Range Management: Common Rangeland Challenges and Solutions for Beef Cattle Producers
Brush Busters Demonstration

Coordinators: Dr. Barron Rector
Dr. Megan Clayton

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2023 Beef Cattle Short Course Cattleman's College Range Management Workshop

Theme: "Common Rangeland Challenges and Solutions for Beef Cattle Producers"

Welcome to the 2023 Beef Cattle Short Course Cattleman's College Range Management Workshop that will be conducted by Extension Range Specialists Dr. Barron Rector, located in College Station and Dr. Megan Clayton, located in Uvalde. We will begin our discussion of challenges and solutions for beef cattle managers and rangeland owners with knowledge of words and terms used in Range Management.

What is rangeland?

Rangelands in Texas are a naturally occurring resource that produce a multitude of benefits to landowners and citizens. Holechek et al. (1998) described rangeland as a renewable land resource. It is defined as uncultivated land and capable of providing habitat for domestic and wild animals. In the book Range Management: Principles and Practices (1998 3rd edition), Holechek defined rangeland as uncultivated land that will provide the necessities of life and for grazing and browsing animals. Herbivory is the essential process that characterizes rangelands.

Historically, the number one use of rangeland in Texas has been for livestock production. Texas rangelands have been managed primarily for grass production to support livestock enterprises with wildlife, specifically game animals, as a secondary objective. In recent times, ranch financial needs and changes in land ownership goals have placed wildlife goals equal to or higher than livestock production. Reduced numbers of livestock have occurred as land use changes from agriculture to recreation, urbanization and small acreage land holdings. This change was speeded up by the periodic occurrence of Texas droughts.

What is management?

In 1973, Drucker described "management as the art and science of making the correct decisions", as related to our everyday decisions and decisions that create short and long-term impact on our ability to grow grass. He further stated that people often get management and the tools of management confused. We find that management becomes the selection of the right things to do. Effective management must select the right things to do within the limitations and sustainability requirement of all resources if they plan to succeed in the future. Resources are allocated over space and time to accomplish needed and desired responses. The approach management takes on making decisions and allocation of resources have significant effects on both short term and long term impacts to all aspects of the ranch, the cattle and the landscape. Long term goals should dictate the choice between alternatives as long as short term needs are met. From an ecological and sustainable range resource perspective, the primary limitation goal must be to never implement decisions or practices that will degrade the natural ecological and processes essential for maintaining range watershed and soil health.

What is range management?

It is the art and science of manipulating the rangeland resource to achieve goals, ie. animal and plant production, biodiversity, clean air and water, ecosystem services and others such as assisting natural processes in the correction of mistakes made by humans.

Holechek et al. (1998) wrote that range management has two basic components; (1) protection and enhancement of the soil and vegetation complex, and (2) maintaining or improving the output of consumable range products, such as red meat, fiber, wood, water and wildlife. They further described that range management is based on five basic concepts: (1) rangeland is a renewable resource, (2) energy from the sun can be captured by green plants that can only be harvested by the grazing animal, (3) rangelands supply humans with food and fiber at very low energy costs compared to those associated with cultivated lands and where ruminant animals are best adapted to use range plants, (4) rangeland productivity is determined by soil, topographic, and climatic characteristics and (5) a variety of "products" including food, fiber, water, recreation, wildlife, minerals, and timber are harvested from rangelands. Through today, the focal point of range management is the control of livestock grazing.

Tools of range management

Prescribed burning
Brush management (chemical, mechanical, biological control and prescribed fire)
Weed management and control
Grazing management
Building fences and water resources
Range Seeding

What is rangeland ecology and management?

Rangeland ecology and management focuses on the relationships between plants, soils, water and the environment. We study the impact of human management, ranching, farming, industrial sites, and other uses of the land for recreation, hunting, urban and suburban establishment that alter the natural processes of the land. We study the impact of human decision making. We dwell on the idea of "what is healthy rangeland?".

We study reclamation and ecosystem restoration as all of the rangeland in Texas has been changed and altered into other states of change from past management and the introduction of non-native plants and animals.

Natural processes – who are they?

Natural processes include Primary and Secondary succession, weather (rain, wind, evaporation, transpiration, infiltration, varying temperatures), water and nutrient cycles, decomposition, fire, disturbances, birth/death, aging, migration, photosynthesis, genetic adaptation/change, predation/herbivory, seasons of the year. It is noted that disturbances drive the rangeland ecosystem, a system that always is in change.

Cattle Stocking Rates

Cattle stocking rate is probably the most important issue to consider. Rangelands produce a finite amount of forage each year and production is dynamic between and within years as influenced by the time of occurrence and amount of rainfall received. Stocking rate is dynamic and should be an important consideration when managing for cattle. This decision determines the number of acres that are allotted to an animal such as in acres/animal unit per year. This is a starting point and then the changes in weather will begin and establish a new future over what may have been planned for in the original setting of a stocking rate. The future is unknown. Monitoring techniques should be used to evaluate the changes in the forage base. Many of our challenges we will face, will be the result of making that stocking rate decision.

Stocking rate is a man determined number that defines the amount of land allotted to each animal for the entire grazeable portion of the year. The stocking rate value is determined to harvest a livestock forage base that will promote the production of animals, animal performance, without harm to the animal, forage base or future productive capability of the resource. Rangeland stocking rate decisions do not follow the rules of annual cropping systems.

Extension Range Specialist Emeritus Dr. Larry White suggested that a successful stockman will evaluate the forage base at the end of the first growing season, late June or early July. If the stockman set the stocking rate right or at a reasonable rate, the stockman will find that all grass has not been eaten that grew and enough grass still remains to graze through July and August until the next expected rain returns.

Issues and Selection of Solutions

You are probably not the first owner and livestock manager on your ranch. When you became the manager and decision maker, did you understand why your property looked the way it did? Did the previous land managers make correct decisions? Whether I inherited the land, bought the property, lease the land or rent it, were you provided with a book of history on all the ranching decisions that had been made previously and the tools of management that were previously used to solve problems? Often we become the owner and manager of rangelands without knowledge of the lands past history. This fact creates the first challenge to face, “why does my land look the way it does?”. See Figure 1 and which condition class best describes your property right now?

We begin by looking at current conditions on our land, the vegetation complex and who are the plants that I see growing. Consider the following, (1) plant identification, (2) grazing management and land condition change, (3) a brush invasion and management approaches, (4) weed replacement of grass and control options, (5) stocking rate decisions and (6) what does success look like? and monitoring techniques.

Literature Cited

Holechek, Jerry L., Rex D. Pieper, Carlton H. Herbel. 1998. Range Management: Principles and Practices (3rd Ed.). Prentice Hall, Upper Saddle River, New Jersey. 542 p.

White, Larry D. 2001. Integrated Management for Water, Brush and Wildlife on Texas Rangelands. Presentation at the Brush, Wildlife and Water Symposium, Kerrville, Texas.

BR/MC/

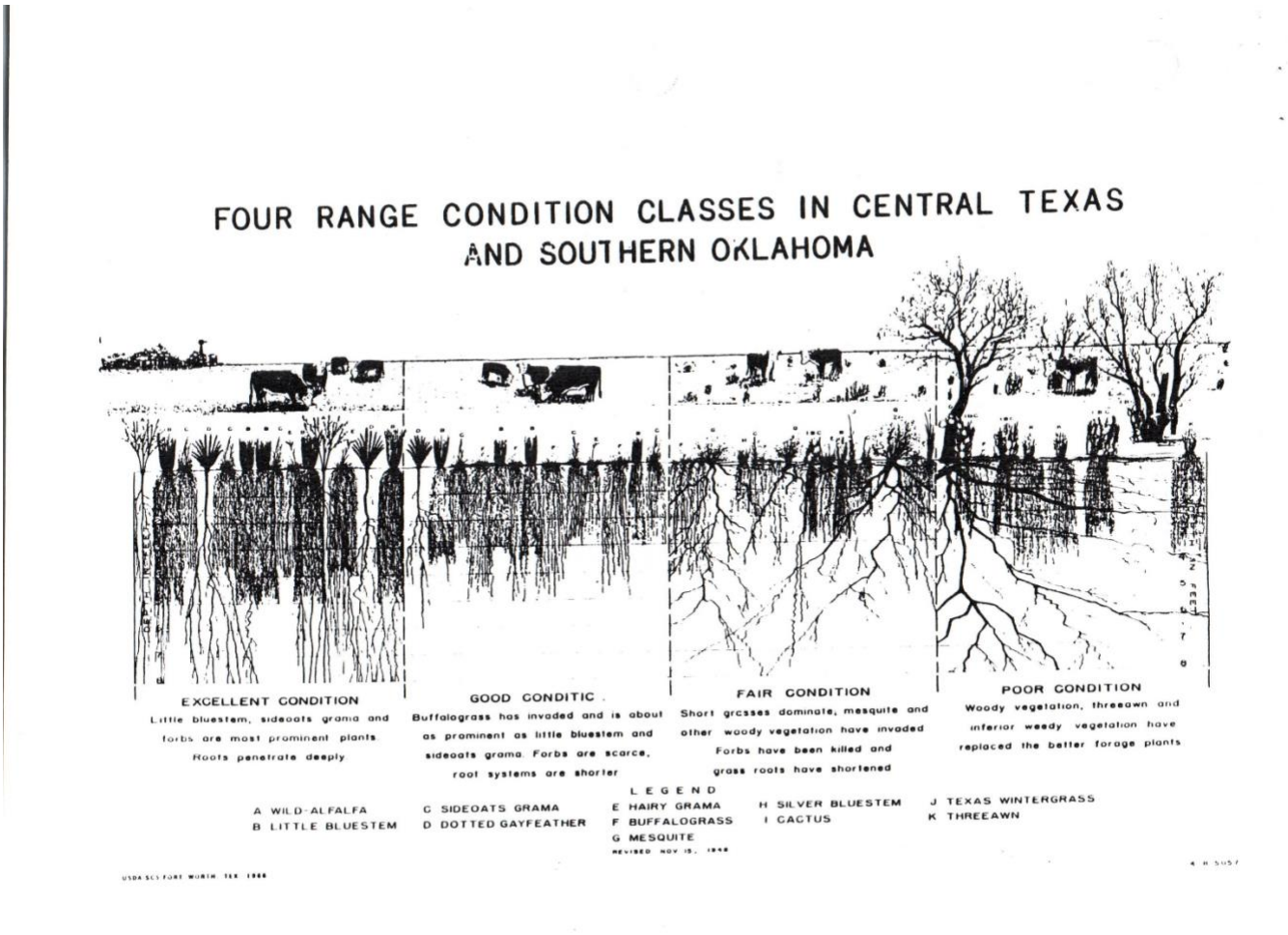

Figure 1. USDA SCS (1966) Four Range Condition Classes in Central Texas and Southern Oklahoma

Beef Cattle Short Course: Rangeland Management Session Resources

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Websites

- Web Soil Survey https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
- Plants of Texas Database https://rangeplants.tamu.edu/
- Texas Native Seed – Seed Selection Tool https://www.ckwri.tamuk.edu/research-programs/texas-native-seeds-program-tns/native-seed-selection-tool
- Native Seeding Online Course https://agrilifelearn.tamu.edu/s/product/native-seeding-certification/01t4x000003swbeAAA
- Generation Next: Our Turn to Ranch Online Course https://generationnext.tamu.edu/

Plant and Mapping App Suggestions:

- onXhunt (Android and Apple; $30/yr for Texas license; 7-day free trial)
  For Android: https://play.google.com/store/apps/details?id=onxmaps.hunt&hl=en_US
  For Apple: https://apps.apple.com/tn/app/onx-hunt-gps-tracking-tools/id672902340
- My Tree ID (Android and Apple; Free!)
  For Android: https://play.google.com/store/apps/details?id=com.tfs.treeid
  For Apple: https://apps.apple.com/us/app/id1525919752
- East Texas Wildflowers (Android and Apple; Free!)
  For Android: https://play.google.com/store/apps/details?id=com.wildflowersearch.etexaswildflowers&hl=en_US
  For Apple https://apps.apple.com/us/app/east-texas-wildflowers/id1095483493
- West Texas Wildflowers (Android and Apple; Free!)
  For Android: https://play.google.com/store/apps/details?id=com.wildflowersearch.wtexaswildflowers&hl=en_US
  For Apple: https://apps.apple.com/us/app/west-texas-wildflowers/id1095506188
- Grazing Management Toxic Plants (Apple; Free!)
  For Android: Currently unavailable
  For Apple: https://apps.apple.com/us/app/grazing-management-toxic-plants/id1177025788
- Seek by iNaturalist (Android and Apple; Free!)

For Android: https://play.google.com/store/apps/details?id=org.inaturalist.seek&hl=en_US&gl=US
For Apple: https://apps.apple.com/us/app/seek-by-inaturalist/id1353224144

- Google Lens
  For Android: https://play.google.com/store/apps/details?id=com.google.ar.lens&hl=en_US&gl=US
  For Apple: https://apps.apple.com/cz/app/google/id284815942

Plant ID Book Suggestions:

- Range Plants of North Central Texas by Ricky Linex (check with local Soil and Water Conservation Districts or NRCS Offices)
- Wildflowers of Texas by Michael Eason
- Field Guide to Common Texas Grasses by Hatch et al.
- Toxic Plants of Texas by Charles Hart et al. – CURRENTLY OUT OF PRINT
- Common Woody Plants & Cacti of South Texas by Richard B. Taylor
- Brush & Weeds of Texas Rangelands by Charles Hart et al. – CURRENTLY OUT OF PRINT
- Field Guide to the Broad-leaved Herbaceous Plants of South Texas by Everitt et al.
- Trees, Shrubs, and Vines of the Texas Hill Country by Jan Wrede
- Trees of Texas by Stahl and McElvaney
- Bluestem Grasses in Texas by Clayton et al. ($20 on Flywire)
  https://tamu.estore.flywire.com/products/book-bluestem-grasses-in-texas-19120

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RANGE MONITORING WITH PHOTO POINTS

Allan McGinty, Larry D. White*

Photo points provide a way for owner/managers to monitor rangeland health with a minimum of time and expense. Photo points, which are simply periodic photographs of specific range sites, can help owner/managers make better management decisions.

Any given pasture is usually composed of several different range sites, each with different plant communities of grasses, forbs and woody plants. This mix of plant species within each range site changes over time because of weather, seasons, brush and weed management, and grazing pressure by livestock and wildlife. The kinds of plants, their quality and quantity within each community dictate the rangeland's potential to produce livestock, wildlife, water and other products.

Managers must monitor changes in these plant communities to ensure that:

- Management is not damaging the soil, water quality or range resource base; and
- Past decisions are producing expected results.

By comparing photographs and detailed notes on the same location over time, managers can see what changes have occurred. Photographs, notes and interpretations serve as a permanent record of each situation for future consideration. The manager's observations and other information are necessary to establish the causes of changes in resource conditions.

*Professors and Extension Range Specialists

HOW OFTEN TO MONITOR

There are two types of photo-point monitoring situations:

- Annual photos for long-term monitoring of range condition and health over years; and
- Seasonal photos for monitoring short-term management impacts such as stocking rates, changes in forage standing crop, or responses to weed and brush control practices.

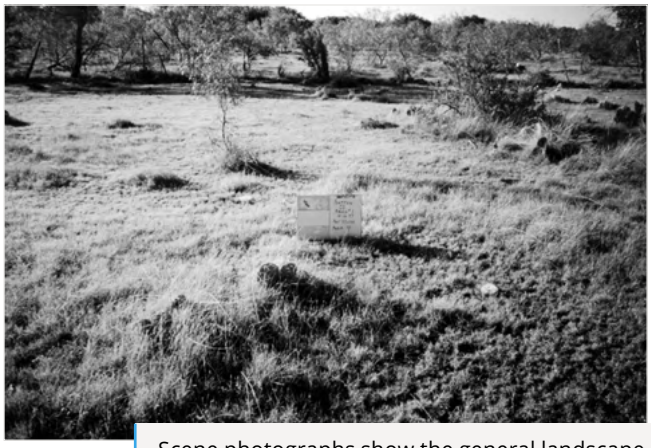
WHEN TO TAKE PHOTOGRAPHS

Photographs that best illustrate the situation should be taken at least once a year and at the same time each year. A good time for annual photographs is in fall before the first killing frost. Shoot more often if you want to monitor more closely. For seasonal monitoring, consider taking photographs at late winter or spring green-up, mid-summer and at frost or before and after grazing a pasture or when controlling brush.

LOCATION AND NUMBER OF PHOTO POINTS

Individual pastures can be composed of many range sites, or areas supporting different types of plant communities. Identify these range sites using county soil survey manuals or with help from the local county Extension agent or Natural Resources Conservation Service personnel. All major range sites should be monitored using photo points. The actual number within each range site depends on the acreage involved and the purpose of monitoring. In most cases, shooting two to five photo points per range site gives acceptable results.

To monitor grazing, do not choose photo points close to water or in the back of the pasture. Select those that represent the range site in general and the use the site receives by grazing animals. Locate other photo points to monitor specific "problem" situations (such as stream bank erosion, sensitive riparian areas, recovery following wildfire).



Scene photographs show the general landscape.

Remember: The photo points you choose now will be used to characterize a much larger area for a long time. Selecting areas that truly represent the range site as a whole is critical to an effective monitoring program.

Choose sites that are reasonably accessible, because you will be returning year after year. Photo points can be located along ranch roads, which also can be used for spotlight deer surveys and routine pasture observations. Balance accessibility with the need for representative photo points.

SETTING UP A PHOTO POINT

After selecting the location of a specific photo point, mark it permanently by driving a steel fence post or metal stake (re-bar) into the ground. Spray the marker with highly visible paint. A nearby fence post can also be sprayed to help locate the plots. Pile rocks around the re-bar to prevent injuries to animals or vehicles. Identify the location of each photo point on a ranch/pasture map or aerial photograph.

Take detailed notes describing the site for each photo point. This may include compass bearing and distance from a highly visible landmark or GPS coordinates if available.

With a felt pen and a yellow paper pad (white is too bright), make a plot sign to include in the photo plot/scene. Include some identification (pasture name, range site, etc.) concerning the specific plot/scene being photographed and the date. Other information can be included, but to be legible, keep it as short as possible.

TYPES OF PHOTOS

Two types of photographs, vertical and scene, are generally used. Photographs taken from a "near" vertical position are best to show details of soil, litter and vegetation. These vertical photos will show changes in plant cover, litter, bare ground and erosion in spaces between plants, for small areas within permanently located plots. Detailed vertical photos are very specific and less representative of the landscape than scene photographs.

Scene photographs show much larger areas, including the general landscape, brush, grass, terrain and soil. If the scene is photographed with the bot- tom of the photo no farther than 10 feet away, the foreground can show herbaceous species, cover, litter, bare ground, etc.

VERTICAL PHOTOGRAPHS

Establish one to several photo points in an area by placing a plot frame on the ground. A convenient frame can be made by two 6-foot folding carpenter's rulers folded at their 3-foot position and placed to face each other, collectively forming a square. PVC pipe joined with elbows also may be used. After placing the plot on the ground, mark the corners by driving 1-foot sections of re-bar rods into two opposite plot corners. This allows the exact relocation of the plot for future observations. Place the plot sign on the ground next to the plot frame before photographing.

Stand so that your shadow is not cast over the photo plot. Take the picture by standing as close to the plot frame as possible while still including all the plot frame and the yellow pad in the picture. Try to shoot as vertical a picture as possible.

SCENE PHOTOGRAPHS

Landscape (scene) photographs also can be taken from the steel post or re-bar marker. Simply stand at the post and take one picture facing each of the cardinal directions, using a compass to frame each shot accurately. If you wish to take only a single scene photograph at each location, place the plot identification at the base of the steel post or re-bar. When shooting the photograph, stand about 10 feet from the plot marker in a predetermined and recorded direction. Include the plot identification and plot marker in the bottom of the photograph.

REPEATING PHOTOGRAPHS

- Identify on your work calendar the dates that repeat photographs should be taken.
- Organize the photos for easy viewing and so that subsequent years may be added in sequence on the same storage sheet.
- Have an updated map showing the location of each photo point.

- Carry the map and previous photographs of the plots to be photographed when re-photographing the plots. Use the previous photograph to locate the exact scene or photo location.
- Reshoot the photograph with proper plot identification encompassing exactly the same scene using the same procedures.
- Use a data information sheet to record any observations before leaving each location. This data information sheet should include the plot ID, date, pasture and any notes concerning species of plants present, general observations, concerns, etc.

INTERPRETING PHOTOGRAPHS

When comparing photographs for a specific photo point over time, look for:

- Changes in the cover or density of desirable or undesirable plants and amount of litter on the ground;
- Changes in the amount of bare ground visible; and
- Evidence of erosion, such as loss of soil between plants.

Records such as those detailing grazing use, brush management and rainfall are invaluable in interpreting these photographs.

STORING SLIDES AND PHOTOGRAPHS

If you use slide film, write the date, photo point number and management unit on the edge of the slides after they are developed. If print film is used, record the same information on an adhesive label and affix the label to the back of the print. Prints (3-by-5- inch) can be stored in sheets holding five photos per page or use one 3-by-5-inch card to index each print on the page.

Photos taken with a digital camera can be processed as either prints or slides or maintained as graphic files. Digital photos can easily be sent to others over the Internet. Keep the data sheets/information and maps for each location with the photographs.

EQUIPMENT NEEDED

- Steel fence posts
- Sections (12 to 18 inches) of re-bar rod
- Hammer or post driver
- Spray paint
- Camera (35 mm preferred) or digital camera
- Film (100 ASA preferred)
- Two 6-foot folding rulers or 3-by-3-foot PVC frame (for vertical plots)
- Farm or ranch map or aerial photograph
- Yellow pad
- Felt marking pen
- Three-ring binder
- Non-acidic, non-PVC print/slide storage sheets
- Data sheets
- Pen or pencil

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GRAZING AND BROWSING: HOW PLANTS ARE AFFECTED

Robert K. Lyons and C. Wayne Hanselka*

Grazing can have a neutral, positive or negative effect on rangeland plants, depending on how it is managed. Land owners and managers can better protect rangeland plants, and, in turn, other rangeland resources, if they understand:

- The effects of grazing and browsing (eating the leaves and young twigs of trees and shrubs) on individual plants and plant populations.
- The indicators that show which plants are in danger of overuse by grazing and browsing animals.
- The grazing management practices that help preserve the rangeland resource.

Understanding these factors and knowing the available management options allows landowners and managers to make better decisions about which actions are best for a particular site and when to take action. Timely action can preserve the long-term health of the rangeland as well as the viability of livestock and wildlife operations.

INTERACTIONS BETWEEN RANGE PLANTS AND RANGE ANIMALS

Rangelands are ecosystems that have adapted to withstand such disturbances as drought, flood, fire, and grazing. All disturbances affect plants to some extent, either directly or indirectly, depending on the timing, intensity, and frequency of the disturbance. Generally, the more diverse the vegetation, the better rangeland can withstand disturbance.

Rangeland plants provide nutrients—proteins, starches and sugars—to grazing and browsing livestock and wildlife. These nutrients, or plant foods, are produced by photosynthesis. Because photosynthesis occurs only in green plant tissue and mostly in the leaves, a plant becomes less able to produce food, at least temporarily, when its leaves are removed (defoliation) by grazing and browsing animals.

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Products of photosynthesis are just as important to plants as they are to animals. Like all other living things, plants need food to survive and grow. The food that plants make for themselves through photosynthesis is used for major plant functions such as surviving dormancy, growing new roots, growing new leaves in the spring, and replacing leaves lost to grazing or browsing.

Most native rangelands evolved under grazing. Therefore, rangeland plants have developed the ability to withstand a certain level of grazing or browsing. Although grazing animals do disturb rangeland, research has shown that rangelands gain few benefits when livestock are totally excluded for long periods.

WHAT HAPPENS TO A PLANT AFTER GRAZING OR BROWSING?

Grazing affects not just the leaves, but also other parts and functions of plants, including the root system, food production after defoliation, and the destination of food products within the plant after defoliation.

Food reserves and the root system

When a plant's leaves are removed, its roots are also affected. Excessive defoliation makes the root system smaller.

Removal of too many leaves has a profound effect on the root system (Figure 1). Research on grasses has demonstrated that when 80 percent of the leaf is removed, the roots stop growing for 12 days. When 90 percent of the leaf is removed, the roots stop growing for 18 days. Root growth drops by half when 60 percent of leaf is removed.

As root growth is reduced or stopped, root volume decreases (Figure 2). Plants with smaller roots have less access to water and other nutrients in the soil needed to manufacture food. A smaller root system also makes plants less drought resistant.

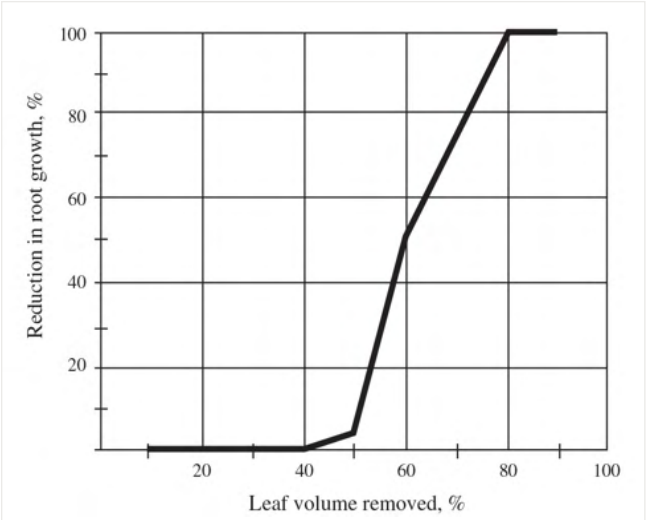

Figure 1. The effect of leaf removal on the root growth of a grass. With 80 percent leaf removal, roots stopped growing for 12 days; with 90 percent removal, root growth stopped for 18 days.

