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PRESCRIBED FIRE:
A TOOL FOR LANDOWNERS, LARGE AND SMALL

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WHY PRESCRIBED FIRE?

Prescribed fire, the most underutilized tool available to the modern landowner, is essential for most ecosystems in the Southern United States (Ryan et al., 2013). Unfortunately, many individuals view fire through an exaggerated lens of catastrophe and destruction. These sensationalized fires have become normalized in today's world, but what if using fire as a tool could prevent wildfires? What if catastrophic fires—such as the deadliest and largest fires in California history, the 2018 Camp and the Mendocino Complex Fires, or the 2011 Bastrop Complex Fire in Texas (Fig. 1)—could be mitigated or prevented (California Department of Forestry and Fire Protection, 2019)?* A solution to these fires could be prescribed burning. Prescribed fire mimics historic fire cycles before European settlement. Currently, the fringe area between homes and wildlands, the Wildland Urban Interface (WUI), is the most wildfire-prone area inhabited by the public. This publication will provide information for vegetation management and other tips to protect homes from wildfires.

The images of California wildfires burning out of control dominated news cycles covering the intensity of a new type of wildfire, despite millions of dollars in suppression efforts. These wildfires burn more acres in shorter periods, inevitably increasing the public's anxiety about the WUI. While the media reports on these wildfires, there are hundreds of prescribed fires (Fig. 2) that are safely and successfully implemented, yet they go relatively unnoticed across the world. In 2011, managers ignited over 6.4 million acres in the 13 Southern U.S. states in relation to forestry operations.

Mechanical and chemical vegetation management methods can cost 10 to 20 times more than prescribed fire, carrying the risk of potential damage to habitat and increased soil erosion. These methods also tend to fall short or only match the benefits of prescribed fire, such as fuel management, debris removal, site preparation, wildlife habitat, vegetation composition, insect and disease management, forage improvement, and overall effectiveness and economics of fire application.

Most prescribed fire publications focus on state or federal burn operations. This prescribed fire guide focuses on methods and applications for landowners

Figure 1. Bastrop County Complex fire. *Photo: Jones et al., 2012*

Figure 2. Winter prescribed fire in South Central Texas. *Photo: Kevin Knapick*

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*The catastrophic fires such as the 2018 Camp Fire (CA) destroyed 18,800 structures and cost 85 lives, the 2018 Mendocino Complex Fire (CA) burned 450,000 acres and destroyed 1,000 homes, and the 2011 Bastrop Complex Fire (TX) (Fig. 1) burned 32,400 acres and destroyed 1,660 homes.

Figure 3. The four brush management categories.
Photo: Wayne Hamilton

possessing less than 10 acres of land up to large ranch owners preparing to manage their property for aesthetic, financial, and safety goals relating to wildfire, recreation, hunting, or grazing operations.

BRUSH MANAGEMENT METHODS

In order to facilitate informed landowner management decision making, several methods of brush control will be examined. Basic brush management practices can be divided into four broad categories: mechanical, chemical, biological, and prescribed fire (Fig. 3). Which method is best for managing volatile fuel loads in defined WUI areas?

In brush management, the phrase "it depends" is utilized frequently, often depending on the specific site, weather, timing, etc. What exactly does "it depends" imply? Prescribed fire, considered the method with the lowest cost but highest risk by landowners, mimics natural ecosystem management (Weir, 2009). This publication presents the four brush management methods separately. These methods are not mutually exclusive from each other, however. Rangelands or forest lands that have been mismanaged for many years may require a combination of the four methods to increase the effectiveness and longevity of treatments to meet landowner goals (Weir, 2009).

Defining "it depends" with the most effective treatment is accomplished through consultation with cooperative county Extension experts, Natural Resource Conservation Service (NRCS) rangeland management specialists, or land consultant companies (Weir, 2009). The subsequent sections will examine each method individually, including the pros, cons, tools, and costs to engage you, the landowner, in this decision-making process. Each section includes weblinks to detailed publications allowing further investigation and understanding of the respective brush management practice presented.

Mechanical methods

Mechanical methods (Table 1) focus on two specific aspects of control: top-growth removal and whole-plant removal (Welch, 2000). Top-growth removal practices result in short-term woody brush control, while whole-plant removal practices result in long-term woody brush control. The effectiveness depends on factors such as climate, topography, soils, and treatment execution (Hamilton et al., 2004 and Welch, 2000).

Applicable mechanical methods trace their origins to the mid-20th century during post-World War II America. Refinement of technology and equipment innovations safeguard their survival despite antiquated modes of action (Hamilton et al., 2004). The popularity of mechanical methods in the 21st century is based on three primary factors: recreational use of rangelands, changes in land ownership trends, and technological advancements (Hamilton et al., 2004).

Landowner focus has shifted to the philosophy of multiple uses, including hunting, livestock, and recreation, creating the need for complex spatial and structural element goals that can be met with mechanical methods (Hamilton et al., 2004). Many landowners will focus on rates of return on their investment, but do the perceived benefits outweigh the financial costs (Table 11) of mechanical methods?

Chemical methods

The most studied of the four brush management methods, more scientific papers have been published about herbicides over the last 50 years than any other method presented in this publication (Hamilton et al., 2004). A primary advantage of herbicides is the knowledge associated with their target weed and brush species, allowing for maximum effectiveness and application economics (Hamilton et al., 2004). Herbicide profiles of target species, chemical behavior, toxicology, ecological effects, mode of action, and monetary costs (Table 2) are all benefits of utilizing herbicides for brush management (Hamilton et al., 2004 and Lyons et al., 2016). The success of chemical brush management depends on target species' susceptibility, application rates, and treatment methods. For specific recommendations, consult *Chemical Weed and Brush Control Suggestions for Rangeland* from Texas A&M AgriLife Extension, NRCS rangeland management specialists, or county Extension agents (Welch, 2000).

The major disadvantage of herbicides (Table 2) is the potential for unintended consequences if applicators do not follow instructions and procedures (Table 3)

Table 1. Mechanical brush management treatments, including pros, cons, treatment life, and considerations. Ground disturbance is a concern for mechanical methods due to soil compaction and loss of organic matter with the likelihood of invasive or noxious species recruitment as well as many undesirable native forbs. *(Adapted from Welch, 2000)*

Method	Pros (brush)	Cons (brush)	Pros (forage)	Cons (forage)	Treatments life (years)	Considerations
Grubbing	Control non-resprouters and basal sprouters	Minimal effectiveness on root sprouters (resprouters)	Pits trap water	Removes grass, hand seeding may be required	5+	Most effective for single-stemmed plants $130–$250/ac
Bulldozing	Control uprooted plants	Leaves rooted plants, resprouters grow quickly, change from single- to multi-stemmed plants	Grass seeding effective	Removes grass, soil compaction	2–3	Soil disturbance, best for nonresprouting plants $100–$300/ac
Chaining (one-way)	Control uprooted plants	Minimal effectiveness on root sprouters (resprouters)	Forage growth improves	Forage growth declines as brush returns	2–3	Chain may not uproot or break small-stemmed plants, increase prickly pear $50–$200/ac
Chaining (two-way)	Increased uprooting vs. one-way chaining	Minimal effectiveness on root sprouters (resprouters)	Forage growth improves	Forage growth declines as brush returns	4–5	Chain may not uproot or break small-stemmed plants, increase prickly pear $100–$400/ac
Racking and stacking	Removes small brush, prickly pear, top removal of Macartney rose	Not recommended as a primary treatment	Forage growth improves	Forage growth declines as brush returns	1–2	Secondary treatment to consolidate debris $100–$175/ac
Stacking	Effective for prickly pear	Can result in prickly pear spread if cladophylls remain on the surface	Forage growth improves	Forage growth declines as brush returns	>5 Reinvasion rate dependent	Removal or thinning of prickly pear and small to medium brush $50–$100/ac
Roller chopping	Knock down and cut small- to medium-sized brush	Rapid regrowth, single to multi-stem change, prickly pear increased	Forage growth improves, seedbed preparation	Forage growth declines as brush returns	2–3	Minimize use in clay soils and wet soils $45–$125/ac
Shredding	Removal of small to medium brush, mulch to cover the soil surface	Rapid regrowth, single to multi-stem change, prickly pear increased	Forage growth improves	Forage growth declines as brush returns	2–3	Limited to brush <4-inch diameter $20–$50/ac
Root plowing	High kill rate if used properly	Not effective on prickly pear or species that can resprout from plant parts	Annual plants survive plowing	Most forage community destroyed	10–20	Major soil profile disturbance may require follow up to repair disturbance $150–$500/ac
Disking	Effective on whitebrush	Effective only on the small shallow-rooted brush	Annual plants survive plowing	Most forage community destroyed	Most forage community destroyed	Should be followed by seeding, secondary for root plowing $25–$75/ac
Mechanical shearing	Effective for non-resprouters	Temporary treatment for resprouters	Forage growth improves	Forage growth declines as brush returns	7–10	Treatment life is species dependent $100–$175/ac

Costs are strictly estimated due to variability in species control effectiveness, stem diameter, soil type, labor, fuel, etc. Every landowner should consult with an expert prior to making any management decision.

Table 2. Pros and cons of herbicide use. *(Hamilton et al., 2004 and Lyons et al., 2016)*	
Pros	
There is a high probability of target species control if applied correctly.	
There has been high amounts of scientific research for application and safety.	
A large number of application guides are available.	
Cons	
There is a risk of an increase in poisonous plant palatability, leading to livestock consumption and losses.	
Misapplication can lead to poor brush and weed control results.	
A chance of herbicide drift to unwanted areas beyond the treatment area is possible.	
Dangerous residues can be left behind.	
A chance of unintended loss of desirable plants is possible.	

