initially, the primary root grows steadily downward with little branching until it reaches the water table, which can be at depths of 3 m or deeper (Brotherson and Winkel 1986). Once the water table is reached, secondary root branching becomes profuse.

Adventitious roots easily develop from submerged or buried salt cedar stems. Thus, expansion in salt cedar infested areas can also be through vegetative growth (Kerpez and Smith 1987).

Reproduction. Seedlings mature rapidly and produce small, white or pinkish flowers often by the end of the first year of growth (Neill 1985). Flowers have four or five sepals and petals, three to five styles, and stamens borne on a fleshy, lobed, hypogynous disk. The flowers produce many 3 to 5-valved capsule fruit usually having a tuft of hair on the end to aid in wind dispersal (Kerpez and Smith 1987). Seeds can also be carried and deposited along sandbars and riverbanks by water (Brotherson and Field 1987). A single large salt cedar plant can produce a half million seeds per year, primarily from late May to October.

Germination. Seeds which develop from mature plants are quite small and light (0.1 mg) (Sisneros 1991), and will germinate on saturated soils or while afloat. Once wetted, fresh seeds usually germinate within 24 h (Kerpez and Smith 1987). Due to their short-lived viability, salt cedar seeds must come in contact with suitable moisture within a few weeks of dispersal. Seedling mortality is high when soils are scoured, dry up too quickly, or submergence for four to six weeks following germination (Shrader 1977).

After summer rains, salt cedar seedlings can rapidly colonize new moist areas because flowering and fruiting cycles provide a continual supply of available seeds (Engel-Wilson and Ohmart 1978). This strategy is of considerable advantage over native riparian species since salt cedar can exploit suitable germinating conditions over a longer time interval (Howe and Knopf 1991).

Seedling Establishment. Establishment of salt cedar seedlings occurs in high seasonally saturated soils (Brotherson and Winkel 1986, Brotherson and Field 1987). This requirement is most often met along river or reservoir banks where slowly receding water levels create optimum seed beds. In the initial stages of establishment, roots grow slowly the first two to four weeks, and will not survive more than one day if the soil dries. Although the seedlings can survive submerged for several weeks, they are easily uprooted by even a weak current and do not tolerate flooding within a period of several months subsequent to germination (Kerpez and Smith 1987).

On some occasions salt cedar can become established in typically dry locations if these areas experience an unusually wet spring and early summer, or if rivers or lakes temporarily flood their boundaries (Carman and Brotherson 1982). Once established, salt cedar can survive almost indefinitely in the absence of surface saturation of the soil (Brotherson and Field 1987).

Ecology

Salt cedar grows to about 1,650 m (5,400 ft) in elevation (Brotherson and Winkel 1986) and prefers very saline soils. Typically, salt cedar occupy sites with intermediate moisture, high water tables, and little erosion. However, mature plants can withstand long periods of water inundation (70-90 days). They can resprout vegetatively after fire, severe flood, or treatment with herbicides and are able to accommodate wide variations in soil and mineral gradients (Brotherson and Field 1987).

Soil. Successful stands of salt cedar are generally found in non-rocky soils composed of silt loams and silt clay loams high in organic matter (Brotherson and Field 1987).

Salinity. Salt cedar is not an obligate halophyte but can survive in areas where groundwater concentration of dissolved solids approaches 15,000 ppm (Carman and Brotherson 1982), but typically occur in areas averaging about 6,000 ppm salt (Brotherson and Winkel 1986).

Following fire, higher alluvium salinity and elevated concentrations of phytotoxic boron can delay the reestablishment of native trees and shrubs, particularly *Populus* and *Salix*. These areas are very susceptible to invasion by salt tolerance species of *Tamarix* (Busch and Smith 1993).

Acidity. Salt cedar has a slight preference for alkaline conditions (pH = 7.5) compared to other native shrubs (Brotherson and Winkel 1986).

Allelopathy

Salt cedar exudes excess salt crystals from openings in its scale-like leaves (Neill 1985). It has been reported to contain 41,000 ppm dissolved solids in the guttation sap (Duncan et al. 1993). Not only can these glands concentrate salt, but they also secrete various other ions, including boron (Busch and Smith 1993). These salts are eventually deposited on the soil surface under the plant, sometimes forming a hard crust (Kerpez and Smith 1987). Such deposits of salt-encrusted needles can inhibit the germination of other species (Egan et al. 1993). A combination of this allelopathic effect and the extensive lateral root system contribute to the ability of salt cedar to out compete other vegetation for space and water (Brotherson and Field 1987). In some communities, salt cedar is the dominant overstory species, whereas salt tolerant grasses, such as saltgrass (*Distichlis spicata*), are dominant in the understory (Brotherson and Winkel 1986).

Water Acquisition. The longer the community has been invaded by salt cedar the greater will be the capacity to lower the water table in the soil (Brotherson et al. 1984). With this overall drying out of the habitat, more xeric plant species which occupy the understory in established salt cedar stands.

A dense stand of salt cedar will grow where the water table is between 1.5 and 6 m from the surface (Table 1). Water use of salt cedar is generally considered high, but evapotranspiration rates can vary with water table depth and soil salinity. Under dry or extremely hot conditions, salt cedar does not always transpire at potential rates (Davenport et al. 1982). Water conservation under these situations is of ecological significance as it enables *Tamarix* species which grow in hot desert environments to open their stomata just at daybreak during the coolest and most humid hours of the day. This allows the plants to acquire adequate CO₂ without losing much water. The stomata close during the hotter afternoon hours, further reducing water loss (Hagemeyer and Waisel 1990). Summer evapotranspiration rates can also vary considerably with stand density and other stress conditions (Davenport et al. 1982).

As a facultative phreatophyte, *Tamarix* species are capable of extracting soil moisture from less saturated soils in areas with deeper water tables. This appears to be an adaptation that obligate native

phreatophytes such as *Populus* and *Salix* do not possess (Busch et al. 1992), and may partially explain the competitive exclusion of these native shrubs by salt cedar in southwestern riparian areas.

Table 2. Characteristics of floodplain zones at varying groundwater depths (from Shrader 1977).

Zone	Depth to groundwater (m)	Salt cedar growth	Other vegetation	Water salvage prospects	Other uses
1	1	dwarfed & multi-stemmed	vigorous saltgrass & bermudagrass	little	good grazing, flood passage, minimal wildlife use
2	1.5-2.5	major stands	excellent saltgrass	large savings	wildlife utilization (doves), some grazing, bees
3	2.5-6	major stands	xeric types	great water savings	wildlife utilization (doves), bees
4	>6	scattered individuals	xeric types	none expected	limited use

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SALT CEDAR IMPACTS ON SALINITY, WATER, FIRE FREQUENCY,
AND FLOODING

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The biological characteristics of saltcedar (*Tamarix ramosissima*) that make it an aggressive weed also can cause undesirable physical changes in the plant's environment. The four most common physical changes are briefly described here. They are: (1) increased soil salinity inhibiting native plant germination and growth, (2) increased water consumption and loss, (3) increased wildfire frequency, and (4) increased frequency and intensity of flooding.

Suggested by its name, saltcedar has the ability to excrete salts from glands on its leaves allowing the plant to tolerate saline soils and groundwater. Rather than excluding salts from the roots as do most plants, saltcedar freely takes up salts and then voids them aboveground. The ions excreted (eg. Na, K, Ca, Cl) are the same as those found in the soil surrounding the plant's roots (Berry 1970). The plant therefore acts as a conduit transporting salts from the groundwater to the leaf surface. The process also concentrates the salts; salt-gland exudate containing 41,000 ppm total solids has been measured on plants rooted in groundwater containing 2,000 ppm total solids (Gatewood et al. 1950). Because saltcedar is deciduous, all of the salts exuded eventually reach the soil surface, and salinity beneath the plant can increase as dropped leaves accumulate year after year until rainfall carries the salts through the soil and back to the groundwater.

Lacking a similar adaptation to saline soils, many native riparian plants can be affected by the salts transported by saltcedar to the soil surface. Growth by cottonwood (*Populus fremontii*) and Goodding's willow (*Salix gooddingii*) is inhibited by salinity greater than 1,500 ppm, whereas saltcedar can tolerate soil salinity up to 36,000 ppm (Jackson et al. 1990). We examined the soil salinity and the groundwater depth and fluctuation, two additional factors critical to riparian plant growth, in areas dominated by saltcedar on the lower Colorado River floodplain to estimate site suitability for restoring native plants. Of the 18,762 acres evaluated, 10 percent was found suitable for cottonwood or willow (*Salix gooddingii* or *S. exigua*), 45 percent was found suitable for honey mesquite (*Prosopis glandulosa*) or screwbean mesquite (*P. pubescens*), and 45 percent was found suitable for quailbush (*Atriplex lentiformis*) (Bureau of Reclamation 1995).

Water consumption has been saltcedar's most-studied physical property, primarily resulting from interest in removing or replacing the plant to conserve water. The term evapotranspiration is used to describe water loss per land area and includes evaporation from soil and transpiration, the biological process whereby plants lose water from their stomates while taking up carbon dioxide. Saltcedar is atypical, because it loses water by

transpiration and evaporation due to the water evaporated from the salt glands.

Evapotranspiration is easy to understand but difficult to measure. Most studies have used one of four techniques: (1) planting plants in tanks and measuring water loss within the tank, (2) measuring the flow of xylem from the roots to the leaves, (3) measuring the decrease in flow within a stream and crediting part of the decrease to evapotranspiration, and (4) measuring microclimate to estimate the movement of water vapor upwards from the plant canopy. Each method has its advantages and disadvantages. For example, one can accurately measure xylem flow within several branches, but extrapolating the measurement over an entire acre may be difficult.

E1 Differences between methods of measuring evapotranspiration and study sites has produced a wide range of water uptake estimates for saltcedar, varying from 1.4 feet per year to 10.5 feet per year (Bureau of Reclamation 1992). A recent study by Desert Research Institute (Ball et al. 1994) using the Bowen Ratio/Energy Balance method estimated an evapotranspiration rate of 2.3-2.5 feet per year from monotypic stands of saltcedar adjacent to the lower Colorado River near Blythe, California. The Bowen Ratio/Energy Balance method estimates evapotranspiration by measuring the amount of energy (mostly sunlight) absorbed by the plant community and used to evaporate water. As a comparison, the same study estimated an evapotranspiration rate of 1.6 feet per year for honey mesquite and 2.3 feet per year for quailbush. Maximum evapotranspiration by saltcedar was observed in the early morning when salt gland exudate was most visible, suggesting that the glands may contribute more to saltcedar's water loss than do the stomates.

e1 The most observable impact of saltcedar on available water has been instances where surface water has visibly increased following plant removal. Two notable examples include saltcedar management projects at Eagle Borax Works Springs in Death Valley National Park (Rowlands 1990) and at Spring Lake near Artesia, New Mexico (Keith Duncan, pers. comm.). At Eagle Borax Works Springs, historical records described a natural spring and its associated ponds progressively drying-up concurrent with the spread of saltcedar beginning in 1950. In 1971, the park staff conducted a controlled burn of 10 acres to restore the site, and 8 weeks later the water elevation had risen 1.2 feet and a 1-acre pond had reappeared. At Spring Lake, saltcedar had invaded and covered a 13-acre spring-fed lake, eliminating its surface water by 1968. Saltcedar was effectively controlled with herbicides in 1989, and by 1992 the water table had resurfaced.

e2 Wildfires are an increasingly common occurrence in saltcedar along the lower Colorado River, partly the result of increasing population densities along the river's shorelines. The prevalence of fires in saltcedar has been attributed to the accumulation of leaf litter (Kerpez and Smith 1987) and dead and senescent woody material (Busch 1995). Between 1981 and 1992, fires burned 9,281 acres, or 35 percent, of saltcedar-dominated vegetation on the lower Colorado River floodplain (Busch 1995). By comparison, fires in communities of honey or screwbean mesquite during the same

period destroyed 629 acres, or 2 percent of the existing mesquite acreage. Assuming that the fires during the 12 years examined are representative and did not significantly overlap, a given stand of saltcedar would be expected to burn every 34 years.

