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Multidisciplinary, Multisite Evaluation of Alternative Sagebrush Steppe Restoration Treatments: The SageSTEP Project

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Key Words: cheatgrass invasion, ecological resilience, ecosystem management, environmental gradients, sagebrush restoration, woodland expansion

INTRODUCTION

This special issue presents short-term ecological effects of restoration treatments imposed as part of the Sagebrush Steppe Treatment Evaluation Project (SageSTEP), and summarizes public attitude survey results related to restoration efforts. Funded by the US Joint Fire Science Program (JFSP; 2005–2011), the Bureau of Land Management (BLM; 2011 to present), the National Interagency Fire Center (2011 to present), and the US Fish and Wildlife Service (2010), SageSTEP was designed and implemented to provide treatment-related information to managers concerned about the rapidly changing condition of sagebrush steppe ecosystems in the US Interior West (McIver et al. 2010). At lower elevations, cheatgrass has become more dominant at the expense of native perennial bunchgrasses, in some locations shifting fire return intervals from > 50–100 yr to < 20 yr, and greatly increasing mean fire size (Whisenant 1990; Miller et al. 2011; Balch et al. 2012). At higher elevations, piñon pine and juniper woodlands have expanded and displaced sagebrush and other shrubs, in some places shifting fire return intervals from 10–50 yr to >> 50 yr, and significantly increasing mean fire severity (Miller and Heyerdahl 2008).

Federal, state, and private land managers and owners have for many years attempted to arrest the conversion of sagebrush steppe communities into woodland and annual grassland and to restore native herbaceous communities by applying treatments such as prescribed fire, mowing, chaining, cutting, mastication, or herbicides. Substantial published information exists on the efficacy of such treatments in sagebrush steppe, but most studies are site-specific, short-term (Miller et al. 2013), and focused on few variables. Recognizing this, the BLM, in collaboration with the JFSP, solicited sagebrush steppe scientists and managers to design SageSTEP, a study that provides multisite, multidisciplinary, long-term information on treatment outcomes over a range of ecological conditions, and that also provides insight on cost and public acceptance of management practices. A planning grant was provided by JFSP in 2003 to design SageSTEP, and the study was ultimately funded by JFSP in 2005.

SageSTEP addresses four principle objectives, each linked to one or more of the design features of the study:

1) **Evaluate ecological effects and identify abiotic and biotic thresholds in sagebrush-steppe communities under a variety of site conditions, related to threats posed by cheatgrass invasion and piñon-juniper expansion.**

This objective was addressed by designing two experiments that evaluated response to woody vegetation removal over gradients of cheatgrass invasion and piñon-juniper expansion. The "sage-cheat" experiment included seven Wyoming Big sagebrush sites located in five states (Fig. 1), each comprising a statistical block of four 20–80 ha plots. Each plot served as either an unmanipulated control, or received a prescribed fire, mowing, or broadleaf herbicide treatment. Active treatments were applied in 2006, 2007, and 2008 (Table 1), and were intended to reduce the sagebrush overstory by about 50% in an effort to alter the competitive balance between perennial bunchgrasses and cheatgrass in the understory. Although treatments that reduce sagebrush may seem to contradict the management goal of preserving sagebrush steppe ecosystems, they may lead to more desirable vegetation states, if they stimulate native perennial herbaceous plants relative to exotic annual plants. Within each plot, between 18 and 24 subplots (0.1 ha) were established, within which we measured most response variables. The pre-emergent herbicide imazapic was applied after plot-level treatments to one-half of the subplots within each plot, in an effort to directly decrease cheatgrass cover. The "woodland" experiment examined piñon and juniper expansion at 14 higher elevation sites located in five states (Fig. 1), each comprising a statistical block of three or four 10–25 ha plots. Each plot served as either an unmanipulated control, or received a prescribed fire, clear-felling, or mastication (Utah only) treatment. Active treatments were applied in 2006, 2007, and 2008, and were intended to remove trees (all treatments) and reduced shrubs (prescribed fire only), in an effort to stimulate the shrub (mechanical treatment only) and herbaceous understory (all treatments). Within each plot, 15 measurement subplots (0.1 ha) were established, spanning a condition gradient defined by the relative pretreatment dominance of trees within each subplot. For both experiments, we measured the vegetation, soils, and butterfly communities;

