

CHALLENGING CHEATGRASS:

CAN TOOLS LIKE THE 'BLACK FINGERS OF DEATH' FIGHT THIS FORMIDABLE INVASIVE SPECIES?

Technological advances, from the development of agriculture thousands of years ago to the recent globalization of travel and commerce, can bring unintended consequences in the wake of anticipated benefits. Throughout history, human beings have intentionally introduced some species, such as agricultural products, and have inadvertently brought other species, including cheatgrass (*Bromus tectorum*), to continents where those species did not previously exist.

Cheatgrass, a Eurasian annual species introduced into the United States in the 19th century, is part of the much larger problem of invasive species that are harmful to the economy and environment in which they now thrive. In the absence of natural enemies that keep an invasive species in balance with other species in its place of origin, the invader can develop into a monoculture that threatens native species over large tracts of land in its new home.

*"The scale of fires we're seeing has introduced a new word: megafires."
- Forest Service Chief Gail Kimbell*

Once highly flammable cheatgrass is established, infrequent natural fires (which used to occur on average every 30 to 110 years and promoted rangeland health) are supplanted by fires of far greater intensity that occur at intervals of only three to five years and can be catastrophically destructive to habitats and humans alike.

Fires fueled by cheatgrass contributed to 2,722,838 acres burned in the Intermountain West in the first nine months of 2007. This is not only a large increase over the 1,842,688 acres destroyed by fire in this region in all of 2006, it is part of a trend that varies by individual year but, over time, tends progressively upwards.



Cheatgrass, which matures and dries out weeks before native plants, fuels wildfires that can burn millions of acres. (Photo courtesy of Mike Pellant, Great Basin Restoration Initiative Coordinator)

Senate Hearing

On October 11, 2007, the Senate Subcommittee on Public Lands and Forests held a hearing about threats to the Great Basin in the 21st century. Several witnesses spoke of the relationship between climate change and cheatgrass.

"We have watched our lower elevation valley floors burn, only to see invasive cheatgrass replace what were once perennial bunch grasses, sage and other shrubs... Climate change has the potential to move the cheatgrass-prone environment to higher elevations."

—Dr. Boyd Spratling, Nevada Cattlemen's Association

"... the increase in rangeland wildfires is partially due to enhanced cheatgrass production stimulated by increasing CO2 levels... Increased wildfires... and conversion to cheatgrass dominance... cause[s] large scale conversion of rangeland carbon sinks [which, beneficially, store carbon in the soil] to carbon sources [which, detrimentally, release excess CO2 into the atmosphere]."

—BLM Range Ecologist Mike Pellant

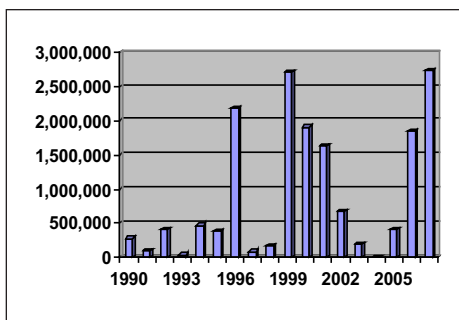
"... climate change and land use... contribute to a likely increase in exotic annual grasses such as cheatgrass... The averaging of 21 climate models predicts that temperatures will increase by up to 6° C (11° F) in the Great Basin/Colorado Plateau region during the next century... [This] is likely to have profound effects on water resources and the living systems that depend on those resources."

—USGS Research Ecologist Jayne Belnap

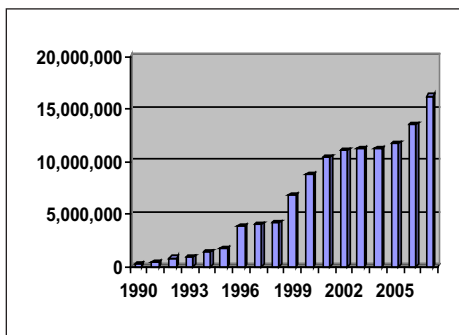
Subcommittee hearing witnesses also emphasized the relationship between cheatgrass and fire. The following charts summarize additional Great Basin fire data from Mike Pellant compiled by RMRS Ecologist Robert Cox and TNC/BLM Fire Ecologist Don Major. These charts are approximate estimates based on data from the Great Western Wildfires spatial dataset for 1990–2003 from Sagemap (<http://sagemap.wr.usgs.gov/>) and the Yearly compilation data for 2004–2007 from Geomac (<http://geomac.usgs.gov/>).

