Tamarix is a genus of Old World shrubs and trees that normally lives in riparian life zones. Some common names of Tamarix include: saltcedar, tamarisk, and athel pine. Some species of Tamarix can grow up to eighteen meters tall and they have tiny, triangular, scale-like leaves that are winter-deciduous. Tamarisk grows in dense, nearly impenetrable thickets and it thrives in high salinity-high alkaline soils. The normal geographic range of Tamarix is in Eurasia and across North, East, and Central Africa, the Middle East, and parts of Western and Southern Asia.

Out of the fifty species of Tamarix only eight species were first brought to North America from Southern Europe and/or the eastern Mediterranean region in the 1800's. The species were first planted as ornamentals, and later utilized as windbreaks and shade trees. Tamarix was also commonly used to stabilize river banks and prevent erosion near the banks of rivers in riparian life zones (8). Tamarix species escaped cultivation and are now widespread throughout the United States with heavier concentrations in the Southwest. This poses four unique problems to the riparian ecosystem in which it was introduced.

The first threat that this invasive species poses is on soil salinity; Tamarix thrives in high salinity-alkaline soils. Because tamarix has deep roots that extend into the soil, Tamarix creates even saltier soils by bringing up alkaline water that is then deposited on the leaf's surface, which then falls off the leaves back onto the soil's surface. The increased salinity of the upper soil profile inhibits the growth, survival, and recruitment of desirable native vegetation: Freemont cottonwood, willow, and other mesquite vegetation. The second way that Tamarix is problematic is that it is a phreatophyte, or a plant with a deep root system, that draws it's water supply from the water table. Studies have shown that a full-grown Tamarix can uptake nearly 200 gallons of water a day. Because of this, many areas in the western United States are losing 2 - 4.5 million

acre-feet of water per year. This is enough water to irrigate 1 million acres of land, or supply more than 20 million people with water for one year (6). The third way that Tamarix is an invasive species is that it increases wildfire frequency. Because the vegetation structure of Tamarix promotes rapid fire spread and high fire intensity, the organism can introduce fire into wetland and riparian communities that are not adapted to periodic burning (8). The fourth way is that Tamarix increases the intensity and frequency of flooding by narrowing channels and waterways. This not only creates more frequent floods, but also limits human and animal use of the waterways.

One of the major ways in which tamarix is being eradicated from the environment in the United States is by using biocontrol. (legacy cite) Two species of insects which eat Tamarix trees have been tested. One is a mealybug (Trabutina mannipara) from Israel that sucks sap from the twigs and the other is a leaf beetle (Diorhabda elongata) from China that eats the leaves (7). The leaf beetles were brought over from China to the US to control and eradicate the Tamarix population over time. Leaf beetles and their larvae consume the foliage of the Tamarix plant which over time reduces the chlorophyll photosynthesis and production. This in turn reduces the starches and sugars that are made for the plant. By repeating this process of defoliation by the leaf beetles, the plant is defoliated and should result in a decrease or dying off of some of the root mass. If this continually happens and the plant isn't allowed to grow new foliage and retain it for an extended length of time, it is possible to kill the plant. Estimates for the Tamarix plant to die this way suggest three to five years, but this could be longer or shorter depending on the size of the plant and its root mass, how often it's defoliated, and how limited the time is that the plant retains foliage (6). This method has been proven to be effective and it has been observed that

natural re-vegetation has occurred where the Tamarisk has been removed; however, manual, human re-vegetation may be required in some areas.

A second way to remove the Tamarix population is by hand-pulling the Tamarix out of the ground. This method can be especially effective in areas where the trees are small and where it is difficult to get to the invaded area. This is also a viable option where herbicides cannot be used, such as a desert spring (7). To determine the best elimination method for this plant the managers of the land consider a couple of factors before deciding on a control method: the size of the area where the invasive species has invaded, the restrictions on herbicides and burning, the presence of desirable plants nearby, the presence of open water, and the cost of labor (2).