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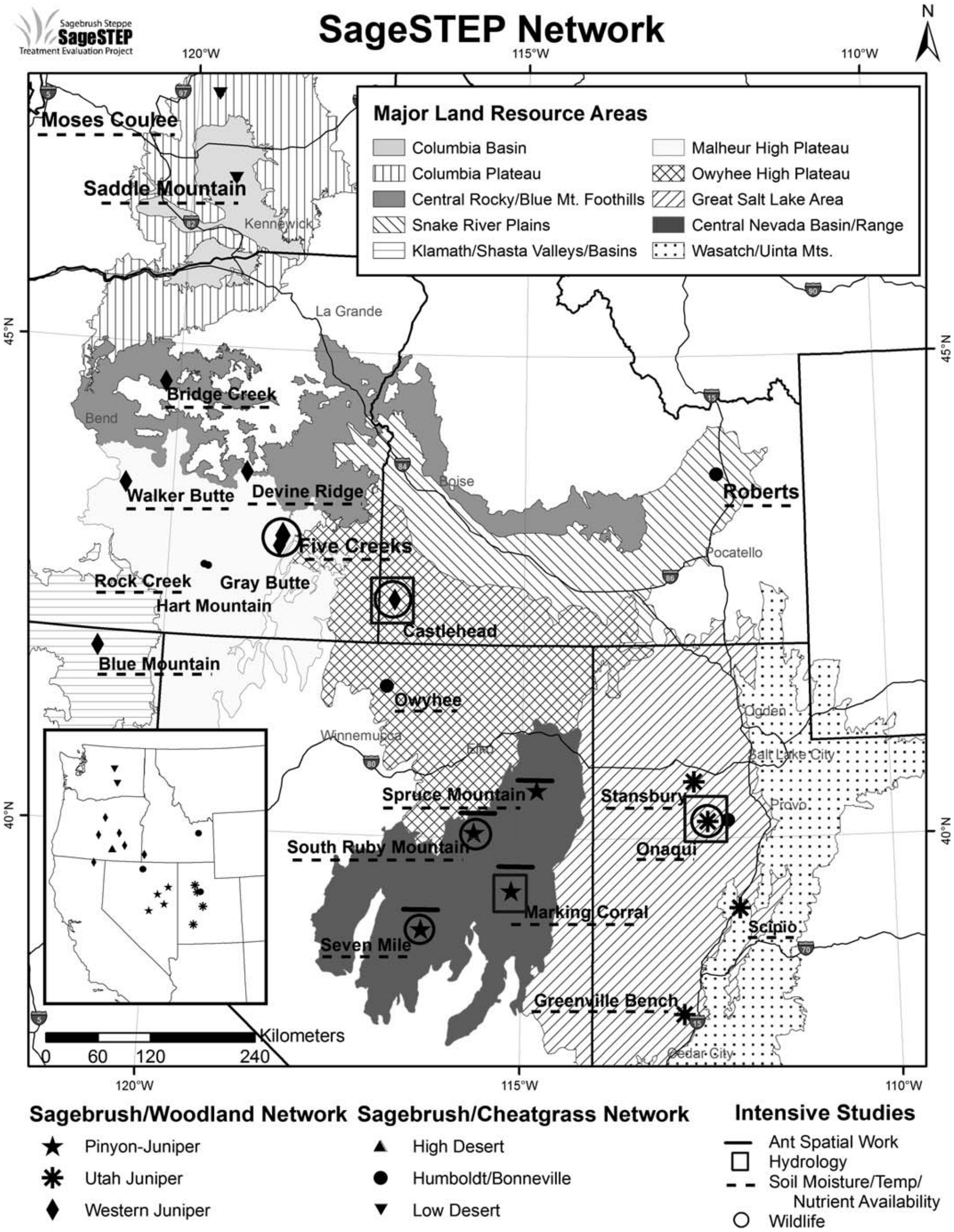

Figure 1. Location of Sagebrush Steppe Treatment Evaluation Project study sites in Great Basin and surrounding sagebrush steppe lands, within major land resource areas (Natural Resources Conservation Service).

for the woodland experiment, we also studied sagebrush-obligate bird communities and hydrological response.

2) **Document how alternative treatments altered fuel beds across the principle invasion gradients (cheatgrass invasion and piñon-juniper expansion), and for different site conditions.**

This objective was addressed by measuring live and woody fuel mass within each subplot in both experiments.

3) **Identify the principle tradeoffs among variables (desirable outcomes for some ecosystem components, undesirable for others), for both fire and fire surrogate treatments, particularly those that might be expected to influence management decisions.**

SageSTEP was designed as a multivariate study, and analysis of response to treatment for different variables measured at the same time and place allows for identification of key tradeoffs among variables.

