Ficus Carica's Negative Impact on Riparian Ecosystems

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Writer's Comment: Figs were one of my favorite fruits growing up so I naturally gravitated towards researching their role in natural ecosystems during my Restoration Ecology class project. I was shocked to find out that my favorite fruit was creating issues in California's riparian ecosystems, and I wanted to learn more about the edible fig's invasiveness. When I was assigned a research paper on a topic of choice in my UWP 104E class, I immediately knew I wanted to write about the edible fig; specifically, how it contributes to the displacement of the riparian ecosystem as well as possible eradication methods. Writing this paper effectively piqued my interest in restoration ecology, prompting me to take more classes focusing on invasive plants within California. With this article, I hope to open the audience's eyes to the unfortunate role that anthropogenic interference plays in the destruction of riparian ecosystems while highlighting the effects of invasive species on climate change.

Instructor's Comment: Joyce Wong's essay on Ficus carica*, otherwise a dicot known as the fig, deals with the invasive nature of this plant type and how "If fig invasion is not controlled, it is likely that fig trees will dominate the riparian forest ecosystem, pushing out native trees and understory shrubs that are vital for the ecological stability of California riparian forests." Joyce reminds us, en route, that the study of such an invasive type is especially crucial when set against the fact that 95% of California's riparian forest lands have already been eliminated. Joyce Wong's research thus serves as not only a detailed study of* Ficus carica *and what eradication methods might prove most effective* *in dealing with an "invasive subcanopy fruiting deciduous tree" but it also serves to remind us—one and all—that we must remain vigilant when it comes to preserving our amazing California inheritance.*

– James McElroy, University Writing Program

Background

Ficus carica, commonly known as fig, is an invasive subcanopy fruiting deciduous tree that resides in moist environments such as riparian forests, streamside habitats, levees, and canal banks in the California Central Valley (Holmes et al., 2014). Unlike most invasive species, the fig can establish itself in low-light, low-disturbance, and native plant-dominated environments (Holmes et al., 2014). These qualities make the fig a successful invader—it rapidly forms dense thickets that are difficult to eliminate (Bossard et al., 2000). Figs spread through root sprouts or broken off limbs which can take root. The latter is a common issue during storms or floods since the limbs that are broken off spread significant distances through streams and other waterways (Bossard et al., 2000). The California Invasive Plant Inventory currently ranks it as having moderate impact capabilities with severe distribution levels (California Invasive Plant Council, 2006).

If fig invasion is not controlled, it is likely that fig trees will dominate the riparian forest ecosystem, pushing out native trees and understory shrubs that are vital for the ecological stability of California riparian forests (Bossard et al., 2000). Riparian forests are extremely rare and endangered in California due to humans converting over 95 percent of riparian forest land into agricultural, pastoral, and developed areas (Bossard et al., 2000). Riparian forests are even more essential due to climate change—climate change is projected to increase flooding, droughts, air temperature, water surface temperature, and distributional shifts amongst organisms. Riparian plants are adapted to hydrological and geomorphic disturbance that creates tolerance for both varying seasonal and annual environmental conditions, along with providing microclimates for species with thermoregulatory limitations (Seavy et al., 2009).

Very little research has been conducted on the fig's role as an invader.

With the small percentage of riparian forests that still exist in California, further fig research is advisable to guarantee the future sustainability of these ecosystems.

Eradication Methods

There are no known effective measures for fig elimination from riparian ecosystems. Trees re-sprout quickly and are extremely difficult to control without herbicides (Bossard et al., 2000). It is important to consider potential eradication methods, as discussed below, to understand what may or may not be effective.

A study conducted at Cosumnes River Preserve near Sacramento, California called for fig tree thickets to be treated via the *hack-and-squirt method*. Fig trees were cut between six and eighteen inches above the ground and the trimmed trees were treated with a 100 percent solution of the herbicide triclopyr. This treatment was successful, although the thickets had to be treated yearly due to re-sprouting (Bossard et al., 2000). At times, trees were retreated two to six months instead of yearly, which seemed to be more effective. However, this exact method was conducted at the Dye Creek Preserve, which is also located near Sacramento, California (Bossard et al., 2000), without success.

