# Integrating Herbicides in Wildlife Habitat Management

## A Technical Guide for Brush Management with Herbicides

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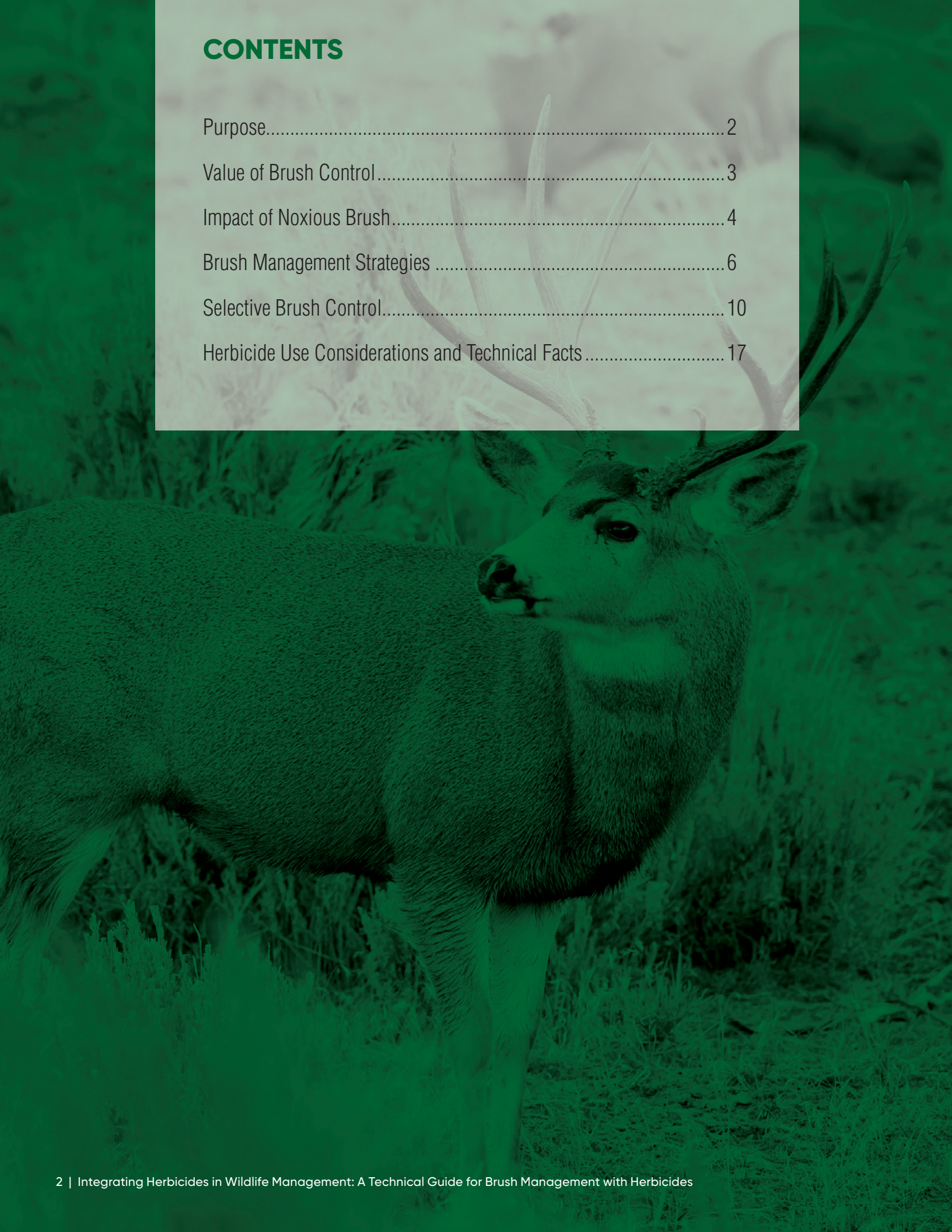


## Purpose

Over recent years, land ownership values have shifted from primarily livestock production to livestock and wildlife production. In fact, many new landowners purchase land with the sole intent of managing for wildlife. Further, many of these new landowners are also new to ecosystem management and are looking for guidance in sound land management principles. Historical perception of herbicide applications was that they would negatively affect desirable brush and forbs. In turn, managers have been reluctant to use large-scale chemical brush control for lands managed for wildlife. With the introduction of Sendero® herbicide for mesquite control, there is a new opportunity to treat mesquite and other targeted brush species with minimal negative effects on desirable shrubs, thereby improving wildlife habitat where noxious brush has encroached. This publication is intended as a technical guide for wildlife habitat managers and consultants to better understand how and when to integrate herbicides into a habitat management plan.

Herbicide selectivity research was conducted from 2013 through 2015 at numerous locations across Texas. The data presented in this technical guide has been divided into Central Texas and South Texas data sets. These two uniquely different regions vary in soil types, climate, grass species diversity and the types of brush within the plant communities. Management goals will depend on landowner objectives and species of wildlife emphasized. This research was a joint project between Texas A&M AgriLife Extension Service, Texas A&M AgriLife Research and Dow AgroSciences. As new information becomes available, this publication will be updated.

## Value of Brush for Browse and Cover

The natural environment where a wildlife species lives is referred to as habitat. Best management practices for wildlife habitat revolve around a set of known needs for the wildlife species of interest on a given property. These needs include food, water, and shelter, as well as how these components are arranged on the landscape. Depending on the landowner's goals, management may be exclusively for game species, such as white-tailed deer, quail, or wild turkey, or many non-game species such as meadowlarks or horned lizards, or some combination thereof.

A high level of plant species diversity is one common goal of wildlife habitat management. Having a large number of plant species within an area provides for a diverse array of wildlife. High plant diversity provides many opportunities for wildlife to satisfy dietary or shelter needs throughout different seasons and weather conditions. (See table 1 for a general summary of many brush species in South and Central Texas and their value to wildlife).

