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Stakeholder contemporary knowledge needs regarding the potential effects of tall structures on sage-grouse

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Abstract: The U.S. Energy Policy Act of 2005 required all state and federal agencies to grant utilities access permits to promote reliable, renewable energy production and transmission. Contemporary transmission relies largely on above-ground electric transmission structures and lines. The construction, operation, and maintenance of tall structures, such as power lines, communication towers, wind turbines, and other installations and their associated activities in sage-grouse (*Centrocercus* spp.) habitats were identified as a conservation threat by the U.S. Fish and Wildlife Service in its decision to designate greater sage-grouse (*C. urophasianus*; hereafter, sage-grouse) as a candidate species for protection under the Endangered Species Act of 1973. The Greater Sage-grouse Range-wide Comprehensive Strategy identified a need to synthesize the research on the effects of tall structures on sage-grouse as the first step in a process to develop best management practices (BMPs) to minimize potential negative impacts on the species. The Utah Wildlife-in-Need Foundation (UWIN) facilitated a public input process in 2010 to assess stakeholder contemporary knowledge regarding the effects of tall structures on sage-grouse. Stakeholders reviewed published information to evaluate the scientific basis for the potential impacts of tall structures on sage-grouse. At the time of the UWIN review, stakeholders concluded that there were no peer-reviewed, experimental studies reported in the scientific literature that specifically documented increased avoidance or predation on sage-grouse because of the construction, operation, and maintenance of tall structures. Consequently, stakeholders were concerned that the science upon which tall structure siting decisions are based was lacking, and as a result, temporal and spatial setbacks and buffers stipulations may differ by governmental agency. Stakeholders recommended that research implemented to address their concerns include experimental designs that simultaneously address multiple knowledge gaps, include metrics assessing potential individual and cumulative impacts of each tall structure type, and a collaborative process that allows preliminary results to be implemented in an adaptive management approach to actively refine BMPs. Lastly, stakeholders recommended that industry be provided mitigation incentives as part of a comprehensive strategy to fund desired research. A review of the scientific literature regarding sage-grouse since completion of the 2010 review produced no new published information, but recent unpublished reports have begun to address the issue.

Key words: *Centrocercus urophasianus*, *Centrocercus minimus,* energy transmission, impacts, literature synthesis, power lines, research, greater sage-grouse, Gunnison sage-grouse, human–wildlife conflicts, stakeholder process, tall structures

The U.S. Energy Policy Act of 2005 required state and federal agencies to grant utilities access permits to promote reliable, renewable energy production and transmission (U.S. Department of Energy and the Interior 2008). Connelly et al. (2004) suggested that structures associated with energy transmission and development (e.g., power lines, communication towers, wind turbines, and other installations) and associated operation and maintenance activities in sage-grouse (*Centrocercus* spp.) habitat may impact the species. Knick et al. (2011) estimated that major power lines covered a minimum of 1,089 km^2 of all sagebrush within designated sage-grouse conservation areas (Knick and Connelly 2011). This estimate did not include smaller distribution lines in rural areas. The U.S. Fish and Wildlife Service (USFWS) recommended the use of various buffer distances between tall structures (Figure 1) and occupied sage-grouse habitats to mitigate any potential impacts (U.S. Fish and Wildlife Service 2003).

In 2005, the Western Association of Fish and Wildlife Agencies (WAFWA) convened the Greater sage-grouse (*C. urophasianus*; hereafter, sage-grouse) Range-wide Issues Forum (hereafter, Forum) to engage stakeholders in the identification of strategies to address species conservation issues identified by Connelly et al. (2004). Forum participants identified range-wide, sage-grouse issues that they believed would require coordination among local, state, provincial, and national governments to resolve as part of a range-wide greater sage-grouse conservation strategy (Stiver et al. 2006). One of the issues identified by the Forum was the effect of tall structures on sage-grouse. Forum participants defined tall structures as power lines, communication towers, wind turbines, and other installations, excluding livestock fencing (Stiver et al. 2006). To complete this objective, the Utah Wildlife-in-Need Foundation (UWIN), in cooperation with Rocky Mountain Power/PacifiCorp (RMP), and the Utah Division of Wildlife Resources (UDWR) facilitated public focus group workshops that included a synthesis of existing literature and contemporary federal, provincial, and state tall-structure siting policies to address Forum concerns. The workshops generated: (1) a literature synthesis of existing information (both published and unpublished) regarding the predicted and potential effects of tall structures on sage-grouse; (2) a summary of contemporary policies regarding siting and other requirements to mitigate potential effects; (3) a list of research and knowledge gaps; and (4) a prioritization of research needs regarding the effects of tall structures on sage-grouse conservation. This article reports the results of this public input process and a subsequent review of the published literature regarding tall structures and sage-grouse.

Figure 1. Knick et al. (2011) discussed the potential ecological impact of major transmission lines on greater sage-grouse (*Centrocercus urophasiansus*). Stakeholders were concerned that the omission of smaller rural electric distribution lines from their analysis could constitute a source of bias. *(Photo courtesy Chad LeBeau)*

Methods

In 2010, UWIN organized, scheduled, and facilitated 4 focus group workshops in Salt Lake City, Utah, on May 25 and June 16, 2010, and Rock Springs, Wyoming, on May 27 and June 10, 2010. Focus groups are recognized as an important tool to conduct human dimensions research for comprehensive and strategic wildlife management planning purposes (DiCamillo 1995, Siemer et al. 2001, and Connelly et al. 2012). Stiver et al. (2006) used a focus group process to identify and prioritize range-wide issues impeding sage-grouse conservation, as well as the desired strategies and research to mitigate the problems.

Decker et al. (1996) emphasized the need for state wildlife management agencies to identify and engage the widest range of stakeholders when considering management options. To identify the widest range of potential sage-grouse and tall structures focus group participants, UWIN facilitated a dialogue during January to February 2010 among representatives from PacifiCorp, Utah State University, University of Wyoming, WAFWA, and the UDWR. This dialogue generated a list of >90 potential stakeholders, including representatives of oil and gas and electrical energy companies, state and federal wildlife and land management agencies, research universities, the Utah and Wyoming governor's and energy offices, nongovernmental organizations, and private interests (Utah Wildlife-in-Need Foundation 2010). Some of the invited stakeholders included individuals that participated in the range-wide sage-grouse conservation forum (Stiver et al. 2006). The identified stakeholders were contacted by UWIN and invited to participate in the focus group workshops. About 30 of the invited stakeholders elected to participate in the workshop focus groups. Those who did not participate in the focus groups provided feedback through e-mail and telephone communication regarding their perspectives on the status of the science reporting the potential impacts to sage-grouse from tall structures (Utah Wildlife-in-Need Foundation 2010).

Stakeholders were e-mailed a letter informing them about the project and inviting their participation. Each stakeholder also was contacted ≥2 times by phone. The primary purpose of the phone conversation was to re-introduce the project, respond to any questions, and reiterate the e-mail invitation. During the calls, stakeholders were asked to identify their concerns regarding the placement of tall structures in sage-grouse habitat and their perceptions regarding the most effective way to abate them. Stakeholder phone interview responses were compiled to identify shared concerns. Prior to the first set of workshops, stakeholders were provided with: (1) a list of the shared concerns compiled through pre-workshop phone conversations; (2) a preliminary literature synthesis of published and unpublished information regarding the effects of tall structures on sage-grouse and other selected wildlife; and (3) a synthesis of existing provincial, federal, and state policies regarding siting requirements to mitigate the potential effects of tall structures on sage-grouse.

At the first workshop, facilitators reviewed the draft literature synthesis, contemporary tall structure siting policies, and concerns identified by the stakeholders through phone conversations with the participants. Stakeholders provided feedback on the materials, and their comments were recorded. Prior to the second workshop, stakeholders were provided with a reconsolidated list of concerns that reflected input from the first set of workshops, a revised literature synthesis specifically for sage-grouse, and an updated list of siting policies. Facilitators worked with stakeholders to build consensus on shared concerns and how to address them. Through this process, the stakeholders identified 8 shared concerns.

At the second set of workshops stakeholders were asked to identify contemporary best management practices (BMPs) and knowledge gaps they believed must be addressed to mitigate potential negative effects of tall structures on sage-grouse. Rather than evaluate the BMPs or siting recommendations, stakeholders were asked to identify steps to address knowledge gaps. Stakeholders were also asked to prioritize the steps by placing them in one of 2 categories: "Must Have" or "Like to Have."

To conduct the literature synthesis, peer-reviewed and non-peer-reviewed literature, technical reports, and project reports were searched for information regarding sage-grouse and tall structures. How the citations or references were used in the literature to describe the potential effects of tall structures on sage-grouse was also noted. The scientific basis for the citation (e.g., observational, experimental or retrospective studies, professional opinion, unpublished data, or personal observations) was also determined.

