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Field Guide for Managing Buffelgrass in the Southwest

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Cover Photos

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Buffelgrass (*Cenchrus ciliaris* L., synonym: *Pennisetum ciliare* L.)

Grass family (Poaceae), Paniceae tribe

Buffelgrass is an introduced forage grass that has become invasive in southwestern states. Because of its threat to the Sonoran Desert ecosystem, buffelgrass has been listed as a noxious weed in Arizona.

This field guide serves as the U.S. Forest Service's recommendations for management of invasive buffelgrass in forests, woodlands, rangeland, 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 four national grasslands that are located in northeastern New Mexico, western Oklahoma and the Texas panhandle.

Description

Buffelgrass (synonyms: anjangrass, African foxtail grass, zacate buffel) is a drought-tolerant bunchgrass originally from the African savannah that was introduced into the US as a forage grass. However, many of the traits that make buffelgrass desirable as a forage grass also cause it to be highly invasive within native plant communities. Buffelgrass includes numerous cultivars and is often cross classified into two very closely related grass genera: *Cenchrus and Pennisetum*. Key characters useful for buffelgrass identification include a bottlebrush-like inflorescence and light-colored hairs that occur at the junction where leaves meet the stem. Buffelgrass is similar in appearance to fountain grass (*Cenchrus setaceus, syn. Pennisetum setaceum*), which is an escaped ornamental grass; however, buffelgrass is generally smaller in size (typically 1 to 1.5 feet tall) and has shorter, thicker inflorescences that are brownish to purplish in coloration.

Growth Characteristics

- Perennial grass that forms tussocks; normally warm season but can grow during winter at lower elevations if conditions are adequate.
- Rapid growth; germinates from seed; matures and flowers within 6 weeks following at least 0.75 inches of rain and moist soil occurring over a 3–5 day period.
- Plants grow in bunches, up to 40 inches tall; knotty and branching at base. Tillers often have secondary branching giving plants a shrub-like (chaemaphytic) appearance.
- Flat leaf blades (3–12 inches long; 0.1–0.3 inches wide), scabrous or with long, soft hairs; sheaths open, keeled, glabrous to having sparse, long, soft hairs; hairy ligule.
- Purplish to reddish, bottlebrush-like inflorescence (0.8–5.1 inches long); spikelets in clusters of 2–4, each with 2 flowers (lower floret reduced); spikelets tan, beige, or slightly orange at maturity; spikelets fall off whole from the rachis.
- Reproduces from seed that normally lies dormant 3 to 18 months; seed viable for at least 3–5 years.
- Apomictic (asexual reproduction without fertilization of seed).

Ecology

Impacts/threats

Although buffelgrass is used as a forage grass for livestock, it is an unwanted weedy invader in many desert plant communities. Buffelgrass can out-compete native vegetation for soil nutrients and moisture. In addition, infestations of buffelgrass can injure native plant communities by altering the fire regime through an increase in the frequency, intensity, and connectivity of fuel. Buffelgrass re-grows quickly following wildfire whereas fire damages or kills nearly all native plants found in Sonoran Desert communities. As a result of these effects, this introduced grass has the potential to displace native plant communities and change ecologically rich areas into a near monoculture of buffelgrass with decreased diversity, species richness, cover, and densities of native plants.

Location

Buffelgrass is spread widely across disturbed and undisturbed habitats in the Southwest including urbanized areas, roadsides, rangeland, old fields, and desert plant communities. It is commonly found on rocky, south-facing

slopes in Arizona uplands. The species has also been used to re-seed rangeland in certain areas of Texas and Mexico where it is valued as a forage grass.

Spread

Seed is spread by wind, water, animals, and vehicles. Whenever buffelgrass becomes established near roads and ditches, opportunities for spread are increased.

Invasive Features

Buffelgrass grows in dense stands, spreads aggressively, and can double in cover every 2–3 years. It is highly adaptable and grows on many soil types including soils that are heavy, sandy, or overlying limestone. However, it is not cold-tolerant and requires summer moisture to thrive. Buffelgrass is often more effective at capturing soil moisture than native species, which contributes to its invasiveness.