Not only does saltcedar readily burn, its adaptation to saline conditions allows it to thrive in the elevated soil salinities that fires often produce (Busch and Smith 1993). In addition, the plant can quickly resprout from below ground after its above-ground parts have been completely burned away. Saltcedar's greater propensity to burn, and its tolerance for post-fire conditions, suggests that fires may be a significant factor promoting the plant's spread along the lower Colorado River.

Saltcedar also has been implicated to increase the frequency and intensity of flooding resulting in increased soil erosion. Dense stands of saltcedar covering a river's floodplain can impede high flows and cause the water to spread out and inundate areas not normally flooded (Robinson 1965). Saltcedar's restriction of the river channel also increases sedimentation, further intensifying flooding, and causing flows to meander outside the original channel and erode soil. The progression of saltcedar encroachment and its effect on sedimentation and flooding on the Brazos River in north-central Texas has been described by Blackburn et al. (1982). As saltcedar deposited onto the floodplain prior to 1941 began to spread, the width of the river channel began to narrow. In 1941, the river channel's mean width along a 75-mile reach was 515 feet, but by 1979 the mean width had reduced to 220 feet. Saltcedar's encroachment also increased sediment deposition onto the floodplain, and flood events with similar flow rates produced flood stages of 10.2 feet in 1941 compared to 18.4 feet in 1971. Higher flood stage in 1971 caused a greater area to be inundated.

Clearing saltcedar has been used as a means of restoring the river channel's original flow capacity. A comparison of cleared and uncleared reaches of the Gila River near Safford, Arizona, found that clearing saltcedar increased flow velocity by 30 percent and decreased water depth by 13 percent (Great Western Research 1989). As an example of a full-scale project removing saltcedar to accommodate high flows, the Flood Control District of Maricopa County mechanically cleared a 1,000-foot wide corridor within approximately 34 miles of the Gila River near Phoenix, Arizona (Dick Perreault, pers. comm.). The corridor succeeded in reducing flooding, however an extreme flood in 1993 exceeded the corridor's flow capacity and caused erosion and property damage at the floodplain's margins. The cleared corridor has not been rehabilitated since the 1993 floods due to increased regulatory requirements.

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A BRIEF OVERVIEW OF THE IMPACT OF TAMARISK INFESTATION ON NATIVE PLANTS AND ANIMALS

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One of most significant threats to global biodiversity is the invasion of exotic species into natural areas due to human activities and commerce (Clout, 1995). Insidious effects of invasive exotic species often include the inexorable displacement, or replacement, of native plant and animal species, disruptions in nutrient and fire cycles, and changes in the pattern of plant succession. The objective of this paper is to provide a brief summary of some of the impacts of tamarisk or salt cedar (genus *Tamarix*) invasion on native plants and animals, with an emphasis on the southwestern United States. This paper summarizes information previously presented by Lovich *et al.* (1994).

Tamarisk invasion has serious consequences on the structure and stability of native plant communities. The decline of riparian stands of cottonwood (*Populus fremontii*) along the Rio Grande in New Mexico is partially attributable to the invasion of tamarisk. The thick stands of exotic plants along the floodplain have severely limited the number of germination sites that are suitable to cottonwood (Howe and Knopf, 1991). Similarly, in the desert region of Australia tamarisk is capable of displacing native plant species, resulting in the dominance of native vegetation by a relatively few species of introduced and salt-tolerant plants. Tamarisk dominance also results in a reduction in the numbers of native birds and reptiles (Griffin *et al.*, 1989) relative to native ecosystems.

A secondary effect of tamarisk invasion is related to increased frequency of fire in impacted areas. The drought-deciduous nature of tamarisk contributes to a heavy fuel load in infested areas, promoting a fire rotation of about 10 to 20 years (Kerpez and Smith, 1987; Rosenberg *et al.*, 1991). The fire tolerance of tamarisk coupled with the fire intolerance of many native shrubs in the southwestern deserts effectively leads to tamarisk dominance in native plant communities in a relatively short time period.

Some authors have suggested that invasion of tamarisk is a sign, not a cause, of habitat modification and degradation (Horton, 1977). Replacement of tamarisk by native plant species will likely require correcting environmental factors that favored the invasion of tamarisk in the first place (Anderson and Miller, 1990). Such factors will need to be identified (see Anderson and Miller, 1992) prior to active revegetation efforts. However, an area dominated by tamarisk is likely to remain so unless altered by natural cataclysms or man (Kerpez and Smith, 1987).

The suitability of tamarisk as wildlife habitat has been a subject of considerable debate. Naturally, it is utilized by wildlife in its native range in the old world. For example, elephants (*Loxodonta africana*) in Namibia, Africa exhibit a definite preference for *Tamarix usneoides* irrespective of plant availability or size (Viljoen, 1989). However, outside of its natural range in the southwestern United States it generally provides unsuitable habitat for most wildlife because neither its foliage nor its flowers (including seeds) have any significant forage value in contrast to native species such as mesquite (a notable exception being the fact that the exotic

honeybee, *Apis mellifera*, utilizes the pollen). However, from a structural standpoint it does provide cover for some species, particularly birds. For example doves (*Zenaida macroura*), Mississippi Kites (*Ictinia mississippiensis*), and various passerine birds are known to nest in tamarisk dominated habitats (Glinske and Ohmart, 1983; Brown and Trosset, 1989; Rosenberg *et al.*, 1991). Rice *et al.* (1983) determined that tamarisk foliage height diversity was an important determinant of avian community organization, although native plant species were more important determinants.

The value of tamarisk to wildlife appears to vary geographically. Utilization of tamarisk by birds was high on the middle Pecos River, intermediate on the lower Rio Grande, and very low on the lower Colorado River. Avian use of tamarisk along the Pecos River may be enhanced due to the occurrence of seed producing shrubs and annuals within or adjacent to the exotic habitat (Hunter *et al.*, 1988). It is important to note that all published studies of the value of tamarisk as wildlife habitat have focused on birds. Purported benefits to selected birds do not necessarily extend to other animals. Additional research is needed on the relationship between tamarisk and other groups of species including invertebrates as compared to native vegetation types.

In spite of the value that tamarisk may have for wildlife cover, most authors have concluded that the invader has little value to native wildlife (Kerpez and Smith, 1987; Anderson and Miller, 1990; Rosenberg *et al.*, 1991). As tamarisk displaces native vegetation the value of the original habitat is progressively diminished for many native animal species.

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PARTNERSHIPS AND VOLUNTEERS FOR CONTROL OF SALT CEDAR

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I. PALM SPRINGS-SOUTH COAST RESOURCE AREA

In the Palm Springs-South Coast Resource Area, the Bureau has entered into several partnerships to control salt cedar on public lands:

- (a) A memorandum of understanding (MOU) was signed in 1991 with the Management and Training Corporation (which manages the State's Eagle Mountain Community Correctional Facility) for the BLM to use a crew of inmates to remove salt cedar at the Dos Palmas ACEC. The BLM furnishes a commuter van, gas, and technical training and supervision, and the prison furnishes a crew of approximately 5-6 inmates, accompanied with their security guard, to carry out duties ranging from cutting tamarisk with chain saws or brush cutters, applying herbicide and stockpiling slash for burning. Inmate crews have proven to be extremely hard working and willing to put up with hot, uncomfortable working situations. With their help, approximately 150 acres of tamarisk-infested critical palm oasis habitat have been cleaned-up of the noxious shrub, resulting in an improvement in the water flow through the oases, an increase in the cover and vigor of native, desirable species, and a greater visual quality for visitors.
- (b) Under an MOU signed with The Nature Conservancy (TNC), TNC volunteers have contributed many work days towards the removal of salt cedar from palm oases at Dos Palmas as well. Where the inmate crews have left at the end of the work week, TNC volunteers have often picked up during the weekend, supervised by a TNC and/or BLM foreman.
- (c) Volunteers from the Mountain Conservancy, a Coachella Valley-based interest group supporting the conservation of the Santa Rosa Mountains, have help the BLM control salt cedar on public lands.

II. BARSTOW RESOURCE AREA

The Barstow Resource Area is working with an ever expanding number of groups, organizations, individuals, corporations, local agencies and others to accomplish the very important task of saltcedar control in desert riparian areas. The Afton Canyon Restoration project, initiated in 1992, taxed the ability of the Barstow Project office to fund and complete all project components within the time frame restraints associated with saltcedar treatment. The realization that we could not accomplish a job of this magnitude by traditional means, caused us to search for new and innovative ways to get the job done. The results achieved during the last three years include the treatment/control of over 400 acres of saltcedar infested riparian habitat, the planting of over 5000 native willow/cottonwood poles and the construction of a three mile riparian protection fence. These accomplishments would have been inconceivable if not for the following community efforts, partnerships, grants and other cooperative ventures:

Cooperators:

- * Mojave Desert Resource Conservation District (RCD)
- * California Environmental Project (CEP)
- * Quail Unlimited (QU)
- * U.S. Fish and Wildlife Service (FWS)
- * U.S. Army
- * South Down Corporation (Portland Cement)
- * San Bernardino County Range Improvement Advisory Committee (RIAC)
- * Global ReLeaf Heritage Forests
- * California State Prisons

Cooperator Contributions:

Mojave Desert RCD and California State Prisons - Through agreements with RCD and the Baker, CA state prison cleared/controlled approximately 300 acres of saltcedar infested riparian habitat within Afton Canyon. The cooperative effort involved the BLM providing funds to the RCD who, in turn, provided two RCD individuals to supervise an eight person prison labor crew.

The **CEP** has, to date, provided \$10,000 service in kind through the work of their six person field crew. The CEP crew, who are from the Los Angeles area, are working on continuing saltcedar projects at the BLM Salt Creek Area of Critical Environmental Concern (ACEC) and Bitter Spring on the Fort Irwin U.S. Army base.

Quail Unlimited has contributed \$8,000 to the Afton Canyon Restoration Project. These funds were utilized to clear and control saltcedar.

The **U.S. FWS** provided a grant of \$30,000 for saltcedar control in Afton Canyon.

Funds utilized to pay RCD prison crew supervisors, provide necessary equipment and procure herbicide.

The **U.S. Army, Ft. Irwin**, has contributed \$50,000 for saltcedar control on Ft. Irwin, within Afton Canyon and Salt Creek.

South Down Corporation, formerly Southwest Portland Cement, located along the Mojave River in Victorville, California has supplied nearly 5000 willow and cottonwood poles for transplantation into Afton Canyon.