The databases of ISI Web of Science, Google Scholar, Agricola, Biological Abstracts, Bio-One, Dissertation Abstracts, and Zoological Record were searched to begin the literature synthesis. The key words or their combinations that were used to conduct the search included: sage-grouse; greater sage-grouse; *Centrocercus urophasianus;* Gunnison sage-grouse; *C. minimus*; tall structures; power lines; power poles; utility lines; transmission lines; distribution lines; fragmentation; mortality; effects of; wind farms; siting requirements; policies; collisions; predation; populations; habitat; wind turbines; communication towers; cell towers; United States; Europe; USFWS; Bureau of Land Management (BLM); U.S. Forest Service; Natural Resources Conservation Service; Western Association of Fish and Wildlife Agencies; Alberta, British Columbia; California; Colorado; Idaho; Montana; Nevada; North Dakota; Oregon; South Dakota; Utah; Washington; Wyoming; energy; and oil and gas development. To complete this review, both e-mail and phone interviews were conducted with state and federal biologists and managers involved in sage-grouse management and research. Abstracts pertinent to the effects of tall structures on sage-grouse were provided to the stakeholders throughout this process. This document was stratified based on type of tall structure, effects, and document (see <www. utahcbcp.org> under the tab Tall Structures).

The literature review was updated in 2013 using the same process to reflect new research pertinent to the topic.

A spreadsheet of contemporary state, provincial, and federal agency policies, rules, regulations, and guidelines for the placement of tall structures and associated facilities in occupied sage-grouse habitats was prepared for stakeholder review. The initial policy documents were obtained from agency web sites and published reports. Because these guidelines were dynamic, once the initial information was compiled, stakeholders and state and federal contacts were e-mailed for review and validation (see <www.utahcbcp.org> under the tab Tall Structures).

Results

Stakeholder concerns

Eight shared concerns were identified by stakeholders through the facilitated focus groups. These concerns represented consensus among the stakeholders on a wide range of issues regarding the potential impacts of tall structures on sage-grouse (Utah Wildlife-in-Need Foundation 2010). The concerns were:

A. **"We lack sound science upon which to base many tall structure decisions."**
The specific research projects identified to fill the knowledge gaps for this concern were prioritized as "Must Have."

B. **"We use research on other species, locations, and dated technologies in establishing BMPs."**
Stakeholders concluded that the primary emphasis must be to conduct research on sage-grouse relevant to tall structure issues. No specific prioritization was identified.

C. **"We do not know what effective temporal and spatial setbacks and buffers are, and existing ones vary by governmental agency."**
Stakeholders concluded that research on the effects of tall structures on lek attendance, population persistence, nest success, migration, and movement of sage-grouse should be conducted. No specific prioritization was identified.

D. **"We are concerned that BMPs are not monitored and may not be effective."**
Stakeholders prioritized the monitoring of current and future BMPs to determine their effectiveness as "Must Have," and they endorsed the use of industry mitigation incentives for funding monitoring.

E. **"We do not know if and why sage-grouse avoid tall structures."**
Stakeholders concluded that a research project specifically to address avoidance concerns was a "Must Have."

F. **"Tall structures may increase predation on sage-grouse."**
Stakeholders identified research projects needed to address knowledge gaps for this concern and concluded that they were "Must Have."

G. **"We do not know the impact of tall structures' ancillary facilities on sage-grouse."**
Stakeholders concluded that they would "Like to Have" research on the impacts on sage-grouse of roads, noise, and other activities related to tall structures.

H. **"We are concerned tall structures fragment sage-grouse habitat."**
Stakeholders identified habitat fragmentation analysis as a "Must Have" and other approaches (i.e., a stepwise multivariate discriminate function analysis) as "Like to Have."

Below, we summarize the discussions that resulted in stakeholders identifying their 8 shared concerns. Essential to this process, was the use of independent facilitators who guided and documented stakeholders' discussions (Connelly et al. 2012).

A. "We lack sound science upon which to base many tall structure decisions."

Stakeholders were interested in learning if the information currently available was adequate to support contemporary decisions about sage-grouse tall structures. Inherent in their concerns was an expressed desire to understand both if a cause-and-effect relationship existed between the placement of tall structures in sage-grouse habitat and reported population declines, and if recommended BMPs could mitigate identified impacts. Manipulative experiments are highly desired to determine cause-and-effect relationships (Shaffer and Johnson 2008). Such experiments are designed to evaluate hypotheses by implementing specific actions

Figure 2. Stakeholders were concerned that perceptions regarding greater sage-grouse (*Centrocercus urophasiansus*) avoidance of tall structures were based on studies conducted to determine the effects of oil and gas developments on habitat-use and vital rates. They concluded that more research was needed to identify specific mechanisms contributing to avoidance.These mechanisms included noise, traffic volumes, predation, disturbance, habitat quality, and topography.

while controlling for other variables in the system or environment. Given that some variables, such as weather, will always be beyond investigators' control, manipulative experiments typically will include controls or reference sites, randomization, and replication (Ostle 1983, Shaffer and Johnson 2008).

The strongest cause-and-effect inference result from impact assessment studies when "before-after-control-impact" (BACI) research designs are employed (Underwood and Chapman 2003). Using BACI, design-specific parameters, such a sage-grouse population vital rates (i.e., nest and brood success, survival), production, and growth are measured for a sufficient period of time (e.g., several years) before and after the impact is applied both at replicate treatment sites and control sites located within the same geographic area. In the case of sage-grouse, retrospective studies that correlated changes in lek trends or occupied habitat to anthropogenic activities have provided information about the effects of human activities on the species and its habitat (Connelly et al. 2004, Johnson et al. 2011, Knick et al. 2011, and Wisdom et al. 2011).

The validity of the scientific process and the conclusions drawn by the investigators are not typically recognized as sound science unless it has been peer-reviewed and published in a scientific journal. This process typically includes submission of a manuscript prepared by the investigators to the recognized journal, followed by a peer-review of 2 or more reviewers selected by the journal editorial staff. The reviewers evaluate scope and scientific merit of the work making recommendations to the journal editorial staff regarding publication status. The review process implemented during this project constituted a stakeholder peer-review of the published literature.

Knowledge gaps. Stakeholders determined that no peer-reviewed, published manuscripts reported the results of experimental studies to document sage-grouse's potential avoidance of tall structures, increased predation related to avian predators using tall structures as perches, increased mortality attributed to collisions, or habitat degradation or fragmentation attributed to tall structures (Utah Wildlife-in-Need Foundation 2010). They concluded that professional opinions, personal observations, unpublished data, anecdotal references, and modeling efforts, as well as peer-reviewed studies on the cumulative effects of oil and gas development and associated infrastructures on sage-grouse, were used to implicate tall structures as potential causal agents of the above effects on sage-grouse (Figure 2). The cumulative effect studies, however, did not single out tall structures defined by this project as specific mechanisms affecting sage-grouse. Stakeholders were concerned that multi-variable analysis approaches may confound interpretation of the effects of specific variables, such as tall structures. They concluded that, based on the results of such studies, it may not be possible to determine whether tall structures were independently responsible for declining sage-grouse populations. Although inferences continue to be made in the peer-reviewed and gray literature regarding the effects of tall structures on sage-grouse populations, the associations, as reported in the reviewed literature, should be carefully evaluated (Shaffer and Johnson 2008).

Stakeholders concluded that no peer-reviewed publications reported the results of BACI studies that were conducted to determine individual or population responses of sage-grouse to tall structures. Although papers reported individual bird mortalities (Borell 1939, Beck et al. 2006), population or landscape-level studies documenting avoidance, reduced fitness or decreased production were nonexistent. Because of the costs associated with landscape-level studies, stakeholders felt that, to accomplish this research, it must be coordinated among a wide range of interests. They believed that these studies must include adequate sampling effort and replication to detect statistically and biologically significant responses that account for differences in topography, habitat conditions, and location (Utah Wildlife-in-Need Foundation 2010, 2011).

Although modeling has correlated some aspects of anthropogenic activities to the likelihood of sage-grouse occupancy of habitats and population persistence, stakeholders were concerned that the models differed regarding the impacts of tall structures (see Knick and Connelly 2011 for review). Knick et al. (2011), Wisdom et al. (2011), and Johnson et al. (2011) used major electric transmission line spatial data to evaluate the ecological effects of these structures on sage-grouse extirpation and lek trends. These lines paralleled natural features, such as river valleys, and were associated with other anthropogenic activities, such as roads. Their landscape analysis did not include smaller electric distribution lines in rural areas. Stakeholders were concerned that this omission could constitute a potential source of bias by overestimating spatial impacts. Other potential sources of bias identified by stakeholders included: (1) observational studies or observations based on personal communication or unpublished data; (2) inadequate descriptions of control and treatments or pre-existing habitat conditions; (3) inferences to sage-grouse from studies conducted on other species; (4) retrospective studies that did not quantify related environmental conditions; (5) inappropriate or misuse of citations; (6) the use of results from cumulative impact studies of other energy development to make inferences about the effects of tall structures on sage-grouse; and (7) small sample sizes (Utah Wildlife-in-Need Foundation 2010).