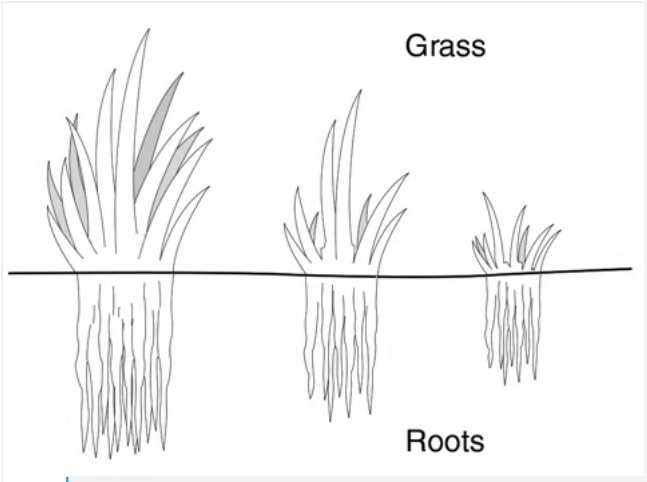

Figure 2. Heavy, frequent defoliation stops root growth and reduces the size of the root system. It reduces the plant's ability to absorb water and other nutrients, thus making the plant less drought resistant and less able to manufacture food.

Early research demonstrated that roots lose stored foods after defoliation. These observations led to the conclusion that the roots and crown of grasses were major sources of food for the initiation of growth after defoliation.

However, recent information indicates that, at least in grasses, stored foods are not as important in initiating this growth. Although food reserves decline in grass roots after defoliation, these reserves do not appear to be sent to the food-producing parts of the plant.

Recent research indicates that this decline in food stored in grass roots after defoliation results from a combination of:

- Remaining leaves sending less of the food they manufacture to the roots, and
- Roots themselves using the root food reserves.

In addition, studies involving grass crowns have shown that this part of the plant stores only about a 3-day supply of food reserves. This finding indicates that this part of the plant does not supply enough food to promote significant growth after defoliation.

If roots do not contribute stored food to promote growth after defoliation, where does the plant get this food?

Food production after defoliation

Grazing and browsing decrease, at least temporarily, a plant's food production by reducing the amount of green plant material available to produce food. Other factors affecting food production after grazing or browsing include the amount, kind, and age of plant material (leaf, sheath, stem) remaining on the plant.

For example, grass leaf blades, whether mature or young, often produce food at a higher rate than leaf sheaths (the leaf base enveloping the stem) or stems. In addition, young leaves produce food at higher rates than older leaves. Therefore, the more leaf material left after grazing, the faster grasses recover from grazing.

In many plant species, including some grasses, the leaves on grazed or browsed plants produce food at higher rates than leaves of the same age on plants that have not been grazed or browsed. In plants where it occurs, this process happens over several days in leaves remaining on a grazed or browsed plant and in new leaves developing after grazing or browsing. This process is one way that some plants partially cope with grazing or browsing.

Destination of food products after defoliation

Plants use the foods they produce for growth and maintenance. Any excess food is sent from the food-producing plant parts to other parts both above and below ground, where it is stored.

Once a plant has been defoliated, it may change the destination of its food products. The destination of that food varies with plant species. In some species, more food is sent to growing shoots and less to roots. This process occurs for a few days until the food-producing tissues can be reestablished. In some grass species,

more food products may even be sent to the more active food-producing leaf blades rather than to less active leaf sheaths.

A plant's ability to send food products to new shoots after defoliation can help it quickly reestablish its food-producing parts. Plant species that have this ability are better able to tolerate grazing.

In investigations of grazing tolerance, researchers compared two western grass species that had different levels of grazing tolerance. They found that after defoliation, the grazing-tolerant species sent more food products to new leaves and fewer products to the roots. In contrast, the grazing intolerant species sent large amounts of food products to the root system. This finding helps explain why some grasses are better able to resist grazing.

HOW DO PLANTS COPE WITH GRAZING AND BROWSING?

The ability of plants to survive grazing or browsing is called grazing or browsing resistance. The most grazing-resistant plants are grasses, followed by forbs (herbaceous plants other than grass), deciduous shrubs and trees, and evergreen shrubs and trees.

When a grass seedling develops, it produces a primary tiller, or shoot. This primary tiller has both a main growing point and secondary growing points located at or below ground level.

Additional tillers can develop from secondary growing points at the base of a tiller. Tillers can also develop from buds at the nodes of stolons (above-ground lateral stems, such as in buffalograss) or rhizomes (below-ground lateral stems, such as in Johnsongrass) of grasses with these structures.

Cool-season grasses begin growth in the fall, maintain some live basal leaves through winter, and continue growth in the spring. Tillers produced in the fall are exposed to cold and can produce seedheads in spring. Tillers initiated in the spring usually do not produce seedheads.

In comparison, warm-season grasses produce new tillers in late summer and early fall. Although these young tillers die back when exposed to frost, their buds will produce new tillers the following spring.

Tillers of most grasses live only one to two years. Individual leaves usually live less than a year and most only a few months.

A plant can produce leaves only at an intact growing point. As long as that growing point is close to the ground, it is protected from being eaten (Figure 3). At some point, most grasses elevate at least some of their growing points to produce tillers, or shoots, that have seedheads.

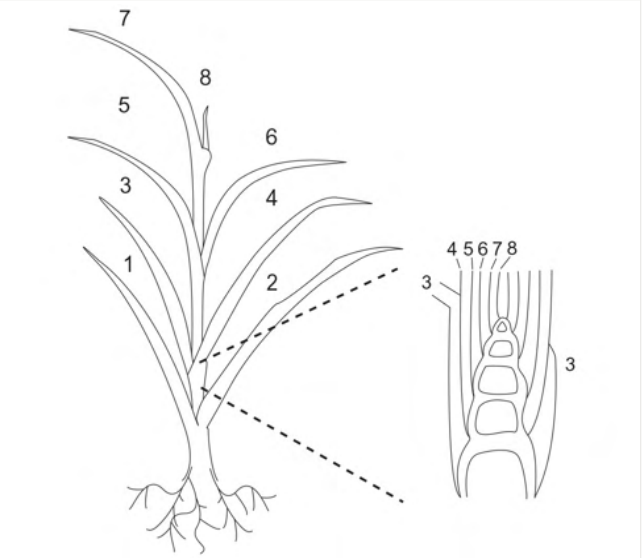

Figure 3. This illustration represents a grass tiller (or shoot) and its main growing point. On the left are the grass tiller and eight leaves, numbered 1 to 8. On the right is an enlargement of the area near the base of this tiller where the main growing point is located. All the leaves shown have developed from this growing point. As long as the growing point is close to the ground as shown here, it is safe from being eaten and can continue to produce leaves for the life of the tiller (1 to 2 years).

Tillers stop producing new leaves when a seedhead develops from the growing point or when the growing point is eaten. Plants then must depend on other tillers to continue producing new leaves or wait until basal buds produce new tillers.

Excessive grazing of a grass plant when its growing points are elevated reduces new leaf production, and therefore, the ability of the plant to produce food and tolerate grazing. Destruction of the growing point also prevents seed production and production of new seedlings. Grasses should be rested from grazing periodically to allow them to produce leaf material to feed the plant and to allow seed production.

Timing of growing point elevation varies among grass species (Table 1). For example, growing points of buffalo grass and other sod-forming grasses remain close to the ground, giving these grasses high grazing resistance.

Little bluestem and sideoats grama keep their growing points close to the ground until just before seedheads emerge. Although this strategy protects growing points from being eaten for a longer period, these two grasses produce many tillers with seedheads, which means that many growing points are exposed. The combined effect

TABLE 1. EXAMPLES OF GROWING POINT ELEVATION AND GRAZING RESISTANCE FOR SOME COMMON RANGE GRASSES.		
GRASS SPECIES	GROWING POINT ELEVATION/REPRODUCTIVE TILLER RATIO	HEAD4
Buffalograss	Remain close to ground	High
Little bluestem	Elevation late w/ large number reproductive tillers	Moderate
Sideoats grama	Elevation late w/ large number reproductive tillers	Moderate
Switchgrass	Elevation early	Low
Yellow indiangrass	Elevation early	Low
Johnsongrass	High proportion of reproductive tillers	Low

of delayed elevation and the production of many tillers with seedheads gives these two grasses moderate grazing resistance.

Yellow indiangrass and switchgrass elevate their growing points above ground level soon after growth begins. This early elevation results in low grazing resistance.

Grasses with low (yellow indiangrass and switchgrass) to moderate (little bluestem and sideoats grama) grazing resistance require more care in grazing management. This care can be accomplished in several ways.

One way to manage these low- to moderate-grazing resistant grasses is to lower grazing pressure by stocking fewer animals to allow some plants to escape grazing.

Another method is to make sure that pastures with these grasses are rested from grazing every 3 or 4 years during the growing season to allow the plants to produce seed.

Still another method that has been used successfully is intensive-early stocking. With this approach, grazing animals are stocked at higher than normal numbers for the first part of the growing season and then removed from pastures for the rest of the growing season. This approach has typically been used with stocker (young steer and heifer) operations.

Johnsongrass is an interesting contradiction. Because it produces strong rhizomes (underground stems), it should be resistant to grazing. However, Johnsongrass also produces a high proportion of reproductive stems, which cancels the advantage of rhizome production and results in lower grazing resistance.

The growing points of forbs, like those of grasses, remain close to the ground early in the growing season. Forb species that elevate growing points early are less resistant to grazing.

For woody plants, growing points are elevated above ground and, therefore, are easily accessible to browsing animals. If these growing points are removed, lateral buds are stimulated to sprout and produce leaves. However, woody plants replace leaves relatively slowly.

Grazing avoidance and grazing tolerance

Grazing resistance can be divided into avoidance and tolerance (Figure 4). Grazing avoidance mechanisms decrease the chance that a plant will be grazed or browsed. Grazing tolerance mechanisms promote growth after grazing or browsing.

Grazing resistance factors can be related to plant anatomy, plant chemistry or plant physiology:

- Anatomical features that help plants resist being grazed include leaf accessibility (leaf angle, leaf length), awns or spines, leaf hair and/or wax, tough leaves, grass species with more vegetative stems (fewer growing points exposed) than reproductive stems, and the ability to replace leaves, which depends on growing points.
- Chemical factors of grazing resistance include those compounds that make plants taste bad, toxic, or hard to digest.
- Physiological factors include sending new food products to new leaves, water-use efficiency, and root growth and function.

Competition and grazing

Competition from neighboring plants for soil nutrients and water affects plant response to defoliation. Studies have shown that when competition is reduced, leaf growth in defoliated plants can be similar to that in nondefoliated plants. Competition can be reduced by 1) lowering grazing pressure by stocking fewer animals and 2) resting plants from grazing.

If competition is not reduced, new leaf growth may not occur because of a lack of available nutrients to grow new leaves. Therefore, plants that are grazed severely while neighboring plants are not grazed or grazed less severely are at a competitive disadvantage.

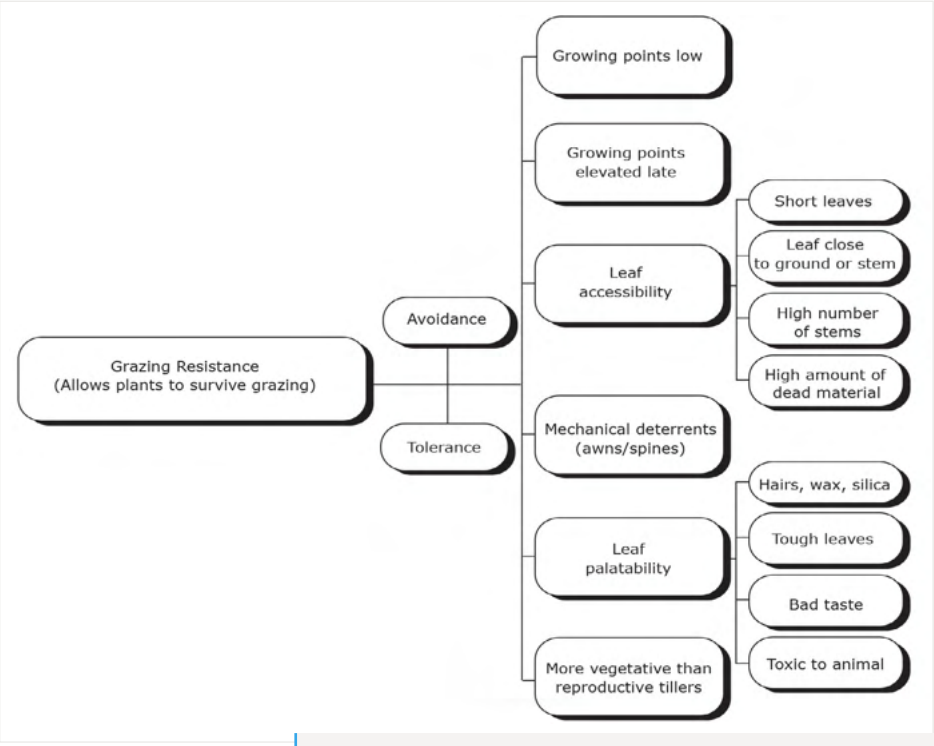

Figure 4. Examples of plant grazing-resistance mechanisms.

become more abundant. From a livestock perspective, proper management involves controlling browsing livestock numbers and controlling access to browse plants to provide rest from browsing. From a wildlife standpoint, proper management involves harvesting animals when wildlife census numbers and browse use signs indicate a danger to the browse resource.

Just as with grasses, browse species can be managed to promote and maintain key species, that is, the preferred plants that make up a significant part of the production of browse available for animals to eat. This task is accomplished by controlling animal numbers and providing rest from browsing.

Do plants benefit from grazing?

It is not clear if plants benefit from being grazed. Certain species may benefit from grazing but not necessarily from being grazed. For example, plants may benefit indirectly from removal of competition or from the creation of a favorable environment for seed germination or directly from removal of self-shading or removal of inactive leaves.

Some grazed plants experience compensatory photosynthesis (food production). However, this response does not mean that the plants benefit from being grazed, only that they have ways to cope with grazing.

BROWSE MANAGEMENT CONSIDERATIONS

Browsing animals such as goats and deer prefer certain browse species. Preferred species vary with natural regions (such as the Edwards Plateau, Rio Grande Plain, Trans Pecos, etc.) of Texas. However, Texas kidneywood and Texas or Spanish oak are examples of highly preferred species; live oak represents a moderately preferred species; and ashe juniper (blueberry cedar) and mesquite are examples of low-preference species.

Without proper management, the more desirable browse species can disappear because of these preferences, while less desirable or undesirable species

HOW TO DETERMINE IF THE RANGE IS BEING OVERUSED

Managers can use browse indicators to help make management decisions about the browse resource. These indicators include degree of use, hedging, and the presence or absence of seedlings.

Degree of use is the amount of the current season's growth that has been removed by browsing animals. It is best observed at the end of the growing season in late fall for deciduous plants and late winter for evergreens. When determining degree of use, consider only current season growth by comparing browsed twigs with unbrowsed twigs.

Browse use can be divided into three levels of current season growth removal: light use is marked by less than 40 percent removal; moderate use ranges from 40 to 65 percent removal; and heavy use is more than 65 percent removal.

Moderate use on key browse species is the correct management goal. When use approaches the upper limit of moderate use for key species, browsing pressure should be reduced by 1) resting areas from browsing livestock use or reducing livestock numbers and/or 2) reducing wildlife numbers.

Hedging is a plant response to browsing marked by twigs that have many lateral branches. A moderate

degree of hedging is acceptable (Figure 5) because it keeps browse material within easy reach of animals and stimulates leaf and twig growth.

However, excessive hedging produces short twigs with smaller than normal leaves and twigs. Eventually, entire plants can die from excessive hedging.

Figure 5. A moderate degree of hedging as shown on this Texas kidneywood plant, a highly desirable browse species, is acceptable.

Another indicator of excess browsing pressure is the hedging of low-preference plants such as agarita (Figure 6). When animals consume plants they do not normally eat, it usually means that not enough of their preferred food is available.

To provide forage, browse plants must be within reach of browsing animals (Figure 7). As hedging increases, the lower branches disappear and a browse line develops. A browse line is the height on trees or shrubs below which there is little or no browse and above which browse cannot be reached by animals.

Figure 6. The hedging on agarita, a low-preference browse plant, indicates excessive use.

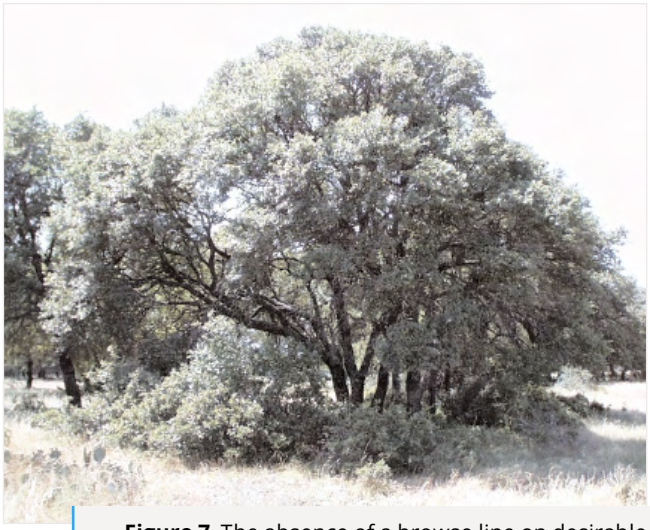

Figure 7. The absence of a browse line on desirable woody species indicates that forage is accessible to animals and that the number of animals is probably in balance with the supply of browse.

Areas where trees or shrubs have a highly developed browse line have a park-like appearance. In the early development of a browse line, light begins to show through the lower vegetation. With continued browsing pressure, a distinct browse line develops (Figure 8). Development of browse lines on low-preference plants such as ashe juniper (blueberry cedar) also indicates excessive use of the range (Figure 9).

The height of browse lines depends on browsing animal species. For example, white-tailed deer usually browse to about 3 to 4 feet, goats to about 4 to 5 feet, and exotic wildlife species to 6 feet and more.

To keep woody plant populations healthy, plants must be allowed to reproduce. Therefore, the presence of seedlings of desirable browse plants is another indicator that managers can use to check for range overuse.

Figure 8. A prominent browse line on moderately preferred browse species such as live oak is an indication of past overuse.

Figure 9. A prominent browse line on ashe juniper (blueberry cedar), a low-preference plant, is an indication of severe overuse of the browse resource.

MANAGEMENT CONSIDERATIONS

Regardless of whether a ranch's production goal is livestock or wildlife, plants feed these animals and protect the soil from erosion. A good steward should aim to conserve the soil and plant resources so that animals are produced in a way that can be sustained over time.

To influence the effect of grazing disturbances on range plants, managers can control three factors of grazing or browsing:

- Intensity refers to the amount of grass or browse that is eaten. It is the most important factor because it affects the amount of leaf available for food production as well as the amount of root system in grasses and the production of seed.
- Timing of grazing affects plants more severely at certain stages of their development. The most critical grazing period is usually from flowering to seed production. Although the least critical period is dormancy, leaving plant residue is important even during dormancy. Research and demonstration work have shown that removing high quantities of forage during dormancy is almost as detrimental to plant productivity as during active growth periods.
- Frequency refers to how often plants are grazed or browsed. Animals tend to come back to the same plants to graze or browse during a growing season. If a plant is repeatedly defoliated, it can be weakened and may die.

To manage grazing and browsing and protect the range resources, managers should:

- Observe the status of and changes in grasses, forbs, and woody species as well as in livestock or wildlife. Make adjustments when either the range plants or animals show signs that the range is being overused.
- Rest grasses periodically, but not at the same time every year. Grasses differ as to when growing points are elevated, making it difficult to find one optimum rest period for all species.
- Leave enough residual forage ungrazed to keep plants healthy and to capture rainfall. The best way to prevent excess rainfall runoff is to maintain adequate ground cover. When the range has enough plant material to promote water infiltration into the soil, less rainfall is required to produce forage.
- Note when the more palatable key species start to show overuse. Grazing and browsing animals are selective: They graze or browse the most palatable forage species first and often. If the more palatable species are overused and disappear, the plant species that survive will be those that can best resist grazing. Animals often avoid eating plants that are abundant but not palatable; instead, they spend time and energy searching for plants that are more palatable but scarce. Therefore, overuse of more palatable species can reduce animal performance.
- Adjust livestock and wildlife browsing by reducing animal numbers and/or resting pastures when you notice more than moderate use or excessive hedging on desirable brush plants and before the development of browse lines.

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HOW MUCH FORAGE DO YOU HAVE?

C. Wayne Hanselka and Allan McGinty*

Forage production varies considerably, depending on rainfall, season of the year and past and present grazing management. Since forage production is unpredictable, forage supply must be monitored and compared to current and predicted forage requirements. For proper management of range resources, animal numbers must be balanced with current forage supply. Forage supply information also can be used to forecast a potential forage shortage or surplus and make needed stocking rate adjustments.

Ranchers often conduct forage surveys informally while riding through their pastures during daily livestock management tasks. Many of them have the experience and observational skill to notice general changes in forage quality and quantity, but having more quantitative information will improve stocking rate decisions and help avoid overuse or underuse of forage resources. Overuse can damage range resources and lead to a crisis situation with fewer livestock marketing alternatives. Underuse can reduce ranch revenue.

This forage survey procedure is easy to use and provides unbiased estimates of the forage supply, requires minimum sampling time, and provides specific information for improving stocking rate grazing management decisions. The only materials required are a range site map (aerial photograph), plot frame, grass shears, paper sacks, drying oven, camera, weigh scales, notepad (data sheet), pencil and calculator. AgriLife Extension publication *Photo Guide to Forage Supplies on Texas Rangelands, RWFM-PU-080* can be used in the field.

WHEN SHOULD FORAGE SUPPLIES BE SURVEYED?

Forage supplies should be monitored visually throughout the year. However, more detailed information might be required before important decisions are made. Since forage production is unpredictable, forage surveys should be conducted at the end of normal forage production cycles. This allows the rancher to estimate immediately how long the accumulated forage supply will last during expected non-growth periods.

Late June-early July and late October-early November surveys are recommended for rangelands that normally receive spring and fall rains. Surveys for summer rainfall areas, such as the Trans-Pecos region of Texas, are best conducted in late October-early November. A March evaluation is needed in all regions to document the forage lost over the winter because of grazing and weathering. Forage remaining in March might have to last until mid-summer if spring rainfall is less than normal.

SEVEN STEPS FOR CONDUCTING A FORAGE SURVEY

1. Determine grazable acres per range site and pasture.

Using a recent aerial photograph and soil survey information, draw the pasture and range site boundaries. Include non-grazable areas, such as lakes, roads, homestead, thick brush, inaccessible terrain and unproductive areas. It might be necessary to inspect each range site to estimate unproductive acreage, including brush mottes or thickets not observable on the aerial photograph. Determine total acres for each range site; then calculate grazable acreage by subtracting non-grazable acreage from the total.

2. Select the appropriate plot size that matches the type of vegetation to be sampled.

Construct the plot frame using a 3⁄8-inch reinforcement rod (welded) or 1⁄2- to 3⁄4-inch PVC pipe with inside dimensions as shown in Table 1.

TABLE 1. SUITABLE PLOT SIZE AND ASSOCIATED CONVERSION FACTORS.

PLOT AREA	LENGTH PER SIDE	CONVERSION FACTOR
4.00 ft^2	24.0 in	680 * wt in ounces = lbs/ac
9.00 ft^2	36.0 in	302 * wt in ounces = lbs/ac
4.50 ft^2	25.6 in	600 * wt in ounces = lbs/ac
9.07 ft^2	36.1 in	300 * wt in ounces = lbs/ac
1.00 ft^2	39.0 in	10 * wt in grams = kg/ha (lb/ac)

*Extension Range Specialist, The Texas A&M University System

TABLE 2. MOISTURE CONVERSIONS (PERCENT DRY MATTER)					
PLANT TYPE	INITIAL GROWTH TO HEADING	HEADED OUT TO FLOWERING	SEED RIPE: LEAF TIPS DRYING	STEMS PARTLY DRY	DORMANT
Mid grasses	40	55	65	90	95
Short grasses	45	60	80	90	95
Forbs	20	40	60	90	100

3. Locate representative areas in each range site.

Because they will be sampled to determine the forage supply, these areas should be representative of the average grazing use for the range site. Do not sample adjacent to bed grounds, water points, mineral/ feeding locations or areas that are seldom grazed.

4. Develop a representative photo guide.

A photographic reference of known forage quantities for the various range sites on the ranch is used to improve estimation consistency between samples. The photo guide represents the variation of forage supply conditions that will be observed in the pastures. Use approximately 10 photographs of known forage quantities arranged from the lowest to the highest quantity. (See *Photo Guide to Forage Supplies on Texas Rangelands, RWFM-PU-080*.)

In the representative range site areas, select plot locations that have different quantities and species mixtures. Place the plot frame over the vegetation to be photographed. The frame perimeter should be clearly visible in the photograph (e.g., the PVC pipe used in the sample photo guide). Because only vegetation rooted in the plot should be sampled, separate vegetation into or out of the plot frame. Each photograph should indicate height, density and cover of vegetation. High contrast black-and-white photographs are recommended.

Stand to photograph the plot. Fill the frame with the plot and include a notepad or small dry erase board with identifying information in the photograph. After photographing the plot, make any important notes and clip all the standing herbaceous vegetation rooted within the plot to the soil surface. Do not include dead plant material on the ground. Place the clipped vegetation in a properly labeled paper bag (pasture name, date, range site and plot number) for drying and weighing.

Calculate the dry weight in pounds per acre represented by the forage in the plot by weighing each sample to the nearest gram or tenth of an ounce. Heat the bag containing the clipped forage sample in a microwave set on high for 30 seconds.

Re-weigh the bag and sample and record the new weight. Continue to heat the bag for another 30 seconds and re-weigh it until the sample stops losing measurable weight. Subtract the weight of the bag and then use Table 1 to convert weight to pounds per acre. Do not microwave samples for more than 30 seconds at a time to avoid spontaneous combustion.