| Table 1. Relative Wildlife Value Ranking of Selected Plant Species in South and Central Texas | | | |
|---|---|---|---|
| Family | Common Name | Scientific Name | Value Ranking |
| Anacardiaceae | Littleleaf sumac | *Rhus microphylla* | Good |
| | Skunkbush sumac | *Rhus aromatica* | Good |
| Berberidaceae | Agarito, algerita | *Mahonia trifoliolata* | Fair |
| Boraginaceae | Mexican olive | *Cordia boissieri* | Good |
| Cactaceae | Pricklypear | *Opuntia spp* | Fair-Good |
| | Tasajillo | *Opuntia leptocaulis* | Fair |
| Celastraceae | Desert yaupon | *Schaefferia cuneifolia* | Fair |
| Chenopodiaceae | Fourwing saltbush | *Atriplex canescens* | Excellent |
| Cupressaceae | Juniper (young) | *Juniperus pinchotii* | Poor |
| Ebenaceae | Texas persimmon | *Diospyros texana* | Fair |
| Ephedraceae | Vine ephedra | *Ephedra antisyphilitica* | Excellent |
| Euphorbiaceae | Bernardia | *Bernardia myricaefolia* | Excellent |
| | Leatherstem | *Jatropha dioica* | Poor |
| | Torrey croton | *Croton incanus* | Fair |
| Fabaceae | Blackbrush | *Acacia rigidula* | Fair |
| | Catclaw acacia | *Acacia greggii* | Fair |
| | Guajillo | *Acacia berlandieri* | Fair-Poor |
| | Honeylocust | *Gleditsia triacanthos* | Fair |
| | Huisache | *Acacia farnesiana* | Fair-Poor |
| | Kidneywood | *Eysenhardtia texana* | Excellent |
| | Mesquite | *Prosopis glandulosa* | Fair |
| | Mountain laurel | *Sophora secundiflora* | Poor |
| | Retama | *Parkinsonia aculeata* | Fair |
| | Texas ebony | *Pithecellobium ebano* | Fair-Good |
| | Twisted acacia | *Acacia schaffneri* | Fair |
| Fagaceae | Live oak | *Quercus virginiana* | Fair-Good |
| Juglandaceae | Native pecan | *Carya illinioensis* | Good |
| Koeberliniaceae | Allthorn | *Koeberlinia spinosa* | Fair |
| Lamiaceae | Shrubby blue sage | *Salvia ballotiflora* | Fair-Poor |
| Liliaceae | Spanish dagger | *Yucca treculeana* | Fair-Poor |
| | Yucca | *Yucca spp* | Fair-Poor |
| Moraceae | Bois d'arc | *Maclura pomifera* | Fair-Good |
| Oleaceae | Elbowbush | *Forestiera angustifolia* | Good |
| Rhamnaceae | Brasil | *Condalia hookeri* | Good |
| | Coyotillo | *Karwinskia humboldtiana* | Poor |
| | Hog plum | *Colubrina texensis* | Good |
| | Lotebush | *Zizyphus obtusifolia* | Fair-Good |

| Table 1. (con't) | | | |
|---|---|---|---|
| Family | Common Name | Scientific Name | Value Ranking |
| Rosaceae | Hawthorne | *Crataegus mollis* | Excellent |
| | Rubiaceae | *Prunus mexicana* | Good |
| | Sand plum | *Prunus gracilis* | Fair-Good |
| Rubiaceae | Buttonbush | *Cephalanthus occidentalis* | Fair |
| Rutaceae | Baretta | *Helietta parvifolia* | Fair |
| | Sapotaceae | *Zanthoxylum fagara* | Fair |
| | Hercules club | *Zanthoxylum clava-herculis* | Good |
| | Pricklyash | *Zanthoxylum hirsutum* | Fair |
| Salicaceae | Willow | *Salix spp* | Fair |
| Sapindaceae | Western soapberry | *Sapindus saponaria* | Fair-Good |
| Sapotaceae | Bumelia | *Bumelia languinosa* | Excellent-Good |
| | Coma | *Bumelia celastrina* | Excellent |
| Scrophulariaceae | Cenizo | *Leucophyllum frutescens* | Fair |
| Simaroubaceae | Amargosa | *Castela texana* | Fair |
| Solanaceae | Wolfberry | *Lycium berlandieri* | Fair |
| Ulmaceae | American elm | *Ulmus americana* | Fair-Good |
| | Hackberry | *Celtis reticulate* | Good |
| | Palo blanco | *Celtis laevigata* | Excellent |
| | Spiny hackberry | *Celtis pallida* | Excellent |
| | Winged elm | *Ulmus alata* | Fair-Good |
| Verbenaceae | Lantana | *Lantana horrida* | Fair-Good |
| | Whitebrush | *Aloysia gratissima* | Poor |
| | Wild oregano | *Lippia graveolens* | Fair |
| Zygophyllaceae | Guayacan | *Guaiacum angustifolium* | Excellent |

The nutritive value of plant leaf material changes throughout the growing season. Young plants or new regrowth typically offer better nutrition and are more easily digested. Wildlife species, such as white-tailed deer, seek out brush and forb leaves, which are typically more nutritious and palatable than grass. Other species, such as quail and turkey, also seek out seeds or berries that may be available only during short periods. Although animals may prefer some plants over others, having a variety of plants will allow for their diet requirements to be met throughout the year, and during periods of high nutritive demand, such as breeding or lactation. A high diversity of plants also promotes increased diversity of insect populations important for game bird species.

The physical structure that plants create according to their different shapes and sizes is also of great importance. Although land is often managed on a pasture or small patch scale, wildlife perceives their habitat on a larger, landscape level. This mosaic of different habitat types, known as interspersion, works together to meet wildlife species' physical and physiological needs. Structurally, plants provide cover from predators during foraging or nesting, as well as protection from weather and temperature extremes. Deer may use ground cover to hide their fawns or as screening while they forage on brush and forbs. Quail or turkey may use bunchgrasses to nest and to provide screening as they and their chicks or poults feed. Taller brush or trees are also used as escape cover. For example, quail or young turkey poults may stay within a softball throw away from brush so they can use it as escape cover from ground predators. Wild turkeys require tall trees for roosting at night for safety. Many woody plants, especially those with protective thorns, provide good cover for tree-nesting bird species such as the northern mockingbird or cardinals.

What dictates the potential for plant diversity in an area? The natural plant biodiversity of a given property is governed largely by soil types, topography and climatic conditions. In addition, previous land use and management, such as farming, overgrazing of livestock, and suppression of natural fires affect and often limit plant diversity. This change to fewer dominant plants or one dominant plant (monoculture) occurs when conditions promote the spread of just a few plants. Those plants slowly dominate other plant species, which die off and are not given adequate conditions to naturally reseed.

**Every brush species has "some" value to "some" wildlife species. However, you can have too much of a good thing, which is the problem with noxious brush species.**

## Section 2. Impact of Noxious Brush on Wildlife Habitat

Texas and southern Great Plains rangelands are consumed with brush invasion. Brush can have both positive and negative effects on rangeland ecosystems and rural economies. With respect to grass production and the livestock industry, increases in brush have an overall negative effect. However, increasing woody cover can enhance wildlife hunting opportunities. What has caused this enormous macro-scale change in Texas vegetation? Some of the key drivers of woody encroachment include reduced frequency of natural fires, cattle grazing effects, both by reducing competition from grasses and distributing brush seed by fecal deposition, and climate effects, especially during extended droughts.

Mesquite and other brush species were thought to have existed in small patches across the landscape prior to European settlement. Written records of some of the earliest settlers talk about encountering patches of mesquite and other brush. The current, prevailing theory is that the bulk of the southern Great Plains was grassland or a very open savanna with mostly grasses and a light density of brush. Brush encroachment continued to increase at a slow rate as deer and other wildlife species deposited seed near the established clusters. These clusters gradually expanded but there was no vector to rapidly transport mesquite seeds to far distant areas until domestic cattle arrived.

