

Case Study

Participatory research in sage-grouse local working groups: case studies from Utah

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Abstract: Across the range of greater sage-grouse (*Centrocercus urophasianus*; sage-grouse), collaborative groups focused on local-scale sage-grouse management, known as local working groups (LWGs), have been a core component of state-level efforts toward conservation of this species. In Utah, LWGs have been highly involved in designing and implementing the research that forms the body of knowledge upon which sage-grouse management decisions are made in the state. The LWG process encourages participatory research involving a wide array of interested stakeholders, including university scientists. Utah's LWGs are facilitated by Utah State University Extension faculty and staff. These personnel provide support for securing research funding, implementation, and analysis, as well as fostering communication among numerous partners around the state. We highlight 4 case studies to demonstrate how the LWGs facilitate both participatory research and resource management informed by science. The research completed through the LWGs has influenced—and been influenced by—on-the-ground management needs of the species, has fostered community support for sage-grouse conservation management actions, and has helped shape Utah's state-level sage-grouse management policy.

Key words: adaptive resource management, *Centrocercus urophasianus*, collaboration, greater sage-grouse, management, participatory research, stakeholders, Utah

MANAGING LARGE NATURAL SYSTEMS for conservation goals is a complicated endeavor, with competing political interests and multiple management jurisdictions adding to already complex ecosystem management challenges (Duvall et al. 2017). Additional challenges come because although responsible management should ideally embrace scientific principles, the traditional scientific process can be disconnected from the local-scale needs of on-the-ground natural resource managers (Sands et al. 2012). Examples of this disconnect include mismatches between research funding availability and on-the-ground knowledge needs, or lack of communication between researchers and wildlife managers. In addition, understanding and managing complex social-ecological systems to meet conservation objectives also requires collaboration among researchers, managers, and other community stakeholders (Riley et al. 2012, Susskind et al. 2012).

Participatory research in a collaborative context is a way to address these myriad challenges. It can provide a process for gathering scientific information at scales appropriate for local management needs. It is also a way to involve more voices in the decisions about questions to ask, considerations in research design, and how the knowledge will be used (Shirk et al. 2012). For these reasons, participatory research has increasingly become a goal for collaborative natural resource management groups (Fernandez-Gimenez et al. 2008).

The term participatory research has been used to refer to a wide variety of endeavors, from active data gathering by collaborative group participants and citizen science projects to joint report writing after literature reviews and gathering of existing knowledge (Shirk et al. 2012). Participatory research takes many forms, according to the needs of the situation, the composition of the group, and many other

factors (Shirk et al. 2012). Combined with an adaptive management approach, wherein the results of research are directly used to learn how to better manage natural resources, participatory research has the potential to meet the learning and application needs of a much wider array of resource management challenges (Fernandez-Gimenez et al. 2008, Williams and Brown 2016).

Many collaborative groups from around the United States and world have begun to explore the advantages of doing research in a more public, participatory way (Leong et al. 2012, Shirk et al. 2012). An advantage to this approach is that it allows groups of stakeholders to manage local resources in an adaptive fashion, gaining knowledge themselves, applying it on the ground via management actions, and then determining what additional information was learned from that experience (Williams and Brown 2016).

Over the last several decades, a tremendous amount of the avian conservation effort in western North America has focused on declines in populations of the greater sage-grouse (*Centrocercus urophasianus*; sage-grouse), a gallinaceous bird that inhabits sagebrush (*Artemisia* spp.) habitats in 11 western states and 2 Canadian provinces (Stiver et al. 2006). In numerous western states, sage-grouse local working groups (LWGs) emerged as a core component of efforts to address these population declines. The LWGs were created to ensure that a wide array of stakeholders could participate collaboratively in the conversations around sage-grouse conservation and management.

As of 2008, over 60 LWGs were operating across the western United States (Belton et al. 2009). Many of the groups that still exist in 2017 have been involved in the process of researching local sage-grouse populations and related topics, such as understanding threats to the species or responses to management actions (Beall and Zeoli 2008, Duvall et al. 2017). The LWGs in the state of Utah, which are facilitated by the Community-Based Conservation Program (CBCP) at Utah State University (USU), have become particularly involved in these types of efforts.

Because each location and natural resource challenge brings its own complexity, every effort to do scientific research in a participatory way has a different story. In this paper, we

describe Utah's sage-grouse LWG involvement in participatory research and subsequent management strategies. Sage-grouse in Utah are managed by the Utah Division of Wildlife Resources (UDWR) as an upland game species as well as a state-sensitive species. Utah supports an estimated 6.8% of the range-wide greater sage-grouse population (Western Association of Fish and Wildlife Agencies 2015).

Utah has had active sage-grouse LWGs for >20 years, since USU Wildlife Extension began organizing regional groups of agricultural producers, wildlife biologists, extension agents, federal agency representatives, and others interested in the situation with local sage-grouse. The involvement of LWGs in research activities resembles the Shirk et al. (2012) classification of "co-created," wherein "public participants interact with scientists through public participation in scientific research" to "develop a study and work with input from scientists to address a question of interest or an issue of concern" (Shirk et al. 2012). In essence, the LWGs involve local stakeholders in identifying research needs, assisting with research implementation, and then applying that learning to resource management. University scientists are key participants, along with federal and state agencies, county offices, landowners, school children, livestock operators, private NGOs, industry, grazing associations, legislators, and many others. Here we provide a description of the LWG process as implemented in Utah using 4 case studies to highlight the potential conservation benefits of participatory research. We emphasize the importance of: 1) including a diversity of stakeholders, 2) involving stakeholders throughout the research process, and 3) communicating and implementing the results.

