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Invasive Species Science Update

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IN THIS ISSUE

From the Editor

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 and lists of publications, can be found online at: www.fs.fed.us/rmrs/groups/invasive-species-working-group.

In this issue, we include topics from the importance of biocrusts on invasive versus native plant establishment, effects of dryland restoration on invasive plants, using native seed mixes (rather than nonnative grass mixes) to inhibit cheatgrass invasion after fire, and exploring volatiles of high-elevation pines to better understand resistance to insects and pathogens. 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.

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Figure 1—*University technicians find very few invasive plants among the thriving native understory 14 years after the thin-only treatment of the Fire & Fire Surrogate Study at University of Montana's Lubrecht Experimental Forest, see page 3 (photo by Justin Crotteau, RMRS).*

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Biocrusts Inhibit Exotic, but Not Native Plant Establishment in Semi-Arid Grasslands

By: Mandy Slate (slatemandy@gmail.com), University of Colorado Boulder; Dean Pearson (dean.pearson@usda.gov), RMRS Forestry Sciences Laboratory, Missoula, Montana

Figure 2—Experimental plots inoculated with biocrust fragments applied to bare soil (top) or jute mesh (bottom). Biocrust cover was 33-76 times greater in plots with jute mesh (photo by Dean Pearson, RMRS).

Biological soil crusts (biocrusts hereafter) are communities of moss, lichen, cyanobacteria and other microorganisms that form on soil surfaces in dryland ecosystems. Biocrusts are critical components of dryland systems; they stabilize soil, regulate water and nutrient cycling, buffer soil temperatures, and influence the establishment of vascular plants. Of particular importance to land managers, intact biocrust communities can suppress the establishment of some exotic plant species (e.g., cheatgrass and spotted knapweed). However, biocrusts are sensitive to compressive forces, and once disturbed are slow to reestablish, leaving disturbed soils prone to erosion, loss of soil nutrients, and exotic plant invasions. Hence, the negative effects of biocrust disturbance on ecosystem function can be long-lasting without active restoration. Yet restoration efforts rarely include biocrusts even when they are known to have been present before the initial disturbance and can facilitate the ability of land managers to mitigate exotic plant invasions.

Researchers from RMRS and MPG Ranch (Florence, MT) recently demonstrated that biocrust reestablishment could be accelerated by adding an inoculant of crumbled biocrust fragments to jute mesh (fig. 2). This low-cost restoration method had a high-success rate, with 33-76 times higher biocrust cover than unassisted biocrust recovery rates three years after the biocrust inoculation. Our biocrust reestablishment rates were achieved using small amounts of biocrust inoculant (12 g/m^2) harvested from nearby intact biocrusts. Since generating additional disturbances is not an ideal byproduct of restoration, biocrusts can also be salvaged prior to planned disturbances and used to restore nearby areas. Biocrust salvaging may provide larger amounts of biocrust inoculant, which could expedite reestablishment rates.

We also found that the soil beneath restored biocrusts had lower soil inorganic NH_4-N levels. Mosses lose carbon and nitrogen during cycles of desiccation and rehydration as a result of cellular damage; resources that can be carried away from rehydrating mosses in precipitation, transferred to soil, and accessed by soil microbes. As the mosses in our biocrusts reestablished, rehydration related pulses of carbon and nitrogen may have promoted soil nitrogen immobilization, accounting for the lower NH_4-N levels measured in restored biocrust plots. In systems where disturbances generally increase soil N availability, this ability of biocrusts to decrease soil N could promote native over exotic plant establishment.

Slate, M.L.; Durham, R.A.; Pearson, D.E. 2019. Strategies for restoring the structure and function of lichen-moss biocrust communities. Restoration Ecology. In press.

Slate, M.L.; Sullivan, B.W; Callaway, R.M. 2019. Desiccation and rehydration of mosses greatly increases resource fluxes that alter soil carbon and nitrogen cycling. Journal of Ecology. 107: 1767-1778.

Slate, M.L.; Callaway, R. M.; Pearson, D.E. 2018. Life in interstitial space: Biocrusts inhibit exotic but not native plant establishment in semi-arid grasslands. Journal of Ecology. 107: 1317-1327.