The **San Bernardino RIAC**, in conjunction with the grazing lessee, provided \$8,000 for the construction of a riparian exclosure fence in Afton Canyon.

American Forests, through the **Global ReLeaf** Program has committed to providing \$5,000, one dollar for each tree, up to 5,000, planted in Afton Canyon.

This is a brief summary of partnerships and grants we have in the past, and are presently working with to cooperatively gain a small level of success in the treatment of saltcedar. The following are grants that the Barstow Resource Area has applied for the 1996-1997 grant years.

National Fish and Wildlife Foundation - Applied for \$12,000 in matching funds from California Environmental Project to control saltcedar in wetland areas within the Barstow Resource Area.

CDFG/OHV Fund - Applied for \$57,000 for land restoration and vehicle control structures. A portion of the requested funds are tied to riparian restoration and saltcedar control.

North American Wetlands Conservation Act - Small grant application request for \$20,000 to continue Afton Canyon/Mojave River restoration and improvement.

III. TIPS ON FINDING PARTNERS

It is important to look for a "fit" for your project. A situation where your project meets the needs, concerns, emotions, expectations and vision of a "partner". Examples would be to involve schools and youth groups in restoration, tree planting and other "up" activities. In contrast, if your project involves heavy machinery, herbicides or other specialized equipment the primary providers of these items may be receptive to becoming contributors and/or partners in return for positive publicity. The following is a list of places to start looking for a environmental "partner" to help with your project.

* Prison Inmates

- * Local Corporations and Companies
- * Environmental Foundations offering Corporate Sponsors
- * Individual volunteers
- * High School Students involved in Environmental Studies
- * Girl/Boy Scouts of America
- * Local Government Entities
- * Environmental Organizations
- * Other Agencies, State and/or Federal
- * Grants and Environmental Foundations

Remember: "partners" want something in return, it may be publicity, a warm glow, recognition or just the satisfaction of doing something good for the environment. It is important that volunteers and/or partners know what they are doing, why it is important and also be able to see the results of their efforts. Feel free to write or e-mail the authors to discuss these ideas and some of the partnerships described above. Good luck!

GUIDELINES FOR RECRUITING VOLUNTEERS

Bill Neill
Desert Protective Council

I have over 12 years of experience at organizing volunteer work parties at about 45 different locations. Participating groups include environmental organizations (Sierra Club, Nature Conservancy, Native Plant Society), 4-wheel-drive clubs, Boy Scouts troops, company employee groups, and Dept. of Fish & Game volunteers.

My primary topic will be: what type of areas are appropriate for volunteers, as opposed to paid staff or convict labor. The main considerations are scenic value, project size and environmental sensitivity.

First, volunteer work trips are partly recreational, so scenic quality is important. In desert riparian areas, I would equate scenic value with topography. I think nearly any desert canyon area would attract volunteers; whereas the flatter areas, even with significant habitat value, will attract less interest, at least on a repeat basis.

Second, it is preferable to give volunteers a project that is small or low density, where they can see tangible progress after a day's work. If the work gets monotonous, that's acceptable if workers are paid money; but all that volunteers obtain is psychological reward, a sense of accomplishment, so the project manager should restrict the scope of work to provide that.

Third, environmentally sensitive areas may be good for volunteers, compared to convict labor. By environmentally sensitive, I mean near water or with abundant native vegetation. Volunteers are capable and responsible people who can follow directions and identify plants on their own. Conversely, when clearing a dry monoculture of saltcedar, that's a good place to use prison crews which need closer supervision.

In recruiting volunteers, I take the attitude that volunteers deserve first-class treatment. So I try to offer amenities to make the experience more comfortable or more interesting -- free or reserved campsites, or hot showers, or 4WD access into areas normally closed to the public, or a guided hike or tour after the work session. In planning a trip I negotiate these amenities with the land manager and then publicize them in my promotional writeup.

For anyone interested in recruiting volunteers, I have a mailing list of about 20 to 30 experienced volunteers that I am willing to share.

CHEMICAL CONTROL OF SALT CEDAR (*Tamarix ramosissima*)

BY

NELROY E. JACKSON

THE AGRICULTURAL GROUP, MONSANTO COMPANY

INTRODUCTION

Saltcedar was introduced into the American Southwest from the Mediterranean region, and has become one of the most destructive exotic pest plants found in many riparian areas. Saltcedar has taken advantage of the man-made changes in water movement, both quantity and velocity to explode its range and has gained the attention and concern of people who live in and enjoy native habitat in the Southwest.

The initial requirement for good weed management is to identify and classify the weeds to be controlled. Saltcedar grows as a brush or tree with small leaves that exude salt. It flowers throughout the year and is a prolific seed producer. It resprouts after fire or mechanical damage. Saltcedar may grow in sparse, isolated clumps or in heavy to pure stands. Because of its aggressive nature, saltcedar produces large amounts of biomass.

METHODS OF WEED MANAGEMENT

There are essentially 4 methods of weed management - mechanical, biological, competition, and chemical. Complete success of a weed management program depends on the integration of all methods of weed control.

Mechanical weed control, including hand-pulling, digging, use of weed eaters, axes, machetes, bulldozers, and fire, may not be the most efficient method for removal of saltcedar. Hand labor is not always available and is costly unless it is volunteered. When heavy equipment is used, soil is often disturbed with consequences such as disturbing invertebrates and other denizens of the ecosystem.

In many situations, weed control with herbicides is the most efficient and effective method of weed control for removal of exotic plants during the restoration process. The chemical method allows regeneration and/or re-population of natives or re-vegetation with native species. The use of herbicides can be specific, selective and fast.

HERBICIDES AVAILABLE

The most critical step is the selection of an appropriate herbicide. Specific factors to be considered in a herbicide program are:- efficacy, environmental safety, soil residual activity, operator safety, application timing, and cost-effectiveness. In most situations, the initial treatment in removal of exotic plants is postemergence to the weeds. Since preemergence herbicides may control seedlings of desirable species, postemergence treatment of seedlings is preferable in situations where growth from a seed source in the soil is a problem. Herbicides with three active ingredients, totaling six tradenames are being used for management of saltcedar. These are shown in table 1.

Table 1. Trade and common names of six herbicides used for saltcedar control.

TRADENAME	COMMON NAME	AQUATIC REGISTRATION
Arsenal®	Imazapyr	No
Garlon® 3A	Triclopyr	No
Garlon® 4	Triclopyr	No
Pathfinder® II	Triclopyr	No
Rodeo®	Glyphosate	Yes
Roundup® Pro	Glyphosate	No

Some of the factors to evaluate when choosing a herbicide are:- efficacy, application flexibility, operator exposure, cost-effectiveness, aquatic registration, toxicology, environmental fate and safety to endangered species. Additional characteristics of the herbicides are given in table 2.

Table 2. Some characteristics of six saltcedar herbicides.

HERBICIDE	SIGNAL WORD	FORMULATION	CONC. (lb. ae/gln)
Arsenal®	Caution	ipa-salt	2
Garlon® 3A	Danger	amine	3
Garlon® 4	Caution	ester	4
Pathfinder® II	Caution	ester	0.75
Rodeo®	Caution	ipa-salt	4
Roundup® Pro	Caution	ipa-salt	3

Roundup Pro and Rodeo are efficacious broadspectrum postemergence herbicides that have no soil residual activity. Arsenal is a broadspectrum herbicide that has residual soil activity. Garlon 3A, Garlon 4 and Pathfinder II are effective on broadleaves, with safety to many grass species and no soil residual activity.

Roundup® and Rodeo® are trademarks of Monsanto Company
 Arsenal® is a trademark of American Cyanamid Company
 Garlon® and Pathfinder® are trademarks of DowElanco Company

Rodeo is the only herbicide of the group that is registered for use in aquatic sites, including lakes, ponds, canals, estuaries and riparian areas, and may be applied to emerged weeds growing in water. These are critical factors in many native habitat restoration projects.

MODES OF ACTION

The modes of action of the three active ingredients are given below:-

- Imazapyr: Inhibits synthesis of the amino-acids – valine, leucine and iso-leucine at the ALS enzyme, leading to non-production of proteins.
- Triclopyr: Auxin-type action, leading to inhibition of cell division and growth.
- Glyphosate: Inhibits synthesis of the amino-acids – tryptophan, phenylalanine and tyrosine at the EPSP synthase enzyme, leading to non-production of proteins.

METHODS OF APPLICATION

Versatility of application methods is also important in the choice of herbicide. These choices include :- broadcast and spot treatment foliar sprays by ground equipment, cut stump treatments, basal bark treatments and aerial application where appropriate. The choices for the six herbicides are summarized in the table below.

HERBICIDE	FOLIAR	CUT STUMP	BASAL BARK	AERIAL
Arsenal™	Yes	Yes	No	Yes
Garlon™ 3A	Yes	Yes	Yes	No
Garlon™ 4	Yes	Yes	Yes	No
Pathfinder™ II	No	Yes	Yes	No
Rodeo®	Yes	Yes	No	Yes
Roundup® Pro	Yes	Yes	No	Yes

SALT CEDAR MANAGEMENT WITH HERBICIDES

There are several conditions that have to be addressed when implementing saltcedar control program. The level of infestation at the site must be considered. A control program should be based upon whether the level of infestation is sparse, in isolated clumps, light, heavy or in pure stands. A program directed at light infestations will be a failure if used for combating pure stands. A successful program will use the appropriate methods and tools for the appropriate level of infestation.

APPLICATION RATES

Recommended application rates for Rodeo and Roundup herbicides are given below:-

Rodeo Aquatic Herbicide:

Spot Treatment: 1½% V/V Solution plus ½% V/V Nonionic Surfactant
Broadcast Treatment: 7½ PT./Acre plus ½% V/V Nonionic Surfactant
Cut Stump Treatment: 100% V/V Solution (Full Strength)

Roundup Pro Herbicide:

Spot Treatment: 2% v/v solution
Broadcast Treatment: 5 QT./Acre
Cut Stump Treatment: 100% v/v Solution (Full Strength)

Arsenal Herbicide:

Ground: 0.75 to 1% V/V solution + 0.5% surfactant
Aerial: 1.5 to 2 QT./Acre
Cut Stump: 12 OZ. per gallon of water

Rodeo and Roundup Pro + Arsenal Tank Mixes:

a. Broadcast rates:

Monsanto: 2 QT. Roundup Pro or 3 PT. Rodeo + 1 PT. Arsenal/Acre (light infestations)

Monsanto: 4 QT. Roundup Pro or 6 PT. Rodeo + 2 PT. Arsenal/Acre (heavy infestations)

AmCy: 1 PT. Roundup Pro + 1 QT. Arsenal/Acre (all infestations)

b. Spot Treatment rates:

Monsanto: 1% Roundup Pro or Rodeo + 0.25% Arsenal

AmCy: 0.5% Roundup Pro + 0.5 to 0.75% Arsenal

There is not total agreement between Monsanto and AmCy on the optimum rates of the products for use in tank mixes. All the recommended ratios work faster and better than either product alone. The enduser will have to decide on the cost per acre as well as the degree of residual control that is acceptable for a site. Roundup Pro and Rodeo treatments tend to release grasses and forbs in treated sites, whereas Arsenal at the higher end of the rate spectrum tends to control this type of vegetation the following year.

