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SUBJECT: ECS - Old World Bluestem Management Field Guide

Purpose: To distribute information to the field.

Effective Date: Effective upon receipt.

Filing Instructions: Technical notes are accessible online at the NRCS New Mexico Field Office Technical Guide (FOTG) website: https://efotg.sc.egov.usda.gov/#/ , Section I.

Summary. To provide the publication *Field Guide for Managing Yellow and Caucasian (Old World) Bluestems in the Southwest* from the United States Forest Service; Southwest Region. This guide can be used in providing information and management recommendations for Yellow bluestem (Bothriochloa ischaemum) and Caucasian bluestem (Bothriochloa bladhii), two introduced bunchgrass species that are becoming invasive in the Southwest.

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Field Guide for Managing Yellow and Caucasian (Old World) Bluestems in the Southwest

Forest Service
Southwestern Region
TP-R3-16-36
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Cover Photos

Top left — Yellow bluestem; courtesy photo by Max Licher, SEINet

Top right — Yellow bluestem panicle; courtesy photo by Billy Warrick; Soil, Crop and More Information

Lower left — Caucasian bluestem panicle; courtesy photo by Max Licher, SEINet

Lower right — Caucasian bluestem; courtesy photo by Max Licher, SEINet

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Yellow bluestem (*Bothriochloa ischaemum* (L.) Keng)
Caucasian bluestem (*Bothriochloa bladhii* (Retz.) S.T. Blake, synonym: *B. caucasica* (Trin.) C.E. Hubb.)

Grass family (Poaceae), Andropogoneae tribe

Yellow and Caucasian bluestems are introduced bunchgrass species that are becoming invasive in southwestern States after successfully invading the Central and Southern Great Plains. This field guide serves as the U.S. Forest Service's recommendations for management of yellow and Caucasian bluestems in forests, woodlands, rangelands, desert, and desert scrub associated with its Southwestern Region. The Southwestern Region covers Arizona and New Mexico, which together have 11 national forests. The Region also administers 4 national grasslands located in northeastern New Mexico, western Oklahoma, and the Texas panhandle.

Description

Yellow bluestem (*Bothriochloa ischaemum*) and Caucasian bluestem (*Bothriochloa bladhii*) are perennial mid-grasses that belong to a group of non-native bluestems collectively referred to as Old World bluestems (OWBs). The term Old World bluestem is a shared common name for approximately 65 species in the closely related genera of *Bothriochloa* Kuntze, *Capillipedium* Stapf, and *Dichanthium* Willemet. *B. bladhii* is used synonymously with *B. caucasica*, which is nearly similar in morphology but has an uncertain taxonomy.

Common names for yellow bluestem include King Ranch bluestem and Turkestan beardgrass; the most common cultivars are King Ranch, Plains, Ganada, WW–Spar, and WW–Iron Master. Caucasian bluestem is also called Australian beardgrass (or bluestem), forest bluegrass, and purple plume grass. It has a single cultivar named WW-B. Dahl. OWB cultivars were developed from introduced germplasm and have been selected for different disease and insect threats, climates, and soil-site conditions.

Yellow bluestem derives its name from its yellow-green culms and leaves. Caucasian bluestem has dense blue-green leaves, and some plants can be strongly aromatic. Close similarity to native bluestems makes early identification of the two OWB species difficult in the spring. Positive identification generally can only be made after panicles have developed. Resources for identifying these two bluestem species can be found in the **Photo Image Libraries** subsection at the end of this document.

OWBs are native to Eurasia, Africa, and Australia. They were first introduced into the U.S. in the early 1900s and have been planted widely throughout the Central and Southern Great Plains for forage and for erosion control in disturbed areas such as roadside rights-of-way (ROWs). OWB seed is readily obtained from many seed companies.