Extended droughts give woody plants an advantage when fire is suppressed and livestock grazing is allowed to continue, putting extra pressure on grasses that are already stressed. If any rain causes even a little grass growth, cattle are there to take the new tillers. Thus, drought coupled with the continual presence of livestock further weakens grasses and leaves them completely unable to compete with woody plants.

Woody plants already have an advantage during droughts because their root systems are deeper than grasses. Thus, whatever soil moisture is available at deeper levels (generally lower than 3 feet deep), can usually be extracted only by woody plants. A tree, such as mesquite, typically has both an extensive network of lateral roots as well as a deep taproot. So during wet periods, the plant utilizes shallow soil moisture through its lateral roots and directly competes with grasses. During dry times when shallow moisture is limiting, the plant can utilize deep moisture.

Wildlife can also contribute to woody plant invasion, but the degree to which they have an effect is thought to be less than cattle. Deer, for example, have been observed to consume mesquite beans, and occasionally a mesquite seedling will be seen emerging from a deer pellet. Some researchers have found that the percent of deer pellets that yielded an established mesquite plant was the same as from cattle dung. However, it is thought that this effect is more localized and that the accelerated expansion of range and infilling of spaces between mesquite clusters with brush was due to the massive influx of cattle in the late 1800s and early 1900s.

Every brush species has “some” value to “some” wildlife species. However, you can have too much of a good thing, which is the problem with noxious brush species. Following are common situations where too much of any one brush species can be a management concern.

### Mesquite-Texas Wintergrass Monocultures

Mesquite provides a wide range of benefits to wildlife, but as a near monoculture, it is not capable of providing all wildlife needs all the time. For example, in North Texas, mesquite can develop into a brush monoculture with a very limited set of understory grasses, usually dominated by cool season grasses such as Texas wintergrass. This situation provides a narrow range of wildlife habitat needs. When a variety of brush species are present, mesquite is one of the least-used plants by white-tailed deer. In South Texas, a mesquite monoculture is often accompanied by bare ground beneath the trees, lacking forage or cover for wildlife.

### Pricklypear

Pricklypear provides food, water, and cover for many wildlife species. For example, in South Texas, it may compose more than 30% of the diet of white-tailed deer in the summer, mainly as a water source. In contrast, in the Edwards Plateau, pricklypear ranks among the leastused as a food source for white-tailed deer. Pricklypear is relatively low in crude protein, but a good source of vitamin A. However, a sole diet of pricklypear for white-tailed deer could lead to difficulty digesting the pricklypear fiber. In addition, the small spines can cause ulcers of the lips, tongue, and digestive tract. Pricklypear is also valuable as cover for quail and small mammals. In a plant community with other beneficial species, a moderate stand of pricklypear can be useful, but as a dense infestation, it can be detrimental to wildlife habitat.

### South Texas Mixed Brush

South Texas mixed brush communities can be good or bad depending on the brush species, their densities and the land-use goals. For example, if the brush is a mix of least-used white-tailed deer species like agarito, allthorn, amargosa, knifeleaf condalia, whitebrush, and wolfberry, there might be limited forage for deer, but it could provide cover for small mammals and birds.

Even if the habitat were dominated by a moderate-use species like guajillo, this situation would provide limited food for white-tailed deer. Although guajillo tests high for crude protein, it contains non-protein nitrogenous compounds that exaggerate the actual protein value of guajillo. Guajillo is also relatively low in energy. For example, a study reported that guajillo could meet crude protein requirements of white-tailed deer if up to 60% of the diet was from guajillo. However, energy requirements could only be met if guajillo made up no more than 20% of the diet.

### Other Situations

Juniper is not particularly valuable as a forage. It ranks in the least-used category for the Edwards Plateau, although it does provide fruit and cover for birds and mammals. Thick juniper stands shade out other species, reducing plant diversity and the ability of the land to support many species of wildlife. Huisache is a common, native tree species in South and East Texas. The plant grows very quickly, taking over pastures within a few years. Although huisache can provide forage, mast, and cover for wildlife species, it is considered a low-use forage for white-tailed deer. Much like juniper, huisache becomes so dense that other plant species are not allowed to thrive, reducing the value of the land for diverse wildlife habitat.

# Section 3. Brush Management Strategies and Wildlife Habitat

### Types of Brush Management Tools as Related to Wildlife Habitat

A variety of treatments have been used for removing or suppressing encroachment of unwanted woody plant species. Only in recent years has there been an attempt to understand how these brush treatments might affect wildlife habitat. Brush sculpting or leaving patches or lanes of untreated brush mixed within treated areas, has become a popular solution to balance the need for brush for wildlife without land becoming a solid brush thicket. However, there is also interest in how these treatments might affect specific brush species within treated patches. The next sections will address broadcast chemical, mechanical and fire options. Specifically, we will address their cost of application and how these treatments affect the target species, secondary shrub species, associated grasses, and soils.

### Chemical Treatments

Reclaim plus Remedy® Ultra was the standard treatment for species like mesquite for many years. As with all aerially applied treatments, this can be applied with a great deal of precision that favors brush sculpting efforts or leaving patches of more desirable trees within the landscape. Reclaim plus Remedy Ultra typically would yield moderately high (50-70%) mesquite root-kill and would completely top-kill the remaining 40% with very little flagging of spurious foliage on tree branches. The 40% that are top-killed mesquite would have apical dominance removed and resprout vigorously from the base. This would limit the treatment life for cattle forage production to about 15 to 20 years before requiring a re-treatment. The resprouting mesquite offers low cover for some wildlife species, so the effects were generally considered good for wildlife. Moreover, the 15 to 20-year treatment life usually allowed some of the warm-season bunchgrasses that could not survive in thick stands of mesquite to increase in abundance. Those grasses provide good quality habitat for ground nesting birds, if livestock grazing is managed to allow bunchgrass litter to accumulate. Prior to herbicide treatment, the only grasses that typically can persist within thick mesquite stands are shortgrasses like buffalograss and the low growing cool-season bunchgrass, Texas wintergrass. Neither of these species groups is adequate to provide ground-nesting bird habitat or sufficient cover for small mammals and reptiles.

Remedy Ultra by itself or the application of “broadleaf weed” herbicides such as 2,4-D, while much less costly, generally top-kill or partially top-kill mesquite without root-killing more than about 10% of the population. Most of the mesquite will quickly resprout and, thus, the cattle forage boost is limited to no more than 7-8 years. In addition, the short treatment life does not provide sufficient time for warm-season bunchgrasses to effectively establish, so any wildlife that are dependent on this kind of grass are not benefitted. Some research that evaluated the application of Reclaim by itself found that it could achieve high mesquite root-kill (60-70%) at higher rates. Mesquite plants that survived were only partially topkilled. The remaining foliage (i.e., “flagging”) was usually a small percentage of the original canopy foliage (<30%) and exerted enough apical dominance to prevent the entire tree from basal resprouting. The overall effect at the landscape level was that of a savanna appearance. This option appeared to have a very long treatment life (estimated to be at least 25 years). This landscape effect would thus eliminate mesquite competitive effects and allow warm-season bunchgrasses to come back. In addition, secondary non-target shrubs were largely unaffected. Wildlife habitat would be enhanced except for those species that might need resprouting mesquite plants for cover. The main reason this option was not adopted more frequently relates to human nature of accepting a less clean or “sloppy” appearance. The post-spray landscape would have many trees with small bits of flagging which is good for the ecosystem for reasons just explained, but unacceptable to landowners who wanted a cleaner visual result.