Garlon and Pathfinder II:

Foliar Treatments: 2 to 4 QT./ACRE of Garlon 4 or 3A. Dilutions with diesel are not recommended.

Modified Cut Stump Treatments: Undiluted Pathfinder II or 50% solution of Garlon 4 or 3A

Basal Bark Treatments: Undiluted Pathfinder II or a 20 - 25% solution of Garlon 4 in natural oil or diesel.

Garlon has been used successfully for many years, particularly as a basal treatment. Only triclopyr is effective in this type of application. There are no timing restrictions for application of Garlon 4 or Pathfinder II. Garlon 3A should be applied during the growing season. Volatility of triclopyr at higher ambient temperatures could lead to undesirable effects on adjacent vegetation.

Some of the symptoms associated with glyphosate or imazapyr applications to saltcedar are yellowing and browning of the leaves, death of the meristem (growing point), "abnormal" regrowth, and multiple budding. Any of these symptoms indicate that the herbicide has had an effect upon the plant. Regrowth from stumps and roots is, unfortunately, often a symptom of a less than lethal dose of any of the herbicides.

TIMING OF APPLICATIONS

Timing of application for optimal control is important for optimum control of saltcedar. Best results from foliar applications of Rodeo, Roundup and Arsenal are obtained when the herbicides are applied in late spring to early fall, particularly when adequate soil moisture is available for good growing conditions. This is shown in the accompanying chart.

POST-SPRAY MANAGEMENT

After initial application of a herbicide to saltcedar, retreatment of escapes, resprouts and new germination of seedlings may be necessary. The amount of re-treatment necessary in the second and third years will be drastically reduced, provided there is no re-invasion of seeds of saltcedar. Re-vegetation of the site may be done by either natural means or by planting native species.

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SUMMARY

Chemical weed control may be the optimal method for control and removal of salt cedar during the establishment of native habitat restoration projects. Roundup, Rodeo, Arsenal, Garlon 3A and 4, and Pathfinder II herbicides are the products most often chosen by managers of native habitat restoration projects because these herbicides are efficacious and cost-effective, with favorable environmental and toxicological properties.

Herbicides may be used effectively, within a defined management plan. Individual products may be applied as a foliar treatment by hand or aurally, or as a Basal Bark or Cut-Stump treatment, based on label recommendations. Post-spray management includes retreatment of escapes and new growth in subsequent years, while saving desirable plants, protecting animal life, enhancing wildlife habitat and protecting water quality in riparian, estuarine and terrestrial areas.

The most desirable weed management in native habitat restoration projects may utilize a combination of chemical, mechanical, biological and competitive methods. Long-term, healthy competition from the desired species, coupled with chemical control of any re-invading exotic plants may be the optimal program. In any given project, the best combination of tools should be selected and molded into a viable weed management program.

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TIMELINE

← NESTING/FLEDGING SEASON →

← SALT CEDAR GROWING SEASON →

← INCREASED RUNOFF/RIVER FLOW →

← INCREASED RUNOFF/FLOW →

JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER

"MOST EFFECTIVE TIME FOR RODEO® APPLICATION"

←

FOLIAR SPRAY

→

← TREAT CUT STUMPS →

→

←

← REVEGETATE →

BASAL BARK TREATMENTS

→

THE USE OF PRESCRIBED FIRE AND MECHANICAL REMOVAL AS MEANS OF CONTROL OF TAMARISK TREES

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The Colorado Desert District of California States Parks has had a long-term program to control tamarisk in critical resource areas, especially in riparian locations of Anza-Borrego Desert State Park. In 1995 a three year program to remove exotic plants in the District was funded by a private donor. The primary means of tamarisk removal is through the use of cutting by lopper or chainsaw with a follow-up of herbicide application using GARLON 4 or RODEO. The basal-bark method of GARLON 4 application has been found very effective for specimens with a basal diameter less than four inches. This method precludes the need to cut the tamarisk, thereby saving tremendous amounts of labor. In areas of tamarisk monoculture such as along the shoreline of the Colorado River, the use of prescribed fire and mechanical removal by bulldozer has been employed.

In January of 1996 a twenty acre plot adjacent to the Colorado River was targeted for a prescribed burn at Picacho State Recreation Area. The north margin of the plot was the river, the east and south margins were campground roads, and the west margin was provided by a bulldozed fireline constructed at a width of 30-50 feet. This plot was deemed ready to burn since the tamarisk had entered dormancy and dead leaves covered both the tree branches and the ground. State Parks was assisted on this project by the Bureau of Land Management and the United States Fish & Wildlife Service, which each provided a fire boat to control the line in dense cane up and down river.

Ignition of the plot occurred at the down river margin, with prescription calling for a backing fire into the plot. Cane (Phragmites) ignited and fire spread rapidly with flame length reaching over thirty-five feet. The Phragmites consumed totally and moved the flame into the adjacent tamarisk where the fire quickly and surprisingly died out. Even though the tamarisk was laden with dead leave material, the stems and trunks appeared to be so water laden that fire would not move into the thicket of tamarisk.

On a previous tamarisk prescribed burn a similar situation occurred, although the previous fire was in October when the tamarisk still held its leaves. In the October 1988 fire in Anza-Borrego Desert State Park, the unsuccessful burn was followed up with the chainsawing of about 20% of the standing tamarisk, then burned again in December of 1988. This strategy was successful, with the dead fuels on the ground building heat and carrying fire into the standing trees. The burned plot was then treated for stump-sprouting using GARLON 3A which we used before converting to GARLON 4.

The partially burned plot at Picacho SRA was bulldozed in its entirety with the massive amount of tamarisk biomass stacked into forty large piles, each approximately 30' x 30' x 15' high. These piles were allowed to dry for three weeks and were then burned in a two day period in March of 1996. A bulldozer was employed once again to turn the piles after each had burned to insure that all organic material was consumed by fire. The plot was then groomed to allow for efficient revegetation of cottonwoods, willows, mesquites, and palo verdes and the installation of an irrigation system.

A one month period brought tamarisk resprouts to the plot and a long-term retreatment program using GARLON 4 has begun. The twenty acre plot has been divided into twenty-five quadrants to allow for a methodical treatment program and for analyzing varying treatment strategies.

POINTS TO CONSIDER:

If possible, use the lowest impact method of tamarisk removal. The sequence of treatments might follow this progression: 1) direct pulling of seedlings, 2) foliar spraying of seedling beds using RODEO, 3) cutting with loppers and spot application of GARLON 4, 4) use of chainsaws followed by GARLON 4, 5) basal bark treatment using GARLON 4 mixed according to label, 6) prescribed burning followed by herbicide, 7) mechanical removal using heavy equipment followed by herbicide treatment of resprouts.

Burning can be effective for tamarisk biomass removal if performed at the proper time of year and herbicide treatment of resprouts is performed. Wildfires in tamarisk thickets should be viewed as an opportunity to begin a cutting/herbicide application treatment program. If prescribing a burn for tamarisk, consider entering the plot a month or two beforehand and cutting 20-25% of the largest trees down and allowing them to fall and dry. Work throughout the entire plot to equally scatter downed trees. This will provide ground fuels for the prescribed burn and preheating of the standing tamarisks, providing a higher likelihood of consumption. If the surrounding vegetation and terrain allow, plan for a head-fire rather than a backing fire, thereby gaining more heat which will bring a higher percentage of tamarisk consumption.

Burning always needs to be followed up with a methodical herbicide treatment program. Use of fire can be beneficial in almost total removal of biomass from the site, thereby allowing easier access to the stumps and root crowns for herbicide treatment. If fire removes less biomass than is necessary for access to the site, the use of heavy equipment can be employed if the site has been reviewed by qualified specialists for resource sensitivity.

BIOLOGICAL CONTROL OF SALT CEDAR IN SOUTHERN CALIFORNIA

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Salt cedar, *Tamarix ramosissima* Ledeb., is one of several *Tamarix* species introduced into the United States for use as a wind break and to prevent soil erosion. In the southwestern United States, it became widely naturalized and during the 1930-50s its populations exploded and occupied large areas of bottomlands and drainages. *Tamarix ramosissima* is now considered the worst weed of southwestern riparian areas. In 1986, the United States Department of Agriculture, Agricultural Research Service, at Temple, Texas, initiated a biological control program against this invasive exotic weed. The goal of this program is to search for and obtain insects that are capable of feeding on and damaging *T. ramosissima*, that would not harm *Frankenia* or other native vegetation, and that do not feed on or at least not significantly damage *Tamarix aphylla*, a less-invasive species used for windbreaks and shade in the southwestern United States.

Insects exert heavy pressure on *Tamarix* in central Asia. Faunistic studies showed that 50-250 insect species feed on *Tamarix* in Asia and Europe. The highest diversity was observed in the former Soviet Union (>250 species), Israel (220 species) and Pakistan (190 species). As a result of these surveys, 15 insect species were identified as candidates for introduction into the United States. Two insects, the mealybug *Trabutina mannipara* from Israel and the leaf beetle *Diorhabda elongata* from China, have preliminary approval for release (see below), four species are currently being tested in quarantine in Temple, Texas, and one more is approved for introduction into quarantine. The other eight species are currently being tested overseas.

Trabutina mannipara is a small mealybug whose nymphs and adults feed on the twigs and branches of *Tamarix*. The mealybug inserts its mouthparts into the plant and remove juices and nutrients. Large densities can build up on a host plant and branches with very high densities may eventually be killed. The adult female is wingless and excretes a tough waxy egg sac that gradually encloses her and in which she lays her eggs. After hatching, the nymphs remain in the egg sac for a few days, then disperse onto the surrounding branches and plants. This mealybug has 2-3 generations per years. In quarantine the waxy young nymphs covered the young twigs of *T. ramosissima* and eventually killed several of the test plants.

The biotype of *T. mannipara* tested in quarantine is known only from deciduous *Tamarix* from the Dead Sea and Sinai areas in Israel. Specimens were never collected from *Tamarix aphylla* in the field. In quarantine, nymphs were forced to live on plants from 14 genera of Violales and willow and cottonwood but survived only on *Tamarix*. Some feeding on *T. aphylla* was observed but populations were not sustained while populations increased 4-20 times on *T. ramosissima*. Given these observations, this biological control agent is expected to have little or no impact on *T. aphylla* in the field.

Diorhabda elongata is a leaf feeding beetle obtained in China where it attacks only *Tamarix* spp. In China, *D. elongata* is common and causes appreciable damage. The adult is 5-6

mm long and is bright yellow with two black strips on its back. Adults live an average of 18 days. Females lay their eggs singly or in groups of up to 14 in a cluster on tender leaves. A single female will lay an average of 30 (range 11-49) eggs in her lifetime. In China, adults become active in mid-April and begin overwintering by the end of September. There are usually three generations per year. *Diorhabda elongata* overwinters as an adult under leaf litter and in cracks in the soil.

Upon hatching from the egg, the young larva begins to feed on the tender leaves of its host. This beetle is an external foliage feeder and damages salt cedar by eating the leaves and tender twigs. Complete defoliation can occur in outbreaks of this beetle. The youngest larvae are black but the older, larger larvae have a broad yellow stripes on each side. The larvae grow through three instars. When finished feeding, *D. elongata* larvae will drop to the ground and pupate in litter or loose soil. The immature stage (egg-to-adult) lasts approximately 29 days at 25°C.

