Science Support for Effectiveness of Actions by Threat to Conserve the Bi-State Sage-grouse Distinct Population Segment

In March, 2012, the Bi-State Executive Oversight Committee for Conservation of Greater-Sage-grouse (EOC) released the "Bi-State Action Plan: Past, Present, and Future Actions for Conservation of the Greater Sage-grouse Bi-State Distinct Population Segment" (hereafter Action Plan). The Bi-State Technical Advisory Committee (TAC), a team that included wildlife and habitat specialists from state and federal agencies with technical assistance and input from private contractors, produced the Action Plan.

Additionally, the TAC developed a conservation planning tool (CPT) that incorporates geospatial information, habitat suitability, and sage-grouse population data to prioritize conservation actions for the Bi-State Distinct Population Segment (BSDPS). Through a rigorous program of vegetation and population monitoring, the CPT serves as a key component of an adaptive management framework for updating the prioritization of conservation actions for the BSDPS.

The Action Plan identified seven primary threats and a suite of project types for each threat that would benefit conservation objectives for the BSDPS of the greater sage-grouse (*Centrocercus urophasianus*). The primary risk categories from the Action Plan are:

- Urbanization
- Infrastructure
- Grazing
- Pinyon-juniper encroachment
- Invasive and noxious species
- Wildfire
- Habitat-based threats

Below are brief explanations of the risk categories (**bold**), the project types (i.e., actions) that were identified in the action plan (*italics*), and, where appropriate, a summary of the current and best available science that supports each action as an effective means for conserving or improving sage-grouse habitats in the BSDPS. Following this review is a description of the vegetation monitoring protocol being used to track vegetation responses to the conservation actions and action effectiveness.

Urbanization

Because much of the habitats for the BSDPS are adjacent to the Sierra Front or near existing areas of urbanization (e.g., Minden/Gardnerville, Smith Valley, Bridgeport, Mammoth Lakes), the threat of urbanization was identified as a primary threat. Although only about 8% of the identified lands in the population management units are in private ownership, important and often limiting brood-rearing habitats are found within these lands. These same landscapes are generally targeted for development because of their proximity to recreation areas, aesthetics, and available water rights. Consequently, actively working to maintain traditional land uses, such as ranching, is preferable, from a sage-grouse conservation perspective, to changes that would be incompatible with the species.

Land Exchange/Purchase/Donation

This action would seek to transfer lands that are at potential risk of development and place them into trust or the public domain. This particular action is an option when a private parcel stands alone in a contiguous area of habitat or within an already protected or conserved area.

Conservation Easements

Conservation easements have been a tool widely applied to manage risk of land development for important habitats across a wide variety of wildlife species. Pocewicz et al. (2011) examined the general effectiveness of conservation easements in Wyoming and found lands with easements had fewer roads and developed structures and had higher levels of multiple indicators of biodiversity. Perhaps not surprisingly, an examination of working ranches in the sagebrush ecological community found that active ranches provided stability and wildlife resource values compared to developed uses of those lands (Davies et al. 2011). Employing easements in areas with high development pressure were called upon as a useful tool to conserve wildlife values and protect ecological function for sagebrush communities.

Within the Bi-State DPS, over 15,000 acres of conservation easements have been purchased within or adjacent to important sage-grouse habitats as indicated by the USGS Resource Selection Function model (Coates et al. 2013) and collective expert opinion.

Infrastructure

Because sage-grouse are a landscape scale species that requires contiguous, large scale habitats to thrive (Knick et al. 2013), multiple conservation challenges arise as a result of infrastructure on the landscape. Infrastructure in sagebrush communities leads to a diffusion of invasive species along and around developed areas (Manier et al. 2014). Roads lead to habitat fragmentation and are vectors for the spread of invasive species (Gelbard and Belnap 2003), serve as potential sources of wildland fire ignition (Linn et al. 2013), create edge effects leading to avoidance of nesting in otherwise suitable habitats (Aldridge and Boyce 2007), and can generate anthropogenic noise and resultant impacts from noise (Blickley 2013). Fences cause collision-related mortalities of sage-grouse (Stevens et al. 2012a). Recent research suggests that vertical structures cannot always be isolated from impacts related to other development activities (Walters et al. 2014), but sage-grouse have been shown to select nest and brood sites in areas with fewer avian predators (Dinkins et al. 2012), and common ravens (*Corvus corax*) nest occurrence was higher along transmission corridors (Howe et al. 2014).

