



**USGS LAND MANAGEMENT RESEARCH PROGRAM
SAGEBUSH & FIRE SCIENCE WEBINAR SERIES
SESSION #2 – February 6, 2025**

DEVELOP ANNUAL HERBACEOUS PERCENT COVER MAPS IN NEAR-REAL TIME

- **Stephen Boyte (USGS EROS)**, Neal Pastick (USGS EROS), Devendra Dahal (KBR EROS)

PROLIFERATION OF FINE FUELS: ASSESSING UNDER FUTURE CLIMATIC CONDITIONS

- Julie Heinrichs (Colorado State Univ), Helen Sofaer (USGS-PIERC), Michele Crist (NIFC-BLM), **Morgan Roche (USGS-FORT)**, Erin Buchholtz (USGS SC-CRU, formerly FORT), Catherine Jarnevich, Dan Manier, Cameron Aldridge (USGS-FORT)

OPTIMIZING SAGEBRUSH RESTORATION AND MANAGEMENT ACTIONS TO INCREASE CONNECTIVITY WITHIN THE SAGEBRUSH CONSERVATION DESIGN

- **Bryan Tarbox (USGS-FORT)**, Erica Christensen (USGS-FORT), Adrian Monroe (USGS-FORT), Michelle Jeffries (USGS-FRESC), Justin Welty (USGS-FRESC), David Pilliod (USGS-FRESC), Cameron Aldridge (USGS-FORT)

ASSESSING CHEATGRASS TREATMENT EFFICACY ACROSS THE SAGEBRUSH BIOME

- **Bryan Tarbox (USGS-FORT)**, Erica Christensen (USGS-FORT), Adrian Monroe (USGS-FORT), Michelle Jeffries (USGS-FRESC), Justin Welty (USGS-FRESC), David Pilliod (USGS-FRESC), Cameron Aldridge (USGS-FORT)

SIMULATING TRENDS IN LAND HEALTH COMPONENTS UNDER TREATMENT SCENARIOS AND SAGEBRUSH CONSERVATION DESIGN

- Erica Christensen (USGS-FORT), Adrian Monroe (USGS-FORT), Bryan Tarbox (USGS-FORT), Cameron Aldridge (USGS-FORT)

SAGEBRUSH BIOME-WIDE VEGETATION CHANGE MONITORING AND WARNING SYSTEM

- **Cameron Aldridge (USGS-FORT)**, Adrian Monroe (USGS-FORT), Matthew Rigge (USGS-EROS) Bryan Tarbox (USGS-FORT), Michael O'Donnell (USGS-FORT), Morgan Roche (USGS-FORT), Erica Christensen (USGS-FORT), Beth Orning (USGS-FORT), Richard Inman (USGS-FORT), and Lief Wiechman (USGS-LMRP)

VECTORS OF ANNUAL GRASS INVASION

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

PREDICTING REBURN RISK TO RESTORATION INVESTMENTS

- Cara Applestein (USGS-FRESC), Jake Price (USGS-FRESC), Matt Germino (USGS-FRESC)

DEVELOP ANNUAL HERBACEOUS PERCENT COVER MAPS (30-M SPATIAL RESOLUTION) IN NEAR-REAL TIME (NRT)

Stephen Boyte (USGS EROS), Neal Pastick (USGS EROS), Devendra Dahal (KBR EROS)

ABSTRACT: Exotic annual grasses that invade semiarid and arid ecosystems in the western United States create extensive fuel beds that alter fire regimes, which includes increasing the spread and frequency of wildfire. Fire contributes to the degradation of waterways, alters the carbon balance, and threatens high-value societal priorities. The altered fire regimes present monumental challenges for land managers as native habitat that supports wildlife is consumed by fire and then oftentimes replaced almost exclusively with exotic annual grass. Exotic grass-dominated ecosystems cannot support native wildlife and make restoration difficult, if not impossible. Objectives of this work include reducing the latency of developing and publicly releasing the early estimates of exotic annual grass (EAG) datasets, increasing the number of EAG datasets developed and publicly released by adhering to a bi-weekly schedule from mid-May to early July. The approach we use involves the application of satellite data, specifically 30-m Harmonized Landsat / Sentinel-2 data, integrated with biophysical and climate data. These data are ingested into regression-tree, deep-learning, and mapping software packages. Producing up-to-date early estimates of exotic annual grass distribution and abundance in the semiarid and arid ecosystems at critical periods is important to land managers. The timely information provided about landscape conditions helps them to understand and manage potential fire threats driven by exotic annual grasses.