Growth Characteristics

Both OWB species –

- Are warm-season, perennial bunchgrasses that are relatively shade-intolerant; typically, they have rhizomes (underground stems) and stolons (above-ground stems) under close grazing or cutting. Yellow bluestem has a more rhizomatous growth form relative to Caucasian bluestem's bunchgrass (caespitose) growth form. Although the early growth form of yellow bluestem is an erect bunchgrass, older stands tend to form a sod.
- Produce spindly looking, flowering culms/tillers that are 2–4 feet tall, depending on moisture. The two species have reproductive and vegetative culms/tillers that are roundish with varying amounts of hair; leaves typically are 0.25 to < 0.5 inches wide and 8-12 inches in length, flat or folded.
- Can initiate rapid growth in the summer and reproduce earlier than native species, which actually deters grazing.
- Produce reddish-purple inflorescences; some cultivar inflorescences may turn fawn to white-colored at maturity. Yellow bluestem's inflorescence is a fan or finger-like panicle; Caucasian bluestem has a panicle that is pyramidal or evergreen tree-shaped.

- Readily germinate from seed and establish reproducing populations within one growing season; such features are highly desirable for hay production. Both OWB species are prolific seed producers, and extensive seed banks can develop in soil.

Ecology

Impacts/Threats

Once established, OWBs can be highly invasive and have the potential to form biodiversity-inhibiting monocultures that can transform grassland vegetation at the community and ecosystem levels of organization. OWB monocultures lack the necessary variety in structure, seasonality of growth, and nutritional availability required to sustain a diverse fauna. Floral diversity may be impacted directly by OWBs through physical displacement, competition, etc. Habitats of some Threatened and Endangered (T&E) species in particular can be threatened by OWBs. In combination with other less desirable non-native grass species such as Lehmann lovegrass (*Eragrostis lehmanniana*), OWBs may form a complex that can act similarly to a monoculture.

Pastures and grasslands invaded by OWBs support fewer insects (a vital part of the food chain) as they lack forbs, which typically host more insects than wind-pollinated grasses. The reduction in forbs may particularly impact native pollinators such as bees and butterflies. In addition, the loss in insect activity could ultimately lead to lower numbers and diversity of songbirds.

OWB infestations can alter carbon:nitrogen (C:N) ratios in soil and the composition of soil microbial communities, including arbuscular mycorrhizae. Growth of native plant species may be inhibited by these changes in soil properties. In addition, a recent study has found that an allelopathic toxin produced by yellow bluestem can reduce reproduction, growth, and survival of native bluestems.

Heavy OWB infestations in pastures or native grassland may require changes in grazing management practices. Mature patches of OWBs are typically avoided by grazing animals, which can cause accumulation of residual dead standing material that is also avoided. High levels of dry matter accumulated in these patches may be prone to wildfire.

Site/Distribution

OWBs can infest both disturbed and non-disturbed sites; however, they tend to establish more readily on disturbed sites. The two species can adapt to highly calcareous soils with high pH but do well on any well-drained soil. Yellow bluestem is best adapted for sandy loam to clay loam soils.

In general, OWBs have relatively little cold tolerance, which makes them unable to withstand environments with extended periods of freezing winter temperatures. Caucasian bluestem is more tolerant to freezing and tends to occur in more northerly climes in the Midwest. Yellow bluestem is more common in the southern U.S. and is winter-hardy in the Central Great Plains only to about 40º N latitude. Both OWBs are found throughout Arizona and New Mexico, although Caucasian bluestem is relatively uncommon at this point in time.

Spread

Sites planted or invaded by OWBs serve as the primary source for further spread onto disturbed and non-disturbed sites. In the Southwest, OWBs generally migrate away from infested roadsides or other disturbed areas in an advancing front across pastures or native grasslands. If unassisted, OWB seed has relatively limited dispersion and will mostly establish seedlings close to parent plants. However, seeds readily disperse via mowing operations in ROWs, vehicular traffic, flowing water, animals, and winds moving across open terrain. Growth of stolons and rhizomes may also contribute to spread on a local basis.

In the Southwest, State and county highway departments have used OWBs in seeding ROWs for erosion control. Use of OWBs was encouraged in the 1980s for Conservation Reserve Program (CRP) lands in Oklahoma, the Texas panhandle, and eastern New Mexico. Yellow bluestem was also planted during the Dust Bowl era on lands acquired by the Federal government for rehabilitation under the Bankhead-Jones Farm Tenant Act of 1937. Such widespread plantings have enabled OWBs to move northward into Nebraska and Missouri from large populations already present in more southerly States.

Invasive Features

Both OWB species are quickly established, produce large numbers of seed, and can tolerate severe drought, heavy grazing, fire, and a limited amount of winter freezing. Many of the characteristics that make OWBs desirable for planting also promote invasion of pastures and native grasslands. For example, both OWBs are tolerant to drought and grazing; however, selecting these traits for forage production has increased their invasiveness.