The interval between large fires in the Great Basin is decreasing and the total number of acres burned is increasing — more than 2.7 million acres burned by the end of summer this year. Cheatgrass is responsible, in part, for the historic increase in these wildfires.

**Great Basin Fire Since 1990
— Acres Burned By Year**



**Great Basin Fire Since 1990
– Cumulative Acres Burned**



Note: The rightmost bar in both charts represents the first nine months of 2007 (small wildfires might not be included). For more information, see “Subcommittee on Public Lands and Forests: To consider the

major environmental threats to the Great Basin in the 21st century (Las Vegas, Nevada)” at http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Hearing&Hearing_ID=1658.

Research Initiatives on Cheatgrass

Scientists at the U.S. Forest Service’s Rocky Mountain Research Station (RMRS) are working on multiple fronts to challenge — and reverse — the deterioration of grassland-steppe ecosystems and the concomitant escalation of cheatgrass fires. Researchers with the Station’s Grassland, Shrubland, and Desert Ecosystems science program, headed by Plant Geneticist Durant McArthur, use the following framework to conduct invasive species research:

- **EARLY DETECTION AND RAPID RESPONSE.** This is the most cost-effective approach but least understood research area. Current efforts include identifying factors, such as past and current land use, that affect the susceptibility of plant communities to invasion; the role of natural disturbances such as wildfires as well as anthropogenic disturbances such as overgrazing or energy development; and behavioral differences exhibited by an invasive species in its homeland when compared to its behavior in an invaded environment like the Great Basin.
- **CONTROL AND MANAGEMENT.** Research extends beyond conventional control methods to explore such techniques as the possible use of indigenous or imported natural enemies (called biocontrol agents) of an invasive species such as cheatgrass. This includes evaluating any potential danger for native plants of any imported biocontrol agent.

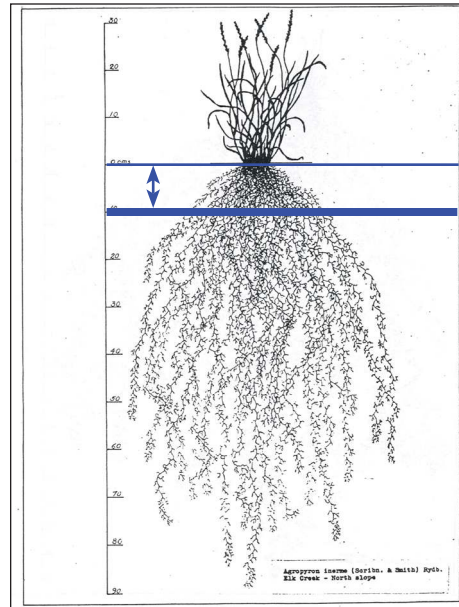
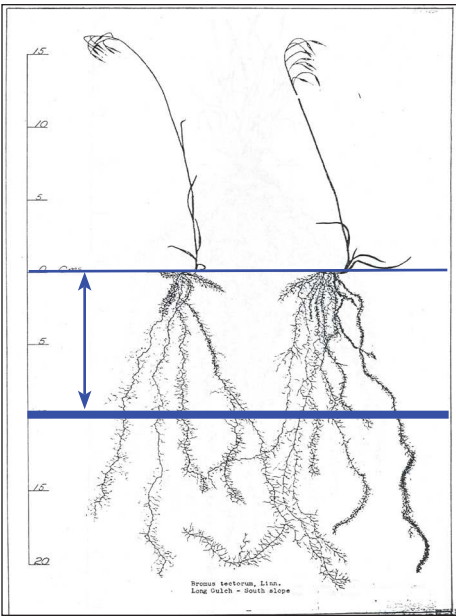
- **REHABILITATION AND RESTORATION.** Research evaluates techniques that enable relatively healthy ecosystems to resist invasive species expansion; aid the recovery of native communities already subject to extensive invasion by reintroducing a mixture of native species; and reduce the possibility of re-invasion in treated areas.