- TOPICS: Fire, Invasives, Wildlife, Exotic Annual Grass
- ADAPTIVE MANAGEMENT APPLICATION: Biological Planning, Monitoring
- PROJECT WEBSITE: [Next Generation Viewer \(mrlc.gov\)](https://mrlc.gov)

PROPOSED DELIVERABLES:

- Ten weekly estimates of exotic annual grass abundance spatial datasets, Q3-4
- Exotic annual grass phenology spatial datasets, Q4
- Annual report, Q1 – FY26

COMPLETED DELIVERABLES/PRODUCTS:

- Ten 2024 weekly early estimates of exotic annual grass abundance spatial datasets for the western U.S. rangelands. <https://doi.org/10.5066/P1Y5TZBM>.
- Exotic annual grass phenology estimates in the western U.S. rangelands based on 30-m HLS NDVI: 2017 – 2023. <https://doi.org/10.5066/P93M8TEK>.

PROLIFERATION OF FINE FUELS

Julie Heinrichs (Colorado State Univ), Helen Sofaer (USGS-PIERC), Michele Crist (USGS-LMRP), Morgan Roche (USGS – FORT), Erin Buchholtz (USGS SC-CRU), Catherine Jarnevich (USGS-FORT), Cameron Aldridge (USGS-FORT)

ABSTRACT: Invasive annual grasses create an array of species, landscape, and ecosystem management challenges. The proliferation and connectivity of fine fuels could increase the spread and consequences of wildland fires; however, there is limited understanding of the degree to which future landscape change could alter fine fuel abundance and spatial patterns within the sagebrush ecosystem. We scoped the potential proliferation of invasive annual grasses (fine fuels) in the Great Basin, under current and

future disturbance conditions. We spatially identified opportunities to disconnect existing fine fuels at multiple spatial scales, and assessed and mapped the rates of change in invasive annual grass cover across the sagebrush biome. We are working to identify the factors that contribute to rapid or slow increases in cover vs where annual invasive grass cover is stable or recovering across the sagebrush biome. We will use these models to develop projections of rates of change in cover in near-term future conditions, and to understand where contemporary and future rates of change will be similar or different. This research complements existing invasive annual grass spatial evaluations by identifying rates of change in annual invasive grass cover, specifically within native sagebrush communities and including environmental factors (e.g., disturbance) by which landscapes can be managed to address annual grass invasions. Products developed can be used to support management prioritizations by identifying areas at low/high risk of near-term invasion.

- TOPICS: Fire, Invasives, Climate, Restoration
- ADAPTIVE MANAGEMENT APPLICATION: Biological Planning, Conservation Design
- PROJECT WEBSITE: [Assessing the Proliferation, Connectivity, and Consequences of Invasive Fine Fuels on the Sagebrush Biome | U.S. Geological Survey \(usgs.gov\)](https://www.usgs.gov/land-management/assessing-the-proliferation-connectivity-and-consequences-of-invasive-fine-fuels-on-the-sagebrush-biome)

PROPOSED DELIVERABLES:

- Buchholtz et al. (In Prep) Disturbance scenarios reveal increased risk of high-abundance invasive annual grasses and threat to sagebrush in the Great Basin (Anticipated submission 2025).
- Roche et al. (In Prep) Characterizing drivers of rates change in annual invasive grass cover in sagebrush ecosystems: Opportunities for differential action. (Anticipated submission 2025).
 - o Effects of numerous anthropogenic and environmental factors on rates of change in annual invasive grass cover; composite map for aiding management decisions on if/where to resist, accept, direct invasion. (Anticipated release 2025)
- Roche et al. (In prep) Near-term projections of rates of change in annual invasive grass cover (Anticipated submission 2025)
 - o Ensemble map of projected rates of change in cover, map showing differences and similarities between contemporary and projected maps (Anticipated release 2025)
- Roche et al. (In prep) Decision-tree of invasive annual grass management actions using contemporary and future rates of invasion (Anticipated submission 2025)