Table 3. Keys to proper herbicide application. *(Lyons et al., 2016)*
Points to Consider
Identify the species and need for control.
Weigh the costs, benefits, and alternative methods of control.
Only buy the recommended herbicide.
Read and follow label directions explicitly for mixing and application.
Utilize proper safety equipment.
Calibrate spray equipment before application occurs.
Mix herbicides in a ventilated area.
Utilize conditions that minimize drift to unwanted areas.
Only apply at the suggested time and rate.
Record the herbicide used, spray time, weather, application rate, date, location, and applicator name.

explicitly (Lyons et al., 2016). The herbicide glyphosate has come under scrutiny due to the International Agency for Research on Cancer (IARC) classifying glyphosate as "probably carcinogenic to humans" while the Environmental Protection Agency (US-EPA), along with Health Canada, European Food Safety Authority (EFSA), Food and Agriculture Organization of the United Nations (FAO), and the World Health Organization (WHO) concluding that glyphosate is unlikely to pose a carcinogenic risk to humans (Nolte et al., 2018). The difference in opinion surrounding glyphosate stems from the fact that the IARC does not assess exposure or user conduct risk assessments to determine carcinogenicity. Instead, the potential carcinogenicity of a substance is studied (Nolte et al., 2018). How these glyphosate revelations may affect public perception of herbicides remains to be seen and may lead to further studies to quell the controversy surrounding glyphosate permanently in the court of public opinion.

Biological methods

Some landowners may consider biological control the most appealing of the four methods due to the long list of advantages (Table 4). However, landowners should use caution before racing to apply this method due to the risk of unintended consequences outlined in Tables 4 and 5 (Hamilton et al., 2004 and Welch, 2000). The mode of action for this method involves the deliberate application of natural enemies, including parasites, predators, and pathogens, to suppress growth through careful importation, conservation, or augmentation (Hamilton et al., 2004). Due to the potential unintended consequences and constraints (Table 5), this method should always be overseen by a qualified professional (Hamilton et al., 2004).

One successful method of biological brush control in Texas utilizes goats, which are browsers, to consume all undesirable species within reach of their mouths (Welch, 2000). Even this seemingly benign method can have unintended consequences. Goats can control plants such as juniper, oak, greenbriar, sumac, and hackberry, along with other undesirable species. However, goats can also overgraze desirable species such as forbs and grasses if users are not observant during management. If the destruction of desirable species is observed beyond landowner-acceptable limits, alternative management strategies may be required (Welch, 2000).

The revelation that mismanagement was a contributing factor to the destruction of the major wildfires of 2017 and 2018 in California has led many Californians to propose biological control from goats as a viable management strategy. Biological control from goats may serve as a primary treatment, but it also serves as an excellent secondary method to extend the treatment effectiveness of other methods, including mechanical or prescribed fire (Welch, 2000).

An example would be redberry juniper (*Juniperus pinchotii*) in Texas. Redberry juniper can be top-killed, but it is also a basal-sprouter, which allows it to survive a prescribed fire. Biological control would be an excellent option for this scenario in concert with prescribed fire where top-kill occurs, but the resprouting shoots are vulnerable to consumption by goats. Grazing needs to be initiated as soon as new foliage is observed following prescribed burning. Fire and grazing can be very effective when a secondary treatment is incorporated into the management plan and utilized correctly under the right conditions by landowners (Hamilton et al., 2004).

Table 4. Biological method pros and cons. *(Adapted from Hamilton et al., 2004 and Welch, 2000)*	
Pros	
Practically permanent management of target species	
Minimally harmful treatment side effects	
Control limited to a specific target or group of target species	
Agents are density-dependent and self-disseminating	
One-time establishment cost	
Evaluation of risk	
High benefit to cost ratio if successful	
No future inputs once established	
Cons	
Biological agents may be difficult to control and require close observation	
Overgrazing of desirable forbs and grasses possible	

Table 5. Situations when biological methods are not applicable to brush or weed control. *(Adapted from Hamilton et al., 2004)*
Constraints
Brush and weeds have high value under certain circumstances
The close relationship between the target and valuable crop species
When immediate target species control is required
The goal of total target elimination from a geographic area
Target species have low distribution or economic impact
The target species co-inhabiting area with valuable crop species

PRESCRIBED FIRE

Prescribed fire is the least utilized brush management technique by private landowners due to the negative connotation associated with wildfire and the high-risk assumption by landowners (Ryan et al., 2013). "Burning is among the oldest of land management practices, yet fire ecology is relatively young as a science ..." (Hamilton et al., 2004). This statement beautifully summarizes the history of prescribed fire. The remainder of this publication will seek to address the question, "Does fire have a place in modern society where it can be applied safely, economically, and effectively?"

One prevailing belief among landowners is that only state or federal agencies who possess the education and resources to execute prescribed burns safely can utilize them. A study by Kreuter et al. (2008) examined the landowner perception of fire findings in six counties within the Edwards Plateau region of Texas. The study concluded that some landowners are hesitant to use fire for a variety of reasons (Fig. 4 and Table 6), coinciding with landowners who utilize fire on their property and praise the use of fire for a variety of reasons (Table 7). However, even among the group of landowners utilizing fire, there remain lingering concerns that must be addressed. These landowners must be reassured that fire is economically sustainable, liability is clearly defined and addressed, training and resources are available, and that they will be represented at the state level (Fig. 4). The use of prescribed burning as a means of brush management is dependent on providing resources to encourage landowners to continue the application of fire, and hesitant landowners will require educational opportunities and reassurance that prescribed burning can be used safely and effectively.

Fire acts as a top removal process and is similar to other methods but relies on the amount of fine fuel to carry flames across the landscape (Fig. 5). Fuel continuity is more important than production. Adequate pre-fire fuel may require grazing exclusion or grazing plan modifications on pastures that are to be burned (Welch, 2000). Benefits relating to prescribed fire

Table 6. Landowner reasons to hesitate using fire from most to least important. *(Kreuter et al., 2008)*
Elevated Importance
Insufficient resources
Insufficient knowledge
Legal concerns
No planning assistance
Loss of forage
The target species co-inhabiting area with valuable crop species
Minimal Importance
No burning association
Minimal effect on the brush
Small property

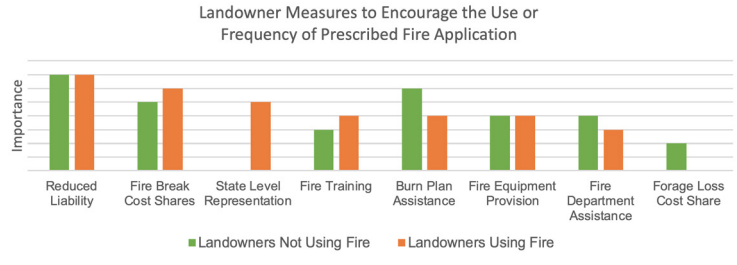

Figure 4. Comparison indicating the importance of specific measures to encourage the use of prescribed fire. *(Adapted from Kreuter et al., 2008)*

Table 7. Reasons landowners use fire: most to least important. *(Kreuter et al., 2008)*
Control of problem plants
Improve forage quality and palatability
Lower costs
Increase plant diversity
Improve wildlife habitat
Presence of burn associations
Burn plan assistance
Relatively easy to apply
Less hazard compared to herbicide
Reduce fuel loads (wildfires)

Figure 5. Fire movement. *Photo: Kevin Knapick*

(Table 7) include reduction or absence of herbicide application, improved grazing conditions, and minimal soil disturbance, however, most fires will only suppress resprouting brush (Welch, 2000).

PRESCRIBED FIRE LANDOWNER CONCERNS

These sections seek to address the concerns outlined above with systematic practical solutions and recommendations. Several recommendations involve state and federal agencies, including the Texas A&M AgriLife Extension Service, Texas A&M Forest Service (TFS), Texas Parks and Wildlife Department (TPWD), and the Natural Resource Conservation Service (NRCS). Cooperation between private landowners, especially new rural landowners and agencies, is essential to the conservation and protection of the valuable natural resources in Texas.

Liability concerns

Many researchers consider prescribed fire to be more economically feasible and effective than chemical or mechanical methods when implemented correctly (Van Liew et al., 2012). Despite these claims, many landowners do not implement prescribed fire due to risk and liability concerns, and even fire users consider this their primary concern (Toledo et al., 2012 and Kreuter et al., 2008). Burners must assess liability before burning, along with reviews of all laws and regulations relating to limited liability. If a prescribed fire is not implemented correctly, unintended damages may occur. (Russell and Lashmet, 2017).

Legal approaches and liability

Three legal statutes exist relating to liability if a prescribed fire causes damage or loss of life and property: simple negligence, gross negligence, and strict liability (Russell and Lashmet, 2017 and Wonkka et al., 2015). Texas, along with many other states, utilizes simple negligence, which implements liability if burners disregard reasonable care during burns (Russell and Lashmet, 2017). Florida, Georgia, and South Carolina are among states utilizing gross negligence, where liability is assigned to landowners if extreme intent of carelessness exists during burning operations (Russell and Lashmet, 2017). Finally, there is strict liability. In states such as Minnesota and Hawaii, strict liability allows liability to be assigned regardless of the planning, execution, or intent of the landowner (Russell and Lashmet, 2017).