Can the Head Smut Fungus Keep Cheatgrass in Check?

One of the more promising research areas under investigation is the use of a biocontrol agent such as the seed fungus *Ustilago bullata* to control cheatgrass. This fungus causes head smut disease in cheatgrass by infecting its germinating seeds. Although the fungus allows cheatgrass to grow to maturity, when the cheatgrass plant flowers, the head smut pathogen prevents the plant from producing seeds and thus prevents it from reproducing.

Historical data indicate that head smut epidemics have temporarily eliminated cheatgrass over large areas in the western United States for a period of time, after which cheatgrass typically re-establishes itself or the area is taken over by other invasive weeds. The research goal is to determine how to change this pattern and reestablish native plants before cheatgrass returns.

Scientists Susan E. Meyer, David L. Nelson, and Suzette Clement are exploring the feasibility of using the head smut fungus as a cost-effective biological method — potentially safer than herbicides — to control cheatgrass before reseeding an area with indigenous species. “We are looking at which variations of the head smut fungus are pathogenic to which types of cheatgrass and, conversely, which types of cheatgrass are resistant or susceptible to which variations of the fungus,” said Meyer.



The roots of cheatgrass, left, are less extensive than the roots of typical native shrubland plants, such as native bluebunch wheatgrass, right, providing a weak anchor for the soil and promoting erosion.

Research also includes environmental factors, such as temperature, that influence infection rates of susceptible types of cheatgrass, as well as the possible threat that the head smut fungus might pose to native species.

“If the head smut fungus proves to be an effective method to control cheatgrass without harming native species, land managers can use this fungus to prevent cheatgrass seed production while reseeding the area with native plant species,” Meyer said.

For more information, see:

- “Evidence for Resistance Polymorphism in the *Bromus tectorum/Ustilago bullata* Pathosystem: Implications for Biocontrol,” at http://www.fs.fed.us/rm/pubs_other/rmrs_2001_meyer_s001.pdf [*Can. J. Plant Pathol.* 23: 19–27 (2001)].
- “Genetic Variation in *Ustilago bullata*: Molecular Genetic Markers and Virulence on *Bromus tectorum* Host Lines” at <http://www.journals.uchicago.edu/IJPS/journal/issues/v166n1/166003/166003.web.pdf> [*Int. J. Plant. Sci.* 166(1):105–115. 2005].

Can the ‘Black Fingers of Death’ Control Cheatgrass?

Another potential biocontrol agent that recent work indicates might prove to be useful in controlling cheatgrass is a soil fungus. Nicknamed the ‘black fingers of death’ (*Pyrenophora semeniperda*) by RMRS scientist Susan Meyer and Gonzaga University Associate Professors of Biology Julie Beckstead and David Boose, this fungus kills cheatgrass seeds in the soil. Although seeds that germinate soon after infection can survive, seeds that don’t germinate until later will not survive. RMRS scientist Susan Meyer and colleagues from the Grassland, Shrubland, and Desert Ecosystems research program, scientists from Brigham Young University, and Professors Beckstead and Boose have started a three-year project to investigate this fungus. According to Meyer, the study will combine field experiments with molecular genetics. The research project is funded by grants from the U.S. Department of Agriculture and the Joint Fire Science Program.

“The relationship between the ‘black fingers of death’ and cheatgrass is a pathogen system (like the relationship between cheatgrass and the head smut fungus) in which cheatgrass is the host for the fungus,” said Meyer. “Research goals include exploring evolutionary changes in both the pathogen and host, determining whether using this soil fungus is effective against cheatgrass, and, at the same time, harmless to the native species that need to be protected or restored,” she said.