Management

Long-term planning, integrated management, and follow-up monitoring are necessary for effective control of buffelgrass. Priority should be given to early detection of buffelgrass and eradicating new infestations that become established on otherwise healthy sites. The perimeter of large infestations should be treated first to prevent the infestation from spreading. To deplete the buffelgrass seed bank, treatments need to be repeated annually for several years and possibly repeated within a growing season if necessary. A combination of various treatment methods and repeated treatments will improve effectiveness of control methods. Fire intensity and fuel connectivity of buffelgrass fires may be decreased by control measures that reduce buffelgrass biomass and density. The following actions should be considered when developing a management approach for buffelgrass:

- Limit disturbance and maintain healthy plant communities that can help prevent or limit new infestations. This may involve using improved grazing management practices to prevent excessive grazing and/or reseeding areas with desirable native grasses and forbs after disturbance.
- Detect, report, and map known buffelgrass populations. Also map the presence and condition of native vegetation. Keep annual records of reported infestations. Identify priority areas for treatment by using records, maps, and other information such as known T&E species habitat, travel corridors, seed pathways, etc.
- Develop a specific action plan to meet goals and objectives for infested areas, which may include eradication of new populations of buffelgrass in sensitive sites.
- Evaluate infested sites to determine which mechanical, cultural, biological, or chemical treatment methods (or combination of treatment methods) are most effective for buffelgrass control. Mechanical and manual removal methods may facilitate further invasion through soil disturbance and erosion; therefore, extra caution should be taken to monitor the site following disturbance to forestall any new infestations these methods may cause.
- Implement a monitoring and follow-up treatment plan for missed plants and seedlings. Also monitor recovery of desirable native plant species following control efforts.

Table 1 summarizes management options for controlling buffelgrass under various situations. Choice of control method(s) for buffelgrass depends on many local factors including degree of infestation, current land use, and site conditions (terrain, accessibility, microclimate, non-target flora and fauna present, etc). Other important considerations include treatment effectiveness, overall cost, and period of time needed to achieve control. More than one control method may be needed for a particular site.

Table 1. Management options*

Site	Physical Methods	Cultural Methods	Biological Methods	Chemical Methods
Roadsides	Use manual pulling, grubbing, or hoeing. Care should be taken to remove the whole root mass to prevent re-sprouting. Transport dug-up buffelgrass in plastic bags to sanitary landfill or leave plants onsite by either (1) using "pile-and-rock" method, or (2) spreading them over the disturbed soil and placing rocks over them. Mowing or grading along roadsides should be used with caution as these methods may increase growth and spread.	Implement requirements for vehicle operation in buffelgrass-infested areas and for reporting infestations along roadsides. Revisit treated sites after rain to remove new buffelgrass seedlings and previously unnoticed plants. Gravel and other road materials transported into uninfested areas should be weed-free.	Classical biological control agents are currently unavailable for use but are being researched.	Use truck or tractor spray equipment. Wash underneath vehicle after spraying to prevent spread.
Rangeland	Use manual pulling, grubbing, or hoeing for small infestations. Care should be taken to remove the whole root mass to prevent resprouting. Transport dug-up buffelgrass in plastic bags to sanitary landfill or leave plants onsite by either (1) using "pile-and-rock" method, or (2) spreading them over the disturbed soil and placing rocks over them.	Avoid excessive land disturbance. Consider reseeding disturbed areas with native species. When moving livestock or vehicles through infested areas, inspect and remove any seeds from animals, clothing, and vehicle surfaces. Revisit treated sites after rain to remove new buffelgrass seedlings and previously unnoticed plants.	Consider using prescribed grazing as part of an integrated management approach. Classical biological control agents are currently unavailable for use but are being researched.	Use backpack spraying, ground broadcast spraying, or aerial spraying depending on accessibility of infested areas. Wash underneath ground equipment after spraying to prevent spread.
Wilderness and other natural areas	Hand removal with simple hand tools may be effective for small buffelgrass stands and may be necessary in rough terrain to protect other resources. Care should be taken to remove the whole root mass to prevent resprouting. Transport dug-up buffelgrass in plastic bags to sanitary landfill or leave plants onsite by either (1) using "pile-and-rock" method, or (2) spreading them over the disturbed soil and placing rocks over them.	Avoid excessive land disturbance. For disturbed areas that have supplemental irrigation available or adequate moisture for germination, consider reseeding with native species. Revisit treated sites after rain to remove new buffelgrass seedlings and plants previously missed. Post signs warning visitors to inspect for seeds and remove them from animals, vehicles, and clothing when leaving an infested area.	Same as above.	Use backpack sprayers on small infestations. Broadcast spraying by aerial or ground methods may be used on thicker stands if allowed. Wash underneath ground equipment after spraying to prevent spread.