In quarantine tests, larvae fed almost entirely on *Tamarix* spp. When forced to feed on *Frankenia*, some larval feeding did occur but no healthy adults developed. Larvae fed on *T. aphylla* as well as *T. ramosissima*, however, adults tended to avoid ovipositing on *T. aphylla*. If released, *D. elongata* probably will damage *T. aphylla* only slightly, if at all.

In March 1994, petitions for field releases of these two insects were submitted to USDA, APHIS for approval for release. The technical advisory group of APHIS, a scientific panel that evaluates introduction requests, recommended that both insects be released and preparation of an Environmental Assessment (as required by NEPA) was initiated. On March 26, 1995, the southwestern subspecies of the willow flycatcher, *Empidonax trailii extimus* Phillips, was placed on the endangered species list. This bird now uses *Tamarix* to nest in some of its range since willows, its natural nest trees, have been displaced by it. Concerns have been raised that no other tree will now grow in place of *Tamarix* if it were removed and thus the flycatcher would be negatively impacted. Approval of the Environmental Assessment is dependent on resolution of concerns regarding the flycatcher. It should be noted that this is not an issue regarding the use of biological control, rather it is an issue of whether *Tamarix* should be controlled at all. Thus resolution of these issues impacts all efforts directed at controlling *Tamarix*.

INTEGRATED WEED MANAGEMENT: CONCEPT AND PRACTICE

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The concept of integrated weed management (IWM) has been around for several decades and practiced by some, but only in the last few years has this concept become popular with federal, state and local agencies. In recent years these agencies have all been involved in the "war on weeds", often entering into cooperative agreements with each other to combat the spread of noxious weeds, which know no jurisdictional boundaries.

IWM has been defined as: "The use of all suitable weed control methods to keep weed populations below the economic injury level. Methods include cultural practices, use of biological, physical, and genetic control agents, and the selective use of herbicides" (OSU Ext.8532 1993). In other words, utilizing a combination of control strategies which will hopefully result in the most effective control of the target pest species, in this case, the group of invasive plants commonly referred to as salt cedar.

The term effective control, for most agencies and organizations refers to both the economics of the control effort and the effectiveness or mortality success of control strategies used. Five control strategies have been defined that are important components to consider in your "war on weeds": cultural, biological, physical, genetic and chemical, through the selective use of herbicides (NPS, Weed Mgmt. 1990). At this time I want to describe and discuss examples of each control strategy (with the exception of genetic control agents) to ensure that everyone is aware of what is available in their salt cedar control arsenal.

The term "biological control" has historically meant the use of insects to control noxious weeds. Since most noxious weeds are exotics (not native to N. America or a specific region) most biological control agents are insects which naturally evolved with the weed species in it's native land. Usually the insect is specific to a particular weed species and usually impacts the plant through defoliation of the leaves or boring into the root/vascular system of the plant. This type of control can occur with adult insects, their larva or both. Recently, researchers have been experimenting with the use of plant pathogens (diseases) and

livestock grazing control. Biological control can be effective but usually requires long periods of quarantine by USDA, can be quite expensive and have limited effectiveness. For the past five years the USDA has been working with a mealy bug and leaf beetle from Israel as biological control agent for saltcedar. There is some concern that these insects could impact the exotic, non-invasive species of commonly referred to as Athel. This species has been imported, and planted throughout the American Southwest.

The use of cultural control methods primarily refers the prevention of noxious weed infestation through the modification or elimination of land use practices by humans which may indirectly cause or aid in the spread of noxious weeds. There are generally five aspects to cultural control, which include: 1) prevention, 2) livestock manipulation, 3) wildlife manipulation, 4) soil disturbance activities and 5) public uses. To effectively control salt cedar, the use of some form of cultural control is often necessary.

The use of physical control is a control strategy commonly used on target species and often serves as the "foundation" of the integrated weed management effort. Physical control usually falls under three categories: 1) manual control, which can be as simple as hand pulling of the weed species (seedlings or mature herbaceous weeds generally) to eliminate individuals and reduce the seed source for usually very small infestations, to using hand tools like a hoe, loppers or a machete; 2) mechanical control, which involves the use of power tools (chainsaws/clearing saws) and heavy equipment (tractors & bulldozers); 3) Control via fire, which is normally achieved through the use of prescribed burns. However, "let burn" designations for specific plant communities during wildfire situations can be an opportunity to explore when controlling target species. Often, prescribed fire is necessary when faced with mature stands of saltcedar. Resulting burns will usually achieve some level of mortality of the target species though very rarely eliminates the entire problem, but allows for access in to the vegetative stand for secondary treatment with mechanical and chemical control methods.

For the majority of weed infestations, the selective use of herbicides is necessary to accomplish the objectives of the control effort. The use of herbicides, in conjunction with cultural and mechanical control methods, usually result in the most effective levels of control on saltcedar (Egan et al 1993). The decision to selectively use herbicides requires a comprehensive planning effort and is site, as well as species specific. There are five important questions that must be answered when considering the use of herbicides as an element to an integrated control approach: 1) what herbicides are effective in producing a high level of mortality with a minimal need for re-treatment; 2) what are the effects of the herbicide on non-target species, including residual effects of the herbicide to the soil; 3) what is the most effective and cost-efficient mode

of application; 4) are properly trained personnel available to apply the herbicide; and 5) are there local, state or federal restrictions for the use of a particular herbicide.

The concept of IWM, as discussed above, refers to the "classic" understanding of IWM: the integrated use of cultural, physical, biological and chemical control strategies to contain or eradicate a population of noxious weeds. There are "other" aspects of IWM which may have been overlooked in the previous discussion, especially those related to weed infestation on open rangelands. Integrated weed management on rangelands involves the use of several control techniques in a well-planned, coordinated, and organized program (Sheley 1995). In Sheley's article, he discusses the need for inventory as the first phase of IWM. The goal is to determine and record the weed species present, the size of the area infested, the density of the infestation, whether other rangelands are under threat of invasion, soil and range types affected and other site factors pertinent to successfully managing weed-infested rangelands.

Planning and implementation is the second phase of IWM (Sheley 1995). Planning is the process by which problems and solutions are identified and prioritized, and an economic plan of action is developed to provide direction for implementing the control program. Implementing an IWM plan includes: 1) preventing weed encroachment into uninfested rangeland; 2) detecting and eradicating new weed introduction; 3) containing large-scale weed infestations; 4) controlling large-scale infestations using an integrated approach; 5) revegetation of control sites when and where appropriate; 6) Adoption of the proper range management practices (cultural control) in conjunction with the development of a weed management program; and 7) Monitoring and evaluation of the IWM plan itself. Monitoring and evaluation are the keys to determining if weed and/or grazing management plans are meeting plan objectives and are the prime determining factors used in altering IWM plans.

Now I want to discuss the practice of IWM on the saltcedar infestation specific to Afton Canyon, located along the Mojave River. The Afton Canyon area was designated an Area of Critical Concern (ACEC) in 1989 (Egan et al 1993). One of the objectives in the management plan for Afton Canyon is to improve riparian habitat and increase surface flow through the removal of saltcedar. In 1992, the Barstow Resource Area decided to tackle the large-scale saltcedar infestation (500 acres+) occurring in Afton Canyon. A decision was made to form an interdisciplinary team which would formulate an integrated strategy to contain and control this large-scale infestation. An inventory was conducted using existing data, recent infrared aerial photography and associated groundtruthing. With the inventory information available, the BLM proceeded into the planning phase to identify and prioritize areas within the canyon were identified and prioritized in relation to appropriate strategies to contain this infestation. We selected that portion of the canyon which we felt

had the highest site potential for control and that would assist in control efforts downstream. The selected control area supported large mature stands of saltcedar, surface water flow and a small relict population of native trees. This portion of the canyon was both historically and currently grazed by cattle and was subject to periodically high levels of off-highway vehicle (OHV) use. During the planning phase, the BLM established monitoring plots to document the existing situation and characterize the vegetative components of the canyon. Monitoring plots identified existing ground and canopy cover and were numerically, as well as photographically, analyzed throughout the subsequent control effort. In addition, cross-channel vegetative trend transects were established to quantify ground cover and existing plant species frequency. It was found to be extremely important to fully document how the area selected for control appeared prior to treatment. This information always proves extremely valuable in the monitoring and evaluation phase of IWM. For similar control efforts, extensive photography is highly recommended.

In July, 1992, we ignited a prescribed fire in the canyon with the hope of maximizing saltcedar mortality and to open up the largest stands of mature saltcedar for secondary physical control. The fire resulted in an approximate 50 acre burn, which did result in a high initial mortality and was successful in opening up these area for secondary treatment. Since 1992, an aggressive control and site restoration effort has dramatically reduced the saltcedar population on public lands in Afton Canyon. The primary control strategy selected was the combined use of hand tools, chainsaws and clearing saws (e.g. physical controls) with concurrent herbicide use (e.g. chemical control) following a fire prescription.

This strategy is commonly referred to as the burn and cut method. It was found to be important to cut the trees s down to as close to ground level as possible and then, as shortly after cutting as possible, applying the herbicide directly with a compression sprayer onto the interior of the exposed stumps or stems. This method most effectively allows the herbicide to translocate directly to the root system and effectively kills the plant. Although this method can be very labor intensive, it does result in a high initial mortality rate, reducing the need for re-treatments and allows for the removal of saltcedar from the site, which in turn allows for more rapid natural revegetation.

There has been a low to moderate level of re-sprouting, particularly in burn areas, which require a foliar herbicide application directly onto the re-sprout. There is a much lower level of re-sprouting and thus re-treatment with the cut stump method, but keep in mind there is going to be some level of re-treatment necessary. There are four herbicide trade names that have been identified as effective in the control of saltcedar: Garlon 4, Pathfinder II, Rodeo and Arsenal (though the latter is not approved for use in Calif.).

The need for periodic monitoring and evaluation is key to a successful IWM strategy. The planning process needs to be dynamic, rather than static. Our initial planning efforts identified the need to revegetate the treated area with native trees and native riparian vegetation, which will ultimately provide much higher value wildlife habitat than the removed saltcedar. Initially, the need to modify or eliminate on-going land use practices was discussed, however this became even more evident as the BLM spent more time in the canyon. Portions of the Mojave Road were re-routed to reduce OHV use in the treatment area and in 1994, a three mile length riparian management fence was constructed both to exclude cattle and OHV from our treatment area, in order to provide the maximum protection for both natural and planted revegetation efforts (e.g. cultural control). As the Mojave River is an "open" system, with upstream lands primarily under private management, there will be an abundant seed source for possible re-infestation from upstream for some time to come.

However, we hope through education that those private land owners will become aware of the need to control saltcedar, for everyone's benefit. The long term outlook on containing this particular large-scale infestation is limited to that which can be accomplished on a small downstream area of federally managed lands and any upstream assistance the BLM can receive from private land owners. This is likely to be the case for the majority of lands currently infested with saltcedar (Lovich et al. 1994).