The most common use for OWBs is cattle forage, although cattle often find them less palatable than warm-season native grasses. Consequently, animals may avoid grazing OWBs in favor of native plants thereby giving OWBs a competitive advantage.

Management

Considerable information exists in regard to planting and managing OWBs for various agronomic purposes such as grazing, forage production, soil erosion prevention, reclamation, etc. However, there is much less experience and information available about controlling these grasses in areas where preservation of native plant communities is a primary management objective. Restoration of pastures or native grasslands dominated by OWBs has proven to be exceedingly difficult if not impossible. Studies conducted in the Great Plains with different OWB control methods have shown varying degrees of success. Results from these studies indicate that an integrated management approach generally improves the efficacy of herbicide control.

OWBs are most effectively managed by preventing their spread. Preventative measures that can be taken include, but are not limited to:

- Do not plant OWB seed for forage, erosion control, reclamation, or other purposes.
- Do not mow OWB-infested areas in ROWs or other corridors of transport once seedheads have started to form.
- Do not feed grass hay from unknown sources or from ROWs.
- Use power washers or air compressors with a blow gun attachment to remove seed from vehicles after going through OWB-infested areas.
- If re-seeding an area, do not use seed obtained from equipment that has also been used to harvest and/or process OWBs.

To manage OWBs, the following actions should be performed:

- Detect, eradicate, or at least contain newly established OWB populations as early as possible, especially along roadways and waterways. In areas where eradication or containment of these species are no longer feasible, efforts should be made to control their rate of spread.
- Report and map known OWB populations. Keep annual records on reported infestations.
- Develop a specific action plan to meet goals and objectives for established OWB infestations, which may emphasize eradication of new OWB infestations in sensitive areas such as T&E species habitat, travel corridors, etc.
- Implement a plan for monitoring and follow-up treatment of missed OWB plants and seedlings. Also, monitor recovery of desirable native plant species following control efforts.

Management Options

Table 1 summarizes management options for common situations involving yellow and Caucasian bluestems. Further details on these management options are explained below. Choice of control method(s) for OWBs depends on many local factors including extent of infestation, current land use, and site conditions (terrain, accessibility, microclimate, presence of non-target flora and fauna, etc.). Other considerations include treatment effectiveness and cost, time needed to achieve control, and whether the management objective is eradication, containment, or slowing the spread of infestation. More than one control method may be needed for a particular site.

Table 1. Management options*

Site	Physical Control	Cultural Control	Biological Control	Chemical Control
Roadsides, fence lines, or non-crop areas	Disk or plow tillable non-crop areas. Use late season, long-term mowing to reduce OWB growth in spring. Since movement of seed can increase infestations along ROWs, do not mow once OWB flowering heads have started to form. Burning used alone is not recommended as it will likely result in increased OWB densities; consider combining burning with herbicide spraying.	Test seed, forage, mulch, and fill materials for OWB seed. Use native grass species or other desirable plant species when reseeding rights-of-way. Avoid driving vehicles and equipment through infested areas. Decontamination procedures should be implemented if travel through these areas is necessary.	Classical biocontrol agents are unavailable.	Use truck or tractor-mounted spraying equipment to broadcast treat. Wash underneath vehicle after application to prevent seed spread.
Rangelands, pastures, or riparian corridors	Disk or plow if OWBs are in previously tilled areas. Use late season, long-term mowing to reduce OWB growth in spring. Since movement of seed can increase infestations along ROWs, do not mow once OWB flowering heads have started to form. Burning used alone is not recommended as it will likely result in increased OWB densities; consider combining burning with herbicide spraying.	Test seed, forage, mulch, and fill materials for OWB seed; use pellets for horses in backcountry areas. Avoid driving vehicles and equipment through infested areas. Decontamination procedures should be implemented if travel through these areas is necessary. Where feasible, consider reseeding areas with native grasses or other desirable plant species following OWB control actions.	To reduce OWB biomass and fuel load, graze in the spring when OWBs may be more palatable or graze standing residue in the fall-winter. Use a protein supplement with fall or winter grazing. Classical biocontrol agents are unavailable.	Use truck or tractor-mounted spraying equipment to broadcast treat. In areas difficult to access, an ATV-mounted sprayer or backpack unit may be the most practical application method. Wash underneath vehicle after application to prevent seed spread.
Wilderness, other natural areas, and/or small infestations	Hand pulling or digging may aid in control. Pull when soil is moist and remove as much root stock as possible; wear gloves for pulling.	same as above	same as above	Use backpack or hand-held sprayers. If allowed, vehicle sprayers may be used to broadcast spray thick OWB stands. Wash underneath vehicle after application to prevent seed spread.

