

## INFORMATION AND TOOLS TO APPLY RESILIENCE AND RESISTANCE

Updated June 26, 2019

### Concept/Review Papers and Book Chapters

Bradford, J.A.; Schlaepfer, D.R.; Lauenroth, W.K.; Palmquist, K.A.; Chambers, J.C.; Maestas, J.D.; Campbell, S.B. 2019. **Climate-driven shifts in soil temperature and moisture regimes suggest opportunities to enhance assessments of dryland resilience and resistance.** *Frontiers in Ecology and Evolution. In press.*

Brooks, M.L.; Brown, C.S.; Chambers, J.C.; D'Antonio, C.M.; Keeley, J.E.; Belnap, J. 2016. **Exotic annual Bromus invasions: Comparisons among species and ecoregions in the western United States [Chapter 2].** In: Germino, M.J.; Chambers, J.C.; Brown, C.S., eds. *Exotic brome-grasses in arid and semiarid ecosystems of the western US: Causes, consequences, and management implications.* Springer: Series on Environmental Management. p. 11-60. <http://www.treesearch.fs.fed.us/pubs/50573>

Chambers, J.C.; Allen, C.R.; Cushman, S.A. 2019. **Operationalizing Ecological Resilience Concepts for Managing Species and Ecosystems at Risk.** *Frontiers in Ecology and Evolution* 7:241. doi: 10.3389/fevo.2019.00241

Chambers, J.C., B.A. Bradley, C.S. Brown, C. D'Antonio, M.J. Germino, J.B. Grace, S.P Hardegree, R.F. Miller, and D.A. Pyke. 2014. **Resilience to stress and disturbance, and resistance to *Bromus tectorum* L. invasion in the cold desert shrublands of western North America.** *Ecosystems* 7:360-375. doi 10.1007/s10021-013-9725-5. <https://www.treesearch.fs.fed.us/pubs/46762>

Chambers, J.C.; Brooks, M.L.; Germino, M.J.; Maestas, J.D.; Board, D.I.; Jones, M.O.; Allred, B.W. 2019. **Operationalizing resilience and resistance concepts to address invasive grass-fire cycles.** *Frontiers in Ecology and Evolution.* 7:185. doi: 10.3389/fevo.2019.00185. <https://www.fs.usda.gov/treesearch/pubs/58188>

Chambers, J.C.; Maestas, J.D.; Pyke, D.A.; Boyd, C.; Pellant, M.; Wuenschel, A. 2017. **Using Resilience and Resistance Concepts to Manage Persistent Threats to Sagebrush Ecosystems and Greater Sagegrouse.** *Rangeland Ecology and Management.* 70:149-164. <https://www.treesearch.fs.fed.us/pubs/53742>

Chambers, J.C.; Germino, M.J.; Belnap, J.; Brown, C.S.; Schupp, E.W.; St. Clair, S.B. 2016. **Plant community resistance to invasion by Bromus species: The roles of community attributes, Bromus interactions with plant communities, and Bromus traits [Chapter 10].** In: Germino, M.J.; Chambers, J.C.; Brown, C.S., eds. *Exotic brome-grasses in arid and semiarid ecosystems of the western US: Causes, consequences, and management implications.* Springer: Series on Environmental Management. p. 275-303. <http://www.treesearch.fs.fed.us/pubs/50574>

Chambers, J.C.; Miller, R.F.; Board, D. I.; Grace, J.B.; Pyke, D.A.; Roundy, B.A.; Schupp, E.W.; Tausch, R.J. . 2014. **Resilience and resistance of sagebrush ecosystems: implications for state and transition models and management treatments.** *Rangeland Ecology and Management.* 67:440–454 | September 2014 | DOI: 10.2111/REM-D-13-00074.1 <https://www.treesearch.fs.fed.us/pubs/48649>

Chambers, J.C.; Roundy, B.A.; Blank, R.R.; Meyer, S.E.; Whittaker, A. 2007. **What makes Great Basin sagebrush ecosystems invasible by *Bromus tectorum*?** Ecological Monographs 77:117-140.