Limited liability

Texas provides the opportunity for limited liability, not required by law, to be applied under certain conditions. (Russell and Lashmet, 2017). First, land eligible for prescribed burning must be classified as agricultural or conservation land. These lands, by definition, include "land suitable for the use and production of plants and fruits for human or animal consumption, and plants grown for the production of fiber, floriculture, viticulture, horticulture, or planting seed." Agriculture and conservation lands also include land for "forestry and the growing of trees for the rendering of trees into lumber, fiber, or other items used for industrial, commercial, or personal consumption." Finally, these lands include "domestic or native farm or ranch animals kept for use or profit; management of native or exotic wildlife; or conservation management of an ecosystem, a forest, a habitat, a species, water, or wildlife." (Russell and Lashmet, 2017). Additionally, burns must be conducted under supervision by a certified and insured prescribed burn manager (CIPBM) or members of a prescribed burn organization (PBO) (Russell and Lashmet, 2017).

Certified and insured prescribed burn managers

CIPBMs, considered the ultimate authority before, during, and after a prescribed burn operation, are responsible for the containment, smoke management, and land management objectives of a prescribed burn

Table 8. CIPBM requirements. *(Russell and Lashmet, 2017)*
Training
Completion of a TPBB training course and exam per region (Fig. 6) of Texas
Three years of prescribed fire experience in the specific region
Thirty days general prescribed burning experience (not region-specific)
Five days as a responsible burn leader
Insurance
Minimum $1 million worth of liability insurance per personal injury or property damage or destruction
Policy period minimum aggregate limit of $2 million

Table 9. CIPBM types. *(Russell and Lashmet, 2017)*
Commercial
Execute prescribed fire on any property for hire allowed by certification.
Private
Execute burns on property owned, leased, or occupied by CIPBM or their employer.
Not-for-Profit
Execute burns on property owned or leased by PBO or PBO members.
Governmental
Execute burns only on government-owned, -leased, or -controlled land.

(Russell and Lashmet, 2017). CIPBMs must meet training and experience requirements to be licensed by the Texas Department of Agriculture (TDA) and the Texas Prescribed Burning Board (TPBB) as outlined in Table 8.

Four types of CIPBMs exist, meaning that landowners should select the correct type of CIPBM relating to their situation (Table 9). The Texas Department of Agriculture website contains the contact information and regional certification information of every commercial and private CIPBM in Texas. This aids in ensuring that every landowner can find a CIPBM who is certified to conduct prescribed fires in their specific region (Fig. 6). The contact and regional certification information can be found at: *http://www.texasagriculture.gov/Home/ProductionAgriculture/PrescribedBurnProgram/FindaBurnManager.aspx*.

One important exception related to limited liability is that it does not apply to CIPBMs who conduct burns on land they own, lease, or occupy (Russell and Lashmet, 2017). CIPBMs wishing to burn on their land and meet limited liability requirements must either enlist another CIPBM to supervise and conduct the burn or obtain membership in a PBO meeting statutory limited liability requirements (Russell and Lashmet, 2017). Overall, CIPBMs provide an excellent resource to landowners wishing to implement or discuss concerns relating to the implementation of prescribed fire on their lands.

Prescribed burn organizations

Prescribed burn organizations (PBO) are defined as "entities established to promote the use of prescribed burning as a tool for land management" (Russell and Lashmet, 2017). PBOs share labor and equipment for burns, burn training, and public outreach campaigns. Here, however, the focus pertains to statutory liability (Wonkka et al., 2015). PBO members are eligible for limited statutory liability during prescribed burns, provided that the member directing the burn completes a Texas Prescribed Burn Board approved training curriculum before the burn date. The PBO must also meet the $1 million liability coverage per bodily injury or property destruction along with a policy maximum aggregate limit of at least $2 million. If PBOs do not meet these requirements, a CIPBM must conduct the burn to meet liability requirements (Russell and Lashmet, 2017).

CIPBM and PBO requirements mean that many landowners, especially small or new landowners, will have the access and ability to utilize prescribed fire on their land if they cannot carry the required coverage or training. PBOs, restricted to certain counties within the state of Texas (Fig. 12), are cooperative groups with members who pay reasonably small dues—around $25 per year—and have membership requirements to assist with a certain number of burns before having one completed on their property. If a landowner does not fall within these areas (Fig. 12), they still have the option

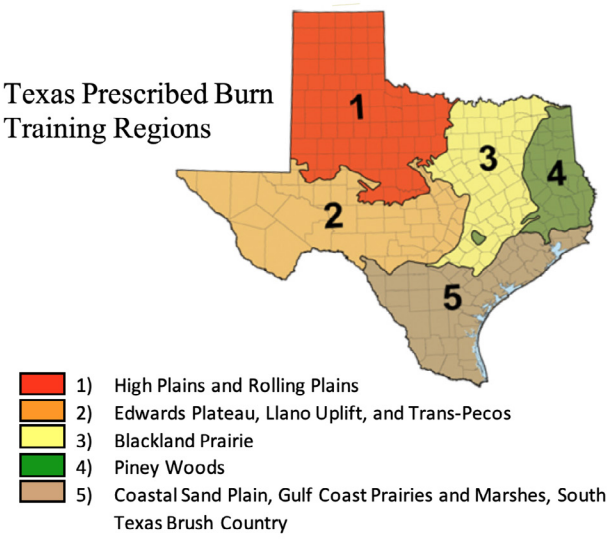

Figure 6. Texas prescribed burn training areas. *(Adapted from Texas Department of Agriculture)*

to utilize CIPBMs to pursue the application of prescribed fire within safe, legal, and ethical boundaries.

Laws and regulations

Several laws and regulations have made it possible for Texans to apply prescribed fire on their land, but the Texas Commission on Environmental Quality (TCEQ) strictly governs burning in Texas. This section summarizes several important laws, rules, and regulations about burning in Texas. Every landowner, regardless of how they apply fire on their property, should always follow all prescribed burning laws to prevent the possibility of large wildfires that can cause extensive damage and loss to life and property.

This section should not be taken as legal advice since laws and regulations are always subject to change. Individuals seeking to apply prescribed fire should always consult with an attorney or expert before conducting burning operations to ensure that they follow the most recent state burning laws.

House Bill 2599

In 1999, House Bill 2599 amended the Natural Resources Code to remove the felony offense associated with pasture burning and guarantees the right of every Texan to burn his or her property. The bill also established the Prescribed Burn Board within the Texas Department of Agriculture (Hinnant, 2011). An analysis of the bill by Representative McReynolds stated, "Currently, a landowner in Texas has the right to use prescribed burning as a land management tool to reduce vegetative fuel that can flare up and cause wildfires. Wildfires pose a serious threat to the state, particularly to suburban areas, and prescribed burning can help reduce this risk, property damage, personal injury, or death resulting from the burning of vegetation fuel." (Hinnant, 2011).

House Bill 2620

House Bill 2620 amended the Local Government Code, authorizing counties the right to prohibit or restrict outdoor burning under drought or serious fire weather conditions as determined by the Texas A&M Forest Service (Hinnant, 2011). Specific exemptions within the bill allow burning related to public health and safety, including firefighter training authorized by TCEQ and prescribed burns conducted by CIPBMs during burn ban situations (Hinnant, 2011).

TCEQ outdoor burning rules

TCEQ sets specific exemptions for outdoor burning in Texas under the Texas Administrative Code Section 111 Subchapter B, found at: *https://www.tceq.texas.gov/assets/public/legal/rules/rules/pdflib/111b.pdf*, and summarized in Table 10. These rules apply to prescribed burns, brush pile burning, and trash burning. CIPBMs are subject to separate rules and regulations, 30 Texas Administrative Code (TAC), Subchapter B Section 111.217, which supersede the rules and regulations outlined in 30 TAC Subchapter B Section 111.219. These separate rules and regulations increase the ability for CIPBMs to provide services for rural landowners, increasing the application of safe prescribed burning. The primary purpose of these rules relates to pollution and smoke management, whereas TPBB rules and regulations govern safe, effective burn plans and burn executions (Hinnant, 2011).

Economic analysis

Prescribed fire is considered to be one of the most cost-efficient brush management systems due to low fuel and labor costs (Van Liew et al., 2012). For new or small landowners, finances may be the biggest constraint to implementing prescribed fire. Firebreak construction, burn plan writing, and team formulation constitutes the majority of the costs associated with prescribed burning. A survey by Kreuter et al. (2008) shows landowners, both fire users and non-users, pointed to costs as a major issue. This section will present an economic analysis comparing summer prescribed fire to alternative chemical and mechanical treatments on common problematic brush species in specific regions of Texas (Fig. 7), along with several opportunities for cost shares to offset the incurred costs of prescribed fire implementation.