These case studies are intended to provide information for other practitioners on the variety of implementation scenarios for engaging collaborative group members in this form of participatory research. Many of the peer-reviewed publications that emerge from this research specifically address on-the-ground conservation and management results. This manuscript focuses on the processes behind LWG research partnerships.

The data that informs this paper came from the observations and experiences of 3

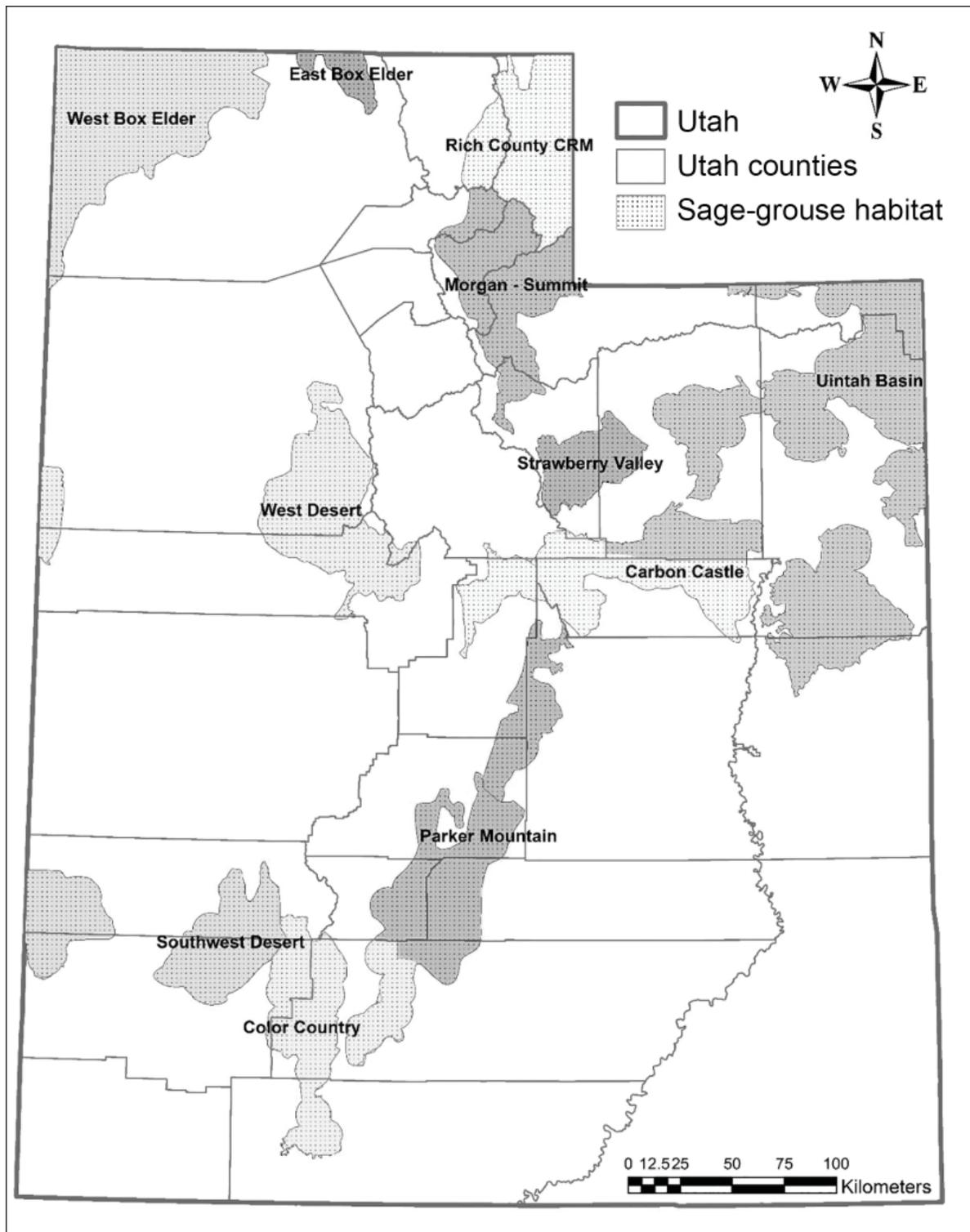


Figure 1. Greater sage-grouse (*Centrocercus urophasianus*) habitat and corresponding local working groups in Utah, 2017.

CBCP facilitators. Two of the contributors are biologists with doctoral degrees in ecology or wildlife sciences; the third has a background in conservation biology and a graduate degree in sociology. All facilitate sage-grouse LWGs in Utah; therefore, their assessments have

inherent bias. Their observations, however, provide insight into how the research projects undertaken by Utah's LWGs have contributed to sage-grouse conservation in the state.

In Utah, sage-grouse populations are distributed throughout the state and occupy

sagebrush habitat areas that are discontinuous, largely due to the natural topography of Utah (Figure 1). The largest populations are found in Box Elder County (northwestern Utah), Uintah County and Rich County (northeastern Utah), and on Parker Mountain (south-central Utah). Other smaller populations are dispersed around the state. Each sage-grouse population is associated with one of 11 LWGs (Figure 1). Although statewide land ownership in Utah is predominantly federal, private lands in the state provide approximately 50% of the current habitat for sage-grouse populations (Dahlgren et al. 2016a). We highlight 4 LWGs distributed across the state.

Parker Mountain

The Parker Mountain is a large, contiguous section of high-altitude sagebrush habitat in south-central Utah. The area supports grazing of both domestic sheep (*Ovis aries*) and cattle (*Bos spp.*), and exhibits one of the most robust populations of sage-grouse in Utah. It is largely undeveloped and very rural.

