USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Rocky Mountain Research Station Invasive Species Working Group

Invasive Species Science Update

April 2021 | Number 13

IN THIS ISSUE

From the Editor

Welcome to the 13th annual issue of the Rocky Mountain Research Station's (RMRS) Invasive Species Science Update. This newsletter is designed to keep managers and other users up to date with recently completed and ongoing research by RMRS scientists, as well as to highlight breaking news related to invasive species issues. The newsletter is produced by the RMRS Invasive Species Working Group (ISWG), a core group of scientists who volunteer to disseminate RMRS invasive species science to managers and the public through this newsletter, the website, and periodic white papers. All of our products, including past issues of the newsletters, can be found online at: https://www.fs.fed.us/rmrs/groups/invasive-species-working-group.

This issue highlights RMRS research spanning topics including using environmental DNA in fish eradication efforts, how bark beetle outbreaks affect weeds, long-term weed dynamics after forest restoration, the Fire Effects Information System's invasive plant species database, uncovering the importance of seed-eating small mammals on plant communities and invasions, and others. We are also excited to report publication of a national assessment of the state of science on invasive species. As always, we welcome feedback on ways to improve the ISWG and this newsletter. If you have comments or questions, please contact the ISWG team leader, Justin Runyon, justin.runyon@usda.gov.

USDA Forest Service—RMRS

***Figure 1**—Biologists with the Kalispel Tribe Natural Resources Department collect eDNA samples to evaluate the success of invasive brook trout removal efforts in Smalle Creek, a headwater stream on the Colville National Forest. Fine scale information on species distributions allows managers to reduce the size of subsequent chemical treatments, saving resources and minimizing impacts to the rest of the aquatic community (Courtesy photo by Shane Harvey, Kalispel Tribe NRD).*

Informing Fish Eradication Efforts With Environmental DNA

By: Kellie Carim (kellie.carim@usda.gov), RMRS National Genomics Center for Wildlife and Fish Conservation, Missoula, Montana

Worldwide, freshwater ecosystems are threatened by invasive species, resulting in impacts to infrastructure, economy, recreation, and native aquatic communities. Chemical piscicides are the most effective tool for eradication of invasive fish. However, these chemical treatments are expensive and time consuming. They are also indiscriminate, removing both invasive and native species in a system. To reduce project cost and minimize impacts to native species communities, eradication projects would ideally treat the entire area occupied by the invasive species and avoid areas where only native species are present. Additionally, treatments would be applied only the minimum number of times necessary to achieve eradication. However, obtaining information on the distribution and persistence of invasive species can be difficult when they are present at low abundance following removal efforts. Highly sensitive methods for detecting animals in low abundance are needed to support this careful targeting.

We studied how environmental DNA (eDNA) sampling can address these challenges through three case studies focused on removal of invasive Brook Trout (*Salvelinus fontinalis*) in small streams of the western United States. Environmental DNA methods were informative throughout all stages of eradication projects in stream settings. Specifically, eDNA methods precisely delimited the invasive population prior to treatment, provided detailed location data on surviving target individuals, and served as an efficient and relatively inexpensive monitoring tool to assess long-term treatment efficacy.

For the best outcome, eDNA results should be interpreted in context of the populations and habitat for the best outcomes. It is important for eDNA experts to work with local fish and wildlife managers to understand where detections (or lack of detections) make sense. Locations with unexpected results should be resampled using eDNA and traditional survey methods. When combined with traditional survey tools, such as electrofishing, eDNA sampling may help reduce the size and number of treatments necessary to reach project goals. This translates directly to increased efficacy of treatments, reduced labor and cost, and reduced impact on native species.

Carim, K.J.; Bean, N.J.; Connor, J.M.; Baker, W.P.; Jaeger, M.; Ruggles, M.P.; McKelvey, K.S.; Franklin, T.W.; Young, M.K.; Schwartz, M.K. 2020. Environmental DNA sampling informs fish eradication efforts: Case studies and lessons learned. North American Journal of Fisheries Management. 40: 488-508. https://www.fs.usda.gov/treesearch/pubs/59969

Mountain Pine Beetle Outbreaks: Effects on Understory Plants and Invasive Weeds

By: Justin Runyon (justin.runyon@usda.gov), RMRS Forestry Sciences Laboratory, Bozeman, Montana; Christopher J. Fettig (Christopher.Fettig@usda.gov), Pacific Southwest Research Station, Davis, California

Bark beetle outbreaks alter forests in many ways, including stand structure and composition, fuels and fire behavior, and wildlife habitat. Less understood are the effects outbreaks have on understory vegetation, despite the importance for overstory succession, nutrient cycling, water quality, soil erosion, and wildlife. Beetle outbreaks can also change forests in ways that could increase invasion by nonnative weeds, but this is rarely studied.

We assessed changes in cover of understory vegetation and presence/abundance of invasive weeds in lodgepole pine (*Pinus contorta*) forests in Colorado, Idaho, Montana, Utah, and Wyoming following recent mountain pine beetle (*Dendroctonus ponderosae*) outbreaks. These sites cover areas where most of the tree mortality caused by mountain pine beetle has occurred in the Intermountain West. Beetle outbreaks began in 2004, peaked around 2008, and returned to endemic levels by 2012. Understory vegetation was sampled in 2010, 2012, 2014, and 2018.

Native understory vegetation did not change much after outbreaks. Total understory cover and cover of shrubs and graminoids remained unchanged 10 years after outbreaks peaked. However, cover of forbs (herbaceous flowering plants) generally increased and was negatively correlated with canopy cover (i.e., forb cover increased as canopy cover decreased). About 20% of plots contained invasive weeds including Canada thistle (*Cirsium arvense*), bull thistle (*C. vulgare*), musk thistle (*Carduus nutans*), lamb's quarters (*Chenopodium album*), prickly lettuce (*Lactuca serriola*), and sulphur cinquefoil (*Potentilla recta*). Canada thistle was dominant, representing about 95% of total weed abundance. The abundance of invasive weeds increased over time, with the total number of invasive plants rising 31% from 2014 to 2018. By 2018, snag fall was the most important predictor of weed abundance and weeds increased with the percent of fallen trees. Soil disturbance created when snags uproot and fall appears to act as sites of weed invasion and spread.

***Figure 2**—The disturbance created when beetle-killed trees tip up and fall is prone to the establishment and spread of invasive weeds. Canada thistle (shown here in a plot in Colorado) frequently invaded these sites which were often the only place in which weeds occurred (USDA Forest Service photo by Justin Runyon).*

Mountain pine beetle outbreaks appear to promote invasion by nonnative weeds. Monitoring and managing invasive weeds at tip up sites could be a cost-effective and efficient tactic to limit invasions following beetle outbreaks.

