



**USGS LAND MANAGEMENT RESEARCH PROGRAM**  
**SAGEBUSH & FIRE SCIENCE WEBINAR SERIES**  
**SESSION #5 – March 6, 2025**

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**RCMAP VEG TRENDS AND UPDATES**

- *Matthew Rigge (USGS-EROS)*

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**INTEGRATING CLIMATE, SAGEBRUSH HABITAT AND R&R**

- *John Bradford (USGS-NWCASC), Daniel Schlaepfer (NAU, USGS-SBSC,), Martin Holdrege (ORISE, USGS-NWCASC)*

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**INFLUENCE OF FUTURE CLIMATE SCENARIOS ON HABITAT AND POPULATION DYNAMICS OF GREATER SAGE-GROUSE**

- *Pete Coates, (USGS-WERC), John Bradford (USGS-SBSC)*

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**UNDERSTANDING AND FORECASTING ENVIRONMENTAL CONTROLS OVER PLANT ESTABLISHMENT IN SAGEBRUSH ECOSYSTEMS TO ENHANCE RESTORATION SUCCESS**

- *John Bradford (USGS-SBSC), Alice Stears (USGS-SBSC), Gregor-Fausto Siegmund (USGS-SBSC)*

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**TREATMENT AND POST-FIRE ASSESSMENT TOOLS FOR MANAGEMENT OF THE SAGEBRUSH ECOSYSTEM**

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**SCIENCE TO SUPPORT ELK MANAGEMENT EFFORTS TO REDUCE CWD RISK**

- *Tabitha Graves (USGS-NOROCK), William Janousek (USGS-NOROCK)*

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## RCMAP VEG TRENDS AND UPDATES

**Matthew Rigge (USGS-EROS)**

**ABSTRACT:** A long-term perspective is key to understanding vegetation response to drought, invasive species, land management decisions, and disturbance. Rangeland Condition Monitoring Assessment and Projection (RCMAP) time-series data enable retrospective analysis of vegetation condition, impacts of weather variation, and understanding of vegetation treatment and altered management practice effectiveness. RCMAP provides robust, long-term, and floristically detailed maps of vegetation cover across western North America using Landsat imagery and machine learning from 1985-2024 at yearly time-steps. In the most recent version, the RCMAP product suite consists of ten fractional components: annual herbaceous, bare ground, herbaceous, litter, non-sagebrush shrub, perennial herbaceous, sagebrush (*Artemisia* spp.), shrub, tree, and shrub height in addition to the temporal trends of each component. Land managers and scientists can use annual fractional cover maps to monitor changes to vegetation composition, evaluate past management practices, target future improvements, determine locations of critical wildlife habitat, assess effects of climate change and interannual variation, appraise landscape, and fragmentation. RCMAP data have been used in many wildlife applications and are being incorporated in the LTET.

- TOPICS: Remote Sensing, Monitoring
- ADAPTIVE MANAGEMENT APPLICATION: Biol. Planning, Conservation Design, Monitoring, Evaluation
- PROJECT WEBSITE: <https://www.mrlc.gov/> and [Rangeland Condition Monitoring, Assessment, and Projection \(RCMAP\) | U.S. Geological Survey](#)

### PROPOSED DELIVERABLES:

- Time-series fractional cover for ten components (FY25-Q2).
- Time-series component cover trends statistics (FY25-Q2).
- Investigation into trends leading up to and following sagebrush mortality events in WY (FY25-Q4).
- Report on error impacts of scaling vegetation data (FY25-Q2).

### COMPLETED DELIVERABLES/PRODUCTS:

- Rigge, M.B., Bunde, B., Postma, K., and Shi, H., 2024, Rangeland Condition Monitoring Assessment and Projection (RCMAP) fractional component time-series across western North America from 1985-2023: U.S. Geological Survey data release, at <https://doi.org/10.5066/P9SJXU1>.
- Rigge, M.B., Bunde, B., McCord, S.E., Harrison, G., Assal, T.J., and Smith, J.L., 2025, Spatial scale dependence of error in fractional component cover maps: Rangeland Ecology & Management, v. 99, p. 77–87, at <https://doi.org/10.1016/j.rama.2025.01.004>.
- Rigge, M.B., Bunde, B., Postma, K., Shi, H., 2022, Rangeland Condition Monitoring Assessment and Projection (RCMAP) Fractional Component Time-Series Across the Western U.S. 1985-2021: U.S. Geological Survey data release, <https://doi.org/10.5066/P9ODAZHC>.
- Rigge, M.B., Postma, K., and Bunde, B., 2024, Projections of rangeland fractional component cover across western Northern American rangelands for representative concentration pathways

(RCP) 4.5 and 8.5 scenarios for the 2020s, 2050s, and 2080s time-periods: U.S. Geological Survey data release, at <https://doi.org/10.5066/P134RA6V>.