Van Liew et al. (2012) examined the feasibility of implementing summer prescribed fire versus alternatives, either mechanical or chemical. Summer prescribed fire is a specific form of prescribed fire,

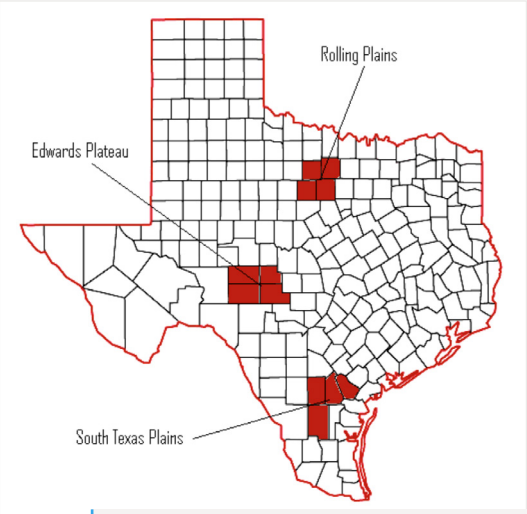

Figure 7. Study regions. *(Van Liew et al., 2012)*

Table 10. TCEQ burning rules. (30 TAC Subchapter B 111.211, 111.219, and 111.217)
30 TAC Subchapter B 111.211 Exception for Prescribed Burn (2014)
1. Prescribed burning for forest, range and wildland or wildlife management, and wildfire hazard mitigation purposes, except coastal saltmarsh management burning. Burning must adhere to 111.219, and structures containing sensitive receptors must not be negatively affected by the burn. Burn managers must notify appropriate officials before burning operations begin.
2. Coastal saltmarsh burning in Aransas, Brazoria, Calhoun, Chambers, Galveston, Harris, Jackson, Jefferson, Kleberg, Matagorda, Nueces, Orange, Refugio, and San Patricio Counties is subject to special considerations within 2(A) and 2(B).
A. All land where burning is to be conducted must be registered with the appropriate commission using a United States Geological Survey map, including roads, canals, lakes, streams, and site access. Divide large acreage into identified, manageable blocks. The information must be received for review 15 working days before burning operations.
B. Before burning, notification, verbal or written, must be made to and authorization received from the appropriate commission regional office. Notification must identify specific areas or blocks to be burned, burning start and end time, and the responsible party during the burning period.
C. Burning shall be subject to the requirements of 111.219.
30 TAC Subchapter B 111.219 General Requirements for Outdoor Burning (1996)
1. TFS must be notified before utilizing prescribed burning for forest management.
2. Burning must be outside the corporate limits of a city or town except where enacted ordinances permit burning consistent with the Texas Clean Air Act, Subchapter E, Authority of Local Governments.
3. Burning must be conducted only when wind and weather conditions ensure that smoke or other pollutants will not adversely affect public roads, landing strips, navigable waters, or off-site structures containing sensitive receptor(s).
4. Burn managers are responsible for and must post flag-person(s) if smoke crosses a road or highway.
5. Burning shall be conducted downwind of or at least 300 feet (90 meters) from structures containing sensitive receptors on adjacent properties without written or oral approval of the legal landowner.
6. Burning must comply with weather conditions in subsections 6(A), 6(B), and 6(C).
A. No burning is allowed earlier than 1 hour after sunrise. Burning must be completed the same day and no later than 1 hour prior to sunset, with the responsible party present during active burning and fire progression. Residual fires or smoldering objects emitting smoke after this time must be extinguished if smoke has the potential to cause a nuisance or traffic hazard. The burn area must not increase after 1 hour prior to sunset.
B. Burning must not occur if winds are less than 6 miles per hour (5 knots) or greater than 23 miles per hour (20 knots).
C. Burning must not be conducted if actual or predicted low-level atmospheric temperature inversion is present limiting smoke transport.
7. Electrical insulation, treated lumber, plastics, non-wood construction or demolition materials, heavy oils, asphaltic materials, explosive materials, chemical wastes, and items containing natural or synthetic rubber must not be burned.
30 TAC Subchapter B 111.217 Requirements for CIPBMs Superseding 111.219 (2017)
1. 4 TAC Chapter 222 (Requirements for Certified Prescribed Burn Managers) and Chapter 228 (Procedures for Certified Insured Prescribed Burn Managers)
2. TFS must be notified before prescribed burning for forest management.
3. Burning must be conducted only when wind and weather conditions ensure that smoke or other pollutants will not adversely affect public roads, landing strips, navigable waters, or off-site structures containing sensitive receptor(s).
4. Burning shall begin and be conducted only when wind direction and other meteorological conditions are such that smoke and other pollutants will not cause adverse effects to any public road, landing strip, navigable water, or off-site structure with sensitive receptors.
5. Burning must comply with weather conditions in subsections 5(A), 5(B), and 5(C).
A. Burning shall begin no earlier than sunrise. Burning must be completed on the same day no later than 1 hour before sunset and must be attended by a responsible party at all times during active burning and fire progression. Residual fires or smoldering objects emitting smoke after this time must be extinguished if smoke has the potential to cause a nuisance or traffic hazard. The burn area must not increase after 1 hour prior to sunset.
B. Burning must not occur if winds are less than 5 miles per hour (4 knots) or greater than 23 miles per hour (20 knots).
C. Burning must not be conducted if an actual or predicted low-level atmospheric temperature inversion is present, limiting smoke transport.
7. Electrical insulation, treated lumber, plastics, non-wood construction or demolition materials, heavy oils, asphaltic materials, explosive materials, chemical wastes, and items containing natural or synthetic rubber must not be burned.

where fire is applied during the summer when the air temperature is higher, and relative humidity is lower than standards recommended by the NRCS (Van Liew et al., 2012). Several common brush species were chosen for comparison (Table 11) of chemical and mechanical treatments against the application of summer prescribed fire. The treatments outlined in the Van Liew et al. (2012) study utilized initial and follow-up treatments over a 20-year planning horizon. To allow for accurate economic comparisons, the summer fire treatments used previous research to ensure that the herbaceous response was virtually the same as the expected herbaceous response from the alternative mechanical and chemical treatments.

Cool-season prescribed fires are fires that are applied during the cooler months, when air temperatures and humidity levels are within the standards established by the NRCS. Rolling Plains and Edwards Plateau initial treatments (Table 11) were followed by cool-season fires, adhering to all NRCS recommendations, every 6 years after initial treatment (Van Liew et al., 2012). The South Texas Plains initial herbicide treatment was followed by a cool-season fire the next year and every 4 years thereafter, while cool-season fires followed summer prescribed fire initial treatment on 4-year intervals (Van Liew et al., 2012). Based on results from Van Liew et al. (2012), prescribed fire for net present value (NPV), benefit-cost ratio (BCR), and internal rate of return

Table 11. Summer fire versus mechanical and chemical treatments for herbaceous production, including net present value (NPV), benefit-cost ratio (BCR), and internal rate of return (IRR). *(Adapted from Van Liew et al., 2012)*

Brush type cover density	Treatment	Total cost ($/ac)	NPV ($/ac)	BCR	IRR
Rolling Plains					
Prickly pear heavy	Summer fire	14.99	5.31	1.536	18.43%
	Aerial chemical (0.57 kg. picloram per ha.)	43.73	-21.80	0.411	-4.90%
Prickly pear moderate	Summer fire	14.99	-0.15	0.985	5.62%
	Foliar chemical IPT (1% surmount)	44.98	-20.88	0.453	-3.85%
Mesquite heavy	Summer fire	14.99	7.41	1.749	22.88%
	Aerial chemical (0.27 kg. each remedy and reclaim)	44.98	-20.88	0.453	-3.85%
Mesquite moderate	Summer fire	14.99	1.67	1.169	9.94%
	Basal chemical IPT (0.27 kg. each remedy and reclaim)	27.99	-10.59	0.522	-2.98%
Edwards Plateau					
Heavy ashe and redberry juniper	Summer fire	14.99	11.13	2.125	29.3%
	Grubbing and stacking	140.44	-107.22	0.164	-11.26%
	Grubbing only	100.46	-69.50	0.232	-8.88%
Moderate mix – juniper	Summer fire	14.99	7.58	1.766	23.60%
Ashe only	Cutting and stacking	97.96	-70.69	0.198	-10.20%
Redberry only	Grubbing and stacking	120.45	-91.90	0.160	---
Mesquite heavy	Summer fire	14.99	1.64	1.165	10.41%
	Aerial chemical (0.27 kg. each remedy and reclaim)	40.48	-22.41	0.340	-7.60%
Mesquite moderate	Summer fire	14.99	2.62	1.265	12.82%
	Basal chemical IPT (15% remedy mixed with diesel)	77.97	-56.97	0.180	---
South Texas Plains					
Huisache heavy	Summer fire	22.49	-0.31	0.978	5.07%
	Aerial chemical (3.51 L/ha. of grazon P+D)	63.85	-39.24	0.259	---
Huisache moderate	Summer fire	22.49	2.01	1.143	10.55%
	Basal chemical IPT (15% remedy mixed with diesel)	86.34	-58.14	0.216	---
Mesquite heavy	Summer fire	22.49	6.60	1.470	20.16%
	Aerial chemical (0.27 kg. each remedy and reclaim)	63.35	-31.86	0.393	-6.22%
Mesquite moderate	Summer fire	22.49	4.56	1.324	15.61%
	Basal chemical IPT (15% remedy mixed with diesel)	88.84	-17.48	0.243	-9.92%

NPV < 0 = cost share necessary to breakeven on investment cost

(IRR) outperformed alternative treatments across three ecosystem types in Texas. Van Liew et al. (2012) utilized forage production as the primary measure to determine the level of economic feasibility for treatments (NPV). Mesquite was a problematic invasive species in all three eco-regions, meaning that economic comparisons can be drawn between treatments (Van Liew et al., 2012). The results of the 2012 study are confined to specific locations (Fig. 7). While a statewide comparison is impossible, this study still allows economic comparisons between methods. This comparison includes variable costs, meaning that the actual costs today may vary from those presented (Van Liew et al., 2012). Negative NPV values (Table 11) predict the need for cost-share offsets of initial treatment costs to break even (Van Liew et al., 2012).

PESTMAN

PESTMAN, a web-based support system designed to assist managers located in Texas and New Mexico, aims to help with economic brush and weed management decision making. Embedded within the program is a comprehensive list of chemical and mechanical treatments for the most common brush and weed species of each state, along with long-term examinations of financial gains or losses associated with management decisions.

PESTMAN creates an immediate economic breakdown for comprehensive management decisions without field trials. Actual treatment costs are variable, making it difficult to approximate an exact cost, but the program still provides excellent decision-making information. In order to maximize PESTMAN's effectiveness, the program can be combined with expert input from county Extension agents, private consultants, or NRCS agents for exact management cost calculations.

PESTMAN's purpose is to provide landowners a tool to examine which land management alternatives will be the most economically feasible for their region and circumstances. This information can then be used in collaboration with experts to design a management plan to meet landowner goals and objectives. The PESTMAN program is available online at: *http://swcarbon.tamu.edu/pestman/#0*.