With the new Sendero herbicide, similar effects as the “Reclaim only” option is expected. This has been the purpose of recent Sendero wildlife habitat studies. Additionally, Sendero can be mixed with other chemicals, including Remedy Ultra or Tordon 22K, to achieve a broader spectrum of species controlled. How these mixtures affect desirable wildlife brush species is also the subject of this research. An added effect of all of the aerial-applied chemical treatments is that the standing dead stems and branches provide perch sites for raptors. Without secondary shrub species, those raptors can threaten ground nesting birds, small mammals and reptiles for a few years until warm season bunch grasses grow to provide herbaceous ground cover.

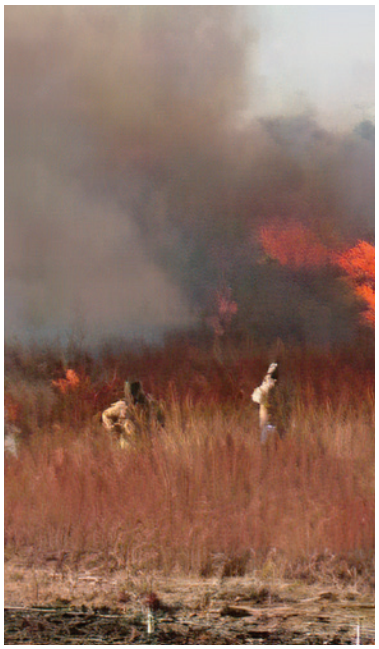

# Mechanical Treatments

There are several mechanical treatments that can cause radically different effects to targeted brush as well as to wildlife habitat. Like aerial application of herbicides, mechanical treatments can be applied with a great deal of precision to create patches or lanes of treated and non-treated areas. The difference between herbicide and mechanical effects are that, while herbicides can generate a variety of foliage responses in the target species (completely root-killed standing dead trees, completely top-killed with basal resprouting, partial top-killed with no basal sprouting and partial topkilled with basal sprouting), mechanical treatments are generally an “all-or-none” proposition. A brush plant is either removed completely or top-killed completely and allowed to resprout.

Mechanical treatments that both inflict mortality on most target brush species and can be applied at a landscape scale are limited to root-plowing. This treatment is rarely used due to cost and potential negative effects on soils, primarily by disrupting soil structure. In addition, effects of root-plowing on secondary shrub species that may be valuable to wildlife are non-selective and usually devastating.

Mechanical treatments that mostly top-kill target brush species include chaining, bulldozing, roller chopping and shredding.These all have the effect of top-killing by removing the entire aboveground structure of the brush plant, but root systems are largely undamaged and basal sprouting starts almost immediately. The first three options are for larger structured brush while shredding is reserved for brush with smaller stems and usually less than 4 feet in height. While few formal studies have been done on this topic, casual observations seem to show that resprouting rates following top-killing from mechanical treatments are much faster than that from top-killing from chemical or fire treatments. There is no residual damage to dormant buds like what partial chemical translocation and heat can inflict. Thus, treatment life is usually lower than what is found for the other top-killing treatments.

Top-killing mechanical treatments usually have devastating effects on the canopy structure of secondary shrub species, such as lotebush, that may be valuable for wildlife habitat. If they resprout, they will eventually recover, but habitat cover they provided is usually lost for 10 to 20 years. Alternatively, reducing the height of the brush can provide new growth forage within reach for many wildlife species. Top-killing mechanical treatments will also crush any existing ground nests. Some top-killing brush treatments, chaining in particular, have the unfortunate characteristic of dragging across the soil surface, which can spread pricklypear cactus pads. It can also radically shift location of litter and surface layers of soil, which contain the highest levels of organic matter. These usually end up being deposited in depressions and small ravines on the landscape and cause upland ridges and flats to general lose topsoil and soil organic matter. Both are slow to accumulate, especially in drier upland areas.



## Prescribed Fire

The re-introduction of natural fires in the form of prescribed fire can help either slow the rate of brush invasion or move landscapes back toward grassland dominance. With respect to effects on wildlife habitat, it is more of a "generalist" that cannot be applied with the microlandscape precision of mechanical or chemical treatments. Moreover, many woody plants in the mixed brush regions of the southern Great Plains and South Texas are resistant to fire in that they may be top-killed by an intense fire, but they will resprout from stem bases. For some species, the window of vulnerability for outright mortality (i.e., "root-kill") from fire is very narrow. For mesquite it is new seedlings less than 2 years old; for resprouting redberry juniper seedlings, it is 6 to 8 years. Typically, in both these situations, 50-70% of seedlings can be killed by fire. For non-sprouting juniper species like eastern red cedar and ashe juniper, fire can root-kill large plants. Thus, the result of fire highly depends on the species in question and the scale of the operation.

Fire is generally thought of as a fence row-to-fence row application with the hope of uniform effect – that is, all or nearly the entire surface of the pasture being blackened. However, three shifts in the paradigm of thinking about fire may have radical effects on wildlife habitat. These are the use of patch burning, the use of growing season fires, and leaving unburned patches on the landscape after a flame front has passed instead of going back in to "clean them up". These techniques are mostly designed to increase diversity and landscape heterogeneity.

## Summary Table Of Wildlife Habitat Treatment Options

Table 2 provides a roughly quantified assessment of the potential impacts of various brush treatment options on wildlife habitat. Chemical treatments that mostly cause root-kill can be characterized as having precise application with a slight risk of drift; high root kill; low to moderate impact on non-target brush; no impact on grasses or soils; no risk of spreading unwanted species; can be relatively high cost; and have high treatment longevity. Chemical treatments that mostly cause top-kill have precise application with a slight risk of drift; low root-kill; low to moderate impact on non-target brush; no impact on grasses or soils; no risk of spreading unwanted species; can be relatively high cost; and have low treatment longevity (but probably not as low as top-killing mechanical treatments).

Mechanical treatments that cause high root-kill can be characterized as having precise application; high root-kill; low impact on non-target brush; moderately negative impact on grasses and soils; moderate risk of distributing unwanted secondary species such as pricklypear across the landscape; extremely high cost and high treatment longevity. Mechanical treatments that yield only top-kill have precise application; low root-kill; high impact on non-target brush; moderate impact on grasses and soils; high risk of distributing unwanted secondary species; moderate cost and very low treatment longevity (lower than chemical or fire).