Samples also may be placed in a shaded, dry area for several days until dry. Although not as accurate, estimates also can be obtained by using a Moisture Conversion Table (Table 2). Finally, determine dry weight (less sack weight) in grams or ounces. Pounds per acre equal grams or ounces per plot multiplied by the appropriate conversion factor shown in Table 1. A photo guide of actual forage supplies in pounds per acre can be developed by taking a series of these photographs.

5. Sample each representative area.

The forage survey on each representative area involves four basic steps: tossing the plot frame, estimating the forage quantity in the plot, determining the samples needed and correcting estimates. In each representative area, walk in a selected direction and toss the plot frame every ten paces. Avoid biasing where the frame hits. Because samples should represent actual conditions, bare spots and different quantities of forage should be sampled. Use the photo guide to estimate the amount of forage in each plot and record information about the site. The more samples you take, the more accurate your estimate will be.

6. Determine the forage supply.

After completing the forage survey, calculate the average estimated pounds per acre of forage for each range site per pasture. This is determined by multiplying grazable acres by the average pounds per acre of forage. Sum all range sites per pasture to calculate the total pounds of forage per pasture.

7. Determine animal unit days of available grazing.

An animal unit is based on the metabolizable energy requirements (17.3 mega calories per day) for a 1,000-pound cow in the last third of pregnancy.

TABLE 3. INTAKE CONVERSIONS FOR VARIOUS CLASSES OF LIVESTOCK	
LIVESTOCK	CONVERSION FACTOR
Sheep	3.0% * body wt
Goats	4.0% * body wt
Stocker cattle	3.0% * body wt
Dry cow	2.0% * body wt
Lactating cow	2.5% * body wt

This requirement converts to a daily forage intake of almost 20 pounds (2 percent of body weight) of 53.6 percent digestible forage. This requirement increases to 2.5 percent of body weight for lactating cows and 3 percent for stocker cattle (Table 3).

Minimum forage thresholds are an important factor to consider when balancing existing forage supplies with livestock numbers (Table 4). They represent the amount of forage that should be present at all times to protect the soil surface from rainfall impact, to slow water movement across the soil, to moderate soil temperatures and to sustain the growth of forage plants.

TABLE 4. OPTIMAL AMOUNTS OF NONGRAZED FORAGE FOR DIFFERENT TYPES OF RANGELAND			
DESERT	SHORTGRASS	MIDGRASS	TALLGRASS
250 lb/ac	300–500 lb/ac	750–1,000 lb/ac	1,200–1,500 lb/ac

To calculate the animal unit days of available grazing, subtract the residue to be left in a pasture (Table 4) from the total pounds of dry forage in that pasture (using the photo guide). For example, 800 pounds of total forage – 500 lbs/ac residue = 300 lbs/ac. The calculation represents the pounds of forage available for use by grazing animals. Unfortunately, grazing animals are only about 50 percent efficient in utilizing the available forage, so multiply the pounds available by .5 to determine the amount of actual forage that will be consumed by livestock (e.g., 300 lbs/ac x .5 = 150 lbs/ac consumed).

Finally, multiply the pounds of forage to be consumed by the grazable acres in the pasture, and then divide by the pounds of forage per head per day for the species and type of livestock to be grazed (Table 3). For example,150 lbs/ac x 100 acres = 15,000 lbs of forage; 15,000 lbs of forage divided by 20 lbs/day = 750 animal unit days of grazing if using 1000 lb dry cows.

Remember two key points: (1) revise your estimates every time it rains and new forage growth occurs, and (2) this technique is more accurate when predicting forage supplies a few weeks ahead as compared to months.

The number of animal unit days of available grazing per pasture can then be used to determine if the forage supply is adequate for the planned stocking rate until reqrowth is expected. Also, the average number of animal units that will be grazed during this time can be determined. Total days that the forage supply will last at the current stocking rate are determined by dividing the planned number of stock units into the animal unit days of available grazing.

CONCLUSION

Using this forage survey procedure, while training the "eye" and using photo guides to estimate forage supplies, should help improve grazing management decisions and reduce the damage that over-grazing can cause. Timelier destocking during drought will help keep plants healthy for future growth. Soil with good vegetative cover traps rainfall effectively and is less apt to erode. Rather than waiting until the forage supply is gone, a forage supply survey will help forecast whether a change in stocking rate is appropriate. This allows better planning to meet crisis situations.

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AgriLIFE EXTENSION
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Estimating Grazeable Acreage for Cattle

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Stocking decisions can be difficult to make. Forage supplies vary from season to season and from year to year, and with more brush on our rangelands than ever before, old stocking rates may be of little value. Many land managers are also realizing that their cattle use only a portion of the land available. The goal of recent research was to determine why cattle use some areas but not others and how ranchers can use such information to estimate the number of grazeable acres they have.

How Grazeability was Studied

Research using cattle fitted with Global Positioning System (GPS) collars shed light on how cattle behave in response to different features of the landscape. The research was conducted on ranches in different regions of Texas to demonstrate the influence of landscape features such as brush density, rock cover, surface slope, water and forage species on livestock grazing. Test sites were in the Davis Mountains, Edwards Plateau and South Texas Plains.

Digital aerial photographs of the test ranches and overlays showing the various ecological sites within each photograph were obtained. An ecological site is an area of land with specific physical characteristics that differs from other kinds of land in the types and amounts of vegetation it produces. Descriptions of these ecological sites define certain landscape features. For example, an ecological site designated as gravelly redland has 36 percent or less surface rock cover. The ecological site maps and aerial photographs enabled researchers to predict which areas cattle would not use because of their apparent brush and rock cover, slope, or inaccessibility. (Landowners can contact a local USDA Natural Resources Conservation Service office for help acquiring digital aerial photographs and ecological site overlays for their property.)

Next, areas that appeared ungrazeable from the maps were observed on the ground. Observers measured brush density and rock cover and determined the herbaceous plant species growing in each area. Again, researchers predicted grazeability from their ground observations.

To test the map and ground observation prediction methods, researchers fitted cattle with GPS collars and recorded their positions for 23 days. Collars were programmed to take a position fix every 5 minutes and are accurate to within 10 to 16 feet of the true location. As Table 1 shows, both map estimates and ground estimates were fairly accurate, as validated by the actual GPS locations of cattle on the ranches. However, ground observation is clearly the more accurate method for predicting the grazeability of an area.

Table 1. A comparison of the accuracy of predicting grazeable areas from map and ground estimates, as validated by GPS studies.

Research area	Map estimates, % correct	Ground estimates, % correct
Edwards Plateau	80	93
South Texas Plains 1*	67	-
South Texas Plains 2	92	92
South Texas Plains 3	88	100
Average	82	95

*No ground observation was done at this site.

What the Research Shows

Brush Density

While aerial photographs can give a general estimate of the brush cover on your property, they do have limitations. If photographs are taken at the time of year when brush plants such as mesquite have dropped their leaves, the extent of brush cover may not be apparent. Photographs are helpful in pinpointing areas that might be too brushy for cattle so that these areas can be checked on the ground. There is often more brush in the pasture than can be seen on an aerial photograph.

Actual brush density should be checked and scored in several areas on the property. Walk a straight line through each area and assign a brush density score every 20 steps. Use Figure 1 as a guide in determining brush density scores.

The GPS collar research showed that, overall, **only 25 percent of areas with a brush density score of 3 were visited by cattle, and that cattle completely avoided areas with scores of 4 or 5 (Fig. 2).** This relationship was true in both the Edwards Plateau and South Texas Plains, regions with very different brush species.

Figure 1. Brush density scores.

BDS = 0
(no brush present, foreground clear to tree line)

BDS = 1
(very light brush, only a few scatted plants)

BDS = 2
(light brush, brush common, but mobility or access not limited)

BDS = 3
(brush thick enough to limit mobility, but cattle can maneuver through it)

BDS = 4
(brush thick, mobility possible only in pathways)

BDS = 5
(very thick brush, mobility through it nearly impossible)

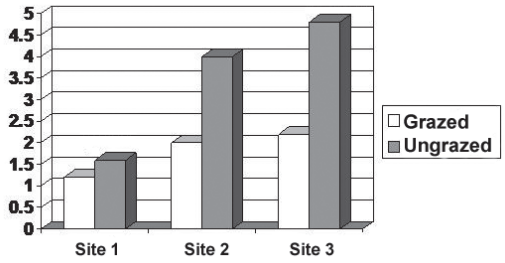

Figure 2. Average brush density scores of grazed and ungrazed areas at three research sites in the South Texas Plains.

Rock Cover

With ecological site descriptions you can identify areas where rock cover might be a problem and spot-check these on the ground at the same time you determine brush density scores. Walk a 300-foot line through the area. At 20-foot intervals, place a PVC frame on the ground as a guide. Examples of various rock cover percentages are shown in Figure 3. The frames used in this study had an outside measurement of about 29 inches and were divided into quarters to make it easier to visualize percent rock cover. To build a frame you will need tubing, four 90-degree elbows, four tees and one cross fitting.

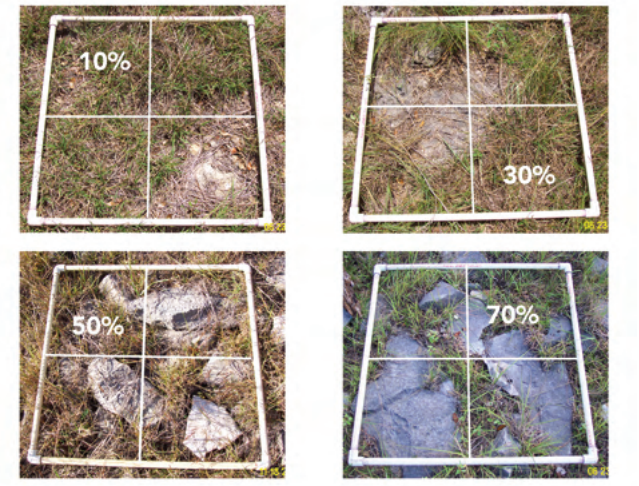

Figure 3. Rock cover percentages.

The GPS collar study showed that **cattle tend to avoid areas with 30 percent or more rock cover.** When determining a rock cover percentage, remember that if an area is uncomfortable for a person to walk on, it will also be uncomfortable for cattle.

Slope

Percent slope is calculated as the change in elevation over a 100-foot distance. Cattle prefer flat areas or broad, gentle slopes and are usually deterred by steep slopes. In the GPS collar study at the Davis Mountains site, **95 percent of cow locations were on slopes of 11 percent or less**. Table 2 shows how slope affects whether or not cattle will use an area. Ecological site descriptions can help you identify areas where slope could limit cattle use.

Table 2. Expected effect of slope on cattle use.

Percent slope	Percent reduction in use
0-10	0
10-30	30
31-60	60
> 60	100

Water

The distance cattle have to travel to find water affects their use of a pasture. In general, **cattle graze within about 1 mile of water**, as was shown in the Davis Mountains study where about 73 percent of cow locations were within a 1-mile radius of either of the two water sources available.

Forage

Another consideration when determining grazeable acreage is what cattle will and will not eat. So you will need to be able to identify some of the major plant species, especially grasses. Grasses such as threeawn (*Aristida* spp.), red grama (*Bouteloua trifida*) and Texas grama (*Bouteloua rigidiseta*) are very unpalatable to cattle. Cattle will avoid areas dominated by these species if more palatable grasses are available elsewhere. Likewise, cattle will not use areas with heavy concentrations of certain perennial weeds such as goldenweed (*Isocoma drummondii*) and wolfweed (*Leucosyris spinosa*).

The frequency of herbaceous species was estimated at the South Texas Plains locations. No dominant grasses emerged as attractants or deterrents in grazed or ungrazed areas. However, at two of these locations the average number of herbaceous species was greater in the grazed areas (Fig. 4).

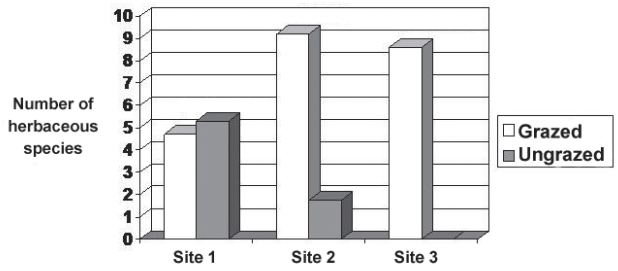

Figure 4. The number of herbaceous species was generally greater in grazed areas than in ungrazed areas at the South Texas locations.

Although there was little difference in the number of herbaceous species within the grazed and ungrazed areas at site 1, the grazed areas did have less Kleberg bluestem, a relatively unpalatable grass. It may be that cattle avoid this grass when possible.

Accessibility

Some areas of pastures may have low brush density scores, little rock cover, adequate water, gentle slopes and palatable forage species, but still not be grazed because they are inaccessible. These areas may be surrounded by dense brush, heavy rock cover and/or steep slopes. Aerial photographs with ecological site layers and descriptions can be very helpful in identifying such areas. If possible, creating roads or trails into these areas will make them more accessible to cattle.

How to Use this Information

Begin by visiting your local NRCS office and requesting up-to-date aerial photographs of your property. There is no charge for these photographs. NRCS personnel can also provide ecological site overlays for the aerial maps and help you figure out how many acres of each kind of ecological site there are. Use these maps and overlays to identify areas that might have dense brush, extensive rock cover or steep slopes. Then, check these areas on the ground; calculate brush density scores and rock cover percentages and make note of the abundance of various forage species. Also verify the accessibility or inaccessibility of suspect areas on the maps.

Here are typical ecological sites, with their surface rock and slope characteristics, for the Edwards Plateau and South Texas Plains regions.

Table 3. Typical ecological sites in the Edwards Plateau and their rock and slope characteristics.

Ecological site	Surface rock, %	Slope, %
Deep redland	7	0-5
Redland	7	0-5
Gravelly redland	≤36	1-12
Low stony hill	≤50	0-15
Steep rocky	35-65	15-45 (some 20-60)

Table 4. Typical ecological sites in the South Texas Plains and their surface rock and slope characteristics.

Ecological site	Surface rock, %	Slope, %
Clay loam	0	<3
Claypan prairie	0	0
Gray sandy loam	0	<2
Lakebed	0	<1
Sandy loam	0	0-5
Tight sandy loam	0	0-3

Use these guidelines to estimate the number of grazeable acres you have.

Total acreage available		_____
Subtract acres with brush density scores of 3 or higher.	–	_____
Subtract acres with 30 percent or more rock cover (unless already subtracted for brush density).	–	_____
Subtract acres dominated by undesirable plants (unless already subtracted for brush density and/or rock cover).	–	_____
Subtract acres with slopes of 10 percent or more (unless already subtracted for brush density, rock cover and/or undesirable plants).	–	_____
Subtract acres 2 miles or more from water (unless already subtracted).	–	_____
Total Grazeable Acreage	=	_____

The Importance of Estimating Grazeable Acreage

It is often possible to increase the amount of grazeable acreage by controlling brush, improving access to certain areas or adding water sources. Seeding rangeland with desirable grass species is another option. So taking time to estimate your grazeable acreage might prove beneficial by revealing management measures that would improve the productivity of your land.

But the major benefit is in determining the proper stocking rate. As this research shows, the number of grazeable acres on a ranch may be much lower than the total acreage, which can have a dramatic effect on stocking rate. At one Edwards Plateau ranch (Fig. 5), the GPS collar study revealed that cattle were using only 39 percent of the total area. The ranch had been stocked at 20 acres per cow based on total acreage, but the effective stocking rate was 9 acres per cow.

By using these guidelines, you will be able to estimate the number of grazeable acres on your property. Then you should make stocking decisions on the basis of the amount of forage available on that acreage.

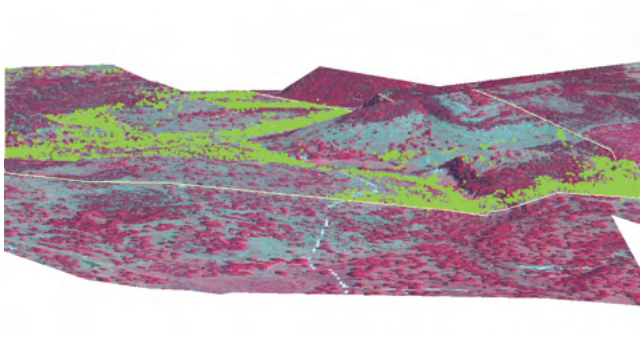

Figure 5. In this three-dimensional photograph, the green dots are cattle locations. Areas with no dots are mostly within the Steep Rocky ecological site or surrounded by this site, which had the most rock cover and slope and the greatest brush density.

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R1810

Determining Carrying Capacity and Stocking Rates

for Range and Pasture in North Dakota

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Establishing the correct stocking rate is critical in optimizing forage performance and maintaining animal performance while ensuring the sustained health and production of the grassland resources.

Many factors affect stocking rate, such as:

- Owner's/operator's management goals
- Animal species (cattle, sheep, horses, etc.)
- Class of livestock (dry cow, lactating cow, bull, steer, etc.)
- Acres available for the grazing season
- Rainfall (dependability, amount and timing)
- Topography
- Soils/ecological sites
- Health of grassland resources (infiltration rates, species composition, annual production)
- Livestock water (quantity, quality and distribution)
- Forage species composition
- Forage quality and palatability
- Forage productivity
- Management practices (prescribed grazing systems, animal densities, cross-fencing, etc.)

USDA NRCS
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Effective managers will balance forage production and animal performance for the long term by incorporating flexibility and contingency plans into their grazing operations to account for changing weather conditions, natural events such as wildfire, and variable livestock markets. Stocking rates may be set appropriately by being mindful of these variables. Stocking rates can be planned by determining the following:

- **Forage demand:** How much forage is required by the type and class of animals grazing the range or pasture unit
- **Available forage:** How much forage is produced during the year and how much is available for livestock consumption
- **Duration:** How long the animals will be using the area

The information provided in this publication is designed to help the grassland manager/owner estimate the initial stocking rate for his/her grazing pasture(s). The accuracy of this estimate will depend greatly on the quality and accuracy of information prior to calculating the stocking rate. For example, are your forage production figures based on estimates or actual field-collected data?

Monitoring forage utilization levels during and at the end of the grazing season is important for valuable feedback on the accuracy of the stocking rate estimation. That will allow the owners/operators to make adjustments on the stocking rates if they need to do so to meet their management goals.

Stocking Rate: the number of specific kinds and classes of animals grazing or using a unit of land for a specific time period. **Stocking rate is a management decision** and one of the most important grazing management decisions a rancher or land manager makes. Regardless of which grazing management system is employed, vegetation type grazed or kind and class of livestock involved, stocking rate has the largest impact on the health of the grassland resource and on animal performance of all management tools available.

> Stocking rate is "forage demand" while carrying capacity is "forage produced."

Carrying Capacity: **a "measurement" (actual or estimated) of how much forage a unit or piece of ground is able to produce** on an average year. The carrying capacity is the maximum stocking rate possible that is consistent with maintaining or improving forage and other vegetation and related resources. It can vary from year to year on the same area due to changes in forage production. Carrying capacity is expressed as the number of animal units that can be grazed for a specific time period. In short, carrying capacity is the amount of forage available for grazing animals. It is expressed as the number of available animal unit months (AUMs), or number of animal units grazed for one month.

Animal unit month

An animal unit month (AUM) is based on the age, class and size of livestock, and the amount of forage they will consume in one month. An AUM also is a common way of expressing stocking rates, such as "my pasture can support 125 AUM in an average year of growth."

> **The standard animal unit is a 1,000-pound cow with a 6-month-old or younger calf by her side.** The kind, class and size of livestock will need to be adjusted based on this standard. Use **Table 1** to find the correct animal unit equivalent (AUE) for your livestock.

Table 1. Animal unit equivalents (AUE) guide[1].

Kinds/Classes of Animals	Animal Unit Equivalent (AUE)	Forage Consumed in Pounds (air-dried[2])	
		Day	Month
1,000-lb. cow, dry	0.92	28	851
1,000-lb. cow, with calf	1.00	30	913
1,100-lb. cow, with calf	1.07	32.5	988
1,200-lb. cow, with calf	1.15	35	1,064
1,300-lb. cow, with calf	1.22	37	1,125
1,400-lb. cow, with calf	1.29	39	1,186
1,500-lb. cow, with calf	1.35	41	1,247
Cattle bull, mature	1.40	42.5	1,295
Weaned calves to yearling	0.60	18	547
Yearling cattle (600-800 lb.)	0.70	21	638
Two-year-old cattle (800-1,000 lb.)	0.90	27	832
Bison cow, mature	1.00	30	913
Bison bull, mature	1.50	45	1,368
Horse, mature	1.25	38	1,155
Sheep, dry	0.15	4.5	135
Sheep, mature with lamb	0.20	6	182
Sheep ram	0.25	7.5	228
Goat, mature	0.15	5	152
Deer, white-tailed, mature	0.15	5	152
Deer, mule, mature	0.20	6	182
Elk, mature	0.60	18	547
Antelope, mature	0.20	6	182
Sheep, bighorn, mature	0.20	6	182
Jackrabbit, white-tailed	0.02	0.6	18
Prairie dog	0.004	0.1	3

[1] Adapted from Natural Resources Conservation Service National Range and Pasture Handbook (1997) and Montana State University Range and Pasture Records (1993).

[2] Air-dry weight refers to forage that is allowed to dry under natural environmental conditions during an extended period of time, such as plants harvested for hay production. This value is approximately 87 percent dry matter versus oven-dry weight, which depicts 100 percent dry matter.

Harvest efficiency

This is the amount of the plant that livestock will impact during the time they are grazing the pasture. This includes the amount of the plant eaten by the animal, as well as the spoilage from waste and trampling. Several factors influence harvest efficiency, including: forage type, forage maturity, forage distribution, topography, livestock distribution and stocking density.

Harvest efficiency includes the "take half, leave half" concept of forage disappearance within the pasture. This concept allows for plants to continue to maintain production while adjusting for lost consumable forage that is senesced, trampled or consumed by wildlife and invertebrates.

Harvest efficiency is expressed as a percent and should be multiplied by the total amount of forage on your pasture to give you the actual amount of forage for use by grazing animals while continuing to maintain proper use of the resource.

We recommend using a harvest efficiency of 25 percent on native plant pastures grazed seasonlong and when determining your initial carrying capacity. On tame grass/legume pastures with introduced species, we recommend using a harvest efficiency of 30 percent. The harvest efficiency is higher on tame grass pastures because they are relatively uniform in plant species composition, forage production and topography, and have reduced grazing selectivity by animals and reduced patch grazing.

When utilizing a properly managed grazing system, harvest efficiency may be increased through time. Use harvest efficiency values (percentage) when calculating carrying capacity using the estimated relative production values method.

A multiplier may be used as a general guideline for goal setting when increasing carrying capacity with a properly functioning grazing management plan when using the AUM/acre method. For every 1 percent increase in harvest efficiency, you receive a 4 percent increase (multiplier) in carrying capacity. See **Table 2** to determine your harvest efficiency value (percentage) or multiplier value when adjusting for properly managed rotational grazing systems.

> If you have not calculated your carrying capacity previously, start with the 25 percent harvest efficiency. Adjustments can be made during the grazing season by monitoring utilization.

Table 2. Multiplier for harvest efficiency values on rangeland and tame grass pastures ranging from 25 to 40 percent. Use these numbers when calculating carrying capacity using the AUM/acre method.

Harvest Efficiency[1]	Multiplier[2]	Harvest Efficiency[1]	Multiplier[2]
(%)		(%)	
25[3]	1.00	33	1.32
26	1.04	34	1.36
27	1.08	35	1.40
28	1.12	36	1.44
29	1.16	37	1.48
30[4]	1.20	38	1.52
31	1.24	39	1.56
32	1.28	40	1.60

[1] Use the harvest efficiency percentage when adjusting carrying capacity using the estimated relative production values method.

[2] Use the multiplier when adjusting carrying capacity using the AUM/acre method.

[3] Use a harvest efficiency of 25 percent on rangeland pastures as a starting point or if grazed seasonlong.

[4] Use a harvest efficiency of 30 percent on tame grass/legume pastures with introduced species as a starting point or if grazed seasonlong.

Harvest efficiency is the portion of the current year's forage production that is consumed by the grazing animals. It includes a 50 percent leave rate for plant health and forage production.

Rangeland pastures

Land on which the native vegetation (climax or natural potential) is predominantly grasses, grasslike plants, forbs or shrubs; includes lands revegetated naturally or artificially when routine management of that vegetation is accomplished mainly through manipulation of grazing. Rangelands include natural grasslands, savannas, shrub lands, most deserts, tundra, alpine communities, coastal marshes and wet meadows.

Tame grass pastures

Grazing lands, planted primarily to introduced or domesticated native forage species, that receive periodic renovation and/or cultural treatments, such as tillage, fertilization, mowing, weed control and irrigation; not in rotation with crops.

Calculating Stocking Rate

The Range Calculator may be used in conjunction with this section. It may be accessed at:

www.ag.ndsu.edu/sheets/range-and-pasture-calculator

Animal units (AU) are used to calculate the relative grazing impact of different kinds and classes of domestic livestock and common grazing wildlife species for one month (AUM = animal unit months).

To determine the number of AUM needed to support your livestock:

1) multiply the number of animals to be grazed on the pasture by the AUE found in Table 1 to determine total AU, then
2) multiple the total AU by number of months planned to graze (see formula below or Worksheet A of the Range Calculator).

