BUFFELGRASS FUEL LOADS IN SAGUARO NATIONAL PARK, ARIZONA, INCREASE FIRE DANGER AND THREATEN NATIVE SPECIES

Saguaro cacti in buffelgrass, Javelina Picnic Area, Saguaro National Park, Arizona. USGS/TODD ESQUE

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Historically, patchy fuels and sparse vegetation have limited individual fires to small areas in the hot deserts of North America, including the Sonoran Desert (Humphrey 1974; Schmid and Rogers 1988). Most Sonoran Desert vegetation is not adapted to fire and some important endemic plant species are vulnerable to recurring fire (Thomas and Goodson 1992; Wilson et al. 1994; McAuliffe 1995). Two species found in the Sonoran Desert, the saguaro cactus (*Carnegiea gigantea*) and foothill palo verde tree (*Cercidium microphyllum*), are very susceptible to wildfire (McLaughlin and Bowers 1982; Rogers 1985; Esque et al. 2004). Exotic grass invasions in desert regions can change the fire regime by providing fuel for fire where fire was once rare. In this article we describe how an invasive exotic plant—buffelgrass (*Pennisetum ciliare*)—is a management problem in the borderlands between the United States and Mexico. We also report the results of our study of buffelgrass fuel loads on two sites in Saguaro National Park, Arizona, and discuss management implications of buffelgrass-related fire risks.

Buffelgrass fire cycle

Buffelgrass, a perennial grass native to Africa and Asia, was introduced to Australia, North America, South America, Caribbean islands, Hawaii, and some Pacific and Indian Ocean islands (Martin 2000) to increase forage production for livestock (figs. 1, 2a, and 2b). It was selected because of its ability to thrive over a wide range of annual precipitation (8–49 in or 200–1,250 mm) on shallow, marginally fertile soils and in high temperatures (Cox et al. 1988). In the Sonoran Desert, buffelgrass has escaped areas of cultivation and invaded riparian areas, roadsides, urban fringes, and wildlands (Búrquez-Montijo et al. 2002). Most cultivated stands of buffelgrass in central Sonora (Mexico) have burned at least once, if not many times, in the last 20 years (Búrquez-Montijo et al. 2002). While most Sonoran Desert plant species are not fire adapted, buffelgrass grows vigorously after a fire (Hamilton and Scifres 1982; Mayeux and Hamilton 1983; Hamilton 1985; Rutman and Dickson 2002). A grass/fire cycle (D'Antonio and Vitousek 1992) can be initiated by exotic grasses such as buffelgrass, whose productivity is enhanced by

Figure 1. A perennial grass from Africa, buffelgrass (beige tufts) was introduced to different regions of the world for livestock forage. In the Sonoran Desert it has invaded wildlands, increasing fuel loads and the susceptibility of natural areas to fire, and threatening protected species. USGS/TODD ESQUE

fire adaptations that increase fuel loads and fire intensities. The cycle is complete as high fire mortality to native plants further advances buffelgrass proliferation and results in a more frequent and intense fire regime.

Natural areas at risk from buffelgrass and the threat of fire include Saguaro National Park, Organ Pipe Cactus National Monument, and Ironwood Forest National Monument in Arizona; and Big Bend National Park, Santa Ana National Wildlife Refuge (NWR), Lower Rio Grande Valley NWR, and Laguna Atascosa NWR in Texas. The addition of frequent fire as a new process in these systems puts protected ecological communities and species at risk because hydrology and community composition, structure, and function may be drastically altered. This can cause losses of both rare and protected species by the direct effects of fire, and possibly more consequential, the loss of these rare and critical habitats by their alteration. For example, desert tortoises (*Gopherus agassizii*) and giant saguaro cactus at Saguaro National Park can be killed outright by fire and may be negatively impacted by habitat changes from fire (Brooks and Esque 2002; Esque et al. 2003). The thornscrub forest protected at southern Texas national wildlife refuges provides biologically diverse habitat for jaguarundis (*Herpailurus yaguarondi cacomitli*) and ocelots (*Leopardus pardalis*). When buffelgrass burns, the thornscrub forest is converted to less structurally diverse grasslands and may change habitat use by these endangered cats. In Big Bend National Park the endangered Chisos Mountains hedgehog cactus (*Echinocereus chisosensis*, fig. 3) is susceptible to buffelgrass fires. In the Lower Rio Grande Valley, buffelgrass invasion is considered to be a serious threat to three federally endangered endemic plants that are protected by the U.S. Fish and Wildlife Service: Walker's manioc (*Manihot walkerea*), Zapata bladderpod (*Physaria thamnophila*), and border ayenia (*Ayenia limitaris*).