For more information visit <http://gonzaga.edu/News-and-Events/newsdetail.asp?EventID=3113>.

How Many Native Species Must Exist to Resist Cheatgrass?

Protecting environments that have experienced cheatgrass incursion but currently retain a high number of native species from further cheatgrass expansion is more cost-effective than trying to restore an environment that is already severely impacted by cheatgrass. Supervisory Research Rangeland Scientist Robin Tausch and Research Ecologist Jeanne Chambers are studying methods to restore sagebrush steppe that has been invaded by cheatgrass, encroached on by pinyon-juniper woodlands, and devastated by catastrophic wildfires.

Funded by the Joint Fire Sciences Program, this five-year study, called SageSTEP (Sagebrush Steppe Treatment Evaluation Project, www.SageSTEP.org/research_overview.html), explores the effectiveness of various management options in reducing wildfires and restoring a healthy ecosystem. One major SageSTEP experiment within this initiative compares the relative success of various options for controlling cheatgrass: prescribed fire; mechanical thinning of sagebrush by mowing; and herbicide application to old sagebrush to encourage the growth of young sagebrush and native understory grasses.

Which Environmental Factors Promote or Deter Cheatgrass Expansion?

Recent investigations by Station scientists Jeanne C. Chambers, Susan E. Meyer, and colleagues show that the vulnerability of Great Basin sagebrush ecosystems to invasion by cheatgrass varies over time and space (including elevation), depending on several interacting environmental factors.

Research shows that cheatgrass invasion:

- Increases with the removal of native perennial herbaceous grasses and forbs (which can occur as a result of overgrazing) in part because cheatgrass can out-compete remaining native plants in accessing soil water and nutrients.
- Is lowest on sites that still contain a high proportion of native perennial herbaceous species.
- Increases with the destruction of native shrubland vegetation through fire, in part because cheatgrass seeds tend to survive fire in comparison to the relatively fire-intolerant native shrubs, whose seeds tend to be destroyed by fire.
- Increases substantially when the removal of native plants and fire are combined.
- Is less at higher elevations due to lower soil temperature (even though higher elevation sites experience more days of available soil water and relatively higher levels of nitrate).
- Is higher at lower elevations due, in part, to higher variability in soil water availability.

For more information, see “What Makes Great Basin Sagebrush Ecosystems Invasible by *Bromus Tectorum*?” at http://www.fs.fed.us/rm/pubs_other/rmrs_2007_chambers_j001.pdf [Ecological Monographs, 77(1), 2007, pp. 117–145].



BLM crews planted 33,800 sagebrush seedlings purchased from the Forest Service's Lucky Peak Nursery to restore 800 acres burned in the Clot Fire in Idaho.

“Ecosystem susceptibility to invasion by nonnative species is poorly understood, but evidence is increasing that spatial and temporal variability in resources has large-scale effects.”
-Research Ecologist Jeanne C. Chambers

How Best to Reseed Native Species?

A major obstacle to the successful reseedling of native plant species in the Intermountain West is the simple fact that not enough seeds are available. In addition, some available seed supplies contain seeds of multiple sub-species originating from sites whose characteristics (such as soil composition or elevation) differ — which makes it impossible to use those seeds for planting appropriate subspecies in locations for which those subspecies are adapted.

Reseeding after a fire must be preceded by a site evaluation that determines factors such as native and invasive species present before the burn, soil characteristics, precipitation, erosion potential, and elevation. It is also important to determine the availability, for each sub-species to be replanted, of high-quality seed that originates in a site similar to the site to be replanted (to account for adaptive variations such as drought or frost tolerance); and, of the available native species for which seeds are available, those that are compatible with each other if planted at the same time.

For reseedling to be successful using current methods, RMRS scientist Nancy L. Shaw and colleagues stress the following:

- Existing cheatgrass must be reduced or destroyed before reseedling can be effective. Current methods include the use of early season burning, tillage, mowing, or herbicides.