Prescribed fire that causes top-kill generally has low precision on application, unless a pasture has many roads and other fuel breaks; low root-kill; high impact on non-target brush; low impact on grasses and soils; very low cost and low treatment longevity. Table 2 suggests that when a variety of factors are considered, the chemical treatment that yields high root-kill of the target species (e.g., mesquite) yields the most desirable integrated effect. Second to this is the chemical treatment that mostly causes top-kill.

# Section 4. Selective Brush Control and Species Tolerance

### Definition of Study Parameters

A study to evaluate the tolerance level of secondary brush species to mesquite and mixed brush herbicides was initiated in 2013. Treatments were established (Table 3) on two sites in South Texas and two sites in Central Texas during each of three years; 2013, 2014 and 2015. Each spray mix was applied by a commercial applicator as an aerial broadcast application during a typical mesquite timing window.

In the end, results presented here were collected from thirty-six 10-25 acre plots on 12 different locations in Texas over a 3-year period. Sites were evaluated at 3 months, 1 year and 2 years after initial treatment, which was usually from June to July. Initial evaluations were taken at 3 months after treatment to estimate initial injury level or canopy defoliation. At 1 and 2 years after treatment, evaluations were made of percent canopy reduction and percent mortality and categorized into one of 4 categories (Table 4). The 2-year evaluation was considered to be the final evaluation. Species results presented are plants directly exposed to the herbicide spray within the treated plot area. Tables 5-10 present results separately for South Texas and Central Texas as plant species lists are different and tolerance levels may differ slightly.

These results represent plant responses within our study areas. While similar results would be expected at additional locations, actual plant response to these herbicides may vary based on environmental and plant conditions before, during and after aerial application. Accurate responses assume that proper herbicide rate and application procedures were followed.

**Table 3. Herbicide Mixtures and Rates Aerially Applied During 2013-2015 in South Texas and Central Texas**

| Treatment | Herbicide | Rate (Product/Ac) |
|---|---|---|
| 1 | Sendero | 28 oz. |
| | | |
| 2 | Sendero + | 28 oz. |
| | Remedy Ultra | 8 oz. |
| | | |
| 3 | Sendero + | 28 oz. |
| | Tordon 22K | 32 oz. |

**Table 4. Category, Symptoms and Injury Level Descriptions for Shrub Tolerance Calculations**

| Code | Category | Symptoms | Injury Level |
|---|---|---|---|
| T | Tolerant | Minimal symptoms may have minor cupping or curling of leaves, no browning of leaves, no mortality | <25% Canopy Reduction<br>0% Mortality |
| MT | Moderately Tolerant | More prevalent leaf symptoms including cupping and browning of leaves, slight reduction in fruiting/flowering, only slight mortality evident | <50% Canopy Reduction<br><25% Mortality |
| MS | Moderately Susceptible | Definite browning of leaves during first year, stand reduction (mortality) is evident | <75% Canopy Reduction<br>25-50% Mortality |
| S | Susceptible | Near total brown-out of leaves after application, stand reduction (mortality) is higher than 50% | ≥75% Canopy Reduction<br>>50 % Mortality |

**Table 5. Tolerance Rankings of Established Shrub Species After Aerial Application of Sendero Herbicide in Central Texas**

| | | | 28oz Sendero | | |
|---|---|---|---|---|---|
| Family | Common Name | Scientific Name | 3 MO | 1 YR | 2YR |
| Anacardiaceae | Littleleaf sumac | *Rhus microphylla* | T | T | T |
| | Skunkbush sumac | *Rhus aromatica* | T | T | T |
| Berberidaceae | Algerita | *Mahonia trifoliolata* | T | T | T |
| Cactaceae | Pricklypear | *Opuntia spp* | T | T | T |
| | Tasajillo | *Opuntia leptocaulis* | T | T | T |
| Chenopodiaceae | Fourwing saltbush | *Atriplex canescens* | T | T | T |
| Cupressaceae | Juniper (young) | *Juniperus pinchotii* | T | T | T |
| Ephedraceae | Ephedra | *Ephedra antisyphilitica* | T | T | T |
| Fabaceae | Catclaw acacia | *Acacia greggii* | S | MT | MT |
| | Honeylocust | *Gleditsia triacanthos* | S | S | S |
| | Mesquite | *Prosopis glandulosa* | S | S | S |
| Fagaceae | Live oak | *Quercus virginiana* | T | T | T |
| Juglandaceae | Native pecan | *Carya illinioensis* | T | T | T |
| Liliaceae | Yucca | *Yucca spp* | T | T | T |
| Moraceae | Bois d'arc | *Maclura pomifera* | T | T | T |
| Rhamnaceae | Lotebush | *Zizyphus obtusifolia* | T | T | T |
| Rosaceae | Hawthorne | *Crataegus mollis* | T | T | T |
| | Mexican plum | *Prunus mexicana* | T | T | T |
| | Sand plum | *Prunus gracilis* | T | T | T |
| Rubiaceae | Buttonbush | *Cephalanthus occidentalis* | T | T | T |
| Rutaceae | Hercules club | *Zanthoxylum clava-herculis* | T | T | T |
| | Pricklyash | *Zanthoxylum hirsutum* | T | T | T |
| Salicaceae | Willow | *Salix spp* | T | T | T |
| Sapindaceae | Western soapberry | *Sapindus saponaria* | T | T | T |
| Sapotaceae | Bumelia | *Bumelia languinosa* | T | T | T |
| Solanaceae | Wolfberry | *Lycium berlandieri* | T | T | T |
| Ulmaceae | American elm | *Ulmus americana* | T | T | T |
| | Hackberry | *Celtis reticulate* | T | T | T |
| | Winged elm | *Ulmus alata* | T | T | T |
| Verbenaceae | Whitebrush | *Aloysia gratissima* | T | T | T |

**Table 6. Tolerance Rankings of Established Shrub Species After Aerial Application of Sendero + Remedy Ultra Herbicides in Central Texas**