COMPLETED DELIVERABLES/PRODUCTS:

- H. Sofaer, C. Jarnevich, E. Buchholtz, B. Cade, J. Abatzoglou, C. Aldridge, P. Comer, D. Manier, L. Parker, J. Heinrichs. 2022. Potential cheatgrass abundance within lightly invaded areas of the Great Basin. *Landscape Ecology* 37:10 2607-2618. And associated data release.
- E. Buchholtz, M. Crist, J. Heinrichs. 2023. Landscape and connectivity metrics as a spatial tool to support invasive annual grass management decisions. *Biological Invasions* 25, 637 - 644.
 - o E. Buchholtz, J. Heinrichs. 2022. Landscape and connectivity metrics based on invasive annual grass cover from 2016-2018 summarized at 15 kilometer grid cells in the Great Basin, USA: U.S. Geological Survey data release, <https://doi.org/10.5066/P9B4H00Q>.
- M. Roche, M. Crist, C. Aldridge, H. Sofaer, C. Jarnevich, J. Heinrichs. 2024. Rates of change in invasive annual grass cover to inform management action in sagebrush ecosystems. *Rangelands* 46:6 183-194 <https://doi.org/10.1016/j.rala.2024.10.001>
 - o Roche, M.D., Crist, M.R., Aldridge, C.L., Sofaer, H.R., Jarnevich, C.S., and Heinrichs, J.A., 2024, Rates of change in invasive annual grass cover to inform potential management

OPTIMIZING SAGEBRUSH RESTORATION AND MANAGEMENT ACTIONS TO INCREASE CONNECTIVITY WITHIN THE SAGEBRUSH CONSERVATION DESIGN

Bryan Tarbox (USGS-FORT), Erica Christensen (USGS-FORT), Adrian Monroe (USGS-FORT), Cameron Aldridge (USGS-FORT)

ABSTRACT: Arid shrublands of western North America face growing threats from disturbances such as wildfire, drought, and invasive species. Effective management and restoration are needed to slow or reverse these processes and maintain or increase connectivity within Core Sagebrush (CSA) and Growth Opportunity Areas (GOA) identified by the Sagebrush Conservation Design (SCD). Sagebrush recovery and restoration are slow processes with high risk of failure, necessitating tools that utilize novel data to differentiate between sites with high probability of natural recovery, those requiring active restoration, those least resilient to disturbance that need protection, and sites with poor likelihood of sustaining sagebrush over the long term. We are developing an optimization tool using vegetation trend models to guide restoration of sagebrush habitats from disturbance. Scenarios will be co-developed with partners but may target specific management actions within the SCD that include: 1) high resiliency sites within GOAs that require protection to allow natural recovery, 2) moderate resiliency sites within GOAs that require active restoration, and 3) low to moderate resiliency sites within CSAs that require more stringent management to remain intact. These outputs will provide critical information for applying the SCD at local scales while improving structural connectivity and minimizing risk.

- TOPICS: Prioritization, Fire, Climate, Restoration Planning, Decision Support Tool
- ADAPTIVE MANAGEMENT APPLICATIONS: Biological Planning, Conservation Design
- PROJECT WEBSITE: <https://www.usgs.gov/centers/fort-collins-science-center/science/predicting-recovery-sagebrush-ecosystems-across-sage>

PROPOSED DELIVERABLES:

- Data release of prioritization maps (FY25-Q4)
- Integration of deliverables into the LTET (FY25-Q4)

ASSESSING CHEATGRASS TREATMENT EFFICACY ACROSS THE SAGEBRUSH BIOME

Bryan Tarbox (USGS-FORT), Erica Christensen (USGS-FORT), Adrian Monroe (USGS-FORT), Cameron Aldridge (USGS-FORT), Michelle Jeffries (USGS-FRESC), Justin Welty (USGS-FRESC), David Pilliod (USGS-FRESC), Megan McLachlan (BLM-NOC), Lindy Garner (USFWS)