Using PESTMAN

Users first input their problem plant scenario (Fig. 8), including common plant name, stem diameter, plant density, or plant cover, along with state and county information to generate available treatment options.

Users are then directed to a screen showing available mechanical options (Fig. 9), including:

- Treatment names
- The treatable diameter or cover
- Cost per hour
- Acres per hour
- Cost per acre
- Effectiveness level

Chemical treatments can also be viewed at this stage (Fig. 10). The treatments are divided between individual plant treatments and broadcast treatments with information, including:

- Herbicide common name
- Effectiveness level
- Labor hours/100 plants
- Cost per acre
- Treatment caveats
- Ability to enter labor cost per hour

Figure 8. PESTMAN general information.

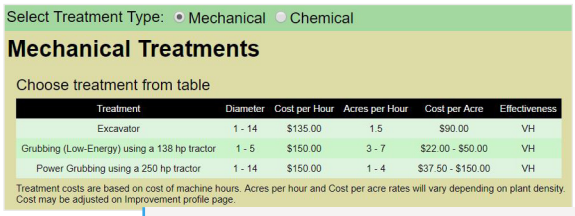

Figure 9. Mechanical treatments screen.

Figure 10. Chemical treatments screen.

Once the user selects a treatment option, a graph (Fig. 11) is generated to compare the percent of forage change to years since treatment. This graph displays a gray line, which is the baseline. The red line indicates the increase from treatment, while the blue line shows a decline with no treatment, and the green line designates the increase from treatment with maintenance.

From here on, the program becomes detail oriented, and users may input advice from qualified consultants for the following components. Users will have the ability to modify the baseline forage production response. Modification is achieved by inputting the estimated percent change with and without treatment for each individual year within a 20-year planning horizon while also adding maintenance treatment details, including:

- Application year
- Treatment name
- Treatment life
- Area treated
- Price per unit area
- Cost-share percentage
- PESTMAN calculated total investment

The treatment plan's customization section allows landowners to tailor the PESTMAN program to their specific situation since every aspect of the treatment can be customized before the economic analysis is completed. PESTMAN is an older program, meaning that many costs may need to be adjusted based on consultation with experts, and new herbicides can be added that may not be contained within the current database. These factors give landowners high flexibility to continue using the older program in an adaptive brush management environment. Landowners will also add operational information to maximize the effectiveness of the economic output. The following operation information will be added:

- Lease graze value
- Animal Unit Equivalence (AUE) per head
- Pre-treatment carrying capacity
- Treatment area
- Planning period
- Discount rate percentage

Together, these generate a detailed economic analysis for the entire brush management plan that includes:

- Years to breakeven
- Breakeven value of Animal Unit Months (AUM)
- Net present value per year and total
- Internal rate of return
- Benefit-cost ratio
- Stocking rate with improvement
- Stocking rate without improvement
- The total cost of the treatment plan

PESTMAN allows landowners to weigh multiple treatment options, both mechanical and chemical, to determine overall monetary costs and stocking response without the risk of mismanagement or real-world consequences. PESTMAN encourages consultation and interaction of informed landowners with experts to facilitate better resource management by weighing mechanical and chemical methods against other brush management alternatives, including fire and biological controls, to determine the most effective treatment based on landowner circumstances.

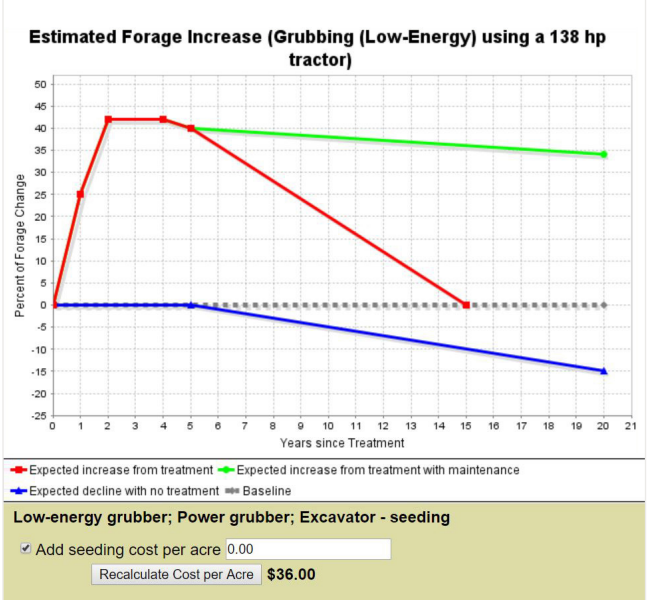

Figure 11. Estimated forage response graph.

Cost-share and grant programs

Cost-share programs and grants are available to Texas landowners to promote land management, with some being specifically for fire and others for general conservation. This section presents several current cost-share programs and grants sponsored by the Texas A&M Forest Service (TFS), Texas Parks and Wildlife Department (TPWD), Natural Resource Conservation Service (NRCS), National Fish and Wildlife Foundation (NFWF), International Paper (IP), and the United States Fish and Wildlife Service (USFWS), including application information, goals, and contact information. Landowners should always consult with host agencies before applying for any cost-share programs to determine the applicability, availability, or changes

relating to cost-share funds or whether a program has changed, been discontinued, or replaced by an updated program.

Community Protection Program Grant

Prescribed Fire Only

Agency: TFS

Goal: The reduction of hazardous high-risk fuels through the use of prescribed burning on private lands to protect high-risk communities and forest resources from catastrophic wildfires.

Requirements: The property must be within 10 miles of a National Forest boundary, within the state of Texas. A map is available on the website.

Application deadline: End of September

Website: *http://texasforestservice.tamu.edu/cppgrant/*

Process: The process involves no cost share, and grant recipients will be reimbursed actual per acre cost of the prescribed burn, not to exceed $30.00 per acre on a total of 800 acres.

National Fire Plan Grant

Prescribed Fire Only

Agency: TFS

Goal: Fund prescribed fire operations to reduce hazardous fuels in and around communities that have been or will be threatened by catastrophic wildfires.

Requirements: Requirements include private property within 30 Texas counties with a completed Community Wildfire Protection Plan (CWPP) within the county. The property is not eligible if within 10 miles of a National Forest. A map is available on the website.

Application deadline: End of September

Website: *http://texasforestservice.tamu.edu/cppgrant/*

Process: The process involves no cost share, and grant recipients will be reimbursed actual per acre cost of the prescribed burn, not to exceed $30.00 per acre on a total of 300 acres.

Priority: Priority is given to property within a CWPP area, risk based on Texas Wildfire Risk Assessment Portal (TxWRAP), or ecosystems that benefit from fire.

Neches River and Cypress Basin Watershed Restoration Program

Prescribed Fire Only

Agency: TFS and USFWS

Goal: Utilize prescribed fire to promote ecological improvement of the Neches River and Cypress Basin watersheds.

Requirements: The property must be within the Neches River or Cypress Basin watersheds. A map is available on the website.

Yearly application deadline: End of September

Website: *http://texasforestservice.tamu.edu/cppgrant/*

Process: The process involves no cost share, and grant recipients will be reimbursed actual per acre cost of the prescribed burn, not to exceed $22.50 per acre on a total of 800 acres.

Texas Longleaf Conservation Assistance Program

Agency: TFS, NFWF, IP, NRCS, USFWS

Goal: Financial and technical assistance to establish and manage longleaf pine

Requirements: Own or control land within nine specific East Texas counties, possess or develop a forest management plan, and comply with Texas Forestry Best Management Practices, found at: *https://tfsweb. tamu. edu/BestManagementPractices/.*

Funding: 50 percent cost share up to:

- $30/acre prescribed fire
- $450/acre site preparation and tree planting
- $275/acre forest stand improvement

Application: Continuous

Website: *https://tfsweb.tamu.edu/longleaf/*

Landowner Incentive Program (LIP)

Agency: TPWD

Goal: Assist private, non-federal landowners with enacting beneficial conservation practices

Requirements: Property in the state of Texas

Process: Contact local TPWD staff biologist to complete ecological land assessments, review goals, and provide information about current incentive and assistance opportunities. A list of TPWD staff biologists can be found at: *https://tpwd.texas.gov/landwater/land/ technical_ guidance/biologists/.*

Website: *https://tpwd.texas.gov/landwater/land/ private/ lip*

Environmental Quality Incentive Program (EQIP)

Agency: NRCS

Goal: Promote agricultural production and environmental quality

Process: EQIP is a comprehensive, highly competitive national program. Interested landowners should contact their local NRCS rangeland management specialist about application details and requirements.

Specialists can be found at: *http://offices.sc.egov.usda.gov/locator/app?agency=nrcs*.

The programs outlined are not a comprehensive list. Landowners should always contact local county Extension agents to inquire about other opportunities or programs to offset the costs associated with land management. A list of county Extension agents can be found at: *https://agrilifepeople.tamu.edu/contact-lists/public/units/p-counties*.

State-level representation

State-level representation was the next highest priority among landowners who implement fire (Kreuter et al., 2008). Several programs exist to serve landowners who utilize prescribed fire representation from the state level down to the county and local levels. State-level representation exists in the form of the Texas Prescribed Burn Board and Prescribed Burn Alliance of Texas.

Texas Prescribed Burning Board

The Texas Prescribed Burning Board (TPBB) is the state authority for prescribed burning laws, regulations, and recommendations. TPBB oversees and monitors CIPBMs, including certification, renewals, and training through comprehensive curriculums with specific and general fire training, depending on the certification region (Russell and Lashmet, 2017). Dedicated to preserving the vast, unique ecosystems and services of Texas, representatives include state agencies, institutions of higher learning, and private citizens chosen by the Commissioner of Agriculture to ensure that every Texan has a voice on the TPBB. The TPBB website contains helpful resources, including CIPBM resources, prescribed burn training, burn templates, legislation, rules, TPBB forms, training regions (Fig. 6), burn associations (Fig. 13), state and federal agency links, and TPBB general information. These resources can be found at: *https://texasagriculture.gov/Home/ProductionAgriculture/PrescribedBurnProgram.aspx*.