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DECISION CRITERIA FOR DEVELOPING SALT CEDAR MANAGEMENT PROGRAMS

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Salt cedar or tamarisk is an exotic tree that has become naturalized throughout riparian areas in the southwestern United States and is continuing to expand its range into other western states. Tamarisk has become the dominate plant species throughout several entire river drainages and tributaries in less than 100 years after introduction. The riparian areas of the southwest have been reduced and altered so severely from numerous impacts that they may be one of the rarest habitats remaining in North America. Although this pernicious pest is difficult to control there are proven methods that have succeeded. Salt cedar control management can appear to be overwhelming for many land managers, control projects can be expensive and labor intensive therefore we must choose our battles wisely and use careful planning.

Before developing a tamarisk control program there are several criteria one should address to assist in the decision making process, they include: inventory, objectives, management constraints, priorities, site restoration potential, and control feasibility.

-Inventory: Know the extent of the populations and degree of infestation within your management area. Be familiar with surrounding areas as they relate to management, seed dispersal and reinvasion potential.

-Objectives: What are your objectives? Some may be to keep it from spreading into new areas, or to protect native plant populations that are being threatened with the presence of tamarisk. Others may decide for complete elimination and manage for zero tolerance while some may accept a specified percentage of total vegetative cover.

-Management Actions and Constraints: Are management practices and/or activities promoting tamarisk establishment? Can you implement a wide range of control methods such as heavy equipment, herbicides, prescribed fire?

-Priorities: What are your areas of highest value to protect or eradicate and maintain free of tamarisk? The areas with the highest probability for success should be at the top of the list. The combination of answers to many of these questions will most likely determine your priority. I recommend to start small and work your way up to larger projects.

-Site Restoration Potential: Does the site have potential to restore to the desired plant community by natural processes and/or transplanting? Soil analysis and water table level monitoring may be critical depending on the cost or size of the project.

-Control Feasibility: Can this project be successful considering the answers to the questions above? Is tamarisk the only species that can thrive in the existing situation? Are site conditions altered so severely that they perpetuate tamarisk presence? Is accessibility of location a limiting factor? Site maintenance must be included in management plan for perpetuity.

It is important to realize that salt cedar is here to stay and there are many situations due anthropogenic impacts that few native plants species if any could survive. We have created many artificial situations which has given this alien plant advantages for survival over native plants and their historical habitat. However we should not consider the spread of salt cedar benign, instead this should increase control efforts in feasible areas relating to the above criteria. Although tamarisk was introduced and allowed to spread by human impacts it is also encroaching upon remote and relatively undisturbed riparian areas without any help from humans. Due to the aggressive nature of tamarisk, once established through time this plant will eventually dominate from disturbances both natural and tamarisk caused leading to the formation of impenetrable monotypic stands. These monotypic thickets of tamarisk eliminates native vegetation and many wildlife species that rely upon plant diversity. There are a few small rivers, streams and springs that have survived the assault from development and multiple uses but are still threatened by the consistent encroachment of salt cedar. The integrity of these valuable habitats will never be intact with the presence of tamarisk. These outlying riparian areas should be the main focus of prioritizing control efforts.

When initiating a salt cedar control program one should start with small projects that have high potential for success before taking on a more difficult project. This does not mean that large projects cannot be successful or that all small projects will be successful. Attempting to control tamarisk in large scale projects along a major river may be successful in isolated restorable areas with the use of heavy equipment and prescribed fire but probably not feasible without the use of these tools. The decision criteria can work for all sizes and diverse situations encountered while planning salt cedar management programs.

There has been an increased awareness and concern due to the dramatic reduction in biological diversity caused from salt cedar invasions which has led to the development of more control programs. This overwhelming problem brings forth many challenges for restoration managers, hopefully this decision criteria will aid in prioritizing and developing successful tamarisk management programs.

OBTAINING THE RIGHT PERMITS

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Holtville, CA

Early in the planning process of a saltcedar management project, a conscientious effort has to be made to obtain the right permits from agencies that have jurisdiction over the proposed project. Although each State is different, there are several commonalities to the permit process. These relate to potential impacts, particularly on environmental quality. Most permits pertain equally to private and public land, regardless of ownership. It is beneficial if saltcedar is listed as a noxious plant in your state, (we were told that it was not listed in Utah, for example). If you are going to purchase and use a herbicide, you may need a license, certificate, or permit. In California, the County Agricultural Commissioner is the place to go for information on pesticide use. In other states, this is a State Government function. Some areas may need entry permits if they are designated wilderness or protected habitats. It would be a good idea to visit the local jurisdiction (e.g. county or city) to see if they have any permit requirements or can be helpful in other ways. Burning permits are issued by Air Quality Management Districts in counties in California, but local fire departments should also know what you are doing. The Departments of Forestry in each state and Resource Conservation Districts should also be contacted.

In most cases, saltcedar is going to be found in riparian areas; along rivers, streams, or at waterholes and springs. The California Department of Fish and Game requires a 1600 permit if your project will "substantially divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river, stream, or lake designated by the department, ... except when the department has been notified pursuant to Section 1601." The 1600 permit, in order to be issued, will require an EIR or negative declaration; a copy of fish, wildlife, or habitat mitigation plans for the project; detailed map showing project location in detail; plans showing the proposed modification of the site; and copies of local, city, county, or other permit conditions. Also required are copies of Army Corps of Engineers 404 permit, copies of Section 10a permit and conditions from US Fish and Wildlife Service for take of endangered and threatened species. Photos, especially aerial, of the site would be very helpful. The following paper discusses the 404 permit and the role of the Army Corps of Engineers in enforcing the Federal Clean Water Act.

Even though the objective of a saltcedar control project is to make improvements in the local environment, there are potential negative consequences if a project is not properly designed or carried out. The permit process can actually help you accomplish your goals with the least amount of problems and legal hassle. The regulatory climate in California has changed considerably in the last 3 years, the permitting agencies have become cooperative on projects for control of invasive exotic weeds. Remember, contact agencies early in the planning process.

INVASIVE WEED CONTROL AND THE NEED FOR SECTION 404 CLEAN WATER ACT PERMITS: THE DUAL ROLE OF THE ARMY CORPS OF ENGINEERS

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Introduction

Over the last 25 years the riparian areas of the southwest have become infested with two non-native weed species known as giant reed (*Arundo donax*) and saltcedar (*Tamarix* spp.). Control of these invasive weeds often requires an integrated strategy, which can include prescribed fire, herbicide application, and mechanized clearing. When mechanized clearing is employed in an aquatic area, a permit may be required from the United States Army Corps of Engineers (Corps) pursuant to Section 404 of the Clean Water Act. In addition to its role as a regulatory agency, the Corps can be a valuable partner in the battle against riparian invaders, such as giant reed and saltcedar. Both these roles are discussed in this paper.

The Clean Water Act

The primary regulatory mechanism for the protection and management of the nation's waters and wetlands is Section 404 of the Clean Water Act (CWA). Section 404 is administered by the Corps according to regulations published in the Federal Register on July 25, 1975. The main objective of the CWA is "to restore and maintain the chemical, physical, and biological integrity of the nation's waters." Section 404 of the CWA regulates the discharge of dredged material, placement of fill material, or excavation within waters of the United States and authorizes the Secretary of the Army, through the Chief of Engineers, to issue permits for such actions. Permits can be issued for individual projects (individual permits) or for general categories of projects (general permits). Waters of the U.S. are defined by the CWA as "rivers, creeks, streams, and lakes extending to their headwaters and any associated wetlands". Wetlands are defined by the CWA as "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions".

In an attempt to reduce administrative paperwork, Section 404 contains provisions for the issuance of general permits which cover classes of activities considered to have minimal adverse environmental incremental or cumulative impacts on waters of the U.S. and, therefore, not requiring individualized permit review. General permits can be issued on a local, regional, or nationwide level. There are currently 40 general permits which have been issued on a nationwide level (hereafter referred to as the "nationwide permits"). Nationwide permits cover activities such as road crossings, utility line crossings, maintenance, navigational aids, and bank stabilization. There is a great deal of controversy regarding whether or not the cumulative impacts of the nationwide permits are minimal. This is particularly true in the case of Nationwide Permit 26, which allows for discharges of fill into up to 10 acres of isolated waters above headwaters. In the Los Angeles Corps District, which covers Southern California and Arizona, approximately 75% of all Corps actions are nationwide permits.

Procedures for Permit Processing (in the Los Angeles District)

The application process often begins during the conceptual design phase of a project with a preapplication meeting. In this meeting potential concerns of the Corps and other resource agencies are discussed and the applicant is encouraged to redesign their project, if necessary, to avoid or reduce impacts to aquatic resources. Applicants are also encouraged to explore the possibility of reducing the impacts of their project to a level where a nationwide permit may be used.

Once a formal application is received, it is assigned to a project manager who will review the case and ultimately make a recommendation to the District Engineer regarding issuance of a permit. Because permit evaluation is limited to the impacts to areas under jurisdiction of the Corps, the project manager must make an initial jurisdictional determination. For non-tidal waters, Corps jurisdiction extends to the ordinary high-water mark (OHWM), which is defined as:

the line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil; destruction of terrestrial vegetation; the presence of litter or debris; or other appropriate means that consider the characteristics of the surrounding areas (33 CFR Section 329.11)

The shoreward limit of Corps jurisdiction for navigable waters is the mean higher high water mark (MHHM), defined as:

extends through the entire surface and bed of all water bodies subject to tidal action to the line on the shore reached by the plane of the mean (higher) high water, which is defined as the average of the higher of the two daily high tides (33 CFR Section 329.12)

In order to meet the jurisdictional definition of wetlands an area must contain fulfill three wetland criteria (USACOE, 1987):

1. at least 50% of the vegetation on the site must be hydrophytic
2. the soils must be classified as hydric or have hydric indicators, such as mottles, oxidized rhizospheres, or gleying
3. the area must be saturated or inundated for greater than five percent of the growing season. In Southern California this is equal to eighteen days.

Discharges of dredged or fill material resulting from normal farming, ranching, and silviculture culture activities are exempt from Section 404 permit requirements under Section 404(f) of the CWA.

Once the limits of Corps jurisdiction are resolved, the project manager determines whether or not the activity meets the terms and conditions of one of the nationwide permits. If a project qualifies under one of the nationwide permits, a letter may be issued verifying compliance with

the nationwide permit program. Verification of compliance may be conditioned with specific terms regarding construction protocol, use of best management practices, avoidance of endangered species habitat, and mitigation requirements to ensure that the project will have minimal incremental or cumulative impacts to aquatic resources. If a project meets the general terms and conditions of a nationwide permit, but will result in greater than minimal impacts, the District Engineer (DE) may take discretionary authority and require the project to be processed as an individual permit. The review process for a nationwide permit is generally less extensive than for an individual permit and can often be completed within thirty days.

Projects which cannot be permitted under a nationwide permit must undergo a more extensive review under the individual permit process, which typically takes 120 days. The Corps decides whether to issue an individual permit based on an evaluation of the probable impacts, including cumulative impacts, of the proposed activity. According to Corps regulations, permits should not be issued for activities which will create "significant" degradation of the waters of the U.S or have "significantly adverse effects on wetlands values". However, the CWA provides no clear definition of "significant" (Hirsch, 1988).

The evaluation process for an individual permit is based on guidelines established under Section 404(b)(1) CWA and on the "public interest review" procedures. The public interest review involves a broad qualitative evaluation of a project's benefits and detriments. Corps regulations identify twenty-one factors which are relevant to permit review. These factors are conservation, economics, aesthetics, general environmental concerns, wetlands, historic properties, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shore erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs, consideration of property ownership, and the general needs and welfare of the people. The public interest review is facilitated by the issuance of a 15-30 day Public Notice soliciting comments from the public and resource agencies, such as U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, and California Department of Fish and Game regarding the proposed project. A public hearing may be held for highly controversial projects.