ABSTRACT: Invasive annual grasses (IAGs) threaten ecological integrity of the sagebrush biome and the species and communities that depend on it. Cheatgrass (*Bromus tectorum*) alone occupies >200,000 km² across the intermountain west and its footprint is steadily increasing over time (at a rate of >2,300 km²/yr). Through the Sagebrush Conservation Design, regional stakeholders devised a management strategy focused on 1) Defending the Core (of sagebrush habitat), 2) Growing the Core, and 3) Mitigating Impacts. However, a comprehensive understanding of the efficacy of IAG management across the

sagebrush biome is needed to align management efforts with this strategy. We are using estimates of annual herbaceous cover from remote sensing products (RCMAP and RAP, 1986-2021), treatment data from multiple land treatment databases, and other spatially explicit data to evaluate the influence of repeated treatments, treatment timings, size of treatments/infestations, perennial grass seedings, wildfire characteristics, and environmental conditions (e.g., soil moisture) on success of IAG control efforts across broad spatiotemporal extents. These results can directly inform multi-agency, cross-jurisdictional management efforts for controlling IAGs and will be integrated into the Land Treatment Exploration Tool (LTET).

- TOPICS: Invasives, Fire, Restoration, Decision Support Tool
- ADAPTIVE MANAGEMENT APPLICATIONS: Biol. Planning, Conservation Design, Monitoring
- PROJECT WEBSITE: [Assessing invasive annual grass treatment efficacy across the sagebrush biome | U.S. Geological Survey \(usgs.gov\)](#)

PROPOSED DELIVERABLES:

- Data release including raster layers of predicted treatment efficacy based on environmental conditions (e.g., soil moisture availability), variance of predicted treatment efficacy, and comparison of predictions between RAP and RCMAP-based analyses (FY25-Q4)
- Manuscript published in peer-reviewed journal detailing approach, results and implications (FY25-Q4)
- Integration of results into the LTET (FY25-Q4)

SIMULATING TRENDS IN LAND HEALTH COMPONENTS UNDER TREATMENT SCENARIOS AND SAGEBRUSH CONSERVATION DESIGN

Erica Christensen (USGS-FORT), Adrian Monroe (USGS-FORT), Bryan Tarbox (USGS-FORT), Cameron Aldridge (USGS-FORT)

ABSTRACT: Threats from disturbance and degradation are increasingly altering the sagebrush (*Artemisia* spp.) biome, eliminating habitat for species of conservation concern such as greater sage-grouse (*Centrocercus urophasianus*). Effective management and restoration are needed to slow or reverse these processes within Core Sagebrush (CSA) and Growth Opportunity Areas (GOA) identified by the Sagebrush Conservation Design (SCD). We recently developed a framework for modeling and predicting sagebrush recovery across the biome (1986–2021) using multiple treatment datasets spanning broad spatiotemporal extents (Land Treatment Digital Library, Conservation Efforts Database, Utah Watershed Restoration Initiative), as well as datasets for fire, soil moisture, and remotely-sensed vegetation cover. Our models provide context-dependent estimates of treatment efficacy and sagebrush recovery rates, as well as spatially explicit predictions with uncertainty metrics. However, understanding how treatments affect other components of land health such as bare ground, perennial herbaceous, and annual herbaceous cover, is needed for a more complete assessment of recovery potential and to prioritize restoration. Additionally, an overlay of our sagebrush recovery and land health component trend maps with CSAs and GOAs, tailored to different restoration practices, would provide managers with additional insights for prioritizing investment of limited management funds into sagebrush conservation and restoration.

- TOPICS: Fire, Climate, Restoration, Decision Support Tool

- ADAPTIVE MANAGEMENT APPLICATIONS: Biological Planning, Conservation Design, Monitoring
- PROJECT WEBSITE: <https://www.usgs.gov/centers/fort-collins-science-center/science/predicting-recovery-sagebrush-ecosystems-across-sage>

PROPOSED DELIVERABLES:

- Co-produced recovery and trend scenarios (spatial product).
- Data release for spatial products predicting trends in land health indicators for any pixel given disturbance and different restoration actions.
- Integration of deliverables in the Land Treatment Exploration Tool.