Table 12. Texas Prescribed Burning Board members. *(Texas Department of Agriculture)*

Texas A&M Forest Service
Texas Parks and Wildlife Department
Texas Commission on Environmental Quality
Texas A&M AgriLife Extension Service
Texas A&M AgriLife Research
Texas Tech University Range and Wildlife Department
Texas Department of Agriculture
State Soil and Water Conservation Board
Five private landowners

Prescribed Burn Alliance of Texas

The Prescribed Burn Alliance of Texas provides state-level oversight of the 11 regional Prescribed Burn Associations (Fig. 13) to ensure that these regional-level associations promote and execute the safe application of prescribed fire. The alliance's website, *pbatexas.org*, serves as an information center to link landowners with the individual associations through the "Associations" tab. These resources include burning basics, safety and laws, mapping burns, education and outreach, and insurance information. Other included links pertain to prescribed fire training lessons and opportunities to contact certified burn instructors, but the heart and soul of this alliance are the 11 individual Prescribed Burn Associations.

Figure 12. Prescribed Burn Alliance of Texas logo. *Credit: Prescribed Burn Alliance of Texas*

Texas Prescribed Burn Associations

Training, equipment, and assistance

Eleven Prescribed Burn Associations exist within the state of Texas (Fig. 13). These associations provide fire training, burn plan writing assistance, safe burn

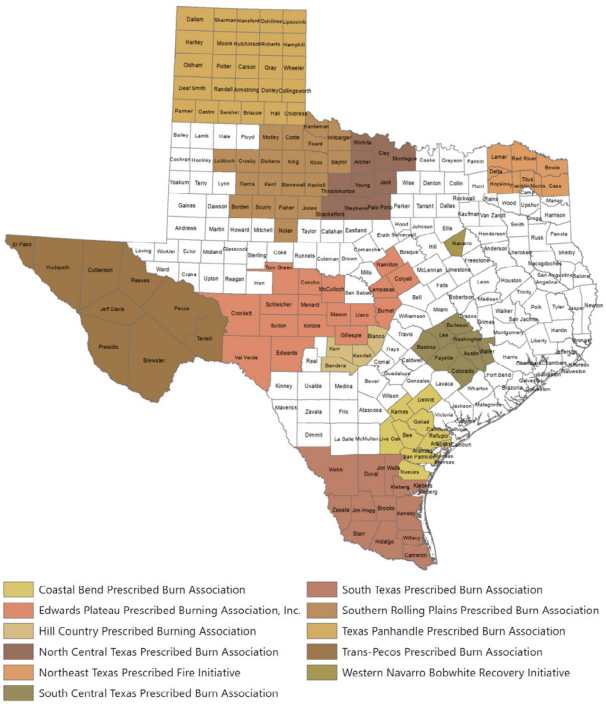

Figure 13. Texas Prescribed Burn Associations. *Credit: Prescribed Burn Alliance of Texas*

execution, and equipment to their members. Representative contact information for each association can be found on the Alliance website: *https://www.pbatexas.org/member-associations*, to connect landowners with their respective associations. Member participation forms the cooperative component of prescribed burn associations. Members pay dues, which are pooled to purchase materials and tools necessary for associations to conduct safe and effective burns for their members.

In addition, these associations provide opportunities for members of the public, including local media, to observe and participate in prescribed burn operations. This outreach component provides a vital opportunity to educate members of the public who may be apprehensive about the use of fire as a management tool. This opportunity for public outreach makes the Prescribed Burn Alliance a vital component to spread and provide hands-on experience with prescribed fire to ensure that it possesses a place in the future for responsible land management in the state of Texas and across the United States.

Training

Each association provides training for its members. Prescribed burning is serious, and safety is paramount, but burns allow community members the opportunity to experience prescribed fire through hands-on training and observation. Those who are fearful of fire are encouraged to attend association burns to experience the numerous safety and planning procedures needed for safe execution of a prescribed burn.

Equipment

Most individuals might assume that executing a prescribed burn always requires on-site fire department personnel and equipment (Fig. 14) that allows immediate response to fires in remote areas, but this is not an absolute need. However, many prescribed burn operations, including state and federal wildfire response operations, utilize "garden tools," or small all-terrain vehicles (ATV) and utility task vehicles (UTV) carrying less than 200 gallons of water to manage fires. Next, we will analyze several common tools used during prescribed burns.

Drip Torches

Drip torches (Fig. 15) are an essential component of prescribed fire since they are the primary ignition instrument utilized by private landowners and burn associations. Drip torches usually contain a 50:50 ratio in mild temperatures or a 60:40 ratio in warmer temperatures of diesel and gasoline, depending on the chosen season of prescribed burn ignition. Other ignition devices, such as flare guns, balls containing potassium permanganate injected with glycol known as "Dragon Eggs," and helitorches, are primarily restricted to state or federal agencies due to the high cost or high risk associated with their use.

Figure 14. Brush apparatus.
Photo: Bulverde Spring Branch Fire and EMS

Figure 15. Drip torch.
Photo: Kevin Knapick

Hand Tools and Supplies

Prescribed fire hand tools (Fig. 16) include shovels, fire rakes, swatters, chainsaws, leaf blowers, pumps, hoses, and brooms. These tools are utilized to control and extinguish small spot fires that may ignite outside firebreaks. Small 5-gallon backpack sprayer pumps may also be used, but rarely are due to their heavy 40-pound weight at full capacity. Many burn

Figure 16. Burn trailer.
Photo: Cross Timbers OKPBA

associations utilize trailers to house shared equipment since most equipment is purchased by the association through membership dues for cooperative use. Equipment sharing minimizes equipment costs for members of an association since associations move their trailer, if available, to the property being burned for utilization by all personnel present on a specific burn.

Hand-held Radio

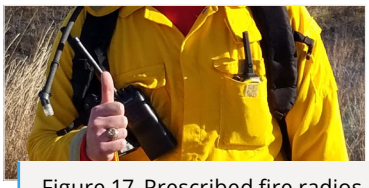

Figure 17. Prescribed fire radios. *Photo: Kevin Knapick*

Burn associations will utilize two-way radios (Fig. 17) to communicate with the fire crew during a burn. Radios are critical in situations that require swift action, such as small spot fires or weather changes. Depending on the availability, some associations and operations may use higher-powered radios to maximize communication potential over larger areas or rough terrain.

Aside from a drip torch, these are key components that must be present to ensure that prescribed fire can be applied safely with minimal danger to the general public outside the burn area.

ATVs and UTVs

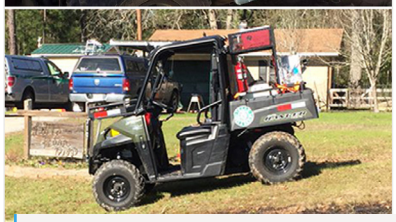

Figure 18. ATV and UTV. *Photos: Kevin Knapick and Morgan Treadwell*

ATVs and UTVs (Fig. 18) carrying small amounts of water are excellent tools to utilize at a prescribed fire. Associations will utilize these vehicles to carry water for fire suppression along with other equipment and burn day necessities. Equipment and necessities present include, but may not be limited to, water for hydration, drip torch fuel, and personnel for spotfire control. These are especially helpful as the burned acreage grows beyond the point where members can patrol the entire perimeter on foot. These vehicles provide an extra level of protection and safety without requiring on-site fire department resources and equipment. These implements are not required for prescribed burns to take place, but their presence adds another layer of safety to the burn prescription to ensure that the prescribed fire does not enter or damage an area outside of the prescription area. Many associations do not purchase these vehicles, as members often supply and transport them on burn day. However, the association may purchase the tanks and pumps required to modify these implements into effective fire control vehicles on burn day.

Tractors or farm implement

Small skid steers (Fig. 19) as well as front-end loaders, plows, disks, etc., are especially useful in prescribed fire operations. These implements create vital fuel breaks and dirt lines that are integral safety components of prescribed fire. These dirt lines or firebreaks (Fig. 20) are the first line of defense to prevent the fire from escaping the prescription area. These lines also serve as the primary points of ignition that drip torch carriers will follow to ignite fires safely.

Figure 19. Skid steer. *Photo: Morgan Treadwell*

Figure 20. Firebreak. *Photo: Morgan Treadwell*

Figure 21. Prescribed fire ignition. *Photo: Morgan Treadwell*

Assistance

Burn associations provide invaluable assistance to landowners seeking to utilize prescribed fire on their property through both burn plan preparation and personnel on burn day. Some members, especially those in charge of the associations, will likely be CIPBMs—meaning that they have the authority to write burn plans. Burn plans are comprehensive documents addressing every aspect of prescribed fire planning and execution (Table 13). To ensure that fire is applied safely and effectively, a sample burn plan is available at: *pbatexas.org/Resources.aspx*, under the "Organization Documents" section found in the "Prescribed Burn Alliance of Texas Information" tab, along with a pre-burn checklist required before ignition.