Runyon, J.B.; Fettig, C.J.; Trilling, J.A.; Munson, A.S.; Mortenson, L.A.; Steed, B.E.; Gibson, K.E.; Jørgensen, C.L.; McKelvey, S.R.; McMillin, J.D.; Audley, J.P.; Negron, J.F. 2020. Changes in understory vegetation including invasive weeds following mountain pine beetle outbreaks. Trees, Forests and People. 2: 100038. https://doi.org/10.1016/j.tfp.2020.100038

Figure 3—Canada thistle often spread from tip up sites into nearby undisturbed areas. In this plot in Colorado, Canada thistle spread to cover most of the plot (USDA Forest Service photo by Justin Runyon).

Invasive Plant Booms Can Lurk Behind Distinct Forest Restoration Benefits

By: Justin Crotteau (justin.crotteau@usda.gov) and Sharon Hood (sharon.hood@usda.gov), RMRS Forestry Sciences Laboratory, Missoula, Montana; Yvette Ortega (yvette.ortega@usda.gov) and Dean Pearson (dean.pearson@usda.gov), RMRS Forestry Sciences Laboratory, Missoula, Montana; Christopher Keyes (christopher.keyes@umontana.edu), University of Montana, Missoula, Montana

Fuel reduction and restoration treatments are key tools that forest managers use to promote resilience to disturbance in dry, low elevation forests. While these treatments are largely effective at creating fire-resistant forest structure and composition, it has been unclear how long these effects last and what the tradeoffs are between native and exotic understory species. Our work at the Lick Creek Demonstration-Research Forest in western Montana provides insight into understory dynamics through 23 years after restoration, which included replicated cut only, cut and wet burn, cut and dry burn, and control (no action) treatment levels. The cutting treatment was a shelterwood with reserves that favored retention of ponderosa pine over Douglas-fir with the goal of recruiting additional ponderosa pine. We found that treatment stimulated native understory plants: forbs, graminoids, and shrubs increased 74% above pretreatment cover by five years after disturbance. However, initially low exotic cover (~2%) responded with greater intensity (up to 12 times pretreatment cover by year 5) such that exotic forbs, particularly the invasive spotted knapweed, composed nearly as much cover as native forbs in the cut and dry burn treatment. Treatments also promoted exotic grasses, including invasive cheatgrass. Both native and exotic pulses were temporary, approaching pretreatment cover levels as time passed. However, non-native cover remained slightly elevated through our final sampling year, 23 years posttreatment. While these general trends were evident across all three active treatment levels, we found that the magnitude of the response for both native and exotic species increased in step with treatment intensity (i.e., cut-and-dry-burn > cut-and-wet-burn > cut-and-no-burn).

Figure 4—*One year after cutting and immediately after burning at Lick Creek Demonstration-Research Forest. Notice charred forest floor and stems (USDA Forest Service photo).*

Figure 5—*Two years after cutting and 1 year after burning at Lick Creek Demonstration-Research Forest. Notice extensive flowering wooly mullein in the understory (USDA Forest Service photo).*

We gained two major implications from this study. First, understory communities appeared resilient to treatments designed to restore fire-resistant forest structure. Native populations quickly responded to increases in available resources, and although increases in cover faded with time, functional composition was not disrupted over the course of the study. Second, timing of follow-up forest restoration treatments should consider exotic population levels prior to reentry. Dry ponderosa pine forests in the northern Rockies historically burned every 7 to 15 years, about which time forest fuels increase and native understory cover decreases. Yet, if re-treatment is scheduled while exotic populations remain elevated and no mitigation strategies are employed, those populations may boom and negate restoration benefits to native understory plant communities. This study highlights the need for long-term monitoring of restoration effectiveness, and for weighing the relative effects of treatment on the many components of the forest ecosystem.

Figure 6—*Seven years after cutting and 6 years after burning at Lick Creek Demonstration-Research Forest. Notice flowering spotted knapweed in the understory (USDA Forest Service photo).*

Figure 7—*Twenty-four years after cutting and 23 years after burning at Lick Creek Demonstration-Research Forest. Notice thick conifer needle cover inhibiting understory plants (USDA Forest Service photo).*

Jang, Woongsoon; Crotteau, Justin S.; Ortega, Yvette K.; Hood, Sharon M.; Keyes, Christopher R.; Pearson, Dean E.; Lutes, Duncan C.; Sala, Anna. 2021. Native and non-native understory vegetation responses to restoration treatments in a dry conifer forest over 23 years. Forest Ecology and Management. 481: 118684. https://doi.org/10.1016/j.foreco.2020.118684

Lutes, Duncan C.; Hood, Sharon M.; Keyes, Christopher R.; Harrington, Michael G.; Pearson, Dean E.; Ortega, Yvette K.; Sala, Anna. 2020. Lick Creek Demonstration-Research Forest: Data and photo archive of 25-year fire and cutting effects on vegetation and fuels. Fort Collins, CO: Forest Service Research Data Archive. Updated 20 March 2020. https://doi.org/10.2737/RDS-2020-0008

The Fire Effects Information System: A Database With Detailed Scientific Reviews of 152 Invasive Plant Species

By: Ilana Abrahamson (ilana.l.abrahamson@usda.gov), RMRS Fire Sciences Laboratory, Missoula, Montana

With the growing body of literature on invasive plants, land managers and planners may struggle to keep up with the scientific literature on species of concern. The Fire Effects Information System (FEIS, https://www.feis-crs.org/feis/) is an online database that offers syntheses of literature about individual plant and animals species' ecology and their relationships with fire (i.e., Species Reviews). These syntheses include 152 invasive plant species. FEIS Species Reviews integrate information on autecology, community ecology, and fire relationships, including effects of fire on invasive plants, the effects of plant invasions on fuel characteristics and fire regimes, and the use of fire to control invasives. Species Reviews recently updated in FEIS include syntheses about the nonnatives yellow starthistle (*Centaurea solstitialis*), diffuse knapweed (*Centaurea diffusa*), and medusahead (*Taeniatherum caput-medusae*). In addition to the synthesis, each review includes tables describing publications that measure the species' responses to fire and nonfire control treatments.