BIOME-WIDE VEGETATION CHANGE MONITORING AND WARNING SYSTEM

Cameron Aldridge (USGS-FORT), Adrian Monroe (USGS-FORT), Matthew Rigge (USGS-EROS), Bryan Tarbox (USGS-FORT), Michael O'Donnell (USGS-FORT), Morgan Roche (USGS-FORT), Erica Christensen (USGS-FORT), Beth Orning (USGS-FORT), Richard Inman (USGS-FORT), and Lief Wiechman (USGS-LMRP)

ABSTRACT: Understanding where and when ecosystems are undergoing changes that could result in detrimental consequences to system function is paramount to implementing successful management that helps resist transitions to less desired states. Monitoring changes in vegetation components such as canopy cover of shrubs and annual grasses is central to assessing changes in ecological function. Similarly, knowing where vegetation components are stable can help target limited conservation resources more efficiently, be it for restoration, enhancing conservation effectiveness, or to more effectively implement management efforts that resist ecological transformation. Such management is critically needed within sagebrush ecosystems, which have been drastically reduced and face continuing degradation by a multitude of well-described threats. Thus, developing a biome-wide vegetation change monitoring and warning system that tracks changes in functioning sagebrush ecosystem components measured through vegetation cover, and provides warnings when deviations may have initiated could help with conservation and management. This would provide land and wildlife managers with a unique tracking system to assess mechanisms driving changes in ecosystem function measured through vegetation responses that can directly inform where and when system components may meet or fail to support certain thresholds to maintain system resiliency or support key plant species and wildlife species of conservation concern (e.g., sage-grouse, mule deer, pygmy rabbit, Brewer's Sparrow). This tracking system would evaluate changes from management and conservation efforts at multiple spatiotemporal scales, as necessary, to effectively 'Defend and Grow the Core' and help inform changes in the Sagebrush Conservation Design (SCD) and the Sagebrush Ecological Integrity classes. We will discuss the data, models and approach to develop this Biome-wide Vegetation Change Monitoring and Warning System.

- TOPICS: Vegetation change, monitoring, warning system, restoration recovery
- ADAPTIVE MANAGEMENT APPLICATION: Tool to identify changes in ecosystem function through tracking changes in vegetation components, to allow for early intervention and appropriation management and restoration actions.
- PROJECT WEBSITE: [Shrubland Alpine & Grassland Ecology \(SAGE\) Wildlife Research Group | U.S. Geological Survey](#)
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PROPOSED DELIVERABLES:

- Models describing changes in vegetation components and factors affecting change
- Maps of stable vegetation conditions that exist based on various individual and complementary vegetation components
- Maps showing when vegetation components are deviating from trends in surrounding landscapes (Warnings)
- Models assessing vegetation recovery across disturbance sites, including factors affecting the effectiveness of recovery to desired conditions
- Maps predicting success of recovery, given certain types of disturbances, and management actions to restore and recover vegetation components
- Tech transfer workshops on how to use products and tools for decision making, across scales, including web-based tool use and applications
- Project webpage and minimum standard deliverables (Logistics Tracker, Briefing Memo, and Annual Report)
- Manuscript(s) submitted to peer-reviewed scientific journals characterizing results from the development of the vegetation tracking system
- A web interface of the products, to be updated annually, tracking trends and warnings in real-time

COMPLETED DELIVERABLES/PRODUCTS:

- Various manuscript and products from above presentation that are foundational components of the Biome-wide Vegetation Change Monitoring and Warning System.

VECTORS OF ANNUAL GRASS INVASION

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

ABSTRACT: In sagebrush ecosystems, disturbances have contributed to invasive annual grass spread and have led to ecosystem management challenges. We lack a clear understanding of which kinds of non-fire disturbances generally act as vectors of annual grass invasion, and which have the greatest and geographically consistent ability to facilitate the invasion of annual grasses. The relative influence of each vector at a given site or region could vary based on the type of vector, area affected by each vector, invasion intensity, propagule pressure, resistance and resilience, burn and treatment history, and environmental characteristics. Given this complexity, there is a need to develop methods for identifying which vectors are most important to manage in different ecological contexts. We are working to determine a) if particular features, actions, or processes are acting as vectors of invasion, b) then assess the relative influence of suspected vectors of annual grass invasion. Potential vectors will include wildfire, fuel breaks, grazing allotments, wild horse and burrow HMAs, roads, oil and gas infrastructure, mines, and fuel and land treatments including herbicide applications, conifer removal, and reseeded. If possible, we will include trail use by human and small-vehicle (OHV) traffic. We will develop metrics to quantify vector impact (e.g., proximity to vector, area and rate of change in invasive cover), and statistical analyses to assess vector-invasion association and influence. To do so, we will use detailed

