T. Gettelman, USGS

Briefing Paper

Research to Support the Management of Sage-Grouse

The U.S. Geological Survey (USGS) has a large number of ongoing research efforts directed at addressing information and science needs related to sage-grouse and its habitat across its range. The USGS has a diversity of expertise and capabilities to address a wide variety of science needs at multiple spatial scales and is committed to provide high quality science to management partners.

USGS sage-grouse and sagebrush-steppe research addresses many of the topics highlighted as priority needs in the Greater Sage-grouse National Research Strategy. The Strategy and this report are organized around four areas of research.

- *Sage-grouse Biology*
- *Habitat Management*
- *Change Agents*
- *Decision Analysis*

Sage-grouse Biology addresses topics related directly to sage-grouse populations and life-history attributes. Examples include development of spatially explicit population models, use of technology to improve population monitoring, and the study of sage-grouse behavioral responses to landscape features and disturbance.

Habitat Management covers topics related to sagebrush ecosystems and management actions to improve habitat conditions. Research includes an assessment of range-wide sage-grouse genetic structure and landscape connectivity, identification of factors that contribute to successful establishment of big sagebrush across the sage-grouse range, and remote-sensing-based characterization of western U.S. shrub lands.

Change Agents includes topics associated with natural and human-caused changes to sage-grouse and sage-grouse habitats. Currently USGS scientists are assessing cheatgrass effects on sage-grouse habitat selection and vital rates, investigating the implications of renewable energy development on sage-grouse populations, and examining potential climate change effects on future sagebrush distributions and vegetation composition.

Decision Analysis tools are being developed by USGS scientists to support the U.S. Fish and Wildlife Service's (USFWS) status assessment of the greater sage-grouse under the Endangered Species Act and provide a consistent framework for use in the development of conservation measures for the Bureau of Land Management Resource Management Plan revisions.

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Photo: T. Gettelman, USGS

Sage-grouse Management

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Sage-grouse Biology

Habitat Requirements and Population Viability for Greater Sage-grouse in Wyoming

The USGS has developed greater sage-grouse habitat-selection models for the nesting, summer, late brood rearing, and winter life stages in Wyoming to assess habitat quality and responses to change across large landscapes. Project findings revealed that habitat selection was different across space and through time and will inform population modeling efforts to evaluate the effectiveness of core areas for conservation. These models will enable quantitative investigation of the long-term dynamics and persistence of sage-grouse populations and result in a data-driven decision-support tool for managers prioritizing limited resources for conservation and management. Models will incorporate the effects of habitat loss and fragmentation resulting from future oil and gas development and associated road infrastructure and changes in habitat suitability resulting from climate change scenarios.

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Publication: *Habitat prioritization across large landscapes, multiple seasons, and novel areas: an example using greater sage-grouse in Wyoming: Wildlife Monographs (2014), http://bit.ly/1wF1FwX*

A Hierarchical Integrated Population Model for Greater Sage-grouse in the Bi-State DPS in California and Nevada

Genetic research has indicated isolation and potential conservation risk for the Greater Sage-grouse Bi-State Distinct Population Segment, as well as different patterns of habitat selection and vital rates relative to the range-wide population. The USGS developed an integrated population model for this area to estimate population growth rates. The model indicates that the Bi-State population is stable overall, but evidence suggests a declining trend for one subpopulation. Researchers are now conducting analyses to assess which components of sage-grouse life-history are driving population change. This approach could be adapted to assess population trends for greater sage-grouse at other regional and landscape scales.

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Publication: *A hierarchical integrated population model for greater sage-grouse (Centrocercus urophasianus) in the Bi-State Distinct Population Segment, California and Nevada: USGS Open-File Report (2014), http://bit.ly/1xm0Vhh*

Winter Ecology of Greater Sage-grouse in Nevada

Perhaps the most ubiquitous characteristic of sage-grouse is their reliance on sagebrush as a food source, particularly during winter when they consume it almost exclusively. However, it is not known to what extent sage-grouse rely on different species of sagebrush as a source of food or for cover, and how these attributes may be affected by environmental characteristics, such as temperature and snow depth. The USGS has initiated research into the winter ecology of greater sage-grouse in eastern Nevada to answer some of these questions. The USGS and cooperators are evaluating sage-grouse use of different sagebrush species as a food source while accounting for the availability of sagebrush under different circumstances. Tracking data will be used to understand how winter conditions influence sage-grouse movement patterns and habitat use.

