



USGS LAND MANAGEMENT RESEARCH PROGRAM
SAGEBUSH & FIRE SCIENCE WEBINAR SERIES
SESSION #4 – February 27, 2025

LONGEVITY OF HERBICIDES TARGETING EXOTIC ANNUAL GRASSES IN SAGEBRUSH-STEPPE SOILS

- *Matt Germino (USGS-FRESC), Brynne Lazarus (USGS-FRESC)*

**A COLLABORATIVE AND ITERATIVE FRAMEWORK FOR DELIVERING APPLIED FUEL BREAK SCIENCE:
WITH A FOCUS ON SAGEBRUSH ECOSYSTEMS AND THE GREAT BASIN**

- *Doug Shinneman (USGS-FRESC), Pete Coates (USGS-WERC), Cam Aldridge (USGS-FORT), Julie Heinrichs (Colorado State University), David Pilliod (USGS-FRESC), Mark Ricca (USGS-FRESC), Michele Crist (USGS-LMRP), Cali Roth (USGS-WERC), Austin Nash (USGS-WERC)*

UAS SURVEY OF SAGEBRUSH FUEL BREAKS

- *Doug Shinneman (USGS-FRESC), Jason Kreidler (USGS-WGSC)*

INVASIVE ANNUAL GRASS - ECONOMIC ASSESSMENT

- *Beth Orning (USGS-FORT), Bryan Tarbox (USGS-FORT), James Meldrum (USGS-FORT), Catherine Jarnevich (USGS-FORT), Cam Aldridge (USGS-FORT)*

**EFFECTIVENESS OF LAYERING TREATMENTS IN THE “MULTIPLE-INTERVENTION” RESPONSE TO
WILDFIRE IN SAGEBRUSH STEPPE**

- *Matt Germino (USGS-FRESC)*

SYNTHESIS OF INDAZIFLAM OUTCOMES FOR PROTECTING SAGEBRUSH ECOSYSTEMS

- *Morgan Roche (USGS-FORT), Julie Heinrichs (Colorado State Univ), Cam Aldridge (USGS-FORT)*

**CAN RUDERAL COMPONENTS OF BIOCRUST BE MAINTAINED UNDER INCREASING THREATS OF
DROUGHT, GRAZING AND WILD HORSES?**

- *Lea Condon (USGS-WERC), Pete Coates (USGS-WERC)*

EFFECTIVENESS OF LAYERING TREATMENTS IN THE “MULTIPLE-INTERVENTION” RESPONSE TO WILDFIRE IN SAGEBRUSH STEPPE

Matt Germino (USGS-FRESC)

ABSTRACT: Development of post-fire treatments to decrease exotic annuals and increase perennial plants is a priority science need for land managers in sagebrush steppe. Post-fire treatments typically entail multiple interventions, such as herbicides or seedings that can have reinforcing or canceling effects. The management objective is to increase perennials, especially grasses, that compete with exotic annual grasses, and ultimately create a trend of increasing perennials and decreasing annuals during recovery. The “layering conundrum” faced by Emergency Stabilization and Rehabilitation (ESR) efforts is as follows: an herbicide treatment may be unsuccessful if perennials are not present to increase (be released) and prevent reinvasion, but drill seeding to increase perennials may be unsuccessful if annual weeds competitively exclude the perennial seedlings. The problem is that herbicides applied too close in time to seedings may kill the desirable perennial seedlings. USGS is conducting research to determine how different sequences of seeding and herbicide can be optimized to reduce exotics and increase perennials, and how the effects are modulated by post-fire grazing resumption, on the Soda Fire that burned 285,000 acres in southwestern Idaho in 2015. From fall 2015 through 2018, the Bureau of Land Management (BLM) created varying sequences of broadcast spraying of imazapic herbicide, drill seeding perennial grasses, and grazing rest treatments in replicated patches (up to 1000’s of acres). The USGS and BLM created untreated “leave” (control) areas for each treatment type, and we have worked together to assess vegetation responses in >2500 plots. This project will help managers determine how treatments can be best phased onto a site to optimize post-fire restoration outcomes in burned sagebrush steppe. We are focusing on the following questions: (1) What are the incremental gains in reducing exotic annuals and increasing desirable perennials with layering of treatments (spraying, drilling, aerial seeding)? (2) Do the responses agree with resistance and resilience concepts (based on soil temperature/moisture regime and pre-fire vegetation condition, etc)? (3) How are seeding+herbicide treatment outcomes affected by grazing, determined by (a) using exclosures and clipping treatments and (b) by difference among the pastures in year of grazing resumption, season of grazing and grazing intensity? (4) How do the responses to treatment combinations translate into simulated fire risk?