4) **Determine the social acceptance of alternative restoration treatments in sagebrush steppe.**

Table 1. Sagebrush Steppe Treatment Evaluation Project site information, including site acronym and name, state, year treated, percent plot area burned in prescribed fire (parentheses after year), elevation, slope, aspect, current native vegetation, precipitation zone, surface soil structure, and soil temperature/moisture regime.

Site[1], State	Year treated	% Burn	Elevation (m)	% Slope	Aspect	Dominant tree/ shrub species	Current native vegetation (precipitation zone)	Surface soil structure	Soil temperature/ moisture regime
Woodland experiment (sites at which treatments targeted reduction in tree cover)									
BM: Blue Mt, CA	2007	75	1 500–1 700	5	N	Western Juniper	Mountain Big Sage, ID Fescue, Sandberg bluegrass, Bluebunch wheatgrass (12–16'')	loamy, mixed	frigid/xeric
BC: Bridge Creek, OR	2006	56	800–900	25	NW	Western Juniper	Basin Big Sage, Bluebunch wheatgrass, Sandberg bluegrass, ID fescue (9–12'')	sandy loam	mesic/aridic-xeric
DR: Devine Ridge, OR	2007	62	1 600–1 700	0–8	W	Western Juniper	Mountain Big Sage, Squirreltail, Sandberg Bluegrass, Thurber needlegrass, Idaho Fescue (12–16'')	loamy-skeletal, mixed	frigid/xeric
WB: Walker Butte, OR	2006	77	1 400–1 500	Flat	—	Western Juniper	Mountain Big Sage, Squirreltail, ID fescue, Thurber needlegrass (9–12'')	ashy, glassy	frigid/xeric
MC: Marking Corral, NV	2006	66	2 300–2 400	6–20	NW, NE, SE	piñon-Utah Juniper	Wyoming Big Sage, Thurber needlegrass (12–16'')	loamy-skeletal, mixed	cool mesic/aridic-xeric
SV: Seven Mile, NV	2007	40	2 300–2 500	6–15	NW, E, SE	piñon-Utah Juniper	Mt Mahogany/Mountain Big Sage, Bluebunch wheatgrass, muttongrass (12–16'')	loamy-skeletal, mixed	cool frigid/xeric
SR: South Ruby, NV	2008	40	2 100–2 200	8–30	All aspects	piñon-Utah Juniper	Wyoming Big Sage/Bitterbrush, Bluebunch wheatgrass, Sandberg bluegrass, Thurber needlegrass (12–16'')	loamy, mixed	cool mesic/xeric
GR: Greenville Bench, UT	2007	38	1 750–1 850	2–28	N	Utah Juniper-Colorado piñon	Wyoming Big Sage, Needle and Thread, Bluebunch wheatgrass (10–12'')	gravelly to cobbly sandy loam	warm frigid/xeric
OJ: Onaqui Mt, UT	2006	85	1 700–2 100	2–30	E	Utah Juniper-Colorado piñon	Wyoming Big Sage, Bluebunch wheatgrass (10–12'')	loamy-skeletal, carbonatic	warm mesic aridic-xeric
SC: Scipio, UT	2007	38	1 700–1 800	2–28	W	Utah Juniper-Colorado piñon	Wyoming Big Sage, Bluebunch Wheatgrass (10–12'')	loamy-skeletal, mixed	warm mesic/aridic
ST: Stansbury, UT[2]	2007	95	1 700–1 850	8–30	W	Utah Juniper-Colorado piñon	Mountain Big Sage, Antelope Bitterbrush, Bluebunch Wheatgrass (12–14'')	loamy-skeletal, mixed	cool mesic/aridic-xeric
Sage-Cheat experiment (sites at which treatments targeted reduction in shrub cover)									
OC: Onaqui Flat, UT	2006	79	1 750–1 850	3–4	E	Treeless: Wyoming Big Sage	Wyoming Big Sage/Antelope bitterbrush, Bluebunch wheatgrass, Slender wheatgrass (8–10'')	fine-loamy	mesic/xeric
OW: Owyhee, NV	2008	45	1 700–1 750	0–10	All aspects	Treeless: Wyoming Big Sage	Wyoming Big Sage, Thurber needlegrass, Bluebunch wheatgrass, Squirreltail, Sandberg bluegrass, Wildrye (8–10'')	fine-silty to fine-loamy	mesic/xeric
RO: Roberts, ID[2]	2007	8	1 550–1 600	0–10	All aspects	Treeless: Wyoming Big Sage	Wyoming Big Sage, Bluebunch wheatgrass (8–10'')	fine to coarse-loamy	frigid/xeric
GB: Gray Butte, OR	2008	50	1 450–1 600	0–10	All aspects	Treeless: Wyoming Big Sage	Wyoming Big Sage, Squirreltail, Thurber needlegrass (10–12'')	fine-loamy to loamy mixed	frigid/xeric
RC: Rock Creek, OR	2007	40	1 450–1 600	0–10	All aspects	Treeless: Wyoming Big Sage	Wyoming Big Sage, Squirreltail, Thurber needlegrass (10–12'')	fine-loamy to loamy mixed	frigid/xeric
MO: Moses Coulee, WA[3]	2008, 2009	55	515–530	0–10	S	Treeless: Wyoming Big Sage	Wyoming Big Sage, Bluebunch wheatgrass, Squirreltail, Sandberg bluegrass (10–12'')	loamy-skeletal to coarse-loamy over sandy	mesic/xeric
SM: Saddle Mt, WA	2008	65	262–286	1–5	S	Treeless: Wyoming Big Sage	Wyoming Big Sage, Bluebunch wheatgrass, Indian ricegrass, Bottlebrush squirreltail (8–10'')	coarse-silty	mesic/xeric