The yellow starthistle Species Review synthesizes scientific information from over 350 sources. Yellow starthistle is an invasive forb that can occur in dense monocultures, displace native plants and decrease diversity, reduce native wildlife habitat and forage, and alter soil water and nutrient availability. Most information about yellow starthistle's response to fire comes from field studies that used prescribed fire to control invasive populations in California grasslands. Fire usually consumes or kills yellow starthistle plants, although plants occasionally sprout after low-severity fire. Consumption is not necessary to kill the plants, although sufficient heat is required to scorch the foliage, stem-girdle, and kill them. Fires are usually not severe enough to kill yellow starthistle seeds in the soil seed bank, and yellow starthistle abundance may increase after fire because postfire conditions are favorable for germination, seedling establishment, plant growth, and seed production. However, if burned again before plants set seed, its abundance may decrease.

The diffuse knapweed Species Review synthesizes scientific information from nearly 200 sources. Diffuse knapweed is an invasive forb in the western United States and southern British Columbia. Information on diffuse knapweed's fire adaptations and response to fire is lacking in the literature. Diffuse knapweed has a deep taproot and may sprout following top-kill from fire if the root crown survives and sufficient moisture is available. Root crowns and seeds in the soil would probably survive a single, low-severity fire but high-severity fire may kill both plants and seeds. Fire creates a seedbed suitable for diffuse knapweed germination and establishment by decreasing shade and interference from established plants, increasing bare ground, and changing water and nutrient availability. Some researchers speculated that fire may be used to control diffuse knapweed, but only where associated grasses increase after fire.

FEIS recently published an annotated bibliography of scientific publications (2000-2019) on medusahead's relationship to fire and its response to fire and other control methods to accompany the 2001 medusahead Species Review. The annotated bibliography includes a summary of medusahead's biology, fire ecology, management considerations, and control methods. Tables include descriptions of publications about medusahead's response to fire (n = 24) and about medusahead's response to nonfire control treatments (n = 56). Fire management considerations for medusahead differ among sites, partly due to differences in plant community species composition, phenology, and fire ecology. In annual grasslands of western California and Oregon, fire may reduce medusahead abundance and promote desirable species, while in perennial grasslands and shrublands in the Intermountain West, fire may injure or kill desirable

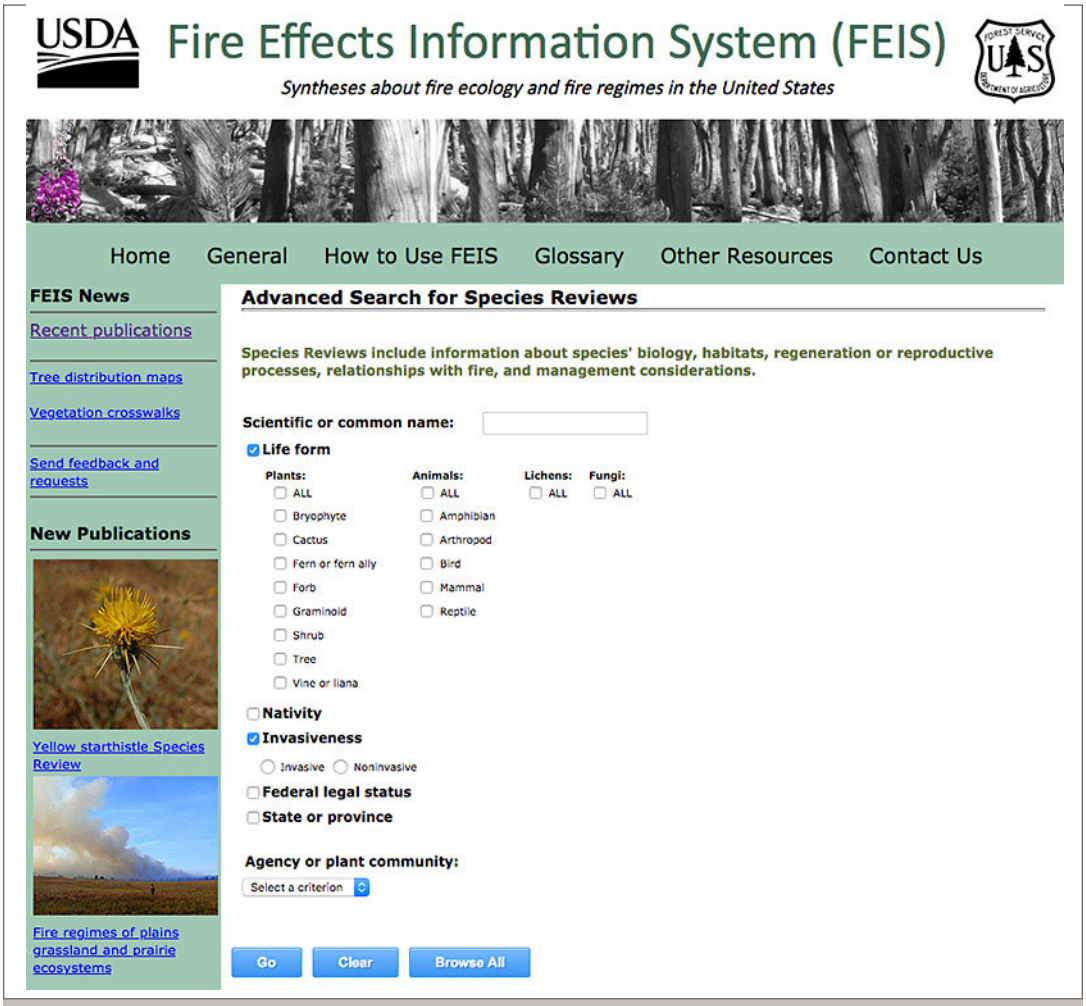

Figure 8—*Advanced search for Species Reviews about invasive plants in the Fire Effects Information System (www.feis-crs.org/feis/).*

bunchgrasses, shrubs, and forbs, creating opportunities for medusahead establishment and spread.

Upcoming Species Reviews about invasive plants include spotted knapweed (*Centaurea stoebe* subsp. *micranthos*), Himalayan blackberry (*Rubus armeniacus* and *Rubus bifrons*), and cutleaf blackberry (*Rubus laciniatus*). FEIS ecologists are also updating the Species Review on saguaro (*Carnegiea gigantea*) and will update the buffelgrass (*Pennisetum ciliare*) Species Review, because buffelgrass is one of the main threats to saguaro populations.