Stakeholder involvement

The Parker Mountain LWG was the first Utah LWG to engage local stakeholders in research efforts. The group consists of representatives of the UDWR and Utah School and Institutional Trust Lands Administration (SITLA); federal agencies such as the U.S. Forest Service (USFS), the Natural Resources Conservation Service (NRCS), and the U.S. Fish and Wildlife Service (USFWS); and USU Extension county agricultural agents, county commissioners, and local agricultural producers, including members of a relatively large private grazing association.

Question formation and implementation

During the first meeting, the Parker Mountain LWG participants determined that although they would like to take actions to help sage-grouse in the area, they needed more information about local sage-grouse populations before any management changes could be designed to help the birds. Thus began the first very high frequency (VHF) radio-telemetry study of sage-grouse on Parker Mountain. As research was conducted, and more questions formulated, the group decided to study sage-grouse response to vegetation treatments. Group members

had witnessed the effects of sagebrush canopy cover reduction on understory vegetation from various chemical and mechanical treatments in other areas and desired to know the impacts of these methods on sage-grouse habitat selection and vital rates on Parker Mountain (Dahlgren et al. 2006). The first experiments involved testing 2 mechanical treatments (Dixie harrow and Lawson aerator) and a chemical treatment (Tebuthiuron/Spike 20P, N-(5-(1,1-dimethylethyl)-(5-14C)-1,3,4-thiadiazol-2-yl)-N,N-dimethylurea; Dow AgroSciences, Indianapolis, Indiana, USA; Figure 2). Later, group members also wanted to see if livestock, in particular domestic sheep, could be used to manipulate sagebrush canopy cover to enhance the herbaceous understory (Guttery 2011).

Funding for the first VHF radio-transmitters and research was provided by the local Parker Mountain Grazing Association. These funds were matched by other LWG partners. Researchers from USU, including graduate students, conducted the research. Local LWG members were involved in many other aspects of the research: they helped capture sage-grouse and deploy transmitters, secure housing for student researchers, and conduct annual lek counts. They also assisted in setting up treatment plots and grazing exclosures. Additional funding obtained through the NRCS Environmental Quality Incentives Program (EQIP) was instrumental in providing support for the early experimental treatments.

Communicating and implementing the results

Following each phase of each research project, the LWG met to discuss the findings and jointly plan the next steps. Research results were presented regularly to the LWG meetings and eventually published in scientific journals to create a literature base for managers in southern Utah. Sagebrush mechanical and chemical treatments were shown to be effective, especially Tebuthiuron treated plots, at reducing sagebrush canopy cover and increasing herbaceous understory (Dahlgren et al. 2006, Dulfon 2016). Sage-grouse monitoring (i.e., pellet counts and dog surveys) found the highest sage-grouse habitat selection to be in Tebuthiuron-treated plots. Information from this small-scale (40 ha) experiment was used by UDWR, the Bureau