*Choice of a particular management option must be in compliance with existing regulations for the land resource.

Physical Control

Physical methods used to control OWBs normally have to be repeated and must be timed properly with seedhead formation to be effective. Mowing and burning used alone do not control OWBs and discontinuing them can re-establish OWB densities to pretreatment levels or worse. Thus, an integrated approach that combines mowing or burning with herbicide application should be used.

Manual Methods

Hand removal – For isolated or patchy plants, hand pulling or digging to remove top growth and roots are the most effective techniques. Hand removal of OWBs can be complicated as these species can form mats. Manual methods may be combined with herbicide application when OWB populations are relatively small or isolated.

Mechanical Methods

Note – *If using machinery to manage OWBs, the equipment should be cleaned after use in infested areas to prevent transfer of seed into un-infested areas.*

Tillage – Tillage with a disk or plow may be used to remove OWBs from previously tilled areas such as old cropland; however, any newly tilled area will need to be planted with desirable vegetation. Better results with tillage may be achieved when conditions are dry enough to desiccate OWB root fragments. Repeated shallow tillage with implements such as a rotary or disc harrow may prevent deeply embedded seeds from coming to the soil surface for possible germination. Nonetheless, tillage without follow-up control measures can increase OWB densities by breaking up root masses and scattering the fragments. It also exposes bare soil, which can become infested by OWBs. See **Integrated Control Methods** at the end of this section for information on integrated approaches using tillage.

Mowing – Mowing along ROWs has the potential to spread OWB seed and can lead to OWB dominance within ROWs. Therefore, infested ROWs and other transport corridors should not be mowed once OWB flowering heads have started to form, as this will move seed into un-infested areas. However, one study conducted in Oklahoma found that sustained mowing done annually in September can reduce OWB cover on a long-term basis as compared to un-mown areas or areas mowed in March or June. Mowing is more effective if combined with pre or post-herbicide treatments.

Prescribed Fire

OWBs rapidly recover after fire and may return at greater densities than before. Thus, burning is not recommended as a single or stand-alone control method. As compared to mowing, burning is better able to reduce OWB cover. Prescribed fire applied past the boot stage but prior to full seed production has shown the greatest potential for reducing OWB cover.

Cultural Control

To prevent OWB seed movement, sanitary measures for vehicles, equipment, and livestock should be implemented. Only clean vehicles and equipment should be allowed to enter un-infested areas. Seed and materials used for planting, mulch, animal forage, or fill should be tested for presence of OWB seed; pellets may be used for horses in backcountry areas.

Public education about the use of non-native grasses, such as OWBs, and their impacts on ecosystems is essential for changing seeding practices. Agencies and landowners should collaborate in promoting use of native or other desirable species rather than OWBs for reseeding areas disturbed by mining, fire, overgrazing, or road construction. In the Southwest, species such as Arizona cottontop (*Digitaria californica*), sideoats grama (*Bouteloua curtipendula*), sprucetop grama (*Bouteloua chondrosioides*), plains bristlegrass (*Setaria macrostachya*), and other native species adapted to relatively lower elevations may be considered.

Biological Control

Grazing

By itself, grazing is inadequate to eradicate or control OWBs as these species are highly tolerant of close grazing or defoliation. OWBs are palatable when young and may have equal or greater forage quality in the early growing season as compared to some native species. However, OWB plants generally mature more quickly than most native

warm-season grasses and correspondingly become less palatable. Burning and mowing old vegetation can increase OWB palatability, and some cultivars may be more palatable to livestock than others.

Although OWBs are usually avoided by grazing animals in favor of native vegetation during periods of adequate moisture, they can be highly selected by grazers during drought periods. OWBs retain green leaf material longer than some native species at the onset of drought, which allows them to recuperate more rapidly when precipitation eventually returns to normal levels.