Fence Removal, Modification and Marking

Stevens et al. (2012a) comprehensively analyzed factors associated with fence collisions by greater sage-grouse and recommended fence modification, removal, and marking within 2 km of active leks and for areas where fence density was >1km/km^2 as an effective means of reducing mortality risk. A study of effectiveness of fence marking found an 83% reduction in collision rates for marked compared to unmarked fences (Stevens et al. 2012b), again recommending that fence marking be limited to fences within 2 km of known leks.

Within the BS DPS, approximately 18 miles of fences have been marked according to NRCS protocol. The majority of the fence marking has occurred in the Sweetwater Flat, Lower Summers Meadow and in proximity to the Desert Creek leks providing greater visibility of fences during the lekking, nesting and brood rearing periods. Additionally, almost 8 miles of fencing has been removed to eliminate fence strikes within nesting and brood rearing habitats.

Road Closures/Removal of Tall Strucutres and Powerlines
Specific research on the benefits of road closure and removal of structures that are detrimental to sage-grouse is not available, but addressing these sources of mortality will clearly improve vital rates for sage-grouse. Because of the cause and effect relationship of these types of infrastructure projects addressed above, the Action Plan specifically outlined actions that could be employed to minimize impacts to sage-grouse. To date, just over 100 miles of roads have been permanently closed within important sage-grouse habitats in the BSDPS, including roads in proximity to leks and within nesting and brood rearing areas.

Grazing
In conducting the risk assessment for the BSDPS, the TAC identified permitted livestock grazing as a relatively low level threat when compared to other threats that can result in permanent or long-term habitat loss such as development activities (i.e., urbanization, infrastructure) or vegetation type conversions (i.e., wildfire, conifer encroachment, and invasive species). As described above under Urbanization, the maintenance of functional landscapes for sage-grouse where current land uses include a mix of private ranch lands and federal grazing allotments is not only compatible with sage-grouse conservation, but preferable to changing land uses to development activities that have adverse effects on western landscapes and the sagebrush biome (Knight et al. 1995, Knight 2007, Davies et al. 2011).

Implementation and Monitoring of Grazing Standards and Guidelines
Livestock grazing is often cited as the most widespread land use across the range of greater-sage grouse including the Bi-State DPS (Knick et al. 2003, Schroeder et al. 2004, Connelly et al. 2011). In general, the effects of livestock grazing are expressed as relative differences in the structure and functioning of sagebrush and associated plant communities that provide sage-grouse habitat that are not readily translated to population-level responses or impacts (Connelly et al. 2011, Garton and Connelly 2011). In addition, the management of livestock grazing and the assessment of habitat conditions is site specific (Mitchell 2000, Crawford et al. 2004). Beck and Mitchell (2000) conducted a review of the available literature and presented evidence for both positive and negative impacts to sage-grouse habitat from livestock grazing. Pyke (2011) identified livestock grazing as the single greatest management tool for implementing passive restoration in the sagebrush biome and highlighted the findings of West et al. (1984) that simple modifications such as shifting to no livestock use may not provide the desired outcomes. Appropriately managed grazing is critical to protecting the sagebrush ecosystem (Davies et al. 2011).

The available literature highlights the value of maintaining functional working landscapes and the importance of site-specific management; thus, the development and implementation of standards and guidelines combined with monitoring and adaptive management at the allotment level is considered the most effective approach for maintaining and improving grazed sage-grouse habitats in the Bi-State area.

Invasive and Noxious Species
Non-native plant species are a risk because they displace native species or communities important for sage-grouse, increase the risk of wildfire that can cause habitat loss or conversion, or can change the structure and function of important wetlands habitats making them of low value or unusable for sage-grouse (Miller and Eddleman 2001, Gelbard and Belnap 2003, Al-Chokhachy et al. 2013).