- Rigge, M., Case, Madelon, Shaff, S. Ellworth, L., Bunde, B., and Postma, K. In Review. Correspondence between satellite-derived and long-term field observations of vegetation cover at Great Basin experimental treatments. Submitted to *Rangeland Ecology and Management*.
- Rigge, M., Bunde, B., Postma, K., Oliver, S. and Mueller, N., 2024. Application of normalized radar backscatter and hyperspectral data to augment rangeland vegetation fractional classification. *Remote Sensing*, 16(13), p.2315.

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## **ASSESSING THE FUTURE CORE SAGEBRUSH AREAS: IMPACTS OF CLIMATE & CLIMATE UNCERTAINTY, WILDFIRE AND INVASIVE SPECIES**

*John Bradford (USGS-SBSC), Daniel Schlaepfer (USGS-SBSC), Martin Holdrege (USGS-SBSC), Kyle Palmquist (Marshall University), William Lauenroth (Yale University), Kevin Doherty (USFWS), Tom Remington (WAFWA)*

**ABSTRACT:** A recent sagebrush conservation design effort (Doherty et al. 2020) identified geographic patterns in high quality core habitats across the biome. Results from this initial effort incorporated a single scenario from our results representing a conservative estimate of potential climate change impacts. However, our broader set of results (which include climate-driven shifts in wildfire probability, multiple climate models and RCPs, and longer time horizons) are likely to indicate more dramatic impacts of climate change interactions with these other factors. This project will examine how this much broader array of potential future scenarios will influence the abundance and distribution of sagebrush core habitat areas, both at the biome-wide scale and within specific focal, high value smaller landscapes. We will address two questions:

- 1) How will biome-wide patterns of sagebrush core habitat areas be altered in coming decades by the combination of climate change, invasive annual grasses, and wildfires?
- 2) How robust are projected 21st century changes in potential sagebrush core habitat areas to uncertainty in future climate conditions represented by climate models and representative concentration pathways?

Our results will inform conservation and restoration decisions and prioritization and help prevent further degradation of existing intact habitats and maximize the long-term effectiveness of land treatment investments.

- TOPICS: Fire, Invasives, Restoration, Decision Support Tool
- ADAPTIVE MANAGEMENT APPLICATION: Biological Planning, Conservation Design
- PROJECT WEBSITE: <https://sites.google.com/view/dryland-ecohydrology-team/future-big-sagebrush-habitats>

### **PROPOSED DELIVERABLES:**

- Holdrege et al. In review. Climate change promotes declines in sagebrush habitat quality
- Data releases for the above publication

### **COMPLETED DELIVERABLES/PRODUCTS:**

- Holdrege, M. C., D. R. Schlaepfer, K. A. Palmquist, M. Crist, K. E. Doherty, W. K. Lauenroth, T. E. Remington, K. Riley, K. C. Short, J. C. Tull, L. A. Wiechman, and J. B. Bradford. 2024. Wildfire

probability estimated from recent climate and fine fuels across the big sagebrush region. *Fire Ecology* 20:22.

- Holdrege, M.C., Schlaepfer, D.R., and Bradford, J.B., 2024, Observed wildfire frequency, modelled wildfire probability, climate, and fine fuels across the big sagebrush region in the western United States: U.S. Geological Survey data release, <https://doi.org/10.5066/P9EFC6YC>.
- Urza, A. K., D. I. Board, J. B. Bradford, J. L. Brown, J. C. Chambers, D. R. Schlaepfer, and K. C. Short. 2024. Disentangling drivers of annual grass invasion: Abiotic susceptibility vs. fire-induced conversion to cheatgrass dominance in the sagebrush biome. *Biological Conservation* 297:110737.
- Boyd, C. S., M. K. Creutzburg, A. V. Kumar, J. T. Smith, K. E. Doherty, B. A. Meador, J. B. Bradford, M. Cahill, S. M. Copeland, C. A. Duquette, L. Garner, M. C. Holdrege, B. Sparklin, and T. B. Cross. 2024. A Strategic and Science-Based Framework for Management of Invasive Annual Grasses in the Sagebrush Biome. *Rangeland Ecology & Management* 97:61-72.