[1]Five Creeks and Castlehead avian sites (see Figure 1 for location) described in Knick et al. 2014; Castlehead hydrology site described in Pierson et al. 2014.
[2]Site burned by wildfire after 2007 treatments applied: Stansbury – 2009 (Big Pole Fire); Roberts – 2010 (Jefferson Fire).
[3]Moses Coulee burn treatment applied 2008, followed by mowing and herbicide treatments in 2009.

To address this objective, we conducted longitudinal surveys of Great Basin residents, regarding their acceptance of the same alternative restoration treatments applied in the SageSTEP study, and also assessed their levels of trust in management agencies to implement them.

IMPLICATIONS

This Special Issue includes 11 articles that together address many aspects of the study objectives. The issue begins with a contribution from Chambers et al., which evaluates how ecological site type influenced both resistance to invasion and resilience after treatment. Working at six Wyoming big sagebrush sites, Pyke et al. examines how fire, mowing, and imazapic treatments influenced plant communities at six of the seven lower elevation Wyoming big sagebrush sites. Miller et al. examines the influence of prescribed fire and cutting treatments on vegetation functional groups, bare ground, litter, and biological crusts, and factors in the influence of pretreatment vegetation composition and structure. Roundy et al. extend the results of Miller and Chambers to discover how different levels of tree infilling influence vegetation response. Vegetation recovery after treatment will depend in part on how surviving plants compete to capture the water and nutrient resources made available by the disturbance. Roundy et al. report how much additional water is made available by removal of woody vegetation at woodland expansion sites. Rau et al. extend the soil water work of Roundy to lower elevation sage-cheat sites, report on how treatments influence nitrogen availability, and describe the influence of soil texture on vegetation response. Hydrological work by Pierson et al. explores site-level variation in how alternative fuel reduction treatments influence runoff and erosion in the short-term. For the fauna, McIver and Macke examine butterfly response to treatment, and link response to the herbaceous vegetation. Knick et al. examine avian response at woodland sites, with a focus on the extent to which treatments influence the sagebrush-obligate bird community. While intensive, field-based studies like SageSTEP are necessary to provide reliable information on ecological response to restoration treatments, managers need less expensive assessment tools to determine when and where to apply treatments. Hulet et al. describe how remote sensing can be used to evaluate longevity of fuel treatments, and to determine the spatial distribution of horizontal fuel structure across large landscapes. Gordon et al. evaluate public acceptance of restoration treatments, and assess the extent to which the public trusts management agencies to implement them. The Special Issue concludes with a synopsis of short-term effects, which focuses on findings from the 11 preceding articles, but also includes information from other published SageSTEP work.

Finally, it is important to note that SageSTEP was designed as a long-term study. This Special Issue reports only short-term results (2–3 yr posttreatment), and while these results do provide an early indication of treatment effects, we predict that it will take at least 10 yr to understand how treatments have influenced most of the measured variables. Therefore, we plan to continue measuring plots until at least 2018, at which time 10 yr will have elapsed since treatment at all of our sites.

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LITERATURE CITED

Balch, J. K., B. A. Bradley, C. M. D'Antonio, and J. Gomez-Dans. 2012. Introduced annual grass increases regional fire activity across the arid western USA (1980–2009). *Global Change Biology* 19:173–183.