Figure 3. Hedgehog cactus (*Echinocereus chisosensis*) in a patch of buffelgrass at Big Bend National Park. Hedgehog cactus is susceptible to fire carried by buffelgrass biomass. USGS/TODD ESQUE

Data on buffelgrass fuel loads in infested wildlands are not previously available. Wildfires fueled by red brome (*Bromus madritensis*), another exotic species, have occurred in desertscrub habitats in southern Arizona, including Saguaro National Park (Esque and Schwalbe 2002). The Mother's Day fire in 1994, for example, consumed 340 acres (138 ha) of Arizona Upland desertscrub, after which 24% of saguaros and 73% of palo verdes had died by 2000 (Esque et al. 2004). Since fuel loads from perennial buffelgrass have the potential to be considerably higher than those from exotic annual grasses, fires in buffelgrass likely would have longer flame lengths, more rapid rates of spread, higher temperatures, and higher mortalities of native flora and fauna.

Researchers and land managers throughout the U.S.-Mexico borderlands have reported an urgent need for control methods for buffelgrass infestations because these infestations put sensitive native species and entire natural systems at risk. To meet this goal, the U.S. Geological Survey and the University of Arizona are working with Saguaro National Park to determine the physical and ecological characteristics of buffelgrass infestations, including fuel loads, and to compare commonly used buffelgrass eradication techniques. Buffelgrass, first found along the roadsides of Saguaro National Park in 1993, has expanded into dry washes and rocky slopes of the backcountry. Concern about buffelgrass throughout Arizona has led to the addition of buffelgrass to the state list of noxious weeds (Arizona Department of Agriculture 2006).

These infestations put sensitive native species and entire natural systems at risk.

Figures 2a (left) and 2b (right). Nonnative buffelgrass (*Pennisetum ciliare*) shown in detail. 2a shows a mature tussock; 2b a young tussock going to seed. USGS/TODD ESQUE

Study location and methods

To examine wildfire potential in areas infested with buffelgrass, in 2003 we began investigation of two areas of Saguaro National Park infested with buffelgrass: Panther Peak and Javelina Picnic Area. The two sites differ in geological parent material but are similar in aspect, and both are located on steep hillsides. We placed experimental plots in continuous stands of buffelgrass within these areas as part of a larger research project comparing control methods for buffelgrass.

Fires in buffelgrass likely would have longer flame lengths, more rapid rates of spread, higher temperatures, and higher mortalities of native flora.

We measured buffelgrass production in June of 2003 on 14 plots (4 at Javelina Picnic Area and 10 at Panther Peak), where buffelgrass was manually pulled from the ground. All plots were 10 x 10 m (~33 x 33 ft) in area. To estimate standing fuel loads, all of the buffelgrass was harvested from study plots by pulling it up by hand. Soil was removed by shaking and hitting the roots against rocks to the greatest extent possible. All of the grass was placed in plastic trash bags and weighed fresh to the nearest gram immediately. In the laboratory, individual plants were selected to represent the sizes of plants growing on the plots. Shoots were separated from roots and weighed separately to provide an estimate of the shoot-to-root ratio. Then samples were oven-dried to constant temperature to estimate moisture content of the buffelgrass plants. These data were used to provide estimates of the total amount of dry buffelgrass on each study plot and then extrapolated to estimate production as the average kilograms per hectare (lb/ac) plus or minus one standard error from the mean (± 1SE).

Results and discussion

The average amount of buffelgrass estimated on four plots at Javelina Picnic Area, and measured as dry aboveground mass, was 2,828 kg/ha ± 335 1SE (2,523 lb/ac ± 298 1SE), and at Panther Peak was 2,480 kg/ha ± 227 1SE (2,213 lb/ac ± 202 1SE). During the study, sites received less than 267 mm (10.5 in) of rain annually (National Oceanic Atmospheric Administration, 2002, 2003, 2004). The buffelgrass measured in June was very dry with only 3.6% water present in the samples on the plots.

Production estimates reported here are well above the minimum amount required to carry fire in arid areas. Furthermore, the fuel loads found in this study, along with the occurrence of fires fueled by buffelgrass in suburban areas of Arizona, Sonora (McNamee 1996; Búrquez-Montijo et al. 2002), and Texas, leave no doubt regarding the ability of buffelgrass to carry fire in infested wildlands of the Sonoran Desert (fig. 4).