Actions needed. Stakeholders concurred that they "Must Have" additional science-based knowledge to develop effective BMPs. They recommended that research protocols: (1) a BACI research platform; (2) be replicable and replicated in multiple states; (3) focus on contemporary energy development technology; (4) use newer research technology such as global positioning system transmitters; (5) produce defensible results; (6) be designed to address multiple knowledge gaps; (7) measure individual and cumulative impacts of each tall structure type; (8) compliment work being done by others; (9) produce preliminary results that can be employed in an adaptive management strategy; (10) be transparent and open with frequent updates; and (11) include industry incentives as mitigation credit for funding research (Utah Wildlife-in-Need Foundation 2010).

Stakeholders believed that to adequately assess the impacts of tall structures on sage-grouse, conditions before and after the activity must be quantified. They recognized that obtaining these baseline data for sage-grouse was likely beyond the capabilities of a single investigator. Stakeholders also believed that data collected over multiple years will be paramount to understanding the relationship between tall structure and sage-grouse, given annual and seasonal variations in weather and its effect on wildlife populations.

B. "We use research on other species, locations and dated technologies in establishing BMPs."

The USFWS (2010) cited Pruett et al. (2009) research regarding lesser prairie chicken (*Tympanuchus pallidicintus*) and greater prairie chicken (*T. cupido*) to support Braun's (1998) statements that sage-grouse avoid suitable habitat near power lines. Braun's (1998) comments were based upon unpublished data.

Published studies conducted in Europe report impacts of overhead wires on black grouse (*Tetrao tetrix*) and ptarmigan (*Lagopus* spp.). These studies were not cited in state policies (Utah Wildlife-in-Need Foundation 2010) or by the USFWS (2010). Miqueta (1990) studied black-grouse deaths by collisions with cables at ski resorts. He concluded that the inconspicuousness of wires, combined with interference to the birds' habits, as well as human disturbance, were main factors causing accidents. Collisions were more frequent on ski-tows and electricity lines than on chairlifts. Bevanger and Brøseth (2001, 2004) recorded the number of ptarmigan (*L. lagopus* and *L. mutus*) killed along 3 power-line sections by colliding with the overhead wires over a 6-year period in a subalpine habitat in southern Norway. The removal of the overhead neutral wire reduced collisions by 50%. Because these studies were conducted in forested habitats, stakeholders concluded that the results had limited application to sage-grouse.

Knowledge gaps. Stakeholders were concerned about using studies conducted on other species or in other geographic regions to fill knowledge gaps for sage-grouse. Prairie grouse (Tetraoninae) are lekking species that occupy broad geographic landscapes and differ in morphology, behavior, life history, seasonal habitat use patterns, and distribution (Johnsgard 2008). Stakeholders concurred that these differences may confound comparisons regarding their individual and population responses to tall structures.

Aldridge (2000), Braun et al. (2002), Holloran (2005), and Naugle et al. (2011) identified the cumulative effects of oil and gas development and associated infrastructures on sage-grouse to include tall structures. The USFWS (2010) extrapolated the results of these studies to describe potential negative effects of tall structures on sage-grouse. Stakeholders were concerned that these studies did not account for changes in habitat conditions or population trends prior to the impacts or for differences in footprint and human activity associated with various anthropogenic features. Because these data were lacking, stakeholders concurred that inferences regarding specific or cumulative effects of tall structures may be limited. However, stakeholders agreed that such studies provide important insights regarding the broader implications of major anthropogenic changes in landscapes and their impacts on sage-grouse (Utah Wildlife-in-Need Foundation 2010).

Braun et al. (2002) summarized the impacts of oil and gas development on sagebrush species in Colorado, Wyoming, and Alberta, Canada. They reported that the impact of energy development on wildlife species had been observed for 3 decades before energy production in sagebrush habitats began. Stakeholders were concerned that over the period covered by their review, additional energy developments were initiated (i.e., oil shale, oil, gas, coal, or coalbed methane). Sage-grouse populations in the study areas, based on lek count data, were declining before development. Braun et al. (2002) acknowledged that lek counts in Alberta were conducted sporadically until the 1990s. Stakeholders believed that these inconsistencies in data collection make it difficult to determine with certainty whether the observed sage-grouse population declines (based on lek count data) were primarily caused by oil and gas development.

Stakeholders believed that the Colorado studies reviewed shared similar problems. Because oil and gas activity began 2 decades before sage-grouse counts were conducted in Colorado, and the counts conducted for the following 3 decades were sporadic and incomplete, Braun et al. (2002) concluded:"No replicated, designed cause-and-effect studies have explored the impacts of oil and gas production on sage-grouse populations." Stakeholders concurred that to adequately assess impacts, habitat conditions before and after the activity in question need to be compared.

Actions needed. Stakeholders agreed that more knowledge was needed regarding the potential effects of tall structures on individual bird behavior (i.e., site avoidance, nest-site selection, habitat use, production, recruitment, and survival) and how these responses may affect the species at the population level. Stakeholders were also concerned that the use of lek counts to establish population trends may confound range-wide mortality estimates and their effects on populations. Because of inconsistency in the application of lek survey methods, population assessments based upon lek counts data remain a source of potential bias (Connelly et al. 2004, Johnson et al. 2011).

Stakeholders identified several logistical constraints impeding research on the potential impacts of tall structures on sage-grouse. In most cases, long-term data collection over multiple seasons and years, especially prior to development activities, was inadequate. The failure to incorporate annual variability when reporting results may not accurately reflect effects relative to site conditions. Also, many of the papers and reports reviewed lacked quantitative data describing the habitat conditions at both the treatment or project sites (e.g., wind facility, road side) and controls or reference sites (when incorporated in the study), and, thus, failed to establish baseline conditions to which impact or effects could be compared (Utah Wildlife-in-Need Foundation 2010, 2011).

C. "We do not know what effective temporal and spatial setbacks and buffers are, and existing ones vary by governmental agency."

Stakeholders were concerned that the wide range of temporal restrictions and spatial setbacks (i.e., buffers) being implemented to mitigate the potential impacts of tall structures on sage-grouse were a source of confusion. Connelly et al. (2000), Schroeder and Robb (2003), BLM (2004), and Rowland (2004) recommended that a 3 km minimum buffer zone be maintained between tall structures and sage-grouse habitat. Connelly et al. (2000) and Connelly et al. (2004) further recommended that power lines be buried or electric-utility structures be modified to discourage their use as raptor perch sites. Undergrounding power lines or installing perch discouragers can pose additional risks to wildlife, habitat, and electrical systems (Avian Power Line Interaction Committee 2006, 2012). State, provincial, and federal sage-grouse management plans contain avoidance guidelines ranging from 0.3 to 8.0-km (Utah Wildlife-in-Need Foundation 2010). Similar stipulations have been made regarding the placement of wind turbines (U.S. Fish and Wildlife Service 2003).

Models developed by Aldridge (2005) for energy development in Alberta, Canada, as applied to the available habitat, suggested that a 3.2-km buffer around each lek site would protect 54% of the nesting and 62% of the brood-rearing habitat (Aldridge 2005). Aldridge (2005) argued that the use of lek-centered buffers was not adequate to protect existing habitats. Fedy et al. (2012) reported that the lek-based core area approach used in Wyoming to conserve sage-grouse was better at protecting summer than winter habitats. However, they concluded that this approach provided a reasonable surrogate for seasonal movement data. Copeland et al. (2013) predicted that the Wyoming core area strategy would reduce sage-grouse population declines statewide to 9 to 15 % and 6 to 9%.

The USFWS (2010) acknowledged the role of state and federal agency nonregulatory and regulatory mechanisms to mitigate the potential negative effects of energy development on sage-grouse. However, it concluded that the current regulations and stipulations guiding energy development were not adequate. The USFWS did not differentiate between the specific aspects of energy development (i.e., renewable or nonrenewable, oil and gas, coal, coal-bed methane natural gas, power lines, roads, etc.). The USFWS (2010) stated that it could not find any scientific support for using a 0.4-km buffer as the basic unit protecting active leks. However, based largely on Holloran's (2005) and Walker et al. (2007) findings, they concluded that the recommended 0.4-km buffer was not adequate to protect sage-grouse.

Knowledge gaps. Stakeholders suggested that the rationale for the buffer and siting recommendations may stem from the fact that sage-grouse evolved on a landscape largely void of vertical obstructions (Connelly et al. 2004). Although there is strong evidence documenting changes in sage-grouse habitat, little is known about the effects of landscape features on sage-grouse populations (Connelly et al. 2004). Stakeholders were concerned that there was little scientific evidence to document the short- or long-term potential effects of tall structures, let alone what mitigation measures are appropriate or effective. Also, they wanted to know if sage-grouse could eventually habituate behaviorally to tall structures in their environment.

