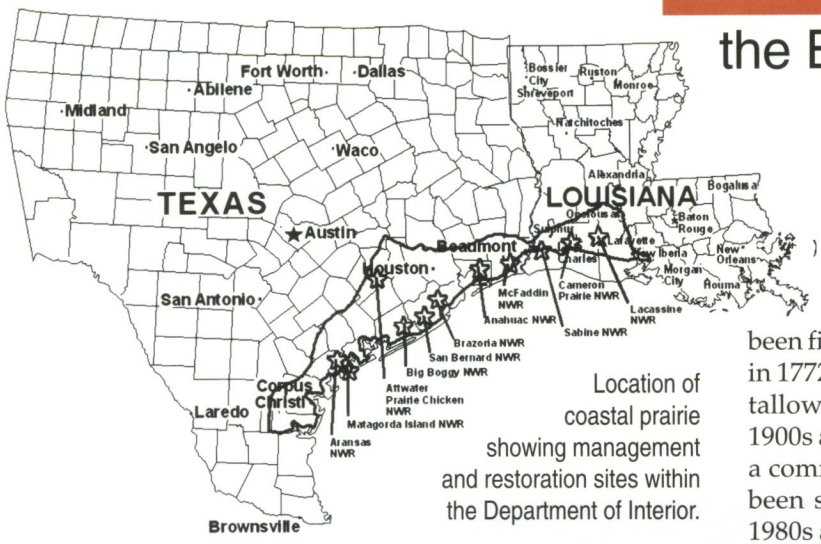
Can Prescribed Fire Save the Endangered Coastal Prairie Ecosystem from Chinese Tallow Invasion?



Location of coastal prairie showing management and restoration sites within the Department of Interior.

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Stretching along the coastal plain from central Louisiana to southern Texas lies a poorly described and badly degraded natural grassland that has long escaped the attention of ecologists and conservationists alike. Prior to European settlement, the coastal prairie ecosystem was a band of grasses and forbs nearly 500 miles long, bordered to the south by marsh and to the north by forest. At that time, herds of bison roamed the region, pronghorn antelope were abundant, and wolves hunted from the riverine strand forests that dissected the plains. In the spring, the drumming of the prairie chicken was commonplace, and wildflowers, butterflies, and grassland birds were abundant throughout the prairie region.

Once railways into this region were completed in the late 1800s, the prairie was opened up to widespread cultivation, and farming began in earnest. Conversion of much of the land to agriculture, particularly in the eastern coastal prairie, was so rapid and complete that biological descriptions of the native communities at that time are rare. Today, it is estimated that less than one percent of the original prairie remains (Smeins et al., 1991). In Louisiana, less than 500 of the original 2.2 million acres still exist, while in Texas, as much as 247,000 of the historic 6.9 million acres persist due primarily to the tradition of livestock ranching instead of cultivation.

Aside from the threats due to habitat loss, degradation, and fragmentation, the remaining pieces of coastal prairie and efforts to restore them are now facing a somewhat different enemy, the exotic tree Chinese tallow. Cultivated in China for about 14 centuries (Bruce et al., 1997), tallow is believed to have been first introduced to North America by Benjamin Franklin in 1772. In the coastal prairie region of Texas and Louisiana, tallow has been introduced numerous times since the early 1900s and has often escaped cultivation. By the 1940s it was a common feature of the landscape and since that time has been spreading and increasing in abundance. During the 1980s and 1990s, tallow abundance reached dramatic levels that have caused it to be recognized as one of the exotic plants of greatest threat to native habitat in the southern United States.

A number of characteristics of tallow contribute to its reputation as a threat to native species, both in prairie as well as in other community types within its range. Because it has been bred as a seed crop, primarily for the oils and waxes in its seeds and fruits, it has rapid growth, early reproduction, and prolific seed production. Seeds are released from pods from September through November (though the seed may remain on the twigs for many months after dehiscence) and dispersal is primarily by birds and water.