- Reseeding is more likely to succeed if the seeds used represent a set of native species typically associated with each other (such as big sagebrush and its obligates) rather than using seeds of only one plant.
- Reseeding native plants might fail (even if multiple native species that belong together are included) unless seeds are obtained from plant populations that are adapted to a specific type of planting site.
- Protecting reseeded land from disturbances, including livestock grazing, for at least three to five years greatly increases chances for success, especially when restoring big sagebrush.
- Monitoring the results of seeding for a few years helps determine the relative success of various seeding techniques in differing environments. According to BLM Range Ecologist Mike Pellant, it is also imperative to select seeds that are drought resistant and thus resilient in the face of climate change. This is especially true for sagebrush because it has a lifespan of 50–100 years.

For more information, see:

- “Reseeding Big Sagebrush: Techniques and Issues” at http://www.fs.fed.us/rm/pubs/rmrs_p038/rmrs_p038_099_108.pdf.
- “Cooperative Native Seed Increase Program” (part of the Great Basin Restoration Initiative) at http://www.fs.fed.us/rm/boise/research/shrub/projects/AOSCA_brochure_updated.pdf.

How Competitive Are Variations of Winterfat in the Presence of Cheatgrass?

Winterfat is a morphologically highly variable shrub native to salt desert shrublands in the Intermountain West. It has been widely displaced by cheatgrass, particularly after the occurrence of fires.

Recent research by RMRS Research Botanist Nancy L. Shaw (who leads the Station’s team for the Great Basin Native Plant Selection and Increase Project funded by BLM) and Ann Hild of the University of Wyoming shows that the success of attempts to reestablish winterfat in cheatgrass-dominated areas varies depending on the type of winterfat seed used. Even so, the presence of cheatgrass reduces the survival of all four types of winterfat seedlings by 90 percent or more. Therefore, successful reintroduction of winterfat involves not only the reseeding of winterfat but also requires the elimination or substantial reduction of cheatgrass.

For more information, see:

- “Emergence and Growth of Four Winterfat Accessions in the Presence of the Exotic Annual Cheatgrass” at http://www.fs.fed.us/rm/pubs/rmrs_p047/rmrs_p047_147_152.pdf (USDA Forest Service RMRS-P-47. 2007).
- Great Basin Native Plant Selection and Increase Project at <http://www.fs.fed.us/rm/boise/research/shrub/greatbasin.shtml>.

What Role Do Soil Microorganisms Play in Cheatgrass Expansion and Control?

RMRS scientists, including ecologists Rosemary L. Pendleton and Burton K. Pendleton, are investigating the potential use of soil microorganisms as a means to control cheatgrass.

Cheatgrass, like other invasive annual grasses, creates “changes in soil moisture regimes, decomposition cycles, nutrient availability, and soil microorganism communities...” (RMRS-P-47 2007) as it successfully competes against the native plants that it displaces.

Research shows that the benefits of the biological crust-forming algae that occur in undisturbed areas of the Great Basin and similar western lands include soil stabilization and nutrient availability and that arbuscular mycorrhizal fungi in these environments aid in nutrient absorption. These findings suggest that such soil microorganisms can improve the establishment of native shrub seedlings in areas where native plants face competition from cheatgrass.

For more information, see “Shrub Establishment in the Presence of Cheatgrass: The Effect of Soil Microorganisms” at http://www.fs.fed.us/rm/pubs/rmrs_p047/rmrs_p047_136_141.pdf (USDA Forest Service RMRS-P-47. 2007).

For information about the RMRS Grassland, Shrubland, and Desert Ecosystems science program, see www.fs.fed.us/rmrs/research/programs/grassland-shrubland-desert/.

For a list of species currently identified as invasive by the Forest Service, see www.fs.fed.us/invasivespecies/speciesprofiles/index.shtml.

For information about cheatgrass in the USDA Forest Service Fire Effects Information System (FEIS) database, see “Species: *Bromus tectorum*” at www.fs.fed.us/database/feis/plants/graminoid/brotec/all.html.



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