Written testimony of
Dr. Richard N. Mack
Professor, School of Biological Sciences
Washington State University
Pullman, Washington

To the
U.S. House of Representatives,
The Subcommittee on National Parks, Forests and Public Lands
of the Committee on Natural Resources

Good morning and thank you for the opportunity to provide testimony here today.

I am Richard N. Mack. I am a Professor of Biological Sciences at Washington State University. I am an ecologist, and for the past 35 years my research has dealt with invasive plant species and more specifically with invasive grasses in the Far West. Much of my research on invasive grasses has concentrated on the century long invasion of cheatgrass (*Bromus tectorum*), a native of arid Eurasia and northern Africa, in its vast new range in the Intermountain West.

I. Plant Invasions in Arid Regions: A Recurring Phenomenology and Learning from One Invasion as Preparation for Combating the Next Invasion

A point that I hope to demonstrate today is that lessons we have learned from investigating the spread, population biology and consequences of the invasion of cheatgrass, an invasion that was underway a century ago, provides valuable lessons in determining the future for other invasive species in arid ecosystems in the U.S., in particular buffelgrass (*Pennisetum ciliare*). The phenomenology of all terrestrial plant invasions shares many characteristics (Rejmanek et al. 2005), although admittedly each invasion has some unique features. As a result of shared characteristics and features, many of the lessons and consequences we see in the long term invasion by cheatgrass have reliable carry-over for our understanding of the still developing invasion by buffelgrass in much of the U.S. Southwest.

As has been true for almost all plant invasions, the invasion by cheatgrass began slowly with its introduction into isolated areas. Populations of this non-native grass grew readily and small pockets of its occupation, perhaps just a few acres, developed at a handful of sites on the Columbia Plateau and in northern Utah in the late 19th century. Unlike buffelgrass, the entry of cheatgrass was almost entirely accidental (Mack 1981). Although the mode of introduction (accidental or deliberate) can affect the number of entry sites, all plant invasions are dependent on a large measure of pre-adaptation of the non-native species to the physical and biotic components of environment in the new range. For both cheatgrass and buffelgrass, a major pre-adaptation has been to an arid environment through a varying array of physiological mechanisms (Smith et al. 1997). Equally important for both these grasses has been a tolerance to grazing by large mammals. Such tolerance is exceptionally important for two reasons in the context of the arid American West: many native species cannot tolerate routine (or even seasonally restricted) removal of plant material by grazing because the plant's ability to replace biomass ultimately requires water, and water is almost always limiting in the American arid grasslands and deserts. Furthermore, to a degree not widely appreciated by the public, our arid treeless regions in the Far West did not support large herds of native ungulates (bison, elk, antelope, deer) before the extensive arrival of settlers in the 19th century (Mack & Thompson 1982). Consequently, our native plant species in this huge region are at a competitive disadvantage with non-natives, such as cheatgrass and buffelgrass, in the greatly altered environment brought about with the introduction of livestock.

The rise of the public's alarm to the spread of cheatgrass also deserves comparison to the events still unfolding with buffelgrass. Although cheatgrass was recognized early on by farmers as a troublesome weed, the whole scope of the damage that it would cause was not recognized until after it was too late to curb the invasion, much less eradicate it, with the tools available in the early 20th century (laborious mechanical removal). Within less than 20 years (1915-1935), cheatgrass went from a problem in croplands on the Columbia Plateau and northern Utah to a regional invader in croplands and the much more extensive rangelands in a five-state area (Mack 1981). The damage this small (usually less than 18 in. tall) grass now wreaks is massive in terms of its contribution of fuel for wildfires on a scale that the native plants never contribute. Proliferation of cheatgrass and the recurring fires its fuel produced has caused almost total replacement of palatable <u>native</u> grasses for livestock with a low value, temporary forage. In addition, cheatgrass remains a persistent weed in crops (mainly wheat, barley and oats) on the Columbia and Snake River Plateaus.