Invasive and Noxious Weed Control
Invasive and noxious weed control programs are typically labor intensive and costly, but the Action Plan recognizes the value of strategic, limited use of control efforts when priority habitats may be threatened by noxious weeds and when opportunities to prevent outbreaks and functional losses of habitats exist.

Pinyon-Juniper Encroachment
The expansion of the pinyon-juniper woodland association (PJ) has been well documented in the Great Basin (e.g., Tausch et al. 1981). Likewise, this expansion has been shown to be a causal factor in the decline of sage-grouse (*Centrocercus urophasianus*) or a factor resulting in non-suitability of habitats in portions of their range, including the BSDPS (Braun 1998, Commons et al. 1999, Miller and Eddleman 2001, Freese 2009, U.S. Fish and Wildlife Service 2013, Baruch-Mordo et al. 2013, Arkle et al. 2014). A detailed analysis of juniper encroachment in southeastern Oregon found that active sage-grouse leks do not occur when conifer cover is >4%, a finding with clear implications and guidance for conservation actions (Baruch-Mordo et al. 2013). Additionally, ecologists have developed clear recommendations for targeting appropriate phases, or age and density structure of these woodlands, to provide the best return on investment for sagebrush and sage-grouse habitat restoration activities (Bates et al. 2011, Davies et al. 2011).

Pinyon-Juniper Removal, Mechanical and Burning
With strategic targeting of phase I and phase II stands of pinyon-juniper (Miller et al. 2005) in the BSDPS, significant opportunities exist for restoring sage-grouse habitats and halting losses of habitats from encroachment with support in the literature for these activities . The methods are straight-forward (e.g., mechanical treatments, prescribed fire), and there is support in the literature on the effectiveness of these approaches for returning sagebrush habitats when planned and executed well (Freese 2009, Bates et al. 2011, Davies et al. 2011, Baruch-Mordo et al. 2013, Provencher and Thompson 2014). The Action Plan is linked to a conservation planning tool that evaluates landscape and vegetation conditions to target priority opportunities for pinyon-juniper removal (P. Coates, personal comm.). Additionally, thinning and removal activities are linked to monitoring programs that measure both vegetation and sage-grouse responses to these actions; the results from these monitoring programs will clarify the population level response of sage-grouse to pinyon-juniper removal that is currently lacking in the literature.

Within the BSDPS, over 21,000 acres of pinyon and juniper removal has taken place within or adjacent to sage-grouse habitat. This includes minor projects to remove phase I tree encroachment from nesting habitat to more intensive mechanical removal within both phase one and phase two areas to expand available sage-grouse habitat and enhance existing conditions within nesting, brood rearing and winter habitats.

Wildfire

Fires have consumed some important habitats for sage-grouse within the Bi-State DPS, particularly within the Pine Nut PMU where approximately 70,000 acres have been affected by wildfire. Not all of these fires have directly impacted sagebrush as many acres of pinyon and juniper woodland habitats have burned. Recently, the Spring Peak fire consumed just over 14,000 acres within the Bodie/Mount Grant PMU; however, an extensive seeding effort, the fact that islands of sagebrush remained within the fire perimeter, and the higher elevation of the burned area associated with favorable characteristics for sagebrush recovery compared to lower elevation sites (e.g., Arkle et al. 2014), provide some assurance that the burned area will recover over time.

Fuels Reduction

Fuel reduction activities using mechanical methods and prescribed fire are targeted in woodlands with heavy understory fuel loads along the wildland-urban interface and in areas where ecological conditions indicate ecological resilience can be enhanced for achieving improvements to sage-grouse habitats or to reduce the risk of losses of adjacent, functional habitats. The use of these treatments is informed by the conservation planning tool and field reconnaissance to account for existing understory conditions to maximize the likelihood of enhancing the desired sagebrush community composition post-treatment and to avoid using the wrong tool in the wrong place (Bates et al. 2011, Hess and Beck 2012, Arkle et al. 2014, Miller and Ratchford 2014, Davies et al. 2014).