Actions needed. Stakeholders recommended that additional research was needed to assess if the potential impacts of tall structures on lek attendance, nest success, seasonal use, avoidance, seasonal habitat-use, home ranges, and migration patterns may be mitigated by different size buffer zones or by topography and habitat quality. Specifically, they recommended a refinement and expansion of Connelly et al. (2004), Knick et al. (2011), Johnson et al. (2011), and Wisdom et al. (2011) retrospective studies of the effects of anthropogenic features on sage-grouse lek trends and occupancy. Such studies should specifically evaluate power lines and incorporate habitat variables and a spatial database that includes rural electric distribution power lines not previously analyzed (Knick et al. 2011).

D. "We are concerned that BMPs are not monitored and may not be effective."

Stakeholders expressed concerns that current BMPs are not being monitored to determine their effectiveness. Some expressed concern that BMPs focused just on avoiding the potential impacts of tall structures on leks may neglect brooding, nesting, and wintering areas.

Knowledge gaps. Proponents of wind energy development projects often monitor the effects of the turbines and wind facility operation on wildlife (Erickson et al. 2005). Most monitoring at wind facilities is conducted to document mortalities directly associated with turbine strikes, while few studies record behavioral responses to turbines. Such reports provide important site specific information, such as differences in topography, site footprint and operations, and species presence; however, stakeholders were concerned that monitoring reports would be limited to identify direct mortality risk to individual birds.

Stakeholders concurred that the peer-reviewed literature contained no published studies that specifically reported the results of tall structure and sage-grouse BMP monitoring. In the case of electric power lines, utilities regularly inspect existing corridors to monitor line conditions. During these surveys, field personnel may document and report evidence of wildlife mortalities or may have additional monitoring programs as part of a utility company's avian protection plan. Such plans and associated data may include effectiveness monitoring components that are often related to direct mortality (S. Liguori, PacifiCorp, Salt Lake City, Utah, personal communication). Such monitoring studies also have assessed the effectiveness of pole modifications designed to reduce avian electrocutions, perching, and nesting (Avian Power Line Interaction Committee 2006). Stakeholders expressed concerns that pole modifications intended to reduce perching may result in increased electrocution risks and facilitation of corvid nest sites.

Actions needed. Stakeholders prioritized the monitoring of current and future BMPs to determine their effectiveness as "Must Have" and encouraged industry incentives as mitigation for funding of this monitoring. Contemporary monitoring data collected by utilities and wind farm operators provide information regarding specific incidences that often are related to direct mortality resulting from infrastructure. Stakeholders concurred that because state, provincial, and federal agencies may lack the resources to implement monitoring programs of the scale and scope needed to determine BMPs effectiveness, coordinated multi-site and multivariate research programs are needed.

E. "We do not know if and why sage-grouse avoid tall structures."

Mabey and Paul (2007) summarized contemporary perspectives regarding the effects of tall structures on grassland and shrub steppe avian species. They concluded that tall structures in open habitats may be particularly disruptive to avian behavior because they are novel elements in the environments of bird species not habituated to their presence. Noise and visual disturbances from tall structure (e.g., wind turbines) operations placed in shrub steppe or grassland habitats may disrupt avian breeding or other behaviors (Mabey and Paul 2007).

Stakeholders noted that Ellis (1984) was frequently misused by authors to support statements that the presence of a transmission line changed sage-grouse dispersal patterns because of habitat fragmentation (Utah Wildlife-in-Need Foundation 2010). Ellis (1984) described male sage-grouse responses to a golden eagle (*Aquila chrysaetos;* Figure 3)

Figure 3. Golden eagle. *(Photo courtesy Sherry Liguori)*

perched on an oil well located 500 m from 2 leks. This paper was misused as a case study by the USFWS (2010) to support statements of increased sage-grouse predation rates after a transmission line was constructed within 0.1 km of an occupied lek in Utah.

Braun (1998) and Braun et al. (2002) are cited by the USFW (2010) to document sage-grouse avoidance of tall structures. Braun et al. (2002) reported that sage-grouse leks within 0.3 km of a new power line had slower growth rates compared to leks located farther from the line. They hypothesized that the slower growth rates were a result of increased raptor predation, but they did not provide any data to quantify the growth or predation rates. This publication was not peer-reviewed.

Stakeholders were concerned that the USFWS (2010) used citations reporting avoidance of sage-grouse of oil and gas development to support conclusions that sage-grouse avoid power lines. Avoidance behaviors by sage-grouse at lek sites and habitats that are near anthropogenic sites have been reported by Lyons and Anderson (2003), and Holloran (2005; see also Walker et al. 2007, Doherty et al. 2008, Holloran et al. 2010). These studies report avoidance as a cumulative effect involving a broad spectrum of anthropomorphic impacts without isolating a specific mechanism. Stakeholders agreed that oil and gas development sites may differ greatly from transmission lines in project footprint (polygonal versus linear) and level of human activity (more frequently human activity at well sites versus annual or twice per year inspections of transmission lines). Consequently, results may not be comparable among different types of anthropogenic infrastructures. This would be particularly true if sage-grouse respond negatively to human activity levels or duration, rather than the infrastructure itself.

Stakeholders noted that Hall and Haney's (1997) unpublished report was cited in state siting policies and by other authors but not by the USFWS (2010). Lammers and Collopy (2007) cited the report as a personal communication to support statements regarding the effect of raptors on sage-grouse. Hall and Haney (1997) reported observing 82 disturbances of sage-grouse at a lek; of those, 29 disturbances were caused by raptors (25 golden eagles and other raptors) that were observed perching on nearby power lines. Ungulates caused 18 disturbances.

Braun (1998) was cited by the USFWS (2010) and other authors as a source for the statement "power lines may fragment sage-grouse habitat even in the absence of raptors." The author (U.S. Fish and Wildlife Service 2010) also cited Graul (1980), Ellis (1984), and Ellis et al. (1987) as supporting documentation. Braun (1987) also cited unpublished data to document that sage-grouse use of suitable habitat near power lines increased as distance from the power lines increased from up to 0.6 km; the author referenced unpublished data to support the argument that the presence of power lines may limit sage-grouse use within 1 km of otherwise suitable habitat. Some states cited Braun (1998) in their guidelines to support the following relationships with energy development: (1) avoidance behavior by grouse of lek sites and habitats that are near anthropogenic sites; (2) higher mortality rates of breeding sage-grouse in oil and gas fields; (3) lower nest initiation rates and success; (4) loss or degradation of critical habitat; and (5) increases in avian predator populations. Stakeholders expressed concern that the Braun (1998) paper was not peer-reviewed.

Johnson et al. (2011) and Wisdom et al. (2011) analyzed lek and distribution data to determine the effects of anthropogenic factors on sage-grouse populations and risk of extirpation, respectively. Their study areas comprised all or parts of 14 states and 3 provinces and encompassed about 2,063,000 km^2 (Connelly et al. 2004). The authors acknowledged the retrospective nature of their studies may constitute a potential source of bias in that many of the factors were in place prior to their studies. Consequently, the immediate effects of some historical factors may be confounded by more recent changes.

Johnson et al. (2011) reported that secondary roads and power lines occurred regularly within their study area. They did not detect any relationship between lek distance to secondary roads and power lines with lek trends. However, lek count trends were negatively correlated with distances to the closest communications tower and to the number of towers within 18 km. They explained the seemingly disparate results by stating that communication towers typically indicated high human-use areas, whereas power lines, especially transmission lines, were more uniformly distributed across the landscape. Thus, the lower trends at sage-grouse leks near communication towers may be in response to these spatially associated activities and not the towers themselves. However, towers themselves may be stressors, and differences in relations between lek trends and the 2 types of vertical structures may be due to the different times they were erected. Most power lines were placed prior to their study period, and any effects they had may have already occurred, or the habitat has since been reclaimed. In contrast, communications towers have only recently become common in the area, and sage-grouse populations may have responded to them during the study period. They reiterated that their results should be viewed with caution because lek counts are subject to bias (Beck and Braun 1980, Applegate 2000), and the surveyed leks may not be representative of the entire population (Johnson and Rowland 2007).

Johnson et al. (2011) cited Ellis (1985*a*) and Braun (1998) as sources documenting sage-grouse avoidance of transmission lines in general and during the breeding season. They also cited Hagen (2003) and Pitman et al. (2005) work on lesser prairie-chickens to infer sage-grouse avoidance of power lines in general and when nesting.