Fryer, Janet L. 2021. *Rubus armeniacus*, R. bifrons: Himalayan blackberry. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory (Producer). http://www.fs.fed.us/database/feis/plants/shrub/rubspp/all.html

Innes, Robin J.; Zouhar, Kris. 2021. *Centaurea solstitialis*, yellow starthistle. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). https://www.fs.fed.us/database/feis/plants/forb/censol/all.html

Innes, Robin J.; Zouhar, Kris. 2020. *Centaurea diffusa*, diffuse knapweed. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory (Producer). https://www.fs.fed.us/database/feis/plants/forb/cendif/all.html

Innes, Robin J. 2019. Annotated bibliography of scientific publications on medusahead 2000-2019: Relationship with fire and response to fire and other control methods. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory (Producer). https://www.fs.fed.us/database/feis/plants/graminoid/taecap/annbib/all.html

Small Mammals Influence Plant Community Structure Around the World by Preferentially Consuming Seeds of Certain Sizes

By: Dean Pearson (dean.pearson@usda.gov) and Yvette Ortega (yvette.ortega@usda.gov), RMRS Forestry Sciences Laboratory, Missoula, Montana; Lukasz Dylewski (ldylewski@man.poznan.pl), Poznań University of Life Sciences, Poznań, Poland

Scientists have long recognized that rodents and other small mammals are such voracious seed predators that they could affect plant abundance in natural systems. However, many plant species produce so many more seeds than are necessary to replace and expand their populations that seed predation may have negligible effects on plant populations and communities.

Most studies of seed predation have simply set out seeds and measured seed removal – a method which can quantify seed predation rates, but fails to demonstrate their effects on plant populations. Only in the past few decades have enough seed sowing experiments been conducted around the world to assess the global effects of small mammal seed predation on plant communities.

Thirty years ago, an elegant field experiment in the U.S. desert southwest demonstrated that selective seed predation by rodents could restructure the local plant community. Excluding rodents that selectively consumed large seeds resulted in a dramatic shift in the plant community from a classic open desert shrubland to a system dominated by large-seeded grasses previously suppressed by rodent seed predation (including some invasive plants).

A recent meta-analysis collating global results from seed predation studies found that small mammals may structure plant communities in similar ways around the world, with an interesting twist. In systems where seeds are relatively small, like deserts and grasslands, small mammal seed predation suppresses the largest-seeded plant species, but in systems where seed sizes are much larger, like tropical forests, these predators tend to suppress relatively smaller-seeded species.

These results indicate not only that small mammal seed predation is important in determining the relative abundance of plant species in natural communities around the world, but also that it can have opposing effects on plant species composition in different ecosystems. These findings have important ramifications for understanding natural plant communities, biological invasions, and for restoring plant communities.

Key Findings:

- Small mammals are voracious seed predators who selectively forage for seeds based on seed size. This selective foraging commonly suppresses establishment of some plant species more than others.
- A global review of seed predation studies indicates that selective seed predation may influence plant abundance in communities around the world, from deserts to tropical forests, and can have opposing effects on plant species composition in different ecosystems.

Figure 9—*Paired seed cages allowing (left) or excluding (right) rodent access to native plant seeds demonstrate rodent effects on blanket flowers (USDA Forest Service photos by Dean Pearson).*

Dylewski, Lukasz; Ortega, Yvette K.; Bogdziewics, Michal; Pearson, Dean E. 2020. Seed size predicts global effects of small mammal seed predation on plant recruitment. Ecology Letters. 23: 1024-1033. https://www.fs.usda.gov/treesearch/pubs/61378

Pearson, Dean E.; Valliant, Morgan; Carlson, Chris; Thelen, Giles C.; Ortega, Yvette K.; Orrock, John L.; Madsen, Matthew D. 2018. Spicing up restoration: Can chili peppers improve restoration seeding by reducing seed predation? Restoration Ecology 27: 254-260. https://www.fs.usda.gov/treesearch/pubs/58219

Larios, Loralee; Pearson, Dean E.; Maron, John L. 2017. Incorporating the effects of generalist seed predators into plant community theory. Functional Ecology. 31: 1856-1867. https://www.fs.usda.gov/treesearch/pubs/61769

Pearson, Dean E.; Icasatti, Nadia S.; Hierro, Jose L.; Bird, Benjamin J. 2014. Are local filters blind to provenance? Ant seed predation suppresses exotic plants more than natives. PLoS ONE. 9(8): e103824. https://www.fs.usda.gov/treesearch/pubs/46859

Pearson, D. E.; Hierro, J. L.; Chiuffo, M.; Villarreal, D. 2014. Rodent seed predation as a biotic filter influencing exotic plant abundance and distribution. Biological Invasions. 16: 1185-1196. https://www.fs.usda.gov/treesearch/pubs/46858

Pearson, Dean E.; Callaway, Ragan M.; Maron, John L. 2011. Biotic resistance via granivory: Establishment by invasive, naturalized, and native asters reflects generalist preference. Ecology. 92(9): 1748-1757. https://www.fs.usda.gov/treesearch/pubs/40366

Invasion Risk Maps for 15 Non-Native Plant Species in the Western U.S.

By: Alexandra Urza (alexandra.urza@usda.gov) and Jeanne Chambers (jeanne.chambers@usda.gov), RMRS Great Basin Ecology Lab, Reno, Nevada; and Devin McMahon (devin.mcmahon@usda.gov), Umpqua National Forest, Oregon

Non-native plant invasions are transforming ecosystems and landscapes in the western U.S. Mitigating the impacts of plant invasions requires rapidly finding and controlling new invasions before they spread. On-the-ground monitoring may not detect new species until invasion is well underway, so maps of modeled invasion risk can help managers anticipate areas where species are likely to establish and spread. The distributions of some non-native species such as cheatgrass (*Bromus tectorum*) are well understood, yet scientists and practitioners lack basic information on many other plant invaders, some of which are rapidly expanding. To help address this knowledge gap, we modeled invasion risk for 15 non-native plant species of concern. Our focal species included six grass species—cheatgrass, red brome (*Bromus rubens*), medusahead (*Taeniatherum caput-medusae*), common Mediterranean grass (*Schismus barbatus*), field brome (*Bromus japonicus*), and bulbous bluegrass (*Poa bulbosa*), and nine forb species—prickly Russian thistle (*Salsola tragus*), clasping pepperweed (*Lepidium perfoliatum*), redstem storksbill (*Erodium cicutarium*), tall tumblemustard (*Sisymbrium altissimum*), curveseed butterwort (*Ceratocephala testiculata*), spring draba (*Draba verna*), saltlover (*Halogeton glomeratus*), prickly lettuce (*Lactuca serriola*), and yellow salsify (*Tragopogon dubius*).