#### DATA RELEASES

- Holdrege, M.C., Schlaepfer, D.R., Palmquist, K.A., Theobald, D.M., and Bradford, J.B., 2024, Current and projected sagebrush ecological integrity across the Western U.S., 2017-2100: U.S. Geological Survey data release, <https://doi.org/10.5066/P13RXYZI>
- Holdrege, M.C., Schlaepfer, D.R., and Bradford, J.B., 2024, Observed wildfire frequency, modeled wildfire probability, climate, and fine fuels across the big sagebrush region in the western United States: U.S. Geological Survey data release, <https://doi.org/10.5066/P9EFC6YC>
- Doherty, K., Theobald, D.M., Holdrege, M.C., Wiechman, L.A., and Bradford, J.B., 2022, Biome-wide sagebrush core habitat and growth areas estimated from a threat-based conservation design: U.S. Geological Survey data release, <https://doi.org/10.5066/P94Y5CDV>

#### PRESENTATIONS

- Holdrege, M. C, Schlaepfer, D. A, and Bradford, J. B. Identifying and assessing sources of uncertainty in climate change effects on big sagebrush plant communities. Society for Range Management 2025 Annual Meeting. Spokane, WA. February 11, 2025.
- Holdrege, M. C, Schlaepfer, D. A, Palmquist, K. A., Lauenroth, W. K., Boyd, C. S., Creutzburg, M. K., Crist, M. R., Doherty, K. E., Remington, T. E., Tull, J. C., Wiechman, L. A., and Bradford, J. B. Climate change amplifies losses of sagebrush ecological integrity. U.S Fish and Wildlife Service Sagebrush climate training. Boise, ID. May 21, 2024. [Link to slides](#), [Link to recording](#)
- Holdrege, M. C, and Bradford, J. B. Climate change impacts on sagebrush ecosystems. U.S Fish and Wildlife Service virtual classroom. March 20, 2024. [Link to recording](#)
- Holdrege, M. C, Schlaepfer, D. A, Palmquist, K. A., Lauenroth, W. K., Boyd, C. S., Creutzburg, M. K., Crist, M. R., Doherty, K. E., Remington, T. E., Tull, J. C., Wiechman, L. A., Bradford, J. B. Assessing the future of core sagebrush areas: impacts of climate & climate uncertainty, wildfire and invasive species. USGS Sagebrush and Fire Research Information Transfer Webinar. February 29, 2024.
- Holdrege, M. C, Schlaepfer, D. A, Palmquist, K. A., Lauenroth, W. K., Boyd, C. S., Creutzburg, M. K., Crist, M. R., Doherty, K. E., Remington, T. E., Tull, J. C., Wiechman, L. A., and Bradford, J. B. Climate change promotes declines in sagebrush habitat quality. Society for Range Management 2024 Annual Meeting. Sparks, NV. January 31, 2024.

- Holdrege, M.C., Lauenroth, W.K., Doherty, K.E., Palmquist, K.A., Schlaepfer D.R., and Bradford J.B. How will climate change alter the extent of core sagebrush areas? Ecological Society of America 2023 Annual Meeting. Portland, OR. August 9, 2023.
- Holdrege, M.C., K.A. Palmquist, M. England, R.R. Renne, D.R. Schlaepfer, K.E. Doherty, T.E. Remington, W.K. Lauenroth, and J.B. Bradford. Grazing management may moderate the effects of climate change on big sagebrush plant communities. 16th Biennial Conference of Science & Management for the Colorado Plateau & Southwest Region. Flagstaff, AZ. September 12, 2022

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## INFLUENCE OF FUTURE CLIMATE SCENARIOS ON HABITAT AND POPULATION DYNAMICS OF GREATER SAGE-GROUSE

*Pete Coates (USGS-WERC), John Bradford (USGS-NW CASC), Shawn O'Neil (USGS-WERC), Carl Lundblad (USGS-WERC), Cameron Aldridge (USGS-FORT), John Tull (USFWS)*