Wisdom et al. (2011) analyzed differences in 22 environmental variables between areas of former range (extirpated range) and areas still occupied (occupied range) by the Gunnison (*C. mimimus*) sage-grouse and greater sage-grouse. They reported that fifteen of 22 variables they analyzed differed between extirpated and occupied ranges. Wisdom et al. (2011) reported that 5 variables (i.e., sagebrush area, elevation, distance to transmission lines, distance to cellular towers, and land ownership) correctly classified >80% of sage-grouse historical locations in extirpated and occupied ranges. Three anthropogenic variables, including distance to transmission lines, distance to cellular towers, and land ownership, differed between occupied and extirpated ranges.

Stakeholders noted that Wisdom et al. (2011) may have misused Connelly et al. (2000), Aldridge and Boyce (2007), Walker et al. (2007) as citations to support the statement, "only transmission lines have been formally evaluated." Stakeholders were also concerned that Wisdom et al. (2011) cited Beck et al. (2006) and Aldridge and Boyce (2007) to imply that transmission lines are a major known source of collision mortality for sage-grouse. Wisdom et al. (2010) also cited Connelly et al. (2000) as the sole source to validate that a statement that transmission lines are known to facilitate raptor predation of sage-grouse. Stakeholders concurred that the papers cited did not provide conclusive evidence of a cause-and-effect relationship. Connelly et al. (2000) were describing the potential effects of fences, and not power lines. Borell (1939) and Beck et al. (2006) provided incidental observations to document sage-grouse mortality as a result of a collision with telephone and power lines, respectively. Power line collisions for sage-grouse have not been documented by the Avian Power Line Interaction Committee (APLIC) utilities (Avian Power Line Interaction Committee 2012). Despite long-term utility surveys to evaluate electrocution and collision risks of power lines in sagebrush habitats throughout the intermountain West, no collisions of sage-grouse have been documented (S. Liguori, personal communication, 2001 to 2012).

Wisdom et al. (2011) reported that distance to transmission lines and cellular towers were strongly associated with sage-grouse extirpation. Stakeholders were concerned that their analysis did not include smaller electric distribution lines in rural areas (Knick et al 2011). Wisdom et al. (2011) concluded that new mechanistic research may be needed to more completely understand the potential relationship of these variables to sage-grouse extirpation and to establish effective management options. As an example, they noted that the use of raptor perch deterrents on tall structures may not mitigate the effects of these structures if sage-grouse population declines result from avoidance of habitats in close proximity and not reduced survival due to changes in predator distributions. Perch deterrents have not proven effective in eliminating raptor or corvid perching on transmission or distribution lines (Avian Power Line Interaction Committee 2006, Lammers and Collopy 2007; Figure 4). Prather and Messmer (2010) also reported perch deterrents placed on smaller rural electric distribution lines were largely ineffective in preventing raptor perching. Perch deterrents also may encourage raptors or corvids to nest on structures and may pose increased electrocution risks for raptors and other protected migratory birds (Avian Power Line Interaction Committee 2006; S. Liguori, PacifiCorp, personal communication).

Nonne et al. (2013) reported the results of a study that used pre- and post-construction telemetry data to assess the potential impacts of a transmission line on sage-grouse populations. They conducted a 10-year study of sage-grouse dynamics in response to a transmission line in central Nevada and reported that habitat conditions had the greatest effect on sage-grouse nest and brood success and overall survival in their study areas than did proximity to the power line. The report found "no negative effects on demographic rates (i.e., male survival and movement, female survival, pre-fledging chick survival, and nest survival) that could be explained by an individual's proximity to the transmission line." They found no evidence that predation increased close to the line, as nest survival and female survival were similar across all distances evaluated (Nonne et al. 2013). The role of micro-habitat structure and annual landscape-scale variation in weather in sage-grouse nest and brood site selection and nest and brood success in xeric habitats (Figure 5) has also been reported by Coates and Delehanty (2010), Kirol et al. (2012), LeBeau (2012), Guttery et al. (2013), and Robinson and Messmer (2013).

Figure 4. Wisdom et al. (2012) recognized that perch deterrents could be one mechanism to reduce the potential for increased sage-grouse (*Centrocercus urophasiansus*) predation rates near power lines. They concluded that if power lines had already increased predation rates, the effect of perch deterrents on reducing predation rates could be misinterpreted. However, Prather and Messmer (2010) reported that perch deterrents were not effective in deterring raptor and corvid perching on rural electric distribution line.

Knowledge gaps. Stakeholders concluded that additional knowledge of potential sage-grouse avoidance of tall structures was a "Must Have" priority, and this information must be specific to structure type. Specifically, stakeholders wanted to know: (1) do sage-grouse avoid tall structures, and, if so, what in particular are they avoiding; (2) if sage-grouse avoid tall structures, what are the individual and populations impacts, and how long would these impacts take to be manifested; (3) will the effects be short- (construction related) or long-term (operation and maintenance); (4) will the effects be limited to the area of disturbance; (5) what measures (siting, construction, and maintenance) can be implemented to mitigate potential impacts; and (6) will these measures be effective (Utah Wildlife-in-Need Foundation 2010)?

Figure 5. Nonne et al. (2013) reported that greater sage-grouse (*Centrocercus urophasiansus*) habitat-use patterns and vital rates did not differ based on proximity to large transmission lines. In their study, habitat was an important factor affecting sage-grouse vital rates.

Connelly et al. (2004) examined the distribution of leks along an interstate highway. They reported a higher rate of lek abandonment near the highway. They acknowledged that because the interstate was completed prior to the initiation of thorough surveys, changes in lek status could have occurred prior to monitoring. Their analysis also did not consider the effects of other highways or land-use activities, or that the interstate may have been placed in less suitable habitat. No similar analysis has been published on energy corridors, structures, or power lines (Connelly et al. 2004), although several electric utilities companies are conducting retrospective analyses in local areas (S. Liguori, personal communication).

Actions needed. Stakeholders concluded that additional retrospective analysis of major power transmission corridors and rural distribution lines on sage-grouse lek distributions, trends, nesting, and brood locations may provide new insights regarding the potential historical effects of tall structures on sage-grouse. Knick et al. (2011), Johnson et al. (2011), and Wisdom et al, (2011) attempted to do this, but did not include smaller distribution lines or account for habitat or topographical effects. Stakeholders decided that the goals of this type of study would be: (1) to identify if there is a correlation between power lines and sage-grouse population levels or distribution; and, (2) if such a correlation exists, to determine what factors (e.g., line type, habitat condition and quality, associated roads, human activity) influence sage-grouse demography. Stakeholders recommended that these analyses include existing corridors and reference or control sites. They decided that the area within the study sites should be characterized by habitat type and condition, season of sage-grouse use, line voltage and structure configuration, date of construction, maintenance frequency, existing roads and railroads, wildfire occurrence, and other surrounding land uses. The actual utility corridors analyzed would be selected in consultation with utility company and state wildlife agency representatives. Preferences should be given to those utility corridors that are known to traverse historic and currently occupied sage-grouse habitat.

Stakeholders concluded that there are no studies documenting a population-level effect of avian predation on sage-grouse resulting from power lines. Observations of golden eagle hunting behavior have documented differences in hunting techniques for different prey species, with golden eagles hunting gallinaceous birds from the wing, either by high stoop or low, coursing flight, as opposed to perch hunting (Kochert et al. 2002; S. Liguori, personal communication). The literature that references avian predation on sage-grouse associated with power lines often does not consider the behavior of the predator species or the overall percentage of predator diet constituted by sage-grouse (avian predation of sage-grouse is opportunistic, as no species relies solely on sage-grouse as its primary prey).

There was concurrence among stakeholders that the true relationship of new line siting distance on sage-grouse behavior, habitat use, and predation, should be evaluated experimentally. These experiments should include a BACI design that evaluates changes in sage-grouse population vital rates and habitat use relative to distance from the tall structure (Utah Wildlife-in-Need Foundation 2010, 2011). They recommended that the goals of these studies should be: (1) to identify if construction of new power lines impacts sage-grouse lekking and nesting behavior; (2) if impacts exist, to determine at what distances from sage-grouse nesting habitat or leks do they occur; and (3) if impacts exist, to provide recommendations to minimize or mitigate effects of new power lines.

Stakeholders believed that lekking, breeding, and nesting behavior (i.e., distances traveled to nest, nest initiation rates, nest success) and habitat-use of sage-grouse should be monitored during the experiments. Ideally, monitoring would be conducted on each study lek at least 3 seasons prior to and 3 seasons after constructing the line. Stakeholders also recommended that the study birds be equipped with both very high frequency and global positioning system transmitters. Additional data regarding sage-grouse brood use of the study areas could be collected using pellet and bird-dog survey techniques (Dahlgren et al. 2006, Dahlgren et al. 2010). See UWIN (2011) for detailed research protocols regarding sage-grouse and tall structures.