Formula: _____ (# Animals) x _____ (AUE (Table 1)) = _____ (Animal Units (AU)) x _____ (Months (M)) = _____ (AUM)

Example 1

100 1,200-lb. cows with calves with a planned grazing schedule from May 15 – Nov. 1 (5.5 months)
4 mature bulls grazed from July 1 – Sept. 15 (2.5 months)

100 x 1.15 = 115 AU x 5.5 M	=	632.5 AUM
4 x 1.50 = 6 AU x 2.5 M	=	15.0 AUM
Total	=	647.5 AUM

Example 2

250 ewes with lambs with a planned grazing schedule from June 1 – Nov. 1 (5 months)
5 rams from Sept. 1 – Nov. 1 (2 months)

250 x 0.20 = 50 AU x 5 M	=	250.0 AUM
5 x 0.25 = 1.25 AU x 2 M	=	2.5 AUM
Total	=	252.5 AUM

Calculating Carrying Capacity

Carrying capacity, or estimated forage quantity in the pasture, can be calculated using different techniques. Two common methods to calculate carrying capacity are: 1) field-based methods or 2) stocking rate estimates based on regional production data provided by the U.S Department of Agriculture's Natural Resources Conservation Service (NRCS; Sedivec and Printz 2012, USDA Natural Resource Conservation Service, 2014).

1) Field-based methods are a more accurate measurement of carrying capacity. Refer to the publication "Ranchers Guide to Grassland Management IV" by Sedivec and Printz (2014) for more detail on field-based methods.
2) When forage production samples are not available to calculate carrying capacity, **estimated** values can be used to determine initial rates based on: I) AUM/acre and II) relative production values (RV; lb/ac).

Before estimating carrying capacity of the pasture, the landowner must determine in which Major Land Resource Area (MLRA, **Figure 1**) the pasture is located. Then the landowner needs to categorize all acres within the pasture by upland and lowland vegetation types (also includes ecological site and soil type). The vegetation type can be determining using 1) Web Soil Survey (USDA Natural Resources Conservation Service 2013), 2) utilizing Geographic Information System (GIS)-generated maps or 3) visual estimates.

Web Soil Survey can be assessed at *http://websoilsurvey.sc.egov.usda.gov/* or by downloading the SoilWeb application on your mobile device. For assistance, contact your local county Extension agent or NRCS office.

Figure 1. Major Land Resource Areas of North Dakota.

Carrying Capacity Using Estimated AUM/acre Method

(for rangeland pastures only)

To determine carrying capacity using estimated AUM/acre, multiply the acres of vegetation type by the recommended estimated stocking rate from **Table 3** to determine AUM available (see formula below or Worksheet B of the Range Calculator). Repeat for each vegetation type found in the pasture. Total the results of each vegetation type to determine total AUM available for the pasture.

Finally, the landowner can determine the carrying capacity for the planned class or type of livestock. Once the carrying capacity is determined using the estimated stocking rate guide from **Table 3**, divide total AUMs by total acres and then divide by AUE to calculate your animal unit equivalent months per acre (AUEM/ac). The AUEM per acre is an estimate of how many acres are required to support the kind and class of livestock **you** are grazing for a period of one month.

Table 3. Estimated stocking rate guide in animal unit months per acre (AUM/ac) by site and multiple land resource areas (MLRA) for the reference plant community associated with each vegetation type/ecological site (modified from Sedivec and Printz (2012) – Ecological Sites of North Dakota).

(Use for rangeland pastures only.)

Vegetation Type/ Ecological Site	53A&B	54	55A&B	56	58C&D
Upland					
Loamy	0.66	0.66	0.71	0.85	0.57
Sandy	0.68	0.66	0.77	0.85	0.55
Clayey	0.63	0.57	0.66	0.82	0.52
Shallow	0.60	0.38	0.52	0.60	0.36
Very shallow/ Thin claypan	0.30	0.24	0.37	0.43	0.22
Lowland					
Overflow	0.96	0.87	1.01	1.15	0.57
Wet meadow	1.23	1.16	1.28	1.37	0.92

If harvest efficiency has been improved through the implementation of a properly managed grazing system, multiply total AUM by the guideline multiplier value found in **Table 2** (multiplier column).

Formula: Acres of Vegetation Type x AUM/acre[1] = AUM[2]
Expressed Carrying Capacity:
AUM ÷ total acres ÷ AUE[3] = AUEM/ac

[1] AUM/acre (Table 3) for vegetation type based on a 0.25 harvest efficiency.
[2] AUM must be calculated for each vegetation type.
[3] AUE for your livestock class or type found in Table 1.

Example 1

1,000-acre rangeland pasture grazed seasonlong containing 790 acres of loamy upland, 150 acres of shallow, 50 acres of overflow and 10 acres of wet meadow near Steele, N.D. (MLRA 53B[1]). Range unit is grazed by 1,300-lb. cow with calf.

Site Type	Acres	x	AUM/ac[2]	=	AUM
Loamy	790	x	0.66	=	521.4
Shallow	150	x	0.60	=	90.0
Overflow	50	x	0.96	=	48.0
Wet meadow	10	x	1.23	=	12.3
Total	1,000			=	**671.7 AUM for total pasture**

[1] Figure 1.
[2] The animal unit months/acre found in Table 3 is based on a 0.25 harvest efficiency under seasonlong grazing.

Expressed carrying capacity is

671.7 AUM ÷ 1,000 acres = 0.67 AUM/ac ÷ 1.22 AUE = 0.55 AUEM/ac;
or
1 ÷ 0.55 AUEM/ac = 1.82 acres per month for each 1,300-lb. cow with calf.

Example 2

Same as Example 1 but managed using an approved grazing system with mature sheep with lambs.

With an approved grazing system and using a 35 percent harvest efficiency, multiplier value is 1.4 (Table 2).
So, 671.7 AUM x 1.4 = **940.4 AUM**.

[1] from Example 1

Expressed carrying capacity is

940.4 AUM ÷ 1,000 acres = 0.94 AUM/ac ÷ 0.20 AUE = 4.7 AUEM/ac;
or
1 ÷ 4.7 AUEM/ac = 0.21 acre per month for each sheep with lamb.

To convert AUM/ac to ac/AUM, divide 1 by AUM/acre. For example, 0.66 AUM/ac would be 1 ÷ 0.67 = 1.49 ac/AUM.

Carrying Capacity Using Estimated Relative Production Values Method

(for rangeland and tame grass pastures)

To determine carrying capacity using estimated relative production values methods, 1) multiply acres of vegetation type by the recommended relative production values from **Table 4** to determine total production, 2) then multiple total production by appropriate harvest efficiency **(Table 2)** to achieve available forage for grazing, 3) then divide by 913 lb. (amount of air-dried forage consumed by one AU per month) to determine total AUM available *(see formula below or Worksheet C of the Range Calculator).*

Acres of Total Harvest Available Forage

Formula: Vegetation Type x RPV[1] = Production (lb.) x Efficiency[2] = for Consumption/913 lb.[3] = AUM[4]

Expressed Carrying Capacity:

AUM ÷ total acres ÷ AUE[5] = AUEM/ac

[1] Relative production value (Table 4).
[2] See Harvest Efficiency section for recommended value (Table 2).
[3] Average consumption of an AU for one month is 913 pounds of air-dried forage.
[4] AUM must be calculated for each vegetation type.
[5] AUE for your livestock class or type found in Table 1.

Table 4. Estimated stocking rate guide using relative production values (RPV; lb/ac) and multiple land resource areas (MLRA) for reference plant communities associated with each vegetation type/ecological site (modified from USDA (2014) relative forage production values by ecological sites).

(Use for both rangeland and tame grass pastures.)

Vegetation Type/ Ecological Site	53A&B	54	55A&B	56	58C&D
Upland					
Loamy	2,400	2,400	2,800	2,850	2,100
Sandy	2,500	2,400	2,800	2,850	2,000
Clayey	2,300	2,100	2,600	2,700	1,900
Shallow	2,200	1,330	2,100	2,150	1,300
Very shallow/ Thin claypan	1,100	800	1,350	1,050	800
Lowland					
Overflow	3,500	3,200	3,800	3,800	2,650
Wet meadow/Sub	4,500	4,250	4,600	4,500	4,000

Repeat for each vegetation type found in the pasture. Total the results of each vegetation type to determine total AUM available for the pasture. If a properly managed grazing system has been installed and is working effectively, increasing the harvest efficiency percentage found in Table 2 may be desired.

To determine the carrying capacity in AUM per acre, divide the total AUM by the acres in the grazing unit. To convert AUM/ac to ac/AUM, divide 1 by AUM/acre.

To determine acres needed to support your class or type of livestock, take the total AUM/ac and divide by AUE to get AUEM/ac. Then divide 1 by the AUEM to determine acres needed to support your class or type of livestock for one month.

Example 1

1,000-acre rangeland pasture grazed seasonlong containing 790 acres of loamy upland, 150 acres of shallow, 50 acres of overflow and 10 acres of wet meadow near Steele, N.D. (MLRA 53B[1]). Range unit is grazed by 1,300-lb. cow with calf.

Site Type	x	Acres	x	RPV[2]	=	Total Pounds Produced	x	Harvest Efficiency[3]	=	Forage Available for Consumption (lb.)/913 lb.[4]	=	AUM
Loamy	x	790	x	2,400 lb.	=	1,896,000	x	0.25	=	474,000/913	=	519.2
Shallow	x	150	x	2,200 lb.	=	330,000	x	0.25	=	82,500/913	=	90.4
Overflow	x	50	x	3,500 lb.	=	175,000	x	0.25	=	43,750/913	=	47.9
Wet meadow	x	10	x	4,500 lb.	=	45,000	x	0.25	=	11,250/913	=	12.3
Total		1,000									=	669.8 AUM

Carrying Capacity is 0.67 AUM/ac (669.8 AUM ÷ 1,000 acres) **or 1.49 ac/AUM** (1,000 acres ÷ 669.8 AUM)

[1] Figure 1
[2] Relative production value (Table 4)
[3] See Harvest Efficiency section for recommended value (Table 2)
[4] Average consumption of an AU for one month is 913 pounds.

Expressed carrying capacity is 669.8 AUM ÷ 1,000 acres = 0.67 AUM/ac ÷ 1.22 AUE = 0.55 AUEM/ac;
or
1 ÷ 0.55 AUEM/ac = 1.82 acres per month for each 1,300-lb. cow with calf.

Example 2

1,000-acre rangeland pasture grazed using an approved grazing system containing 790 acres of loamy upland, 150 acres of shallow, 50 acres of overflow and 10 acres of wet meadow near Steele, N.D. (MLRA 53B[1]). Range unit is grazed by mature sheep with lambs.

Site Type	x	Acres	x	RPV[2]	=	Total Pounds Produced	x	Harvest Efficiency[3]	=	Forage Available for Consumption (lb.)/913 lb.[4]	=	AUM
Loamy	x	790	x	2,400 lb.	=	1,896,000	x	0.35	=	663,600/913	=	726.8
Shallow	x	150	x	2,200 lb.	=	330,000	x	0.35	=	115,500/913	=	126.5
Overflow	x	50	x	3,500 lb.	=	175,000	x	0.35	=	61,250/913	=	67.1
Wet meadow	x	10	x	4,500 lb.	=	45,000	x	0.35	=	15,750/913	=	17.3
Total		1,000									=	937.7 AUM

Carrying Capacity is 0.94 AUM/ac (937.7 AUM ÷ 1,000 acres) **or 1.07 ac/AUM** (1,000 acres ÷ 937.7 AUM)

[1] Figure 1
[2] Relative production value (Table 4)
[3] See Harvest Efficiency section for recommended value (Table 2)
[4] Average consumption of an AU for one month is 913 pounds.

Expressed carrying capacity is 937.7 AUM ÷ 1,000 acres = 0.94 AUM/ac ÷ 0.20 AUE = 4.7 AUEM/ac;
or
1 ÷ 4.7 AUEM/ac = 0.21 acres per month for each sheep with lamb.

Management Recommendations

- The **stocking rate** should not be greater than the carry capacity to assure proper resource management. Frequently, the stocking rate may be lower than the carrying capacity due to different ecological and management objectives.

- The **carrying capacity** is influenced by the current condition of the ecological site.

  See R1556, "Ecological Sites of North Dakota"
  (Sedivec and Printz 2012)
  www.ag.ndsu.edu/pubs/ansci/range/r1556.pdf

- We highly recommend that **monitoring tools** be implemented to prevent overgrazing and to determine whether you are meeting your management goals.

  See R1780, "The North Dakota Grazing Monitoring Stick: A Way to Measure Range and Pasture Utilization"
  (Meehan et al., 2015)
  www.ag.ndsu.edu/pubs/ansci/range/r1780.pdf

- The **estimated stocking rate** could be based on local knowledge and past stocking rates if the similarity index, health and trend have met the producer's objectives **without degrading the resource**.

- In times of drought, **early adjustments** of the stocking rate will need to occur due to loss of forage production.

  See R1819, "Strategies for Managing Drought in the Northern Plains"
  (Sedivec et al., 2016)

Stocking Rate Calculations

Pasture _____ Date _____

Acres _____ MLRA _____
See Figure 1

Grazing System _____

Class of Animal	# of Head	AUE	Animal Units (AU)	Month (M)	AUMs
Total					

Formulas: AU = # of head X AUE (Table 1)
AUM = AU X Months

Notes: _____

Carrying Capacity Calculations

Using estimated AUMs/ac Stocking Rates

Pasture _____ Date _____

Acres _____ MLRA _____
See Figure 1

Grazing System _____

Site Type	Vegetation Type	Acres	AUM/ac	AUM
Upland	Loamy			
Upland	Sandy			
Upland	Clayey			
Upland	Shallow			
Upland	Very shallow/thin claypan			
Lowland	Overflow			
Lowland	Wet meadow			
	Total			

% harvest efficiency	Available AUMS
	Total AUM/ac
	Total ac/AUM

Formulas: Acres of Vegetation Type X AUM/ac (Table 3) = Total AUMs/ac (given a 25% harvest efficency)
Total AUMs/ac X Harvest Efficiency Mutiplier (Table 2) = Total AUMs/ac
Total AUMs/ac ÷ AUE (or average AUE) = AUEM/ac (estimated number of head per acre based on **your** stocking rate)
1 ÷ AUEMs/ac = ac/AUEM (estimated number acres needed based on **your** stocking rate)

Notes: _____

_____

_____

Carrying Capacity Calculations

Using Production

Pasture _____ Date _____

Acres _____ MLRA _____
See Figure 1

Grazing System _____

Site Type	Vegetation Type	Acres	RV or Actual (lb/ac)	Production (lbs)
Upland	Loamy			
Upland	Sandy			
Upland	Clayey			
Upland	Shallow			
Upland	Very shallow/thin claypan			
Lowland	Overflow			
Lowland	Wet meadow			
	Total Production			
% harvest efficiency				
Total AUMs **AUM/ac** **ac/AUM**				

Formulas: Acres of Vegetation Type X RV (Table 4) or actual production = Total Production (lbs)
Total Production X Percent Harvest Efficiency (Table 2) = Total Available Forage (lbs)
Total Available Forage ÷ 913 lbs = AUMs
AUMs ÷ Acres in Pasture = AUMs/ac or Acres in Pasture ÷ AUMs = ac/AUM
AUMs/ac ÷ AUE (or average AUE) = AUEM/ac (estimated number of head per acre based on **your** stocking rate)
1 ÷ AUEMs/ac = ac/AUEM (estimated number acres needed based on **your** stocking rate)

Notes: _____

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RangeDetect Series

Stocking Rate: The Key Grazing Management Decision

Robert K. Lyons and Richard V. Machen*

Without question, stocking rate is the most important grazing management decision a rancher makes. Stocking rate is the amount of land allotted to each animal for the entire grazeable portion of the year. Stock density is the number of acres allotted to each animal at a specific point in time. Carrying capacity, on the other hand, is the maximum long-term stocking rate that can be sustained without detrimental effects on the land resource. A number of factors must be considered when establishing a stocking rate. These factors include animal species, size and physiological stage, size of the pasture or ranch, and number of grazeable acres. Ranches differ in annual rainfall, forage production, forage species, brush cover, topography, water distribution, and kind of livestock. All of these factors affect stocking rates.

When cattle have a choice, annual diets consist of 80 percent or more grass and usually no more than 10 percent browse (leaves and twigs from brush). Cattle make limited use of slopes greater than 10 percent or areas more than 2 miles from water. Therefore, when establishing a stocking rate for cattle, very brushy areas, steep areas, and areas too far from water must be excluded to determine the number of grazeable acres.

There are two perspectives to stocking rate. One is the land resource. The second is animal performance. Because of animal forage preferences, it is possible to be properly stocked from a resource conservation perspective and over-stocked in terms of animal performance.

Forage Production Considerations

Rainfall and Forage Production

For most of Texas, rainfall is the most important determinant of forage production. If rainfall is equal across various sites, then the soils and forage species combinations of a site are the most important factors in a site's forage production potential.

Resource managers tend to look at average rainfall as a benchmark. However, relying on average rainfall amounts is risky because rainfall across most of Texas is highly variable from year to year (as the recent drought reminds us). The farther west in the state, the more variable annual rainfall becomes. Annual rainfall totals and averages can be deceptive. One huge rain over a short period of time can increase total rainfall for the year with minimal effect on soil moisture and forage production. In Figure 1, total annual rainfall, average annual rainfall, and drought level (drought is considered to be 75 percent of average annual rainfall) are illustrated for Dimmit County, Texas from 1931 to 1994. For most years in this example, rainfall is either above or below average. In fact, for at least half the years, annual rainfall was below average. Furthermore, in this example there is only about an 11 percent chance that total rainfall within any one year will be within 1 inch of the long-term annual average. So, if a rancher bases stocking rate on average annual rainfall, the range will be overstocked at least half the time.

A major goal in grazing management must be to leave enough forage in a pasture to protect the soil and maintain plant vigor (Table 1).

Table 1. Suggested forage residue levels for maintaining soil stability and plant vigor.

Vegetation type	Pounds/acre	Stubble height (inches)
Tallgrass	1200-1500	12-14
Midgrass	750-1100	6-8
Shortgrass	300-500	2-3

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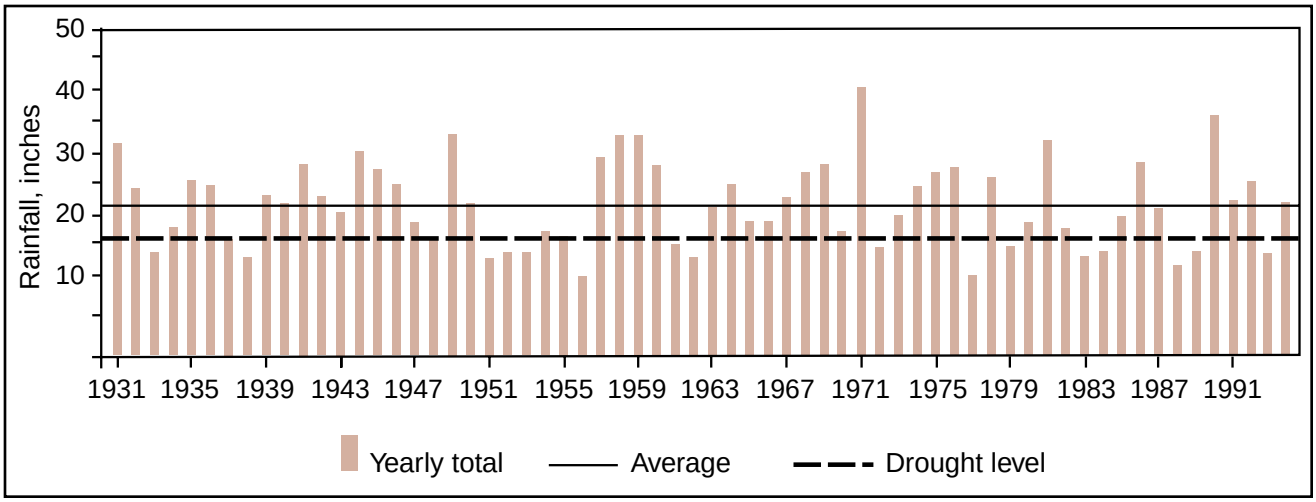

Figure 1. In this example of rainfall variability in Dimmit County, Texas, total annual rainfall for at least 50 percent of the years was below the average annual rainfall. In addition, there is only an 11 percent chance that annual rainfall for any one year will be within 1 inch of the annual average.

Forage residues affect future forage production. Figure 2 illustrates relationships among forage residue, rainfall, and forage production. In this example, leaving 500 pounds of residue produced twice as much forage as leaving only 100 pounds. Furthermore, leaving 1500 pounds of residue produced as much forage as 500 pounds of residue even though rainfall was far less. Areas with greater residue are more efficient at capturing and retaining rainfall.

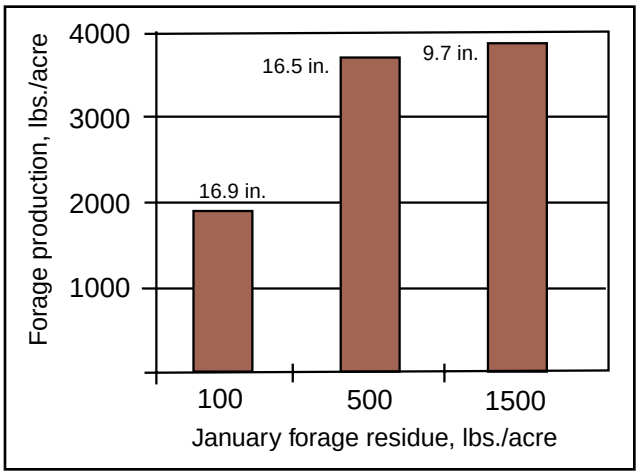

Figure 2. Effect of forage residue on forage production. Numbers above bars indicate rainfall.

Conduct forage inventories in late June or early July, October and March to estimate available forage and make stocking adjustments. For cattlemen, grass is the primary production goal and it must be managed properly to sustain long-term productivity. Too often a blanket stocking rate is used for a county or region when the stocking rate should be tailored to each grazing management unit, whether a pasture or an entire ranch.

What Does a Given Stocking Rate Mean?

The old rule of thumb “take half, leave half” is well publicized, but may not be well understood. This rule applies to average annual forage production. It does not mean that half the forage can be allotted to grazing animals. Part of what is taken will go to the animals, but part will disappear through trampling, decay and insect damage. This disappearance is usually about 25 percent of the average annual production. Therefore, only 25 percent is left for the grazing animal.

As an example, let’s assume that a rancher is using a stocking rate of 20 acres per animal unit per year (AUY).

An animal unit consumes 26 pounds of forage per day, or 9,490 pounds per year.

(26 x 365 = 9,490)

The rancher has allotted 20 acres to produce the 9,490 pounds of forage needed per AUY. Therefore, each acre must produce 475 pounds of forage yearly to support grazing.

(9,490 ÷ 20 = 475)

If 475 pounds represents 25 percent of the total forage needed (because 25 percent of the total will be lost to trampling, etc., and 50 percent will be left as residue), then the total forage production will need to be 1,900 pounds per acre.

(475 x 4 = 1,900)

In this example, 950 pounds of forage per acre would be left to maintain soil stability and plant vigor.

Range Sites

Range sites are areas with distinctive combinations of soils, land features, and natural vegetation. Range sites differ in the kinds and amounts of forage they produce

and in their carrying capacity. The comparison in Table 2 illustrates this point.

Table 2. Differences in carrying capacity between two range sites, both in excellent condition.

Range site	Favorable year, acres/animal unit	Unfavorable year, acres/animal unit
Clayey bottomland	8	13
Gravelly ridge	13	25

Range Condition

Range condition is a numerical score comparing current plant composition with pristine (believed to exist before the occupation of European man) plant composition. Table 3 compares carrying capacities for the various range condition classes of one range site.

Table 3. Carrying capacities for different range condition classes for one range site.

Range condition	Acres/animal unit year
Excellent	10-15
Good	16-20
Fair	21-28
Poor	29-40

Livestock Considerations

Not Every Cow is An Animal Unit

Resource management professionals are sometimes asked to recommend a stocking rate for a particular area or particular kind of grazing livestock. These recommendations are typically based on one cow or animal unit per "x" acres. However, not every cow is an animal unit. In fact, an animal unit, like most units of measure, is arbitrary. The definition of an animal unit has continually changed. Currently, the most widely accepted definition of an animal unit is a mature, 1,000-pound cow and her calf, representing an average daily dry matter forage intake of 26 pounds. This average daily forage intake can also be expressed as a percentage (2.6 percent) of the cow's body weight. Stocking rate recommendations should be based more on potential forage intake than on numbers of animals. If you know the potential forage intake of a particular species of livestock, you can determine the total forage production needed to leave an adequate amount of residue.

Cow Size

The mature size of beef cows has steadily increased since the 1950s. Today's "average" beef cow probably weighs 1,150 to 1,200 pounds. Therefore, these cows are not equivalent to one animal unit. Different size cows require different stocking rates.

For example, if the estimated stocking rate for a 1,000-pound cow is 20 acres, the **estimated stocking rate for the 1,150-pound cow** (assuming both have the same forage intake rate of 2.6 percent of body weight) is found as follows:

1,150 pounds x 0.026 = 30 pounds forage intake per day ÷ 26 pounds forage per animal unit = 1.15 animal units per cow

Therefore, 1.15 animal units per cow x 20 acres per animal unit = **23 acres per 1,150-pound cow.**

Cow Body Condition

Estimating forage intake from a cow's weight can cause some degree of error if the cow's body condition score is not considered. Weight per body condition score (about 8 percent of weight at a body condition score of 5) varies from about 72 pounds for a 900-pound cow to about 104 pounds for a 1,300-pound cow. For example, a cow weighing 1,000 pounds at a 5 body condition score would weigh about 840 pounds at a 3 body condition score or 1,160 pounds at a 7 body condition score. The fact that this cow is lighter or heavier because of body fat content does not mean she will consume less or more forage than when she weighs 1,000 pounds. By using a condition score 5 weight for cattle, these calculations can be standardized, and forage intake can be estimated relative to intake potential as animal size (gut capacity) increases.