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Predation Effects on Sage-grouse Population Dynamics

Information about the extent of sage-grouse predation and the mechanisms that influence it at all life stages is incomplete. The USGS has initiated a large-scale investigation of predation effects and underlying ecological drivers of predation at sites located throughout Nevada and California. Through use of nest videography, avian predator surveys, habitat assessment, geospatial analysis, and telemetry- and GPS-based sage-grouse monitoring, USGS and collaborators are evaluating how habitat composition, anthropogenic impacts, and other spatial and temporal processes influence nest predation rates, as well as age-specific and sex-specific survival rates. This information can be used to inform future management efforts to reduce predation impacts on sage-grouse populations.

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Publication: *Greater sage-grouse nest predators in the Virginia Mountains of northwestern Nevada: Journal of Fish and Wildlife Management (2013), http://bit.ly/1qCqwfX*

Effects of Lek Count Timing on Greater Sage-grouse Population Trend Estimates

Annual counts of males displaying at lek sites are an important tool for monitoring greater sage-grouse populations, but seasonal and diurnal variation in lek attendance may increase variance and bias of trend analyses. Recommendations for protocol to minimize observation error have called for restricting lek counts to within 30 minutes from sunrise, but this also may limit the number of lek counts available for analysis. USGS researchers and colleagues used lek count data collected across Wyoming during 1990-2014 to investigate the effect of including lek counts collected <60 and <90 minutes after sunrise on bias and precision of population trend estimates. They also used simulation based on a lek attendance model to compare observed and estimated values of annual change in population size from scenarios of varying lek sample size, population size, lek count timing, and count frequency. The results of this study can help improve sage-grouse monitoring efforts and help with estimation of sage-grouse population trends.

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Genomic Techniques Identify Genetic Variation in Greater and Gunnison Sage-grouse

New genomic approaches are revolutionizing our understanding of patterns and functional significance of genetic diversity in sage-grouse. The USGS is harnessing these genomic approaches in many ways. We have developed new molecular markers (microsatellites and single nucleotide polymorphisms) that are useful for both species of sage-grouse. We are also using genomic methods to clarify patterns of genetic variation between greater and Gunnison sage-grouse that allow us to examine mechanisms underlying the speciation event that separated the two species. Finally, we are using new genomic markers to investigate genes under selection that may be associated with adaptation to certain environmental conditions across the landscape.

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A Sage-grouse Perspective on Disturbance and Landscape Arrangement

Anthropogenic and natural disturbance are primary causes of habitat fragmentation and loss underlying population declines of greater sage-grouse. Therefore, understanding how sage-grouse actually perceive and move through their landscape when dispersing to new breeding areas or migrating between seasonal use areas can provide important insights into measuring the effects of disturbance. In a new study, USGS and University of Idaho researchers are tracking fine-resolution movements of adult sage-grouse. Locations recorded at 1-, 5-, and 15-minute intervals are providing information on how sage-grouse perceive the landscape and move relative to disturbance features. This study will fill a critical need for information about disturbance effects that can be used in developing conservation or mitigation actions.

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Habitat Management

SageSuccess Project: Sagebrush Restoration for Sage-grouse

The SageSuccess Project is a joint effort between USGS and the Bureau of Land Management (BLM) to examine the factors that contribute to establishment of big sagebrush across the range of the sage-grouse, and whether seeding and planting sagebrush ultimately creates high quality sage-grouse habitat. The project will examine seedings and plantings completed between 1990 and 2013, and assess factors including seed source, climate, soils, soil moisture, fire history, land use, and treatment implementation method. Researchers will identify and compare the subspecies of seed provided to BLM to the native/requested subspecies using genetic and chemical signatures. Where seed sources are known, the contribution of seed transfer across geographic, elevation, and climate zones to seeding outcomes will be assessed. This research will inform site-level management activities and explore new practices or improvements of existing methods to restore sagebrush.

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Sagebrush Seed Source Affects Restoration Success

Big sagebrush provides important habitat for greater sage-grouse and other wildlife. An increasing number of large wildfires threaten the distribution of big sagebrush. Because big sagebrush cannot re-sprout after a burn, and natural seedling establishment is limited, land managers have made efforts to recolonize big sagebrush by aerial or drill seeding burned areas. A new study in the Snake River Birds of Prey National Conservation Area in Idaho will examine how seeds from different climates and different genetic characteristics grow in variable climates. Scientists will also explore how different sagebrush seeds cope with traditional treatments, such as using herbicides or mowing to control competing vegetation. Results from this study will be useful to restoration managers interested in maximizing big sagebrush seedling establishment after wildfire, especially in the face of climate variability.