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

Physical Control

Physical methods used to control buffelgrass should focus on minimizing plant spread and mitigating adverse impacts from fire. These methods usually have to be repeated and must be timed properly to be effective.

Manual Methods

Hand-pulling, grubbing, or digging – Mature buffelgrass has a tough root crown and a long, dense root mass that makes manual removal difficult. Hand-pulling, grubbing, and hoeing buffelgrass are effective (but difficult), year-round methods for control. Hand removal is easiest when soil is moist, temperatures are cool, and plants are in their early life stage. Simple digging tools (digging bar, hoe, shovel, Pulaski, etc.) may be used to aid root removal. Regardless of method, the root crown must be removed totally. To prevent seed dispersal, plants that have been pulled-up should be placed in plastic bags and properly disposed of in sanitary landfills. For areas too remote for transport of plastic bags, pulled-up buffelgrass plants may be left onsite by (1) putting them into a pile and then placing rocks over them or (2) spreading them over the disturbed soil and placing rocks over them. Recent research has shown that distributing the pulled plants over the disturbed soil can help prevent buffelgrass seeds in the soil from germinating. Sites undergoing buffelgrass removal should be revisited after rain, and any seedlings that have emerged should be pulled up or spot-sprayed. Several consecutive years of hand-removal may be required in order to eliminate an infestation completely.

Mechanical Methods

Tillage – To remove buffelgrass from previously seeded cropland or rangeland areas, use properly timed and repeated tillage with a deep plow or disc. Cultivation is most effective in hot, dry weather that greatly stresses plants. Tillage will exhaust carbohydrate reserves stored in roots but will not eradicate seeds. Therefore, tillage probably should be combined with herbicide control.

Mowing – Large-scale mechanical clearing methods such as repeated grading and mowing may suppress buffelgrass growth; however, these treatments often favor re-establishment and increased dominance. In general, mowing should be discouraged as a stand alone method since buffelgrass can set seed at any height. When mowing, cut buffelgrass before seed stalks are developed; clean vehicles and clothing before moving to another site. Spot spraying or hand-grubbing after significant rainfall should be used as a follow-up treatment to mowing. In certain situations, mowing buffelgrass 2–4 weeks before herbicide application has been an effective control combination. Allow at least 25% of the original plant height or foliage to return before spraying it at a later time to ensure all plants are at a similar growth stage when treated.

Prescribed Fire

Buffelgrass re-grows quickly after a fire, and it may return at greater densities than before. In addition, most native vegetation in the Sonoran Desert is not fire adapted. Thus, fire is not recommended as a single or stand-alone control method. Currently, researchers are investigating a strategy of prescribed fire-herbicide-reseeding for restoration of highly disturbed areas such as abandoned agricultural fields.

Cultural Control

Sanitation may be used as part of an overall management program to prevent buffelgrass spread. Animals, clothing, and vehicle surfaces should be inspected for attached buffelgrass seed when moving livestock or vehicles through infested areas. Signs may also be posted in sensitive areas to warn visitors to remove attached seed before leaving an infested area. Gravel and other road materials transported into uninfested areas should be weed-free.