- TOPIC: Fire, Invasives, Restoration
- ADAPTIVE MANAGEMENT APPLICATION: Conservation Delivery, Monitoring
- PROJECT WEBSITE: <https://www.usgs.gov/centers/forest-and-rangeland-ecosystem-science-center/science/grazing-effects-annual-grass-fire>

PROPOSED DELIVERABLES:

- Determination of how grazing resumption or biomass removal through clipping after fire has affected perennial bunchgrass resilience and resistance to cheatgrass invasion, with or without seeding of either native or naturalized bunchgrasses.
- Identification of threshold levels of perennial or annual grass abundances or traits that are predictive of the retention or loss of resistance and resilience with post-fire grazing resumption or clipping.

COMPLETED DELIVERABLES/PRODUCTS:

- Germino, M.J., Torma, P., Fisk, M.R. and Applestein, C.V., 2022. Monitoring for adaptive management of burned sagebrush-steppe rangelands: addressing variability and uncertainty on the 2015 Soda Megafire. *Rangelands*, 44:99-110.
- Germino, M.J., Anthony, C.R., Kluender, C.R., Ellsworth, E., Moser, A.M., Applestein, C. and Fisk, M.R., 2022. Relationship of greater sage-grouse to natural and assisted recovery of key vegetation types following wildfire: insights from scat. *Restoration Ecology*, p.e13758.
- Anthony, C.R. and Germino, M.J., 2022. Predictive models of selective cattle use of large, burned landscapes in semiarid sagebrush-steppe. *Rangeland Ecology & Management* 85:1-8
- Kluender, C.R. and Germino, M.J., 2024. A nontarget, disturbance-resilient native species influences post-fire recovery and multiphasic herbicide-seeding outcomes in drylands threatened by exotic annual grasses. *Restoration Ecology*, 32(1), p.e14013.
- Kluender CR, Germino MJ. 2024. Propensity score matching mitigates risk of faulty inferences in observational studies of effectiveness of restoration trials. *Journal of Applied Ecology* 61:1127-1137
- Many presentations given annually to BLM field/district/national levels and other agency staff, including field tours, webinars, and in-person presentations at offices and society meetings.

A COLLABORATIVE AND ITERATIVE FRAMEWORK FOR DELIVERING APPLIED FUEL BREAK SCIENCE: WITH A FOCUS ON SAGEBRUSH ECOSYSTEMS AND THE GREAT BASIN

Doug Shinneman (USGS-FRESC), Pete Coates (USGS-WERC), Cameron Aldridge (USGS-FORT), Julie Heinrichs (Colorado State University), David Pilliod (USGS-FRESC), Mark Ricca (USGS-FRESC), Michele Crist (BLM-NIFC); Cali Weise (USGS-WERC)

ABSTRACT: Fuel breaks are used to alleviate the threat of wildfire to imperiled sagebrush ecosystems, yet a robust understanding of their effects is hindered by information gaps regarding their effectiveness at reducing wildfire and their potential effects on ecosystems (e.g., habitat fragmentation, exotic species). Our goal is to develop a fuel break monitoring framework that could help fill these information gaps, compatible with existing agency objectives. Specifically, we sought to: 1) develop and evaluate sampling protocols in existing fuel break networks; 2) share analysis results of our field data with agency advisors/partners to develop strategic fuel break monitoring strategies; and 3) initiate an approach to monitor fuel break networks both before and after implementation. During Phase I of this research, we sampled fuels, vegetation, and wildlife usage in existing fuel break networks located in Nevada and Idaho, across a range of treatment types, disturbance histories, and environmental gradients. We are currently in Phase II of this research, which involves establishing a network of monitoring sites to be sampled before and after fuel breaks are implemented using a before-after-control-impact (BACI) study design. This study design will permit comprehensive analyses of changes to vegetation, fuels, and wildlife in and around fuel breaks that can be assessed relative to specific agency fuel break objectives, and it can serve as a model for monitoring fuel breaks in rangelands nationwide. We expect results from this research will help to identify immediate and long-term changes following establishment of fuel breaks, informing decisions about fuel break placement and maintenance.