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Quantifying Fuels and the Effects of Reduction Treatments in Sagebrush Habitats

A key to understanding and managing fire in large sagebrush steppe landscapes is to develop adequate spatial models of successional change and plant productivity that are coupled to quantitative measures of fuels. Sagebrush shrubland ecosystems in the western Snake River Plain, Idaho are a prime example of altered successional trajectories and dynamic fuel conditions, which challenge land managers to predict and control fire behavior, restore native communities, and provide ecosystem services. The USGS is investigating and quantifying the influence of land use (i.e., grazing), nonnative species, and altered fire regimes on successional pathways and associated fuel loads in the Snake River Birds of Prey National Conservation Area, Idaho with the overarching goal to better quantify and predict fuel loads and the effects of fuels manipulations in sagebrush habitats.

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Handbook for Restoration of Sagebrush-Grassland Ecosystems

USGS scientists are developing a three-part handbook to provide an approach for effective implementation of restoration practices. Part I offers knowledge of background concepts that are necessary for a practitioner/manager to apply two decision tools that are the core of this restoration handbook. Part II is the landscape-level decision tool designed to help managers develop effective strategies for restoration project placement. Part III describes project-level restoration tools, including decisions regarding use of either passive or active restoration techniques. Parts II and III are designed to be followed in a step-by-step progression to ensure that critical decisions are made in the appropriate order to ascertain the best management practices with the least amount of back-tracking on the part of decision-makers and practitioners.

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Sagebrush Management in Light of Sage-grouse, Fire, and Invasive Species

Researchers from the USGS, BLM, U.S. Forest Service (USFS), Natural Resource Conservation Service (NRCS), Agricultural Research Service (ARS), and Western Association of Fish and Wildlife Agencies (WAFWA) have produced a tool to help management agencies prioritize regional-scale management actions while maximizing conservation effectiveness. A strategic approach was developed for conservation of sagebrush ecosystems and sage-grouse that focuses specifically on habitat threats caused by invasive annual grasses and altered fire regimes. The tool uses information about 1) factors that influence sagebrush ecosystem resilience to disturbance and resistance to invasive annual grasses and 2) the distribution, relative abundance, and persistence of sage-grouse populations to help develop management strategies at both landscape and site scales.

Contact: David Pyke; USGS Forest and Rangeland Ecosystem Science Center; david_a_pyke@usgs.gov; 541-750-0989

Publication: *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: USFS General Technical Report (2014), http://1.usa.gov/1qYDd6f*

Response of Shrubland Birds to Prescribed-Fire Treatments

Prescribed fire is commonly used to reduce the cover of pinyon or juniper and benefit birds, particularly sage-grouse that depend on sagebrush habitats. The USGS studied yearly changes in the bird community after prescribed fire to measure how birds use the new vegetative structure and to evaluate if the bird community responds as expected. Initial results (five to seven years post-treatment) suggest that prescribed fire, as currently conducted in established woodland communities, is relatively ineffective in creating habitat for sagebrush-obligate birds. In addition, fires reduced existing sagebrush cover, which will further delay establishing a desired sagebrush bird community. In contrast, mechanical treatments that removed all tree cover at locations adjacent to existing sagebrush landscape were effective in restoring sagebrush bird communities.

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Publication: *Ecological scale of bird community response to pinyon-juniper removal:Range Ecology and Management (2014), http://dx.doi.org/10.2111/REM-D-13-00023.1*

Community Composition of Biological Soil Crusts of Nevada's Shrub-steppe

Biological soil crusts often exist in spaces between arid and semiarid plants and can improve soil stability, hydrology, nutrient cycling, and potentially the resistance of plant communities to invasive annual grasses. The USGS will lead a new study to examine the extent of biological soil crusts in Nevada's shrub-steppe and some of the potential factors influencing the absence of crusts across sagebrush ecosystems. Researchers will inspect data collected by other agencies, including the NRCS and the BLM, to prioritize more detailed sampling of ecological sites with the potential to support biological soil crusts. Objectives include determining how soil properties, climate, livestock use, and fire affect the community composition of biological soil crusts. The resulting information will increase awareness of how crusts respond to disturbances and the ecological factors that influence these important biological communities, which consist of mosses, lichens, algae, fungi, liverworts, and cyanobacteria.