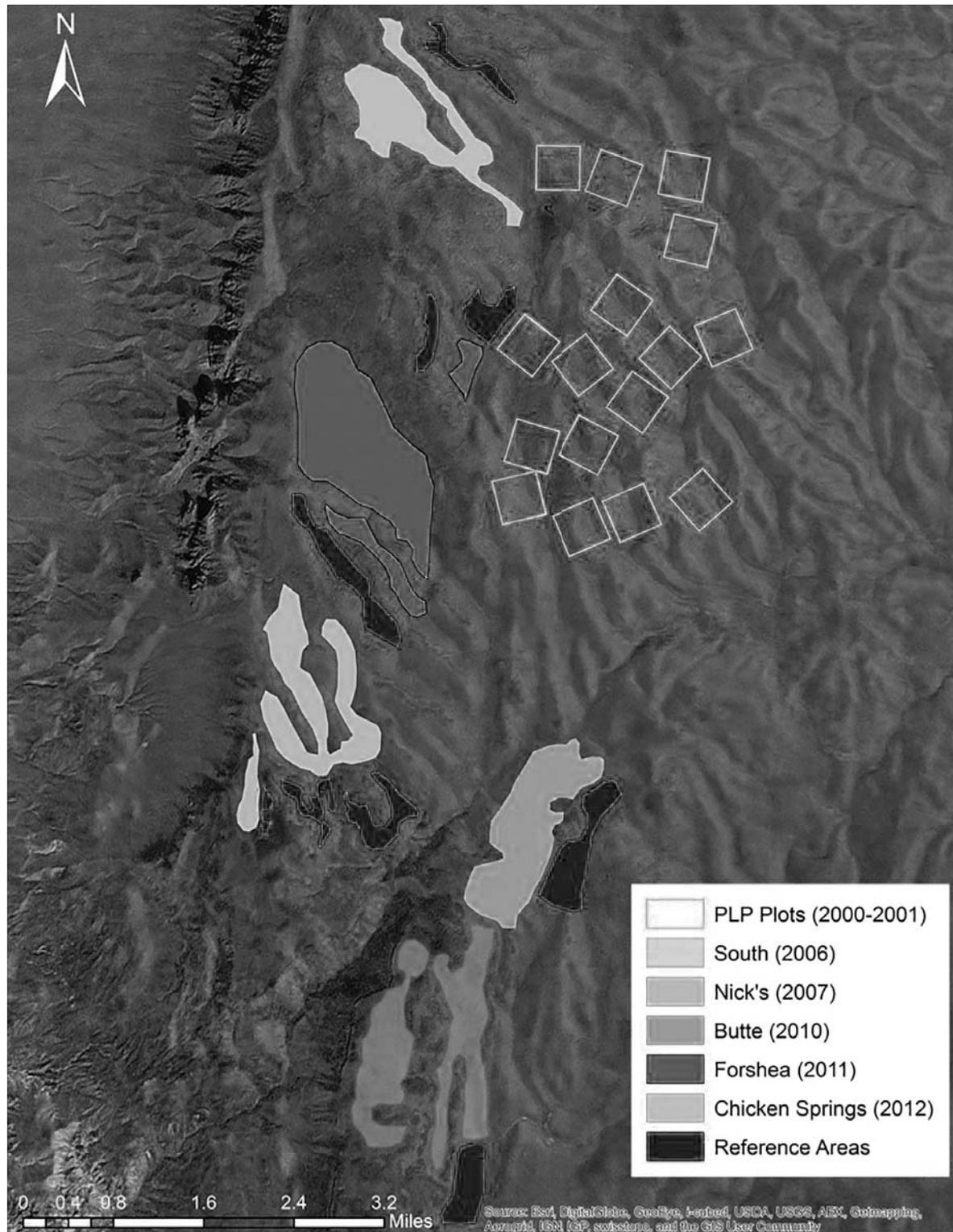


Figure 2. The experimental design for sagebrush (*Artemisia spp.*) treatment areas implemented to benefit greater sage-grouse (*Centrocercus urophasianus*) populations on Parker Mountain Sage-grouse Management Area, located in southcentral Utah, 2000–2012. Parker Lake Pasture (PLP) 40.5-ha square plots are outlined. The higher elevation treatment (Tebuthiuron) and reference areas (the irregular polygons) are referenced by the name of the pasture they fell within, and the year of treatment implementation is included in parentheses.

of Land Management (BLM), and USFS in an adaptive management process to treat larger (i.e., ≥ 200 ha) brooding areas with Tebuthiuron to enhance brooding habitat through increased herbaceous understory and to improve livestock forage in these same areas (Figure 2).

Additional experiments using domestic sheep were conducted to determine if grazing could be used to reduce the sagebrush canopy cover and stimulate herbaceous understory cover following treatment (Guttery 2011). The sagebrush canopy browsed by sheep recovered much faster than chemical or mechanical treatments. Sage-grouse also preferred the sheep-browsed plot over unbrowsed control plots (Guttery 2011). Researchers subsequently suggested that a management plan that rotated sheep herds around summer brooding habitats in the fall could provide a mosaic of different-aged stands of sagebrush and herbaceous understory with varying stages of recovery. The grazing association is considering shifting their pattern of sheep grazing to improve the mosaic of sagebrush on Parker Mountain.

The Parker Mountain LWG has used adaptive management principles to help implement habitat management within the resource area. The research and management approach of the LWGs evolved from telemetry-based research on sage-grouse and measuring habitat characteristics at use sites to small-scale habitat management in experimental designs, learning from monitoring plots to larger-scale management actions to improve habitat and livestock forage (Dulfon 2016). Using scientific-data-driven information to guide management has been a key to the collaborative work of the Parker Mountain LWG, including habitat improvement projects.

West Desert

The West Desert LWG is located west of the Salt Lake City metropolitan area. The area is on the drier fringes of sage-grouse habitat in Utah, in an area heavily impacted by dispersed recreational use. Land ownership is a patchwork of private, state, and federal ownership. Fires and cheatgrass (*Bromus tectorum*) are substantial concerns in the area.

Stakeholder involvement

Participants in the West Desert LWG come from a wide array of public and private stakeholders.

The UDWR, BLM, USFS, and NRCS are represented. Representatives from state grazing and recreation agencies, several conservation districts, counties (i.e., elected commissioners, weed and trails managers), Native American tribes, project contractors, and local military installations also participate. Scientists from USU, including graduate students, are also very involved.

Question formation and implementation

The sage-grouse population—as determined by spring 2015 lek counts in the area—was in decline. Populations in the area had continued a downward trend when other populations around the state began a cyclic upswing (Chelak and Messmer 2016). The LWG held several brainstorming sessions to better understand and hopefully develop a plan to reverse the decline. Although a study from nearly a decade before had established key baseline information on population size, vital rates, and habitat use (Robinson and Messmer 2013), no research had been conducted by the West Desert LWG since 2007.

The group had anecdotal information about a long list of possible threats to sage-grouse in the area (Robinson and Messmer 2013). Conifer encroachment into sagebrush areas, increased fire risk due to cheatgrass invasion, concern over unmanaged recreation use in key sage-grouse areas, predation from ravens (*Corvus corax*) and red fox (*Vulpes vulpes*), poaching, and loss or degradation of wet areas (such as wet meadows, springs, and riparian areas important to early-brood-rearing habitat needs) were among the concerns articulated by the group. A complete understanding of this complex set of factors seemed impossible, but the group felt that new research was critical to understand what was happening.

During discussions of how to save the population from disappearing before research could be finished, a key question arose: can we bring sage-grouse from somewhere else to augment the population? This idea gained traction and became a core element of the research and conservation efforts. The LWG, aided by USU biologists, proposed a multi-year translocation project to bring sage-grouse from 2 other areas in Utah with stable populations, track sage-grouse survival and reproduction,

and use bird movement data to better understand how sage-grouse react to habitat projects, fires, and possibly recreation activities (Chelak and Messmer 2016). Based on state- and federal-level commitments to conserve sage-grouse in the area, funding was secured from multiple partners to fund the translocations and associated research. Local working group support for the research was an important factor in gaining funding support from upper levels of many of those agencies.