Invasive Plant Cover Increases After Dry Forest Restoration, Then Fades Away

By: Justin Crotteau (justin.crotteau@usda.gov), RMRS Forestry Sciences Laboratory, Missoula, Montana; Sharon Hood (sharon.hood@usda.gov), RMRS Fire Sciences Laboratory, Missoula, Montana; Christopher Keyes (christopher.keyes@umontana.edu), University of Montana Applied Forest Management Program, Missoula, Montana

In the Inland Northwest, dense, dry pine forests with historically frequent fire return intervals are prime targets for restoration. Much of the motivation for restoration is aimed at the resiliency of the large-pine overstory to future disturbances. But there is concern that restoration—which often requires active management strategies—will stimulate invasive plant populations and lead to the demise of the native understory community. In the years following the Fire and Fire Surrogate Study's treatment plot installment at the University of Montana's Lubrecht Experimental Forest, we found that invasive plant species increased in cover shortly after treatment (Control, Burn-only, Thin-only, and Thin+Burn). Overall, thinning resulted in significantly greater invasive plant cover than not thinning (i.e., combined Control and Burn only treatments).The greatest invasive species increases occurred in the combination Thin+Burn treatment, where cover was nearly four times greater than in Thin-only or Burn-only units 2 years after treatment. Average invasive cover in the Burn-only and Thin-only treatments was negligible, remaining below 1 percent over the course of three measurements (0, 2, and 14 years posttreatment). Across all treatments, the increase in invasive cover that we observed at year 2 was ephemeral. By 14 years posttreatment, there was little invasive cover in any treatment, while native understory cover increased or remained stable compared to pretreatment levels.

In a longer running, ongoing study at the Lick Creek Research/Demonstration Forest on the Bitterroot National Forest, we are finding a similar theme. There, combined cutting and burning seems to have an even greater effect on invasive plant species cover (about 10-20% cover), but this 3-5 year posttreatment pulse declined to background levels in the years following (by 23 years posttreatment).

Together, these studies show that Inland Northwest dry forest restoration treatments with both cutting and burning have a definite impact on understory composition and invasive plant species populations. However, elevated invasive plant cover appears to be a transient stage in the posttreatment recovery. These studies do not negate the value of best management practices to avoid exotic species invasion, but they do suggest that short-term (e.g., 2-5 year) evaluation of restoration effectiveness on understory plant communities may appear dire, while longer-term effects of restoration may prove to better accomplish plant community goals of restoration treatments.

Crotteau, J.S; Keyes, C.R.; Hood, S.M.; Larson, A.J. In Press. Vegetation dynamics following compound disturbance in a dry pine forest: fuel treatment then bark beetle outbreak. Ecological Applications. Article e02023. https://doi.org/10.1002/eap.2023.

Jang, W.; Crotteau, J.S.; Keyes, C.R.; Hood, S.M.; Lutes, D.C.; Sala, A.; Pearson, D.E.; Ortega, Y.K. In Prep. Native and non-native understory vegetation response to restoration treatments in a dry conifer forest over 23 years.

Restoration Remedy: Seeding Native Species to Promote Ecosystem Recovery After Fire

By: Alexandra Urza (alexandra.urza@usda.gov), Jeanne Chambers (Jeanne.chambers@usda.gov), and Dave Board (david.i.board@usda.gov), RMRS Great Basin Ecology lab, Reno, Nevada; Peter Weisberg (pweisberg@cabnr.unr.edu), Department of Natural Resources and Environmental Science, University of Nevada, Reno

Expansion and dominance of the highly flammable invasive annual grass, cheatgrass (*Bromus tectorum*), is transforming native sagebrush ecosystems in the western United States. Invasion is often facilitated by fire, including prescribed fires intended to restore shrub-dominated landscapes. Fire-induced cheatgrass invasion does not occur in all landscapes, however, and our research group is striving to help managers predict areas with high invasion risk and identify appropriate management responses. This information is critical for prioritizing management investments across large landscapes.

In 2001, a Joint Fire Sciences Program Demonstration Area was established in Underdown Canyon on the Humboldt-Toiyabe National Forest in the Shoshone Mountains of central Nevada. Landscape-scale prescribed burns were implemented over a gradient of elevation, and postfire seeding treatments were designed to represent typical postfire management scenarios: unseeded, seeded with a functionally diverse mix of native perennial species, and seeded with a conventional mix of nonnative introduced perennial grass species. We now have more than 15 years of observations on plant community responses to fire and postfire seeding treatments. After fire, cheatgrass invasion was highest in lower elevation, warm and dry sites. Seeding a mix of native perennial shrubs, forbs, and grasses was more effective at increasing perennial cover and inhibiting cheatgrass invasion than seeding a mix of nonnative perennial grasses. This suggests that native-only seed mixes should be used if restoring native vegetation is a management goal, because the nonnative introduced species typically used in restoration tend to outcompete native species when they are seeded together.