Cow Productivity

Another factor that creates differences in stocking rate estimates is production level. Cows that produce heavier calves usually produce more milk, and therefore, eat more forage. These cows need more acres to satisfy their forage demand and still leave the proper amount of forage residue. Average annual forage intake rates of 2.6, 3.0 or 3.5 percent can be achieved by beef cows with low, medium or high milk production levels, respectively. Cows are certainly capable of eating even more. For example, one dairy cow was documented to have a dry matter intake rate of 7 percent of body weight.

If the estimated stocking rate for a low-milking, 1,000-pound cow is 20 acres, a high-milking, 1,000-pound cow might need 27 acres. If the high-milking cow also weighs 1,150 pounds, the estimated stocking rate would be 31 acres per cow.

Setting Stocking Rates for Different Kinds of Livestock

When determining stocking rates for sheep and goats, range managers usually use the rule of thumb that five sheep or six goats equal one animal unit, implying that this number of sheep or goats consumes the same amount of forage as a 1,000-pound cow and her calf consuming forage at the rate of 2.6 percent of the cow's weight. By using body weights and appropriate forage intake rates for each species, more specific stocking rates can be determined. For sheep, a typical forage intake rate is 3.0 to 3.5 percent of body weight. Goats typically have a forage intake rate of 4.0 to 4.5 percent of body weight. Again, highly productive animals would have intake rates at the high end of the range. To illustrate this approach, calculate the animal unit equivalent for Boer goats weighing 130 pounds and having a forage intake rate of 4 percent.

Estimated forage consumption for these goats is 5.2 pounds of dry forage per day.

(130 pounds x 0.04 =5.2 pounds)

This means that it would take about five of these goats to equal one animal unit. (26 pounds per animal unit ÷ 5.2 pounds per goat = 5 goats per animal unit)

Determining stocking rates for combinations of animal species is controversial. The controversy centers around whether to consider diet overlap between species.

The conservative approach assumes different animal species eat the same plants and have 100 percent diet overlap. With this approach, total carrying capacity is simply determined according to animal numbers and animal units for each species. The rationale for this approach is that carrying capacity varies with terrain, season, weather and other factors, and therefore, diet overlap is too variable to try to estimate.

A second approach is to try to account for diet overlap. Most Texas studies suggest that potential diet overlap for cattle and goats is about 50 percent. In theory, then, these two species would not compete directly with each other. The following calculations estimate stocking rate for these two species using the diet overlap approach.

A ranch has an estimated carrying capacity of 100 animal units and the rancher wants to stock 100 Boer goats weighing 130 pounds as in the example above (5 Boer goats per animal unit) along with cows.

(100 Boer goats ÷ 5 goats/animal unit = 20 animal units)

(20 goat animal units x 0.5 diet overlap with cattle = 10 goat animal units)

(100 animal units - 10 goat animal units = 90 cow animal units)

If cows to be stocked weigh 1,150 pounds at body condition score 5, each cow is about 1.15 animal units (see calculation above).

(90 cow animal units ÷ 1.15 animal units per cow = 78 cows)

Estimated stocking rate: 78 1,150-pound cows and 100 130-pound Boer goats

If diet overlap is not considered, the total animals stocked in this example would be:

100 Boer goats ÷ 5 goats/animal unit = 20 goat animal units

100 animal units - 20 goat animal units = 80 cow animal units

80 cow animal units ÷ 1.15 animal units/cow = 70 cows

Estimated stocking rate: 70 1,150-pound cows and 100 130-pound Boer goats

Balancing Forage Supply and Demand

Flexible Stocking Rates

Many successful ranchers maintain flexibility in stocking rates. Flexibility is essential because rainfall is unevenly distributed both within and across years. In fact, records indicate that in one of every two years less than average rainfall will be received. Stocking based on average rainfall and forage production will overstock a ranch about 50 percent of the time. To be flexible, some managers devote 40 to 80 percent of their carrying capacity to stocker cattle and 20 to 60 percent to a cow-calf operation. This approach avoids the forced liquidation of the breeding herd in dry years.

Stocking Rate and Animal Performance

Heavy stocking rates are detrimental to both land resources and livestock performance. Over time, heavy stocking causes the more palatable and productive forage species to disappear. These desirable forages are replaced by less productive, less palatable plants that capture less rainfall, thus lowering the capacity of the soil to store moisture and increasing the risk of erosion.

Over the short term, a heavy stocking rate may lower forage quality by removing green foliage and forcing animals to consume more dead, standing forage. Over the long term, a heavy stocking rate removes almost all edible forage so that only immature plants remain. While this immature forage is high quality, there isn't enough of it. In grazing, both forage quality and forage quantity are important, and both affect livestock productivity and net profits.

Figure 3 illustrates the classic relationships among stocking rate, individual animal performance, gain per acre, and net profits. In the tallgrass prairie example shown here, individual animal gain decreases as stocking rate increases, while gain per acre increases. Net profits increase to a point, then decline. In contrast, in the midgrass prairie example represented in Figure 4, net returns decline rapidly from a peak at 5 acres per steer.

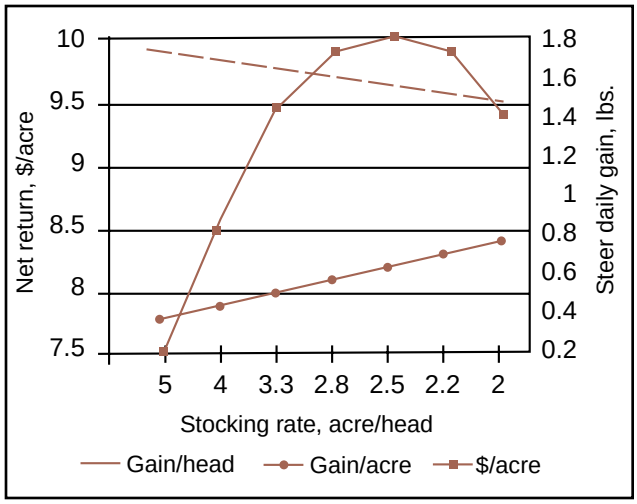

Figure 3. Relationships among stocking rate, individual steer gain, gain per acre, and net profits for a tallgrass prairie site.

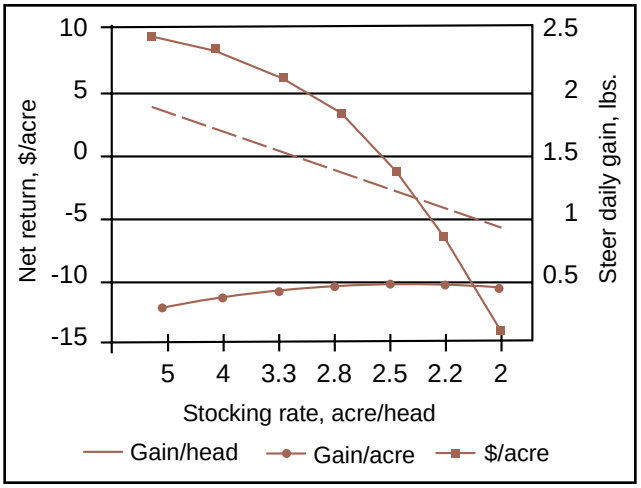

Figure 4. Relationships among stocking rate, individual steer gain, gain per acre, and net profits for a midgrass prairie site.

The effect of stocking rate also can be seen in cow performance. Figure 5 shows average body condition scores over 3 years at weaning, calving and breeding for spring- and fall-calving cows managed at different stock densities (acres per cow at a given point in time) on the same ranch. Body condition scores were higher for the fall-calving herd during each of these periods, particularly at calving. Cows in the spring herd were unable to improve body condition from weaning to calving. Fall-calving

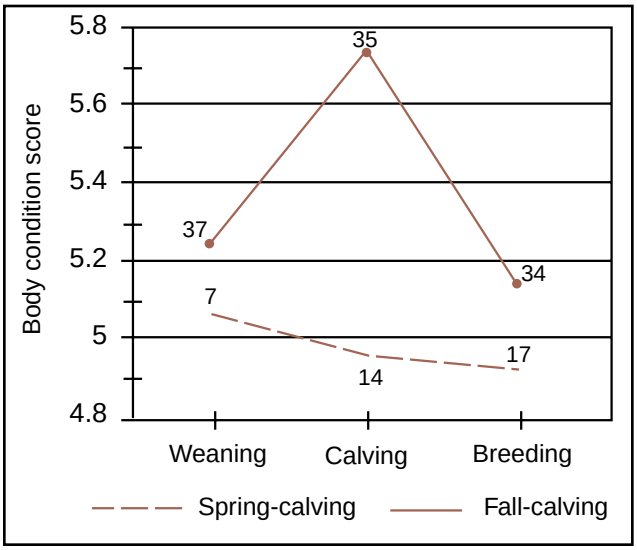

Figure 5. Effect of stock density (acres per cow for a given point in time) on cow body condition score in spring- and fall-calving herds on the same Hill County ranch. Numbers above lines indicate the stock density.

cows had two to five times more acres available per cow than spring-calving cows. The differences in body condition scores between the two herds were due mostly to differences in stock densities and related forage availability. The higher stock density (fewer acres per cow) in the spring-calving herd resulted in less available forage and lower condition scores. Spring herd condition score at breeding was about the same as at calving because these cows calved when forage quality was improving. Fall herd condition scores declined from calving to breeding because forage quality was declining during this period.

Forage Preference/Type Differences

Grazing/browsing livestock have forage preferences that can affect stocking rates. Research has shown that as much as 80 percent of a grazing animal's diet can come from as little as 1 percent of the forage standing crop.

Research in Oklahoma suggests that steer gain decreased at different rates on tallgrass and midgrass sites. With the same levels of decreasing forage availability, decline in weight gain was about four times faster on midgrass prairie. Reasons for these differences are not clear, but probably relate to forage preferences.

Animal adaptation to a forage type can have a significant effect on animal performance. For example, cattle are grazers, with about 80 percent of their annual diet consisting of grass. Cattle are not physically equipped to eat browse (leaves and twigs from woody vegetation). Therefore, stocking rates that force cattle to eat browse can drastically reduce forage intake. Figure 6 illustrates the effect of browse consumption on potential forage intake of steers grazing South Texas rangeland.

Figure 6. Effect of browse consumption on potential forage intake of beef steers grazing South Texas rangelands.

Recommendations

Although timing, intensity and frequency of grazing are important, stocking rate is the most important grazing management decision. Because stocking rate affects animal productivity, net profits, and the renewable range resource, it should be tailored to each pasture and ranch. Remember, to make maximum use of rainfall, leave enough forage residue or stubble to capture rainfall as soil moisture. Rainfall, forage production, and forage use by grazing animals are not static. Consequently, stocking rate flexibility is the key to sustainability and to protecting the range resource.

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TEXAS RANGELAND MONITORING: LEVEL THREE

C. Wayne Hanselka, Charles R. Hart and Allan McGinty[1]

Monitoring is an essential tool in rangeland management. Monitoring is the way to determine whether goals are being achieved with current management strategies. A sound rangeland monitoing program identifies trends and helps the manager make better decisions in managing natural resources. It also confirms good management practices while revealing potential problems early.

The Texas Rangeland Monitoring Program is a rapid, simple and inexpensive way to monitor vegetation structure and the ecological processes of semi-arid rangelands.

Level one monitors changes in plant communities and soils using permanent photo points (see AgriLife Extension publication *RWFM-PU-056, "Range Monitoring with Photo Points"*). Level two monitoring adds more detail related to rangeland health by documenting and tracking changes in the herbaceous and woody plant communities (see AgriLife Extension publication *RWFM-PU-069, "Texas Rangeland Monitoring: Level Two"*). Level three monitoring adds additional indicators related to ecological processes important to rangeland health.

RANGELAND HEALTH

Rangeland health is the degree to which the integrity of the soil, vegetation, water, air and ecological processes are balanced and sustained. Ecological processes are those that enable an ecosystem to function as it should to retain soil, capture and store water, and support a viable biotic community. These processes are nutrient cycling, energy flow, water cycling, and vegetation dynamics.

Level three monitoring uses a quantitative scoring system that ranges from 1 (nonfunctional) to 5 (fully functional as would be expected in an unaltered reference area). Each variable in the landscape pattern and the four ecological processes is scored, and then the scores are averaged to obtain a functional score for each process.

[1] Extension Range Specialists

LANDSCAPE TERRAIN AND PATTERN

Landscape patterns affect ecological function. Water and nutrients are redistributed and captured by numerous "patches" and "sinks" such as grass clumps, brush thickets, depressions, etc. Thus, the functioning of the rangeland is strongly influenced by terrain (shape and slope) and patchiness of vegetation (numbers, size and spacing). Losses can occur from fire and grazing.

To score the landscape pattern, first establish a line transect as described in AgriLife Extension publication *RWFM-PU-056*. Survey the shape of the terrain along the line to locate topographic features such as depressions and flats, and vegetation patches such as large grass plants, grass clumps, shrubs, brush thickets, etc. (Fig. 1). There are three indicators that are estimated or measured:

1. **Number of patches per unit area.** This is an estimate of the number of patches, by patch type, on the site. Count the number of patches that intersect the line transect and note what kinds of patches they are. Then document the number of patches per unit of space, such as the number per 10 feet or the number per square foot. Rate them from few (1) to many (5).

   Few (1) = no patches per 10 feet
   Many (5) = ten patches per 10 feet

Figure 1. Number, size, and the distance between patches affect the functioning of ecological processes.

2. **Patch size.** This is the area of each patch that is intercepted by the transect. Estimate the length and width of each patch and calculate its area. Rate patches small (1) or large (2).

   Small (1) = 1 square foot
   Large (5) = > 25 square feet

3. **Distance between patches.** The third indicator is the distance between patches. The closer together the vegetation patches, the less water is lost from evaporation or runoff from bare soil. Estimate or measure the distance between patches along the transect and calculate the average distance. Rate them from far apart (1) to close together (5).

   Far apart (1) = 100 feet between patches
   Close together (5) = 1 foot between patches

ECOLOGICAL PROCESSES

Nutrient cycling

Minerals and nutrients cycle through the ecological system and may be 1) removed from the soil by plants and returned to the soil as plants decay, or 2) consumed by animals and returned to the system through animal waste or decomposing bodies. Nutrients are temporarily lost to the system through livestock grazing and by being tied up in plant materials that are slow to decompose. The rate of litter breakdown is the most important indicator of mineral and nutrient cycling. In a healthy system nutrients are returned quickly. In an unhealthy system dead leaves stay on grasses and oxidize rather than decaying, and dry manure and dung pats remain intact without being broken down by insects and other decomposers. Rate litter breakdown from slow (1) to rapid (5).

Energy flow

Plants capture solar energy and convert it to carbohydrates used by the plants and/or transferred to other parts of the ecosystem. The abundance of broad-leaved plants and the closeness of plant spacing are measures of energy flow; this is measured by the extent of the live plant canopy over the transect. Note the total area of leaf and the health of plants. Rate the live canopy of plants from poor (1) to abundant (5).

Poor (1) = 0 percent
Abundant (5) = > 75 percent

Water cycling

While the amount and timing of rainfall are important, the productivity of rangeland is more closely tied to the amount of soil moisture captured when it rains and the presence of desirable plant species to use that moisture. Current and past management practices determine how much rainfall penetrates the soil, the kinds of plants on the land, and the amount of runoff, sediment and non-point source pollutants that leave the property. Factors that affect how much rainfall penetrates the soil, runs off or evaporates include the type and density of vegetative cover, the intensity of rain, the amount of moisture in the soil before the rain, the capacity of the soil to hold water, and the slope of the land.

There are three indicators of the functioning of the water cycle.

- **Soil capping.** Hard, capped soil and compaction layers indicate a problem with water infiltration, aeration and seed germination (Fig. 2). Associated signs are litter dams, rills and gullies, water runoff patterns, etc. Rate soil capping from mature capping (1) to no capping (5).
- **Plant pedestaling.** Erosion (by wind or water) moves soil from around the bases of plants, exposing root crowns and leaving roots on small platforms or pedestals (Fig. 3). Extreme pedestaling may kill plants. Rate pedestaling from extreme (1) to none (5).

Figure 2. Compacted or capped soil inhibits aeration, water infiltration and seedling establishment.

Figure 3. Erosion removes soil from the base of plants, leaving them on a “pedestal.”

- **Bareground.** Good vegetative cover slows the movement of water and lessens the impact of raindrops on the soil surface. The greater the impact and the faster the water moves, the more soil will be washed away. The slower the movement of water, the more time there is for it to soak into the soil. Monitoring the amount of bare ground and evidence of erosion will show how management is affecting the soil surface. Rate the amount of bare ground from high (1) to low (5).

  High percentage (1) = > 75 percent
  Low percentage (5) = < 25 percent

Vegetation dynamics. The status of vegetation is the key to the land's stability, resiliency, productivity and health. The kinds (species) and classes (grasses, forbs, woody plants, etc.) of plants affect both the water cycle and the nutrient cycle. There are two indicators of vegetation dynamics.

- **Species diversity.** A wide diversity of species indicates an advanced plant community (Fig. 4). Variety allows for full use of resources at all times of the year. Rate species diversity from simple (1) to complex (5).

  Simple (1) = < 5
  Complex (5) = > 25

Figure 4. A wide diversity of plant species indicates an advanced plant community.

- **Annuals vs. perennials.** If annual plants dominate the landscape, the plant community is weak, production is low, root systems are weak, there are few energy-collecting broadleaf plants, and plants contribute little to soil cover and stability. Count the perennials and rate them from few (1) to many (5).

  Few (1) = < 5 percent perennials
  Many (5) = > 50 percent perennials

INTERPRETING RANGELAND HEALTH

When all indicators have been evaluated and rated they can be scored and plotted. This will give a "snapshot" of the health of that particular range site. The more "high" ratings there are, the more functional the rangeland system. Lower ratings indicate potential problems. Having several "snapshots" over time allows the manager to see trends and take corrective actions if necessary.

Managers must know what is happening on their lands. They must check for signs of increasing bare ground, reduced litter, lower forage production, changing plant species, and stream bank erosion. These signs indicate whether the land is healthy or deteriorating. If there are problems, management practices can be changed before the land degrades further. Learning to read the landscape will pay off in greater productivity now and sustainable production in the future.

For additional information *http://texnat.tamu.edu.*

2023 Beef Cattle Short Course Cattleman's College Brush Busters® Workshop
Brush Busters®: A Common Sense Program for Rangeland Brush Management

Workshop Organizers: Barron S. Rector, Associate Professor and Extension Range Specialist, College Station; Dr. Megan Clayton, Professor and Extension Range Specialist, Uvalde; and Dr. Stacy Hines, Assistant Professor and Extension Rangeland Habitat Management Specialist, Corpus Christi; Texas A&M AgriLife Extension Service.

Landowners and managers in Texas face a series of growing problems. Brush is increasing. herbicide costs and regulations are escalating. Ranch size is decreasing, reducing brush control options. Urban encroachment is reducing control-options, especially broadcast aerial herbicide applications. Landownership patterns are changing. Ignoring brush on rangeland or improved pastures until it is dense and mature is a common error among landowners.

In response to these problems, the Brush Busters® program was developed. This program is an effective, user-friendly, do-it-yourself approach to brush management on rangeland that stresses use of individual plant treatment to reduce treatment costs, improve control effectiveness, limit damage to desirable plants, and lengthen treatment-life of broad-scale practices. This program is highly selective and effective, environmentally-friendly, and usually much less expensive than conventional broadcast mechanical or herbicide control methods.

Brush Busters® methods make it possible to control brush in the seedling, sapling, or re-growth stages while it is most vulnerable, before it causes debilitation of desirable forage plants or accelerates soil erosion, and before brush produces seeds which may germinate and re-infest pastures. To date, the Brush Busters® program has targeted mesquite, pricklypear, huisache, saltcedar, yucca, Chinese tallowtree, Macartney rose, greenbriar, cedar (ashe juniper and redberry juniper), honey locust, Texas persimmon, minor brush species like coyotillo and lotebush, and cut-stump treatments for numerous woody plant species.

Brush Busters® methods are easily understood, even by those with little or no previous experience with brush management. We recommend only "select" treatments capable of killing at least 7 of 10 plants treated. Every attempt is made to keep equipment costs and complexity to a minimum, and whenever possible, to use non-restricted herbicides.

This workshop will provide detailed instructions and demonstrations of Brush Busters® methods for several species and for cut-stump treatments. Topics discussed will include application equipment, herbicides, adjuvants, timing, and treatment conditions for effective application of Brush Busters® methods. Each participant will receive Brush Busters® pamphlets in the BCSC Proceedings that provide simple, three-step directions for effective control of each species. Participants will also receive 3 hours of pesticide applicator CEUs.

For more information, review the Brush Busters® publications and related materials at AgriLifeLearn.tamu.edu by searching for the plant name under "Publications" or at Dr. Clayton's website SouthTexasRangelands.tamu.edu/useful-publications/. The downloadable links for the Brush Busters® Cost Calculator app are also at this website.

TEXAS A&M AGRILIFE EXTENSION

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CHEMICAL WEED AND BRUSH CONTROL

REFERENCE GUIDE FOR RANGELAND




TEXAS A&M AGRILIFE EXTENSION

ESC-046 9/20

QUICK REFERENCE FOR COMMON RANGELAND AND PASTURE HERBICIDES

Joshua McGinty, Vanessa Corriher-Olson, Megan Clayton, and Robert Lyons*

ACTIVE INGREDIENT(S)	TRADE NAME(S)	GRAZING RESTRICTIONS	HAY HARVEST RESTRICTIONS	RAINFAST INTERVAL	PESTICIDE APPLICATOR LICENSE REQUIRED?
2,4-D + aminopyralid	GrazonNext HL	None[1]	7 days[2,3,4]	2 hours	Yes
2,4-D + aminopyralid	PasturAll HL	None[1]	7 days[2,3,4]	2 to 4 hours[5]	Yes
2,4-D + dicamba	Weedmaster, Range Star, Outlaw, Latigo	None, except for lactating animals (7 days)	7 days	4 hours	Yes
2,4-D + picloram	Graslan L, Grazon P+D, Gunslinger	None, except for lactating dairy animals (7 days)	30 days	2 to 4 hours[5]	Yes
2,4-D + triclopyr	Crossbow, Everett	None, except for lactating dairy animals (next growing season)	None, unless feeding to lactating dairy animals (14 days)	6 hours[5]	Yes
2-4-D	2,4-D Amine 4 (several)	0 to 7 days (varies by manufacturer)	7 days	6 hours	Yes
2-4-D	2,4-D LV4 (several)	0 to 7 days (varies by manufacturer)	7 to 30 days (varies by manufacturer)	1 hour	Yes
2-4-D	2,4-D LV6 (several)	0 to 7 days (varies by manufacturer)	7 days	1 hour	Yes
Aminocyclopyrachlor + triclopyr	Invora	None[1]	Not labeled for hay production	1 hour	Yes[7]
Aminopyralid	Milestone	None[1]	None[2,3,4]	2 to 4 hours[5]	No
Aminopyralid + clopyralid	Sendero	None[1]	None[2,3,4]	4 hours[5]	No
Aminopyralid + florpyrauxifen-benzyl	DuraCor	None[1]	14 days to allow maximum herbicide activity[2,3,4]	2 hours	No
Aminopyralid + metsulfuron-methyl	Chaparral/Opensight	None[1]	None[2,3,4]	2 to 4 hours[5]	No
Aminopyralid + picloram + fluroxypyr	MezaVue	None[1], except for lactating dairy animals (14 days)	7 days to allow maximum herbicide activity[2,3,4]	4 hours[5]	Yes
Clopyralid	Clean Slate, Clopyralid 3, Pyramid	None	None	2 hours	No
Dicamba (DGA salt)	Clarity	7 days (1 pt/A), 21 days (2 pt/A), 40 days (4 pt/A)	37 days (1 pt/A), 51 days (2 pt/A), 70 days (4 pt/A)	4 hours	Yes
Dicamba (DMA salt)	Banvel	0 days	7 days	4 to 6 hours[5]	Yes
Dicamba + halosulfuron-methyl	Yukon	None	37 days	3 hours	Yes
Glyphosate	Glyphosate products (several)	0 to 8 weeks (varies by manufacturer)	0 to 8 weeks (varies by manufacturer)	4 to 6 hours	No
Hexazinone	Pronone Power Pellet	None (<600 pellets/A), 60 days (600 to 5,000 pellets/A), 1 year (>5,000 pellets/A)	None (<600 pellets/A), 60 days (600 to 5,000 pellets/A), 1 year (>5,000 pellets/A)	None	No

continued on next page

*Assistant Professor and Extension Agronomist, Associate Professor and Extension Forage Specialist, Associate Professor and Extension Range Specialist, and Professor and Extension Range Specialist

ACTIVE INGREDIENT(S)	TRADE NAME(S)	GRAZING RESTRICTIONS	HAY HARVEST RESTRICTIONS	RAINFAST INTERVAL	PESTICIDE APPLICATOR LICENSE REQUIRED?
Hexazinone	Velpar L VU	None, unless applying more than 4.5 pt/A (60 days)	38 days, unless applying more than 4.5 pt/A (60 days)	24 hours if soil is saturated	No
Imazapic	Plateau, Impose	None specified	7 days	1 hour	No
Imazapyr	Arsenal, Habitat, Imazapyr 2 SL	None	7 days	1 hour	No
Metsulfuron-methyl	Escort XP, Patriot, MSM 60	None	None	4 hours	No
Metsulfuron-methyl + 2,4-D + dicamba	Cimarron Max	None, except for lactating dairy animals (7 days)	37 days	4 hours	Yes
Metsulfuron-methyl + chlorsulfuron	Cimarron Plus	None	None	4 hours	No
Nicosulfuron + metsulfuron-methyl	Pastora	None	None	4 hours	No
Pendimethalin	Prowl H2O	None[6]	None[6]	None	No
Picloram	Tordon 22K, Triumph 22K, Picloram 22K	None, except for lactating dairy animals (14 days)	None, unless applying more than 1.0 qt/A (14 days)	2 hours[5]	Yes
Picloram + fluroxypyr	Surmount	None, except for lactating dairy animals (14 days)	None, unless feeding to lactating dairy animals (14 days)	4 hours[5]	Yes
Saflufenacil	Sharpen	None	None	1 hour	No
Sulfosulfuron	Outrider	None	Allow 2 weeks for best results	2 hours	No
Tebuthiuron	Spike 20P, Tebuthiuron 20P, Tebuthiuron 80WG	None	1 year	None	No
Triclopyr	Remedy Ultra, Pathfinder II, Triclopyr 4E	None, except for lactating dairy animals (next growing season)	14 days	6 hours[5]	No
Triclopyr + clopyralid	Prescott	None, except for lactating dairy animals (next growing season)	14 days, unless feeding to lactating dairy animals (next growing season)	2 hours	No
Triclopyr + fluroxypyr	PastureGard HL	None, except for lactating dairy animals (next growing season)	14 days	6 hours[5]	No

[1]Manure and urine from animals consuming grass or hay treated with this product may contain enough herbicide to cause injury to susceptible broadleaf plants.
[2]Hay from areas treated within the preceding 18 months can only be used on the farm or ranch where the product was applied unless allowed by supplemental labeling.
[3]Hay from areas treated within the preceding 18 months cannot be used for silage, haylage, baylage, and green chop unless allowed by supplemental labeling.
[4]Do not use hay or straw from areas treated within the preceding 18 months or manure from animals feeding on treated hay in compost.
[5]This is a general recommendation; rainfast interval is not specified on product label.
[6]According to supplemental label NVA 2016-04-195-0015.
[7]Picolinic acid chemistry training is required every 2 years.