The LWG has continued to play an important role in implementing the research. During the first year of the study, day-to-day information on the seasonal accessibility of local leks designated for the release of translocated birds proved critical to knowing where releases would be most feasible. Many individuals from the LWG also participated in the manpower-heavy trapping, driving, and releasing nights. Organized by the graduate student for the project, volunteers helped trap, weigh, measure, collar, transport, and release the radio-marked sage-grouse (Chelak and Messmer 2016).

Communicating and implementing the results

The LWG and funding partners take an active role in reviewing preliminary data and asking questions to continue to direct the research inquiry. The West Desert LWG had access to information generated from research being conducted by another LWG, the West Box Elder LWG in northwestern Utah. Research completed there had recently established the value of conifer removal for sage-grouse habitat improvement (Sandford et al. 2015, Sandford et al. 2017). Therefore, in addition to discussions about the need to monitor the population trends more closely, the LWG shifted conifer removal project planning into high gear. Project areas were identified based on understandings of sage-grouse movements at that moment in time, with the expectation that research findings could help identify corridors or higher-priority project areas. Once research was underway and initial movement patterns by sage-grouse marked with global positioning system (GPS) transmitters were shown to the group, habitat managers from multiple agencies began using this information to adjust the design for existing conifer removal

projects (Chelak and Messmer 2016). Projects were focused on important corridors used by resident birds to move between winter and summer habitats. These changes were made based on preliminary data, as no peer-reviewed publications were available due to the project being only partially complete at the time.

Several additional actions were taken by managers involved in the group, directly related to the conversations around the research. For example, the LWG was aware that for the translocations to be successful, a more aggressive predation management program would be needed (Baxter et al. 2013, Robinson and Messmer 2013). Therefore, processes to increase predator management efficiency were implemented before the research had even been funded. In addition, because of the GPS radio-marked sage-grouse, the LWG was also able to observe how sage-grouse responded to an unexpected fire in the area in 2016, which helped inform discussions of how best to rehabilitate the area. Once the research was started, the LWG still had questions about recreation impacts on sage-grouse. The research plan for subsequent years was adapted to include methods to assess potential relationships between recreation and sage-grouse habitat use or movements.

In addition to the sage-grouse-specific data being gathered in the West Desert LWG area, a separate research project is being implemented in the area to explore the impact of conifer removal on water resources, which is believed to be locally important for sage-grouse habitat quality (Robinson and Messmer 2013). The LWG moved easily from discussions about research being conducted on bird movements to helping in the preliminary design phases of the conifer/water study (Chelak and Messmer 2016). Local ranchers provided insight into water storage and dynamics locally, agency staff inquired about instrumentation, and everyone appreciated the opportunity to add value to research that would help paint the larger picture of the many interacting factors in the complex West Desert environment. As of the writing of this manuscript, the multi-year study has been funded and instrumentation of key watersheds is in process. Although the 2 research projects are separately designed and conducted, they both contribute to a broader understanding that the working group will use

in the future to inform project decisions.

Morgan-Summit

The Morgan-Summit LWG encompasses a large area of primarily private land in the high-elevation northern part of Utah, near the border with Wyoming. The Morgan-Summit area has the best known and most accessible sage-grouse lek in Utah. Sage-grouse males strut on private land immediately next to (and frequently in the middle of) a state highway (Figure 3).

Stakeholder involvement

Because the Morgan-Summit LWG is primarily private land, the participants differ somewhat from other groups in the state. Representatives from NRCS and nonprofit land trusts, who work with local landowners on land conservation issues, are key to the group. County representatives, such as planning staff, are also involved, as the pressures of housing development are a concern for sage-grouse in the area. The UDWR employees and interested landowners, as well as occasional environmental representatives, also attend meetings.

Question formation and implementation

The working group was interested in how to support and enhance the sage-grouse population in the area but lacked detailed information to do so. The local sage-grouse population was anecdotally known to stay in a small local area and be non-migratory. Local leks were relatively well known to local ranchers and landowners but had not been formally researched beyond annual lek counts (Flack and Messmer 2015). Because projects designed to improve habitat for sage-grouse rely on knowing how sage-grouse use the area (either as winter or summer habitat, but generally not both), the LWG was cautious and had not proposed projects. They were unsure of how dependent the local populations were on the small areas they frequented. The group was also interested to understand the degree to which the small, apparently insular populations were dependent on key parcels of private ground. This information was needed to better understand the potential impacts of development or value of particular conservation easements. Most of the questions from the group involved basic bird movement patterns and population vital rates on what appeared to be a



Figure 3. The Morgan-Summit area has the best-known and most accessible greater sage-grouse (*Centrocercus urophasianus*; sage-grouse) lek in Utah. Sage-grouse males strut on private land immediately next to (and frequently in the middle of) a state highway (photo courtesy of B. Flack).

spatially isolated landscape.

Despite the high level of interest of the LWG in having more data, the urgency of funding research was low. Because the area occupied by the sage-grouse was largely private land, no federal funds were available to study the birds. Over the course of years, a compilation of funding sources finally provided sufficient funds for a 2-year study of the local populations. Funding partners included Summit County, UDWR, Jack H. Berryman Institute, a local grazing cooperative that contributed in-kind effort of a fixed-wing aircraft to assist in locating radio-marked sage-grouse, and mitigation funding from the Kern River Corporation pipeline going through the area. Housing was provided for the researchers at a local state park, reducing the overall project costs. Local landowners were key partners in the research efforts, as permission to access each parcel of land was critical to the ability of the researchers to conduct their research.