Over 8,800 acres have been subject to fire rehabilitation efforts in the BSDPS. These efforts have mainly been concentrated within the Pine Nut PMU, but have also taken place in the South Mono and Bodie/Mount Grant PMUs (e.g., Spring Peak Fire Restoration).

Fire Closure Crowley Lake 4th of July

The fireworks ban at Crowley Lake removed a high risk of fire from stray fireworks that could cause ignition of important sage-grouse habitats in that area.

Rehabilitation/Restoration

Site restoration activities occur in response to wildfire and proactively through the conservation planning tool for sites identified as good candidates for enhancing or returning sagebrush habitats that can benefit sage-grouse following wildfire. Post-wildfire treatments generally involve seeding and monitoring to track the rate of success. Seeding as a restoration tool varies in success, but is mostly influenced by elevation, precipitation after seeding, and site condition pre-wildfire; additionally, recovery of functional sagebrush habitats following wildfire can take decades to be realized and requires long-term monitoring to assure conservation objectives are met for restoring potential habitats post-wildfire (Arkle et al. 2014). Monitoring programs are already established and incorporated into restored sites in the BSDPS.

Habitat-Based Threats

The Action Plan identifies habitat-based threats to riparian meadows as a primary risk factor. Wet meadows provide important brood-rearing habitat for sage-grouse (Rasmussen and

Griner 1938). Also, mesic meadows have also been identified as important conservation targets because riparian sites may be the limiting habitat for local sage-grouse populations (Connelly and Braun 1997, Braun 1998, Doherty et al. 2010). For the BSDPS, the conservation planning tool is used to prioritize riparian sites for restoration based on the relative value of those sites to sage-grouse populations.

Riparian Meadow Quality – Livestock Exclusions, Irrigation, Prescribed Fire, Mechanical Treatments, Chemical Treatments

There are cases where conservation easements can be used to meet conservation objectives, as noted earlier. In other cases, riparian function has been reduced or lost on either public or private lands, and rehabilitation activities, including removing headcuts, reduction of encroaching vegetation, and returning surface, may benefit sage-grouse (Pyke 2011). In instances where grazing is determined to be a factor in reducing sage-grouse habitat values at riparian sites, grazing exclosures can be used to restore or improve those values, as has been shown for other bird species at Great Basin riparian sites (Dobkin et al. 1998).

Vegetation Monitoring Protocol

The Nevada Partners for Conservation and Development (NPCD) is housed and coordinated from NDOW, and the mission of the NPCD is to implement habitat restoration projects and to demonstrate the effectiveness of the projects. Currently, the NPCD is working on numerous habitat projects across northern Nevada and BSDPS. At a given habitat project site, the NPCD will establish numerous vegetation sampling locations within the treatment and also in adjacent areas not intended to be treated. The non-treated sites serve as control sites against which the results of the treatment can be evaluated. Sampling is conducted prior to treatments to establish baseline conditions for as many years possible in an effort to account for inter-annual climatic variation; the same sites are visited following treatments. Various comparisons between pre- and post-treatment sites as well as comparisons of treated to control sites allows for project effects to be determined.

In order to show project effects to the vegetation, the NPCD is implementing a statistically rigorous and ecologically meaningful monitoring protocol (Laycock 1987, Elzinga et al. 1998, Bestelmeyer et al. 2006, Forbis and Provencher 2007). The methods NPCD employs are consistent with the Bureau of Land Mnagement's (BLM) Assessment, Inventory and Monitoring (AIM; Taylor et al. 2012), the U.S. Geological Survey's Chronosequence (Knutson et al. 2009), the BLM's Emergency Stabilization and Rehabilitation and the U.S.D.A. Forest Service's Burn Area Emergency Response (Robichaud et al. 2000). The NPCD's methods are designed to be simple, cost-effective, and replicable in an effort to increase the likelihood for ongoing resampling of vegetation survey sites into the future. One requirement is that all personnel know the flora in the area. The NPCD hires and trains crews each year for these skills.