The Worst Damage by Invasive, <u>Combustible</u> Grasses is not Immediately Seen

The worst damage caused by cheatgrass however (and ominously similar to the growing role of buffelgrass) has been the aftereffects of huge (as much as 500,000 acres) fires that almost yearly ravage its new range here in the West. In addition to the immediate loss of property and even human life caused by cheatgrass-fueled fires is the loss of soil from this region. These fires consume all vegetation in their path and the result is a lifeless, blackened landscape with no vegetation left that could check sheet-wash and erosion. This soil, which is an irreplaceable natural resource for the Nation, is destined to wash into the region's waterways. The Snake and then the Columbia River are the eventual resting places for this new sediment. Sediment clogging these rivers threatens the efficacy, and even outright sustainability of the hydroelectric dams along these waterways, including Grand Coulee Dam in Washington and the Bonneville Dam on the Columbia River at the Oregon-Washington border. So severe is erosion from the Snake-Columbia watershed that the US Army Corps of Engineers must routinely dredge these waterways of sediment to maintain the rivers as navigable waterways and to minimize sediment that would interfere with turbine performance in these dams (http://www.nww.usace.army.mil/dmmp/default.htm). Much of this cost (and the attendant concerns about environmental damage caused by annual dredging [http://findarticles.com/p/news-articles/columbian-vancouverwash/mi_8100/is_20050619/corps-seeks-input-dredging-snake/ai_n51309342/] can be blamed on cheatgrass and the fires it fuels in the region.

Here again, the invasion of cheatgrass and its consequences in the Intermountain West presage events and circumstances that are unfolding with the buffelgrass invasion in the Southwest. As a non-native grass deliberately chosen for forage, buffelgrass was introduced initially into more locales than was the accidentally-introduced cheatgrass decades earlier. But much of the subsequent spread of buffelgrass has occurred through its own seed dispersal, rather than direct introduction by humans. Similar to the unfolding invasion of cheatgrass, the early small infestations of buffelgrass were worrisome to some, but ignored by many others – until the new range occupation became only too apparent.

Invasions of Invasive Species take on an Accelerating Pace

The rate of new range occupation and increase in abundance of invasive species forcefully illustrates one of the most powerful aspects of the performance of an invasive species under conditions it finds ideal (and simultaneously illustrates an important difference between the need for swift reaction to combat its spread, compared with a pollutant, such as a heavy metal contaminant in soil). Species have various modes of persistence, including the production of seeds. Under conditions a species finds ideal (as defined by the species), its vegetative growth and its seed production may be prolific and form a performance trajectory that grows with compound interest. The accrued interest for a species, such as buffelgrass, is the rapid increase in seeds and in-turn new parent plants. This growth in numbers adds individuals to the population at an exponential rate, so that the doubling time for the population becomes increasingly short, e.g. from decades to just a few years. Consequently, the immigrant population grows and expands its range: a few individuals in a small locale increase to many individuals occupying a much larger area (Mack 1981; Williamson 1996). When viewed in a map, the initially occupied areas grow, and eventually coalesce at an accelerating rate (Elton 1958; Mack 1981). The alarm that is being legitimately sounded now about the spread and prominence of buffelgrass is a recurring public reaction to the development of a biological invasion.

II. The Need for a New Course of Action in Combating Buffelgrass

Given the size of areas occupied by invasive grasses such as buffelgrass, one might readily conclude that these species and the harm they cause are with us for good, and that at best all we can do as a Nation is pay for site restoration after an invasive grass burns over a huge area. (This approach is roughly analogous to cleanup after a hurricane or an earthquake, i.e., cleanup is our only option; prevention of the next calamity is not possible.) Although site restoration through re-seeding and careful conservation of areas once occupied by an invasive species is always required, we need to take a much broader, science-based, view of not only restoring areas damaged by buffelgrass but also actively implementing a sustained program to roll-back the invasion.