We used publicly available data from more than 148,000 vegetation survey plots to describe the environmental characteristics of each species' current range. We then used presence and absence data to develop models predicting suitable habitat for each species based on climate, topography, soils, and disturbance. We projected the model predictions across the landscape to produce maps of invasion risk. Each of the species we modeled requires a distinct set of environmental conditions and consequently, they differ in their potential to invade new areas. Raster files of our invasion risk maps are publicly available to download.

***Figure 10**—Area in northwestern Nevada invaded by prickly Russian thistle and cheatgrass (USDA Forest Service photo by Ali Urza).*

These invasion risk maps can be used by resource managers to design monitoring and control strategies and to prioritize landscape-scale planning.

Download invasion risk maps:
https://doi.org/10.2737/RDS-2020-0078

McMahon, Devin E.; Urza, Alexandra K.; Brown, Jessi L.; Phelan, Conor; Chambers, Jeanne C. 2021. Modelling species distributions and environmental suitability highlights risk of plant invasions in western United States. Diversity and Distributions. 27: 710-728. https://www.fs.usda.gov/treesearch/pubs/62096

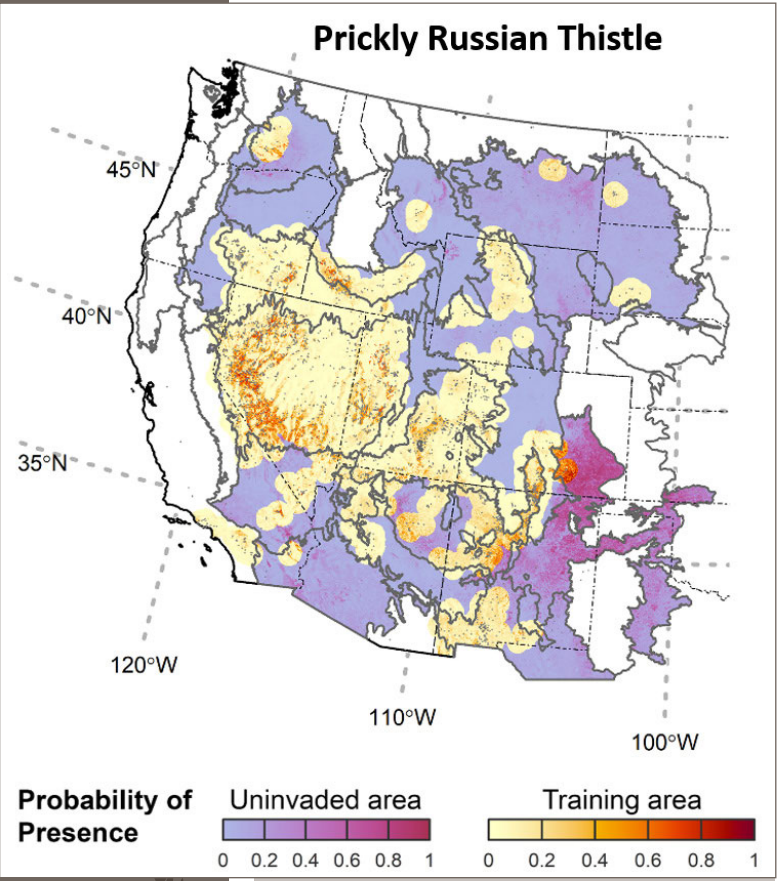

***Figure 11**—Predicted habitat suitability for prickly Russian thistle. The color ramp from yellow to red shows probability of presence within the current range (red = high probability). The color ramp from blue to red shows habitat suitability in currently uninvaded areas (red = high risk of invasion).*

Managing Invasive Plants on Great Plains Grasslands

By: John Gaskin (john.gaskin@usda.gov), USDA ARS Northern Plains Agricultural Research Laboratory, Sidney, Montana

The Great Plains of North America encompass approximately 1,300,000 km^2 of land from Texas to Saskatchewan. The integrity of these lands is under continual assault by long-established and newly arrived invasive plant species, which can threaten native species and diminish land values and ecological goods and services by degrading desired grassland resources. The Great Plains are a mixture of privately and publicly owned lands, which leads to a patchwork of varying management goals and strategies for controlling invasive plants. Continually updated knowledge is required for efficient and effective management of threats posed by changing environments and invasive plants.

In a recent review paper (Gaskin et al. 2020) we discuss, at some length, current challenges, contemporary management strategies, and management tools and their integration in hopes of presenting a knowledge resource for new and experienced land managers and others involved in making decisions regarding invasive plant management in the Great Plains. The authors are an assemblage of grassland managers and university and government research scientists from across the Great Plains. Highlighted topics include invasive grasses and woody plants, herbicide and biological control within integrated weed management, restoration, and the effects of climate change on invasion.

Gaskin, John F.; Espeland, Erin; Johnson, Casey D.; Larson, Diane L.; Mangold, Jane M.; McGee, Rachel A.; Milner, Chuck; Paudel, Shishir; Pearson, Dean E.; Perkins, Lora B.; Prosser, Chadley W.; Runyon, Justin B.; Sing, Sharlene E.; Sylvain, Zachary A.; Symstad, Amy J.; Tekiela, Daniel R. 2020. Managing invasive plants on Great Plains grasslands: A discussion of current challenges. Rangeland Ecology and Management. doi: 10.1016/j.rama.2020.04.003 1550-7424. https://www.fs.usda.gov/treesearch/pubs/61379

***Figure 12**—A new paper reviews invasive plant management and challenges in the Great Plains. https://www.fs.usda.gov/treesearch/pubs/61379*

Enhancing Saltcedar (*Tamarix* spp.) Biocontrol With Semiochemical Lures

By: Sharlene Sing (sharlene.sing@usda.gov), RMRS Forestry Sciences Laboratory, Bozeman, Montana; David Weaver (weaver@montana.edu) and Megan Hofland (meganj@montana.edu), Montana State University, Bozeman, Montana; Alex Gaffke (Alexander.Gaffke@usda.gov), USDA ARS Center for Medical, Agricultural and Veterinary Entomology, Gainesville, Florida

***Figure 13**—Diorhabda carinulata aggregation pheromone-based lure on cattle ear tag inside wire mesh cage (ARS photo by Alex Gaffke).*

"Saltcedar" (*Tamarix* spp.) refers to a complex of four species of exotic, invasive shrubs, trees and their hybrids. Introduced to the U.S. in the early 1800s for erosion control and horticulture, saltcedar has become the third most prevalent woody riparian taxonomic group in the western United States. In 2001 USDA APHIS PPQ approved the field release of the tamarisk beetle *Diorhabda elongata* for classical biological control of saltcedar (*Tamarix* spp.). Of the four *Diorhabda* species known to be established in the U.S., the northern tamarisk leaf beetle, *D. carinulata* (Desbrochers), is considered the best match to challenging environmental conditions (e.g., long, cold winters and intense spring flooding) in Montana.