- TOPIC: Fire, Invasives, Wildlife, Climate, Monitoring, Decision Support
- ADAPTIVE MANAGEMENT APPLICATION: Biol. Planning, Conservation Design, Monitoring, Evaluation

- PROJECT WEBSITE: <https://www.usgs.gov/centers/forest-and-rangeland-ecosystem-science-center/science/fuel-break-science-great-basin>

PROPOSED DELIVERABLES:

- Annual Reports (FY23, FY24)
- Journal article(s) – predictive models of fuel break conditions (vegetation, fuels, wildlife) based on analysis of fuel breaks from Phase I of this research (Q3-4, FY25)
- Fuel break guidance document (USGS-Open file report, or similar) that outlines sampling and monitoring protocols compatible with agency objectives and existing programs (developed from assessment of exploratory sampling methods, data analysis, and workshops/agency expert consultation) (Q4, FY25)
- Implementation of monitoring/sampling design for Phase II of this research (Q2, FY24 & FY25)
- Characterization of vegetation/fuels conditions and wildlife usage at pre- and post-installation fuel break sites, include in publications on a BACI analysis of treatment effects over time (contingent on sampling more than two years after treatment).

COMPLETED DELIVERABLES/PRODUCTS:

- Shinneman, D. J., E. K. Strand, M. Pellant, J. T. Abatzoglou, M. W. Brunson, N. F. Glenn, J. A. Heinrichs, M. Sadegh, and N. M. Vaillant. 2023. Future Direction of Fuels Management in Sagebrush Rangelands. *Rangeland Ecology & Management* 86:50–63. <https://doi.org/10.1016/j.rama.2022.10.009>
- Roche, M., D.J. Saher, E., Buchholtz, M. Crist, D.J. Shinneman, C.L. Aldridge, B. Brussee, P.S. Coates, C. Weise, and J.A. Heinrichs. (In review). Ecological trade-offs associated with fuel breaks in the sagebrush ecosystem. Submitted to *Frontiers in Ecology and the Environment*. [also supported by Heinrichs et al., Project #07]

UAS SURVEY OF SAGEBRUSH FUEL BREAKS

Doug Shinneman (USGS-FRESC), Jason Kreidler (USGS-WGSC), Taylor J. Dudunake (USGS Idaho Water Science Center), Peter Coates (USGS Western Ecological Research Center), Cali Weise (USGS Western Ecological Research Center), Ben Gustafson (USGS Western Ecological Research Center)

ABSTRACT: Fuel breaks in sagebrush rangelands are increasingly being implemented to reduce the threat of wildfire to natural resources, threatened ecosystems and wildlife, and human safety. Information about changes in vegetation and fuel loadings in fire-prone areas is needed to assess fuel break effectiveness, as well as to determine optimal fuel break re-treatment maintenance schedules. Using sensors mounted on uncrewed aerial systems (UAS, or “drones”) might provide an efficient method to systematically monitor and assess changes in and near fuel breaks over time across a broad range of conditions and environmental settings. We are using UAS-derived high-resolution imagery and vegetation structure data in and near fuel breaks to accomplish the following: 1) classify different rangeland fuel types (e.g., litter, grasses, shrubs) and fuel structures (e.g., fine fuel continuity, shrub height); 2) compare conditions at different fuel treatment sites; and 3) explore the potential to scale UAS-data to high resolution satellite imagery. We are developing techniques to couple data obtained from UAS-mounted sensors with traditional field-sampling methods to develop classifications of fuels and vegetation conditions (based on composition and structure) in and near fuel breaks. Through multi-scale analysis of field data and imagery derived products, we will explore the utility of this approach for sagebrush steppe fuels management and other natural resource decision-making. We are developing

these approaches in collaboration with several DOI agency personnel who have expertise in fuels management, remote sensing, and UAS technology, with a goal of producing practical, actionable science that informs fuels management planning by the BLM and other DOI agencies.