There is some indication that unlike most native trees, tallow seeds may survive for several years, permitting the development of a seed bank and enhancing its colonization capacity. Because of its rather large seed and shade tolerant seedlings, tallow has been observed to invade undisturbed habitat, though, like most invasive species, its entry into a system is enhanced by disturbance. Once it establishes, tallow grows rapidly and resists both flooding and drought, an uncommon feature for most species.

Through both rapid growth and reproduction, this invader can effectively suppress native woody and herbaceous species alike, creating near monoculture forests devoid of prairie species, either plant or animal. It has been reported that tallow is capable of invading and dominating an open habitat in as few as 10 years (Bruce et al., 1995).

Recently, our studies of tallow have focused on the question of whether prescribed fire might be an effective control. As for most prairie types, as well as for many other kinds of ecosystems, wildfire is believed to have played a critical role in the formation and maintenance of the coastal prairie (Smeins et al., 1991). Before the widespread conversion to agriculture and the subdivision of the landscape by roadways, wildfires swept through the

The remaining fragments of the coastal prairie ecosystem and efforts to restore it are currently threatened by Chinese tallow (*Sapium sebiferum*), an invading exotic tree. With its capacity for rapid growth and prolific reproduction, tallow is capable of converting native prairie into a near monoculture forest in only a few years. Although tallow possesses several adaptations to fire, evidence is mounting that prescribed burning may be an effective management tool for limiting its invasion into coastal prairie.

prairie on what is presumed to have been a regular basis. During periods of hotter and drier weather, fires would have been more frequent, while in periods of cooler or wetter weather, substantial intervals between fires would have allowed the encroachment of shrubs until the next period of hot fires (Archer et al., 1988).

It is unlikely that fire was the sole determining factor for the prairie's persistence in the wet climate of the coastal prairie region. Much evidence exists to suggest that this prairie was also edaphic or soil regulated, especially in the eastern portion where rainfall is most plentiful. Here the soils are hard, cracking clays or fine, silty loams underlain by a hardpan inimical to the ready establishment and growth of trees. The increase in woody plant cover in the recent decades since wildfire has become uncommon suggests that these edaphic features alone are not sufficient to restrict tree growth. Rather, it is likely that a combination of soil properties, periodic droughts made more severe by the soils, and frequent fires maintained the ecosystem in a state of "disclimax" where trees and shrubs were frequently disfavored. To some degree, natural grazers such as bison, antelope, and deer may have also contributed to the restriction of trees and shrubs, but the common occurrence of all these species in forests suggests that their role in prairie maintenance was not a dominant one.

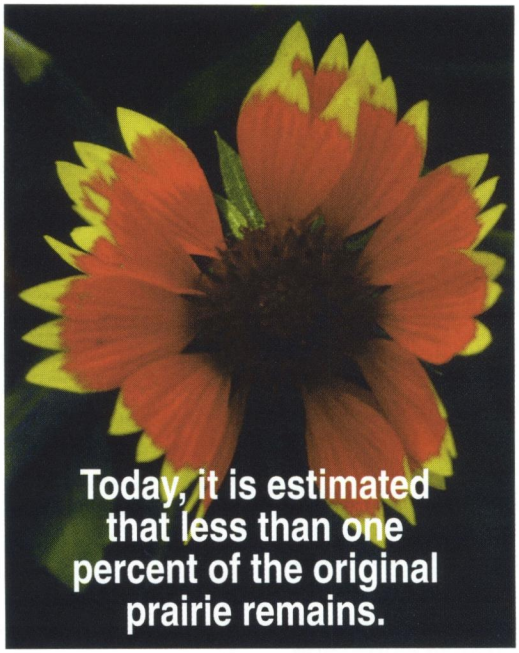


Photo by Rob Sosnowski

When fire moves through the prairie, the native woody plants are typically killed or severely damaged, resulting in a maintenance of fire-tolerant and sometimes even fire-promoting grasses and forbs (Scifres and Hamilton, 1993). Through the process of repeated burning, it is believed that these communities become strongly selected for fire-tolerant species over those less able to withstand the many effects that fire can have on growth, survival, and reproduction. For some other fire-dependent ecosystems, it has been suggested that species may even be selected for their flammability as a way of disadvantaging their less fire-tolerant neighbors (Williamson and Black, 1981). While this feature of prairie vegetation has not been established, it is clear that typical prairie species must be adapted to frequent fire.