The Section 404(b)(1) guidelines are often considered the driving force in the Corps permit process (Liebesman and Hundemann, 1992). The 404(b)(1) guidelines prohibit discharges of dredged or fill material if there is a less environmentally damaging practicable alternative. Practicability is determined based on technological, economic, social, and logistic considerations. If a proposed project has greater than significant impacts, attempts must be made to avoid and minimize impacts. Impacts which cannot be avoided must be mitigated to a level where the net impacts to waters of the U.S are not significant. In some cases, projects which result in significant impacts may be permitted if they provide a substantial benefit to the public, such as projects affecting national security or considerable production of energy.

The Corps must ensure that permitted projects comply with all other applicable federal resource protection laws such as the Endangered Species Act, the National Historic Preservation Act, and the Coastal Zone Management Act (see Section 2.3.4). In addition, certification that the proposed activity will comply with all applicable effluent limitations and water quality standards

of Section 401 of the CWA is needed prior to issuance of a Section 404 permit. The need for a Section 404 permit constitutes a federal action under the National Environmental Policy Act (NEPA). Therefore, during the review of a proposed project an Environmental Assessment (EA) is prepared according to NEPA guidelines. If the impacts of the proposed activity are determined to be significant according to NEPA, an Environmental Impact Statement (EIS) must be prepared and reviewed according to all NEPA requirements.

If a proposed project complies with all the NEPA requirements, the 404(b)(1) guidelines, is determined not to be contrary to the public interest, and does not violate any federal resource protection laws, the Corps will issue an individual permit authorizing the proposed discharge of dredged or fill material into water of the U.S or wetlands. If a proposed project violates any of the above, then the Corps must deny the Section 404 permit. Of the estimated 100,000 activities regulated annually by the Corps, 83% are authorized by general permits, such as the nationwide permits. Less than 5% of individual permit applications are denied annually; however, up to 30% of individual permit applications are withdrawn. (Liebesman and Hundemann, 1992; Thompson and Yocom, 1993). Under Section 404(c) EPA has the authority to override a Corps' decision to grant a permit if they feel the discharge would result in "unacceptable adverse effects on municipal water supplies, shellfish, fishing areas, wildlife, or recreation areas. Since 1972, only 11 vetoes have been initiated (Thompson and Yocom, 1993).

The Corps of Engineers as a Partner in Invasive Weed Control

Effective management of invasive weeds requires watershed-scale efforts, with weed control beginning in headwaters areas and proceeding downstream to minimize reinfestation of previously treated areas. Such large-scale efforts are often beyond the resources of individual organizations. The widespread jurisdiction of the Corps of Engineers allows Corps representatives to gather information on needs and projects throughout watersheds, putting the Corps in a position to coordinate efforts among various organizations. Two such coordinated efforts are currently ongoing in the Santa Ana and Santa Margarita watersheds in southern California. These watersheds are two of the largest in southern California (2,450 square miles and 750 square miles, respectively) and both encompass multiple counties, cities, special districts, and military installations. The Corps is working with federal, state, and local agencies, the military, and private groups, such as The Nature Conservancy, to help coordinate invasive weed control programs in these watersheds. Exposure to multiple control programs and strategies has allowed the Corps to develop technical expertise and help disseminate knowledge gained through successes and failures.

Corps' regulations, guidelines, and Memorandum of Agreement (MOA) allow for compensatory mitigation to be performed in order to offset the unavoidable impacts associated with permitted activities. Invasive weed removal can serve as compensatory mitigation for certain projects affecting aquatic resources and can be incorporated into the Best Management Practices of many projects. The Corps can require permittees whose activities involve temporary or construction related disturbance of aquatic areas to ensure that the disturbed areas are not invaded by saltcedar, giant reed, or other weeds. This can help reduce proliferation of infestation, as often

happens in recently disturbed areas. When on-site mitigation is not appropriate, the Corps can direct permittees to mitigate the impacts of their activities by removing invasive weeds in strategic areas of the watershed; thereby contributed to the overall control program.

The recent rise in popularity of mitigation banks provides another tool for use in large-scale invasive weed control programs. Wetland mitigation banks strive to establish large, contiguous wetland areas which can be used to mitigate for a number of independent impacts. This allows eligible permittees to purchase compensatory mitigation credits from another entity that has already produced and banked them, thereby eliminating the need to produce compensatory mitigation areas on-site (IWR, 1994). The Corps has been an active participant in the establishment a mitigation bank in the Santa Ana River which is focused on invasive weed removal. The goal of the Santa Ana River Mitigation Bank (SARMB) is to reestablish native riparian ecological diversity and other riparian functions through the removal of invasive weeds. The 137 acre SARMB is located in a portion of the Santa Ana River where the native riparian habitat has been replaced with monotypic stands of *Arundo donax* (giant reed). The establishment of this mitigation bank should provide the resources to remove giant reed from a ecologically important reach of the Santa Ana River. At the same time, the proposed SARMB will provide an ecologically meaningful and economically efficient alternative for permittees fulfill compensatory mitigation requirements of Corps permits. If successful, this mitigation bank could serve as template for the establishment of other mitigation banks focused on invasive weed removal.

It should be clarified that a Section 404 permit is not always necessary to undertake an invasive weed removal program. Prescribed burns, herbicide application, and using hand-held tools to cut plants do not require authorization from the Corps of Engineers. Corps permits are necessary when mechanized landclearing, excavation, stockpiling, or other activities occur which affect the substrate of an aquatic area (*e.g.* rivers, lakes, wetlands). Many smaller (*i.e.* less than ten acres) invasive weed removal projects may qualify for authorization by nationwide permits. However, in recognition of the fact that invasive weed removal generally results in environmental enhancement, the Los Angeles District of the Corps of Engineers has proposed issuance of a General Permit, which would authorize mechanized removal of invasive weeds from waters of the U.S. in southern California. If this General Permit is issued, it would provide for expedited approval of mechanized invasive weed removal contingent upon following a series of pre-determined environmental protective measures. This General Permit would also allow people to take advantage of opportunities for invasive weed control which arise immediately following flood or fire.

Corps participation on interagency teams allows for protection of resources and the public interest, coordination of large-scale invasive weed control efforts, dissemination of technical information, and identification of opportunities to ease regulatory hurdles to invasive weed control. This allows the Corps to fulfill the dual role of regulatory agency and partner in invasive weed eradication.

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**AN
APPROACH
TO
SITE RESTORATION AND MAINTENANCE
FOR
SALTCEDAR CONTROL**

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"If a tree dies, plant another in its place."

*Linnaeus (1707-1778)
Swedish Botanist*

There is more relevance in the above statement with regard to the control of native/exotic invasive plants than one might recognize at first glance. This is particularly true in relation to the control of the exotic plant group commonly referred to as saltcedar (*Tamarix ramosissima*, *T. parviflora*, *T. chinensis*), which has replaced several million acres of native vegetation within southwestern stream and wetland natural areas. Resultant saltcedar-dominated natural areas appear to be affected hydrologically and the saltcedar plant communities subsequently formed have been found to be far less productive, diverse and ecologically functional, than the native plant communities they replace. Several control strategies have been developed to remove saltcedar from natural areas for a variety of management objectives, but vegetative site restoration and maintenance are the only two common elements of those control programs that have been effective over the long term. Vegetative site restoration involves not only restoring the native plant community, terrain and hydrology of a natural area but the ecological processes and disturbance cycles necessary to sustain that native plant community over time. Unfortunately, little has been written as specific guidance for site restoration and maintenance associated with saltcedar control. This document briefly discusses the concept of site restoration and maintenance in relation to saltcedar control and outlines a seven point approach to consider in the implementation of such a control program.

Vegetative site restoration and long-term maintenance of such efforts in any natural area are difficult tasks in and of themselves. When combined with having to do battle with 1) a plant species such as saltcedar that has an incredible capacity to invade, i.e., ability to allocate a large proportion of available resources to seed production and vegetative growth as well as adaptations for both wind and water dispersal of these elements; and 2) native streamside and wetland plant communities that have characteristics of easy invasibility, i.e., areas with a large perimeter to volume ratio, altered natural disturbance regimes, mesic habitat conditions and contact with

human activities (Bossard 1992); site restoration and maintenance can prove to be a daunting task.

Major challenges to site restoration and maintenance in natural areas affected by saltcedar control programs often include:

- 1) a lack of adequate funding for the detection and effective control of exotic plants, as well as site restoration/maintenance, in non-agricultural systems;
- 2) a lack of strong public agency policy toward resolving conflicts that influence the effectiveness of control, restoration and maintenance efforts, such as allowing continued livestock grazing, use of travelways, water diversion, flood control, etc. in restoration areas;
- 3) a potential for continued, as well as new, ground surface or water flow disturbances;
- 4) a potential for introductions or reintroductions of exotic plants, as well as a potential for large expansions of invasive native plant species; and
- 5) an underfunding of biological and ecological studies of invasive species and the communities they invade (Brussard 1991, Schierenbeck 1995).

These challenges can appear overwhelming for project managers, but a little creativity and networking can go a long way in meeting these challenges, or at least towards minimizing their influence upon project objectives. Above all, natural area site restoration and maintenance is an evolving management field that should be viewed as a combination of art, experimentation and applied science. Selected techniques, strategies and planning have to be frequently designed from scratch, monitored and modified to fit the needs or realities at a particular site.

Although it has become increasingly obvious that intensive management is required for the maintenance of natural ecosystems (Brussard 1991), the amount of on-the-ground site restoration and maintenance work necessary to achieve effective saltcedar control can range from little effort over an extended time (Neill 1985) to intensive effort on an annual basis (Taylor 1994), depending on whether the particular system is open to water flow or closed, the degree of saltcedar infestation, control/restoration techniques used and the amount of labor/supply resources dedicated to control efforts. Site restoration costs can similarly range from low to high (Egan *et al.*, 1993), with site maintenance costs increasing as site restoration success decreases. Applied restoration techniques have shown both success and failure, but their basis is conceptually sound (Bureau of Reclamation 1990a).

Due to the inherent resilience of streamside and wetland plant communities, site restoration goals can often be achieved with minimal effort if control efforts encompass a large enough area, control efforts are sustained and land management practices are altered to promote conditions conducive to native plants rather than saltcedar (Lovich *et al* 1994, Dudley and Collins 1995). Long-term maintenance of restored areas in relation to saltcedar in the American Southwest is more problematic, depending foremost upon how open the natural area is to

waterborne saltcedar sources; the proximity of windborne saltcedar seed sources; and the degree to which site restoration was effective in establishing both native ground and canopy, vegetative cover.

Site restoration is a relatively young field of natural area management in terms of available empirical information and successfully demonstrated techniques. Each site, each system, is different and we still have a lot to learn. The following seven point approach to site restoration and maintenance is recommended as general guidance for individuals and organizations currently involved in, or contemplating, saltcedar control in natural areas.