Another potentially viable method currently being researched is *basal bark application*, which involves herbicide application in an eight-to-twelve-inch-wide band around the uncut trees' trunks with diameters larger than two inches. In a study conducted by Holmes et al. (2009), basal bark treatment was used for the controlling invasive fig trees in six different groves located in the Hatfield State Recreation Area, McConnell State Recreation, and Bobcat Ranch along Putah Creek. The herbicide of choice—composed of 25 percent triclopyr herbicide and 75 percent methylated seed oil—was applied with a backpack sprayer at low pressure to the trees' lower 30 to 45 centimeters for trees with basal diameters greater than 7 centimeters and the lower 15 to 20 centimeters for trees with basal diameters less than 7 centimeters (Holmes et al., 2009). Three different herbicide treatments were used: *standard basal bark treatment* (the six fig groves), *limited basal bark treatment* (seven small, isolated fig groves at Hatfield to observe whether herbicide would transfer from treated to untreated), and *foliar spay treatment* (the fig groves along Putah Creek, treated with foliar spray that contain 2 percent glyphosate, 0.5

percent surfacrant, and 1 percent antifoaming agent).

Holmes et al. (2009) found that the standard basal bark treatment provided successful results compared to limited basal bark treatment and foliar spray treatment: at Hatfield and McConnell, approximately 99.3 percent of fig trees were eliminated, with no sign of live buds or green inner bark after 270 days or 600 days after treatment. Limited basal bark treatment had eradicated around 66.7 percent of fig trees but found that the herbicide did not transfer from treated to untreated fig trees. Holmes et al. (2009) state that if the fig thickets were entirely clonal the triclopyr would spread via a common root system; the fig thickets at Hatfield may have been partially clonal, or the roots did not translocate the herbicide due to disrupted root connections, or some fig trees being established from falling fig seed. Foliar spray treatment at Bobcat Ranch killed only 0.3 percent of fig trees and required specialized vehicles and equipment which are unable to access fig thickets (Holmes et al., 2009), making this treatment inadequate. Basal bark treatment was also a successful fig eradication method at Catalina Island—Ratay et al. (2007) first used the hack-and-squirt method practiced at Cosumnes River with 100 percent Habitat® (Imazapyr) that failed. Basal bark application using Pathfinder II™ (Triclopyr) herbicide was applied for a year and fig control was successful, leading to follow-up treatment on small branches or seedlings that were difficult to find (Ratay et al., 2007).

During the basal bark treatment, Holmes et al. (2009) discovered the herbicide was over-applicated due to the high fig grove bio-density, resulting in herbicides such as triclopyr slowly degrading and absorbing; this created a higher-than-average soil leaching capacity, indirectly affected native plant seedling emergence and growth rates. Holmes et al. (2009) found that native plant mortality was statistically greater in treated plots; the mortality was 16 percent after 41 days and increased by 5 percent after 78 days. However, the native plant mortality levels did not meet the criteria for restoration efforts, diminishing some concerns that the triclopyr would destroy native plants (Holmes et al., 2009). The herbicide contaminating the soil or extensive flooding that occurred in four sites may have produced false native plant mortality levels (Holmes et al., 2009).

Fig Ecology

Holmes et al. (2014) also discusses the overlaying patterns and processes of the fig invasion at Caswell Memorial State Park, located in the Central Valley. The spatial location, diameter of the largest tree, reproductive status, total number of trees, and floodplain positions were recorded for each invasion site at the park (Holmes et al., 2014). After collecting the data, a chronosequence was created to examine the figs' rate of invasion. Data collection consisted only of fig trees that were older than 10 years due to the discovery that figs do not expand laterally for the first 10-15 years of maturation. It was found that invasion sites with several older trees, as well as sites that were closely compacted, had significantly higher rates of lateral expansion when compared to invasion sites that were expanding from a single point. Even though the first fig tree invaded Caswell Memorial State Park in 1934, there was an 18-year lag before the fig population became fully established (Holmes et al., 2014). After this period, the fig population expanded at an exponential rate even with herbicide control in 2002 due to the figs' extensive dispersal methods increasing population size per hectare from 1935 to 2005 (Holmes et al., 2014). Growth rates among figs positioned within river, slough, and terrace floodplain positions were not statistically different, suggesting that fig trees do not have a water table preference.