To help limit buffelgrass establishment, landscape disturbance should be minimized. Areas disturbed by fire, overgrazing, road building, etc. should be considered for reseeding with native plants such as Arizona cottontop (*Digitaria californica*), plains bristlegrass (*Setaria macrostachya*), sideoats grama (*Bouteloua curtipendula*), sprucetop grama (*B. chondrosioides*), and other native species adapted to lower elevations in southern Arizona.

Public education about buffelgrass and its impacts on ecosystems is an essential component for successful control. The media should be used when possible to focus public attention on prevention, early detection, and long-term commitment to buffelgrass removal. Collaboration among diverse stakeholders should be encouraged, and citizen volunteer groups should be enlisted to monitor and manually remove buffelgrass from residential neighborhoods and along roadways. In southern Arizona, various agencies and organizations collaborate in managing buffelgrass and regularly host group events such as "Beat Back Buffelgrass Day" to remove the invasive grass from roadsides and sensitive areas. Since buffelgrass has become an integral part of the cattle industry in some regions, culturally sensitive collaboration may be required to prevent buffelgrass from spreading beyond areas where it is used as forage.

Biological Control

Grazing

Buffelgrass is moderately palatable to livestock as a forage grass, and livestock grazing of buffelgrass may play a role in reducing fuel loads and lowering wildfire threats. However, grazing alone will not control buffelgrass and should only be used for buffelgrass management as part of an integrated management approach. Intensive grazing may be implemented to stimulate plant growth prior to herbicide application during the actively growing stage.

Classical Biological Control

A spittlebug (*Aeneolamia albofasciata*), fungal blight (*Magnaporthe grisea*), and leaf spot (*Cochliobolus australiensis*) have the potential to damage buffelgrass stands. This grass reproduces vegetatively or asexually and has low genetic diversity, which suggests that it is unlikely to develop natural resistance to blight or leaf spot. However, no classical biological control agent has been approved to date by the USDA for use against buffelgrass.

Chemical Control

The primary herbicides used for buffelgrass control are glyphosate and imazapyr. These broad spectrum chemicals are non-selective and will impact non-target species. This includes most woody and broadleaf species. In addition, non-target plants may be killed or injured by imazapyr through off-target movement in soil or by root transfer of imazapyr between intertwined root systems. As a consequence, special attention should be given to controlling the amount of imazapyr applied to each plant to reduce these risks. This includes timing the application, performing necessary calibrations, and using backpacks equipped with flow control valves. Testing is currently underway in Texas and Arizona to determine the effectiveness of alternative grass active herbicides that might be used in the future for buffelgrass control, but results are unknown at this time.

All herbicides listed in table 2 will effectively control buffelgrass when properly applied; however, they may also damage non-target species. Therefore, precautions should be taken when non-target plants (including woody species) need to be protected. Glyphosate and imazapyr are both generic herbicides and are sold under a broad number of trade names. These various herbicide products are often formulated differently and have unique requirements and restrictions. Thus, it is very important to read the label carefully and follow all instructions and guidelines when mixing and applying either herbicide. Aquatically approved formulations for glyphosate (e.g., Rodeo®) and imazapyr (e.g., Habitat®) should be used near water.

For foliar applications with glyphosate, buffelgrass plants should be at least 50% green before spraying. However, better control is obtained when plants are actively growing and are more than 80% green. This generally occurs within 2–6 weeks following heavy summer rains.