Other methods of elimination include bulldozing and root-plowing to open up large forests of Tamarix trees, using controlled fires, or using the chemical method of herbicide. This chemical method involves cutting the stump of a tamarisk two inches above the soil surface and treating it with herbicide within minutes. However, there are a few issues with these other methods that need to be considered.

The first is that any pieces of root that are left in the ground of the Tamarix plant can re-sprout. This is especially problematic for the mowing and root-plowing method as they can rarely get the roots out completely. The second is that Tamarix is adapted to fire and recovers more quickly than native riparian species after a burn. Although animals may seem like a viable option for tamarix control, it is not so. Cattle will sometimes eat young Tamarix shrubs and goats may eat the regrowth of Tamarix after an invaded area is burned, but grazing is not a satisfactory control method as animals prefer other plants. Birds, cattle, and other animals do not normally

eat Tamarix because the seeds, leaves, and fruit of the plant are too small, tough, and salty for these animals.

One other way to control Tamarix is by using existing agricultural infrastructure. In a study done by D.P. Bunting and his colleagues, they implemented two irrigation treatments over two years to promote native Fremont Cottonwood establishment over the invasive Tamarix (1). The study used both frequent shallow-irrigation and infrequent deep-irrigation. The results of the study demonstrated that average Freemont Cottonwood growth rates were higher than Tamarix in both years, and that overall Fremont Cottonwood mortality was lower than Tamarix in both years. The results demonstrated that Freemont Cottonwood can out-compete Tamarix by using retired agricultural settings. (1)

Another study done by Anna A. Sher and her colleagues demonstrates the use of flood disturbance to restore the ecosystem by promoting its dominant plant species over the invasive Tamarix species (5). The study investigated the competition between the native plant species (Populous Deltoids) and the non-native species Tamarix. Due to the larger size of the native Populus, it was predicted that its superior competitive ability could lead to its dominance when conditions allow for native establishment. The conclusion of the experiment determined that even in the presence of an invasive species (Tamarix) that positively responds to ecosystem disturbance, re-establishment of post-flooding hydrology and flooding regimes can help to restore the ecosystem of its native, dominant plant species; In this case, Populus Deltoids (5).

Studies have shown that the diversity of wildlife is much higher in native habitats than in non-native habitats. Wildlife biologists believe that the removal of non-natives, such as Tamarix,

and the restoration of the native habitat will enhance the overall quality of the wildlife habitat (6). In a study done by Kennedy and his colleagues they found that the removal of the non-native Tamarix increased native fish density while decreasing the amount of non-native fish species (3). These non-native fish species, such as mosquitofish and crayfish, have both been found to decline the native fish population through a means of predation of eggs. The eradication of the non-native tamarix species not only allows for native plants to grow, but also creates a domino effect throughout the ecosystem allowing for other native species such as fish to return in a higher density (3). Although many wildlife taxa prefer native cottonwood, willow, and mesquite habitats to Tamarix, Tamarix can also serve as adequate habitat for numerous species. Other replacement vegetation such as shrubs, grasses, and weeds can sometimes be less likely to be an improvement for wildlife, although mixtures of vegetation types can result in high wildlife use (4). The complexity in wildlife response will continue to make generalizations difficult regarding wildlife habitat restoration. The composition of this replacement vegetation is very important for water salvage and to prevent future re-infestation. Vegetation types that are likely to replace the non-native Tamarix depend on the site conditions and the restoration approaches that can be implemented. In some cases, re-vegetation with riparian plant species is likely to be a viable option, while in other cases planting more salt and alkaline tolerant plant species would be more appropriate (4).

The failure to effectively restore the area with native plant species can result in re-colonization of not only Tamarix, but other non-native plant species as well. Even water-use studies have shown that increases in water-yield following Tamarix control are likely to occur only when an area that used to be infested is replaced with different vegetation with a lower leaf surface area than Tamarix (4). By implementing the different methods of elimination, many of

the riparian ecosystems in the United States that have been invaded by Tamarix can potentially regain their native plant and animal species, and return to a state of high wildlife diversity.

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