Communicating and implementing the results

At each LWG meeting during the research project, the graduate student provided updates about bird movements and nesting success, as well as any logistical or social challenges encountered (Flack and Messmer 2015). As needed, the LWG provided assistance in resolving questions. The research was also presented at special events for local landowners, who rarely attended LWG meetings but were

interested in the research findings.

Because the Morgan-Summit LWG did not have any ongoing projects to be adjusted based on the data, the discussions at meetings focused on the potential meaning of initial data, and possible actions that might be taken long term based on the new knowledge. For example, understanding the very insular nature of the populations, which spent the majority of the year in very small pockets surrounding each lek, helped the group understand how development might potentially impact certain groups of birds. The movement of several collared sage-grouse to a particular parcel of state-owned land prompted important discussions about the future of that parcel, informed by sage-grouse and other wildlife and economic data.

Naturally, the data generated many follow-up questions, for which there was unfortunately not additional research funding. For example, the LWG remains interested in the highly localized behavior of the birds, hoping to someday conduct research on vegetation in areas used and not used by them to understand whether changes to vegetation might encourage them to expand the areas they used. The data may also prove helpful for the local land trusts, who now have additional information that can help focus funding for local conservation easements.

Color Country

The Color Country LWG in southern Utah is home to the southernmost sage-grouse population in North America (Frey et al. 2013). Within the working group area is an active, locally owned coal mine that provides jobs to sustain a rural economy. Thus, a dominant topic of LWG conversation was the effects of a surface coal mine on the local sage-grouse population. The LWG, which includes representatives from the coal mine, has worked to understand the impacts of the mine, as well as the success of habitat mitigation work, on the birds in the area (Frey et al. 2013).

Stakeholder involvement

To develop the LWG conservation plan, regularly scheduled open houses, in addition to inviting targeted stakeholders, helped identify where stakeholders had seen sage-grouse, what the community believed were the limiting issues for sage-grouse in the area, and what the

LWG could do about these issues. During the plan formulation, meetings included agency representatives from the BLM, USFS, Grand Staircase Escalante National Monument, UDWR, NRCS, Utah Farm Bureau Federation, USFWS, county commissioners and representatives, USU Extension county agricultural agents, local county residents, and the facilitator. Once the plan was completed in 2006, local residents who no longer attended meetings regularly chose to have the NRCS and county representatives voice their concerns.

In 2008, members of Alton Coal Development (ACD) began attending meetings regularly, in advance of the operation of their coal mine on private land. The intent of their participation was to have the assistance of the local working group in developing and implementing mitigation actions before land disturbance began. Involvement from researchers at Brigham Young University was also a key element of LWG participatory research efforts.

Question formation and implementation

Beginning in 2009, the group began to contemplate the scheduled coal mine activities. Several questions emerged, including: 1) can habitat mitigation succeed in advance of scheduled mining activities to provide areas of refuge prior to displacement, 2) will sage-grouse avoid the area surrounding the mine, and 3) will sage-grouse return to a lek location once it has been reclaimed? Members of the LWG had already collaborated on a project prior to the initiation of the mine; therefore, there was knowledge of habitat use and movement patterns prior to this new disturbance.

To investigate the response of sage-grouse to mining activities, a project was funded by the BLM and ACD to use satellite GPS telemetry to monitor sage-grouse in the area. This project was managed by the LWG facilitator (a USU wildlife biologist) with direct input from the members of the group. This project began in 2014 and is projected to continue until 2021. While USU, the BLM, and ACD had direct responsibility to design the project, all aspects were discussed with the LWG at the regularly scheduled meetings.

For example, because the sage-grouse population was small (10–12 attending males) and might be sensitive to any additional