What Is Being Done (and What Can also be Done) Now

The current control of buffelgrass locally has often produced positive results, such as the laudable campaign to limit its spread in the Saguaro National Park and Organ Pipe Cactus National Monument. Using dedicated volunteers, U.S. National Park personnel have removed buffelgrass from many areas within both sites, perhaps most important has been its removal along roads, which serve as excellent corridors for the grass's spread http://www.nps.gov/orpi/naturescience/invasive-plant-species.htm). Other groups within the Tucson area have also banded together to remove local grass infestations. These efforts pay immediate dividends by protecting sites of high cultural and conservation value and should be encouraged, expanded and sustained.

Another, non-mutually exclusive approach that can be done now (short term) is admittedly more controversial. Although buffelgrass has been banned for planting and transporting in Arizona since 2005 (Schiermeier 2005), the grass is available for sale elsewhere in the U.S. and even overseas. Furthermore, an active research program has been pursued elsewhere in the U.S. to breed cold tolerance into buffelgrass so as to expand its geographic range as a forage grass (Hanselka 1988; Hussey & Bashaw 1996; Hussey and Burson 2005). This line of investigation has led to the release for sale of a cold tolerant strain "Pecos Buffelgrass® (http://www.pogueagri.com/Buffelgrass_Pecos_Brand.aspx). I am unaware of any evidence that this variety has become invasive. But developing new varieties of this grass that would extend its geographic range seems problematic, particularly in any cases in which the new variety is derived from the same basic genotypes as those that are now invasive in the Southwest. Policy-makers could consider strengthening the prohibition of this grass's sale and transport as well as evaluate whether developing new buffelgrass varieties is in the overall public interest.

What can be done in the Long Term – Exploring Biological Control

I contend that while a variety of tools have been used to control invasive grasses, such as buffelgrass, including herbicide application, mechanical removal, and controlled burns of accumulating fuel, we need to investigate additional approaches to this problem that are more effective at all landscape scales. The cumulative areas already occupied by buffelgrass defy effective control, much less permanent removal, by any of the tools that gave been employed so far. Herbicides are rarely practical over large areas, and often incur public comment on the potential for collateral damage to waterways, livestock, native species and humans; mechanical removal is impractical for an invader that now occupies so large an area. (Although it can be effective in protecting small areas of special interest or sensitivity.) Controlled burns are a highly contentious issue in the West – certainly appropriate in some circumstances in forested sites but is problematic or even counter-productive in habitats that buffelgrass occupies. (And of course, it is not feasible near buildings, highways or anywhere near where humans reside.)

Biological Control – the last big (untried) tool in the toolkit for combating invasive grasses

The biggest single tool left remaining in the invasive plant toolkit for combating buffelgrass (and other invasive grasses in the West) is biological control. Biological control refers to the release of organisms, usually native to the native range of the invader, which readily attack the invasive species– and only that species. The USDA has a long, successful history of having discovered, developed and released effective biological control agents in the U.S. Invasive plant species that have been effectively curbed in this manner over large areas include St. Johns Wort and Dalmatian toadflax (Coombs et al. 2004). The biological control agents released in these cases have been insects, but it is unlikely that any insect can be found that attacks only buffelgrass. (Grass species rarely have specific insect predators or grazers.)

The search for biological control agents for buffelgrass will instead need to be for microorganisms (e.g. bacteria, fungi) that have the requisite lethality and specificity for this invader (e.g., Auld and Morin 1995; Hintz 2007). Specificity in attack of buffelgrass or any invasive grass is of paramount importance, given the need to prevent introduction of any microbial agent that inadvertently also attacks a native or valued introduced grass. (Admittedly the most severe concern would deal with commercial grasses employed in food production, such as corn, wheat, oats and rice.). Neither the invasive grass nor the microbial species to be evaluated as control agents are genetically uniform, although most buffelgrass in the U.S. was produced through asexual seed production, i.e., the seed develops without requite pollination (Gutierrez-Ozuna et al. 2009). Whatever the extent of the grass's genetic variation, whether termed subspecies, races, varieties or most specifically, genotypes, it will nevertheless need to be characterized. The same characterization will be necessary for any microbial taxa that may show promise of buffelgrass control under laboratory conditions.