The methods are described briefly below:

- Survey crews navigate to sampling locations using GIS and GPS;
- Sampling sites consist of three 50-m transects oriented at 0, 120 and 240 degree compass bearings;

- Once at the sampling location, all plants found within the perimeter of the site are identified to species;
- Photographs are taken along each transect (Bonham and Ahmed 1989), foliar cover by species is measured via line point intercept along transects (Canfield 1941), and the height of shrubs and perennial grasses/forbs is measured along each transect;
- Gaps in the perennial vegetation canopy are measured and a 2-m x 50-m belt transect is measured to count shrubs and trees and place individuals into various size categories (Elzinga et al. 1998).

The measures employed provide a complete picture of the vegetation including species at each site, all noxious or other nonnative plants, percent cover of all species, structure (height) of the shrubs and perennial understory and density by species (Daubenmire 1959, Elzinga et al. 1998, Bestelmeyer et al. 2006, Forbis and Provencher 2007).

LITERATURE CITED

Al-Chokhachy, R., A. M. Ray, B. B. Roper, and E. Archer. 2013. Exotic Plant Colonization and Occupancy Within Riparian Areas of the Interior Columbia River and Upper Missouri River Basins, USA. Wetlands 33:409–420.

Aldridge, C. L., and M. S. Boyce. 2007. Linking occurrence and fitness to persistence: habitat-based approach for endangered greater sage-grouse. Ecological applications : a publication of the Ecological Society of America 17:508–26.

Arkle, R., D. Pilliod, and S. Hanser. 2014. Quantifying restoration effectiveness using multi-scale habitat models: implications for sage-grouse in the Great Basin. Ecosphere 5:1–32.

Baruch-Mordo, S., J. S. Evans, J. P. Severson, D. E. Naugle, J. D. Maestas, J. M. Kiesecker, M. J. Falkowski, C. a. Hagen, and K. P. Reese. 2013. Saving sage-grouse from the trees: A proactive solution to reducing a key threat to a candidate species. Biological Conservation 167:233–241.

Bates, J., K. Davies, and R. Sharp. 2011. Shrub-steppe early succession following juniper cutting and prescribed fire. Environmental Management 47:468–81.

Beck, J. L., and D. L. Mitchell. 2000. Influences of livestock grouse grazing on sage habitat. Wildlife Society Bulletin 28:993–1002.

Bestelmeyer, B. T., D. a. Trujillo, a. J. Tugel, and K. M. Havstad. 2006. A multi-scale classification of vegetation dynamics in arid lands: what is the right scale for models, monitoring, and restoration? Journal of Arid Environments 65:296–318.

Blickley, J. L. 2013. The effects of anthropogenic noise on Greater Sage-Grouse (*Centrocercus urophasianus*) lek attendance, communication, and behavior. University of California, Davis.

Bonham, C., and J. Ahmed. 1989. Measurements for terrestrial vegetation. John WIley and Sons, New York, New York. 338 pp.

Braun, C. E. 1998. Sage-grouse declines in western North America: what are the problems? Pages 139–156 Western Association of Fish and Wildlife Agencies.

Canfield, R. H. 1941. Application of the line interception method in sampling range vegetation. Journal of Forestry 39:388–394.

Coates, P. S., M. L. Casazza, E. J. Blomberg, S. C. Gardner, S. P. Espinosa, J. L. Yee, L. Wiechman, and B. J. Halstead. 2013. Evaluating greater sage-grouse seasonal space use relative to leks: implications for surface use designations in sagebrush ecosystems. Journal of Wildlife Management 77:1598–1609.

Commons, M., R. Baydack, and C. Braun. 1999. Sage grouse response to pinyon-juniper management. Pages 238–239 *in* S. B. Monsen and R. Stevens, editors. Proceedings: ecology and management of pinyon-juniper communities within the Interior West. RMRS-P9, United States Department of Agriculture Forest Service, Fort Collins, Colorado, USA.

Connelly, J., S. Knick, and C. Braun. 2011. Conservation of greater sage-grouse: a synthesis of current trends and future management. Studies in Avian Biology 38:549–563.

Connelly, J. W., and C. E. Braun. 1997. Long-term changes in sage grouse *Centrocercus urophasianus* populations in western North America. Wildlife Biology 3:229–234.