| | | | 28oz Sendero + 8oz Remedy | | |
|---|---|---|---|---|---|
| Family | Common Name | Scientific Name | 3 MO | 1 YR | 2YR |
| Anacardiaceae | Littleleaf sumac | *Rhus microphylla* | T | T | T |
| | Skunkbush sumac | *Rhus aromatica* | MT | T | T |
| Berberidaceae | Algerita | *Mahonia trifoliolata* | MT | T | T |
| Cactaceae | Pricklypear | *Opuntia spp* | MT | T | T |
| | Tasajillo | *Opuntia leptocaulis* | T | T | MT |
| Chenopodiaceae | Fourwing saltbush | *Atriplex canescens* | T | T | T |
| Cupressaceae | Juniper (young) | *Juniperus pinchotii* | T | T | T |
| Ephedraceae | Ephedra | *Ephedra antisyphilitica* | T | T | T |
| Fabaceae | Catclaw acacia | *Acacia greggii* | S | MS | MT |
| | Honeylocust | *Gleditsia triacanthos* | S | S | S |
| | Mesquite | *Prosopis glandulosa* | S | S | S |
| Fagaceae | Live oak | *Quercus virginiana* | T | MT | MT |
| Juglandaceae | Native pecan | *Carya illinioensis* | MT | MT | T |
| Liliaceae | Yucca | *Yucca spp* | T | T | T |
| Moraceae | Bois d'arc | *Maclura pomifera* | T | T | T |
| Rhamnaceae | Lotebush | *Zizyphus obtusifolia* | MT | T | T |
| Rosaceae | Hawthorne | *Crataegus mollis* | T | T | T |
| | Mexican plum | *Prunus mexicana* | T | T | T |
| | Sand plum | *Prunus gracilis* | T | T | T |
| Rubiaceae | Buttonbush | *Cephalanthus occidentalis* | T | T | T |
| Rutaceae | Hercules club | *Zanthoxylum clava-herculis* | T | T | T |
| | Pricklyash | *Zanthoxylum hirsutum* | T | T | T |
| Salicaceae | Willow | *Salix spp* | MT | MT | MT |
| Sapindaceae | Western soapberry | *Sapindus saponaria* | MT | MT | T |
| Sapotaceae | Bumelia | *Bumelia languinosa* | T | T | T |
| Solanaceae | Wolfberry | *Lycium berlandieri* | MT | T | T |
| Ulmaceae | American elm | *Ulmus americana* | MS | T | T |
| | Hackberry | *Celtis reticulate* | MT | MT | MT |
| | Winged elm | *Ulmus alata* | T | T | T |
| Verbenaceae | Whitebrush | *Aloysia gratissima* | T | T | T |

**Table 7. Tolerance Rankings of Established Shrub Species After Aerial Application of Sendero + Tordon 22k Herbicides in Central Texas**

| | | | 28oz Sendero + 32oz Tordon | | |
|---|---|---|---|---|---|
| Family | Common Name | Scientific Name | 3 MO | 1 YR | 2YR |
| Anacardiaceae | Littleleaf sumac | *Rhus microphylla* | MS | MS | MT |
| | Skunkbush sumac | *Rhus aromatica* | MS | MS | MS |
| Berberidaceae | Algerita | *Mahonia trifoliolata* | MT | T | T |
| Cactaceae | Pricklypear | *Opuntia spp* | MT | MT | S |
| | Tasajillo | *Opuntia leptocaulis* | MT | MT | S |
| Chenopodiaceae | Fourwing saltbush | *Atriplex canescens* | T | T | T |
| Cupressaceae | Juniper (young) | *Juniperus pinchotii* | MT | MS | MT |
| Ephedraceae | Ephedra | *Ephedra antisyphilitica* | T | T | T |
| Fabaceae | Catclaw acacia | *Acacia greggii* | S | S | MT |
| | Honeylocust | *Gleditsia triacanthos* | S | S | S |
| | Mesquite | *Prosopis glandulosa* | S | S | S |
| Fagaceae | Live oak | *Quercus virginiana* | S | MS | MT |
| Juglandaceae | Native pecan | *Carya illinioensis* | MT | MT | MT |
| Liliaceae | Yucca | *Yucca spp* | T | T | T |
| Moraceae | Bois d'arc | *Maclura pomifera* | MT | MT | MT |
| Rhamnaceae | Lotebush | *Zizyphus obtusifolia* | MT | T | T |
| Rosaceae | Hawthorne | *Crataegus mollis* | MT | MT | MT |
| | Mexican plum | *Prunus mexicana* | MS | MS | MS |
| | Sand plum | *Prunus gracilis* | S | S | S |
| Rubiaceae | Buttonbush | *Cephalanthus occidentalis* | MT | MT | MT |
| Rutaceae | Hercules club | *Zanthoxylum clava-herculis* | T | T | T |
| | Pricklyash | *Zanthoxylum hirsutum* | T | T | T |
| Salicaceae | Willow | *Salix spp* | MT | MT | MS |
| Sapindaceae | Western soapberry | *Sapindus saponaria* | MT | MT | T |
| Sapotaceae | Bumelia | *Bumelia languinosa* | T | T | T |
| Solanaceae | Wolfberry | *Lycium berlandieri* | MT | MT | MT |
| Ulmaceae | American elm | *Ulmus americana* | MS | T | T |
| | Hackberry | *Celtis reticulate* | S | MS | MS |
| | Winged elm | *Ulmus alata* | T | T | T |
| Verbenaceae | Whitebrush | *Aloysia gratissima* | T | T | T |

**Table 8. Tolerance Rankings of Established Shrub Species After Aerial Application of Sendero Herbicide in South Texas**

| | | | 28oz Sendero | | |
|---|---|---|---|---|---|
| Family | Common Name | Scientific Name | 3 MO | 1 YR | 2YR |
| Berberidaceae | Agarito | *Mahonia trifoliolata* | T | T | T |
| Boraginaceae | Mexican olive | *Cordia boissieri* | T | T | T |
| Cactaceae | Pricklypear | *Opuntia spp* | T | T | T |
| | Tasajillo | *Opuntia leptocaulis* | T | T | T |
| Celastraceae | Desert yaupon | *Schaefferia cuneifolia* | T | T | T |
| Ebenaceae | Texas persimmon | *Diospyros texana* | T | T | T |
| Ephedraceae | Vine ephedra | *Ephedra antisyphilitica* | T | T | T |
| Euphorbiaceae | Leatherstem | *Jatropha dioica* | MT | T | T |
| Fabaceae | Blackbrush | *Acacia rigidula* | MS | MS | MT |
| | Catclaw acacia | *Acacia greggii* | S | MS | T |
| | Guajillo | *Acacia berlandieri* | MS | MS | MT |
| | Huisache | *Acacia farnesiana* | S | T | T |
| | Kidneywood | *Eysenhardtia texana* | MT | MS | T |
| | Mesquite | *Prosopis glandulosa* | S | S | S |
| | Twisted acacia | *Acacia schaffneri* | S | MS | T |
| Koeberliniaceae | Allthorn | *Koeberlinia spinosa* | T | T | T |
| Lamiaceae | Shrubby blue sage | *Salvia ballotiflora* | MT | T | T |
| Liliaceae | Spanish dagger | *Yucca treculeana* | T | T | T |
| | Yucca | *Yucca spp* | T | T | T |
| Oleaceae | Elbowbush | *Forestiera angustifolia* | T | T | T |
| Rhamnaceae | Brasil | *Condalia hookeri* | MS | T | T |
| | Coyotillo | *Karwinskia humboldtiana* | T | T | T |
| | Hog plum | *Colubrina texensis* | MT | T | T |
| | Lotebush | *Zizyphus obtusifolia* | MT | T | T |
| Rutaceae | Lime pricklyash | *Zanthoxylum fagara* | T | T | T |
| Sapotaceae | Coma | *Bumelia celastrina* | T | T | T |
| Scrophulariaceae | Cenizo | *Leucophyllum frutescens* | T | T | T |
| Simaroubaceae | Amargosa | *Castela texana* | T | T | T |
| Solanaceae | Wolfberry | *Lycium berlandieri* | T | T | T |
| Ulmaceae | Spiny hackberry | *Celtis pallida* | MS | T | T |
| Verbenaceae | Whitebrush | *Aloysia gratissima* | MT | T | T |
| | Wild oregano | *Lippia graveolens* | T | T | T |
| Zygophyllaceae | Guayacan | *Guaiacum angustifolium* | T | T | T |