Chambers, J. C., R. F. Miller, D. I. Board, D. A. Pyke, B. A. Roundy, J. B. Grace, E. W. Schupp, and R. J. Tausch. 2014. Resilience and resistance of sagebrush ecosystem: implications for state and transition models and management treatments. *Rangeland Ecology & Management* 67:440–454.

Gordon, R., M. Brunson, and B. Shindler. 2014. Acceptance, acceptability, and trust for sagebrush restoration options in the Great Basin: a longitudinal perspective. *Rangeland Ecology & Management* 67:573–583.

Hulet, A., B. A. Roundy, S. L. Petersen, S. C. Bunting, R. R. Jensen, and D. B. Roundy. 2014. Utilizing national agriculture imagery program data to estimate tree cover and biomass of piñon and juniper woodlands. *Rangeland Ecology & Management* 67:563–572.

Knick, S. T., S. E. Hanser, and M. Leu. 2014. Ecological scale of bird community response to piñon-juniper removal. *Rangeland Ecology & Management* 67:553–562.

McIver, J. D., M. Brunson, S. Bunting, J. Chambers, N. Devoe, P. Doescher, J. Grace, D. Johnson, S. Knick, R. Miller, M. Pellant, F. Pierson, D. Pyke, K. Rollins, B. Roundy, G. Schupp, R. Tausch, and D. Turner. 2010. The Sagebrush Steppe Treatment Evaluation Project (SageSTEP): A Test of State-and-Transition Theory. Ft. Collins, CO, USA: USDA Forest Service, Rocky Mountain Research Station. General Technical Report, RMRS-GTR-237.

McIver, J., and E. Macke. 2014. Short-term butterfly response to sagebrush steppe restoration treatments. *Rangeland Ecology & Management* 67:539–552.

Miller, R. F., and E. K. Heyerdahl. 2008. Fine-scale variation of historical fire regimes in semi-arid shrubland and woodland: an example from California, USA. *International Journal of Wildland Fire* 17:245–254.

Miller, R. F., S. T. Knick, D. A. Pyke, C. W. Meinke, S. E. Hanser, M. J. Wisdom, and A. L. Hild. 2011. Characteristics of sagebrush habitats and limitations to long-term conservation. *In:* S. T. Knick and J. W. Connelly [eds.]. Greater sage-grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology 38. Berkeley, CA, USA: University of California Press. p. 145–184.

Miller, R. F., J. Ratchford, B. A. Roundy, R. J. Tausch, C. Pereia, A. Hulet, and J. Chambers. 2014. Response of conifer encroached shrublands in the Great Basin to prescribed fire and mechanical treatments. *Rangeland Ecology & Management* 67:468–481.

Pierson, F. B., C. J. Williams, P. R. Kormos, and O. Z. Al-Hamdan. 2014. Short-term effects of tree removal treatments on infiltration, runoff, and erosion in woodland-encroached sagebrush steppe. *Rangeland Ecology & Management* 67:522–538.

Pyke, D. A., S. Shaff, A. Lindgren, E. W. Schupp, P. S. Doescher, J. C. Chambers, J. S. Burnham, and M. M. Huso. 2014. Region-wide ecological responses of arid Wyoming big sagebrush communities to fuel treatments. *Rangeland Ecology & Management* 67:455–467.

Rau, B. M., J. C. Chambers, D. A. Pyke, B. A. Roundy, E. W. Schupp, P. Doescher, and T. G. Caldwell. 2014. Soil resources influence vegetation and response to fire and fire surrogate treatments in sagebrush-steppe ecosystems. *Rangeland Ecology & Management* 67:506–521.

Roundy, B., R. F. Miller, R. J. Tausch, K. Young, A. Hulet, B. Rau, B. Jessop, J. C. Chambers, and D. Egget. 2014. Understory cover responses to piñon-juniper control across tree cover gradients in the Great Basin. *Rangeland Ecology & Management* 67:482–494.

Roundy, B., K. Young, N. Cline, A. Hulet, R. F. Miller, R. J. Tausch, and B. Rau. 2014. Piñon-juniper reduction increases soil water availability of the resource growth pool. *Rangeland Ecology & Management* 67:495–505.

Whisenant, S. G. 1990. Changing fire frequencies on Idaho's Snake River Plains: ecological and management implications. *In:* E. D. McArthur, E. M. Romney, S. D. Smith, and P. T. Tueller [comps.]. Proceedings—symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management; 5–7 April 1989; Las Vegas, NV, USA. Ogden, UT, USA: US Department of Agriculture, Forest Service, Intermountain Research Station. General Technical Report INT-GTR-276. p. 4–10.