A number of human activities have reduced the incidence of fire in the coastal prairie. Historically, lightning strike fires would have moved across vast areas until they encountered streams or other natural barriers, or were put out by rain (Anderson, 1990). Fragmentation of the landscape is a key feature that greatly reduces the probability that a remnant prairie will burn naturally. Fire suppression activities, as well as grazing and mowing (which reduce available fuel) lower the odds of wildfire occurrence. As a result, human-set fires have come to be the cause of a great percentage of the fires, though certainly wildfires (including escaped human-set fires) are still common. For the people responsible for managing native prairie habitat, prescribed fire is currently viewed as one of the primary tools of choice for controlling tallow. Alternative methods such as mowing and herbicides, while useful, are expensive, labor intensive, and sometimes counter to management objectives.

A consequence of the low frequency of fires in the coastal prairie has been the increased development of woody vegetation. In most cases, however, these overgrown systems are still vulnerable to fire when it finally occurs. For example, in areas where eastern baccharis, a native coastal shrub, grows unmolested for many years, one hot, growing-season burn can completely kill the tops of the shrubs, reducing the plants to basal sprouts and stimulating a resurgence of native grasses and forbs, usually with a profusion of flowering. Thus, even with fire suppression, it seems that the community remains "pyrogenic", capable of supporting a strong fire that resets succession.

When the exotic Chinese tallow tree enters the picture, this normal pattern of fire-induced succession can be dramatically altered. Tallow has a number of adaptations to fire. First, as trees get larger, thickening of the bark provides protection for the cambium layer where secondary growth takes place. Above some minimum size, tallow appears to become resistant to being killed or "top-killed" (death of the above-ground portion of the plant) by fire. Second, for smaller trees or large trees subject to a very hot fire, the response to being top-killed is a vigorous resprouting that can produce 6.5 feet of regrowth in only a single season. Thus, the plants can recover from fire quickly. Third, when damaged by fire or mechanical cutting, tallow typically responds by root sprouting at some distance from the original stem, resulting in clonal spread for distances greater than 16.5 feet. Fourth, only the hottest fires ignite tallow and it does not typically propagate the fire as a crown fire, unlike many trees and shrubs. Finally, and perhaps most importantly, stands of tallow are excellent at competitively excluding the fuel species that drive fire. It is common to watch a prescribed fire burn right up to the edge of a tallow stand and simply go out because of a lack of fuel. Because of these last two features, low flammability and strong ability to suppress fire, it is possible for tallow to render the ecosystem nonflammable.