**ABSTRACT:** Under climate change, sagebrush ecosystems and sagebrush-dependent wildlife species such as greater sage-grouse (*Centrocercus urophasianus*) are likely to become increasingly subject to extreme drought and temperature conditions that may determine long-term availability of forage resources across seasons and life stages. Sage-grouse populations are experiencing long-term declines, however the direct and indirect effects that climate change may have on sage-grouse populations are not well-understood. USGS will evaluate the impacts on sage-grouse population dynamics from projected changes in precipitation, drought, and habitat availability. Future drought and disturbance events may occur more frequently based on climate model projections. Drought and disturbance interactions may reduce habitat suitability and prevent sage-grouse from recovering to their pre-drought abundance, possibly contributing to extirpation of vulnerable populations. USGS is using hierarchical population and vital rate (nest, brood, and adult survival) models to explore the influences of drought, precipitation, and temperature on sage-grouse, dating back to 1985 across 4 western states (CA, ID, OR, NV). USGS will then extend the population trend analyses range-wide and use those estimated relationships to identify spatially explicit long-term projections of future sage-grouse population trajectories based on future climate change scenarios identified by the Intergovernmental Panel on Climate Change and current general circulation models.

- TOPICS: Climate, Fire, Greater Sage-Grouse, Invasives, Restoration, Wildlife
- ADAPTIVE MANAGEMENT APPLICATION: Monitoring, Evaluation, Biol. Planning, Conservation Design
- PROJECT WEBSITE: <https://www.usgs.gov/centers/werc/science/influence-future-climate-scenarios-habitat-and-population-dynamics-greater>

### PROPOSED DELIVERABLES:

- Comprehensive review paper describing current knowledge of sage-grouse responses to climatic factors (in review/revision FY25)
  - o Lundblad, C. G., S. T. O'Neil, B. E. Brussee, P. S. Coates, J. B. Bradford, G. Wann, C. L. Aldridge, and J. C. Tull. In revision, 2025. Sensitivities of sage-grouse to weather and climate: Implications for management of an indicator species in a moisture-limited ecosystem. In revision with Wildlife Monographs. IP-158437

- Peer-reviewed scientific manuscript describing sage-grouse demographic and population responses to climate factors, including precipitation and drought, in the Great Basin (in review, FY25)
  - o O'Neil, S. T., C. G. Lundblad, B. E. Brussee, J. C. Tull, M. L. Casazza, J. Small, C.L. Aldridge, and P. S. Coates. In review, 2025. Precipitation timing mediates life-stage and population-level associations with changing climate for an indicator species. Scientific Reports. IP-171093
- Draft peer reviewed scientific manuscript on sage-grouse population projections under future climate change scenarios (FY25)
- Selected non-sensitive data and spatially explicit mapping products, published via USGS ScienceBase data release, supporting the work presented in manuscript -- sage-grouse population projections under future climate change scenarios (FY25)
- Model code and/or software, published via USGS software release in GitLab, supporting the work presented in manuscripts (contingent on completion of project manuscripts)
  - o O'Neil, S. T., B. E. Brussee, C. G. Lundblad, and P. S. Coates. In review, 2025. Hierarchical models evaluating precipitation and drought effects on Greater sage-grouse (*Centrocercus urophasianus*) in the Great Basin, USA. 1.0.0 U.S. Geological Survey software release.
  - o Coates, P. S., S. T. O'Neil, C. G. Lundblad, B. E. Brussee, and M. P. Chenaille. 2025. Greater sage-grouse survival encounter histories and counts in association with precipitation, temperature, and drought in the Great Basin, USA. USGS Data Release. IP-172801.