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BRUSH BUSTERS MIXING GUIDE:

Individual Plant Treatment Applications

Robert K. Lyons and Megan K. Clayton*

AMOUNT OF PRODUCT NEEDED FOR HERBICIDE MIXES USING PERCENT AND SPRAY VOLUME												
Total amount of herbicide mix desired	Product amount (%) needed for individual plant treatment applications											
	0.25%	0.5%	0.75%	1%*	1.5%	2%	3%	4%	5%	10%	15%	25%
	Amount of product											
1 gal	0.32 oz	0.64 oz	1 oz	1.28 oz	2 oz	2.56 oz	4 oz	5.12 oz	6.4 oz	12.8 oz	19 oz	32 oz
3 gal*	1 oz	2 oz	3 oz	4 oz*	6 oz	8 oz	11.5 oz	15.5 oz	19 oz	38.5 oz	58 oz	96 oz
5 gal	1.6 oz	3.2 oz	5 oz	6.4 oz	10 oz	13 oz	19 oz	26 oz	32 oz	64 oz	96 oz	1.25 gal
10 gal	3.2 oz	6.4 oz	10 oz	13 oz	19 oz	26 oz	38 oz	51 oz	64 oz	1 gal	1.5 gal	2.5 gal
14 gal	4.5 oz	9 oz	13.5 oz	18 oz	27 oz	36 oz	54 oz	72 oz	90 oz	1.4 gal	2.1 gal	3.5 gal
25 gal	8 oz	16 oz	24 oz	32 oz	48 oz	64 oz	96 oz	1 gal	1.25 gal	2.5 gal	3.75 gal	6.25 gal
50 gal	16 oz	32 oz	48 oz	64 oz	96 oz	1 gal	1.5 gal	2 gal	2.5 gal	5 gal	7.5 gal	12.5 gal
100 gal	32 oz	64 oz	96 oz	1 gal	1.5 gal	2 gal	3 gal	4 gal	5 gal	10 gal	15 gal	25 gal

***Spray Mix Example:** To prepare 3 gallons of a 1% herbicide leaf spray mixture with 0.25% non-ionic surfactant (NIS) and 0.5% blue dye: Add half the water volume to the tank, pour in the correct amount of herbicide (4 oz; see chart), add 0.25% NIS (1 oz; see chart), add 0.5% blue dye (2 oz; see chart). Add the remaining water volume and mix well.

Note: For leaf spray applications, add the recommended amount of non-ionic surfactant (NIS), methylated seed oil (MSO), or methylated seed oil-organo silicate (MSO-OS) according to product label specifications, using only water as the herbicide carrier. For stem or cut stump applications, recommendations include using either triclopyr ester with a diesel or basal oil carrier or Invora (mesquite only) and an MSO-OS adjuvant with water as a carrier.

128 oz = 1 gallon

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HOW TO AVOID LUMPS WHEN TREATING CUT STUMPS:

Individual Plant Treatment Cut Stump Applications

Robert K. Lyons and Megan K. Clayton*

Woody plants are an important component of most Texas rangelands, providing food and cover for livestock and wildlife. However, if an area is too dense with woody plants, they compete with more desirable vegetation. Most woody plant species resprout profusely from belowground crowns or roots if aboveground growth is damaged or removed.

Here is an easy, inexpensive, and environmentally responsible method to control many species of woody plants using cut stump spray treatments. It involves spraying a small but potent concentration of herbicide directly onto cut stumps. Remember, controlling woody plants is not a one-time job. Both livestock and wildlife spread seeds, so monitor your land regularly to control unwanted seedlings.

This Brush Buster control method was developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of the Texas A&M University System. Your results may vary, but you should usually be able to kill 76 to 100 percent of the trees you treat with little or no damage to desirable vegetation.

Brush Busters recommends two different spray mixes for cut stump applications depending on the target brush species. One spray mix is for many species of hardwoods, while the other is for redberry cedar. After treatment, you may leave the cut stems and branches on the soil as mulch or stack and burn them.

BRUSH BUSTERS CUT STUMP METHOD

When to apply: Anytime during the year, although best results occur during the growing season.

1. Prepare the Equipment

Almost any type of pump-up hand sprayer can be used, but the most efficient way to apply the stem spray to many trees is with a backpack sprayer.

Make sure the sprayer's nozzle has a small orifice. One such nozzle is called the ConeJet™ 5500-X1 (or X2–X3).

To cover the stump adequately with a sprayer attached to hydraulic shears (skid/steer loader), use an adjustable cone nozzle with a relatively large orifice, such as a ConeJet™ 5500-X12 nozzle.

2. Mix the Herbicide Spray

Select the appropriate spray mixture in the "Spray Mix" section on the next page according to which brush species will be treated.

3. Cut and Spray the Stump

Remove top growth using pruning shears, a sharp ax, brush cutter, chainsaw, hydraulic shears, loppers, etc.

Make a flat cut on every plant stem as close as possible to the soil surface, but not below the soil surface. Before spraying, brush any soil or sawdust off the cut stump surface.

Spray the stump immediately after cutting. Adjust the spray nozzle to deliver a coarse mist in a cone-shaped pattern. Hold the nozzle within 1 or 2 inches of the stump and spray the entire cut surface until it is wet, especially the outer edges. Spray any remaining stem from the cut to the ground level, almost to the point of runoff.

When using a spray system attached to hydraulic shears, position the spray nozzle directly over the cut stump, high enough to ensure all of the stump is within the spray pattern. Using the dye as an indicator, spray the entire cut surface of the stump almost to the point of runoff.

Keep These Points in Mind:

- Follow herbicide label directions.
- This method is best for plants with a single stem or a few stems growing from the base (redberry juniper never has single basal stems).
- Do not spray when basal stems are wet.
- After mixing the herbicide into the carrier (diesel or water), shake or agitate the solution vigorously.
- Cost of treatment rises rapidly as the number of woody plants and stems per acre increases. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.

*Professors and Extension Range Specialists, The Texas A&M University System

BRUSH BUSTERS CUT STUMP SPRAY MIX OPTIONS

A. Spray Mix with Triclopry Ester for Hardwoods

Works well on: Algerita (agarito), baccharis, blackbrush, bois d'arc, bumelia, catclaw acacia, catclaw mimosa, Chinese tallow tree, elm, hackberry, huisache, lotebush (bluethorn), mesquite, all oaks, pricklyash (Hercules' club), saltcedar, Texas persimmon, winged elm, and yaupon.

Mixing instructions: A mixture of 15 percent triclopyr ester herbicide (trade names: Remedy Ultra, Clear Pasture, Triclopyr R&P, and Triclopyr 4EC) and 85 percent diesel fuel oil or vegetable oil is recommended (see mixing table below). Diesel fuel oil or vegetable oil act as coating agents and penetrants to ensure good herbicide coverage and absorption. Using vegetable oil instead of diesel fuel oil increases cost but may be desirable in some situations.

Pour the required amount of herbicide into a mixing container or spray tank, then bring to final volume with diesel fuel oil or vegetable oil. Vigorously shake or agitate to ensure thorough mixing. One ounce of Hi-Light™ blue dye can be added for each gallon of spray mix to help identify treated plants.

RECOMMENDED CUT STUMP SPRAY MIX FOR HARDWOODS HERBICIDE MIX OPTION (IN DIESEL OR BASAL OIL)

Ingredient	Concentration in Spray Solution	Tank Size		
		1 gal	5 gal	10 gal
Triclopyr ester herbicide	15%	19 oz	96 oz	1.5 gal
Hi-Light™ blue dye	1 oz/gal	1 oz	5 oz	10 oz

B. Spray Mix with Picloram for Redberry Cedar

Works well on: Redberry cedar (juniper). You do not need to spray the stumps with herbicide to kill blueberry cedar (Ashe juniper) or eastern red cedar.

Mixing instructions: A mixture of 4 percent picloram herbicide (trade names: Tordon 22K, Triumph 22K, Picloram 22K) in water is recommended for redberry cedar (see mixing table below). A high-quality (80 to 90 percent active ingredient) non-ionic surfactant ensures good herbicide coverage and absorption. Add a spray marking dye such as Hi-Light™ blue dye to mark the stumps that have been sprayed.

When mixing, add half the desired quantity of water to the spray tank. Then add the picloram herbicide, surfactant, and dye to the tank. Finally, use water under pressure to agitate and mix the spray, filling the tank to the final volume.

RECOMMENDED CUT STUMP SPRAY MIX FOR REDBERRY CEDAR HERBICIDE MIX OPTION (IN WATER)

Ingredient	Concentration in Spray Solution	Tank Size	
		1 gal	4 gal
Picloram herbicide	4%	5 oz	21 oz
Non-ionic surfactant	0.25%	0.32 oz	1.5 oz
Hi-Light™ blue dye	0.25%	0.32 oz	1.5 oz

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HOW TO BEAT HUISACHE:
Individual Plant Treatment Leaf and Stem Applications

Megan K. Clayton and Robert K. Lyons*

Huisache is a common plant on rangeland and pasture in the southern half of Texas. It is a tough, aggressive, noxious species that limits forage production and decreases the value of wildlife habitat.

Here are two three-step methods to control huisache; both are easy, inexpensive, and environmentally responsible. They involve spraying a small but potent concentration of herbicide directly on each plant to selectively control unwanted huisache. Remember, controlling huisache is not a one-time job. Both livestock and wildlife spread seeds, so monitor your land regularly to control unwanted seedlings.

These Brush Busters control methods were developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of the Texas A&M University System. Your results may vary with weather and other plant conditions, but you should usually be able to kill 76 to 100 percent of the trees you treat.

These Brush Busters control methods depend on the tree shape and size. For huisache with three or less smooth bark stems coming out of the ground, the stem spray method may be a good option. For bushy huisache less than 6 feet tall with many stems at ground level, the leaf spray method may be the best option. Either method can be successful.

BRUSH BUSTERS LEAF SPRAY METHOD

Works well on: Huisache that have good leaf canopy and are less than 6 feet tall. This method is also known as high-volume foliar spraying.

When to apply: Begin in September after any late-summer growth has stopped, indicated by no new leaf growth at the end of stems. Good soil moisture and mature, healthy leaves are necessary for improved plant kill. Continue until November or when the soil temperature drops below 75°F at 12 inches deep.

1. Prepare the Equipment

Many types of sprayers work well for this method. Backpack sprayers are the most efficient for small acreage places or those with a high density of huisache trees. Larger places with lower densities may find ATV or UTV sprayers more efficient. Before you start spraying, make sure you have an adjustable cone nozzle, such as the Conejet™ 5500-X6 or X8 nozzle that can deliver a coarse spray with larger droplets to the top of a 6-foot tree.

2. Mix the Herbicide Spray

You can achieve 76 to 100 percent mortality by spraying with one of several herbicide options (see options A, B, or C in the table on the next page) under ideal conditions. To prepare the spray mix, add the selected herbicide to water. To make sure the foliage is coated thoroughly, add a high-quality (80 to 90 percent active ingredient) non-ionic surfactant (see table on the next page) to the spray mix or crop oil, methylated seed oil (MSO), or MSO-OS (organosilicone) adjuvant at manufacturer specified rates. Add a dye, such as Hi-Light™ blue dye, to mark plants that have been sprayed and ensure proper coverage.

3. Spray the Huisache

Adjust the nozzle to deliver a coarse spray in a wide pattern. Wet ALL the leaves of each huisache plant until the leaves glisten but not to the point of dripping.

Keep These Points in Mind:

- Follow herbicide label directions.
- For best results, do not spray when:
  - Rains have stimulated new growth at the end of the stems
  - Leaves are wet from rain or dew
  - Foliage shows damage from hail, insects, or disease
  - Working upwind of desirable trees, shrubs, or crops
- The cost of treatment rises rapidly as the brush becomes bigger and denser. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Controlling huisache is not a one-time job. You will need to monitor your land every year to check for new plants.

*Professors and Extension Range Specialists, The Texas A&M University System

RECOMMENDED LEAF SPRAY HERBICIDE MIX OPTIONS*						
	Ingredient	Concentration in Spray Solution	Tank Size			
			1 gal	3 gal	14 gal	25 gal
Option A	Grazon P+D, Gunslinger, Picloram+D, or Sendero	1%	1.28 oz	3.84 oz	18 oz	32 oz
Option B**	Invora**	1.5%	1.92 oz	5.76 oz	27 oz	48 oz
Option C	Graslan L	0.63%	0.8 oz	2.4 oz	11 oz	20 oz
Add to option A, B, and C	Non-ionic surfactant	0.25%	0.32 oz	1 oz	4.5 oz	8 oz
	Hi-Light™ blue dye	0.25 to 0.5%	0.32–0.64 oz	1–2 oz	4.5–9 oz	8–16 oz

*All leaf spray solutions are mixed in water.
**Invora is labeled for privately owned rangelands only *(excludes hayfields)* and requires Picolinic Acid Chemistry Training for all applicators.

BRUSH BUSTERS STEM SPRAY METHOD

Works well: For controlling young seedlings or older trees with three or fewer basal stems. Multi-stemmed huisache plants are much more difficult to control than younger trees or undisturbed plants.

Research and demonstrations have shown excellent results while using minimum amounts of herbicide.

When to apply: Anytime during the year, although best results occur during the growing season.

1. Prepare the Equipment

Almost any type of pump-up hand sprayer can be used, but the most efficient way to apply the stem spray to many trees is with a backpack sprayer.

Make sure the sprayer's nozzle has a small orifice. One such nozzle is called the Conejet™ 5500-X1 (or X2). Compared to standard nozzles, this nozzle can reduce the amount of spray applied by 80 percent, making the use of chemicals much more cost-effective.

2. Mix the Herbicide Spray

A mixture of triclopyr ester (trade names: Remedy Ultra, Clear Pasture, Triclopyr R&P, and Triclopyr 4EC) and diesel fuel oil is very effective for this method. Diesel acts as a coating agent to ensure good absorption. A basal bark (vegetable) oil may be used instead of diesel if desired.

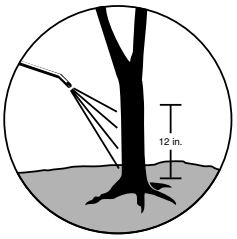
Recommended Herbicide Mix

Pour 25 percent triclopyr ester into the mixing container, then add diesel fuel to bring the mixture to the total volume desired. Agitate the mixture vigorously.

Huisache Type and Stem Diameter	% Triclopyr	Herbicide/ Gallon	Herbicide Carrier/Gallon
Smooth bark, stems up to 4 inches in diameter	25%	32 oz	96 oz diesel or basal bark oil
Add Hi-Light™ blue dye (optional)		0.32–0.64 oz	

3. Spray the Huisache

Adjust the sprayer nozzle to deliver a narrow, cone-shaped mist. Spray the mixture lightly but evenly on all the plant stems from the ground line up to 12 inches. Apply the mixture to all sides of every stem, but do not wet it so much that it runs off the stem and puddles.



Keep These Points in Mind:

- Follow the herbicide label directions.
- The cost of treatment escalates rapidly as brush becomes denser or the number of basal stems per plant increases. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Multi-stemmed or rough-barked plants are more difficult to control with this method.
- Do not spray when the basal stems are wet.
- After mixing the herbicide with diesel, shake or agitate the solution vigorously.
- This method is more difficult to apply if there is dense grass around the basal stems.

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HOW TO BEAT MESQUITE:
Individual Plant Treatment Leaf and Stem Applications

Robert K. Lyons and Megan K. Clayton*

The mesquite tree is one of the toughest, most noxious brush species on Texas rangelands. It thrives across the western two thirds of the state, both in rural pastures and on urban lots.

Here are two three-step methods to control mesquite; both are easy, inexpensive, and environmentally responsible. They involve spraying a small but potent concentration of herbicide directly on each plant to selectively control unwanted mesquite. Remember, controlling mesquite is not a one-time job. Both livestock and wildlife spread seeds, so monitor your land regularly to control unwanted seedlings.

These Brush Busters control methods were developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of the Texas A&M University System. Your results may vary with weather and other plant conditions, but you should usually be able to kill 76 to 100 percent of the trees you treat.

These Brush Busters control methods depend on the tree shape and size. For mesquite with three or fewer smooth bark stems coming out of the ground, the stem spray method may be a good option. For bushy mesquite less than 6 feet tall with many stems at ground level, the leaf spray method may be the best option. Either method can be successful.

Honey Mesquite leaves and beans. *Courtesy of: TREES, SHRUBS AND WOODY VINES OF THE SOUTHWEST by Robert A. Vines, Illustrated by Sarah Kahlden Arendale, Copyright ©1960*

BRUSH BUSTERS LEAF SPRAY METHOD

Works well on: Mesquite plants that have good leaf canopy and are less than 6 feet tall. This method is also known as high-volume foliar spraying.

When to apply: Begin in spring, when mesquite leaves change color from light pea-green to a uniform dark-green; continue through July 31st for East and South Texas, while other parts of the state may be able to spray through September. If mesquite has been top killed by fire, hand cutting, herbicide methods, or any mechanical methods, allow two full growing seasons before using the Brush Busters leaf spray method.

*Professors and Extension Range Specialists, The Texas A&M University System

1. Prepare the Equipment

Many types of sprayers work well for this method. Backpack sprayers are the most efficient for small acreage places or those with a high density of mesquite trees. Larger places with lower densities may find ATV or UTV sprayers more efficient. Before you start spraying, make sure that you have an adjustable cone nozzle, such as the Conejet™ 5500-X6 or X8 nozzle that can deliver a coarse spray with larger droplets to the top of a 6-foot tree.

2. Mix the Herbicide Spray

You can achieve 76 to 100 percent mortality by spraying with one of several herbicide options (see options A, B, or C in the table on the next page) under ideal conditions. To prepare the spray mix, add the selected herbicide to water. To make sure the foliage is coated thoroughly, add a high-quality (80 to 90 percent active ingredient) non-ionic surfactant (see table on the next page) to the spray mix or crop oil, methylated seed oil (MSO), or MSO-OS (organosilicone) adjuvant at manufacturer specified rates. Add a dye, such as Hi-Light™ blue dye, to mark plants that have been sprayed and ensure proper coverage.

3. Spray the Mesquite

Adjust the nozzle to deliver a coarse spray in a wide pattern. Wet ALL the leaves of each mesquite plant until the leaves glisten but not to the point of dripping.

Keep These Points in Mind:

- Follow herbicide label directions.
- For best results, do not spray when:
  - Rains have stimulated new growth at the end of the stems
  - Leaves are wet from rain or dew
  - Foliage shows damage from hail, insects, or disease
  - Working upwind of desirable trees, shrubs, or crops
- The cost of treatment rises rapidly as the brush becomes bigger and denser. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Controlling mesquite is not a one-time job. You will need to monitor your land every year to check for new plants.

RECOMMENDED LEAF SPRAY HERBICIDE MIX OPTIONS*						
	Ingredient	Concentration in Spray Solution	Tank Size			
			1 gal	3 gal	14 gal	25 gal
Option A	Sendero	1%	1.28 oz	4 oz	18 oz	32 oz
Option B**	Invora**	1.5%	1.92 oz	5.76 oz	27 oz	48 oz
Option C	Remedy Ultra, Clear Pasture, Triclopyr R&P and Triclopyr 4EC	0.5%	0.64 oz	2 oz	9 oz	16 oz
	Pyramid R&P and Clopyralid 3	0.5%	0.64 oz	2 oz	9 oz	16 oz
Add to option A, B, and C	Surfactant	1/4%	0.32 oz	1 oz	4.5 oz	8 oz
	Hi-Light™ blue dye	1/4–1/2%	0.32–0.64 oz	1–2 oz	4.5–9 oz	8–16 oz

*All leaf spray solutions are mixed in water.
**Invora is labeled for privately owned rangelands only *(excludes hay fields)* and requires Picolinic Acid Chemistry Training for all applicators.

BRUSH BUSTERS STEM SPRAY METHOD

Works well: For controlling young seedlings or older trees with three or fewer basal stems. Multi-stemmed mesquite plants are much more difficult to control than younger trees or undisturbed plants.

Research and demonstrations have shown excellent results while using minimum amounts of herbicide.

When to apply: Anytime during the year, although the best results occur during the growing season. The Invora mixture (option B) is best applied late spring through summer.

1. Prepare the Equipment

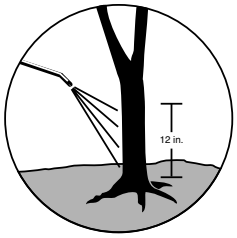
Almost any type of pump-up hand sprayer can be used, but the most efficient way to apply the stem spray to many trees is with a backpack sprayer.

Make sure the sprayer's nozzle has a small orifice. One such nozzle is the Conejet™ 5500-X1 (or X2). Compared to standard nozzles, this nozzle can reduce the amount of spray applied by 80 percent, making the use of chemicals much more cost-effective.

2. Mix the Herbicide Spray

For spraying mesquite stems, there are two mixture options.

For triclopyr ester applications (option A), pour the required amount of herbicide (trade names: Remedy Ultra, Clear Pasture, Triclopyr R&P, and Triclopyr 4EC) into the mixing container (concentration depends on mesquite stem diameter and bark roughness), and then bring to the desired total volume by addition of diesel fuel or basal bark oil, which act as coating agents to ensure good absorption. Shake vigorously to ensure thorough mixing.



For Invora stem applications (option B), fill the mixing container half full of water. Add Invora, a methylated seed oil organo-silicone (MSO-OS; 1 percent) adjuvant, and Hi-Light™ blue dye (0.25 to 0.5 percent). Then add water to the desired volume and mix well.

RECOMMENDED STEM SPRAY HERBICIDE MIXES				
	Mesquite Type and Stem Diameter	Herbicide	Herbicide/ Gallon	Herbicide Carrier/Gallon
Option A	Smooth bark 1.5 in or less	Triclopyr ester, 15%	19 oz	109 oz diesel or basal bark oil
	Smooth bark 1.5 to 4 in	Triclopyr ester, 25%	32 oz	96 oz diesel or basal bark oil
	Rough bark	Triclopyr ester, 25%	32 oz	96 oz diesel or basal bark oil
Add to option A	Hi-Light™ blue dye (optional)		0.32–0.64 oz	
Option B*	Smooth bark 4 in or less	Invora*, 15%	19 oz	109 oz water
Add to option B	MSO-OS Adjuvant		1.28 oz	
	Hi-Light™ blue dye		0.32–0.64 oz	

*Invora is labeled for privately owned rangelands only (*excludes hay fields*) and requires Picolinic Acid Chemistry Training for all applicators.

3. Spray the Mesquite

Adjust the sprayer nozzle to deliver a narrow, cone-shaped mist. Spray the mixture lightly but evenly on all the plant stems from the ground line up to 12 inches. Apply the mixture to all sides of every stem, but do not wet it so much that it runs off the stem and puddles.

Keep These Points in Mind:

- Follow all label directions.
- The cost of treatment increases as plant density and the number of stems per plant increases. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Rough-bark mesquites (usually older trees) are much harder to kill than smooth-bark mesquites.
- Multi-stemmed plants are more difficult to control with this method. It is best to use this on plants with three or fewer stems.
- Do not spray when the basal stems are wet.
- Dense grass around basal stems makes this method more difficult to apply.
- With triclopyr ester, use herbicides that contain 4 pounds per gallon of triclopyr acid equivalent (ae).

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HOW TO BRUSH OFF MINOR SPECIES

Individual Plant Treatment Leaf Application

Robert K. Lyons and Megan K. Clayton*

Brush species that can become local problems but are not widespread across the state include agarito, bumelia, catclaw acacia, catclaw mimosa, coyotillo, flameleaf sumac, lotebush, tasajillo, Texas mountain laurel, and whitebrush. These species typically occur in mixed-brush communities but have the potential to grow out of balance in some situations.

Here is a three-step leaf application method to control these species that is easy, inexpensive, and environmentally responsible. It involves spraying a small but potent concentration of herbicide directly on each plant to selectively control unwanted species. Remember, controlling brush is not a one-time job. Both livestock and wildlife spread seeds, so monitor your land regularly to control unwanted seedlings.

This Brush Busters control method was developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of the Texas A&M University System. Your results may vary with weather and other plant conditions, but you should usually be able to kill 76 to 100 percent of the plants you treat.

BRUSH BUSTERS LEAF SPRAY METHOD

Works well on: Plants that have good leaf canopy and are less than 6 feet tall. This method is also known as high-volume foliar spraying.

When to apply: Begin in late spring through summer with mature, healthy leaves. Plants should have a full leaf canopy and good soil moisture, especially plants like whitebrush that lose their leaves during dry periods.