Use of imazapyr to control buffelgrass potentially provides greater flexibility over glyphosate since glyphosate applications rely entirely on a relatively short green-up period. As an alternative to using glyphosate during green-up periods, imazapyr may be applied foliarly at a 1% v/v rate with an individual plant treatment (IPT) regardless of whether the buffelgrass is growing or dormant. With a

Table 2. Herbicide recommendations

Common Chemical Name (active ingredient)	Product Example[1]	Product Example Rate per Acre (broadcast)	Backpack Sprayer Treatment Using Product Example[2]	Time of Application	Remarks
Glyphosate	Makaze Roundup Ultra Rodeo Accord Kleenup Pro many others available	Use 2.25 quarts per acre for formulations with 4 lbs ae per gallon (e.g., Rodeo) or 3 quarts per acre for formulations with 3 lbs ae per gallon (e.g., Roundup Pro). A 1% w/w addition of ammonium sulfate or other acidifier may be necessary to adjust water to a neutral pH.	2–5% solution	Spray when buffelgrass is actively growing as indicated by bright green and glossy leaves. At least 50% of plant should be green.	A rate of 2.25 lbs ae/ac is recommended. Read label carefully to mix the proper rate of application. This herbicide is a non-selective amino acid inhibitor and will kill desirable vegetation, including forbs and woody species.
Imazapyr	Habitat, Arsenal, Stalker, Assult, many others available	2 qt (with a 2 lbs ae per gallon formulation) MSO may increase effectiveness of imazapyr applications	0.5% to 1.5% solution[3]	Foliar or basal applications may be made at any time regardless of whether buffelgrass is green or dormant.	Apply as 15 gallons per acre or higher total solution when broadcast spraying. Herbicidal activity may be slow. Allow two full growing seasons before followup treatment. This herbicide is a nonselective amino acid inhibitor and will kill desirable vegetation, including forbs and woody species. Nontarget plants may also be killed or injured by root transfer of imazapyr between intertwined root systems.

[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 buffelgrass.

[2] Herbicide/water ratio – As an example, a 3 percent mixture for a gallon of spray water is made by adding a sufficient volume of water to 4 ounces of liquid herbicide until a volume of 1 gallon is reached (4 oz/gal ÷ 128 oz/gal = 0.03 or 3 percent).

[3] Product example rate reduced to protect non-target plants.

half-life of 25-142 days, some amount of imazapyr will be present on stems or in soil when buffelgrass growth and uptake commences after rainfall. The imazapyr should be mixed with methylated seed oil (MSO) at a 1% v/v rate with water. To minimize impacts to non-target species, a basal application can be made by using an adjustable cone nozzle with a constant flow valve that delivers a stream of large droplets (about 22 ml total) to the inner portions of a buffelgrass plant crown.

To limit impacts to the surrounding plant community from spraying, a backpack or hand-held sprayer may be used to

spray buffelgrass directly. Since herbicide activity mainly involves the foliage, enough spray should be used to coat the leaves, but not so much that it is dripping off the plant. Adding a blue or red dye to the solution will aid in identifying treated plants. A team of applicators walking together in a line about 10 feet apart is most effective for spraying a defined area systematically. This method is particularly effective for treating smaller, less dense infestations. For large infestations, it may be more practical to use an ATV or UTV sprayer or a conventional boom sprayer that is pulled or mounted to a truck or tractor. Aerial application is currently being used in Arizona as a method of controlling buffelgrass infestations on a landscape basis.

Control Strategies

Invasion of buffelgrass into the Sonoran Desert and other non-agricultural areas in the Southwest is a major concern. Wherever buffelgrass becomes established, a primary focus should be on reduction of fuel loads to decrease the likelihood of wildfire. Initial treatment should attempt to reduce biomass, density, and viability of live buffelgrass plants in addition to disrupting seed production as much as possible. Secondary treatments should aim to prevent seed formation as well as reducing biomass and density of buffelgrass even further. Finally, previously treated areas should be monitored to control emerging seedlings. In most cases, at least two or more consecutive years of treatment will be necessary to eliminate buffelgrass stands and deplete the seedbank. In addition to buffelgrass reduction, indicators of successful treatment should include the return of desirable native plant species and an increase in species diversity. If necessary, consider reseeding buffelgrass-infested areas that have been treated, overgrazed, or burned over with native plant species as discussed in the Cultural Control section of this field guide.