#### COMPLETED DELIVERABLES/PRODUCTS:

- O'Neil, S. T., C.G. Lundblad, J.C. Tull, J.B. Bradford, D.R. Schlaepfer, B.E. Brussee, G.T. Wann, C.L. Aldridge, L.A. Wiechman, and P.S. Coates. 2025. Greater sage-grouse and climate change: Retrospective analysis informs plausible outcomes under future climates. Invited presentation, Society for Rangeland Management 2025 annual conference, Spokane, WA
- Tull, J.C., O'Neil, S. T., C.G. Lundblad, J.B. Bradford, D.R. Schlaepfer, B.E. Brussee, G.T. Wann, C.L. Aldridge, L.A. Wiechman, and P.S. Coates. 2025. Bridging science and management to incorporate climate change uncertainty in greater sage-grouse conservation. Invited presentation, Society for Rangeland Management 2025 annual conference, Spokane, WA
- Lundblad, C.G., S.T. O'Neil, B.E. Brussee, J.B. Bradford, G.T. Wann, J.C. Tull, M. Casazza, C.L. Aldridge, and P.S. Coates. 2024. Sage-grouse and climate change: synthesis, analysis, and adaptation. Invited presentation, American Ornithological Society annual conference, Estes Park, CO
- Lundblad, C.G., S.T. O'Neil, B.E. Brussee, J.B. Bradford, G.T. Wann, J.C. Tull, M. Casazza, C.L. Aldridge, and P.S. Coates. 2024. Sage-grouse responses to weather and climate depend on precipitation timing and life stage. Presentation to the Western Association of Fish and Wildlife Agencies 34th biennial meeting, Wenatchee, Washington
- Lundblad, C.L., P.S. Coates, S.T. O'Neil, B.E. Brussee, and J.C. Tull. 2024. *A Review and Synthesis of the Effects of Climate on Sage-Grouse, an Indicator Species of Sagebrush Ecosystem Health*. Presentation to the Society for Rangeland Management 2024 annual conference in Sparks, Nevada
- O'Neil, S.T., P.S. Coates, C.G. Lundblad, B.E. Brussee, and J.C. Tull. 2024. *A retrospective analysis of Greater sage-grouse population and survival response to precipitation and drought across 5*

*western states, 1985–2022.* Presentation to the Society for Rangeland Management 2024 annual conference in Sparks, Nevada

- Lundblad, C.G., P.S. Coates, S.T. O’Neil, B.E. Brussee, and J.C. Tull. 2024. *Maximizing sage-grouse performance and persistence in a semiarid ecosystem threatened by climate change.* Invited presentation to the Society for Rangeland Management 2024 annual conference in Sparks, Nevada
- Lundblad, C.G., P.S. Coates, S.T. O’Neil, B.E. Brussee, and J.C. Tull. 2024. *Implications of climate change for sage-grouse and the future of western sagebrush ecosystems.* Presentation to The Wildlife Society Western Section’s 2024 annual conference in Sonoma County, California.

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## UNDERSTANDING AND FORECASTING ENVIRONMENTAL CONTROLS OVER PLANT ESTABLISHMENT IN SAGEBRUSH ECOSYSTEMS TO ENHANCE RESTORATION SUCCESS

*John Bradford (USGS-NWCASCS & SBSC), Gregor Siegmund (USGS-SBSC), Alice Stears (USGS-SBSC), Daniel Schlaepfer (USGS-SBSC), Leland Bennion (Boise State Univ.), Allison Simler-Williamson (Boise State Univ), David Pilliod (USGS FRESC), Michelle Jeffries (USGS FRESC)*

**ABSTRACT:** In the western US, federal agencies manage millions of acres of drylands that experience frequent disturbance from fire, land use, and environmental change. Active restoration practices, such as direct seeding, are frequently used by land managers, and require support for and investment in the personnel and infrastructure needed for seed sourcing, production, and field seedings. But plant regeneration from seed remains a major bottleneck in reestablishing dryland plant communities from seed because rates of success are highly variable and may include complete failure. Resilience of dryland ecosystems can be enhanced by 1) targeting restoration treatments toward places and times when conditions are likely to support plant establishment, and 2) ensuring that the species and seed sources utilized will be viable under future climate and drought conditions. This work seeks to improve restoration outcomes by addressing both of those challenges. For a range of important restoration species, we will build functionality into the Land Treatment Exploration Tool (LTET) that both forecasts seed establishment success in coming years and depicts how long-term 21<sup>st</sup> century climate change will alter establishment and overall viability.

- TOPIC: Fire, Invasives, Climate, Restoration
- ADAPTIVE MANAGEMENT APPLICATION: Biol. Planning, Cons. Design, Monitoring, Evaluation
- PROJECT WEBSITE: <https://sites.google.com/view/dryland-ecohydrology-team/forecasting-dryland-restoration-success>

### PROPOSED DELIVERABLES:

- Publications and datasets assessing state of knowledge about plant establishment requirements, and information about how climate change will alter overall ecological resilience in drylands.