1. Prepare the Equipment

Many types of sprayers work well for this method. Backpack sprayers are the most efficient for small acreages or those with a high density of trees. Larger places with lower densities may find ATV or UTV sprayers more efficient. Before you start spraying, make sure that you have an adjustable cone nozzle, such as the ConeJet™ 5500-X6 or X8 nozzle that can deliver a coarse spray with larger droplets to the top of a 6-foot tree.

2. Mix the Herbicide Spray

You can achieve 76 to 100 percent mortality by spraying with 1.5 percent Invora herbicide under ideal conditions. To prepare the spray mix, add the appropriate amount of Invora herbicide to water. To make sure the foliage is coated thoroughly, add a high-quality (80 to 90 percent active ingredient) non-ionic surfactant (see table) to the spray mix or MSO-OS (organo-silicone) adjuvant at manufacturer specified rates. Add a dye, such as Hi-Light™ blue dye, to mark plants that have been sprayed to ensure proper coverage.

RECOMMENDED LEAF SPRAY HERBICIDE MIX OPTIONS*

Ingredient	Concentration in Spray Solution	Tank Size			
		1 gal	3 gal	14 gal	25 gal
Invora**	1.5%	1.92 oz	5.76 oz	27 oz	48 oz
Non-ionic surfactant	0.25%	0.32 oz	1 oz	4.5 oz	8 oz
Hi-Light™ blue dye	0.25–0.5%	0.32–0.64 oz	1–2 oz	4.5–9 oz	8–16 oz

*All leaf spray solutions are mixed in water.

**Invora is labeled for privately owned rangelands only (*excludes hayfields*) and requires Picolinic Acid Chemistry Training for all applicators.

3. Spray the Plants

Adjust the nozzle to deliver a coarse spray in a wide pattern. Wet ALL the leaves of each plant until the leaves glisten but not to the point of dripping.

Keep These Points in Mind:

- Follow the herbicide label directions.
- For best results, do not spray when:
  - Rains have stimulated new growth at the end of the stems
  - Leaves are wet from rain or dew
  - Foliage shows damage from hail, insects, or disease
  - Working upwind of desirable trees, shrubs, or crops
- The cost of treatment rises rapidly as brush becomes bigger and denser. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Controlling brush is not a one-time job. You will need to monitor your land every year to check for new plants.

*Professors and Extension Range Specialists, The Texas A&M University System

RWFM-PU-123 11/2021

HOW TO CONTROL HONEY LOCUST

Individual Plant Treatment Leaf Application

Barron S. Rector[1] and Megan K. Clayton[2]

Honey locust is a frequent invader in East and Central Texas as well as in creek bottoms and riparian areas throughout the state. Honey locust is native to Texas and can grow up to 100 feet tall, creating dense thickets that prohibit travel for livestock and wildlife. The trunk and branches of honey locust are densely thorny, with older trees having clusters of thorns on the bark. Although the leaves have little value for wildlife or livestock, the pods contain up to 30 percent sugar and are readily consumed.

Honey locust and beans. *Courtesy of: TREES, SHRUBS AND WOODY VINES OF THE SOUTHWEST by Robert A. Vines, Illustrated by Sarah Kahlden Arendale, Copyright ©1960*

This Brush Busters three-step leaf application method for honey locust control is easy, inexpensive, and environmentally responsible. It involves spraying a potent concentration of herbicide directly on each plant to selectively control unwanted honey locust. Remember, controlling honey locust is not a one-time job. Both livestock and wildlife spread seeds, so monitor your land regularly to control unwanted seedlings.

This Brush Busters control method was developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of the Texas A&M University System. Your results may vary with weather, but you should usually be able to kill 76 to 100 percent of the trees you treat.

BRUSH BUSTERS LEAF SPRAY METHOD

Works well on: Honey locust plants that have good leaf canopy and are less than 6 feet tall. This method is also known as high-volume foliar spraying.

When to apply: Begin in late spring after the leaves mature and throughout the summer as long as the leaves remain healthy.

1. Prepare the Equipment

Many types of sprayers work well for this method. Backpack sprayers are the most efficient for small acreages or those with a high density of honey locust trees. Larger places with lower densities may find ATV or UTV sprayers more efficient. Before you start spraying, make sure that you have an adjustable cone nozzle, such as the ConeJet™ 5500-X6 or X8 nozzle that can deliver a coarse spray with larger droplets to the top of a 6-foot tree.

2. Mix the Herbicide Spray

You can achieve 76 to 100 percent mortality with one of several herbicide options (see “Options” in the table on the next page) under ideal conditions. If you have honey locust and mesquite in the same pasture, Sendero will provide a very high level of control on both species. If you have honey locust and prickly pear, MezaVue will control both species. GrazonNext HL, MezaVue, and Grazon P+D require a private applicator license, while Sendero is an unrestricted herbicide that does not require a license.

To prepare the spray mix, add the selected herbicide to water. To make sure the foliage is coated thoroughly, add a high-quality (80 to 90 percent active ingredient) non-ionic surfactant (see table) to the spray mix or crop oil, methylated seed oil (MSO), or MSO-OS (organo-silicone) adjuvant at manufacturer specified rates. Add a dye, such as Hi-Light™ blue dye, to mark plants that have been sprayed to ensure proper coverage.

3. Spray the Honey Locust

Adjust the nozzle to deliver a coarse spray in a wide pattern. Wet ALL the leaves of each honey locust plant until the leaves glisten but not to the point of dripping.

Keep These Points in Mind:

- Follow herbicide label directions.
- For best results, do not spray when:
  - Rains have stimulated new growth at the end of the stems
  - Leaves are wet from rain or dew
  - Foliage shows damage from hail, insects, or disease
  - Working upwind of desirable trees, shrubs, or crops
- The cost of treatment rises rapidly as brush becomes bigger and denser. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Controlling honey locust is not a one-time job. You will need to monitor your land every year to check for new plants.

[1] Associate Professor and Extension Range Specialist, The Texas A&M University System
[2] Professor and Extension Range Specialist, The Texas A&M University System

RECOMMENDED LEAF SPRAY HERBICIDE MIX OPTIONS*						
Option	Ingredient	Concentration in Spray Solution	Tank Size			
			1 gal	3 gal	14 gal	25 gal
A	Sendero	1%	1.28 oz	4 oz	18 oz	32 oz
B	GrazonNext HL	1%				
C	MezaVue	1%				
D	Grazon P+D or Gunslinger	1%				
Add to options above	Non-ionic surfactant	0.25%	0.32 oz	1 oz	4.5 oz	8 oz
	Hi-Light™ blue dye	0.25–0.5%	0.32–0.64 oz	1–2 oz	4.5–9 oz	8–16 oz

*All leaf spray solutions are mixed in water.

RWFM-PU-064 11/2021

HOW TO CONTROL MACARTNEY ROSE:

Individual Plant Treatment Leaf Spray Application

Megan K. Clayton and Robert K. Lyons*

Macartney rose, also known as Cherokee rose and rose hedge, presents severe management problems for livestock producers in Southeast Texas to the Middle Coastal Prairie. Imported from Asia in the late 1800s as a hedge for fencing purposes, the plant has escaped and naturalized.

Although dense stands can be somewhat controlled by using herbicides, mechanical methods, and prescribed burning, no single method has been totally effective. The most successful approach to control Macartney rose is to implement an integrated system using several methods applied sequentially. The plant is easiest to manage when there are a few single, small plants (disturbed or undisturbed).

Here is a three-step method to control Macartney rose that is easy, inexpensive, and environmentally responsible. It involves spraying a small but potent concentration of herbicide directly on each plant to selectively control unwanted rose. Macartney rose has some use as browse and for wildlife cover, but if it is allowed to establish dense colonies, the disadvantages greatly outweigh its limited merits.

This Brush Busters control method was developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of the Texas A&M University System. Your results may vary with weather and other plant conditions, but you should usually be able to kill 76 to 100 percent of plants you treat.

BRUSH BUSTERS LEAF SPRAY METHOD

Works well on: Individual disturbed or undisturbed Macartney rose clumps:

- Undisturbed: Undisturbed plants that are 5 feet or less in height and diameter.
- Disturbed: Apply herbicide treatment to mowed or otherwise disturbed plants within 3 years of disturbance. Avoid spraying earlier than 9 to 12 months after mowing or when plants have high amounts of new growth. Expect poor control if plants are less than 3 feet tall when sprayed.

When to apply: Begin in the spring under good growing conditions when soil temperature reaches 75°F at 12 to 18 inches deep. Stop in late spring during flowering and hip (fruit) formation. Begin again late summer or early fall under good growing conditions, and continue until soil temperatures drop below 75°F.

1. Prepare the Equipment

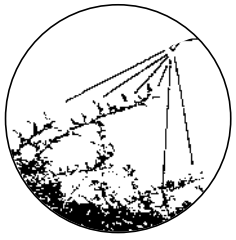
Many types of sprayers work well for this method. Backpack sprayers are the most efficient for small acreages or those with a high density of Macartney rose plants. Larger places with lower densities may find ATV or UTV sprayers more efficient. Before you start spraying, make sure you have an adjustable nozzle, such as the ConeJet™ 5500-X6 or X8 nozzle that can deliver a coarse spray with larger droplets to the top of a 5-foot clump.

2. Mix the Herbicide Spray

You can achieve 76 to 100 percent mortality by spraying with an herbicide containing picloram and 2,4:D (1:4; trade names Grazon P+D, Gunslinger, or Picloram+D) under ideal conditions. To prepare the spray mix, add the selected herbicide to water. To make sure the foliage is coated thoroughly, add a high-quality (80 to 90 percent active ingredient) non-ionic surfactant (see table on next page) to the spray mix or crop oil, methylated seed oil (MSO), or MSO-OS (organo-silicone) adjuvant at manufacturer specified rates. Add a dye, such as Hi-Light™ blue dye, to mark plants that have been sprayed and ensure proper coverage.

3. Spray the Macartney Rose

Adjust the nozzle to deliver a coarse spray in a wide pattern. Wet ALL the leaves of each Macartney rose plant until leaves glisten but not to the point of dripping. The spray pressures may need to be high to penetrate larger plants with heavier canopies.



*Professors and Extension Range Specialists, The Texas A&M University System

RECOMMENDED LEAF SPRAY HERBICIDE MIX*					
Ingredient	Concentration in Spray Solution	Tank Size			
		1 gal	3 gal	14 gal	25 gal
Picloram:2,4-D (1:4) herbicide	1%	1.28 oz	3.84 oz	18 oz	32 oz
Non-ionic surfactant	0.25%	0.32 oz	1 oz	4.5 oz	8 oz
Hi-Light™ blue dye	0.25–0.5%	0.32–0.64 oz	1–2 oz	4.5–9 oz	8–16 oz

*All leaf spray solutions are mixed in water.

Keep These Points in Mind:

- Follow herbicide label directions.
- For best results, do not spray when:
  - Rains have stimulated new growth at the end of stems
  - Leaves are wet from rain or dew
  - Plants are less than 3 feet tall after mowing
  - Foliage shows damage from hail, insects, or disease
  - Working upwind of desirable trees, shrubs, or crops
  - Flowers or fruits are present
  - Soil temperatures are below 75°F
- Cost of treatment rises rapidly as Macartney rose becomes bigger and denser. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Controlling Macartney rose is not a one-time job. You will need to monitor your land every year to check for new plants.
- Macartney rose usually grows on soils with a high clay content. Soil-applied herbicides are generally ineffective for controlling rose on these soils.

RWFM-PU-100
February 2023

HOW TO CONTROL PRICKLY PEAR AND OTHER CACTI:

Individual Plant Treatment Pad & Stem Application or Top Removal Method

Robert K. Lyons and Megan K. Clayton*

Prickly pear is a valuable rangeland plant, but it can form dense colonies and interfere with the movement and handling of livestock, decrease forage utilization, and compete with desirable vegetation. Prickly pear are extremely tolerant of drought and harsh conditions. Therefore, they thrive across Texas—especially in the western half of the state.

Here are two methods to selectively control prickly pear that are easy, inexpensive, and environmentally responsible. One involves spraying a small but potent concentration of herbicide directly on the pads and stems to selectively control unwanted prickly pear. The second method uses a mechanical option to simply remove the top part of the plant.

These Brush Busters control methods were developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of The Texas A&M University System. Results may vary with weather and other plant conditions, but correct applications should usually be able to kill 76 to 100 percent of treated prickly pear pads.

Remember: Controlling prickly pear is not a one-time job. Both livestock and wildlife spread seeds and scatter pads that can root into new plants, so monitor your land regularly to control unwanted seedlings.

BRUSH BUSTERS PAD AND STEM SPRAY METHOD

Works well on: Relatively thin stands of prickly pear. Dense stands may benefit from a broadcast treatment first.

When to apply: Anytime throughout the year when there is adequate soil moisture, except during extremely cold weather. Absence of rainfall for extended periods after spraying may reduce plant mortality.

1. Prepare the Equipment

Many types of sprayers work well for this method. Backpack sprayers are the most efficient for small acreages or those with a high density of prickly pear. Larger places with lower densities may find ATV or UTV sprayers more efficient. An adjustable cone nozzle—such as the ConeJet™ 5500-X6 or X8 nozzle that can deliver a coarse spray—will be more efficient for smaller plants, while a fan-type nozzle may be best for larger plants.

2. Mix the Herbicide Spray

You can achieve 76 to 100 percent mortality by spraying with one of several herbicide options, including MezaVue (aminopyralid + picloram + fluroxypyr), Surmount/Trooper Pro (picloram + fluroxypyr), Tordon 22K/Triumph 22K/Picloram 22K (picloram), or PastureGard HL (triclopyr + fluroxypyr). To prepare the spray mix, add the selected herbicide at a 1 percent rate to water. To make sure the pads and stems are coated thoroughly, add a high-quality (80 to 90 percent active ingredient) non-ionic surfactant to the spray mix or crop oil, methylated seed oil (MSO), or MSO-OS (organo-silicone) adjuvant at manufacturer's specified rates (see table on next page). Add a dye, such as Hi-Light™ blue dye, to mark plants that have been sprayed and ensure proper coverage.

3. Spray the Prickly Pear

Adjust the nozzle to deliver a coarse spray in a wide pattern. Wet ALL the pads and stems of each prickly pear plant but not to the point of runoff. It is best to spray both sides of the pad for more consistent results.

Keep These Points in Mind:

- Follow herbicide label directions.
- Prickly pear may die very slowly—taking up to 2 to 3 years after application for potential plant mortality to occur.
- For best results, do not spray when:
  - Pads are wet from rain or dew.
  - Daily maximum air temperature has not exceeded 50 degrees F for at least 3 consecutive days.
  - Working upwind of desirable trees, shrubs, or crops.
  - Prickly pear growth is dense.
- Cost of treatment rises rapidly as prickly pear becomes bigger and denser. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Large prickly pear plants may be used as quail nesting sites where bunchgrass is limited or serve as a food source for deer or javelina.

*Professors and Extension Range Specialists, The Texas A&M University System

RECOMMENDED PAD AND STEM SPRAY HERBICIDE MIX OPTIONS*					
Ingredient	Concentration in Spray Solution	Tank Size			
		1 gal	3 gal	14 gal	25 gal
MezaVue, PastureGard HL, Surmount/Trooper Pro, or Tordon 22K/Triumph 22K/ Picloram 22K	1%	1.28 oz	3.84 oz	18 oz	32 oz
Non-ionic surfactant	0.25%	0.32 oz	1 oz	4.5 oz	8 oz
Hi-Light™ blue dye	0.25–0.5%	0.32–0.64 oz	1–2 oz	4.5–9 oz	8–16 oz

*All spray solutions are mixed in water.

BRUSH BUSTERS TOP REMOVAL METHOD

Cut the main root of prickly pear 2 to 4 inches below the soil surface with a grubbing hoe or shovel. Remove the detached plants from the area or stack them on piles of brush. Remember: Any prickly pear pads that come in contact with the ground have the ability to root and become new plants.

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HOW TO MASTER CEDAR:

Individual Plant Treatment Leaf and Spot Spray Applications or Top Removal Method

Robert K. Lyons and Megan K. Clayton*

Cedars can be very aggressive and damaging woody plants on Texas rangelands. There are two major cedar species west of Interstate 35: redberry cedar and blueberry cedar.

It is important to know which species you have because treatments vary. As the names imply, blueberry cedar has blue berries, and redberry cedar has red berries. In addition, redberry cedar has small specks of white wax on its leaves and twigs. Blueberry cedar is more common in Central and South-Central Texas, while redberry cedar is more common in West, West-Central, and North-Central Texas. It is not uncommon for the two species to occur together.

Brush Busters recommends three ways to control cedar that are easy, inexpensive, environmentally responsible, and effective. Two herbicide treatments—leaf spray and soil spot spray—work best on cedar less than 3 feet tall. The top removal method, which involves cutting the tree at ground level, will control blueberry cedar, but redberry cedar must be grubbed (cut) below the soil surface.

These Brush Busters control methods were developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of the Texas A&M University System. Your results may vary with weather and other plant conditions, but you should usually be able to kill 76 to 100 percent of trees you treat.

It is very important to control cedar as seedlings and saplings. Controlling mature cedars requires heavy equipment or large amounts of herbicides and is usually very expensive. Controlling cedar is not a one-time job. Livestock and wildlife spread the seeds easily, so you will need to check your land occasionally and treat unwanted seedlings.

BRUSH BUSTERS LEAF SPRAY METHOD

Works well on: Blueberry or redberry cedars that are less than 3 feet tall.

When to apply: Spring through summer when cedar is actively growing.

1. Prepare the Equipment

Many types of sprayers work well for this method. Backpack sprayers are the most efficient for small acreage places or those with a high density of cedar trees. Larger places with lower densities may find ATV or UTV sprayers more efficient. Before you start spraying, make sure that you have an adjustable nozzle, such as the Conejet™ 5500-X6 or X8 nozzle that can deliver a coarse spray with larger droplets.

2. Mix the Herbicide Spray

A mixture of picloram herbicide (trade names: Tordon 22K, Triumph 22K, or Picloram 22K) in water is very effective for this method. To make sure foliage is coated thoroughly, add a high-quality (80 to 90 percent active ingredient) non-ionic surfactant to the spray mix. Add a dye, such as Hi-Light™ blue dye, to mark plants that have been sprayed and ensure proper coverage (see table on next page).

3. Spray the Cedar

Adjust the nozzle to deliver a coarse spray in a wide pattern. Wet ALL the leaves of each cedar plant to the point of runoff.

Keep These Points in Mind:

- Follow herbicide label directions.
- For best results, do not spray when:
  - Leaves are wet from rain or dew
  - Working upwind of desirable trees, shrubs, or crops
- The cost of treatment increases rapidly as the density and size of cedars increase. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Large, mature blueberry cedar may be a nesting habitat for the endangered golden-cheeked warbler. If in doubt, contact the United States Fish and Wildlife Service before treating.
- Do not spray within 100 feet of known sinkholes or fractures that would allow herbicide to enter underground water aquifers.
- Do not treat large numbers of cedars beneath canopies or within three times the height or diameter of desirable trees such as oaks or pecans.

*Professors and Extension Range Specialists, The Texas A&M University System

RECOMMENDED LEAF SPRAY HERBICIDE MIX OPTIONS*					
Ingredient	Concentration in Spray Solution	Tank Size			
		1 gal	3 gal	14 gal	25 gal
Picloram herbicide	1%	1.28 oz	4 oz	18 oz	32 oz
Surfactant	0.25%	0.32 oz	1 oz	4.5 oz	8 oz
Hi-Light™ blue dye	0.25–0.5%	0.32–0.64 oz	1–2 oz	4.5–9 oz	8–16 oz

*All leaf spray solutions are mixed in water.

BRUSH BUSTERS SPOT SPRAY METHOD

Works well on: Blueberry or redberry cedars that are less than 3 feet tall.

When to apply: Late winter to mid-spring (ideally before expected rainfall).

1. Prepare the Equipment

Soil spot sprays should be applied with an exact-delivery handgun. This piece of equipment is available from most herbicide retail outlets. The handgun delivers a thin stream of predetermined volume when triggered. Adjust the handgun to deliver 2 milliliters (cc) for each pull of the trigger. If only a few plants are to be treated, a disposable syringe can be used. Thoroughly clean all spray equipment immediately after use.

2. Prepare the Herbicide

Velpar L™ is a recommended herbicide for soil spot sprays to control cedar. The herbicide is used undiluted by attaching an exact-delivery handgun or syringe to the herbicide container. Pronone Power Pellet™ can also be used. Each pellet is equivalent to 2 ml (cc) of Velpar L™.

3. Apply the Herbicide

Apply undiluted Velpar L™ or Pronone Power Pellet™ to the soil surface midway between the cedar stem and the canopy-edge. Apply 2 ml for every 3 feet of plant height or every 3 feet of plant canopy diameter (whichever is greater). If plant size requires more than a single 2 ml application, space applications equally around the plant. Apply each 2 ml dose to a single spot on the soil surface. On slopes, apply most of the herbicide on the uphill side of the stem.

Keep These Points in Mind:

- Follow herbicide label directions.
- Do not use on marshy or poorly drained sites.
- Do not use on clay soils.
- Do not apply to snow-covered or frozen ground.
- Do not apply within three times the height or canopy diameter (whichever is greater) of desirable trees such as oaks or pecans.
- Rainfall is required to "activate" Velpar L™ or Pronone Power Pellet™ in the soil. Plants will begin to show symptoms within 3 to 6 weeks of initial rainfall. One to three growing seasons may be required before plants die. During this time, cedars usually sprout new leaves several times.
- Grasses and weeds will be killed where each spot of Velpar L™ or Pronone Power Pellet™ is applied. Recovery may take 2 to 3 years.
- The cost of treatment rises rapidly as the density and size of cedar increases.

BRUSH BUSTERS TOP REMOVAL METHOD

Blueberry cedar: Remove the plant top at or near the ground line with a chainsaw, pruner, axe, etc. Seedlings (plants less than 2 feet tall) can be killed easily by hand grubbing.

Redberry cedar: Since redberry cedar re-sprouts, top removal will not effectively control plants that are over 8 to 10 years old. Redberry cedar seedlings (plants less than 2 feet tall) can be easily killed if they are grubbed below the basal "knob," located at or slightly beneath the soil surface.

RWFM-PU-059 05/22

HOW TO PUT A HALT TO SALTCEDAR

Individual Plant Treatment Leaf and Stem Applications

Megan K. Clayton[1], Barron Rector[2], and Joshua McGinty[3]

Saltcedar is one of the most invasive, hard-to-control woody plants in the world. Introduced from Eurasia into the western United States in the early 1800s, this plant rapidly spreads along rivers, lakes, and streams. Once established, it quickly chokes out desirable vegetation. Most important, saltcedar can draw water from underground aquifers—as much as 200 gallons per plant per day.

Here are two three-step methods to control saltcedar; both are easy, inexpensive, and environmentally responsible. They involve spraying a small but potent concentration of herbicide directly on each plant to selectively control unwanted saltcedar. Remember, controlling saltcedar is not a one-time job. Both livestock and wildlife spread seeds, so monitor your land regularly to control unwanted seedlings.

These Brush Busters control methods were developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of the Texas A&M University System. Your results may vary with weather and other plant conditions, but you should usually be able to kill 76 to 100 percent of the trees you treat.

These Brush Busters control methods depend on the tree density and size. For low densities of smooth-barked saltcedar with few stems, the stem spray method may be a good option. For dense stands of saltcedar less than 6 feet tall, the leaf spray method may be more suitable. Either method can be successful.

BRUSH BUSTERS LEAF SPRAY METHOD

Works well: On saltcedar that have good leaf canopy and are less than 6 feet tall. This method is also known as high-volume foliar spraying.

When to apply: Begin in July and spray through September or until leaves begin to turn yellow.

1. Prepare the Equipment

You may use a pump-up garden sprayer, backpack sprayer, cattle sprayer, or sprayer mounted on a 4-wheel, all-terrain vehicle (ATV). Backpack sprayers and ATV sprayers will be more efficient if there are many plants to spray. Before you start spraying, make sure that you have an adjustable cone nozzle, such as the Conejet™ 5500-X6 or X8 nozzle that can deliver a coarse spray with larger droplets to the top of a 6-foot tree.

[1] Professor and Extension Range Specialist
[2] Associate Professor and Extension Range Specialist
[3] Associate Professor and Extension Agronomist

2. Mix Herbicides

You can achieve 76 to 100 percent mortality by spraying saltcedar with a mixture of the herbicides imazapyr (trade names: Arsenal®, Habitat® [aquatic product] and glyphosate (trade names: Roundup PowerMAX®, Rodeo® [aquatic product], Roundup WeatherMAX®, many generic formulations available). If spraying over water, it is important to select herbicides with an aquatic label.

The amount of glyphosate herbicide needed in the mix depends on the strength of glyphosate active ingredient (acid equivalent) in the container. This acid equivalent is noted underneath the percent of active ingredients on the front of the herbicide container label. Use the glyphosate conversion chart below to determine the amount of herbicide to include.

To prepare the spray mix, add 0.5 percent of imazypyr and the correct amount of glyphosate (see Conversion Chart) to water (see table below). To make sure the foliage is coated thoroughly, add a high-quality (80 to 90 percent active ingredient) non-ionic surfactant to the spray mix. Add a dye, such as Hi-Light® blue dye, to mark plants that have been sprayed and ensure proper coverage.

RECOMMENDED LEAF SPRAY HERBICIDE MIX OPTIONS*

Ingredient	Concentration in Spray Solution	Tank Size			
		1 gal	3 gal	14 gal	25 gal
Imazapyr	0.5%	0.64 oz	2 oz	9 oz	16 oz
Glyphosate	See Table Below				
Surfactant (if needed)	0.25%	0.32 oz	1 oz	4.5 oz	8 oz
Hi-Light™ blue dye	0.25–0.5%	0.32–0.64 oz	1–2 oz	4.5–9 oz	8–16 oz

*All spray solutions are mixed in water.