invasive annual grass data (e.g., AIM, RCMAP, RAP, local invasive annual grass data), along with vector data (e.g., dated roads, mapped energy developments, fuel breaks databases, LTDL) in two focal regions: the heavily invaded Northern Great Basin and lesser invaded Wyoming as contrasting invasion and ecological contexts. To identify and assess the contribution of vectors, we will first establish the time of infestation (i.e., invasive annual grass percent cover above a threshold) and analyze landscape metrics to express how the infestation changed through time (e.g., area, proximity to vectors, change in cover), with corresponding changes in vectors. We will then assess the metrics and statistical evidence (i.e., coefficients or similar) to indicate whether a disturbance is serving as a vector of invasion, and the relative influence of each vector. We will compare the results among the two focal landscapes to evaluate the consistency of vectors and vector-strengths among places with different invasion intensities and vector profiles (types and densities of vectors).

- TOPICS: Invasive species, Disturbance, Vectors
- ADAPTIVE MANAGEMENT APPLICATION: Biological Planning, Conservation Design, Disturbance Management
- PROJECT WEBSITE: [Evaluating potential vectors of annual grass invasion | U.S. Geological Survey](#)

PROPOSED DELIVERABLES:

- Peer reviewed manuscript
- Vector-threat map
- Infographic describing relative influence of each vector
- Data release
 - o Estimated rates of spread from vectors
 - o Maps across spatial planning units (e.g. sagebrush conservation design categories, ecoregions, priority restoration areas)

PREDICTING REBURN RISK TO RESTORATION INVESTMENTS

Cara Applestein (USGS-FRESC), Jake Price (USGS-FRESC), Matt Germino (USGS-FRESC)

ABSTRACT: Land management treatments in sagebrush steppe are an important opportunity to break the annual-grass fire cycle, provided they offer long-lasting resistance to annual-grass invasion and do not burn. However, for BLM areas seeded as part of the Emergency Stabilization and Rehabilitation (ESR) program, one of the largest programs for land management treatments, about 1/4 have at least partially reburned over the last 30 years, according to a recent study. Reburning of treatments can cause a loss of investment if fire-intolerant perennials do not recover and/or significant invasions occur, in which case the risks of wildfire are compounded by increased potential for ecological degradation. Information is needed on predicting future risks related to reburning – including post-fire hazards related to ecological degradation – for past land management investments to a) identify protection measures that could be applied now (i.e., with BiL or IRA funds), and b) help design and positioning of future treatment investments to minimize their risk of reburning in ways that cause ecological degradation. We will continue to determine how herbicide and seeding treatments (conducted after fire) affect reburning hazards and provide guidance on how reburning hazards of existing or planned treatment investments can be minimized. We will ask how treatments affect the probability of



reburning using FLAMMAP simulations, specifically as a function of treatment success and contagion to areas of high wildfire risk, and modeled fire intensity (kW/m): collectively burn hazard.

- TOPICS: Fire, Invasives, Restoration, Decision support
- ADAPTIVE MANAGEMENT APPLICATION: Biological planning, fire mitigation planning
- PROJECT WEBSITE: [Predicting Burn Risk to Land Management Investments | U.S. Geological Survey](#)

PROPOSED DELIVERABLES:

- Fuel maps of three landscapes that were burned, treated, and then experienced reburning (Amazon 2006/Snowstorm 2017, Soda 2015/Jump 2024, and Bear Den 2007/Laidlaw Butte 2016) - FY25, Q2
- Peer-reviewed technical note on methodology for relating field-based cover to FBFM type for different monitoring methods – Expected submit FY25, Q3
- Peer-reviewed paper on the effect of post-fire treatments on the reburn risk 10 years after fire. (w/ data release) - Expected submit FY25, Q4

COMPLETED DELIVERABLES/PRODUCTS:

- Fuel maps for Craters of the Moon in 2022-2024