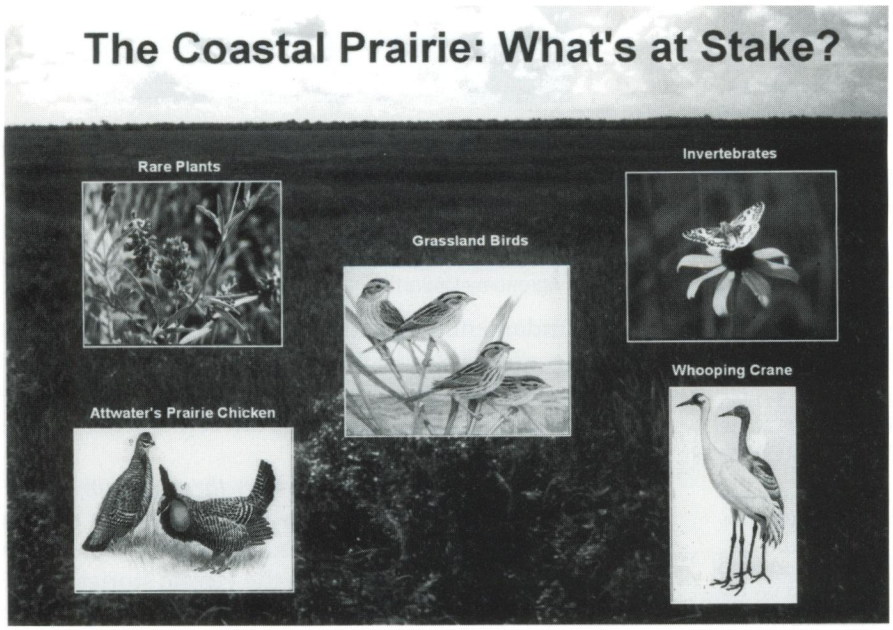
The conversion of prairie from pyrogenic to nonflammable has potentially severe consequences for both the fate and management of prairie. In essence, the system changes from being fire regulated to being tallow regulated. There is some evidence that once tallow stands are well developed, soil properties may become altered (Cameron and Spencer, 1989), having consequences for the plant and soil invertebrate communities that are, as yet, unknown (Harcombe et

al., 1993). Certainly, stands of tallow greatly reduce available light and can be expected to alter soil moisture profiles, microclimate, and, therefore, a wide range of habitat characteristics. Once a site has become tallow regulated, the only means of recovering the ecosystem is through applications of herbicides in combination with mechanical activities. Such approaches, while necessary in certain cases, should be viewed as the last line of defense because of the potential for undesirable effects on the native community as well as the expense and effort.

Recently, our studies of tallow have focused on the question of whether prescribed fire might be able to provide effective control if used early in the process of invasion or as a preventative to successful invasion. The basic idea is that below some critical size, tallow is vulnerable to fire and that the critical size will depend on the intensity of the fire. In areas with poor fuels or subjected to a low intensity fire, only the smallest trees will be killed or top-killed. In areas with high fuel loads and intense fires, however, much larger trees will be heavily impacted. To a certain extent the critical factor determining whether a fire is effective is whether the trees are shorter in stature following the fire than before the fire. As an example, if a tallow tree is 6.5 feet tall before being subjected to fire, a reasonably hot fire may damage the canopy of the tree considerably. Shortly after the burn the tree will begin resprouting, which may occur from basal shoots or along the main axis at some distance above the ground. It is also possible that some of the tallest branches may not be damaged at all if they escaped the upward influence of the flames and the main axis was not girdled by damage to the cambium. Assuming that the below-ground parts of the tree are not completely killed, which is typically the case for trees of even modest size, the recovery process continues until the next fire. If at the time for the next burn the tree is smaller than it was before the first burn, we can see that the tree is getting smaller over time and we are moving toward increasing damage to the tree, resulting in control. If, on the other hand, the tree is larger than it was before the first burn, the tree is moving increasingly toward invulnerability, both because of its increasing size and because of its increasing effect on fuel species.

Since 1996 our research group has been examining the question of whether a minimum critical tree size exists for control of tallow using fire, and if so, what factors determine that size. Our study is being conducted at the Brazoria National Wildlife Refuge, a unit of the U.S. Fish and Wildlife Service. In 1990, the refuge acquired an approximately 30,000 acre tract of coastal prairie and wetlands for conserving and restoring this land for wildlife habitat. Since that time, refuge staff have been using various management practices, including the extensive use of prescribed fire, in order to bring this habitat back into a relatively natural state.