Urza, A.K.; Weisberg, P.J.; Chambers, J.C.; Board, D.; Flake, S. 2019. Seeding native species increases resistance to annual grass invasion following prescribed burning of semiarid woodlands. Biological Invasions. 21(6): 1993-2007. https://www.fs.usda.gov/treesearch/pubs/57832

Urza, A.K.; Weisberg, P.J.; Chambers, J.C.; Dhaemers, J.M.; Board, D. 2017. Post-fire vegetation response at the woodland-shrubland interface is mediated by the pre-fire community. Ecosphere. 8(3): e01851. https://www.fs.usda.gov/treesearch/pubs/54502

Figure 3*—Prescribed fire operations in Underdown Canyon Demonstration Project (photo by Jeanne Chambers, RMRS).*

Figure 4—Postfire vegetation sampling in Underdown Canyon Demonstration Project (photo by Jeanne Chambers, RMRS).

Figure 5—Mule deer, two years after prescribed fire treatment in Underdown Canyon Demonstration Project (photo by Jeanne Chambers, RMRS).

Can Volatiles of High-Elevation Five-Needle Pines Provide Insights Into Insect and Pathogen Resistance?

By: Justin Runyon (justin.runyon@usda.gov), RMRS Forestry Sciences Laboratory, Bozeman, Montana

A hallmark of pine trees is the characteristic and strong fragrance emanating from their foliage. While aesthetically pleasing to humans, these volatile organic compounds (VOCs) serve many functions that allow plants to adapt to their environment. Key among these roles is defense against insects and pathogens. For example, plant VOCs can repel herbivores and directly kill pathogenic bacteria and fungi. Given these important roles, comparison of VOCs among closely related plants that vary in their resistance to herbivores and pathogens could provide insights into mechanisms underlying resistance. A recent study compared the VOCs from foliage (fig. 6) of eight species of high-elevation five-needle pines in Europe and North America. These species vary in resistance to the main herbivore (native mountain pine beetle) and pathogen (nonnative white pine blister rust) causing tree mortality. The most important compounds for classifying resistant and susceptible tree species were identified.

Figure 6—Collecting volatile compounds emitted by Great Basin Bristlecone pine on Cave Mountain, Nevada (photo by Justin Runyon, RMRS).

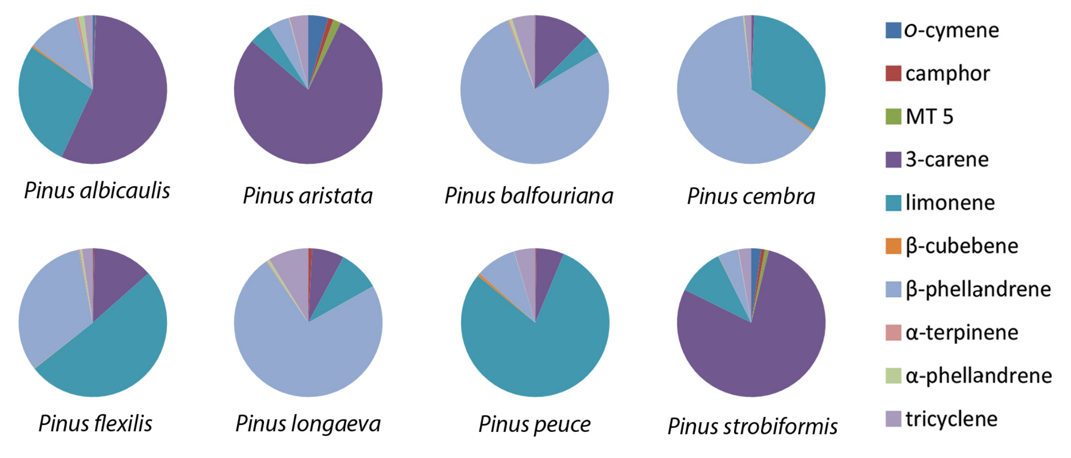
Contrary to expectations that High Five pine species would vary by presence/absence of compounds in VOC blends, all species emitted essentially the same compounds, but in different amounts. Each species has a VOC 'fingerprint' resulting from emission of distinctive ratios of compounds, rather than through presence of species-specific compounds (fig. 7). The most important compounds distinguishing resistant versus susceptible species differed for mountain pine beetle and white pine blister rust (see table 4 in Runyon et al. 2020).

These findings provide insights and should guide research into understanding resistance and in developing tools to manage these important trees. For instance, studies into the functions of five-needle pine VOCs in defense against abiotic or biotic stressors should focus on blend ratios rather than on individual compounds. For example, the VOCs emitted by some high-elevation five-needle pine species attract female mountain pine beetles, whereas VOCs from other species strongly repel this foremost herbivore. The VOCs responsible are unknown, but must be some blend of two or more compounds. Likewise, understanding the role VOCs might play in resistance to invasive white pine blister should focus on ratios rather than single compounds, focusing first on the compounds identified in Runyon et al. (2020) whose quantities distinguish susceptible and resistant pine species.