Negative nontarget impacts have been associated with the rapid and extensive defoliation of dense, landscape scale saltcedar stands by *Diorhabda* spp. outside targeted treatment areas in the Southwest. Conversely, in Montana, saltcedar infestations generally consist of sparse, isolated small patches not known to provide critical habitat or breeding resources for native wildlife. Retaining beetles on comparatively depauperate infestations at the time of release has been problematic with population growth slow in many areas, resulting in minimal biological control of saltcedar by *D. carinulata*.

Behavioral manipulation of insects with semiochemicals such as aggregation pheromones was therefore evaluated to determine if herbivory could be intensified where beetle population densities are inherently

***Figure 14**—Releasing Diorhabda carinulata in eastern Montana (Courtesy photo by Megan Hofland, Montana State University).*

***Figure 15**—Saltcedar (Tamarix spp.) infestation along the Yellowstone River (Courtesy photo by Megan Hofland, Montana State University).*

low. Deployment of *D. carinulata's* aggregation pheromone was investigated in field trials. The results indicate saltcedar baited with aggregation pheromone lures attracted and retained higher densities of *D. carinulata*. Baited plants not only had higher densities of adults and larvae, but also displayed higher levels of foliar damage. This intensified damage resulted in increased foliar dieback and a reduction in canopy volume of the target plants. Repellent semiochemicals were also investigated. Behavioral assays determined that semiochemicals produced by larval *D. carinulata*, including feeding-induced plant produced repellent defensive secretions that may serve as spacing pheromones, were repellent to conspecific adults in laboratory bioassays. Preliminary results will be further evaluated through field-based trials of repellent baits.

Use of the aggregation pheromone increased the efficacy of this biological control agent. These results also suggest a role for aggregation pheromone-based lures in monitoring *Diorhabda* spp. population abundance and distribution, both for weed management and wildlife conservation purposes. These results indicate that semiochemicals could be useful in potentiating, retaining, and directing populations of *D. carinulata*, and demonstrate the potential for application in other biological control agent-weed systems.

Gaffke, Alexander M.; Sing, Sharlene E.; Dudley, Tom L.; Bean, Daniel W.; Russak, Justin A.; Mafra-Neto, Agenor; Peterson, Robert K. D.; Weaver, David K. 2020. Establishing *Diorhabda carinulata*: Impact of release disturbances on pheromone emission and influence of pheromone lures on establishment. Journal of Chemical Ecology. 46: 378-386. https://www.fs.usda.gov/treesearch/pubs/60334

Gaffke, Alexander M.; Sing, Sharlene E.; Millar, Jocelyn G.; Dudley, Tom L.; Bean, Daniel W.; Peterson, Robert K. D.; Weaver, David K. 2020. An herbivore-induced plant volatile from saltcedar (*Tamarix* spp.) is repellent to *Diorhabda carinulata* (Coleoptera: Chrysomelidae).

Environmental Entomology. 49: 1063-1070. https://www.fs.usda.gov/treesearch/pubs/60804

Gaffke, Alexander M.; Sing, Sharlene E.; Dudley, Tom L.; Bean, Daniel W.; Russak, Justin A.; Mafra-Neto, Agenor; Peterson, Robert K. D.; Weaver, David K. 2019. Field demonstration of a semiochemical treatment that enhances *Diorhabda carinulata* biological control of *Tamarix* spp. Scientific Reports. 9: 13051. https://www.fs.usda.gov/treesearch/pubs/58603

Gaffke, Alexander M.; Sing, Sharlene E.; Dudley, Tom L.; Bean, Daniel W.; Russak, Justin A.; Mafra-Neto, Agenor; Grieco, Paul A.; Peterson, Robert K. D.; Weaver, David K. 2018. Semiochemicals to enhance herbivory by *Diorhabda carinulata* aggregations in saltcedar (*Tamarix* spp.) infestations. Pest Management Science. 74: 1494-1503. https://www.fs.usda.gov/treesearch/pubs/56030

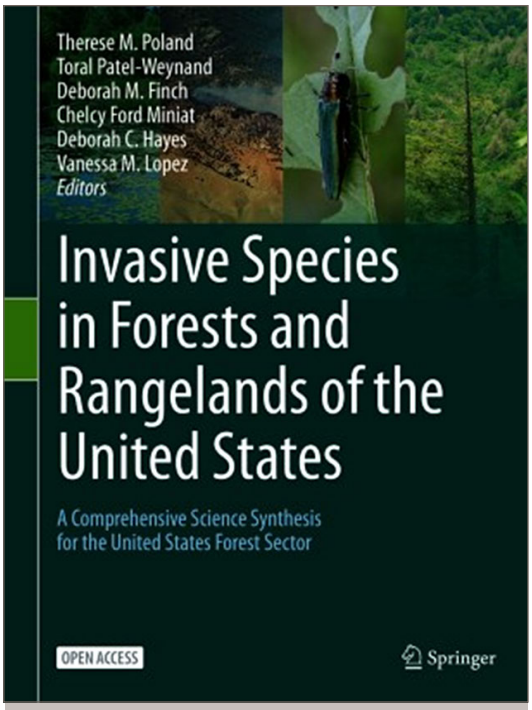

***Figure 16**—A national assessment of the state of science on invasive species is now published: https://www.fs.usda.gov/treesearch/pubs/61982*

Other News

Invasive Species National Assessment Is Published

The U.S. Forest Service completed a national assessment of the state of science on invasive species. The book, Invasive Species in Forests and Rangelands of the United States, is edited by Forest Service scientists and university partners. The chapters cover topics including early intervention strategies, management and restoration, inventory and monitoring, tools and technologies, impacts of invasive species, climate change effects, social and societal aspects, and other topics. Summaries detailing regional invasive species issues are also part of this extensive review. This publication will help the Forest Service protect forests and grasslands from invasion and better manage those public lands impacted by invasive species. The book is open access and can be found here: https://link.springer.com/book/10.1007/978-3-030-45367-1 and on Treesearch: https://www.fs.usda.gov/treesearch/pubs/61982.