GLYPHOSATE CONVERSION CHART

Glyphosate Acid Equivalent (lb/gal; not percent)	Concentration in Spray Solution	Tank Size			
		1 gal	3 gal	14 gal	25 gal
3 lb/gal	0.67%	0.85 oz	3 oz	12 oz	21.5 oz
4 lb/gal	0.5%	0.64 oz	2 oz	9 oz	16 oz
4.5 lb/gal	0.44%	0.57 oz	2 oz	8 oz	14.5 oz
4.8 lb/gal	0.42%	0.42 oz	2 oz	7.5 oz	13.5 oz

3. Spray the Saltcedar

Adjust the nozzle to deliver a course spray in a wide pattern. Wet ALL the leaves of each saltcedar plant until the leaves glisten but not to the point of dripping.

Keep These Points in Mind:

- Follow herbicide label directions.
- For best results, do not spray when:
  - Leaves have turned yellow
  - Rains have stimulated new growth at the end of the stems
  - Leaves are wet from rain or dew
  - Foliage shows damage from hail, insects, or disease
  - Working upwind of desirable trees, shrubs, or crops
- Check the imazapyr product label for restrictions on use related to endangered species and livestock grazing or haying.
- Where spray may contact aquatic environments, use glyphosate, imazapyr, and surfactants with appropriate aquatic labels
- The cost of treatment rises rapidly as the brush becomes bigger and denser. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Leave treated saltcedar undisturbed for two full years after treatment for best results.
- Controlling saltcedar is not a one-time job. You will need to monitor your land every year to check for new plants.

BRUSH BUSTERS STEM SPRAY METHOD

Works well: On low densities of saltcedar and larger, tree-type plants with few stems. Multi-stemmed saltcedar plants are much more difficult to control.

Research and demonstrations have shown excellent results while using minimum amounts of herbicide.

When to apply: Anytime during the year, although best results occur during the growing season.

1. Prepare the Equipment

Almost any type of pump-up hand sprayer can be used, but the most efficient way to apply the stem spray to many trees is with a backpack sprayer.

Make sure the sprayer's nozzle has a small orifice. One such nozzle is the Conejet™ 5500- X1 (or X2). Compared to standard nozzles, this nozzle can reduce the amount of spray applied by 80 percent, making the use of chemicals much more cost-effective.

2. Mix the Herbicide Spray

A mixture of triclopyr ester (trade names: Remedy® Ultra, Relegate®, Triclopyr 4E, Clear Pasture, Triclopyr 4EC, many generic 4 lb/gal a.e. formulations available) and diesel fuel oil is very effective for this method. Diesel acts as a coating agent to ensure good absorption. A basal bark (vegetable) oil may be used instead of diesel if desired.

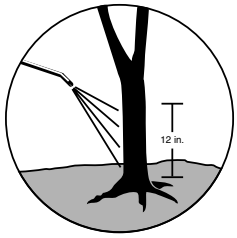
Recommended Herbicide Mix

Pour 25 percent triclopyr ester into the mixing container, then add diesel fuel to bring the mixture to the total volume desired. Agitate the mixture vigorously.

Glyphosate Acid Equivalent (lb/gal; not percent)	Concentration in Spray Solution	Amount/gallon mix
Triclopyr ester	25%	32 oz
Diesel	75%	96 oz
Hi-Light™ blue dye (optional)	0.25–0.5%	0.32–0.64 oz

3. Spray the Saltcedar

Adjust the sprayer nozzle to deliver a narrow, cone-shaped mist. Spray the mixture lightly but evenly on all the plant stems from the ground line up to 12 inches. Apply the mixture to all sides of every stem, but do not wet it so much that it runs off the stem and puddles.



Keep These Points in Mind:

- Follow the herbicide label directions.
- The cost of treatment escalates rapidly as brush becomes denser or the number of basal stems per plant increases. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Multi-stemmed or rough-barked plants are more difficult to control with this method.
- Do not spray when the basal stems are wet.
- After mixing herbicide with diesel, shake or agitate the solution vigorously.
- This method is more difficult to apply if there is dense grass around the basal stems.

RWFM-PU-062 10/2021

HOW TO TAKE OUT TALLOW TREES:
Individual Plant Treatment Leaf and Stem Applications

Robert K. Lyons and Megan K. Clayton*

Chinese tallow trees have invaded and become dense on many upland and wetland sites in prairie and woodland communities of the Texas Coastal Prairie. Tallow trees establish easily, grow quickly, and produce large quantities of seed. The trees resprout quickly from crown and root buds when top-growth is mechanically removed.

Here are two three-step methods to control Chinese tallow trees; both are easy, inexpensive, and environmentally responsible. They involve spraying a small but potent concentration of herbicide directly on each plant to selectively control unwanted trees. Remember, controlling Chinese tallow trees is not a one-time job. The plant produces thousands of seeds that are relatively long-lived and spread by water, birds, and other animals. A tremendous number of seeds build up under parent plants, so monitor your land regularly to find and remove seedlings.

These Brush Busters control methods were developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of the Texas A&M University System. Your results may vary with weather and other plant conditions, but you should usually be able to kill 76 to 100 percent of trees you treat.

Choose the Brush Busters method recommended for the number and size of plants you wish to control. If you have only a few plants, the stem spray method may work best. If you have many plants, but most are less than 6 feet tall, the leaf spray method may be a good option. Either method can be successful.

BRUSH BUSTERS LEAF SPRAY METHOD

Works well on: Chinese tallow trees that have good leaf canopy and are less than 6 feet tall. This method is also known as high-volume foliar spraying.

When to apply: Begin in April or May after tallow tree leaves mature and continue through September or until the leaves begin to turn yellow to red.

1. Prepare the Equipment

Many types of sprayers work well for this method. Backpack sprayers are the most efficient for small acreage places or those with a high density of trees. Larger places with lower densities may find ATV or UTV sprayers more efficient. Before you start spraying, make sure that you have an adjustable cone nozzle, such as the Conejet™ 5500-X6 or X8 nozzle that can deliver a coarse spray with larger droplets to the top of a 6-foot tree.

2. Mix the Herbicide Spray

You can achieve 76 to 100 percent mortality by spraying with an herbicide containing picloram and 2,4:D (1:4; trade names Grazon P+D, Gunslinger, or Picloram+D) under ideal conditions. To prepare the spray mix, add the herbicide to water (see table on the next page). To make sure the foliage is coated thoroughly, add a high-quality (80 to 90 percent active ingredients) non-ionic surfactant to the spray mix. Add a dye, such as Hi-Light™ blue dye, to mark plants that have been sprayed and ensure proper coverage.

3. Spray the Tallow Trees

Adjust the nozzle to deliver a coarse spray in a wide pattern.

Wet ALL the leaves of each tallow tree plant until the leaves glisten but not to the point of dripping.

Keep These Points in Mind:

- Follow herbicide label directions.
- For best results, do not spray when:
  - Rains have stimulated new growth at the end of the stems
  - Leaves are wet from rain or dew
  - Foliage shows damage from hail, insects, or disease
  - Working upwind of desirable trees, shrubs, or crops
- The cost of treatment rises rapidly as trees become bigger and denser. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Controlling Chinese tallow trees is not a one-time job. You need to monitor your land every year to check for new plants.

*Professors and Extension Range Specialists, The Texas A&M University System

RECOMMENDED LEAF SPRAY HERBICIDE MIX OPTIONS*					
Ingredient	Concentration in Spray Solution	Tank Size			
		1 gal	3 gal	14 gal	25 gal
Picloram:2,4-D (1:4) herbicide	1%	1.28 oz	3.84 oz	18 oz	32 oz
Surfactant	0.25%	0.32 oz	1 oz	5 oz	8 oz
Hi-Light™ blue dye	0.25–0.5%	0.32–0.64 oz	1–2 oz	5–9 oz	8–16 oz

*All leaf spray solutions are mixed in water.

BRUSH BUSTERS STEM SPRAY METHOD

Works well on: Young seedlings or older trees with three or fewer basal stems. Multi-stemmed tallow tree plants are much more difficult to control than younger trees or undisturbed plants.

Research and demonstrations have shown excellent results while using minimum amounts of herbicide.

When to apply: Any time during the year, although the best results occur during the growing season.

1. Prepare the Equipment

Almost any type of pump-up hand sprayer can be used, but the most efficient way to apply the stem spray to many trees is with a backpack sprayer.

Make sure the sprayer nozzle has a small orifice. One such nozzle is the Conejet™ 5500-X1 (or X2). Compared to standard nozzles, this nozzle can reduce the amount of spray applied by 80 percent, making the use of chemicals much more cost-effective.

2. Prepare the Herbicide Spray

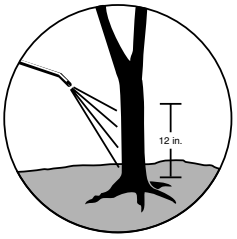
A mixture of triclopyr ester (trade names: Remedy Ultra, Clear Pasture, Triclopyr R&P, and Triclopyr 4EC) and diesel fuel oil is very effective for this method. Diesel acts as a coating agent to ensure good absorption. A basal bark (vegetable) oil may be used instead of diesel if desired.

The herbicide concentration will depend on Chinese tallow tree bark roughness. Pour the correct amount of herbicide into the mixing container, then add diesel fuel (or basal bark oil) to bring the mixture to the total volume desired. Agitate the mixture vigorously.

RECOMMENDED STEM SPRAY HERBICIDE MIXES				
	Tallow Tree Stem	Herbicide	Herbicide/ Gallon	Herbicide Carrier/Gallon
Option A	Smooth bark	Triclopyr ester, 15%	19 oz	109 oz diesel or basal bark oil
Option B	Rough bark	Triclopyr ester, 25%	32 oz	96 oz diesel or basal bark oil
Add to option A or B (optional)		Hi-Light™ blue dye	0.32–0.64 oz	

3. Spray the Chinese Tallow Trees

Adjust the sprayer nozzle to deliver a narrow, cone-shaped mist. Spray the mixture lightly but evenly on all the plant stems from the ground up to 12 inches. Apply the mixture to all sides of every stem, but do not wet to the point that it runs off the stem and puddles.



Keep These Points in Mind:

- Follow all label directions.
- The cost of treatment increases as plant density and the number of stems per plant increases. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Rough-bark tallow trees (usually older trees) are much harder to kill than smooth-bark plants.
- Multi-stemmed plants are more difficult to control with this method. It is best to use on plants with three or fewer stems.
- Do not spray when basal stems are wet.
- Dense grass around basal stems makes this method more difficult to apply.
- With triclopyr ester, use herbicides that contain 4 pounds per gallon of triclopyr acid equivalent (ae).

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HOW TO TAKE THE GREEN OUT OF GREENBRIAR:
Individual Plant Treatment Stem Application

Robert K. Lyons and Megan K. Clayton*

Greenbriar is a native, perennial, woody vine of the Smilax family. Individual plants may vary in leaf shape and color and in the number of spines they contain. Greenbriar may have underground stems and/or tubers. The canes or above-ground stems are soft and fleshy in the early stages of growth but quickly mature into stout, woody vines with tendrils for climbing trees, fences, and other structures.

The small, mostly yellowish-green flowers are borne in umbrella-shaped clusters from April through June and produce many small clusters of reddish to purplish to black berries.

Greenbriar, whether spined or spineless, often becomes a problem by forming large, almost impenetrable thickets that can prevent access by people and livestock.

There are no ground or aerial broadcast recommendations for effectively controlling greenbriar. Broadcast applications of various herbicides have not provided consistent control of this tough, woody vine. However, the following three-step method is easy to use, environmentally responsible, and effective. This method treats individual plants with a mixture of herbicide and diesel fuel oil or vegetable oil applied to basal stems.

This Brush Busters control method was developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of the Texas A&M University System. Your results may vary, but you should usually be able to kill 76 to 100 percent of vines you treat.

Keep in mind that controlling greenbriar is not a one-time job. Greenbriar has hard-to-kill tubers and produces many seeds that will eventually produce new plants. Monitor your land regularly to control unwanted plants.

BRUSH BUSTERS STEM SPRAY METHOD

Works well on: Greenbriar growing on fence lines or where basal stems are easy to access for spraying.

When to apply: During winter, when most of the leaves are gone, and basal stems can be covered more easily with the spray mix.

1. Prepare the Equipment

Almost any type of pump-up hand sprayer can be used, but the most efficient way to apply the stem spray to many trees is with a backpack sprayer.

Make sure the sprayer's nozzle has a small orifice. One such nozzle is the Conejet™ 5500-X1 (or X2). Compared to standard nozzles, this nozzle can reduce the amount of spray applied by 80 percent, making the use of the chemicals much more cost-effective.

*Professors and Extension Range Specialists, The Texas A&M University System

2. Mix the Herbicide Spray

A mixture of triclopyr ester (trade names: Remedy Ultra, Clear Pasture, Triclopyr R&P, and Triclopyr 4EC) and diesel fuel oil is very effective for this method. Diesel acts as a coating agent to ensure good absorption. A commercial basal bark (vegetable) oil carrier can be substituted for diesel if desired.

Recommended Herbicide Mix

Pour 25 percent triclopyr ester into the mixing container, then add diesel fuel to bring the mixture to the total volume desired. Agitate the mixture vigorously.

Ingredient	Concentration of Total Mix	Amount/ Gallon Mixed
Triclopyr ester herbicide	25%	32 oz
Diesel or basal bark oil	75%	96 oz
Hi-Light™ blue dye (optional)		0.32–0.64 oz

3. Spray the Greenbriar

Adjust the sprayer nozzle to deliver a narrow, cone-shaped mist.

Spray the mixture lightly but evenly on all plant stems from the ground level up to 12 inches. Apply the mixture to all sides of every stem, but do not wet it so much that it runs off the stem and puddles.

Keep These Points in Mind:

- Follow the herbicide label directions.
- The cost of treatment escalates rapidly as greenbriar becomes denser. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Do not spray when basal stems are wet.
- The best results occur during winter when more basal stems are exposed.
- After mixing herbicide with diesel fuel or basal bark oil, shake or agitate the solution.
- Controlling greenbriar is not a one-time job, and retreatment may be necessary.

RWFM-PU-106 11/2021

HOW TO TAKE THE LUCK OUT OF CONTROLLING YUCCA

Individual Plant Treatment Whorl Applications

Robert K. Lyons and Megan K. Clayton*

Yucca infests about 19 million acres of Texas rangeland, mostly in the western two-thirds of the state. Some of the more than 30 yucca species in Texas are beneficial to livestock and wildlife. For example, deer and livestock relish the flowers and fruit of Spanish dagger yucca.

However, many species cause problems when they develop dense stands, consuming water and nutrients needed by more desirable plants. Examples of problem species include San Angelo yucca and twisted leaf yucca.

Yucca plants have one or more whorls of leaves growing from a common root crown. The leaves are long, straight, fibrous, sharply pointed, and covered with a thick wax.

Here are two Brush Busters whorl application methods to control yucca that are effective, easy to use, and environmentally responsible. One method uses a low-volume herbicide plus oil, while the other uses undiluted herbicide. These methods can enable you to remove the yucca without damaging desirable plants.

Controlling yucca is not a one-time job. Because livestock and wildlife spread the seeds, new plants will emerge continually. Check pastures periodically to control unwanted plants.

This Brush Busters control method was developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of the Texas A&M University System. Your results may vary with weather, but you should usually be able to kill 76 to 100 percent of the plants you treat.

BRUSH BUSTERS HERBICIDE + OIL WHORL SPRAY

Works well: For controlling yucca and honey mesquite at the same time with the same treatment. Mesquite stem diameter must be less than 1.5 inches.

When to apply: Spring or summer during the growing season.

1. Prepare the Equipment

Almost any type of pump-up hand sprayer can be used, but the most efficient way to apply the spray to many plants is with a backpack sprayer.

Make sure the sprayer's nozzle has a small orifice. One such nozzle is the ConeJet™ 5500-X1 (or X2). Compared to standard nozzles, this nozzle can reduce the amount of spray applied by 80 percent, making the use of chemicals much more cost-effective.

2. Mix the Herbicide Spray

Use a mixture of triclopyr ester (trade names: Remedy Ultra, Clear Pasture, and Triclopyr 4EC) and diesel fuel oil or basal oil. Diesel acts as a coating agent to ensure that the herbicide covers the plant and is absorbed well.

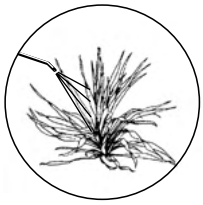
Pour the required amount of triclopyr ester into the mixing container, then add enough oil to get the total desired volume. To identify plants already treated, add Hi-Light™ blue dye (0.25 to 0.5 percent). Shake vigorously until mixed thoroughly.

RECOMMENDED STEM SPRAY HERBICIDE MIX OPTIONS

Ingredient	Concentration in Spray Solution	Tank Size		
		1 gal	5 gal	10 gal
Remedy Ultra, Clear Pasture, Triclopyr 4EC	15%	19 oz	95 oz	1.5 gal
Diesel or Basal oil	85%	109 oz	4.25 gal	8.5 gal
Hi-Light™ blue dye (optional)	0.25–0.5%	0.32–0.64 oz	1.6–3.2 oz	3.2–6.4 oz

3. Spray the Yucca

Position the nozzle in the center of each whorl and spray for at least 2 seconds.



Keep These Points in Mind:

- If applied properly, the triclopyr ester + oil method is the least expensive method for controlling yucca. The cost rises if basal oil is used instead of diesel.
- Follow the herbicide label directions.
- Do not spray wet yuccas.

*Professors and Extension Range Specialists, The Texas A&M University System

BRUSH BUSTERS UNDILUTED WHORL SPRAY

Works well: For controlling only a few yucca plants or if applicator does not have a pump-up hand/backpack sprayer with the proper nozzle as used in the "Herbicide + Oil Whorl Spray" method.

When to apply: Spring or summer during the growing season.

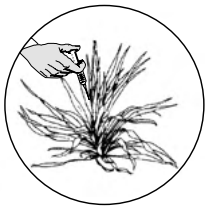
1. Prepare the Equipment

Use an application device that can measure and deliver individual 2 cc to 4 cc (milliliters) doses of herbicide. To treat a few yucca plants, you may use a disposable syringe.

When treating many plants, use an automatic syringe or exact-delivery handgun, such as a drench gun. Because these two devices connect to a reservoir (such as a drench bladder or herbicide container), you do not have to refill them manually.

Triclopyr ester, the active ingredient in herbicides for this method, corrodes plastics. After each use, thoroughly clean the syringe or drench gun with warm, soapy water and lubricate it with mineral oil.

2. Spray the Yucca



Apply undiluted triclopyr ester (trade names: Remedy Ultra, Clear Pasture, and Triclopyr 4EC) into the center of each whorl. Control at the 2-cc rate may drop 10 percent or more compared to the 4-cc rate.

Keep These Points in Mind:

- Follow directions on the herbicide label.
- Do not spray wet yuccas.
- Do not use premixed or ready-to-use triclopyr herbicides for this method.
- Clean application equipment thoroughly after each use.

RWFM-PU-375 11/2021

HOW TO TAME TEXAS PERSIMMON

Individual Plant Treatment Leaf and Stem Applications

Robert K. Lyons and Megan K. Clayton*

Texas persimmon is a common plant on rangeland and pastures in Central Texas, Edwards Plateau, Post Oak Savannah, South Texas Plains, and the Coastal Prairie. It is a deterrent to effective range management in some areas where densities become high.

Here are two three-step methods to control Texas persimmon that are easy, inexpensive, and environmentally responsible. They involve spraying a small but potent concentration of herbicide directly on each plant. Using these Brush Busters methods, you can selectively control unwanted Texas persimmon. Remember, controlling Texas persimmon is not a one-time job, so monitor your land regularly to control unwanted seedlings.

These Brush Busters control methods were developed and approved by professionals with Texas A&M AgriLife Extension Service and Texas A&M AgriLife Research, both agencies of the Texas A&M University System. Your results may vary with weather and other plant conditions, but you should usually be able to kill 76 to 100 percent of the trees you treat.

Additionally, these methods depend on the tree shape and size. For Texas persimmon with three or fewer well-defined, smooth-bark stems coming out of the ground, the stem spray method may be a good option. For bushy Texas persimmon less than 6 feet tall with many stems at ground level, the leaf spray method may be the best option. Either method can be successful.

BRUSH BUSTERS LEAF SPRAY METHOD

Works well on: Texas persimmon plants that have good leaf canopy and are less than 6 feet tall. This method is also known as high-volume foliar spraying.

When to apply: Begin in spring when leaves are mature. Most consistent results have been obtained before July 1st. Stop spraying if leaves fall off when the limbs are shaken. Good soil moisture and healthy leaves are necessary for improved plant kill.

1. Prepare the Equipment

Many types of sprayers work well for this method. Backpack sprayers are the most efficient for small acreages with a high density of Texas persimmon trees. Larger places with lower densities may find ATV or UTV sprayers more efficient. Before you start spraying, make sure you have an adjustable cone nozzle, such as the ConeJet™ 5500-X6 or X8 nozzle that can deliver a coarse spray with larger droplets to the top of a 6-foot tree.

2. Mix the Herbicide Spray

You can achieve 76 to 100 percent mortality by spraying with 2 percent Invora herbicide under ideal conditions. To prepare the spray mix, add the appropriate amount of Invora herbicide to water. To make sure the foliage is coated thoroughly, add a high-quality (80 to 90 percent active ingredient) non-ionic surfactant (see the table on next page) to the spray mix or MSO-OS (organo-silicone) adjuvant at manufacturer specified rates. Add a dye, such as Hi-Light™ blue dye, to mark the plants that have been sprayed and ensure proper coverage.

3. Spray the Texas Persimmon

Adjust the nozzle to deliver a coarse spray in a wide pattern. Wet ALL the leaves of each Texas persimmon plant until the leaves glisten but not to the point of dripping.

Keep These Points in Mind:

- Follow the herbicide label directions.
- For best results, do not spray when:
  - Rains have stimulated new growth at the end of the stems
  - Leaves are wet from rain or dew
  - Foliage shows damage from hail, insects, or disease
  - Working upwind of desirable trees, shrubs, or crops
- The cost of treatment rises rapidly as brush becomes bigger and denser. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Controlling Texas persimmon is not a one-time job. You will need to monitor your land every year to check for new plants.

*Professors and Extension Range Specialists, The Texas A&M University System

RECOMMENDED LEAF SPRAY HERBICIDE MIX OPTIONS*					
Ingredient	Concentration in Spray Solution	Tank Size			
		1 gal	3 gal	14 gal	25 gal
Invora**	2%	2.56 oz	8 oz	36 oz	64 oz
Non-ionic surfactant	0.25%	0.32 oz	1 oz	4.5 oz	8 oz
Hi-Light™ blue dye	0.25–0.5%	0.32–0.64 oz	1–2 oz	4.5–9 oz	8–16 oz

*All spray solutions are mixed in water.

**Invora is labeled for privately owned rangeland only (*excludes hayfields*) and requires Picolinic Acid Chemistry Training for all applicators.

BRUSH BUSTERS STEM SPRAY METHOD

Works well: For controlling young seedlings or older trees with three or fewer basal stems. Stems should be no larger than 4 inches in diameter. Multi-stemmed Texas persimmon plants are much more difficult to control than younger trees or undisturbed plants.

This method is known as the low-volume, basal-stem treatment technique. Research and demonstrations have shown excellent results using minimum amounts of herbicide.

When to apply: After leaves are mature and before June 15th.

1. Prepare the Equipment

Almost any type of pump-up hand sprayer can be used, but the most efficient way to apply the stem spray to many trees is with a backpack sprayer.

Make sure the sprayer's nozzle has a small orifice. One such nozzle is the ConeJet™ 5500-X1 (or X2). Compared to standard nozzles, this nozzle can reduce the amount of spray applied by 80 percent, making the use of chemicals much more cost-effective.

2. Mix the Herbicide Spray

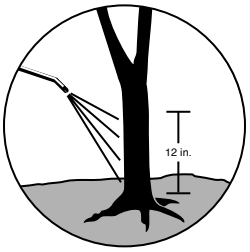
A mixture of triclopyr ester (trade names: Remedy Ultra, Clear Pasture, Triclopyr R&P, and Triclopyr 4EC) and diesel fuel oil is very effective for this method. Diesel acts as a coating agent to ensure that the herbicide covers the plant and is absorbed well.

Pour the required amount of triclopyr ester into the mixing container, then add diesel fuel to bring the mixture to the total volume desired. To identify plants already treated, add Hi-Light™ blue dye (0.25 to 0.5 percent). Agitate the mixture vigorously to ensure thorough mixing.

RECOMMENDED STEM SPRAY HERBICIDE MIXES				
Ingredient	Concentration in Spray Solution	Tank Size		
		1 gal	5 gal	10 gal
Remedy Ultra, Clear Pasture, Triclopyr 4EC	25%	32 oz	1.25 gal	2.5 gal
Diesel or Basal oil	75%	96 oz	3.75 gal	7.5 gal
Hi-Light™ blue dye (optional)	0.25–0.5%	0.32–0.64 oz	1.6–3.2 oz	3.2–6.4 oz

3. Spray the Texas Persimmon

Adjust the sprayer nozzle to deliver a narrow, cone-shaped mist. Spray the mixture lightly but evenly on all the plant stems from the ground line up to 12 inches. Apply the mixture to all sides of every stem, but do not wet it so much that it runs off the stem and puddles.



Keep These Points in Mind:

- Follow the herbicide label directions.
- The cost of treatment increases as plant density and the number of stems per plant increases. Download the Brush Busters Cost Calculator app to easily estimate treatment costs.
- Multiple-stemmed plants or rough-barked Texas persimmon trees are more difficult to control with this method.
- Do not spray when the basal stems are wet.
- Dense grass around basal stems makes this method more difficult to apply.
- Use triclopyr ester herbicides that contain 4 pounds per gallon of triclopyr ester acid equivalent (ae).