# APPENDIX 6. PRELIMINARY LIST OF RESEARCH NEEDS

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# PRELIMINARY LIST OF RESEARCH NEEDS

Below is a preliminary list of science needs critical to control efforts or adaptation of buffelgrass in the Sonoran Desert Region. By providing this list, we hope to engage the scientific community and provide modest guidance to government agencies that fund invasive species research.

1. *Development of coordination center and data clearinghouse:* Managing species like buffelgrass requires good science, including the development of common metadata standards governing collection and archiving of data, and use of a common set of research protocols. An invasive species coordination center would provide a valuable service in developing and enforcing scientific standards, initiating and coordinating monitoring activities, and conducting the kinds of data analysis required to assess progress and trends. The center would also help generate and disseminate predictions for future conditions. A committee of the Governor's Arizona Invasive Species Council AISC is currently discussing different options for the structure such as location and funding of such a center.

2. *Evaluation of mechanical and chemical control methods (including site characteristics, and timing and repetition of treatments*): There have been very few empirical or experimental studies that evaluate the effectiveness of different control methods over the short or the long term. There are many determining factors, including type of treatment (mechanical or chemical), site characteristics (e.g., roadsides vs. natural areas, floodplains vs. hillslopes), timing of treatment, stage of buffelgrass growth, longevity of buffelgrass invasion at site, persistence of soil seed banks, etc.

3. *Use of remote sensing to map and monitor buffelgrass*: A handful of studies have reported on the mapping and monitoring of buffelgrass using a combination of remotely sensed multispectral, hyperspectral, fine and coarse resolution, and time series data sources. Those studies that have successfully identified buffelgrass with remote sensing based research have utilized long time series of vegetation greenness data and satellite-based vegetation phenology metrics, and have for the most part focused on large scale homogeneous infestations. Hyperspectral and smaller scale, higher resolution results that inform early detection or provide efficient monitoring should be pursued. One example has been a scaling study for the state of Sonora, where 15 samples of high-resolution images were used to identify and quantify areas of buffelgrass. These images were overlayed on coarser-resolution TM images to determine the extent and magnitude at the state-wide level (Franklin et al. 2006). Such scaling tools provide fast, accurate, and inexpensive opportunities to identify and target buffelgrass invasions. The unique ecological characteristics of buffelgrass lend themselves to an integrated modeling-remote sensing approach for detection and monitoring. Field-based observations of citizen scientists using cell phones or other geospatial tools to map and photograph infestations could help expand the monitoring network.

4. *Development of phenological models for green-up and herbicide application:* Buffelgrass has been observed to remain dormant throughout much of the year in southern Arizona, growing and reproducing actively for only brief periods following sufficient rainfall in all but the coolest months of December and January. These periods of active growth can last for a few days to over a month, depending on temperatures and rainfall amounts, before the plants again return to dormancy. Certain management activities, such as chemical control, require that plants be actively growing, generally in full green-up, for herbicides to be effective. Phenological models triggered by temperature/precipitation cues need to be developed and validated with observational data. Based on average conditions, these models would identify the most probable windows in time for herbicide application. More importantly, to mobilize herbicide application efforts, these models would use real time and site-specific precipitation measurements to forecast adequate green-up with a one to two-week lead time. Treatment teams could then be deployed to specific sites as green-up occurs.

5. *Realistic spread and niche models for different strains of buffelgrass (including 'common' and 'Frio') that take into account landscape structure, pathways of dispersal, and climate variability and change:* The spread and distribution of buffelgrass will be determined by the size of the population, rapid dispersal by vehicular traffic, and a favorable climate (lack of freezing in the winter and wet summers). Niche models were developed by Ward (2003) and then Olsson (2006) for 'common' buffelgrass in southern and central Arizona, and the dynamics of spread are being considered in a decision support system for buffelgrass management in Pima County (see #10 below). Predictive niche modeling is needed to assess the further spread of buffelgrass with ongoing and projected warming. Such modeling should take into account the dramatic increase in winter and spring temperature minima in the Sonoran Desert since the mid-1980's (Weiss and Overpeck, 2005), the projected warming in the 21st Century from the most recent climate models, and the introduction in 2004 of the cold-resistant 'Frio' strain in desert grassland between 1400-1450 m elevation near Cananea, Mexico (Hussey and Burson 2005; Ibarra-Flores et al. 2005).

6. *Restoration of treated or burned areas*: The extent to which treated areas need restoration is unclear. In natural areas, the seed rain of surviving native vegetation may be adequate for rapid recovery of natural vegetation. Along roadsides and other disturbed areas, reseeding with native plants or other restoration actions may be necessary after treatment. Buffelgrass patches that have burned, whether in natural or disturbed areas, may require more aggressive measures to exclude buffelgrass. Herbicide application days to weeks after a fire, when green springs are large enough to spray, may be quite effective. Restoration experiments with control plots should be encouraged in large treatments, including long-term monitoring of restoration success.