F. "Tall structures may increase predation on sage-grouse."

Boyko et al. (2004) modeled how the risk of predation by golden eagles could affect sage-grouse lek dynamics. Although observations of successful predation by golden eagles on sage-grouse are scarce, numerous authors have documented attacks by golden eagles on lekking male sage-grouse (Patterson 1952, Wiley 1973, Hartzler 1974, Bradbury et al. 1989, Gibson and Bachman 1992). Boyko et al. (2004) predicted that high mean levels of predation risk coupled with small lek size (<12 birds) should reduce lek attendance. However, the relative tendency of golden eagles to attack large (>50 birds) versus small leks had little influence on lekking behavior.

Corvids also may prey on sage-grouse eggs, chicks, and juvenile birds (Batterson and Morse 1948, Patterson 1952, Nelson 1955, Young 1994, Delong et al. 1995, Sveum 1995). Common ravens (*Corvus corax;* Figure 5) in particular have been implicated as important predators of sage-grouse and other prairie grouse nests (Manzer and Hannon 2005, Coates 2007). Dinkins et al. (2012) reported that sage-grouse in Wyoming nested in areas where there were lower densities of common ravens, black-billed (American) magpies (*Pica hudsonia*), golden eagles, and hawks (*Buteo* spp.) compared with random locations. Additionally, they selected brood-rearing locations with lower densities of those same avian predators compared with random locations. They concluded that by selecting nest and brood-rearing locations with lower avian predator densities, sage-grouse may reduce the risk of nest depredation and predation on eggs, chicks, and hens.

Connelly et al. (2000, 2004) suggested that because of the potential for raptors and corvids to use power poles as new perches and nest sites, placement of these facilities in seasonal sage-grouse habitats could impact the species through increased predation of adults, juveniles, and eggs, or could result in sage-grouse abandoning sites. Wolff et al. (1999) reported that although the addition of perches in prairie chicken habitat can increase raptor visitations, they may have little effect on high-density prey populations.

Stakeholders noted that Ellis (1984, 1985*a*, *b*), Ellis et al. (1987, 1989), Steenhof et al. (1993), Knight and Kawashima (1993), Hall and Haney (1997), Braun (1998), Connelly et al. (2000), and Coates (2007) were the publications most frequently cited by the USFWS (2010) support their conclusions regarding the potential relationship between tall structures and sage-grouse predation. Ellis (1985*b*) was cited by the USFWS (2010) in its listing decision to support the statement that increased abundance of raptors and corvids within occupied sage-grouse habitats can result in increased predation. Ellis (1985*a*, *b*) reported that sage-grouse predation rates increased from 26 to 73% after a transmission line was constructed within 0.1 km of an occupied lek in Utah. He did not report any data regarding changes in corvid and raptor abundance or habitat changes as a result of the power line, but concluded its construction near the lek fragmented that habitat and resulted in its abandonment. These reports were not peer-reviewed.

Ellis et al. (1987) was also cited by the USFS (2010) as a source documenting increased corvid and raptor predation because of power lines. Golden eagles, power lines, and perches are not mentioned in the paper. The focus of the paper was the identification of day-use areas of male sage-grouse at leks. Ellis et al. (1987) concluded that sage-grouse use the same day-use areas annually. Stakeholders were concerned that Ellis et al. (1987) was misused to imply that if tall structures are placed in these day-use areas, sage-grouse will avoid them (U.S. Fish and Wildlife Service 2010).

Ellis et al. (1989) reported on sage-grouse habitat-use and how day-use areas near leks should be managed. Golden eagles, power lines, and perches are not mentioned in the paper. They concluded that sage-grouse use-areas near leks constituted 0.25 km^2. The authors recommended that if the day-use areas cannot be identified, managers should maintain sagebrush cover within 3 km of leks.

Knight and Kawashima (1993) studied linear right-of-ways to determine if any relationships exist between these right-of-ways and vertebrate populations. Specifically, they examined the relationship among these areas and common raven and red-tailed hawk (*Buteo jamaicensis*) populations in the Mojave Desert of California. Their data suggested that ravens were more abundant along highways because of automobile-generated carrion, whereas both ravens and red-tailed hawks were more common along power lines because of the presence of superior perch and nest sites. They recommended that land managers evaluate possible changes in vertebrate populations and community-level interactions when assessing the effects of future linear right-of-way projects. The stakeholders noted that the USFWS (2010) cited this study to substantiate statements that power lines create perches and nesting platforms for raptors and corvids and, thus, contributed to increased species abundance and, hence, sage-grouse predation risks (Utah Wildlife-in-Need Foundation 2010).

Stakeholders noted that Steenhof et al. (1993) also was frequently cited to document the effects of power lines on increasing raptor and corvid abundance. Steenhof et al. (1993) attributed population increases in 4 raptor species and common ravens in their southern Idaho and Oregon study areas to the use of supplemental, artificial nesting platforms installed during construction of the transmission line in 1980. Sage-grouse are not mentioned in the paper.

Coates and Delehanty (2010) reported that increased common raven numbers had negative effects on sage-grouse nest survival, especially in areas with relatively low shrub canopy cover. They encouraged wildlife managers to reduce interactions between ravens and nesting sage-grouse by managing raven populations and restoring and maintaining shrub canopy cover in sage-grouse nesting areas. However, no similar peer-reviewed studies reported similar effects for golden eagles. Stakeholders suggested that the potential impacts of golden eagle and corvid-use of tall structures on sage-grouse relative to the species hunting behaviors and densities also must be considered.

Stakeholders wanted to know the frequency of sage-grouse in golden eagle diets. Marzluff et al. (1997) reported that shrub-steppe communities provide important foraging habitat for the golden eagles. However, small to medium-sized mammals, such as hares (*Lepus* spp.), ground squirrels (*Citellus* spp.), marmots (*Marmota* spp.), and mountain beavers (*Aplodontia rufa*) were noted as primary prey for golden eagles (McGahan 1968, Olendorff 1976, Bruce et al. 1982, Steenhof and Kochert 1988, Marzluff et al. 1997). Steenhof et al. (1997) and McIntyre (2002) reported increased productivity in golden eagles in years with higher abundance of lagomorphs. Kochert et al. (2002) reported that mammals constituted 80 to 90% of golden eagle diet, with hares (*Lepus* spp.), rabbits (*Sylvilagus* spp.), ground squirrels (*Spermophilus* spp.), prairie dogs (*Cynomys* spp.), and marmots (*Marmota* spp.) comprising the primary prey species in North America.

Golden eagle densities in the western states were reported to range from 1 pair per 34 to 251 km^2 (Phillips et al. 1984). Home range size, size of core areas, and travel distances can vary dramatically based on habitat composition, potential prey abundance, and individual preferences (Marzluff et al. 1997). In arid regions, golden eagles require large expanses of undisturbed shrub habitat (Marzluff et al. 1997). Kochert et al. (1999) recommended that shrub stands be preserved within 3 km of golden eagle nests. This distance accounted for 95% of eagle movements that were measured during the breeding season in western Idaho (Marzluff et al. 1997).

Populations of synanthropic avian predators, such as common ravens, American crows (*Corvus brachyrhynchos*), and black-billed magpies are increasing in North America (Sauer et al. 2003). Boarman and Heinrich (1999) reported that daily forays of common ravens differ by region and breeding status, but they can travel >10 km from nest or roost sites. Non-breeding ravens traveled daily an average 6.9 to 62.5 km in Idaho to 27 km in Michigan (range 0.8 to 147 km) from roost sites to distant food sources (Boarman and Heinrich 1999). Breeding pairs hunted on average 0.57 km from the nest (Boarman and Heinrich 1999).

Connelly et al. (2004) estimated that a minimum of 15,296 km^2 of contemporary sage-grouse range contained power lines. Based on this estimate and the foraging distances of golden eagles and corvids, they estimated that power lines, as a potential source of additional perches, could influence 672,344 to 837,390 km^2 or 32 to 40% of the available sagebrush habitats. Stakeholders were concerned that this estimate did not account for the effects of environmental conditions (i.e., habitat conditions, primary prey abundance, availability of other natural or anthropogenic perch sites) on raptor or golden eagle densities, or on species-specific hunting behaviors (e.g., golden eagle perch-hunting versus in-flight hunting strategies for different prey species).

Knowledge gaps. Stakeholders were concerned about if there is a causal relationship between tall structures and sage-grouse predation (Utah Wildlife-in-Need Foundation 2010). Specific concerns expressed included: (1) are sage-grouse avoiding tall structures; (2) if so, is it because tall structures provide perches for predators or because sage-grouse just do not like them; and (3) do sage-grouse avoid associated service roads because they may create travel routes for predators?