In 1996, studies were initiated at the Brazoria Refuge to determine the effectiveness of fire on tallow populations in areas previously subjected to grazing (virgin prairie, that is, never plowed) or rice farming (abandoned field). Special attention has been paid in these studies to determine the relationship between tree size and fire effects, and to factors that might influence the effectiveness of fire. Because of the heterogeneous nature of fire in



woodlands, measurements of both fuel conditions and effects on woody plants are being made by using a tree-centered approach. Fires were conducted in both growing season and dormant season conditions, and the fate and subsequent recovery of trees were examined during the following year.

Initial results seemed to confirm the worst fears of conservationists. Investigations immediately after the fire indicated that nearly all trees were resprouting or only slightly damaged. Of the 400 trees being studied, the only trees that appeared dead were 4-inch-tall seedlings transplanted into the site as part of the experiment. Not a single tree of the natural population was killed. In the abandoned field sites, one clear problem was inadequate fuel conditions and a very incomplete fire, with only 24-37% of the trees actually being burned. At the prairie site, however, fires directly affected 73-100% of all trees. Regardless, even trees exposed to the most extreme flames showed vigorous resprouting shortly after the fire.

When trees were re-examined at the end of the growing season in 1997, we were surprised to find that rather than showing continuous recovery, many trees showed evidence of much greater damage than initially apparent. Of those trees subjected to fire, all new seedlings had died, and 70% of trees 6.5 feet or less in height, as well as more than 30 trees in the range of 6.5-16.4 feet, were either killed or top-killed. While the tallow populations were not decimated, it was clear that this single burn event had an impact. Further, other variables measured revealed that for many surviving trees, leaf area was dramatically reduced and final heights were less than those before the fire.

Detailed examination of the results indicates that there is considerable variation in the effects of fire. While analyses are still preliminary, it appears that the long-term effects of the growing season burn were substantially greater than those from the dormant season burn, particularly on the survival and growth of basal resprouts. Also, total stand fuel loads, the species composition of the fuels, and fuel continuity appear to have contributed to generally hotter and more complete fires at the virgin prairie sites compared to the abandoned field sites. These hotter fires not only burned more trees but were more likely to kill trees outright.

Much is yet to be determined concerning the potential for fire to reduce tallow populations. Subsequent burns have been conducted to ascertain the effects of repeated fires so as to better judge long-term fire management programs. How quickly will the fuel recover? How does the interval between burns influence fire's impact? Are tallow resprouts more susceptible to damage by fire? How does the season of burn affect the total community? Does burning ever enhance the potential for tallow to invade? What has been established is that hot fires can kill or top-kill even large tallow trees and have long-term residual impacts. When we consider how few success stories there are with exotic plants in natural ecosystems, we are encouraged. The long-term viability of the coastal prairie ecosystem, as well as the persistence and recovery of endangered species such as the Attwater's prairie chicken, depend on the prairie not becoming a tallow controlled system.

Acknowledgments

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Weed Reads

A Review of *Alien Invaders - the continuing threat of exotic species*, by Sneed B. Collard III, A Venture Book, New York. 1996. 144 pp.

by Randall K. Stocker, UF/IFAS Center for Aquatic and Invasive Plants and Agronomy Department, University of Florida, Gainesville, FL

The fundamental objective of a useful resource text on non-indigenous invasive plant and animal issues should be to clearly present how we got where we are, review options to solve these problems, and provide some sense of where we are heading.

On almost all fronts, *Alien Invaders-the continuing threat of exotic species* does a good job, and in many areas an excellent job, of providing solidly based information for its probable audience. The text reviews the classic stories of invasive pest problems, borrowing on both plant and animal examples ranging around the planet. Large, clear photographs are numerous and assist in capturing the essence of this public awareness issue. Chapter headings include "What are Alien Invaders?," "New Zealand Nightmare," "Dawn of the Super Invader," "Making a Successful Invader," "Endangered States," "Stopping Invaders and Leaving Them Alone," and "Shaping Our Exotic Future."

The level of detail provided suggests that the target audience will be upper elementary, middle and high school students as well as the general public. At the elementary and middle school level, *Alien Invaders* can form the basis