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Landscape Influence on Gene Flow in Greater Sage-grouse

The USGS and collaborators are using genetic information contained in sage-grouse feathers collected at leks to delineate the range-wide network of breeding populations. The genetic data are being analyzed in combination with landscape information to identify geographic distance, topographic features, anthropogenic land uses, and other factors that influence sage-grouse dispersal and genetic exchange. Feathers collected at leks across the sage-grouse range from 2012 through 2014 currently are being processed at labs in Fort Collins, Colorado and Missoula, Montana. The results from this study, perhaps the largest terrestrial effort of its kind, will be important for conservation planning to delineate core or priority populations, and to reduce population fragmentation, isolation, and risk of extirpation.

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Remote Sensing Characterization and Monitoring of Shrubland Components

The USGS in collaboration with the BLM is producing a remote sensing-based characterization of western U.S. shrublands. This work provides a 30 meter per-pixel canopy cover estimate of shrubland components of all shrub, sagebrush, herbaceous, annual herbaceous, litter, bare ground and shrub height. This approach is designed to maximize the flexibility of these products to support a wide variety of habitat and monitoring requirements. Provisional products developed in 2013 for southwest Idaho, southeast Oregon, northwest Nevada and northeast California and in 2014 for the Mojave Desert have been completed and will be available for download at www.mrlc.gov. 2014 products developed for the Great Basin and southern Idaho will be available later this year. 2015 products are currently being produced for Montana and Wyoming with release scheduled for early 2016. Products will be integrated into the National Land Cover Database for future updating and monitoring.

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Publications: *Characterization of shrubland ecosystem components as continuous fields in the northwest United States: Remote Sensing of Environment (2015), http://dx.doi.org/10.1016/j.rse.2015.07.014*

Forecasting sagebrush ecosystem components and greater sage-grouse habitat for 2050: Learning from past climate patterns and Landsat imagery to predict the future: Ecological Indicators (2015), http://dx.doi.org/10.1016/j.ecolind.2015.03.002

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State-Wide Mapping of Greater Sage-grouse Habitat

The USGS and partners across multiple western states are studying the cumulative impacts of expanding human activities across these landscapes. By combining land-cover information with other data on sage-grouse movement patterns, life history and reproductive ecology, and habitat preferences, researchers can create maps to assist in forecasting the interaction of proposed land-use activities to the sagebrush ecosystem. This information will increase understanding of the distribution and dynamics of habitat conditions across the landscape, and the relationship between habitat conditions and dynamics of wildlife populations. Maps may help predict where fragmentation of sage-grouse movement corridors and breeding grounds might occur, and assess the relationships between land-use and native and invasive species.

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Nevada work contact: Peter S. Coates; USGS Western Ecological Research Center; pcoates@usgs.gov; 530-669-5073

Publication: *Spatially explicit modeling of greater sage-grouse (Centrocercus urophasianus) habitat in Nevada and northeastern California—A decision-support tool for management: USGS Open-File Report (2014), http://bit.ly/1qlAiEz*

Change Agents

Renewable Energy Development and Greater Sage-grouse in Nevada

Much of Nevada is targeted for proposed energy transmission corridors, and potential paths would dissect prime, contiguous sagebrush-steppe habitat. The USGS is conducting greater sage-grouse research on a broad geographical scale at multiple study sites related to wind-energy development and the associated powerline corridors in Nevada. The goal is to answer questions related to effects of developing renewable energy on sage-grouse habitat selection, population vital rates, and movement patterns. This research provides resource managers with information and tools needed to develop guidelines for future renewable energy projects that strive to minimize negative effects on greater sage-grouse.

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Effects of Invasive Cheatgrass on Sage-grouse in Nevada

Pervasive exotic plants, cheatgrass in particular, are among the primary threats to greater sage-grouse in the Great Basin. The USGS has multiple ongoing studies throughout the Great Basin evaluating the effects of cheatgrass on greater sage-grouse habitat selection and population vital rates. Researchers have measured cheatgrass abundance and height at radio- and GPS-marked sage-grouse locations and at random points. In a collaborative effort, USGS and others are incorporating these cheatgrass data in nest-site selection and nest-survival models in the Virginia Mountains of northwestern Nevada. Additionally, researchers are analyzing the effects of cheatgrass on selection and survival within the brood-rearing life phase in study areas across Nevada. This work will provide land managers with information about the relative effects of cheatgrass at multiple life stages, improving the ability to effectively target management and mitigation efforts.