Stakeholders acknowledged that raptors and corvids use power poles as perches and nest sites, and, as such, these tall structures can provide alternative perching or nesting substrates in areas where natural sites are limited (Figure 6). However, they were concerned that the reviewed studies did not assess the direct effects of power lines on increased predation risks for sage-grouse. Stakeholders were concerned the above studies were cited to imply that if raptor and corvid use of areas inhabited by sage-grouse increased because of the presence of tall structures, predation will also increase, without consideration of raptor diet and hunting behavior (Utah Wildlife-in-Need Foundation 2010). Some authors noted

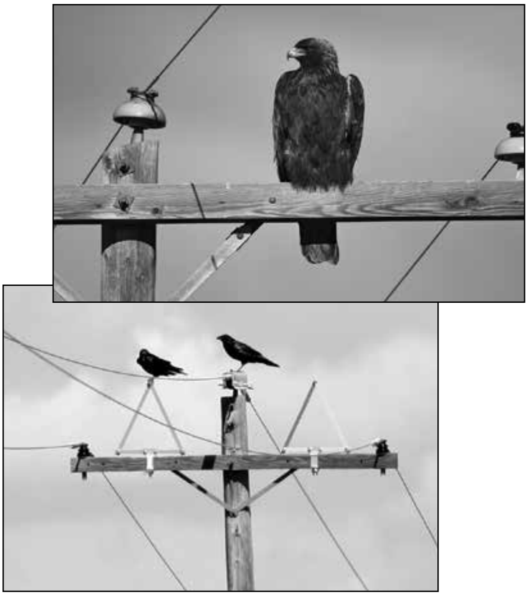

Figure 6. Stakeholders were concerned that power lines by providing new perching and nesting sites could increase greater sage-grouse (*Centrocercus urophasiansus*) predation by corvids and raptors. (*Photos courtesy Sherry Liguori*)

that the potential risk for tall structures to increase raptor and corvid predation on sage-grouse could be mitigated by maintaining and restoring sagebrush canopy cover (Bui et al. 2010, Coates and Delehanty 2010, Hagen 2011, Nonne et al. 2011, LeBeau 2012, and Nonne et al. 2013).

Actions needed. Stakeholders felt that if tall structures and activities associated with their operation and maintenance subsidize predators (i.e., perches, travel lanes, alternative food sources), predation on sage-grouse may increase (Utah Wildlife-in-Need Foundation 2010). However to obtain conclusive information, additional research will be needed to evaluate the relationship between sage-grouse population dynamics, habitat conditions (i.e., fragmentation or degradation), and predator communities, including those that are naturally occurring, exotic, and subsidized. Stakeholders concluded that they "Must Have" additional research to determine: (1) if higher predator densities associated with tall structures result in increased golden eagle and corvid predation on sage-grouse; (2) if this predation is significant at the population level; and (3) if predation can be mitigated by alteration of habitat and topography (Utah Wildlife-in-Need Foundation 2010). Because predator behavior is often overlooked in sage-grouse predation studies, stakeholders agreed that this variable should be considered as well.

G. "We do not know the impact of tall structures' ancillary facilities on sage-grouse."

Stakeholders concluded that roads were the primary ancillary facility that may be associated with transmission and distribution power lines. The ecological impact of roads on wildlife may include: (1) increased mortality from collisions with vehicles; (2) disruption of animal behavior (e.g., nesting, breeding, foraging) because of habitat changes or noise disturbance; (3) alteration of physical environment; (4) alteration of chemical environment through leaching or erosion; (5) spread of exotic and invasive plant and wildlife; and (6) increased habitat alteration and use by humans (Belcher and Wilson 1989, Forman and Alexander 1998, Trombulak and Frissell 2002, Gelbard and Belnap 2003, Mabey and Paul 2007, Ouren et al. 2007).

Road management practices may lead to the establishment of habitats that may act as local or regional population sinks (Mabey and Paul 2007). Roads can provide corridors for predators to move into previously unoccupied areas. For some mammalian species, dispersal along roads has increased their distribution. Corvids may also use primary and secondary roads as travel routes, expanding their movements into previously unused regions (Bui et al. 2010).

Connelly et al. (2004) plotted the distribution of 804 sage-grouse leks within 100 km of Interstate 80 across southern Wyoming and northeastern Utah. They reported no leks within 2 km of the interstate and that distance was a good predictor of lek activity within 15 km of the interstate. They also reported that leks within 7.5 km of the interstate appeared to decline at a higher rate than those located farther from the highway. The interstate was completed prior to the initiation of formal surveys, thus, the changes that the authors reported could have occurred prior to the surveys. Stakeholders were concerned that this analysis did not consider the effects of other highways, other land-use activities, or habitat conditions. Additionally, stakeholders concluded that this study may not be applicable to power line corridors because of differences in road type (i.e., major interstate versus unimproved access road).

Aldridge et al. (2008) did not find road density to be an important factor affecting sage-grouse persistence or range-wide patterns in sage-grouse extirpation. The authors, however, did not consider the intensity of human use of roads in their modeling efforts. They also acknowledged that their analyses may have been influenced by incomplete road data sets.

Johnson et al. (2011) reported that lek trends during 1997 to 2007 were lower in areas with active oil or natural gas wells and highways than areas with secondary roads or power lines. They concluded that the declines in count trends for leks located near highways during the study period suggest a continuing disturbance associated with highways, possibly due to increased traffic levels.

Stakeholders were interested in learning if traffic levels or volumes (i.e., disturbance) rather than the actual presence of a road were more of a factor in reduced lek counts (Remington and Braun 1991, Holloran 2005). Lyons and Anderson (2003) reported that increased traffic disturbance related to energy developments affected sage-grouse initiation rates and increased distances moved from leks. Female sage-grouse moved greater distances from leks and had lower rates of nest initiation in areas disturbed by vehicle traffic (1 to 12 vehicles per day).

Knowledge gaps. Stakeholders concluded that no specific studies associated with tall structures isolated the effects of roads on sage-grouse. The studies reviewed quantified the relationship between sage-grouse behavior and roads, traffic, or other road associated factors, and found that traffic volumes, rather than the actual presence of a road, caused a disturbance effect (Lyons and Anderson 2003, Holloran 2005).

Actions needed. Stakeholders were concerned about the potential impacts of ancillary facilities of tall structures on sage-grouse, and they felt that better information was needed regarding the direct, cumulative impacts of all infrastructure associated with tall structures on sage-grouse. Stakeholders concluded that they would "Like to Have" additional knowledge on the impacts to sage-grouse from different road types, densities, and use patterns. They also believed that it would be difficult to isolate the potential impacts of ancillary facilities from that of tall structures. The effect of roads associated with tall structures on sage-grouse must be evaluated within the context of the landscape in question. Power line access roads may include existing roads (paved or unimproved) or new roads that are typically unimproved dirt and gravel roads or "2-tracks". Depending on land ownership and other uses of the road, utility access roads may be gated and locked. Based on the literature review, how a road is used (i.e., traffic volumes and types) relative to the landscape may be more important to sage-grouse than the mere presence of roads. Stakeholders found no published comparative studies regarding the impacts of roads on sage-grouse that controlled landscape level factors that considered habitat condition and road operation and maintenance.

H. "We are concerned tall structures fragment sage-grouse habitat."

The USFWS (2010) in citing Connelly et al. (2004) defined habitat fragmentation as, "the separation or splitting apart of previously contiguous, functional habitat components of a species." Fragmentation can result from direct habitat losses that leave the remaining habitat in noncontiguous patches or from alteration of habitat areas that render the altered patches unusable to a species (i.e., functional habitat loss). Functional habitat loss includes disturbances that change a habitat's successional state or remove 1 or more habitat functions, physical barriers that preclude use of otherwise suitable areas, and activities that prevent animals from using suitable habitat patches due to behavioral avoidance (U.S. Fish and Wildlife Service 2010). Sagebrush communities exhibit a high degree of variation in their resistance and resilience to change, beyond natural variation (Pyke 2011). Stakeholders agreed that the question to be answered remains: if tall structures fragment sage-grouse habitat, does their presence constitute a functional habitat loss that changes habitat-use and reduces an individual animals fitness in terms of survival or productivity?

Knowledge gaps. By the USFWS (2010) definition, tall structures and associated infrastructures that bisect contiguous sagebrush habitats constitute fragmentation. Stakeholders, however, concluded that the actual contribution of such infrastructure to functional habitat loss of the surrounding areas is not well-studied. To understand the possible impacts of tall structures on sage-grouse, it will be important to also understand how tall structures may affect the dynamics and behavior of predator populations. Stakeholders were concerned that impacts of tall structures on sage-grouse appeared to be linked to perceived increased predation risks because of new perches and possible areas of subsidized predator populations. After a review of the literature, the stakeholders concluded that there are no predators that depended on the sage-grouse as their primary food source. Stakeholders concurred that data regarding the relative abundance of potential sage-grouse predators pre- and post-tall structure installation should be quantified as part of any tall structure and fragmentation research.