An integrated management strategy of using a combination of physical methods, chemical treatments, and cultural controls should enhance the success rate for managing buffelgrass. The following strategies for combined treatment should be considered to contain and reduce buffelgrass dominance:

- **Manual-herbicide strategy** – Remove buffelgrass by hand methods using simple tools such as a hoe, shovel, digging bar, or Pulaski. Take care to remove as much of the root as possible without breaking them off. While this method can be done at any time of the year, it is easiest when soil is moist, temperatures are cool, and plants are in their early growth stage. Monitor previously treated sites following significant warm season rains and provide follow-up treatment by pulling or spot spraying emerging seedlings.
- **Mechanical-herbicide strategy** – Mow dense buffelgrass stands (such as those along roadsides) to stimulate growth and ensure all plants are at a similar growth stage. Use truck or ATV-mounted sprayers to apply herbicide during active growth, as indicated by the appearance of bright green, shiny leaves. Monitor previously treated sites following significant warm season rains and provide follow-up treatment by pulling or spot spraying emerging seedlings.
- **Grazing-herbicide strategy** – Graze buffelgrass to stimulate plant growth and follow this with a chemical treatment during the active growth stage. Monitor previously treated sites after significant warm season rains and provide follow-up treatment by pulling or spot spraying emerging seedlings.
- **Prescribed fire-herbicide strategy** – In conjunction with prescribed fire or immediately after a wildfire, spray newly emerged buffelgrass shoots and leaves using a broadcast herbicide treatment. Monitor and use follow-up treatments on the burned area.

Adaptive Management

Available information and current research suggest there will not be one overarching process or method for effective control of buffelgrass. Therefore, realistic goals and objectives should be established to manage buffelgrass infestations occurring widely throughout a given landscape.

To improve long-term success, consider using an adaptive management approach with the overall goal of restoring desirable plant communities. The stepwise process for adaptive management involves

1. Assessment of the overall weed problem,
2. Establishing management goals and objectives,
3. Implementation of control strategies,
4. Monitoring the effectiveness of management actions,
5. Evaluating actual outcomes in relation to expected results, and
6. Adjusting practices as necessary.

Steps of this process should be repeated in sequence as part of a continuous learning cycle that improves management planning and strategy by learning from the outcomes of previous management actions. In general, a control strategy with an adaptive management approach may be considered to be successful if

1. Stakeholders are actively involved and remain committed to the process,
2. Monitoring and assessment are used to adjust and improve management decisions, and
3. Management goals and/or objectives for the resource are being achieved.

References and Further Information

Arizona-Sonora Desert Museum. 2012. Fountaingrass (Pennisetum setaceum). Available at http://www.desertmuseum.org/invaders/invaders_fountaingrass.php (accessed Dec. 2012).

Baldwin, K. 2009. Buffelgrass Control Research Project Background Information. Available at: http://www.buffelgrass.org/pdf/buffelgrass-research-background-information.pdf and http://www.nps.gov/sagu/naturescience/upload/8-5-09BuffelgrassInfoBOS0809.pdf (accessed Feb. 2010)

Bales, L.S., E.D. Grahmann, F.S. Smith, T.E. Fulbright, and M.W. Hehman. 2009. Evaluation of Herbicides for Control of Buffelgrass and Kleberg Bluestem. Available at http://ckwri.tamuk.edu/fileadmin/user_upload/docs/STN/Posters/Evaluation_of_Herbicides_for_Control_of_Buffelgrass_and_Kleberg_bluestem.pdf (accessed Feb. 2010)

Betancourt, M. (producer). 2008. Buffelgrass Invasion (video). Available at http://www.youtube.com/watch?v=nQtIVzSrqZY

Devoe, N., B. Nowak, and S. Florence. 2009. Effective Management of Invasive Plants. Rangelands 31(3):21-24. Available at http://www.srmjournals.org/doi/full/10.2111/1551-501X-31.3.21 (accessed Feb. 2010)