Key to finding Effective Microbial Control Agents will be characterizing their specificity

To develop an effective bio-control program against buffelgrass (as well as other invasive grasses in the West) will require commitment to a research program by USDA (in association, for example, with researchers at land grant universities and others) to identify microbial agents that meet a high standard for efficacy in control of the invader and strict specificity. Such research will likely involve a long term financial commitment by state and federal governments to ensure that the project is given the opportunity to succeed. (Development of biological control agents from initial collections through evaluation to release on the target species often involve a work that spans as much as 10 years or more). Research for biological control agents does not guarantee a successful outcome: some searches for effective agents against other plant invaders have yet to identify an effective agent (Coombs et al. 2004). And as pointed out above, great care will be needed to ensure that no introduced agent can attack any non-target grass, especially a crop species. Unintended target species often include close taxonomic relatives of an invasive species. Although no *Pennisetum* species are native to the U.S., pearl millet

(*Pennisetum glaucum*), a commercial crop, is a relative. Consequently, care certainly would need to be directed at insuring the release of an agent that does not attack pearl millet.

As illustrated with the presence of a valued relative of buffelgrass in the U.S., the scientific hurdles in such a research program are admittedly sobering. But I certainly do not mean to paint a pessimistic picture. The opportunity for success in this research has never been better: recent advances in the molecular technology needed to screen and characterize the genetics of large number of microorganisms has taken quantum leaps, even the last half dozen years. Analyses that once took years, can now be completed in a few months and at a small fraction of the cost 10 years ago. For example, the federally funded Human Genome Project, a massive research program to map all the genes that we humans possess, took more than a decade and cost 3 billion dollars (http://www.technologyreview.com/Biotech/18809/?a=f). In sharp contrast, 80% of the Paleo-Eskimo genome, i.e., duplicating the original Human Genome Project but for a specific group of humans, was completed recently in 2 months for $500,000 (Rasmussen et al. 2010). These costs and the length of the analyses will undoubtedly drop further with rapidly improving technology in the next few years. Nevertheless, federal commitment to this program through the USDA and its research partners will involve multi-year careful laboratory evaluation of potential bio-control agents.

Although I am optimistic about the ability to rapidly screen potentially hundreds of microbial taxa for efficacy and specificity, I deliberately avoid painting an overly optimistic picture of the ability to find effective agents for buffelgrass. There are no assurances of success in the search for biological control agents. I emphasize nonetheless that the search for these agents, given the growing scale of the damage attributable to this invader, is worth the endeavor. Without it, buffelgrass will continue to expand its range, and this range expansion will occur even without our factoring in the potential for this grass to expand its range under future global warming.

Postscript: What Can be Done Now and in the Future

Buffelgrass was deliberately introduced in an era in which the ability to evaluate the potential detrimental features of a non-native grass were rudimentary (e.g. prohibition of parasitic plants and species known to harbor pathogens that could attack crops). In retrospect, the introduction of buffelgrass and other species should have been blocked, and these lessons are reflected in current quarantine laws and Weed Risk Assessments (WRA), illustrated by the Plant Protection Act of 2000. (http://www.aphis.usda.gov/lpa/pubs/fsheet_faq_notice/fs_phproact.html). USDA APHIS diligently carries out enforcement of this and other regulations. Needed however is a strengthening of our ability to detect and prohibit the entry of problematic species that may pass or at least not fail current screening procedures. Although some invasive or otherwise noxious species would likely arrive under any evaluation protocol short of a total (an economically untenable) ban on plant imports, post-immigration (but pre-release) experimental field testing and evaluation of these species would likely pay important dividends. For example, had buffelgrass been evaluated in field trials in its intended range in the Southwest before its widespread introduction, its invasive properties would likely have been detected. Much cheaper to the Nation than the high cost of a potential "Product recall" for buffelgrass and other deliberate plant introductions that have become invasive would be an effective, transparent, science-based procedure for their detection and removal. Steps are underway to develop such a system for the future (Mack 2005; Davis et al., in press).

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