Crawford, J., R. Olson, and N. West. 2004. Ecology and management of sage-grouse and sage-grouse habitat. Rangeland Ecology and Management 57:2–19.

Daubenmire, R. 1959. A Canopy-Coverage Method of Vegetational Analysis. Northwest Science 33:43–64.

Davies, K. W., J. D. Bates, M. D. Madsen, and a M. Nafus. 2014. Restoration of mountain big sagebrush steppe following prescribed burning to control western juniper. Environmental Management 53:1015–22.

Davies, K. W., C. S. Boyd, J. L. Beck, J. D. Bates, T. J. Svejcar, and M. a. Gregg. 2011. Saving the sagebrush sea: An ecosystem conservation plan for big sagebrush plant communities. Biological Conservation 144:2573–2584.

Dinkins, J., M. Conover, C. Kirol, and J. Beck. 2012. Greater Sage-Grouse (*Centrocercus urophasianus*) select nest sites and brood sites away from avian predators. The Auk 129:600–610.

Dobkin, D., A. Rich, and W. Pyle. 1998. Habitat and avifaunal recovery from livestock grazing in a riparian meadow system of the northwestern Great Basin. Conservation Biology 12:209–221.

Doherty, K. E., D. E. Naugle, and B. L. Walker. 2010. Greater Sage-Grouse Nesting Habitat: The Importance of Managing at Multiple Scales. Journal of Wildlife Management 74:1544–1553.

Elzinga, C., D. Salzer, and J. Willoughby. 1998. Measuring & Monitoring Plant Populations. Lincoln, Nebraska.

Forbis, T., and L. Provencher. 2007. A method for landscape-scale vegetation assessment: application to Great Basin rangeland ecosystems. Rangeland Ecology and Management 60:209–217.

Freese, M. T. 2009. Linking greater sage-grouse habitat use and suitability across spatiotemporal scales in central Oregon. Oregon State University.

Garton, E., and J. Connelly. 2011. Greater sage-grouse population dynamics and probability of persistence. Studies in Avian Biology 38:293–381.

Gelbard, J. L., and J. Belnap. 2003. Roads as conduits for exotic plant invasions in a semiarid landscape. Conservation Biology 17:420–432.

Hess, J. E., and J. L. Beck. 2012. Burning and mowing Wyoming big sagebrush: Do treated sites meet minimum guidelines for greater sage-grouse breeding habitats? Wildlife Society Bulletin 36:85–93.

Howe, K. B., P. S. Coates, and D. J. Delehanty. 2014. Selection of anthropogenic features and vegetation characteristics by nesting Common Ravens in the sagebrush ecosystem. The Condor 116:35–49.

Knick, S., D. Dobkin, and J. Rotenberry. 2003. Teetering on the edge or too late? Conservation and research issues for avifauna of sagebrush habitats. The Condor:611–634.

Knick, S. T., S. E. Hanser, and K. L. Preston. 2013. Modeling ecological minimum requirements for distribution of greater sage-grouse leks: implications for population connectivity across their western range, U.S.A. Ecology and evolution 3:1539–51.

Knight, R. L. 2007. Ranchers as a Keystone Species in a West That Works. Rangelands 29:4–9.

Knight, R. L., G. N. Wallace, and W. E. Riebsame. 1995. Ranching the view: subdivisions versus agriculture. Conservation Biology 9:459–461.

Knutson, K., D. Pyke, T. Wirth, and D. Pilliod. 2009. A chronosequence feasibility assessment of emergency fire rehabilitation records within the intermountain western United States-final report to the Joint Fire Science Program Project 08-S-08. Open File Report 2009-1099, U.S. Geological Survey, Reston, Virginia.

Laycock, W. A. 1987. Setting objectives and picking appropriate methods for monitoring vegetation on rangelands. Pages 24–30 Rangeland monitoring workshop proceedings. U.S. Department of Interior, Bureau of Land Management, Denver, Colorado.