Runyon, J.B.; Gray, C.A.; Jenkins, M.J. 2020. Volatiles of high-elevation five-needle pines: Chemical signatures through ratios and insight into insect and pathogen resistance. Journal of Chemical Ecology. https://doi.org/10.1007/s10886-020-01150-0

Gray, C.A.; Runyon, J.B.; Jenkins, M.J.; Giunta, A.D. 2015. Mountain pine beetles use volatile cues to locate host limber pine and avoid non-host Great Basin bristlecone pine. PLoS ONE. 10(9): e0135752.

Figure 7—*Relative amounts of the 10 most important volatile compounds for distinguishing high-elevation five-needle pine species. Note the differences in ratios among species (from Runyon et al. 2020).*



Spotlight: The Tansy Ragwort Flea Beetle

The tansy ragwort flea beetle (*Longitarsus jacobaeae*) is a biocontrol agent from Eurasia that was introduced to control invasive tansy ragwort. Adults feed on leaves, larvae feed on roots, and this can kill plants. The flea beetle has been very effective at reducing populations of tansy ragwort: research in Oregon showed a 90 percent reduction in flowering plants a few years after introduction and it has rather been similarly effective in Montana.

Figure 8—*Tansy ragwort flea beetles feeding on tansy ragwort in northwest Montana (photo by Justin Runyon, RMRS).*

Figure 9—*Tansy ragwort flea beetles can be effective biocontrol agents and have successfully controlled tansy ragwort in parts of Oregon and Montana. Tansy ragwort plant before (left) and after (right) flea beetle feeding in northwest Montana (photos by Justin Runyon, RMRS).*

Other News

Postdoctoral Research Plant Ecologist, Provo, UT

The USDA Forest Service's Rocky Mountain Research Station is planning to hire a 2-year postdoctoral Research Plant Ecologist. The position is at the GS-11 level (about $64,000/year with benefits) and is located in Provo, Utah. The post-doctoral research ecologist will work primarily on the problem of annual brome invasion into marginally invasible arid and semiarid habitat occupied by plant species of conservation concern. The individual will join a research team engaged in basic and applied research in plant conservation with the goal of preventing extinction and promoting recovery of federally listed species. The post-doctoral project will focus on elucidating mechanisms facilitating recent annual brome invasion into formerly uninvaded habitat and developing methodology for annual brome control at intermediate spatial scales, for example, on nature preserves. The successful candidate will also have the opportunity to initiate a semi-independent research program in invasion ecology and/or plant conservation biology. For more information see: https://fsoutreach.gdcii.com/?id=46C31D77D1CC41F78399BE82F61638EF

Montana Invasive Species Bulletins

An archive of the Montana Invasive Species Bulletins produced by the Montana Invasive Species Council (MISC) is available online: http://dnrc.mt.gov/divisions/cardd/montana-invasive-species-program/misc/invasive-species-bulletin-collection

NAISMA Annual Conference, Whitefish MT, October 2020

The North American Invasive Species Management Association's (NAISMA) Annual Conference will be held at the Lodge at Whitefish Lake in Whitefish, Montana, October 6-8, 2020. For more information see: https://www.naisma.org/conferences/

Natural Areas Conference, Reno NV, October 2020

The Natural Areas Conference will be held at the Grand Sierra Resort in Reno, Nevada, October 13-16, 2020. Focus areas include "Invasive species management - new and effective approaches". For more information see: https://www.naturalareas.org/2020_conference.php

Other Recent Publications

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Chambers, Jeanne C.; Brooks, Matthew L.; Germino, Matthew J.; Maestas, Jeremy D.; Board, David I.; Jones, Matthew O.; Allred, Brady W. 2019. Operationalizing resilience and resistance concepts to address invasive grass-fire cycles. Frontiers in Ecology and Evolution. 7: 185.

Chambers, Jeanne C.; Allen, Craig R.; Cushman, Samuel A. 2019. Operationalizing ecological resilience concepts for managing species and ecosystems at risk. Frontiers in Ecology and Evolution. 7: 241.