- TOPIC: Fire, Invasives, Monitoring, Decision Support, Remote Sensing
- ADAPTIVE MANAGEMENT APPLICATION: Biol. Planning, Conservation Design, Monitoring, Evaluation
- PROJECT WEBSITE: <https://www.usgs.gov/centers/forest-and-rangeland-ecosystem-science-center/science/fuel-break-science-great-basin>

PROPOSED DELIVERABLES:

- Peer-reviewed publication describing the methods used in this effort and potential applications for informing fuels monitoring and management needs.
- A data release of the processed imagery and associated information will be published through ScienceBase.

INVASIVE ANNUAL GRASS - ECONOMIC ASSESSMENT

James Meldrum (USGS-FORT), Elizabeth Orning (USGS-FORT), Bryan Tarbox (USGS-FORT), (Catherine Jarnevič (USGS-FORT), Cameron Aldridge (USGS-FORT), Lindy Garner (USFWS), John Tull (USFWS), Seth Flanigan (BLM)

ABSTRACT: This project seeks to identify biome-wide costs, amortized into the future, needed to address the invasive annual grass threat spatially with a Defend and Grow the Core approach as presented in the Sagebrush Conservation Design. The assessment will use a bioeconomic state and transition simulation model (STSM) to monetize prevention, early detection and rapid response, aggressive management, and restoration for varying ecological conditions across the sagebrush ecosystem. Economic comparisons of allocation scenarios that vary based on site conditions and ecological outcomes will define cost savings and sustainable management that will inform program and management investments that align with durable landscape conservation that protects resilient landscapes. Scientists with the USGS Fort Collins Science Center are working with an interagency expert panel to develop a cost assessment matrix based on existing science and expert elicitation, design a series of allocation management scenarios, and use bioeconomic modeling to monetize the costs for each scenario. Resources needed will be outlined at a coarse, landscape-scale to identify multi-year costs and benefits of a spatially-prioritized Defend and Grow the Core approach. Scenario analysis based on these estimates will support maximizing the cost-effectiveness of invasive annual grass management strategies.

- TOPICS: Fire, Invasives, Restoration, Decision Support Tool
- ADAPTIVE MANAGEMENT APPLICATION: Biological Planning, Conservation Design
- PROJECT WEBSITE: [Economic assessment of addressing annual invasive grasses across the sagebrush biome | U.S. Geological Survey \(usgs.gov\)](#)

PROPOSED DELIVERABLES:

- Spatial layer of generalized IAG treatment costs for the biome (FY24 Q4)
- Report including “cost matrix” of treatment costs as a function of invasion level and site condition and comparing multi-year monetary costs for a set of allocation scenarios (FY24 Q4)

COMPLETED DELIVERABLES/PRODUCTS:

- Tarbox, B., Orning, E., Jarnevich, C., Aldridge, C., Meldrum, J.R. 2023. *Simulating long-term costs and effectiveness of sagebrush conservation strategies for invasive annual grass*. Presentation to the SyncroSim 2023 User Conference in Fort Collins, Colorado.
- Orning, E., Tarbox, B., Jarnevich, C., Aldridge, C., Meldrum, J.R. 2024. *Long-term costs and effects of biome-wide sagebrush conservation strategies for invasive annual grasses*. Presentation to the Society for Rangeland Management 2024 annual conference in Sparks, Nevada.
- Meldrum, J.R., Orning, E.K., Tarbox, B.C., Huber, C., Jarnevich, C.S., Aldridge, C.L. 2024. *The unknown costs and benefits of addressing invasive annual grasses across the sagebrush biome*. Presentation to the W5133 Annual Meeting: Economic Valuation and Management of Natural Resources on Public and Private Lands in Fort Collins, Colorado.
- Orning, E.K., B.C. Tarbox, C.S. Jarnevich, C.L. Aldridge, and J.R. Meldrum. 2024. *Costs, benefits, and implications for addressing invasive annual grass across the sagebrush biome under the Sagebrush Conservation Design*. Presentation to the joint Wyoming Wildlife Society (TWS) & Wyoming Landscape Conservation Initiative (WLCI) annual meeting in Cody, Wyoming.
- Orning, E.K., B.C. Tarbox, C.S. Jarnevich, L. Garner, J.C. Tull, L.A. Wiechman, C.L. Aldridge, and J.R. Meldrum. 2025. *Coupling co-production and simulation modeling to evaluate biome-wide costs and benefits of invasive annual grass under the sagebrush conservation design*. Presentation to the Society for Range Management Annual Meeting in Spokane, Washington.
- Orning, E.K., B.C. Tarbox, C.S. Jarnevich, L. Garner, J.C. Tull, L.A. Wiechman, C.L. Aldridge, and J.R. Meldrum. 2025. *Coupling co-production and simulation modeling to evaluate invasive annual grass under the sagebrush conservation design*. Presentation to the 2025 Greater Sage-Grouse Mitigation Summit in Reno, Nevada.