### COMPLETED DELIVERABLES/PRODUCTS:

#### Publications:

- Supporting dryland restoration success with applied ecological forecasting of seeding outcomes. *in review* at *Frontiers in Ecology and the Environment*

- Perennial grass recruitment dynamics inferred from post-fire restoration seeding. *in prep* for submission in Spring 2025
- Larson, J.E., Agneray, A.C., Boyd, C.S., Bradford, J.B., Kildisheva, O.A., Suding, K.N., and Copeland, S.M., 2023, A recruitment niche framework for improving seed-based restoration: Restoration Ecology, e13959,

#### Data releases:

- Perennial grass occurrence after post-fire seeding treatments across the sagebrush biome (1984-2020). *in prep* for release
- Schlaepfer, D.S. and Bradford, J.B. In Review. Projected indicators of dryland resistance and resilience for rangelands in the Sagebrush Biome for the 21st century. U.S. Geological Survey Data Release.
- Schlaepfer, D.S. and Bradford, J.B. In review. Ecologically relevant annual (1980-2021) moisture and temperature metrics for rangelands in the Sagebrush Biome. U.S. Geological Survey Data Release.

#### Presentations:

- Bradford et al. 2023. Climate-smart indicators of sagebrush resistance and resilience for the 21st century. Society for Rangeland Management Annual Meeting. Feb 13-16, Boise, Idaho
- Siegmund, G.S., Schlaepfer, D.R., Bennion, L., Jeffries, M., Stears, A., Simler-Williamson, A., Pilliod, D., and Bradford, J.B. 2024. Perennial plant recruitment dynamics inferred from post-fire restoration seeding. Ecological Society of America Annual Meeting, Long Beach CA. (August 2024).
- Siegmund, G.S., Schlaepfer, D.R., ...and Bradford, J.B. 2024. Synthesizing knowledge about the environmental drivers of plant regeneration to support restoration seeding. Society for Rangeland Management Annual meeting, Reno, NV (February 2024)
- Siegmund, G., Schlaepfer, D.R., Pilliod, D., Simler-Williamson, A.B., Jeffries, M., and J.B. Bradford. 2023. Environmental controls on plant regeneration in drylands: Synthesizing data and models to support restoration seeding. Ecological Society of America Annual Meeting. August 2023, Portland Oregon.

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## TREATMENT AND POST-FIRE ASSESSMENT TOOLS FOR MANAGEMENT OF THE SAGEBRUSH ECOSYSTEM

*Mike Duniway (USGS-SBSC), Gayle Tyree (USGS-SBSC)*

**ABSTRACT:** The sagebrush ecosystems and habitats have been dramatically impacted by the wildfire-cheatgrass cycle, land-use, and drought, with climate change expected to exacerbate these trends. New funding for conservation and restoration from congress (BIL and IRA) as well as initiatives from the White House provide an unprecedented opportunity for landscape-scale restoration and conservation actions in the sagebrush biome. While there is significant data and literature on sagebrush ecosystems and habitats, improved and timely information is still needed regarding effectiveness of past and ongoing restoration or rehabilitation efforts to inform adaptive management. We are using recently developed assessment tools, remotely sensed fractional cover products, and predictive soil maps to inform sagebrush biome decision processes, with a focus on restoration and rehabilitation. The Disturbance Automated Reference Tool (DART) was initially developed to assess reclamation outcomes following oil and gas development and has subsequently been applied to evaluate woody encroachment

treatments and removal of livestock from grazing allotments. This work includes updating the tool coding and data for the sagebrush biome, expanding underlying covariates for CONUS application, and apply updated DART to sagebrush conservation and restoration actions. In addition, we are developing a DART web application (separately funded).

- TOPICS: Web App, Fire, Restoration, Grazing, Decision Support Tool
- ADAPTIVE MANAGEMENT APPLICATION: Monitoring, Evaluation
- PROJECT WEBSITE: <https://www.usgs.gov/centers/southwest-biological-science-center/science/new-tools-modern-land-management-decisions>

#### PROPOSED DELIVERABLES:

- Manuscripts:
  - o #1 - Manuscript analyzing reclamation or rehabilitation outcomes in the sagebrush biome in the Great Divide-Upper Green watershed. FY2024 Q4
  - o #2 – Assessment of livestock removal from Hart Mountain and Sheldon USFWS refuges manuscript (with FRESC). FY2025 Q1.
- Code and apps:
  - o ‘Soft release’ of web application for partner agencies to test and provide feedback. FY2024 Q2.
  - o Final publication of web application and accompanying code and submission of manuscript. FY2025 Q1.