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Cheatgrass Dynamics in the Northern Great Basin

Remote sensing technologies are used to effectively monitor terrestrial vegetation globally, including cheatgrass in the Northern Great Basin (NGB). The presence of cheatgrass in the NGB has helped increase fire frequency and fire spread, and fire is one primary reason for the reduction in the extent of native shrub-steppe used for livestock grazing and critical to greater sage-grouse survival. Future climate scenarios forecast that the NGB will experience increased temperatures and altered precipitation timing and totals, changes which will alter cheatgrass dynamics. USGS scientists have previously integrated remote sensing data, site-specific variables, and weather data into robust ecological models to estimate cheatgrass percent cover for 11 years throughout the NBG. In this study, the USGS is examining the potential climate-mediated changes in future cheatgrass dynamics. Specifically, researchers are using the outputs of previous cheatgrass percent-cover models and modifying models by substituting future climate data for weather data to reveal differences between recent cheatgrass and potential future cheatgrass dynamics. Future cheatgrass percent-cover may be influenced by multiple mitigating factors including changes in precipitation timing and totals, and freeze-thaw cycles. Understanding the effects of these factors can help direct land management activities to improve control of cheatgrass.

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Wildfire Patterns and Interactions with Vegetation

Previous studies have indicated that the area burned by wildfires has increased during the past few decades in desert and semi-desert regions of North America; however, these reports are typically based on point data or fire perimeter data that are often inaccurate and potentially misleading. They are also based on geographic scales that are not ideally suited for inferring effects on the greater sage-grouse. USGS researchers are using highly accurate burn severity data derived from satellite imagery to perform more precise analyses to better characterize trends in area burned within the range of the sage-grouse. They will use climate and environmental variables to evaluate potential future trends in area burned among all seven greater sage-grouse management zones. Researchers will also assess how potential, future shifts in sagebrush vegetation under climate change will affect sage-grouse habitat distribution, including the increasing influence of non-native grass species.

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Publication: *Fire Patterns in the Range of the Greater Sage-Grouse, 1984-2013–Implications for Conservation and Management: U.S. Geological Survey Open-File Report (2015), http://dx.doi.org/10.3133/ofr20151167*

Sage-grouse Responses to Burns and Sagebrush Restoration in Fire-Impacted Landscapes

To support the design of sagebrush-fire restoration efforts and link restoration outcomes with impacts on sage-grouse, USGS scientists will simulate sage-grouse responses to fire-induced loss of sagebrush and examine alternative restoration scenarios using empirical sagebrush and sage-grouse data within a spatially explicit individual-based modeling framework. Phase 1 efforts will evaluate the survival and success of sagebrush transplantations and generate sagebrush reclamation recommendations that can be directly implemented and evaluated at future burn sites. Phase 2 efforts will focus on the empirical evaluation of modeling recommendations at burn sites and will characterize sagebrush restoration success and the associated occurrence and fitness of sage-grouse. This project will help with understanding how best to evaluate the effects of large burns on sage-grouse populations, as well as help to prioritize and successfully restore these habitats for sage-grouse.

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Effects of Wildfire and Climate on Persistence of Greater Sage-grouse

Wildfire and climate change are frequently identified as two important factors contributing to the decline of sage-grouse populations, yet fire regimes and climate patterns can vary substantially across broad geographic ranges. Hence, the magnitude and predictability of fire and climate effects on sage-grouse population dynamics and resource utilization at landscape scales are poorly understood, and large-scale synthesis is necessary to forecast predictions. The USGS has embarked on a hierarchical assessment of sage-grouse population trends over the past 30 years in relation to wildfire and climate gradients in the Great Basin throughout northeastern California, Nevada, Oregon, and Idaho.