Holmes et al. (2014) also found that figs are capable of several dispersal distances: fig groves 30 years or older had hundreds of reproductive trees and saplings due to fig fruit seeds and extensive root networks. Invasion theory estimates that short distance dispersal can cause linear expansion rates (Shigesada et al., 1995), and Holmes et al.'s (2014) statistical analysis showed that the figs expand laterally outward at a constant linear rate. Fig groves also dispersed their seeds at 20 to 200 meters, which occurs through birds or deer that consume the fruit and also through a symbiotic relationship with the wasp *Blastophaga psenes*. It was found that in Caswell, the wasps had become naturalized in the population and increased local propagule production (Holmes et al., 2014).

Possible Solutions

Based on current fig research, Holmes et al. (2009) see basal bark application as an effective treatment, but are open to discovering more effective control strategies with limited herbicide use to protect native species. The results of both Holmes et al. and Ratay et al. demonstrate standard basal bark application is the most useful method for fig eradication compared to foliar spraying, hack-and-squirt, and limited basal bark treatment. The hack-and-squirt method was effective at Cosumnes River Preserve but not at Dye Creek Preserve or Catalina Islands (Bossard et al., 2000, Ratay et al., 2007). Data from Cosumnes River Preserve is also unavailable, making it difficult to discern why it was successful only there. Holmes et al. (2009) state that the hack-and-squirt method is labor-intensive and more dangerous than basal bark treatment because trees need to be cut first; furthermore, fig leaves contain two furocoumarin compounds that are activated on exposure to light of 320-370 nanometers, causing a skin rash in humans when contact is made (Bossard et al., 2000, Ratay et al., 2007).

Adding physical control such as Bossard et al.'s (2000) hypothesis to repetitively cut re-sprouted saplings to exhaust the root network to basal bark treatment may improve fig control and eradication. Before maturation, fig trees have shallow root systems and are often located in heavy, wet soils, making manual removal simple. However, it is important to keep in mind that fig trees root-sprout, which means the above-ground sapling that is pulled out could be linked to an extensive underground network of roots (Bossard et al., 2000). Ratay et al. demonstrate this in their study—they also successfully treated *Asparagus asparagoides* (bridal creeper) at Catalina Island through manually removing its rhizomatous root system and solarizing the soil after Glyphosate Pro II (Glyphosate) herbicide was unsuccessful. As Bossard et al. (2000) stated, manual removal has not been tested on the fig but, similarly to bridal creeper, fig has an extensive root system. Solarizing the soils figs grow in can eradicate seed banks that have been dispersed, as Cohen et al. (2008) and Richardson et al. (2007) found by successfully eradicating invasive Australian Acacia species seed banks and de-stimulating germination. Combining basal bark application with manual control and solarization could make total fig eradication increase and reduce the amount of herbicide leaching into soils and native plants.

Research on the effects of orchards and home-grown figs on the dispersal rates of figs would further inform development plans. Dispersal distances should be monitored to see how they are affected by *B. psenes*, birds, deer, and other species that may consume the fig fruit. Agriculturists within and around riparian ecosystems should focus on this to prevent further invasions. Holmes et al. (2014) found that seeds collected from wild fig populations in four California watersheds had high viability levels, occurring only when the fig's syconia is pollinated by *B. psenes*. Nationally, California ranks third in fig production (Bossard et al., 2000) and there are no laws preventing people from growing fig trees in their homes.

Monitoring California fig orchards to quantify their likely role in dispersing fig seeds onto riparian corridors would be advisable, since the most recent data states there are approximately 57,278 acres of fig orchards (California Figs, 2017) that could contribute to figs spreading. Being cautious with how the figs are transported throughout California and the rest of the United States from the orchards is essential in preventing further dispersal. Monitoring home-grown figs would be more challenging because every home-grown fig tree would need to be tracked down and each homeowner would need to be convinced to participate in the monitoring study. California also does not classify the fig tree as a noxious weed (California Code of Regulations, 2017); without government support, home-grown figs cannot be monitored. However, it is possible to focus on home-grown figs near riparian ecosystems to increase the likelihood the California government will agree to monitoring.