Germino, M.J.; Chambers, J.C.; Brown, C.S, eds. 2016. **Exotic brome-grasses in arid and semiarid ecosystems of the western US: Causes, consequences, and management implications.** Springer: Series on Environmental Management. 439 p. [Non-Treesearch Publication - RITS Product ID: 78646](#)

Germino, M.J.; Chambers, J.C.; Brown, C.S. 2016. **Introduction: Exotic annual Bromus in the western USA [Chapter 1].** In: Germino, M.J.; Chambers, J.C.; Brown, C.S., eds. Exotic brome-grasses in arid and semiarid ecosystems of the western US: Causes, consequences, and management implications. Springer: Series on Environmental Management. p. 1-7. <http://www.treesearch.fs.fed.us/pubs/50575>

Pyke, D.A.; Chambers, J.C.; Beck, J.L.; Brooks, M.L.; Meador, B.A. 2016. **Land uses, fire, and invasion: Exotic annual Bromus and human dimensions [Chapter 11].** In: Germino, M.J.; Chambers, J.C.; Brown, C.S., eds. Exotic brome-grasses in arid and semiarid ecosystems of the western US: Causes, consequences, and management implications. Springer: Series on Environmental Management. p. 307-336. <http://www.treesearch.fs.fed.us/pubs/50577>

Ricca, M.A.; Coates, P.S.; Gustafson, K.B.; Brussee, B.E.; Chambers, J.C.; Lisius, S.; Espinosa, S.P.; Gardner, S.; Ziegler, P.; Casazza, M.L. 2018. **Using indices of species distribution, resilience, and resistance as an ecological currency for conservation planning of greater sage-grouse.** Ecological Applications. 28(4): 878–896. <https://www.fs.usda.gov/treesearch/pubs/56423>

## Management GTRs/publications

Chambers, J.C.; Beck, J.L.; Campbell, S.; Carlson, J.; Christiansen, T.J.; Clause, K.J.; Dinkins, J.B.; Doherty, K.E.; Griffin, K.A.; Havlina, D.W.; Henke, K.F.; Hennig, J.D.; Kurth, L.L.; Maestas, J.D.; Manning, M.; Mayer, K.E.; Meador, B.A.; McCarthy, C.; Perea, M.A.; Pyke, D.A. 2016. **Using resilience and resistance concepts to manage threats to sagebrush ecosystems, Gunnison sage-grouse, and greater sage-grouse in their eastern range: a strategic multi-scale approach.** Gen. Tech. Rep. RMRS-GTR-356. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 143 p. <https://www.treesearch.fs.fed.us/pubs/53201>

Chambers, J.C.; Beck, J.L.; Bradford, J.B.; Bybee, J.; Campbell, S.; Carlson, J.; Christiansen, T.J.; Clause, K.J.; Collins, G.; Crist, M.R.; Dinkins, J.B.; Doherty, K.E.; Edwards, F.; Espinosa, S.; Griffin, K.A.; Griffin, P.; Haas, J.R.; Hanser, S.E.; Havlina, D.W.; Henke, K.F.; Hennig, J.D.; Joyce, L.A.; Kilkenny, F.M.; Kulpa, S.M.; Kurth, L.L.; Maestas, J.D.; Manning, M.; Mayer, K.E.; Meador, B.A.; McCarthy, C.; Pellant, M.; Perea, M.A.; Prentice, K.L.; Pyke, D.A.; Wiechman, L.A.; Wuenschel, A. 2017. **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.** RMRS-GTR-360. Fort Collins, CO: U.S Department of Agriculture, Forest Service, Rocky Mountain Research Station. <https://www.treesearch.fs.fed.us/pubs/53983>

Crist, M.R.; Chambers, J.C.; Phillips, S.L.; Prentice, K.L.; Wiechman, L.A. eds. 2019. **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.** RMRS-GTR-389. Fort Collins, CO: U.S Department of Agriculture, Forest Service, Rocky Mountain Research Station. <https://www.fs.usda.gov/treesearch/pubs/57911>