Actions needed. Stakeholders felt that: (1) sage-grouse may be displaced from important habitats if they exhibit an aversion to tall structures; (2) tall structure height, density etc. may impact habitat, including seasonal use and landscape variability; (3) sage-grouse may avoid high concentrations of tall structures, causing changes in habitat use and abandonment of high quality breeding areas; and (4) sage-grouse may be more tolerant of tall structures in areas where they have better habitat and associated canopy cover. Stakeholders concurred that they "Must Have" better knowledge about sage-grouse habitat fragmentation. They desired more knowledge on the impacts of the different types of commonly used tall structures throughout the different seasons of habitat use, including lekking, nesting, brood-rearing, and winter habitats. They recommended that knowledge must be based on the linear footprint of transmission and distribution lines (Utah Wildlife-in-Need Foundation 2010).

Although there have been many observations and recommendations concerning the importance of suitable habitat for reducing predation pressure on adult sage-grouse, stake-holders concurred that detailed information was lacking (Schroeder and Baydack 2001). Atamain et al. (2006) assessed the impact of the Falcon-Gondor transmission line in Nevada on sage-grouse demography and population dynamics. Their results suggested that sage-grouse nests with 65% total shrub cover had twice the probability of success than nests with 25% cover, regardless of distance from the transmission line. Although the transmission line, by definition, constituted fragmentation (U.S. Fish and Wildlife Service 2010), stakeholders did not believe it constituted functional habitat loss. They concluded that rigorous testing was still needed to know whether habitat protection and restoration will allow sage-grouse to persist in areas where tall structures occur.

Discussion

Stakeholder focus groups are a common aspect of the wildlife management agency human dimensions tool kit (Stiver et al. 2006, Connelly et al. 2012). The focus groups that were convened by UWIN represented a diversity of sage-grouse stakeholders. Although, we were not able to engage all of the stakeholders identified in the project scoping process in the facilitated focus groups (Utah Wildlife-in-Need Foundation 2010), UWIN staff provided regular updates on the progress of the process and solicited feedback from stakeholders who were not able to participate in the focus groups. This effort increased both the visibility of the process and the quality of the outcome. In addition, all stakeholders who actively participated in the focus group and those originally identified in the scoping process received drafts of the UWIN report prior to project completion. The final report was presented to WAFWA for final review.

Stakeholder's concluded that no there were no results in the published, peer-reviewed literature of experimental studies designed to evaluate the potential landscape effects of tall structures on sage-grouse. Stakeholders desired additional landscape-level studies to assess the potential effects of tall structures on sage-grouse (Utah Wildlife-in-Need Foundation 2011). They agreed that these studies have not been conducted because of uncertainty in new transmission project permitting timeframes, perceptions that such work has already been completed, and funding constraints (Utah Wildlife-in-Need Foundation 2010). Stakeholders concurred that such research is needed, and incentives for industry to provide research funding as a component of project mitigation should be considered. Since the UWIN (2010) literature review, 1 unpublished report (Nonne et al. 2013) has provided results from long-term (i.e., 10 years) monitoring of a transmission line on sage-grouse.

Stakeholders concluded that viable estimates of sage-grouse mortality resulting from power line collisions and predation are lacking. The literature contained personal observations of mortality attributed to tall structures, but the number of observations are low relative to the tall structure foot print. Utility APPs and APLIC can provide resources and information on power line collision risks (Avian Power Line Interaction Committee 2012). Stakeholders believed a better understanding of the extent and causal factor of mortality attributed to tall structures would help state and federal agencies to refine siting criteria and develop BMPs and other conservation measures to mitigate potential impacts.

Contemporary sage-grouse BMPs are largely lek-centered. The stakeholder review of the literature could not identify a consistent source or scientific basis for recommended lek buffer zones. The USFWS (2010) acknowledged similar concerns in the greater sage-grouse status review. Stakeholders concluded no research has been conducted to evaluate the effectiveness of current BMPs or buffers. For effective BMPs to be developed, stakeholders concurred that better science-based information will be needed regarding the effects of tall structures on sage-grouse reproductive success, recruitment, and survival at the population level.

Stakeholders recognized that there was good evidence that the current methods of estimating sage-grouse populations and responses to habitat fragmentation based on lek counts are inadequate (Connelly et al. 2004). The increased use of empirically based corrective models to generate less-biased estimates of sage-grouse demographic and population parameters will address part of this inherent bias (Knick et al. 2003, Johnson et al. 2011). However, additional experimentation will be needed to provide better scientific basis for these models (Utah Wildlife-in-Need Foundation 2011).

Stakeholders concluded that a major impediment they encountered in reviewing the papers or reports cited regarding the potential effects of tall structures on sage-grouse were largely related to a lack of BACI experimental designs. Specific stakeholder concerns included: (1) observational studies or observations based on personal communication or unpublished data; (2) inadequate descriptions of control and treatments or pre-existing habitat conditions; (3) inferences to sage-grouse from studies conducted on other species; (4) retrospective studies that did not quantify related environmental conditions; (5) inappropriate or misuse of citations; (6) the use of results from cumulative impact studies of other energy development to make inferences about the effects of tall structures on sage-grouse; and (7) small sample sizes (Utah Wildlife-in-Need Foundation 2010).

To adequately assess the impacts of tall structures on sage-grouse, conditions before and after the activity in question must be compared (Utah Wildlife-in-Need Foundation 2011). In many cases, obtaining this type of baseline data for sage-grouse may not be within the control of an individual investigator. Stakeholders recognized that depending on the project planning, permitting duration, and funding constraints, there may not be enough time to collect adequate data over several seasons and years. They concurred that data collected over multiple years, both pre- and post-installation will be paramount to understanding tall structure and sage-grouse interaction, given annual and seasonal variations in weather.

Stakeholders identified specific questions regarding the relationship between sage-grouse and tall structures that needed additional study. These questions included: (1) do sage-grouse avoid tall structures and, in particular, what are they avoiding; (2) if sage-grouse avoid tall structures, what are the individual and population impacts, and when would the impacts be manifested; (3) will the effects be permanent; (4) will the effects be limited to the area of disturbance; (5) what measures (BMPs) can be implemented to mitigate impacts and alleviate negative impacts; and, (6) will these BMPs be universally effective?

Stakeholders noted that many of the papers reviewed that cited impacts of tall structures on sage-grouse were based on observational studies. Thus, even when logistical factors may limit the study location and control sites, they agreed that relevant characteristics of experimental and control sites (e.g., vegetation, hydrology, topography, other surrounding land uses) must be quantified so, at a minimum, post-hoc analyses can identify confounding factors that may have influenced observed patterns.

To address stakeholder concerns, UWIN facilitated a consortium process in 2011 that engaged sage-grouse biologists, statisticians, and managers from agencies, academia, industry in a process to develop a standardized research protocol for assessing the potential impacts of tall structures on sage-grouse. The protocol was subsequently endorsed by WAFWA in 2011 as the standard for assessing the potential impacts of tall structures on sage-grouse (Utah Wildlife-in-Need Foundation 2011).

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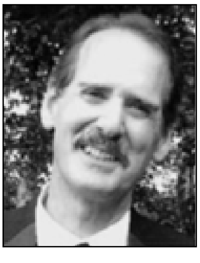

Robert (Bob) Hasenyager (deceased) grew up in Illinois, but was a Utahn at heart. After graduating from Princeton High School, he spent the summer working for the U.S. Forest Service in Kanosh, Utah. That led to a basketball scholarship at Dixie College. Knowing he wanted to pursue a career protecting wildlife and nature, he graduated with a wildlife degree from Utah State University in 1975. Upon graduating from USU, he began his 35 year career working for the Utah Division of Wildlife Resources. He received his MBA from USU in 1988. He created Utah Wildlife-In-Need, a foundation whose purpose is to perpetuate wildlife species and natural places for future generations. He passed away on April 5, 2013, at home after waging a 14-month battle with renal cell carcinoma.

James Burruss has 30 years of diverse experience in regulatory permitting, compliance, environmental impact assessments, mitigation plan development, monitoring, and avian-safe design of large and small-scale energy generation, substation, transmission, and distribution projects. He has served as environmental project lead, regulatory compliance specialist, and principal biologist on a variety of energy generation and transmission projects, including electric transmission and distribution lines, wind power, hydroelectric, and fossil-fuel projects. His experience includes program and project management, opportunity and constraints analyses, impact assessment, permitting, agency consultation, design and implementation of resource studies and mitigation programs, compliance monitoring, stakeholder collaboration, and interface with resource agencies at the state and federal level, including the U.S. Fish and Wildlife Service, Federal Energy Regulatory Commission, U.S. Forest Service, U.S. Army Corp of Engineers, U.S. Bureau of Land Management, and the Environmental Protection Agency. He has particular expertise in applications of the Federal Endangered Species Act, Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, National Environmental Policy Act, Clean Water Act, and related resource laws and regulations.

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