LONGEVITY OF HERBICIDES TARGETING EXOTIC ANNUAL GRASSES IN SAGEBRUSH-STEPPE SOILS

Matt Germino (USGS-FRESC), Brynne Lazarus (USGS-FRESC)

ABSTRACT: Pre-emergent herbicides are a critical tool for reducing exotic annual grasses such as cheatgrass where they have invaded or are beginning to invade sagebrush steppe. The length of time that exotic grasses are reduced after herbicide application has typically been considered to be too short - perceived to be usually only a year or so – for native or naturalized perennial herbs to increase sufficiently to provide longer-term biotic resistance to re-invasion. A new herbicide, *Rejuvra*, is under consideration because it is considered to have a more extended effect. However, there are few datasets that can inform us on the longevity of herbicide effects on both the targeted invasives and non-target native species. Our objective is to address this data gap on herbicide longevity in sagebrush steppe, across a variety of plant communities, soil types, and climates, using long-standing and carefully designed field experiments. We were specifically supported to sustain measurements and analyses of vegetation responses for herbicide applications, specifically *imazapic*, *rimsulfuron*, *indaziflam*, in experiments located throughout southern Idaho. The trials began as far back as 2016 and as recent as 2019 and are thus the longest-standing trials of *Rejuvra* in sagebrush steppe rangelands that are of high concern to BLM, FWS, and other agencies.

- TOPICS: Invasives, Restoration
- ADAPTIVE MANAGEMENT APPLICATION (Monitoring, Evaluation)
- PROJECT WEBSITE: [Longevity of Herbicides Targeting Exotic Annual Grasses in Sagebrush-Steppe Soils | U.S. Geological Survey \(usgs.gov\)](#)

PROPOSED DELIVERABLES:

- Journal publication on biocrust effects (Q4 FY23)
- Annual reports (Q4 FY23-FY25)
- Webinar and papers on synthesis, best practices (Q3,Q4 FY25)
- Final journal publications (Q3 FY25)

COMPLETED DELIVERABLES/PRODUCTS:

- Donaldson, R. and Germino, M.J., 2022. Intra-site sources of restoration variability in severely invaded rangeland: Strong temporal effects of herbicide–weather interactions; weak spatial effects of plant community patch type and litter. *Ecological Solutions and Evidence*, 3(3), p.e12172. <https://doi.org/10.1002/2688-8319.12172>
- Lazarus, B.E. and Germino, M.J., 2022. Plant community context controls short-versus medium-term effects of pre-emergent herbicides on target and non-target species after fire. *Applied Vegetation Science*, 25(2), p.e12662. <https://doi.org/10.1007/s10530-021-02481-z>
- Kluender C, Germino MJ, Lazarus B, Mathews T. 2024. Patchy post-fire response of cheatgrass and sagebrush-steppe to indaziflam and imazapic: landscape and microscale drivers. *Rangeland Ecology and Management*. 98: 232-240 <https://doi.org/10.1016/j.rama.2024.08.029>
- Many webinars and society meeting presentations from in FY 2023 and 2024