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Publication: *Long-term effects of wildfire on greater sage-grouse—Integrating population and ecosystem concepts for management in the Great Basin: U.S. Geological Survey Open-File Report (2015), http://dx.doi.org/10.3133/ofr20151165*

Fire and Post-Fire Seeding Alter Insect Assemblages in Sagebrush Habitat

Wildfire and subsequent post-fire restoration are common in western North America, yet information on how these events alter animal communities is generally lacking, especially for insects. USGS scientists characterized the composition of insect assemblages 3-15 years after wildfire and post-fire seeding in sagebrush-steppe habitats in southwestern Idaho and compared the diversity and abundance of insect families among three treatments: burned and seeded, burned and unseeded, and unburned. They captured and identified over 40,000 individual insects from 204 insect families. Researchers found that the composition of insect assemblages varied by treatment, particularly between burned and unburned plots, and insects were responding to differences in vegetation after wildfire, especially the reduction in shrub cover. However, insect communities were also influenced by vegetation differences between burned plots that had been seeded and that were allowed to recover without treatment. These differences were subtle and appear to have been influenced by factors such as increased forb density in seeded plots. These findings suggest that wildfire and post-fire seeding can have long-lasting (at least up to 15 years) effects on insect communities in sagebrush-steppe habitats; the implications for insect pollination, herbivory, prey resources for other wildlife, and ecosystem services are unknown but warrant further study.

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Wildfire Effects on Sage-grouse: A Before and After Case Study

In 2012, a large wildfire burned more than 300,000 acres of priority sage-grouse habitat in northeastern California and northwestern Nevada. The burned area was considered the core of the remaining sage-grouse population in northern California. Beginning in the fall of 2014, the USGS used this opportunity to implement a study to compare post-fire vital rates, resource utilization, and genetics to the same measures estimated in the same area before the fire. Results from this study will increase ecological understanding of how sage-grouse respond demographically and spatially to wildfire, and will help land managers better evaluate the efficacy of post-fire actions designed to restore sagebrush habitat and restore ecosystem services.

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Post-Fire Recovery of Sagebrush Steppe Ecosystems in the Northern Columbia Basin

The historical extent of sagebrush ecosystems in the northern Columbia Basin (NCB) of Washington has been greatly reduced since Euro-American settlement, and remaining patches are typically isolated and highly fragmented. Yet these remaining patches are critical to sagebrush-obligate fauna in the region, including the sage-grouse and the sharp-tailed grouse. However, the historical role of fire in sagebrush ecosystems is poorly understood, in part because evidence of past fire events is transient or difficult to detect. Moreover, little fire research has been conducted in sagebrush habitat of the NCB, such that land managers may have to rely on research from more distant regions of the sagebrush biome, not all of which may be ecologically applicable. Thus, a regional-scale fire ecology assessment should help land managers in the NCB carry out effective management and restoration activities. The USGS is quantifying and characterizing post-fire recovery and successional trends in the sagebrush-steppe of the NCB. Specifically, we are investigating how time-since-fire, climate, edaphic conditions, and land use affect rates of post-fire recovery in sagebrush systems, with a focus on sagebrush characteristics (e.g., density, age) and plant species composition. This information should help land managers better understand restoration potential after fire in these ecosystems.

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Plant Community Composition and Vegetation Structure in Core Sage-grouse Habitats

The composition and abundance of plant species in sagebrush ecosystems are important habitat attributes for sage-grouse; however, the combined effects of altered disturbance regimes (notably fire) and biological invasions (notably cheatgrass) are impacting plant community dynamics, and these effects are anticipated to accelerate with warmer climatic conditions. The goal of this project is to understand how these interacting change agents may influence plant community dynamics in core sage-grouse habitat areas. The USGS and university collaborators are working to integrate field measurements of plant community structure and soil conditions with ecological simulation models to assess the influence of changing climate and disturbance regimes on the plant species composition and vegetation structure of sagebrush-dominated ecosystems.

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Assessing the Future of Sagebrush Ecosystems

Sagebrush directly acquires water from the soil, and altered patterns of available soil moisture because of climate change may influence the health and distribution of sagebrush ecosystems. The goal of this project is to characterize the ecohydrological conditions that support sagebrush ecosystems, identify how those conditions will change in the future, and assess the range-wide potential impacts for sage-grouse habitat. In collaboration with university scientists, USGS is working to 1) quantify how climate change may impact areas suitable to support sagebrush, 2) understand the controls over sagebrush regeneration (a key limiting life stage for sagebrush), 3) describe uncertainty in species distribution models, and 4) improve the quality and usability of models that identify future suitable sagebrush extent.