Invasive Species SCIENCEx Webinars During 2021 and 2022

The recently launched Forest Service Research & Development-wide SCIENCEx webinar series featured daily presentations focused on invasive species management during National Invasive Species Awareness Week, February 22-26, 2021. Scientists from across the U.S. Forest Service research stations were invited to deliver presentations, including Anna Schoettle (Plant Ecophysiologist, RMRS) whose presentation was titled “White Pine Blister Rust in a Changing Climate in Mountain-Top Ecosystems: Taking the Long View and Acting Now” and Ali Urza and Brice Hanberry (Ecologists, RMRS) who presented “Cheatgrass Impacts and Management Options in Western U.S. Ecosystems”. These presentations, as well as full recorded webinars can be found at: https://www.fs.fed.us/research/invasive-species-webinars/.

SCIENCEx organizers plan to feature invasive species during National Invasive Species Awareness Week in 2022 as well. SCIENCEx is a webinar series jointly produced by U.S. Forest Service research stations to communicate and discuss the latest research and best practices for addressing large natural resource challenges. SCIENCEx webinars connect R&D science directly with federal, state, county, local, and tribal land managers, offering research applications. Sign up to receive the national U.S. Forest Service R&D monthly newsletter for regular updates on SCIENCEx. You can also send specific questions or comments to Lara.Murray@usda.gov.

Second Conference on the Research and Management of High Elevation Five Needle Pines in Western North America, October 5-7, 2021

https://highfivepines.org/

Scientists, management professionals, and outdoor enthusiasts are invited to explore and share the latest knowledge of these key species and critical habitats. The virtual conference will cover topics including the ecology, genetics, disturbance dynamics, blister rust and rust resistance, restoration actions, planting, and climate change impacts for the six 'High-5' species important to both U.S. and Canada: whitebark, limber, Great Basin bristlecone, Rocky Mountain bristlecone, foxtail, and southwestern white pines. Special sessions focusing on the U.S. National Whitebark Pine Restoration Plan will be featured.

NAISMA Annual Conference, Whitefish MT, September 2021

The North American Invasive Species Management Association's (NAISMA) Annual Conference will be held in Missoula, Montana, September 27-30, 2021. The theme is Transboundary Cooperation and the meeting is cohosted by the Montana Invasive Species Council. For more information see: https://naisma.org/conferences/.

IUFRO 2021—Biological Invasions in Forests: Trade, Ecology and Management

The International Union of Forest Research Organizations (IUFRO) is hosting a conference on Biological Invasions in Forests in Prague, Czech Republic, September 20-24, 2021. This conference will address the causes, consequences, and management of biological invasions in forests. For more information visit: https://iufro.czu.cz/en.

Schoettle Presents on Management and Conservation of Five-Needle Pines

Anna Schoettle (Plant Ecophysiologist, RMRS) delivered a short presentation *Great Basin High-5 Proactive Strategy – A partnership to enhance the resilience of whitebark, bristlecone, and limber pine ecosystems* at the Region 4—Rocky Mountain Research Station Science Partner Workshop in February 2021. The project is developing a strategy for building a science foundation to assist with prioritizing management and conservation of the five-needle pines threatened by the invasive pathogen white pine blister rust in a changing climate in the Great Basin.

The Asian Giant Hornet arrives in North America

The arrival in North America of the Asian giant hornet (*Vespa mandarinia*), sometimes called the "murder hornet", has garnered extensive media attention. Native to Asia, *V. mandarinia* was first found in 2019 on Vancouver Island, British Columbia, Canada. Workers and queens have since been found in Washington State. It is still not known if Asian giant hornets are established in North America and extensive efforts are underway to locate nests and eradicate this invader.

Recent research suggests that most of the Intermountain West of the U.S. is not suitable habitat for *V. mandarinia* (https://www.pnas.org/content/pnas/117/40/24646.full.pdf). The most suitable habitats for Asian giant hornet have relatively warm temperatures and high precipitation. However, human activity could

facilitate invasions and allow persistence of the Asian giant hornet in some areas of the Intermountain West.

A recent episode of Out West, the official podcast of the Western Governors' Association, discusses the Asian giant hornet and separating fact from fiction: https://westgov.podbean.com/e/out-west-the-buzz-about-murder-hornets-%e2%80%93-separating-fact-from-fiction/.

Other Recent Publications

Chambers, Jeanne; Campbell, Steve; Maestas, Jeremy; Cartwright, Jennifer. 2020. Sagebrush ecosystem resilience and resistance [Chapter 24]. In: Cartwright, Jennifer, ed. A guidebook to spatial datasets for conservation planning under climate change in the Pacific Northwest. Reston, VA: U.S. Geological Survey, Northwest Climate Adaptation Science Center. p. 196-206. https://www.fs.usda.gov/treesearch/pubs/61681

Chambers, Jeanne C.; Allen, Craig R.; Cushman, Samuel A., eds. 2020. Operationalizing the concepts of resilience and resistance for managing ecosystems and species at risk. Lausanne, Switzerland: Frontiers Media SA. 223 p. https://www.fs.usda.gov/treesearch/pubs/60604

Garfinkel, Andrea R.; Cannon, Phil G.; Klopfenstein, Ned B.; Stewart, Jane E.; Kim, Mee-Sook. 2020. Identification of genetic groups within the invasive brown root rot pathogen, *Pyrrhoderma noxium* (formerly *Phellinus noxius*). In: Reynolds, Gregory J.; Wilhelmi, Nicholas P.; Palacios, Patsy, compilers. Proceeding of the 66th Western International Forest Disease Work Conference; 3-7 June 2019; Estes Park, CO. WIFDWC: www.wifdwc.org. p. 141-145. https://www.fs.usda.gov/treesearch/pubs/61280

Hanna, J. W.; Mulvey, R. L.; Kim, M. -S.; Stewart, J. E.; Bright, B. C.; Warwell, M. V.; Klopfenstein, N. B. 2020. Bioclimatic modeling of *Armillaria* species in southeastern Alaska, including potentially invasive *Armillaria* species under changing climate. In: Reynolds, Gregory J.; Wilhelmi, Nicholas P.; Palacios, Patsy, compilers. Proceeding of the 66th Western International Forest Disease Work Conference; 3-7 June 2019; Estes Park, CO. WIFDWC: www.wifdwc.org. p. 171-176. https://www.fs.usda.gov/treesearch/pubs/61282

Jacobs, Douglass F.; Davis, Anthony S.; Dumroese, R. Kasten; Burney, Owen T. 2020. Nursery cultural techniques facilitate restoration of *Acacia koa* competing with invasive grass in a dry tropical forest. Forests. 11: 1124. https://www.fs.usda.gov/treesearch/pubs/61710