Table 13. Burn plan components.
(Prescribed Burn Alliance of Texas)

CIPBM name and information
Burn boss (burn director)
Burn justification and previous burn results if available
Notifications (TFS, county officials, fire and sheriff departments, utilities)
Neighbor notifications and approvals
Burn area description (fuels, firelines, topography, and structures to protect)
Crew and equipment requirements
Ignition procedures
Smoke management plan
Water sources
Fire weather conditions and limits
Current weather on the burn day, at regular intervals before and during burn
Burn map (Fig. 13)
Contingency plans for fire escape

Every burn plan component is critical in facilitating a successful prescribed burn. One component, however, is essential: the burn map (Fig. 22). The burn map is not only used for ignition operations but also for locating spot fires, medical emergencies, smoke management, and wind conditions. These maps can be as simple or complex as the CIPBM desires, but some components make maps better than others. Components such as alphabetized or numeric marking of corners, firelines, ignition sequence, compass cross, desired wind direction, water sources, and structures in or near the burn area can improve a map considerably. Marking the corners of the burn area before the actual burn allows quick reference for ignition and spotfire suppression crews once everyone is spread out along the firebreaks. Information on your map will equate to less confusion on the burn day during the pre-burn briefing with the fire crew, ignition operations, and mop-up operations post-burn.

Figure 22. Prescribed burn map.
Map credit: South Central Texas Prescribed Burn Association

Forage loss

One final landowner concern, especially from landowners who are hesitant to utilize prescribed fire, is the loss of forage for grazing or groundcover. Most land managers in this situation will need to defer a pasture or change their management plan to ensure that pastures have enough forage to carry a prescribed fire or continue to supply livestock nutrition requirements post-burn. Prescribed burning improves grazing conditions in the short term by improving the quality, palatability, and availability of grass and forbs for livestock (Waldrop and Goodrick, 2015). While there will be a temporary loss of forage, livestock are attracted to burn areas once grasses and forbs begin to reemerge to graze on the high-quality forage (Waldrop and Goodrick, 2015).

A special burn system, called "patch-burn grazing," was developed to meet the forage loss concerns of ranchers. This system burns only certain sections of a pasture and

is recommended by professionals. Patch-burn grazing burns pastures in small sections to reduce homogeneity by creating a mosaic of recently burned, non-burned, and previously burned areas. The size of burned patches and the frequency of burning is dependent upon the goals and objectives of the landowners.

Planning and implementing prescribed fire is an excellent opportunity to engage with a county Extension agent or NRCS rangeland management specialist who can direct landowners to the appropriate techniques and timing to meet their livestock management goals along with CIPBMs or burn associations. Many ranchers seek methods to avoid woody encroachment on their pastures, and cost-effective prescribed fire has the potential to provide a higher rate of return than traditional mechanical or chemical methods.

In conclusion, while forage loss is a concern during a prescribed fire, landowners can plan ahead to compensate for the temporary forage loss until fresh forage emerges, leading to higher livestock condition and health.

TECHNICAL RESOURCES

Several web-based resources exist that can be critical sources of information for prescribed fire application, education, and perception. This section will outline several resources that can benefit landowners seeking self-education about prescribed fire, landowners actively examining the use and applicability of prescribed fire for their property, weather and smoke management, wildfire awareness, and property preparation materials for wildfire events.

Texas Prescribed Fire Handbook

Prioritizing the need for effective, legal, and safe prescribed burning, this website: *https://agrilife.org/rxburn*, consolidates every major component of prescribed fire into one, user-friendly location. The website tabs include "Planning," "Burn Boss," "Safety," and "Weather and Fuel" sections. The "Planning" tab contains information regarding the steps to planning a burn, general prescription, firebreak construction, and fuel quantity and moisture estimates. "Burn Boss" contains details for those directing and planning prescribed burns, including resources for contacts and emergency numbers,

Figure 23. Texas Prescribed Fire Handbook logo. *Credit: Texas A&M AgriLife Extension*

checklists, role descriptions, crew duty descriptions, and essential prescribed fire documents. The "Safety" tab contains everything to ensure that a prescribed burn is as safe as possible, including first aid, personal gear, fire safety, fire orders, go/no-go checklist, hand tool safety, and vehicle safety. Finally, the "Weather and Fuel" tab contains links to multiple resources to ensure that all weather and fuel information falls within the burn plan parameters to execute and keep a prescribed burn prescribed. Other resources on the website include links to videos and publications to provide educational opportunities about the benefits and management of prescribed fire.

Texas A&M Forest Service

Embedded within the "Manage Forests and Land" tab of the Texas A&M Forest Service website lies a comprehensive section on prescribed fire with numerous resources similar to those in the *AgriLife Extension Prescribed Burn Handbook*. This resource can be found at: *https://tfsweb.tamu.edu/PrescribedBurnToolbox/*, and includes general information such as burn plan writing, go/no-go checklist, the state smoke management plan, and links to TFS funding programs.

Figure 24. Texas A&M Forest Service logo. *Credit: Texas A&M Forest Service*

Other links relating to weather information, fuel information, TFS contacts, mapping tools, and a host of useful websites relating to prescribed fire application are also included.

There are many resources available to landowners. Though some may appear redundant, it is still imperative that landowners educate themselves with multiple sources of information since some publications and information may be geared toward different audiences. For example, TFS information will generally be geared toward landowners within forested areas, while AgriLife Extension resources may be geared toward landowners on rangeland areas.

Smoke management

Prescribed fires will create smoke (Fig. 25), but landowners can manage their smoke to minimize the impacts on those around them. One component of a prescribed burn plan is the smoke management plan, using weather conditions to elevate and transport smoke out of the area without impacting neighbors, roads, or cities nearby. This section will present several

open-source and user-friendly models that landowners and CIPBMs can use to predict and mitigate smoke impacts from prescribed burns. Be sure to check these resources often, as prescribed fire smoke management tools and models are always being updated and introduced as technology improves.

Figure 25. Wildland fire smoke from green fuel. *Photo: Kevin Knapick*

SERPPAS Prescribed Fire Smoke Management Pocket Guide

Available at: *smokeapp.serppas.org*, this guide combines smoke guidelines, fact sheets, a fuel calculator, and a "Resources" tab to provide a handy guide for smoke management. The "Guidelines" section dives deep into smoke management specifics based on fuel loads, identifying smoke sensitive areas, notifications, ignition patterns for smoke management, and how to minimize impacts from smoke.

VSMOKE-Web

This web-based modeling program allows users to input location, fire size, duration, ignition methods, fuel loads, transport wind heights, and wind direction to generate maps (Fig. 26) to identify potential smoke impacts at moderate, unhealthy, very unhealthy, and hazardous levels in areas around the burn. Burn managers can dictate smoke management by changing ignition type, wind direction, and wind speed to select burn days to minimize smoke impacts on the community and the general public. This resource was developed by the Georgia Forestry Commission (GFC) and is available at: *weather.gfc.state.ga.us*.

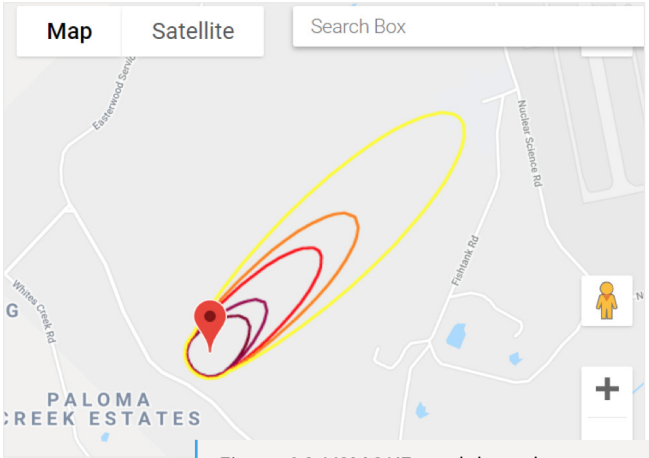

Figure 26. VSMOKE model result. *Credit: GFC*

WILDFIRE RISK AND PREPARATION

In 2011, extreme drought coupled with multiple ignition sources facilitated the most unprecedented wildfire year in Texas history. The 2011 wildfire season consisted of 31,453 fires, burning over 4 million acres while destroying 2,947 homes—costing 4 firefighters and 6 civilians their lives. Firefighters saved 39,000 homes that year, but wildfire activity across the state of Texas has increased over the last 2 decades and will continue to do so as population growth and development lead to city expansions into rural WUI areas (Jones et al., 2012).

In the past, many landowners considered wildfires to be a rural area issue. However, the expansion of urban environments into previously undeveloped lands coupled with human carelessness can lead to even small acreage fires destroying multiple homes (Jones et al., 2012). Landowners must prepare now to mitigate fire severity. There are many means and methods for wildfire mitigation. This section includes resources from the Texas A&M Forest Service to allow landowners to assess their wildfire risk to allow the protection of lives and property from future wildfires.

Texas Wildfire Risk Assessment Portal (TxWRAP)

Risk assessment is the first step to mitigate wildfires. The TxWRAP Public Viewer (Fig. 27), found at: *https://www.texaswildfirerisk.com*, is designed to allow landowners to view wildfire risk potential based on several risk factors. These factors include the WUI response index, WUI zones, community protection zones, fire intensity scale, and wildfire ignition density. The WUI response index map allows landowners to

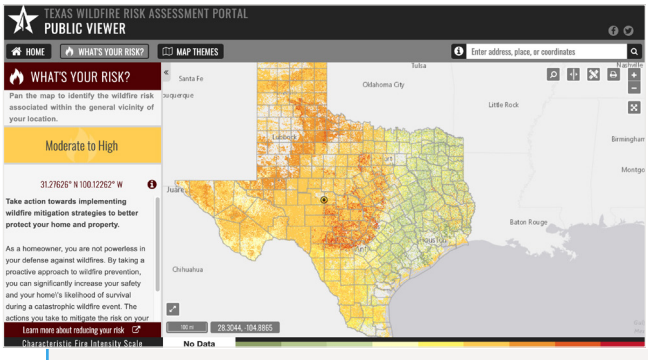

Figure 27. TxWRAP public view. *Credit: Texas A&M Forest Service*

visualize the potential impact wildfires may have on their lives and property. TFS professionals utilize this tool to determine wildfire risk along with grant funding for mitigation projects. A similar application, found at: *https://www.southernwildfirerisk.com/Map/Public/#whats-your-risk*, is operated by the Southern Group of State Foresters, allowing landowners across all 13 southern states to analyze the risk of wildfires and plan accordingly to mitigate risk before a wildfire strikes their community.