Linn, P. Van, K. Nussear, and T. Esque. 2013. Estimating wildfire risk on a Mojave Desert landscape using remote sensing and field sampling. International Journal of Wildland Fire 22:770–779.

Manier, D. J., C. L. Aldridge, M. O'Donnell, and S. J. Schell. 2014. Human infrastructure and invasive plant occurrence across rangelands of southwestern Wyoming, USA. Rangeland Ecology and Management 67:160–172.

Miller, R., J. D. Bates, T. J. Svejcar, F. B. Pierson, and L. E. Eddleman. 2005. Biology, ecology, and management of western juniper (*Juniperus occidentalis*). Technical Bulleting 152, Oregon State University, Agricultural Experiment Station, Corvalis, Oregon.

Miller, R. F., and L. E. Eddleman. 2001. Spatial and temporal changes of sage grouse habitat in the sagebrush biome. Eastern Oregon Agricultural Research Center, Oregon State University, Burns, OR.

Miller, R., and J. Ratchford. *In press*. Response of conifer encroached shrublands in the Great Basin to prescribed fire and mechanical treatments. Rangeland Ecology and Management.

Mitchell, J. E. 2000. Rangeland resource trends in the united states a technical document supporting the 2000. Fort Collins, Colorado, USA.

Pocewicz, A., J. M. Kiesecker, G. P. Jones, H. E. Copeland, J. Daline, and B. A. Mealor. 2011. Effectiveness of conservation easements for reducing development and maintaining biodiversity in sagebrush ecosystems. Biological Conservation 144:567–574.

Provencher, L., and J. Thompson. 2014. Vegetation Responses to Pinyon–Juniper Treatments in Eastern Nevada. Rangeland Ecology & Management 67:195–205.

Pyke, D. 2011. Restoring and rehabilitating sagebrush habitats. Studies in Avian Biology 38:531–548.

Rasmussen, D. I., and L. A. Griner. 1938. Life history and management studies of the sage grouse in Utah, with special reference to nesting and feeding habits. North American Wildlife Conference Transactions 3:852–864.

Robichaud, P., J. Beyers, and D. Neary. 2000. Evaluating the effectiveness of postfire rehabilitation treatments. General Technical Report RMRS-GTR-63. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.

Schroeder, M. A., C. L. Aldridge, A. D. Apa, J. R. Bohne, E. Clait, S. D. Bunnell, J. W. Connelly, P. A. Deibert, S. C. Gardner, M. A. Hilliard, G. D. Kobriger, S. M. Mcadam, C. W. Mccarthy, J. J. Mccarthy, D. L. Mitchell, E. V Rickerson, and S. J. Stiver. 2004. Distribution of sage-grouse in north america distribution of sage-grouse in north america. The Condor 106:363–376.

Stevens, B. S., J. W. Connelly, and K. P. Reese. 2012a. Multi-scale assessment of greater sage-grouse fence collision as a function of site and broad scale factors. The Journal of Wildlife Management 76:1370–1380.

Stevens, B. S., K. P. Reese, J. W. Connelly, and D. D. Musil. 2012b. Greater sage-grouse and fences: does marking reduce collisions? Wildlife Society Bulletin 36:297–303.

Tausch, R., N. West, and A. Nabi. 1981. Tree age and dominance patterns in Great Basin pinyon-juniper woodlands. Journal of Range Management 34:259–264.

Taylor, J., G. Toevs, J. Karl, M. Bobo, M. Karl, S. Miller, and C. Spurrier. 2012. AIM-monitoring: a component of the BLM assessment, inventory, and monitoring strategy. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver, Colorado.

U.S. Fish and Wildlife Service. 2013. Greater sage-grouse (*Centrorcercus urophasianus*) conservation objectives: final report. Denver, Colorado.

Walters, K., K. Kosciuch, and J. Jones. *In press*. Can the effect of tall structures on birds be isolated from other aspects of development? Wildlife Society Bulletin.

West, N. E., F. D. Provenza, P. S. Johnson, and M. K. Owens. 1984. Vegetation change after 13 years of livestock graing exclusion on sagebrush semidesert in west central Utah. Journal of Range Management 37:262–264.