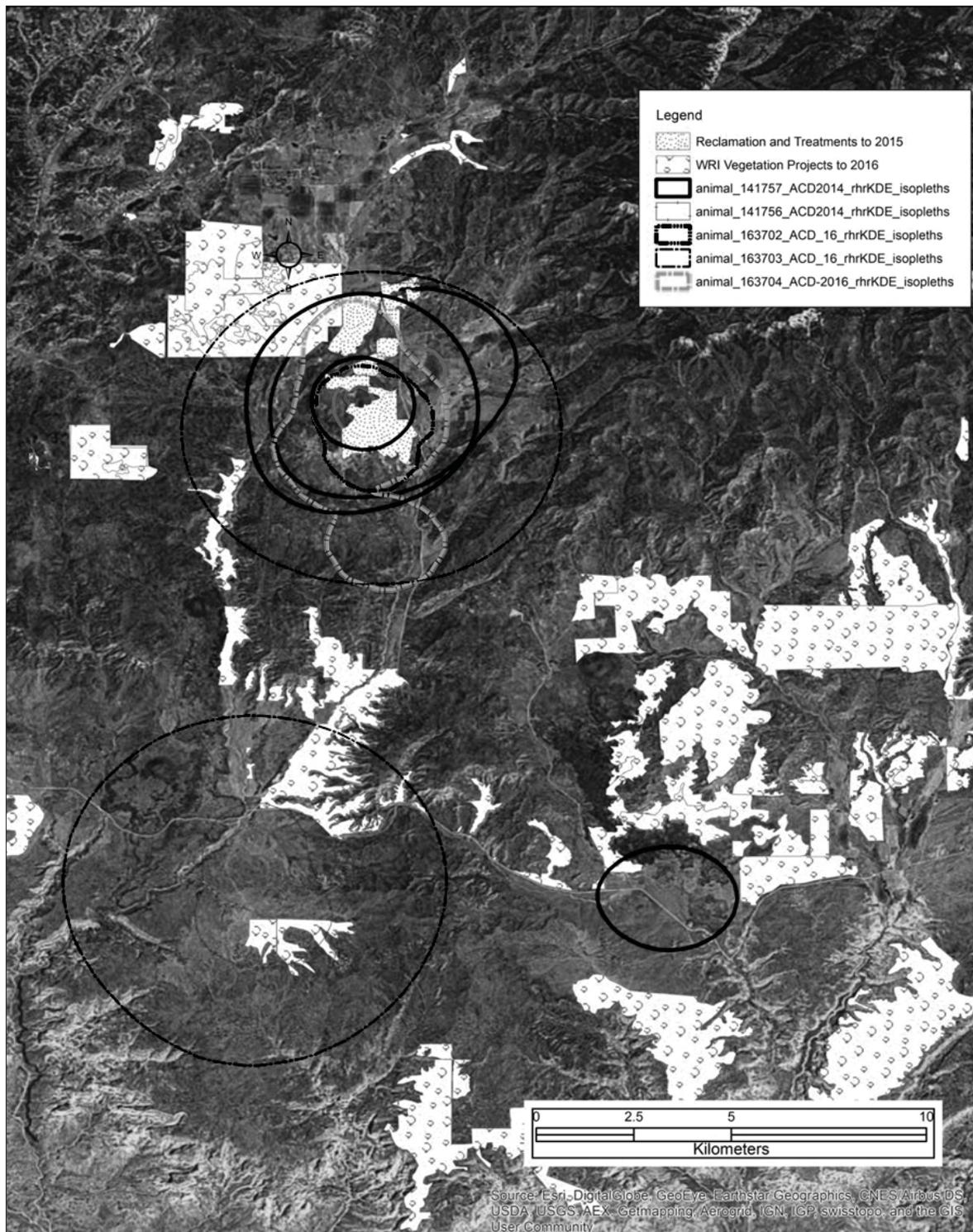


Figure 4. Greater sage-grouse (*Centrocercus urophasianus*; sage-grouse) radio-telemetry locations in Panguitch Sage-grouse Management Area relative to Utah Department of Natural Resource's Watershed Restoration Initiative habitat treatment projects and Alton Coal Development Reclamation Projects, Sink Valley, located in southwestern Utah, 2014–2016. This population is the southernmost sage-grouse population in North America.

disturbance, the LWG decided it was best to start with a small sample size of just 4–5 birds, consisting of at least 2 males and 2 females. They decided to study both sexes because it

had been previously shown that the males travelled farther and more often than the females; however, they were interested in the recruitment of sage-grouse in the area as well.

Members of the LWG volunteered to trap sage-grouse to initiate the project, as well as for each subsequent trapping event (Figure 4).

Communicating and implementing the results

Although data are still being collected, the first few years of data were illuminating for the group. At each meeting, a summary of the last 3 months of data was presented to the group. Additionally, an interim report has been disseminated to the group each year. The results of the first few years, combined with additional data collected by ADC, were reported by Petersen et al. (2016). These analyses suggested that habitat projects may mitigate mine disturbances to create alternate suitable habitat for sage-grouse (Figure 4). Within 5 years of the mining activity, sage-grouse had adapted to the strategic mining plan designed to have minimal impact (this included scheduling mining activity to minimize sound disturbance as well as strategically timing the mining that occurred adjacent to the lek).

Female grouse were recorded moving across the mining footprint with chicks. The data also confirmed connectivity of the Alton lek population to Hoyt's Ranch lek, 8 km to the north, which is also used by sage-grouse that visit several other leks in the area (Petersen et al. 2016). Furthermore, these data demonstrated that habitat treatments, including mitigation actions, improved a corridor for birds using winter habitat south of Alton and Sink Valley (Frey et al. 2013). Additionally, as with all LWG projects, research updates and outcomes were presented in the CBCP newsletter so that stakeholders statewide were aware of the research.

Working with the LWG; Utah Division of Oil, Gas, and Mining; and UDWR, the ACD used information obtained by the research to develop a mitigation plan for a potential new acquisition in the area (Figure 4). The mitigation plan and the location of off-site mitigation actions have been designed to increase sage-grouse habitat near the mining footprint. These data are also being used to revise the Environmental Impact Statement (EIS) and supplemental draft EIS of the mine for ACD application to lease BLM properties for coal extraction.

Outside of coal mining activities, the data collected by the LWG have been used to develop and guide projects to restore sagebrush

communities in the region. For example, the analysis of movement and spatial use patterns has highlighted areas where previous treatments have inadvertently created corridors for grouse to travel to new seasonal habitats, including winter habitats. Additionally, the analysis highlighted areas that were not used by sage-grouse during season migrations. These areas were subsequently proposed for projects by the BLM through the Utah Department of Natural Resources Watershed Restoration Initiative program, treated to remove trees or restore sagebrush understory, and now have documented use by the study population of sage-grouse (S. Frey, unpublished data).

Use of research beyond individual LWGs

The use of research data generated through the LWGs was not restricted to the local scale. It has also informed state- and federal-level planning efforts in ways that have made those plans more adapted to local resource conditions.

At the state level, the management plans for sage-grouse in the state of Utah have incorporated the data from the many years of research done through the LWGs. Plans written by the UDWR in 2002 and 2009 included sage-grouse population ecology and responses to management actions relevant to the geographically diverse populations of sage-grouse around the state. The plans include provisions for habitat protection, habitat improvement, sage-grouse population goals, and threat reduction measures. In 2013, an updated state plan, "Conservation of Greater Sage-grouse in Utah," was finalized after an extensive collaborative process by a task force appointed by Governor Gary Herbert (Utah Plan 2013). This plan, which is currently in effect as of this writing, used the LWG knowledge base of sage-grouse populations, local threats, and local management solutions as a key foundation. There also appears to be a relatively high level of trust throughout relevant agencies in the information used to build the current state plan, based on the many individuals who were involved in some way in the research that provides its scientific foundation.