Chambers, J.C.; Pyke, D.A.; Maestas, J.; Pellant, M.; Boyd, C.S.; Campbell, S.; Espinosa, S.; Havlina, D.; Mayer, K.; Wuenschel, A. 2014. **Using resistance and resilience concepts to reduce impacts of annual grasses and altered fire regimes on the sagebrush ecosystem and sage-grouse— A strategic multi-scale approach.** Fort Collins, CO, USA: U.S. Department of Agriculture, Forest Service, RMRS-GTR-326. <https://www.treesearch.fs.fed.us/pubs/46329>

Maestas, J.D.; Campbell, S.B.; Chambers, J.C.; Pellant, M.; Miller, R.F. 2016. **Tapping soil survey information for rapid assessment of sagebrush ecosystem resilience and resistance.** *Rangelands*. 38: 120-128. . <https://www.treesearch.fs.fed.us/pubs/52452>

## Handbooks

Pyke, D.A., Chambers, J.C., Pellant, M., Knick, S.T., Miller, R.F., Beck, J.L., Doescher, P.S., Schupp, E.W., Roundy, B.A., Brunson, M., and McIver, J.D. 2015. **Restoration handbook for sagebrush steppe ecosystems with emphasis on greater sage-grouse habitat—Part 1. Concepts for understanding and applying restoration:** U.S. Geological Survey Circular 1416, 44 p., <http://dx.doi.org/10.3133/cir1416>.

Pyke, D.A., Knick, S.T., Chambers, J.C., Pellant, M., Miller, R.F., Beck, J.L., Doescher, P.S., Schupp, E.W., Roundy, B.A., Brunson, M., and McIver, J.D. 2015. **Restoration handbook for sagebrush steppe ecosystems with emphasis on greater sage-grouse habitat—Part 2. Landscape level restoration decisions:** U.S. Geological Survey Circular 1418, 21 p., <http://dx.doi.org/10.3133/cir1418>.

Pyke, D.A.; Chambers, J.C.; Pellant, M.; Miller, R.F.; Beck, J.L.; Doescher, P.S.; Roundy, B.A.; Schupp, E.W.; Knick, S.T.; Brunson, M.; McIver, J.D. 2017. **Restoration handbook for sagebrush steppe ecosystems with emphasis on greater sage-grouse habitat—Part 3. Site level restoration decisions:** U.S. Geological Survey Circular 1426, 62 p., <https://doi.org/10.3133/cir1426>

## Field Guides and FactSheets

Miller R. F., J. C. Chambers, and M. Pellant. 2014. **A field guide to selecting the most appropriate treatments in sagebrush and pinyon-juniper ecosystems in the Great Basin: evaluating resilience to disturbance and resistance to invasive annual grasses and predicting vegetation response.** Fort Collins, CO, USA: U.S. Department of Agriculture, Forest Service, RMRS-GTR-322. <https://www.treesearch.fs.fed.us/pubs/45771> (Score sheet on page 61)

Miller R. F., J. C. Chambers, and M. Pellant. 2015. **A field guide for rapid assessment of post-wildfire recovery potential in sagebrush and pinon-juniper ecosystems in the Great Basin: Evaluating resilience to disturbance and resistance to invasive annual grasses and predicting vegetation response.** Gen. Tech. Rep. RMRS-GTR-338. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 70 p. <http://www.treesearch.fs.fed.us/pubs/49019> (Score sheet on page 63)

Chambers, J. C., ed. 2016. **Great Basin Factsheet Series 2016 - Information and tools to restore and conserve Great Basin ecosystems.** Reno, NV: Great Basin Fire Science Exchange. 79 p. <https://www.treesearch.fs.fed.us/pubs/53208>

Chambers, J.C., J.D. Maestas, and M. Pellant. 2015. **Putting Resilience and Resistance Concepts into Practice.** In Chambers, J.C. (ed). Great Basin Factsheet Series 2016 - Information and tools to restore

and conserve Great Basin ecosystems. Reno, NV: Great Basin Fire Science Exchange.  
<https://www.treesearch.fs.fed.us/pubs/53208>

Maestas, J.D., and S.B. Campbell. 2014. **Mapping Potential Ecosystem Resilience and Resistance across Sage-Grouse Range using Soil Temperature and Moisture Regimes**. Fact Sheet. Sage Grouse Initiative  
<http://www.sagegrouseinitiative.com/wp-content/uploads/2014/08/Soil-Temp-Moist-Data-Fact-Sheet.pdf>