Liu, Jun-Jun; Sniezko, Richard A.; Sissons, Robert; Krakowski, Jodie; Alger, Genoa; Schoettle, Anna W.; Williams, Holly; Zamany, Arezoo; Zitomer, Rachel A.; Kegle, Angelia. 2020. Association mapping and development of marker-assisted selection tools for the resistance to white pine blister rust in the Alberta limber pine populations. Frontiers in Plant Science. 11: 557672. https://www.fs.usda.gov/treesearch/pubs/62151

Liu, Jun-Jun; Schoettle, Anna W.; Sniezko, Richard A. 2020. Development and application of high density genetic map of limber pine (*Pinus flexilis* James) for genomics-based breeding. In: Nelson, C. Dana; Koch, Jennifer L.; Sniezko, Richard A., eds. Proceedings of the Sixth International Workshop on the Genetics of Host-Parasite Interactions in Forestry—Tree Resistance to Insects and Diseases: Putting Promise into Practice. Gen. Tech. Rep. SRS–252. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. https://www.fs.usda.gov/treesearch/pubs/61904

McKelvey K. S.; Block W. M.; Jain T. B.; Luce C. H.; Page-Dumroese D. S.; Richardson B. A.; Saab V. A.; Schoettle A. W.; Sieg C.H.; Williams D. R. 2021. Adapting research, management, and governance to confront socioecological uncertainties in novel ecosystems. Frontiers in Forests and Global Change. 4: 644696. https://doi.org/10.3389/ffgc.2021.644696

Invasive Species Working Group Team Leader

Justin Runyon

USDA Forest Service Rocky Mountain Research Station
1648 S 7th Ave
Bozeman, MT 59717
voice 406-994-4872
fax 406-994-5916

https://www.fs.fed.us/rmrs/groups/invasive-species-working-group

Niemiec, Rebecca M.; McCaffrey, Sarah; Jones, Megan S. 2020. Clarifying the degree and type of public good collective action problem posed by natural resource management challenges. Ecology and Society 25: 30. https://www.fs.usda.gov/treesearch/pubs/60276

Roundy, Bruce A.; Miller, R. F.; Tausch, R. J.; Chambers, J. C.; Rau, B. M. 2020. Long-term effects of tree expansion and reduction on soil climate in a semiarid ecosystem. Ecosphere. 11(9): e03241. https://www.fs.usda.gov/treesearch/pubs/61246

Schoettle Anna W. 2019. Taking the long view and acting now — prioritizing management of high elevation five-needle pines. Mountain Views. 13(2): 2-7. https://www.fs.fed.us/psw/cirmount/publications/pdf/Mtn_Views_dec_19.pdf

Schoettle, Anna W. 2020. Genetic resistance to white pine blister rust is key but how it is managed will determine the future of high elevation five-needle pines. In: Reynolds, Gregory J.; Wilhelmi, Nicholas P.; Palacios, Patsy, compilers. Proceeding of the 66th Western International Forest Disease Work Conference; 3-7 June 2019; Estes Park, CO. WIFDWC: www.wifdwc.org. p. 81-88. https://www.fs.usda.gov/treesearch/pubs/62152

Sitz, Rachael A.; Kim, Mee-Sook; Cannon, Phil G.; Alfenas, Acelino C.; Glen, Morag; McTaggart, Alistair R.; Klopfenstein, Ned B.; Stewart, Jane E. 2020. The need for rapid molecular diagnostics to distinguish biotypes of the myrtle rust pathogen (*Austropuccinia psidii*). In: Reynolds, Gregory J.; Wilhelmi, Nicholas P.; Palacios, Patsy, compilers. Proceeding of the 66th Western International Forest Disease Work Conference; 3-7 June 2019; Estes Park, CO. WIFDWC: www.wifdwc.org. p. 213-214. https://www.fs.usda.gov/treesearch/pubs/61289

Stewart, J. E.; Kim, M. S.; Ota, Y.; Sahashi, N.; Hanna, J. W.; Akiba, M.; Ata, J. P.; Atibalentia, N.; Brooks, F.; Chung, C.-L.; Dann, E. K.; Mohd Farid, A.; Hattori, T.; Lee, S. S.; Otto, K.; Pegg, G. S.; Schlub, R. L.; Shuey, L. S.; Tang, A. M. C.; Tsai, J.-N.; Cannon, P. G.; Klopfenstein, N. B. 2020. Phylogenetic and population genetic analyses reveal three distinct lineages of the invasive brown root-rot pathogen, *Phellinus noxius*, and bioclimatic modeling predicts differences in associated climate niches. European Journal of Plant Pathology. 156: 751-756. https://www.fs.usda.gov/treesearch/pubs/60706

Taylor, Justin B.; Cass, Kristina L.; Armond, David N.; Madsen, Matthew D.; Pearson, Dean E.; St. Clair, Samuel B. 2020. Deterring rodent seed-predation using seed-coating technologies. Restoration Ecology. 28(4): 927-936. https://www.fs.usda.gov/treesearch/pubs/61381

Waring, Kristen; Cushman, Sam; Eckert, Andrew; Flores-Renteria, Lluvia; Sniezko, Richard; Still, Christopher; Wehenkel, Christian; Whipple, Amy; Wing, Michael; Bagley, Justin; Bucholz, Ethan; Gonzalez-Elizondo, Socorro; Haagsma, Marja; Hartsell, Jessica; Garms, Cory; Heck, Evan; Johnson, Jeremy; Landguth, Erin; Saenz, Alejandro Leal; Menon, Mitra; Moler, Ehren; Page, Gerald; Shaw, John; Shirk, Andrew; Swenson, Jared. 2020. Ecology and evolution of a tree species challenged by dual threats. In: Reynolds, Gregory J.; Wilhelmi, Nicholas P.; Palacios, Patsy, compilers. Proceeding of the 66th Western International Forest Disease Work Conference; 3-7 June 2019; Estes Park, CO. WIFDWC: www.wifdwc.org. p. 89-94. https://www.fs.usda.gov/treesearch/pubs/62157

Williamson, Matthew A.; Fleishman, Erica; Mac Nally, Ralph C.; Chambers, Jeanne C.; Bradley, Bethany A.; Dobkin, David S.; Board, David I.; Fogarty, Frank A.; Horning, Ned; Leu, Matthias; Zillig, Martha Wohlfeil. 2020. Fire, livestock grazing, topography, and precipitation affect occurrence and prevalence of cheatgrass (*Bromus tectorum*) in the central Great Basin, USA. Biological Invasions. 22: 663-680. https://www.fs.usda.gov/treesearch/pubs/61682