SYNTHESIS OF INDAZIFLAM OUTCOMES FOR PROTECTING SAGEBRUSH ECOSYSTEMS

Morgan Roche (USGS-FORT), Julie Heinrichs (Colorado State Univ), Cam Aldridge (USGS-FORT)

ABSTRACT: There are limited invasive annual grass management strategies that provide predictably effective long-term control of invasive annual grasses at the large spatial scales relevant for the extent of the invasion. The widely-used herbicides are usually only effective for a relatively short time and thus require frequent re-applications to produce the desired effect. Herbicide application is a time- and cost-intensive strategy that produces mixed success, so an effective, long-acting herbicide would be beneficial for cost- and time-savings for land managers. Additionally, vegetation responses to herbicides often vary across sites, and we lack a broad understanding of the factors that contribute to these variable outcomes. Indaziflam (Rejuvra) is a pre-emergent herbicide that has promising evidence for longer-term control of invasive annual grasses. However, it is unclear in which ecological and vegetation conditions Indaziflam is expected to produce desired effects. We aim to synthesize field studies of Indaziflam treatments to enhance our overall understanding of the pre-treatment conditions needed to produce consistent control of invasive annual grasses. This information can be used to support decisions on the use of Indaziflam across sagebrush ecosystems to protect these threatened ecosystems from expansion of invasive annual grasses.

- TOPIC: Fire, Invasives, Climate, Restoration
- ADAPTIVE MANAGEMENT APPLICATION: Biol. Planning, Cons. Design, Monitoring, Evaluation
- PROJECT WEBSITE: [Effects of the herbicide, Indaziflam, on invasive annual grasses | U.S. Geological Survey](#)

PROPOSED DELIVERABLES:

- Peer-reviewed manuscript or report (Q4 FY25-Q1 FY26)

- Data release (Q4 FY25-Q1 FY26)
- Science communication document (Q4 FY25-Q1 FY26)

CAN RUDERAL COMPONENTS OF BIOCRUST BE MAINTAINED UNDER INCREASING THREATS OF DROUGHT, GRAZING AND WILD HORSES?

Lea Condon (USGS-WERC), John Bradford (USGS-SBSC), Kate Shoenecker (USGS-FORT), Peter Coates (USGS-WERC), Aleta Nafus (NOC-BLM)

ABSTRACT: Community analyses consistently show that biocrusts are negatively associated with the abundance of invasive annual grasses that are responsible for increasing fire across the Great Basin. Although biocrusts thrive under soil and climate conditions that are stressful for vascular plants, components of biocrusts, as represented by morphogroups, vary in tolerance of climate, soils, and disturbance, such that plant communities demonstrate consistent compositions of biocrusts. For example, we know that mosses will succumb to frequent wetting and drying events at short intervals. Preliminary results show that some components of biocrusts: mosses and cyanobacteria can be maintained in the presence of grazing given interactions between soil texture and moisture, providing a firm substrate, and increasing the resistance of biocrusts to trampling. Although ruderal biocrusts can be maintained under certain conditions, wild horses can reduce biocrusts. We propose teasing apart the effects of these stressors on morphogroups of biocrusts, using existing data, to help the Bureau of Land Management prioritize management efforts.

- TOPICS: Grazing, Drought, Biocrusts
- ADAPTIVE MANAGEMENT APPLICATION: Monitoring, Evaluation
- PROJECT WEBSITE: [Can ruderal components of biocrust \(mosses and cyanobacteria\) be maintained under increasing threats of drought, grazing and feral horses? | U.S. Geological Survey](#)

PROPOSED DELIVERABLES

- Data release of field data addressing the above-mentioned stressors FY25
- Maps of potential biocrusts given modeled relationships with stressors FY25
- Peer-reviewed journal article(s) FY25

COMPLETED DELIVERABLES/PRODUCTS:

- Condon, LA, Rosentreter, R, Veblen, KE, Coates, PS. 2024. Season of grazing interacts with soil texture, selecting for associations of biocrust morphogroups. *Geoderma* 445: 116783.
- Condon, LA, Bradford, JB, Coates PS 2024. Biological soil crusts are more prevalent in warmer and drier environments within the Great Basin ecoregion: implications for managing annual grass invasion. *Restoration Ecology* 32: e14150.