Sage Grouse Initiative. 2015. **Wildfire and Cheatgrass: New Science Helps Reduce Threats to Sage Grouse**. Science to Solutions Series Number 5. Sage Grouse Initiative, 6pp  
<http://www.sagegrouseinitiative.com/wp-content/uploads/2013/07/Science-to-Solutions-Wildfire-and-Cheatgrass-New-Science-Helps-Reduce-Threats-to-Sage-Grouse-HIGH-RES-060815-copy.pdf>

## Assessments

USDA Forest Service. Greater Sage-grouse Fire and Invasive Assessment.  
[https://www.fs.fed.us/adaptivemanagement/projects\\_main\\_sagegrouse.php](https://www.fs.fed.us/adaptivemanagement/projects_main_sagegrouse.php)

USDI Bureau of Land Management. 2014. Greater Sage-Grouse Wildfire, Invasive Annual Grasses, and Conifer Expansion Assessment. 42 p. <https://landscape.blm.gov/geoportal/catalog/FIAT/FIAT.page>

## Tools/Data

*Science Framework data layers*. Geospatial data, maps, and models and the associated references to support the Science Framework are listed in Appendix 8 of the Science Framework (Chambers et al. 2017; GTR 360) and provided through the U.S. Geological Survey (USGS) ScienceBase (<https://www.sciencebase.gov/catalog/item/576bf69ce4b07657d1a26ea2>) and BLM Landscape Approach Data Portal (<https://landscape.blm.gov/geoportal/>). Contact Steve Hanser ([shanser@usgs.gov](mailto:shanser@usgs.gov)) for additional information on ScienceBase files and Megan Walt ([mwalz@blm.gov](mailto:mwalz@blm.gov)) or Victoria Smith-Campbell ([vsneathcampbell@blm.gov](mailto:vsneathcampbell@blm.gov)) for additional information on the Landscape Approach Data Portal.

*Conservation and Restoration Strategy Planning Tool*. An interagency team, led by the U.S. Geological Survey (USGS), is developing a web application to support implementation of the Conservation and Restoration Strategy and the WAFWA Sagebrush Conservation Strategy. This tool will increase access to data contained in the Science Framework (Chambers et al. 2017; GTR 360) and provide analytical tools to support multiple planning needs. Contact Zack Bowen ([bowenz@usgs.gov](mailto:bowenz@usgs.gov)) for additional information.

*Land Treatment Digital Library (LTDL) Planning Tool*. An interagency team, led by USGS and BLM, is developing an easy-to-use, online tool that will allow users to access historic treatment data that match the spatial or treatment characteristics of a proposed project. This tool will provide a mechanism for information sharing during the planning phase of land treatments to improve adaptive management and treatment success. Contact David Pilliod ([dpilliod@usgs.gov](mailto:dpilliod@usgs.gov)) for additional information.

*Conservation Efforts Database (CED; [conservationefforts.org](http://conservationefforts.org))*. An interagency team, led by FWS and USGS, has developed an easy-to-use, online tool that allows users to provide spatially-explicit and non-spatial information related to conservation efforts across the sagebrush biome. The CED is a highly secure, cloud-based, spatially-enabled tool that can be used to document and track conservation actions

across large, multi-jurisdictional landscapes. The CED was initially created to support the 2015 greater sage-grouse status review. The CED has been restructured to track conservation actions aimed at reducing or eliminating the impacts driving habitat loss and degradation in the sagebrush biome. The CED allows multiple-users to securely enter data (single entry or batch upload) from any location; stores supporting documents (e.g., reports, protocols) uploaded by partners; links conservation actions to one or more threats (one-to-many relationships); includes reporting functions that summarize conservation actions at multiple scales (e.g., management zones, populations, priority conservation areas); maps data to user specifications; summarizes actions at multiple scales from easements to state wildlife action plans to regional planning efforts. Contact Lief Wiechman ([lief\\_wiechman@fws.gov](mailto:lief_wiechman@fws.gov)) for information.