**Table 9. Tolerance Rankings of Established Shrub Species After Aerial Application of Sendero + Remedy Ultra Herbicides in South Texas.**

| | | | 28oz Sendero + 8oz Remedy | | |
|---|---|---|---|---|---|
| Family | Common Name | Scientific Name | 3 MO | 1 YR | 2YR |
| Berberidaceae | Agarito | *Mahonia trifoliolata* | T | T | T |
| Boraginaceae | Mexican olive | *Cordia boissieri* | T | T | T |
| Cactaceae | Pricklypear | *Opuntia spp* | T | T | T |
| | Tasajillo | *Opuntia leptocaulis* | MT | MT | MT |
| Celastraceae | Desert yaupon | *Schaefferia cuneifolia* | T | T | T |
| Ebenaceae | Texas persimmon | *Diospyros texana* | MT | T | T |
| Ephedraceae | Vine ephedra | *Ephedra antisyphilitica* | T | T | T |
| Euphorbiaceae | Leatherstem | *Jatropha dioica* | MT | T | T |
| Fabaceae | Blackbrush | *Acacia rigidula* | S | MS | MS |
| | Catclaw acacia | *Acacia greggii* | S | S | MT |
| | Guajillo | *Acacia berlandieri* | MS | MS | MT |
| | Huisache | *Acacia farnesiana* | MS | T | T |
| | Kidneywood | *Eysenhardtia texana* | MS | MS | T |
| | Mesquite | *Prosopis glandulosa* | S | S | S |
| | Twisted acacia | *Acacia schaffneri* | S | MS | MT |
| Koeberliniaceae | Allthorn | *Koeberlinia spinosa* | MT | T | T |
| Lamiaceae | Shrubby blue sage | *Salvia ballotiflora* | MT | T | T |
| Liliaceae | Spanish dagger | *Yucca treculeana* | T | T | T |
| | Yucca | *Yucca spp* | T | T | T |
| Oleaceae | Elbowbush | *Forestiera angustifolia* | MT | T | T |
| Rhamnaceae | Brasil | *Condalia hookeri* | MT | T | T |
| | Coyotillo | *Karwinskia humboldtiana* | MT | T | T |
| | Hog plum | *Colubrina texensis* | MT | T | T |
| | Lotebush | *Zizyphus obtusifolia* | MT | T | T |
| Rutaceae | Lime pricklyash | *Zanthoxylum fagara* | T | T | T |
| Sapotaceae | Coma | *Bumelia celastrina* | MS | T | T |
| Scrophulariaceae | Cenizo | *Leucophyllum frutescens* | T | T | T |
| Simaroubaceae | Amargosa | *Castela texana* | T | T | T |
| Solanaceae | Wolfberry | *Lycium berlandieri* | T | T | T |
| Ulmaceae | Spiny hackberry | *Celtis pallida* | S | T | T |
| Verbenaceae | Whitebrush | *Aloysia gratissima* | T | T | T |
| | Wild oregano | *Lippia graveolens* | T | T | T |
| Zygophyllaceae | Guayacan | *Guaiacum angustifolium* | T | T | T |

**Table 10. Tolerance Rankings of Established Shrub Species After Aerial Application of Sendero + Tordon 22k Herbicides in South Texas**

| | | | 28oz Sendero + 32oz Tordon | | |
|---|---|---|---|---|---|
| Family | Common Name | Scientific Name | 3 MO | 1 YR | 2YR |
| Berberidaceae | Agarito | *Mahonia trifoliolata* | T | T | T |
| Boraginaceae | Mexican olive | *Cordia boissieri* | MT | T | T |
| Cactaceae | Pricklypear | *Opuntia spp* | MT | MT | MS |
| | Tasajillo | *Opuntia leptocaulis* | MT | MS | MS |
| Celastraceae | Desert yaupon | *Schaefferia cuneifolia* | T | MT | T |
| Ebenaceae | Texas persimmon | *Diospyros texana* | T | T | T |
| Ephedraceae | Vine ephedra | *Ephedra antisyphilitica* | T | T | T |
| Euphorbiaceae | Leatherstem | *Jatropha dioica* | MS | MS | MT |
| Fabaceae | Blackbrush | *Acacia rigidula* | S | S | MS |
| | Catclaw acacia | *Acacia greggii* | S | MS | MT |
| | Guajillo | *Acacia berlandieri* | S | MS | MS |
| | Huisache | *Acacia farnesiana* | S | MS | MS |
| | Kidneywood | *Eysenhardtia texana* | MS | MS | T |
| | Mesquite | *Prosopis glandulosa* | S | S | S |
| | Twisted acacia | *Acacia schaffneri* | MS | MS | MT |
| Koeberliniaceae | Allthorn | *Koeberlinia spinosa* | T | T | T |
| Lamiaceae | Shrubby blue sage | *Salvia ballotiflora* | MT | T | T |
| Liliaceae | Spanish dagger | *Yucca treculeana* | T | T | T |
| | Yucca | *Yucca spp* | T | T | T |
| Oleaceae | Elbowbush | *Forestiera angustifolia* | T | T | MT |
| Rhamnaceae | Brasil | *Condalia hookeri* | MS | T | T |
| | Coyotillo | *Karwinskia humboldtiana* | MT | T | T |
| | Hog plum | *Colubrina texensis* | S | T | T |
| | Lotebush | *Zizyphus obtusifolia* | T | T | T |
| Rutaceae | Lime pricklyash | *Zanthoxylum fagara* | MT | T | T |
| Sapotaceae | Coma | *Bumelia celastrina* | MT | T | T |
| Scrophulariaceae | Cenizo | *Leucophyllum frutescens* | T | T | T |
| Simaroubaceae | Amargosa | *Castela texana* | MT | T | T |
| Solanaceae | Wolfberry | *Lycium berlandieri* | T | T | T |
| Ulmaceae | Spiny hackberry | *Celtis pallida* | S | MS | MS |
| Verbenaceae | Whitebrush | *Aloysia gratissima* | T | T | T |
| | Wild oregano | *Lippia graveolens* | T | T | T |
| Zygophyllaceae | Guayacan | *Guaiacum angustifolium* | T | T | T |

Sendero®

HERBICIDE

# Section 5. Herbicide Use Considerations and Technical Facts

Sendero herbicide is labeled for a maximum use rate of 1.75 pints (28 oz.) per year as a broadcast spray application. For most species including mesquite, huisache and honeylocust, Sendero is recommended at 1.75 pints of product per acre either alone or in tank mix combinations.