*7. Modeling of fuel loads, ignition sources, fire behavior, fire risks, fire frequency and intervals, and the resulting fire impacts as patches coalesce and invasion progresses:* Data on buffelgrass fuel loads are just now becoming available (see Esque et al. 2007 for Saguaro National Park), but fire spread models have yet to be parameterized and adapted for buffelgrass fires. Further, coupling fire models to ignition sources and deriving fire frequency or fire intervals for assessing the potential threats to homes and businesses at the wildland urban interface where buffelgrass is or will become an issue is an important follow-on need. Models will become invaluable as the size and continuity of buffelgrass patches increases. These models will be useful not just for fighting fires, but also for prescribing firebreaks in critical urban and natural areas. An example is the foothills of the Santa Catalina Mountains, where fires in continuous patches of buffelgrass (e.g., Soldier Canyon near the Catalina Highway) can now spread up the mountain into chaparral and woodland.

*8. Impact of buffelgrass invasion on critical habitat and rare species:* Buffelgrass is reducing critical habitat and may accelerate extirpation of rare species in the Sonoran Desert. There is a need to anticipate these impacts to avoid conflict with urban development and other land uses. Scientific assessment is needed to determine which areas and species are and will be at risk. Rather than approach this piecemeal and species by species, a regional dialogue is encouraged that involves community leaders in both the public and corporate sectors.

*9. Unintended impacts of herbicides:* While glyphosate is used routinely in chemical treatments of unwanted vegetation in agricultural settings, it has not been applied broadly and repetitively on natural, desert landscapes. Because of the widespread distribution of buffelgrass in southern Arizona, massive amounts of chemicals would need to be applied to effectively control the infestations, which could lead to selection for herbicide resistance in the buffelgrass population. Recent studies suggest that glyphosate (the active ingredient in Roundup ® and the most effective herbicide at controlling buffelgrass) can adversely affect the development of amphibians and can affect cell division in humans (Bonn 2005). Spraying in riparian areas should probably be avoided, though information on impacts in desert riparian areas is unavailable.

10. *Cascading effects of buffelgrass on native species:* Native species – both flora and fauna – are being dramatically impacted as their native habitat transforms from a typical Sonoran Desert ecosystem to one that is dominated by African grasses. Many native birds, rodents, rabbits and turtles do not consume buffelgrass, which then requires them to move to other areas in search of food. This, in turn, impacts the carnivores (who eat the rodents and rabbits) and has the potential to dramatically impact plant populations as more herbivores move into ‘native’ areas that are not yet dominated by buffelgrass, which then puts that area at higher risk of buffelgrass invasion because of the added environmental stress. Although many of these species are not currently classified as ‘sensitive’ or ‘rare’, they will likely be classified as such in the near future in some areas as a result of increasing populations of buffelgrass.

11. *Riparian area impacts following buffelgrass fires*: Long-range studies are needed to assess the potential for catastrophic debris flow events to occur in areas that have been infested with buffelgrass and that burn. Areas that have been denuded of vegetation following fires are more susceptible to large debris flow events that dramatically impact and alter riparian systems. Little is currently known how areas infested with buffelgrass respond following fires and whether these areas are at a greater risk to debris flows.

12. *Web-based Decision Support Systems (DSS)*: Research is urgently needed for collaborative development of decision support tools for buffelgrass management. Such tools will enhance knowledge and understanding about the locations, size, vectors and dynamics of spread, effectiveness of treatments, and other important information – including fire forecasting, fire spread modeling, and how various factors interact with each other to intensify or reduce the overall threat. Improved understanding, in turn, will foster better decision making about where, how, and when to target specific control measures. The University of Arizona is developing such a model for buffelgrass invasion in Pima County, but research is needed to populate, parameterize and test critical routines in the model (the principal contact for the Pima County DSS is George Frisvold). The web-based DSS will allow users to specify their area of interest; upload buffelgrass observations; specify resources and constraints; choose decision priorities; and evaluate the effects of multiple treatment scenarios. The DSS will have two decision paths; one will predict the cost of treatment and another will solve a dynamic optimization problem by scheduling resources to maximize or minimize a user-chosen objective function. Neighborhood groups, government agencies, and cooperative weed management areas can use the online DSS remotely. By allowing users to upload their observations, a data flow pipeline will be linked to mapping products, providing a framework for long-term monitoring and management of buffelgrass.

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