Dobbs, John T.; Kim, Mee-Sook; Dudley, Nicklos S.; Jones, Tyler C.; Dumroese, R. Kasten; Cannon, Phil G.; Hauff, Robert D.; Klopfenstein, Ned B.; Stewart, Jane E. 2019. Development of tools for early detection, monitoring and management of the koa wilt pathogen (*Fusarium oxysporum* f. sp. *koae*) in Hawaiíi. In: Cleaver, C.; Palacious, P., compilers. Proceedings of the 65th annual Western International Forest Disease Work Conference; 2-6 October 2017; Parksville, BC, Canada. WIFDWC. p. 105-108.

Dylewski, Ł.; Myczko, Ł.; Pearson, D.E. 2019. Native generalist consumers interact strongly with seeds of the invasive wild cucumber (*Echinocystis lobata*). NeoBiota. 53: 25–39. https://doi.org/10.3897/neobiota.53.37431

El Waer, Hisham N.; Henry, Annie; Merewether, Katie; Sher, Anna A. 2018. Invasion and restoration of western rivers dominated by *Tamarix* spp. [Chapter 4]. In: Johnson, R. Roy; Carothers, Steven W.; Finch, Deborah M.; Kingsley, Kenneth J.; Stanley, John T., tech. eds. 2018. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 47-61. doi: http://doi.org/10.2737/RMRS-GTR-377-CHAP4.

Gaffke, Alexander M.; Sing, Sharlene E.; Dudley, Tom L.; Bean, Daniel W.; [et al.]. 2019. Field demonstration of a semiochemical treatment that enhances *Diorhabda carinulata* biological control of *Tamarix* spp. Scientific Reports. 9: 13051.

Garner, Lindy; Ielmini, Michael; Chambers, Jeanne C.; Mayer, Kenneth E.; Crist, Michele R. 2019. Invasive plant management [Chapter 5]. In: Crist, Michele R.; Chambers, Jeanne C.; Phillips, Susan L.; Prentice, Karen L.; Wiechman, Lief A., eds. Science framework for conservation and restoration of the sagebrush biome: Linking the Department of the Interior's Integrated Rangeland Fire Management Strategy to long-term strategic conservation actions. Part 2. Management applications. Gen. Tech. Rep. RMRS-GTR-389. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 89-112.

Leger, Elizabeth A.; Atwater, Daniel Z.; James, Jeremy J. 2019. Seed and seedling traits have strong impacts on establishment of a perennial bunchgrass in invaded semi-arid systems. Journal of Applied Ecology. 56: 1343-1354.

Masi, Marco; Meyer, Susan; Gorecki, Marcin; Pescitelli, Gennaro; [et al.]. 2018. Phytotoxic activity of metabolites isolated from *Rutstroemia* sp.n., the causal agent of bleach blonde syndrome on cheatgrass (*Bromus tectorum*). Molecules. 23: 1734.

McCartney, Kevin R.; Kumar, Sunil; Sing, Sharlene E.; Ward, Sarah M. 2019. Using invaded-range species distribution modeling to estimate the potential distribution of *Linaria* species and their hybrids in the U.S. northern Rockies. Invasive Plant Science and Management. 12: 97-111.

McLeod, Mary Anne. 2018. Unintended consequences: Tamarisk control and increasing threats to the southwestern willow flycatcher [Chapter 5]. In: Johnson, R. Roy; Carothers, Steven W.; Finch, Deborah M.; Kingsley, Kenneth J.; Stanley, John T., tech. eds. 2018. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 62-84. doi: http://doi.org/10.2737/RMRS-GTR-377-CHAP5.

Meldrum, James R.; Champ, Patricia; Bond, Craig; Schoettle, Anna. 2020. Paired stated preference methods for valuing management of white pine blister rust: Order effects and outcome uncertainty. Journal of Forest Economics. 35: 75-101.

Meyer, Susan E.; Beckstead, Julie; Allen, Phil S. 2018. Niche specialization in *Bromus tectorum* seed bank pathogens. Seed Science Research. doi: 10.1017/S0960258518000193.

Ortega, Y.K.; Valliant, M.T.; Pearson, D.E. 2019. To list or not to list: using time since invasion to refine impact assessment for an exotic plant proposed as noxious. Ecosphere. 10(11), e02961.

Ott, Jeffrey E.; Kilkenny, Francis F.; Summers, Daniel D.; Thompson, Tyler W. 2019. Long-term vegetation recovery and invasive annual suppression in native and introduced postfire seeding treatments. Rangeland Ecology and Management. 72(4): 640-653.

Urza, Alexandra K.; Weisberg, Peter J.; Chambers, Jeanne C.; Board, David; Flake, Samuel W. 2019. Seeding native species increases resistance to annual grass invasion following prescribed burning of semiarid woodlands. Biological Invasions. 21: 1993-2007.

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