SEVEN POINT APPROACH TO SITE RESTORATION AND MAINTENANCE

- 1. Look at the entire watershed or system and identify the factors which allow the invader and desired plant species to proliferate, as well as the influence of human activities on the site. Use an historic background if possible. Plan with a long-term vision. Control, restore and maintain strategically.**
- 2. Plan for a sufficiently large restoration site in order to provide for the natural conditions necessary to promote plant and animal community diversity. Focus on a goal of plant community transition zone or "edge" habitat reduction and apply restoration maintenance efforts in such "edge" areas.**
- 3. Make use of natural processes such as flood and fire as well as applied control efforts to assist in site restoration and maintenance when opportunities arise. Two examples include: retention of burnt saltcedar woody material resulting from a controlled fire to create suitable germination sites for seeding; and utilizing floodborne sediment to plant native tree poles.**
- 4. Eliminate livestock grazing, minimize motor vehicle and railroad influences and modify fire suppression efforts in affected natural areas. Minimize soil disturbance, protect native vegetation, utilize fire to assist in saltcedar control and follow suppression efforts with additional control efforts needed to effectively kill burned, invasive plant species capable of resprouting.**
- 5. Minimize recreation conflicts within or near the subject natural area. Be cognizant of the full array of recreational uses that may occur and their associated influences on natural features, upon invasive plant control, site restoration and maintenance goals.**
- 6. Monitor and maintain desired site conditions on a regular basis. Revise control, restoration and maintenance strategies accordingly. Even a minimal monitoring and action effort can ward off stumbling blocks to achieving your restoration goals and is likely to be cost-effective in the long run.**
- 7. Lastly, keep informed. Maintain close liaison with others involved with habitat restoration work, particularly those involved with non-indigenous plant species control.**

The principles outlined in the above approach are based upon information summarized in Schierenbeck's 1995 documentary, "The Threat To The California Flora From Invasive Species: Problems And Possible Solutions" as well as a review of saltcedar control efforts to date. This approach is offered specifically for saltcedar control, but may also have applicability in site restoration for other invasive plant control efforts in our nation's natural areas.

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SALT CEDAR MANAGEMENT: A SUCCESS STORY

Curtis E. Deuser
National Park Service

Background and Program Development: Lake Mead National Recreation Area has many miles of tamarisk thickets along the shores of Lake Mead and Lake Mojave and in numerous springs and canyons. Records reveal that some tamarisk control work was conducted in the 1970's by some foresighted park rangers, however this work was left abandoned and unmaintained. Some tamarisk control projects have been conducted annually since the early 1980's by park rangers in the Black Canyon to allow access to beach camping along the Colorado River. In 1986 the parks' natural resource management division began a more concerted effort by inventorying and mapping vegetation resources at more than 30 isolated springs and undertook a study on tamarisk control methods. Although the spring inventory was very crude it was the most helpful management tool to proceed before undertaking a tamarisk control program. Resource managers then decided to develop priorities focusing on the springs which form isolated islands of biological diversity amongst a sea of arid landscape.

Implementation: Eradication efforts began in 1988 by forming small groups of 2-4 employees and volunteers that worked in various areas ranging in size from one acre to several miles of drainage. The larger areas with high salt cedar density were removed using prison crews and trained park service restoration crews. The areas of highest density and remoteness were accomplished using hot shot firefighter crews. Park staff maintains areas free of tamarisk after the initial labor intensive removals are completed.

Restoration: Post tamarisk removal site recovery success has kept managers positive by directly observing the fruition of their efforts. Re-establishment of native vegetation has been impressive by both natural recolonization and active revegetation by transplanting. Specific project results are presented from data collected from vegetation plots at the Sacatone Spring experimental restoration site (refer to attachments).

Accomplishments: Eighteen spring drainages have been successfully restored by the eradication and maintenance of tamarisk including large dense areas from sites 1 to 7 miles in length. Achieved excellent revegetation success at six sites by transplanting native trees. Developed and refined four effective tamarisk control methods using prescribed fire, cut-stump, low volume basal herbicide application, and heavy equipment. Conducted large scale salt cedar removal projects at four beaches on Lake Mojave by using heavy equipment and fire.

Current and Future Plans: Currently initiating a relatively large scale riparian restoration project at the tamarisk dominated Las Vegas Wash, methods of control will include heavy equipment, fire, and flooding. Developing a GIS map of tamarisk control areas and

zero tolerance zones to assist with maintenance scheduling and planning. Finalizing the Pesticide Use Plan for Tamarisk Control. Funding proposals continue to be submitted for riparian restoration at three other high priority sites. Pursuing a National Park Service wide approach to managing salt cedar populations and the possible development of exotic plant control crews for project implementation.

TABLE 1

LAKE MEAD NATIONAL RECREATION AREA

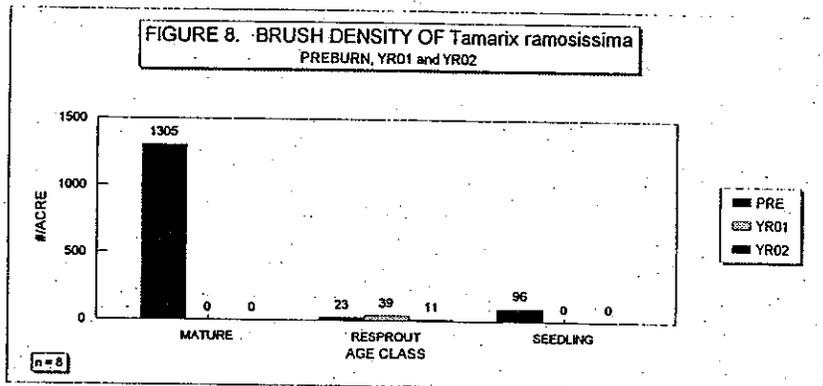
SACATONE WASH BURN UNIT

BRUSH BELT DATA

COMPARISON OF BRUSH DENSITY PRE AND POSTBURN OF SELECTED BRUSH SPECIES, TRANSECTS BTARA1D06 01 - 08

BRUSH DENSITY (#/ACRE) OF *Tamarix ramosissima*

AGE CLASS	1991 PRE	1993 YR01	1994 YR02
MATURE	1305	0	0
RESPROUT	23	39	11
SEEDLING	96	0	0



BRUSH DENSITY (#/ACRE) OF *Baccharis sergiloides*

AGE CLASS	1991 PRE	1993 YR01	1994 YR02
MATURE	585	309	782
RESPROUT	0	39	11
SEEDLING	28	326	107

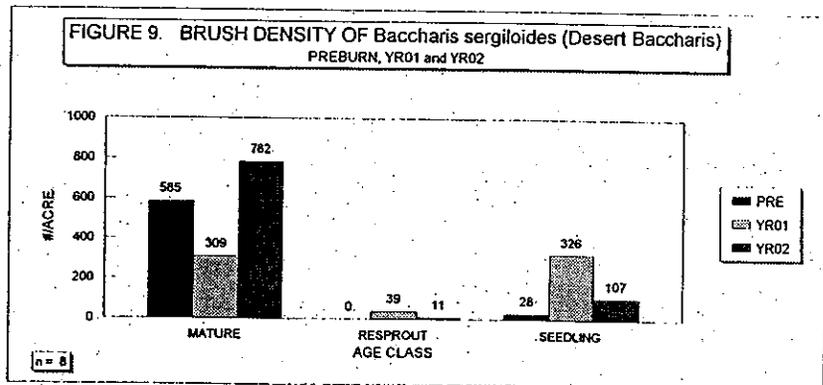
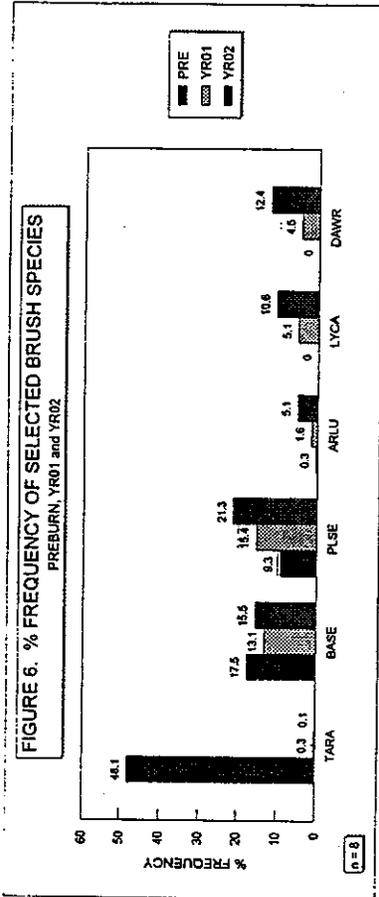


TABLE 2

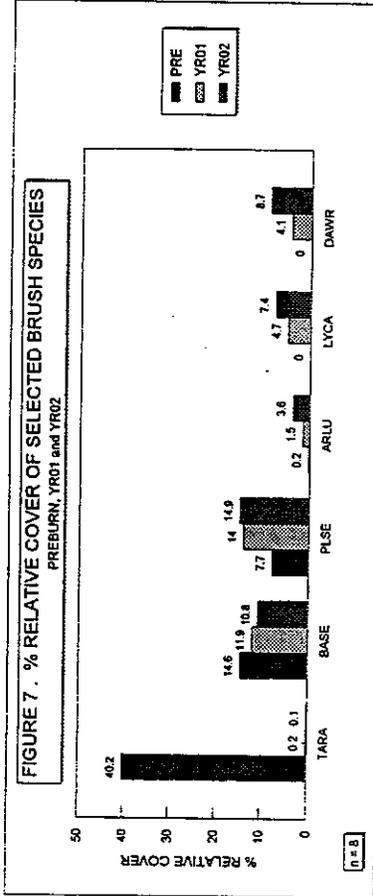
LAKE MEAD NATIONAL RECREATION AREA
SACATONE WASH BURN UNIT
LINE TRANSECT DATA

COMPARISON OF FREQUENCY AND RELATIVE COVER PRE AND POSTBURN OF SELECTED BRUSH SPECIES, TRANSECTS BTARA1D08 01 - 08

SPECIE CODE	% FREQUENCY	
	PRE	YR01
TARA	48.1	0.3
BASE	17.5	13.1
PLSE	9.3	15.4
ARLU	0.3	1.6
LYCA	0	5.1
DAWR	0	4.5



SPECIE CODE	% RELATIVE COVER	
	PRE	YR01
TARA	40.2	0.2
BASE	14.6	11.9
PLSE	7.7	14
ARLU	0.2	1.5
LYCA	0	4.7
DAWR	0	4.1



SPECIE CODE	SCIENTIFIC NAME	COMMON NAME	HABIT
TARA	<i>Tamarix remosissima</i>	Tamarisk	non-native shrub
BASE	<i>Baccharis sergoides</i>	Desert Baccharis	native shrub
PLSE	<i>Pluchea sericea</i>	Arrow weed	native shrub
ARLU	<i>Artemisia ludoviciana</i>	Silver wormwood	native shrub
LYCA	<i>Lycium californicum</i>	California locoweed	native sub-shrub
DAWR	<i>Datura wrightii</i>	Jimson Weed	native sub-shrub

THE SALT CEDAR MANAGEMENT WORKSHOP
WAS PRODUCED IN COOPERATION WITH



Monsanto

The Agricultural Group



US DEPARTMENT
OF THE INTERIOR
NATIONAL
BIOLOGICAL
SERVICE