*Sage Grouse Initiative Web Application.* (<http://map.sagegrouseinitiative.com/>) Web tool that allows anyone to quickly and easily visualize and download certain data layers, such as:

- *Ecosystem R&R* (depicts rangewide R&R index; gridded R&R class layer and detailed soils geodatabase available for download)
- *Tree Canopy Cover* (High-resolution 1-m map of tree canopy cover across most sage grouse habitats)
- *Cultivation Risk* (Depicts suitability for cropping based on climate, soils, and topography to assess potential risk of cultivation to sage grouse habitat in the eastern range)
- *Mesic Resources* (This layer depicts the estimated extent and availability of mesic resources through time across the entire range of sage grouse. Mesic resources are defined here as sites with higher vegetative productivity during the late growing season (July 15 to September 30) relative to surrounding areas, including temporary wetlands, wet meadows, riparian areas, high-elevation sagebrush uplands, and irrigated fields.)

*Web Soil Survey R&R report function.* A tool has recently been developed through the Web Soil Survey (<http://websoilsurvey.nrcs.usda.gov/app/>) that produces a “Sagebrush Ecosystem Resilience and Resistance Soils Report” to assist with completing Score Sheets for rating R&R in Miller et al. (2014, 2015). It provides managers with relevant soil survey information on site characteristics to aid project-level assessments. Instructions for generating report are here:

[http://www.sagegrouseinitiative.com/wp-content/uploads/2013/07/WSS\\_RR\\_Report-Instructions.pdf](http://www.sagegrouseinitiative.com/wp-content/uploads/2013/07/WSS_RR_Report-Instructions.pdf)

## Videos and Webinars

*On-Demand Videos: Putting R&R Concepts into Practice.* This 1.5 hour symposium was presented at the conference Sagebrush Ecosystems Conservation: All Lands, All Hands in February 2016. Presentations help increase land managers’ awareness and understanding of how R&R applications can help them better maintain desired sagebrush communities. Presentations: Science foundation (Jeanne Chambers), Landscape scale applications (Mike Pellant), Site scale applications (Rick Miller), and Tapping soil survey (Jeremy Maestas). Videos available here: <https://www.sagegrouseinitiative.com/symposium-replay-putting-resilience-resistance-concepts-practice/>

*BLM Restoration of Sagebrush Ecosystems Course.* BLM, in partnership with GBFSE, hosts restoration training for BLM staff and partners. In 2016 Boise class, R&R concepts were incorporated throughout. Participation: Boise 2016 ~60; Reno 2017 ~30. Organized by: Mike Pellant. Instructors: Pellant, Dave Pyke, Jeff Rose, Steve Campbell, Steve Hanser, Richard Lee, Beth Newingham, and Jeremy Maestas.

*Webinar: Using Resilience and Resistance Concepts to Manage Threats to Sagebrush Ecosystems, Gunnison Sage-Grouse, and Greater Sage-Grouse.* April 29, 2016. Jeanne Chambers, Jeff Beck, Steve Campbell et al. <https://www.youtube.com/watch?v=aTDIO4NgDvg>

*Webinar:* A science framework for assessing threats to sagebrush ecosystems and greater sage-grouse and prioritizing conservation and restoration actions. Sep 26, 2016. Jeanne Chambers and Steve Hanser. <http://greatnorthernlcc.org/event/867>

*Webinar:* Rangeland Management Strategies and Tools – Promoting Resiliency and Addressing Invasive Species. Western Governors Association. Jan 12, 2017. Jeremy Maestas, Chad Boyd, Brian Mealor, Jay Kerby. <https://www.youtube.com/watch?v=aMZN142YdPQ>

*Webinars:* Society for Range Management. Feb 1, 2018. A Strategic Multi-Scale Approach for Managing Threats to Sagebrush Ecosystems Based on Resilience and Resistance Concepts. Multiple Authors. <https://www.partnersinthesage.com/blog/2018/2/9/30-videos-now-available>

*Webinar:* Management applications for the Science Framework for Conserving and Restoring Sagebrush Ecosystems. Great Basin Fire Science Exchange. Jun 26, 2019. Jeanne Chambers and Michele Crist. <https://youtu.be/2-5qCYiTDd8>