Stocking rates that do not account for areas occupied by OWBs may inadvertently overutilize native vegetation. Therefore, stocking may need to be adjusted to favor native grasses. Continuous, intensive grazing should generally be used only on lands close to a full monoculture of OWBs; otherwise, native plants will probably be over-utilized.

Intensive grazing of OWBs with cattle in the early part of the growing season may enhance grazing use. Fall grazing of OWBs using a deferred-rest, rotational grazing system may also provide better utilization. However, additional protein is required since protein and nutritional values for OWBs decline significantly in the fall and winter. Protein supplements in granular, block, crystal, or liquid form can be used in conjunction with grazing dead OWB plants. Protein supplements can increase palatability, % crude protein, and total digestible nutrients (TDN) in fall-winter diets. Although these protein sources can be fed in containers, some forms of protein supplement may be placed directly on patches of standing dead OWBs.

Treatments that reduce standing dead material such as mowing or burning may encourage greater utilization of OWBs by grazing animals. A high stocking rate with grazing animals may remove dead material, which will stimulate new OWB growth that can be treated by a foliar herbicide. Trampling by cattle can be used to break down clumps and mounds of OWBs if the cattle are concentrated within a relatively small area. To concentrate animals, a temporary electric fence that is periodically moved to areas needing treatment may be used. Placement of protein, mineral, or salt in troughs, tanks, tubs, or blocks within areas of standing dead OWBs and then eventually moving these feedstuff materials to other affected sites can provide sufficient trampling for reduction of clumps and mounds while also benefitting livestock distribution.

It is not known whether OWB seed ingested by grazing animals remains viable after passing through the animal; however, it would be prudent to isolate animals in a drylot and avoid moving them directly from OWB-infested pastures into un-infested areas for at least 7 days to allow passage of any possible viable seed.

Classical Biological Control

At present, no known organisms or pathogens (insects, fungi, viruses, etc.) are present in the U.S. that are natural enemies or biocontrol agents for either OWB species.

Chemical Control

The primary herbicides used for OWB control are glyphosate and imazapyr (Table 2). Both herbicides will provide bluestem control when properly applied; however, the two herbicides are non-selective and will impact non-target species. Therefore, precautionary measures should be taken if non-target plants (including woody species) need to be protected. Repeated use of the same herbicide on OWB infestations could lead to herbicide resistance; thus, the two herbicides should be alternated in their use.

Glyphosate will kill or control most other plants intermixed with OWBs, while imazapyr allows some native tallgrasses to survive and persist after application. Studies done in the Midwest have shown that Western wheatgrass (*Pascopyrum smithii*), tall dropseed (*Sporobolus compositus*), sideoats grama, and western ragweed (*Ambrosia psilostachya*) had the best survival after glyphosate treatments; however, the herbicide is very damaging to most mid and tall grasses. Big bluestem (*Andropogon gerardi*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), and sideoats grama were found in the Midwestern studies to be tolerant of some imazapyr treatments, and they may increase in density following OWB removal.

Table 2. Herbicide recommendations

Common Chemical Name (active ingredient)	Product Example[1]	Broadcast Treatment (rate per acre)	Spot Treatment (spray solution)[2]	Time of Application	Remarks
Glyphosate – single application	Roundup, Roundup Ultra, Rodeo, Accord [others available]	2-3 lbs per acre	1.5% of a 5.5 lb per gallon product *or* 2.0% of a 4 lb per gallon product	Favorable growing conditions and adequate moisture should be present; apply when OWBs are in boot stage or any time prior to seed production while leaves are green and plant is actively growing.	Glyphosate is formulated as a product with either 2 lb, 4 lb, or 5.5 lb active ingredient per gallon. Certain brands require addition of a non-ionic surfactant (NIS). Read label carefully to mix the proper rate of application. Do not add ammonium sulfate when spraying rangelands. Also, consider tank mixes of both glyphosate and imazapyr for increased control. See herbicide label for details. Although immobile in soil, glyphosate is a non-selective amino acid inhibitor; its spray drift can damage non-target plants, including forbs and woody species.
Glyphosate – split application	same as above	1-2 lbs per acre	same as above	First application is at the 5-leaf stage. Second application is 8 weeks later.	
Imazapyr – single application	Habitat, Arsenal [others available]	0.5 lbs per acre	1.0% of a 2 lb per gallon product	Favorable growing conditions and adequate moisture should be present; apply when OWBs are in boot stage or any time prior to seed production while leaves are green and plant is actively growing.	Herbicidal activity may be slow, and the extent of control may not be evident until the following growing season. Imazapyr is a non-selective amino acid inhibitor. In addition to spray drift, non-target plants may also be killed or injured by imazapyr through runoff, residue movement in soil, or root exudates from treated plants.
Imazapyr – split application	same as above	0.25 lbs per acre	same as above	First application is at the 5-leaf stage. Second application is 8 weeks later.	