Friedel, M., D. Butler, S. van Leeuwen, J. Virtue, and D. Agnew. 2008 Weed Management Guide: Buffelgrass. Available at http://www.weedscrc.org.au/documents/wmg_buffel%20grass.pdf (accessed Feb. 2010)

Grice, T. and T. Martin. 2006. Weed Management: Managing for Biodiversity in the Rangelands. Australia Department of the Environment and Heritage. ISBN 0 6425 51243. pp. 30-37. Available at http://www.environment.gov.au/land/publications/pubs/weed-management17-20.pdf (accessed Feb. 2010)

Hershdorfer, M. and R. Garner. 2007. Santa Rita Experimental Range: Buffelgrass Control in PMC Exclosure. Tucson Plant Materials Center. Tucson, AZ. Available at http://www.plant-materials.nrcs.usda.gov/pubs/azpmcpr8027.pdf

Jernigan, M.B. 2013. Use of Uprooted Invasive Buffelgrass (Pennisetum ciliare) Parent Plants at Thatch to Reduce Progeny Seedling Emergence. M.S. thesis. School of Natural Resources and the Environment. Univ. Arizona. Tucson, AZ

Morisawa, T. 2000. Weed Alert: Cenchrus ciliaris L. The Nature Conservancy. Available at http://www.invasive.org/gist/moredocs/cencil01.pdf (accessed Feb. 2010)

Northam, E., W. Meyer, J. Arnold-Musa, E. Carrillo, K. Egen, and M. Hershdorfer. 2009. Non-Native Invasive Plants of Arizona. Produced by Conservation Districts and RC & D Areas of Arizona and the University of Arizona Cooperative Extension. pp. 8-9. Peer reviewed publication #AZ1482. Available at http://cals.arizona.edu/pubs/natresources/az1482.pdf (accessed Feb. 2010)

Tu, M. 2002. Cenchrus ciliaris L. The Nature Conservancy: Wildlands Invasive Species Team. Dept of Vegetable Crops and Weed Sciences University of California Davis. Available at http://www.imapinvasives.org/GIST/ESA/esapages/documnts/cenccil.pdf (accessed Feb. 2010)

USDA Natural Resources Conservation Service. 2010. The PLANTS Database. National Plant Data Center. Baton Rouge, LA. Available at http://plants.usda.gov (accessed Nov. 2010)

VanDevender, T.R. and M.A. Demmitt. 2006. Conservation of Arizona Upland Sonoran Desert Habitat. Status and Threats of Buffelgrass (Pennisetum ciliare) in Arizona and Sonora Project # 2004-0013-003. Arizona-Sonora Desert Museum. Available at http://www.desertmuseum.org/programs/buffel_survey_report.pdf (accessed Feb. 2010)

Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC. Available at http://www.doi.gov/initiatives/AdaptiveManagement (accessed April 2011)

Suggested Websites

Arizona Native Plant Society Invasive Species Factsheet for Buffelgrass: http://www.aznps.com/invasives/Buffel

Arizona-Sonora Desert Museum: http://www.desertmuseum.org/invaders/invaders_buffelgrass.php

For information about calibrating spray equipment: NMSU Cooperative Extension Service Guide #A-613 Sprayer Calibration http://aces.nmsu.edu/pubs/_a/A-613.pdf

Herbicide labels online: http://www.cdms.net/LabelsMsds/LMDefault.aspx

Invasive Plant Atlas of the United States: http://www.invasive.org/weedus/index.html

Southern Arizona Buffelgrass Coordinating Center: http://www.buffelgrass.org

Texas Invasive Species Website: http://www.texasinvasives.org

For more information or other field guides, contact:

USDA Forest Service
Southwestern Region
Forest Health
333 Broadway Blvd., SE
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Or visit:

http://www.fs.usda.gov/main/r3/forest-grasslandhealth/invasivespecies