Mitigation publications

The 2011 Texas Wildfire Season led to several painful lessons outlined in *2011 Texas Wildfires Common Denominators of Home Destruction*. To tackle the issue of wildfire preparation, the Texas A&M Forest Service created several publications to allow landowners the opportunity to educate themselves about wildfire mitigation. These publications contain several home defense strategies using brush management, home construction, and landscape planning to increase the potential for a home to survive a wildfire.

Be Embers Aware

Be Embers Aware—published online at: *http://texasforestservice.tamu.edu/ProtectYourHome/*—focuses on identifying entry points that embers can utilize to infiltrate a home during a wildfire by focusing on areas around the home, yard, and property. Embers pose the most critical danger to homes during a wildfire, meaning they must be addressed for basic home defense.

Figure 28a. Be Embers Aware. *Credit: Texas A&M Forest Service*

Firewise Landscaping in Texas

This publication focuses on education related to landscape planning and goals, emphasizing correct plant choice, design elements, fire-resistant plants, defensible space in landscape design, and completing landscape goals to prevent home loss or damage while maintaining landowner's desired aesthetics. The overarching purpose of this publication is not to tell landowners which plants they can and cannot plant, but to ensure that the right plant is placed in the right space to balance aesthetics and fire safety. Visit: *https://tfsweb.tamu.edu/ProtectYourHome/*, to view this publication online.

Figure 28b. Firewise Landscaping in Texas. *Credit: Texas A&M Forest Service*

Fire Resistant Materials

Fire Resistant Materials focuses on firewise construction of gutters, roofs, eaves, soffits, exterior walls, windows, vents, decks, fencing, and skirting, along with a construction checklist to mitigate home destruction from wildfires. You can find this publication online at: *http://texasforestservice.tamu.edu/ProtectYourHome/*.

Figure 28c. Fire Resistant Materials. *Credit: Texas A&M Forest Service*

Ready, Set, Go!

The *Ready, Set, Go!* program, developed from the principle of plan creation, plan execution, and evacuation, provides landowners with excellent hands-on wildfire preparation guidance. The TFS publication, found online at: *http://texasforestservice.tamu.edu/ProtectYourHome/*, allows homeowners to create a personal action plan by providing a "Get Ready" checklist before the fire starts, "Get Set" checklist as the fire approaches, and "Go" checklist for early evacuation. Each checklist provides comprehensive planning to ensure that all aspects of wildfire preparation occur before a wildfire strikes. This publication also contains a checklist for rural landowners who might have a different set of priorities than those in urban areas. Texas currently has 531 *Ready, Set, Go!* members across 153 counties (Fig. 30), and the Texas A&M Forest Service desires 100 percent participation from Texas landowners. Contact your local TFS WUI specialist at: *texasforestservice.tamu.edu/ProtectYourCommunity/*, to learn more about mitigating your wildfire risk at home.

Figure 29. Ready, Set, Go! *Credit: Texas A&M Forest Service*

Community Wildfire Protection Plans

Community Wildfire Protection Plans (CWPP) create collaboration with local governments, fire departments, TFS WUI specialists, and other agencies to identify wildfire risks facing a community and create specific protection and mitigation plans to address these needs. These plans will identify and create management projects to reduce the ignition potential near structures,

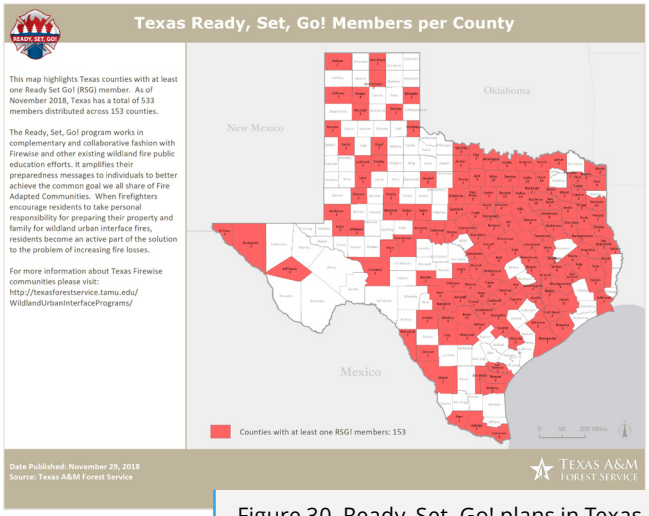

Figure 30. Ready, Set, Go! plans in Texas. *Credit: Texas A&M Forest Service*

address building materials on structures for fire resistance, identify the capacity building and training needs for local first responders, and promote wildfire awareness within the community. The leader's guide, CWPP creation guide, and sample CWPP from the city of Bryan, Texas, can be found at: *texasforestservice.tamu.edu/ProtectYourCommunity/*. Currently, 55 cities and 20 counties (Fig. 31) have written CWPPs, with more in development to protect Texas cities and citizens.

Firewise Communities

Firewise teaches community members how to live within wildfire-prone areas and encourages proactive cooperation to prevent losses of life and property. This program focuses on smaller communities, homeowner associations, and master-planned communities to assess wildfire risk and create networking opportunities between homeowners, organizations, and fire departments.

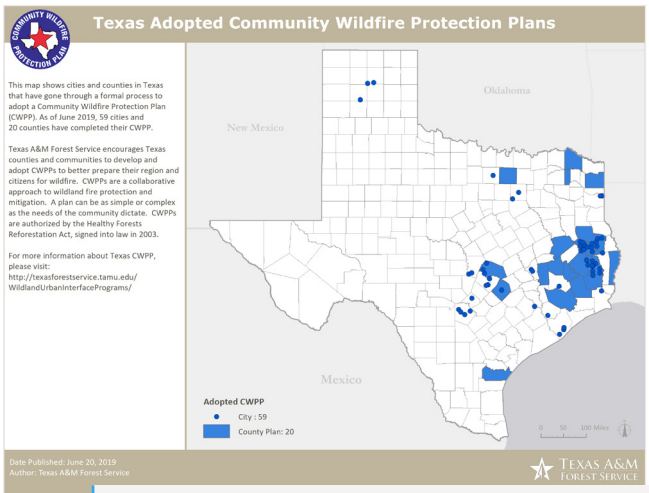

Figure 31. CWPPs in Texas. *Credit: Texas A&M Forest Service*

Texas currently has 93 Firewise Communities across 40 counties (Fig. 32), but more are needed and added periodically. Firewise requirements include engaging with a TFS WUI specialist to complete a community assessment to develop wildfire solutions, a local Firewise task force to maintain the program, $2 per capita investment annually for Firewise projects, and annual reports documenting compliance with the program. Homeowners can find detailed information at: *http://texasforestservice.tamu.edu/ProtectYourHome/.*

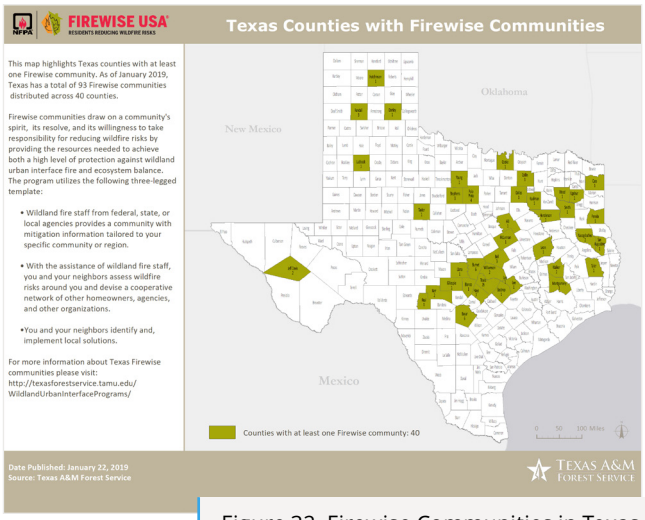

Figure 32. Firewise Communities in Texas. *Credit: Texas A&M Forest Service*

CONCLUSION

Four major brush management strategies exist that landowners can utilize to reduce woody vegetation and potentially hazardous fuels. When compared to the four other range management strategies in this publication, prescribed fire is the most cost-effective method when managing for herbaceous production, but only when conducted safely and by all laws and regulations established by TCEQ and TPBB.

Many landowners have questions and concerns about utilizing prescribed fire, from liability concerns to cost-share assistance and training. Several resources exist to alleviate costs and concerns through state agencies as well as prescribed burn associations to help plan long-term management investments along with the critical burn plans associated with prescribed fire implementation.

To assist landowners with economic planning, programs such as PESTMAN exist to allow experimentation with costs and benefits to determine the best management strategy for landowners to maximize their investment. Prescribed burn associations exist to alleviate the costs and labor associated with implementing prescribed fire and will provide training and observation opportunities

for concerned land-owners to experience prescribed fire firsthand. Online resources exist to provide educational opportunities and resources to landowners and CIPBMs to ensure that fire is applied safely and effectively to meet management objectives.

Finally, fire is the historical management practice that sustained Southern ecosystems for hundreds of years. It is our responsibility to ensure that it evolves to coexist with an expanding urban culture to maximize its effectiveness to sustain our ecosystems and protect our communities for future generations to enjoy.

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