The fuel loads we measured in Saguaro National Park are large enough to carry wildfire and present a threat to the resources managed by the park. The buffelgrass fuel loads on our study plots were found to be high in comparison to fine fuels from annuals (native and exotics combined) in desert biomes of North America, which range from zero to more than 700 kg/ha (624.9 lb/ac) (Beatley 1969; Halvorson and Patten 1975; Hunter 1991; Brooks et al. 2003; Esque and Schwalbe 2002). A minimum of 1,680 kg/ha (1,498 lb/ac) is required for American grasslands to burn and 3,000 kg/ha (2,677 lb/ac) of fuel is necessary for fire to carry in moist African savannas (van Wilgen and Scholes 1997; Hély et al. 2003; Stevens 2004), but it takes as little as 500 to1,000 kg/ha (446 to 892 lb/ac) of fuel for fire to carry in arid areas of Africa (van Wilgen and Scholes 1997). For comparison, we measured potential fuels on previously burned (at least one growth season after fires) and unburned sites at Saguaro National Park and found that red brome comprised about 43% of the fine fuels of annual plants and ranged between 0.25 and 2.3 kg/ha (0.22 to 2.05 lbs/ac) on previously burned and unburned sites, respectively.

Figure 4. An infested control plot at the Javelina Picnic Area study site at Saguaro National Park illustrates the large fuel load created by buffelgrass. USGS biologists estimate the total standing biomass of buffelgrass. USGS/TODD ESQUE

Other reasons for concern

Though some Sonoran Desert plants show the ability to regenerate or re-sprout after a fire (Wilson et al. 1994), many species do not. Regrowth from seed may require 20 years or more for a return to pre-fire vegetative cover conditions and an order of magnitude more than that to replace mature saguaro stands assuming the sites do not burn again during recovery (Rogers and Steele 1980; McLaughlin and Bowers 1982; Cave and Patten 1984; Esque and Schwalbe 2002). In contrast, buffelgrass can re-sprout quickly after a fire and may outcompete native plant species or even replace them. Buffelgrass encourages a fire cycle, which desert plants and animals are not adapted to. An increase in fire occurrence could lead to local extirpations of long-lived species like the saguaro, palo verde, and desert tortoise (fig. 5). Therefore, if buffelgrass persists in natural areas and continues to spread, these areas could convert from saguaro and palo verde desertscrub into grassy mesquite (*Prosopis* spp.) and acacia (*Acacia* spp.) savannas, similar in structure to the native areas of buffelgrass and, since North American Sonoran Desert plants are not adapted to fire, such a trend might lead to biological impoverishment similar to that observed where the exotic cheatgrass (*Bromus tectorum* L.) has degraded Great Basin Desert biomes (Billings 1990).

Figure 5. With the encroachment of buffelgrass, an increase in fire could follow, resulting in local extirpation of desert tortoises, like this one.

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High fuel loads from buffelgrass in otherwise undisturbed wildlands and the threat of subsequent fires illustrates the need for more information on these infestations and possible methods to control them. Based on current observations 1% of the desertscrub plant community at Saguaro National Park is infested with buffelgrass and those patches have the potential to grow rapidly, having more than doubled in area over the last four years (Danielle Foster, National Park Service, unpublished data). Land managers and scientists share a growing concern not only with buffelgrass but also with other exotic perennial grasses in the southwestern United States, such as fountaingrass (*Pennisetum setaceum*), which present similar threats from invasion and subsequent fire (Williams and Baruch 2000).

Although the general distribution of buffelgrass within national parks and ecological reserves in the United States and Mexico is known, the associated risks of fire in the urban-wildland interface, the threats to rare and protected species, and changes in biotic communities are not well documented. This information gap is hindering land managers in developing strategies to control this invasive species, as it is difficult to select areas in which to concentrate efforts without first knowing the extent of the problem.

Buffelgrass will continue to be a fire risk in urban areas and wildlands throughout its range in the United States and Mexico until comprehensive control strategies are developed and successfully implemented. The National Park Service, U.S. Geological Survey, and the University of Arizona have entered into a partnership to provide partial solutions to the buffelgrass problem. A research project has been developed to study the most cost-effective way to control buffelgrass with techniques that are allowable in national parks in addition to analyzing the costs and benefits of such activities both financially and environmentally. Preliminary information from this study was used to develop an integrated pest management plan at Saguaro National Park that included limited use of herbicides where necessary. The work initiated at Saguaro National Park has been expanded into surrounding natural areas and vacant lots in Pima County surrounding the national park. Local experts feel that the expanded control efforts are necessary for the removal of this invasive exotic grass. The methods employed to control buffelgrass appear to be effective on the patches where control measures have been applied. However, success depends on reducing the probability of re-invasion from nearby patches both on and off of parklands.

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