Federal planning efforts by the BLM over a multi-year period also made substantial use of the high level of locally relevant sage-

grouse knowledge generated by participatory research from Utah LWGs. When the BLM was tasked to amend all relevant land-use plans across the range of sage-grouse to include additional conservation measures for the species, Utah BLM relied heavily on the LWG research data to understand in detail how sage-grouse populations in Utah move seasonally, what habitat they use, and what projects have helped or impacted populations, among other information (BLM 2015, Dahlgren et al. 2016b). During the BLM planning process, LWG facilitators and researcher participants were asked to provide the latest information to build the BLM plan. In addition, maps and projections were updated and corrected based on LWG information.

Discussion

The 4 case studies presented here showcase the diversity of participatory research efforts in sage-grouse LWGs and how that information has been used by local managers. The LWGs in Utah have completed a wide range of research on sage-grouse populations, their ecology, conservation threats, and actions that can mitigate threats to the species. From direct population research (Robinson and Messmer 2013, Caudill et al. 2016, Dahlgren et al. 2016b, and others) to responses of sage-grouse to habitat manipulations (Dahlgren et al. 2006, Frey et al. 2013, Sandford et al. 2015, Cook et al. 2017, Sandford et al. 2017, and others), livestock grazing (Dahlgren et al. 2015), predator management (Baxter et al. 2008), and translocations (Baxter et al. 2013, Gruber-Hadden et al. 2016, Duvuvuei et al. 2017) the groups have learned much of what they need to know to better manage greater sage-grouse in their local area.

Conducting research at a local level benefits the LWGs by providing detailed information on seasonal local movements of birds. This informs habitat management choices as projects are proposed and evaluated, clarity on threats to local sage-grouse populations, and baseline information on population dynamics that allow for greater long-term understanding of those populations. However, the research done at the LWG scale also has had benefits beyond the local areas where the research projects are conducted. Utah LWGs have capitalized upon

one another's research results. Two LWGs in the southern part of the state, for example, work together with datasets to propose and implement management projects that improved the connectivity of habitat between the 2 regions of the groups.

Additionally, research results reported by other LWGs around the state are often applicable to groups with similar landscapes, similar threats to sage-grouse, or similar project goals. With the university program as a hub for the groups, research results and management suggestions are accessible to LWGs throughout the state. In addition to providing access to existing research, the structure also provides motivation for new work. Momentum for additional research and management projects has come from LWGs that learned of research done by other LWGs, inspiring them to work together to identify management questions, funding sources, and ways group participants can assist with implementation and analysis of their own projects.

The participatory nature of the research conducted in LWGs has generated more than just scientific data on sage-grouse and their habitat. The process of participating in research has been a learning experience for everyone involved. Asking questions that are researchable, relevant, of manageable scope, and fundable is as much art as science, and in a collaborative group setting, it may be even more complex (Long et al. 2016). It involves participation in conversations about what is already known, what might be additionally relevant, and what questions might be asked to determine how better to support or recover sage-grouse populations locally. The involvement of multiple stakeholders, from agency personnel to landowners, provides an opportunity to learn from many individuals with different information, experiences, and perspectives. The research and discussion process has improved the questions being asked, as well as helping to build trust and respect for other participants in the process. It has also blurred the line between scientists and other participants. A variety of individuals and organizations helped develop research questions and provide funding, expertise, manpower, equipment, and other in-kind assistance during the projects. This personal

involvement helps demystify the process of research and makes management choices based on that research more easily acceptable to and defensible by the diverse involved stakeholders (Leong et al. 2012).

There are several important caveats to the experiences of LWGs in Utah. First, undertaking such an effort to coordinate stakeholders, facilitate meetings, engage university researchers, and many other tasks associated with the basic infrastructure currently functioning in Utah is likely not within reach of most wildlife management situations. The scale of engagement in sage-grouse issues across the western United States, as reflected in Utah, is unprecedented and therefore may be difficult to use as a model. Second, research at this scale requires a large amount of funding. Sage-grouse conservation has been a regional western priority for many years, and state and federal funding has been available for work to understand the species that is generally not available to other wildlife. Thirdly, the translation of research projects into peer-reviewed literature, the standard format for validation of scientific results, normally requires the engagement of academia to some degree. The degree to which peer-reviewed literature has emerged from the LWG experience in Utah has relied heavily on particularly strong individual advocates and the funding available to them, which may also be difficult to replicate in other circumstances.

Conclusion

Despite the different experiences and research topics in each of the LWG case studies described above, there is evidence that the experience of participatory research has resulted in similar positive outcomes for the groups locally and for the broader knowledge of sage-grouse and related issues in Utah. At the basic level, the groups now have more applicable information about sage-grouse seasonal habitats, responses to habitat treatments, population fluctuations, and relationship to threats such as predation and tall structures. More broadly, each phase of participating in research helps promote trust in science, and trust in one another. It also helps build the sense of ownership of LWG participants in the research coming out of their group and others. Due to the many individuals involved, the LWG-generated

research in Utah has created a group of highly invested individuals whose connections to the communities and sage-grouse issue developed a cadre of committed resource managers familiar with the research, the groups, and the local issues. Although there are always more questions to be answered than there will be time or funding available to research, the history of LWG involvement in on-the-ground local sage-grouse research has created a groundswell of support for this kind of collaborative research work, which feeds into better informed resource management at many levels.

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