Observations of the fig's re-rooting capacity after storm situations would also be valuable, although there would be difficulty obtaining this data due to the environmental stochasticity. Thus, this form of monitoring, depending on the amount of previous research available, may need to take place over the course of five- to ten years to ensure that all species-plant interactions and all types of environmental conditions are observed. However, the monitoring times may depend also on the site, due to the amount of available resources and niche space the fig may depend on, as seen at Caswell (Holmes et al., 2014). Once comprehensive monitoring is accomplished within the site, eradication plans can be tailored to suit the affected ecosystems.

Through the combination of known eradication techniques such as herbicidal treatments and manual removal of re-rooting branches within time-specific periods of maximal spread, managers could switch to an active-suppression tactic. If the data shows that the fig trees within extensive storm zones spread the most after a storm with heavy winds, personnel could be deployed to manually remove broken branches. This would in turn reduce the need for herbicidal treatments which also damage native plant life. If figs are found to spread most during a germinating period, however, then more precise applications of herbicides would be needed to inflict a stress-state that limits total seed output. Replicates and a control group should be in place to confirm that the treatment is working so that it may be applied to other sites in the future.

Regardless of whether or not more effective manual or chemical eradication measures are found, there is a clear need for managerial intervention due to the exponential spread of fig systems which has already been observed throughout several states and over many years (Holmes et al., 2014). Restoration ecologists must monitor riparian ecosystems for invasives to prevent misidentification that will make implementing control and eradication programs more time-consuming and costly (Holmes et al., 2014). Riparian forest ecosystems are vital to the Earth's changing climate (Seavy et al., 2009). As the current administration proposes drastic cuts in environmental studies and even deletes environmental information from Government websites, the hard work of environmental education and, ultimately, the restoration of these ecosystems becomes more crucial than ever.

Works Cited

Bossard, C., Randall, J. and Hoshovsky, M. 2000. "Ficus Carica." *Invasive Plants of California's Wildlands*. University of California, Berkeley. Print.

California Code of Regulations. 2015. "§4500. Noxious Weed Species." https://www.cdfa.ca.gov/plant/docs/4500Text04012015.pdf. Accessed March 2017.

California Figs. "About Figs." https://www.californiafigs.com/index.php?pageid=8. Accessed March 2017.

California Invasive Plant Council. 2006. "California Invasive Plant Inventory".

Cohen, O., Riov, J. Katan, J. Gamliel, A. and Bar, P. 2008. "Reducing

Persistent Seed Banks of Invasive Plants by Solar Solarization – The Case of Acacia saligna." *Weed Science*. 56. 860-865.

Holmes, K.A. and Berry, A.M. 2009. "Evaluation of Off-Target Effects Due to Basal Bark Treatment for Control of Invasive Fig Trees (Ficus carica)". *Invasive Plant Science and Management* 2:4. 345-351.

Holmes, K. A., Greco, S.E. and Berry, A.M. 2014. "Pattern and Process of Fig (Ficus carica) Invasion in a California Riparian Forest." *Invasive Plant Science and Management* 7:1. 46-58.

Ratay, S. and Knapp, J. 2007. "Figs and bridal creeper: Two stubborn weeds that require ingenuity." California Invasive Plant Council Symposium 2007. San Diego, CA, California Invasive Plant Council.

Richardson, D. and Kluge, R. 2008. "Seed banks of invasive Australian Acacia Species in South Africa: Role in invasiveness and options for management." *Perspectives in Plant Ecology, Evolution, and Systematics*. 10. 161-177.

Seavy N.E. et al. 2009. "Why Climate Change Makes Riparian Restoration More Important than Ever: Recommendations for Practice and Research." *Ecological Restoration*. 27:3. 330-338.

Shigesada, N. Kawasaki, K. and Takeda, Y. 1995. "Modeling stratified diffusion in biological invasions." *The American Naturalist* 146:2. 229-251.