#### COMPLETED DELIVERABLES/PRODUCTS:

- Fick, S. E., T. W. Nauman, C. C. Brungard, and M. C. Duniway. 2021. Evaluating natural experiments in ecology: using synthetic controls in assessments of remotely sensed land-treatments. *Ecological Applications* 31:e2264. <https://doi.org/10.1002/eap.2264>
- Fick, S. E., T. W. Nauman, C. C. Brungard, and M. C. Duniway. 2022. What determines the effectiveness of Pinyon-Juniper clearing treatments? Evidence from the remote sensing archive and counter-factual scenarios. *Forest Ecology and Management* 505:119879. <https://www.sciencedirect.com/science/article/pii/S0378112721009701>
- McNellis, B. E., A. C. Knight, T. W. Nauman, S. Chambers, C. W. Brungard, S. E. Fick, C. G. Livensperger, S. Borthwick, and M. C. Duniway. 2023. Livestock removal increases plant cover across a heterogeneous dryland landscape on the Colorado Plateau. *Environmental Research Letters*. <http://iopscience.iop.org/article/10.1088/1748-9326/acb728>
- Monroe, A. P., T. W. Nauman, C. L. Aldridge, M. S. O’Donnell, M. C. Duniway, B. S. Cade, D. J. Manier, and P. J. Anderson. 2022. Assessing vegetation recovery from energy development using a dynamic reference approach. *Ecology and Evolution* 12:e8508. <https://onlinelibrary.wiley.com/doi/abs/10.1002/ece3.8508>
- Nauman, T. W., M. C. Duniway, M. L. Villarreal, and T. B. Poitras. 2017. Disturbance automated reference toolset (DART): Assessing patterns in ecological recovery from energy development on the Colorado Plateau. *Science of The Total Environment* 584–585:476-488. <http://www.sciencedirect.com/science/article/pii/S0048969717300347>

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## SCIENCE TO SUPPORT ELK MANAGEMENT EFFORTS TO REDUCE CWD RISK

Will Janousek (USGS-NOROCK), Tabitha Graves (USGS-NOROCK)

**ABSTRACT:** In the United States, wildlife managers are entrusted with preserving populations of culturally and economically important ungulate populations in the face of the ongoing spread of chronic wasting disease (CWD). The US Fish and Wildlife Service established a 'Step-Down' adaptive management plan to reduce reliance of elk on supplemental winter feeding on the National Elk Refuge. The end goal of reducing the unnaturally high aggregation of elk during the winter is to mitigate the threat of disease outbreaks and to meet the objectives of sustainable populations of elk on the Refuge. In this case study, we evaluated six years of data from GPS-collared elk (2017-2022) to determine the efficacy of shortening the length of the annual feeding period on the Refuge to reduce elk aggregation. We measured aggregation using proximity rates, based on pairwise interactions over time, in both raw form as an index as well as predicted proximity as a function of other abiotic influences. We created a new R package, wildagg, to help with the process of computing the metrics from this study and to improve the future repeatability of this evaluation. Aggregation declined in years with less feeding on the Refuge according to raw aggregation metrics when examined in isolation and dependent on the baseline feeding year used for comparison. However, accounting for abiotic factors while modeling proximity rates suggested in some years the decision to shorten the feeding period had less influence on aggregation than predicted. These results underscore the complexity of measuring management outcomes and the usefulness of multiple approaches to evaluation.

- TOPIC: Disease, Wildlife Management, Monitoring, Decision Support Tools
- ADAPTIVE MANAGEMENT APPLICATION: Biol. Planning, Monitoring, Evaluation
- PROJECT WEBSITES:
- [USGS Chronic Wasting Disease Research at NOROCK | U.S. Geological Survey](#)
- [Predicting the effects of supplemental feeding and chronic wasting disease in Greater Yellowstone Ecosystem elk | U.S. Geological Survey](#)

### PROPOSED DELIVERABLES:

- Janousek, W.M., E.K. Cole, S.R. Dewey, and T.A. Graves. 2025. Informing adaptive management to reduce ungulate aggregations: A case study involving the feeding of elk. *Wildlife Society Bulletin, In Press.*

### COMPLETED DELIVERABLES/PRODUCTS:

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