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Publications: *Future regeneration of big sagebrush support predicted changes in habitat suitability at trailing and leading edges: Ecosphere (2015), http://bit.ly/1vVoqOd.*

Modeling regeneration responses of big sagebrush (Artemisia tridentata) to abiotic conditions: Ecological Modeling (2014), http://bit.ly/1qCqwfX

Effects of ecohydrological variables on current and future ranges, local suitability patterns, and model accuracy in big sagebrush: Ecography (2012), http://bit.ly/Wmib4Q

S. Hanser, USGS

Sagebrush Responses to Climate: Experiments to Inform Vulnerability Assessments and Restoration Practices

Sagebrush occupies a wide geographic and climate range in the western United States, and its responses to climate shifts likely vary across latitudes, elevations, and sagebrush types. The USGS has established an array of long-term, experimental climate manipulations across the Snake River Plain Ecoregion, and the outcomes are useful in assessing habitat change for greater sage-grouse. Experimental warming effects are being evaluated in sites ranging from low sagebrush of pristine basins in Grand Teton National Park to disturbed and invaded sites in southwest Idaho. Treatments also include long-term manipulations of snow or rainfall, with and without the presence of exotic or introduced grasses.

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Effects of Spring Livestock Grazing on Greater Sage-grouse

Cattle grazing may be the most common land use within sage-grouse nesting habitat. The project will quantify the effects of spring cattle grazing on sage-grouse. The USGS is working with university and agency collaborators to conduct landscape-scale experiments to evaluate the effects of different levels of spring cattle grazing on survival, habitat selection, and reproductive traits of greater sage-grouse. This is intended to be a 10-year study with replicate study sites across Idaho. At each study site, we are selecting 3 pastures on BLM grazing allotments that will receive one of 3 grazing treatments: zero spring cattle grazing, 20-40% grass off-take, and 40-60% grass off-take. We will also measure the effects of different grazing intensities on vegetation (sage-grouse habitat features) and arthropod abundance.

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Perennial Grass Response to Post-Fire Grazing Management in the Great Basin

Perennial grasses are a vital component of a functioning sagebrush ecosystem and an important source of food for grazing cattle. In the event of a wildfire, burned perennial grasses need time to recover, but when are perennial grasses stable enough to accommodate grazing again? USGS has initiated a new study to investigate this question. The researchers will study seasonal timing of grazing after fires and the length of grazing rest after fire to determine how these factors affect perennial grass recovery. In addition, they will examine the length of grazing rest after post-fire seeding to determine any impacts on seedling establishment and growth. Results can aid recommendations for post-fire management of livestock grazing when rehabilitation of resilient sagebrush-steppe habitat is the focus. Findings could also guide post-fire grazing management on lands that provide critical sage-grouse habitat.

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S. Shaff, USGS

Decision Analysis

Conservation Buffer Distance Estimates for Greater Sage-grouse

Conservation measures within specified distances (i.e., buffer distances) around sage-grouse leks have been developed by land managers to reduce the impacts of human land use on greater sage-grouse populations. Across the range of greater sage-grouse, a wide variety of buffer distances have been posed in the literature and by managers as appropriate for providing protections for the species and implementing conservation measures. Providing a common reference for sage-grouse can help decision-makers make informed land management decisions about buffer distances. The USGS summarized the published scientific literature on estimates of buffer distances or disturbance thresholds for greater sage-grouse associated with categories of land use or disturbance that are typically found in land management plans. For each land-use category, USGS provided a minimum and maximum buffer distance found in the literature, and a scientific range of possible buffer distances. The buffer distances provide a consistent framework for use in the development of conservation measures and provided the basis for the BLM Resource Management Plan revisions in the West. When taken into context with other factors, such as local or regional conditions, habitat quality, or the cumulative effects of conservation and management actions, this can be a powerful tool to help inform management actions across the range of greater sage-grouse.

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Publication: *Conservation buffer distance estimates for Greater Sage-Grouse: a review: USGS Open-File Report (2014), http://pubs.er.usgs.gov/publication/ofr20141239*

Conservation Efforts Database

The Conservation Efforts Database (CED; conservationefforts.org) is a partnership between the USGS and USFWS to efficiently and effectively collect and analyze ongoing conservation efforts for the greater sage-grouse. Understanding the distribution and type of conservation actions happening across the landscape will allow visualization and quantification of the extent to which threats are being addressed. The CED is capable of 1) allowing users to enter data from different locations, 2) storing documents, 3) linking conservation actions to one or more threats, 4) reporting documentation and summaries of the conservation actions at multiple scales, and 5) accounting for actions at multiple scales from small easements to state-wide planning efforts.

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