Apply the specified rate of Sendero as a coarse low-pressure spray. Do not apply this product with mist blower systems that deliver very fine spray droplets. Spray volume should be sufficient to uniformly cover foliage or intended application site. Increase spray volume to ensure thorough and uniform coverage when target vegetation is tall and/or dense. To enhance foliage wetting and coverage, a non-ionic agricultural surfactant or other adjuvant may be added to the spray mixture as specified by the adjuvant label.

### Ground Broadcast Application

Higher spray volumes (greater than 10 gallons per acre) generally provide better coverage and better control, particularly in dense and/or tall foliage.

### Aerial Broadcast Application

Do not apply less than 4 gallons per acre total spray volume. Five gallons per acre or greater will generally provide better coverage and better control, particularly in dense and/or tall foliage.

### High-Volume Foliar Application

High volume foliar treatments may be applied at rates equivalent to a maximum of 1.75 pints per acre per annual growing season. Use sufficient spray volume to thoroughly and uniformly wet foliage and stems.

### Spot Application

Spot treatments may be applied at an equivalent broadcast rate of up to 1.75 pints of Sendero per acre per annual growing season. Spray volume should be sufficient to thoroughly and uniformly wet foliage, but not to the point of runoff. Repeat treatments may be made, but the total amount of Sendero applied must not exceed 1.75 pints per acre per year. To prevent misapplication, spot treatments should be applied with a calibrated sprayer. Consult the Sendero label for more detailed information on application and rates.

### Proper Conditions Required for Acceptable Honey Mesquite Control With Sendero Herbicide Applications

- Proper application window (40 to 90 days post bud break).
- Soil temperatures > 75°F at 12 inches below soil surface in the shade.
- Mesquite leaf condition healthy, with only dark green growth indicating mature foliage.
- Minimal insect, rodent, weather injury to leaves and trees.
- Soil moisture through the season that is adequate for proper leaf development.
- Best to not spray during active flowering or bean elongation.

## Tordon® 22K

**HERBICIDE**

Tordon 22K herbicide is labeled for a maximum use rate of 2 pints (32 oz.) per year as a broadcast spray application. As a Sendero tank mix partner, Tordon 22K is recommended at 1 to 2 pints of product per acre.

Avoid spray drift. Exposure to very small quantities of spray or drift, which may not be visible, may cause serious injury to susceptible plants during active growth or dormant periods. To minimize spray drift, use low nozzle pressure; apply as a coarse spray; and use nozzles designed for herbicide application that do not produce a fine droplet spray.

### Ground Equipment

With ground equipment spray drift can be lessened by keeping the spray boom as low as possible; by applying 10 gallons or more of spray per acre; by keeping the operating spray pressures at the manufacturer's recommended minimum pressures for the specific nozzle type used (low pressure nozzles are available from spray equipment manufacturers); by spraying when the wind velocity is low (follow state regulations). Avoid calm conditions, which may be conducive to air inversions.

### Aerial Application

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment-and weather-related factors determine the potential for spray drift. The applicator and the landowner are responsible for considering all these factors when making decisions. Consult the Tordon 22K label for more detailed information on aerial application requirements.

## Remedy® Ultra

**HERBICIDE**

Remedy Ultra herbicide is labeled for a maximum use rate of 2 pints (32 oz.) per year as a broadcast spray application. As a Sendero tank-mix partner, Remedy Ultra is recommended at 0.5 to 1 pint of product per acre. Remedy Ultra is formulated as ester. As such, care should be taken to avoid both physical and chemical drift. Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment and weather-related factors determine the potential for spray drift. The applicator and the landowner are responsible for considering these factors when making decisions.

### Ground Equipment

With ground equipment, spray drift can be reduced by keeping the spray boom as low as possible; by applying 20 gallons or more of spray per acre; by keeping the operating spray pressures at the lower end of the manufacturer's recommended pressures for the specific nozzle type used; and by spraying when wind velocity is low.

### Aerial Application

Remedy Ultra may be aerially applied by fixed wing aircraft or helicopter. Keep spray pressure low enough to provide coarse spray droplets. Spray only when the wind velocity is low and avoid application during extreme heat or during air inversions.

# Herbicide Basic Facts

Sendero herbicide is formulated with both clopyralid and aminopyralid active ingredients. Tordon 22K is picloram while Remedy Ultra is triclopyr. All four of these molecules are considered growth regulators in the pyridine family of chemistry.

### Clopyralid Key Features

- A systemic herbicide that causes metabolic disruption resulting in unregulated plant growth.
- Translocated in both the phloem and xylem, therefore it can move to the meristematic areas of both shoots and roots, which helps provide control of hard-to-control annual and perennial susceptible weeds.
- Because clopyralid is a systemic herbicide, rather than a contact herbicide, it can be effective even when only part of the plant is treated. As a result of this, low pressure, low volume, aerial and “wiper” application methods are effective.
- Has been shown to have a relatively low potential to leach or accumulate in the environment.
- Has a low avian and mammalian toxicity profile.
- Range and Pasture use rates are from 0.125 to 0.5 lbs. a.i./acre.

### Aminopyralid Key Features

- A systemic herbicide that causes metabolic disruption resulting in unregulated plant growth.
- Translocated in both the phloem and xylem, therefore it can move to the meristematic areas of both shoots and roots, which helps provide control of hard to control annual and perennial susceptible weeds.
- Possesses both foliar and soil activity.
- Offers a high level of tolerance on a wide range of temperate and tropical forage grasses.
- Has a favorable toxicity profile, practically non-toxic to fish, avian, honeybees and mammals and rated below the EPA’s Level of Concern (LOC) for adverse effects to any of these organisms.
- Range and Pasture use rates are from 0.05 to 0.11 lbs. a.i./acre.

### Picloram Key Features

- A plant growth regulator.
- Translocated in both the phloem and xylem, therefore controls several annual and perennial weeds. Because picloram is systemic rather than a contact herbicide, it can be effective even when only part of the plant is treated.
- As a result of this, low pressure, low volume, aerial and “wiper” application methods can be used.
- The dose response curve for efficacy on target species may be quite flat. That is, effects on plant growth may be seen at doses far below the lethal dose.
- Can be mobile in soil.
- Has low mammalian toxicity.
- Range and Pasture use rates are from 0.125 to 0.5 lbs. a.i./acre.

### Triclopyr Key Features

- A plant growth regulator.
- Translocated in both the phloem and xylem, and therefore controls several annual and perennial weeds.
- Because triclopyr is systemic rather than a contact herbicide, it can be effective even when only part of the plant is treated. As a result of this, low pressure, low volume, aerial and “wiper” application methods can be used.
- Has potential for mobility in soil.
- Has a favorable mammalian toxicity profile.
- Range and Pasture use rates are from 0.125 to 0.5 lbs. a.i./acre.

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