[1] Trade names for products are provided for example purposes only, and other products with the same active ingredient(s) may be available. Individual product labels should be examined for specific information and appropriate use with OWBs.

[2] Spray solution is the herbicide/water ratio in a spray mix that may be used for spot treatment with backpack or hand-held sprayers. The amount of product applied during an annual growing season must not exceed the maximum application rate per acre as specified by the product label – refer to the product label for the site type and application.

Aquatically approved herbicide formulations and surfactants of glyphosate and imazapyr must be used in or near water. Each herbicide product has different requirements and restrictions. Therefore, label instructions should be carefully followed when mixing and applying any herbicide.

Herbicide Application

Applying herbicide to OWBs as a single treatment without follow-up can be ineffective or worse than not using herbicide at all. Following initial glyphosate treatment, OWB seedlings can continue to emerge for as long as 3 years. In many instances, OWBs have been observed to recover within 1 year after treatment (YAT) or 2 YAT due to emergence of new seedlings from the soil seed bank and from basal buds of mature plants that escaped herbicide treatment.

OWB control on a short-term basis has been successful with both single and split applications of glyphosate and imazapyr during the growing season. Whether applied as a single dose or as split applications, both herbicides typically give similar OWB control. Mixtures of imazapyr and glyphosate can also provide short-term control. Under dry conditions, greater rates of herbicide are required to achieve the same control as lower rates of herbicide used during favorable growing conditions, especially with glyphosate.

For split applications of glyphosate using a broadcast treatment, apply 1-2 lb/acre at the 5-leaf stage and then treat again at the same rate eight weeks later. With favorable growing conditions and adequate moisture, a single dose of 2-3 lb/acre glyphosate may be broadcast applied as an alternative treatment when OWB plants are in the boot stage. Infestations can also be treated with a single dose of glyphosate at 2-3 lb/acre at any time late in the season prior to seed production if leaves remain green and the plants are still growing or photosynthesizing well. Single dose glyphosate applications in late season have been found to be more effective as compared to early season applications.

Alternatively, imazapyr can be broadcast applied in a split application at 0.25 lb/acre at the 5-leaf stage and then again at the same rate eight weeks later. Imazapyr may also be applied in a single dose at a rate of 0.5 lb/acre when the plant is in the boot stage or later prior to seed production, as long as the plant is green and favorable growing conditions exist.

For herbicide control of individual plants or small patches with a handheld or backpack sprayer, apply a 1.5% solution of a 5.5 lb glyphosate/gallon product or a 2.0% solution of a 4 lb glyphosate/gallon product. Alternatively, a 1.0% solution of a 2 lb imazapyr/gallon product can be applied.

Application Techniques

To limit impacts to desirable plants during herbicide applications, direct spray of OWBs from a backpack or hand-held sprayer is preferable to broadcast treatment. Enough spray should be used to wet leaves but avoid dripping from the plant. Adding a blue or red dye to the solution will aid in identifying treated plants. A team of applicators walking together side-by-side (about 10 feet apart) is an effective way to spray a defined area systematically. This method is particularly effective for treating relatively small, less dense infestations.

A ropewick application method may provide modest OWB control. Ropewick applicators can be hand-held or else towed or mounted on a tractor, ATV, or UTV. Ropewick applications do not control new or young seedlings, but they may control well-established plants with a taller canopy. If native species are mown or heavily grazed first, the ropewick can be set lower and made more effective. According to one Midwest study, a ropewick application using glyphosate and water in a 50:50 ratio on a volume to volume basis provided an average of 65% control in the third season following annual ropewick applications made in the first 2 years.

For large infestations, it may be more practical to use a boomless or conventional boom sprayer that is mounted on a vehicle (ATV, UTV, truck, or tractor) or else is towed. Any equipment (including backpack sprayers) used to spray herbicide should be calibrated. See the **Suggested Web Sites** subsection at the end of this document for calibration information. Before

spraying, always consider the need to reseed with desirable native grasses after herbicide application.

Integrated Control Methods

Grazing, mowing, or burning OWB infestations—applied singly or in combination—do not adequately control OWBs. The timing and frequency of these treatments may actually increase OWB vigor relative to native plants and make OWBs even more competitive. However, use of these treatments either prior to herbicide application or between split herbicide applications greatly increases herbicide effectiveness on OWBs, as the new green foliage arising from the treatment will potentially enhance total herbicide uptake and translocation. Herbicide label restrictions for grazing should be followed.

Tillage

If OWBs are present in tillable areas such as previously cropped areas, then plowing or deep disk tillage followed by treatment of new OWB plants with glyphosate, imazapyr, or a mixture of the two can greatly reduce OWB cover. Follow-up treatments of emergent OWBs on the fallow land and eventual reseeding with desirable vegetation are required to keep OWBs from re-populating. Conducting tillage and seeding of an annual crop such as winter wheat for 3 or more consecutive years should also provide significant OWB control. Reseeding to native grasses and forbs may then be possible if coupled with several years of herbicide treatments to control new OWB seedlings and plants that escaped previous treatment.

Management Strategies

In the Southwest, seeding of OWBs has historically been limited to ROWs, CRP lands, and drought-affected rangelands. OWB species are not currently recognized as a problem in Arizona or New Mexico as they are not yet broadly established in pastures and native grasslands of either State. However, OWB infestations are expected to continue expanding and eventually become a major threat similar to the Midwest where OWBs have become highly invasive across grassland areas. Success in keeping OWBs from becoming a more widespread and expensive problem will necessitate stakeholders (agencies, landowners, etc.) working together collaboratively, particularly in managing pathways (road systems, waterways, etc.) by which OWBs can invade. A major emphasis should be to maintain or restore diversity and resiliency of native plant communities.

Control and restoration efforts for OWBs require long-term planning, sustained management, and follow-up monitoring. To protect pastures and native grasslands, eradication or at least containment should be employed against OWB infestations wherever feasible. Efforts to control OWBs in ROWs should especially be emphasized and coordinated with State and county highway departments. Satellite populations and perimeter edges of large infestations may be treated first with the entire infestation scheduled to be eradicated, contained, and/or at least reduced in a series of steps over a period of several years.

For lands where eradication or containment of OWBs are no longer practicable due to widespread infestations, management efforts should focus on (1) slowing their spread if possible and (2) reducing OWB dominance in heavily infested areas to increase plant and/or faunal diversity. However, it may be more cost-effective in some situations to put control efforts toward protecting areas that remain free of OWBs rather than causing disturbance in areas that are already extensively infested by them.

In most cases, at least 3 or more consecutive seasons of field treatments will be necessary to eliminate or substantially reduce OWB infestations and soil seedbanks following initial treatment. Treated areas will require monitoring and likely retreatment to control newly emerging seedlings and recovering patches of OWBs. Since it is useless to treat an area only one time without retreatment, sufficient resources must be allocated for the area where control is attempted. After initial treatment, it is essential that resources are available to respray or retreat the treated area as necessary.

References and Further Information

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Photo Image Libraries

Photo images of OWBs may be found:

Flora of North America. Available at http://floranorthamerica.org/

SEINet Plants Database. Available at http://swbiodiversity.org/seinet/

Suggested Web Sites

For information about calibrating spray equipment:

KSU Research and Extension. Hand Sprayer Calibration Steps Worksheet. Available at http://www.bae.ksu.edu/faculty/wolf/PDF/MF2915-Hand%20Sprayer.pdf

NMSU Cooperative Extension Service Guide A-613, Sprayer Calibration. Available at http://aces.nmsu.edu/pubs/_a/A613.pdf

For more information or other field guides, contact:

USDA Forest Service
Southwestern Region
Forest Health
333 Broadway Blvd., SE
Albuquerque, NM 87102

Or visit the Southwestern Region's website for invasive species:

http://www.fs.usda.gov/goto/r3/invasivespecies