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Contemporary Knowledge and Research Needs Regarding the Potential Effects of Tall Structures on Sage-grouse (Centrocercus urophasianus and C. minimus)

UWIN Cooperative
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EXECUTIVE SUMMARY

The Energy Policy Act of 2005 requires all state and federal agencies to grant utilities access permits to promote reliable, renewable energy production and transmission. Contemporary transmission of energy relies largely on above ground electric-utility structures and transmission lines. Connelly et al. (2004) suggested that these structures (e.g. power lines, communication towers, wind turbines, and other installations) and associated activities in sage-grouse (*Centrocercus* spp.) habitat may impact the species.

The Greater Sage-grouse (*C. urophasianus*) Range-wide Issues Forum (Forum), sponsored by the Western Association of Fish and Wildlife Agencies (WAFWA), was convened in 2005 to engage a diverse group of stakeholders in the identification of strategies to address species conservation issues identified by Connelly et al. (2004). The Forum preceded the development of the Rangewide Greater Sage-grouse Comprehensive Strategy (Stiver 2006). Forum participants identified a need to better understand the effects of tall structures on sage-grouse. To address this need they recommended compiling and evaluating existing published research on the effects of tall structures on greater sage-grouse. If the science was not currently available, they believed this literature synthesis would facilitate the development of research protocols for conducting new studies to assess direct impacts of tall structures on greater sage-grouse and implementation of effective best management practices (BMPs) that would minimize negative impacts on the species.

Recognizing that the Forum goals had not been met, Utah Wildlife in Need (UWIN), a nonprofit foundation, in cooperation with Rocky Mountain Power (RMP) and the Utah Division of Wildlife Resources (DWR) facilitated a process to synthesize stakeholder contemporary knowledge regarding the effects of tall structures on sage-grouse. For the purpose of this report tall structures include electric distribution and transmission lines, wind turbines, and associated infrastructure. The project assessed the adequacy of existing information to predict and mitigate the potential impacts of tall structures on sage-grouse, identified information gaps and needs, and prioritized research needed to provide new knowledge for policy development. The project combined a public input process (workshops) with a synthesis of published and unpublished information.

We learned during the project that there were ***no*** peer-reviewed, experimental studies designed specifically to evaluate the landscape effects of tall structures on sage-grouse. This is significant because it demonstrated that additional knowledge **must be acquired** before all the goals of the Greater Sage-grouse Comprehensive Conservation Strategy's tall structure issue can be realized. Forum goals 3 and 4, respectively, are to "Develop scientific and consistent siting and Operation and Maintenance (O&M) criteria for "tall structures" in greater sage-grouse habitat that will minimize negative impacts on greater sage-grouse" and "Develop BMP's and appropriate mitigation measures that can be implemented for siting and O&M activities associated with tall structures." Project participant's most pervasive and broadly held concern was "the science upon which to base many tall structure decisions is lacking."

Project participants were also concerned that research on other species, locations, and dated technologies are used to establish BMPs that may not adequately mitigate the potential effects of tall structures on sage-grouse. Additionally, because we do not know what constitutes "effective" temporal and spatial setbacks and buffers, siting policies and requirements policies continue to differ by governmental agency. Because BMP's are not monitored, these differences are magnified which facilitates an atmosphere of uncertainty. This uncertainty raised additional questions as to whether sage-grouse actually avoid tall structures. If sage-grouse are adversely affected by tall structures, workshop participants wanted to know if it was in response to increased predation risks associated with the physical structure, ancillary facilities such as roads, or functional habitat loss attributed to fragmentation.

Participants recommended that research implemented to address their concerns include; 1) a rigorous, replicable research protocol developed by a committee of experts, 2) a BACI experimental research platform, 3) adequate replication representative of the sagebrush (*Artemisia* spp.) landscapes currently inhabited by sage-grouse, 4) current industry technology, 5) current research technology including the use of GPS transmitters, 6) "court" defensible results, 7) experimental designs that simultaneously addresses multiple knowledge gaps, 8) metrics assessing individual and cumulative impacts of each tall structure type, 9) a collaborative process, 10) mechanisms that allow preliminary results to be employed in an adaptive management approach leading to the refinement of effective BMPs, 11) transparency and open dialogue with frequent partnership updates, and 12) industry incentives to include mitigation credits for proactive funding of identified research.

INTRODUCTION

The Energy Policy Act of 2005 requires all state and federal agencies to grant utilities access permits to promote reliable, renewable energy production and transmission. Contemporary transmission of energy relies largely on above ground electric-utility structures and transmission lines. Connelly et al. (2004) suggested that these structures (e.g. power lines, communication towers, wind turbines, and other installations) and associated activities in sage-grouse habitat may impact the species. The U. S. Fish and Wildlife Service (2003) also reported that because renewable energy resources require many of the same features for construction and operation as do non-renewable energy projects they may also impact sage-grouse. Concomitantly, they recommended the use of various buffer distances between tall structures and occupied sage-grouse habitats to mitigate potential impacts.

The Greater Sage-grouse Range-wide Issues Forum (Forum), sponsored by the Western Association of Fish and Wildlife Agencies (WAFWA), was convened in 2005 to engage a diverse group of stakeholders in the identification of strategies to address species conservation issues identified by Connelly et al. (2004). The Forum identified strategies were incorporated into the Rangewide Greater Sage-grouse Conservation Strategy (Stiver 2006). The goal of the Forum was to contribute to the development of a range-wide conservation strategy that would "maintain or, where possible, increase the present distribution and abundance of greater sage-grouse and sagebrush habitat." The U.S. Institute for Environmental Conflict Resolution organized, facilitated, and published a final report of the findings and recommendations (http://sagegrouse.ecr.gov/).

Forum participants identified range-wide greater sage-grouse and related sagebrush habitat issues they believed could not be adequately addressed at local, state, and provincial scales. They also identified strategies to address the issues. One of the issue sub-categories identified by Forum participants was the effect of tall structures on sage-grouse. Forum participants defined tall structures as power lines, communication towers, wind turbines, and other installations. They developed the following problem statement, goals and objectives for tall structures.

Problem Statement: Tall structures and associated activities in greater sage-grouse habitat may impact greater sage-grouse.

Desired Condition: Existing and new tall structures have no or minimal impacts on greater sage-grouse.

Goal 1: Compile and evaluate existing published research on effects to greater sage-grouse due to direct impacts.

> **Objective 1.1:** Evaluate adequacy of existing research information to assess or predict potential direct impacts of tall structures on greater sage-grouse.

Goal 2: Develop research protocols for conducting new studies to assess direct impacts of tall structures on greater sage-grouse.

> **Objective 2.1:** Develop peer-reviewed and scientific protocols to assess impacts of tall structures and potential mitigation methods.

Goal 3: Develop scientific and consistent siting and Operation and Maintenance (O&M) criteria for "tall structures" in greater sage-grouse habitat that will minimize negative impacts on greater sage-grouse.

> **Objective 3.1:** Compile existing siting and O&M criteria or conditions in federal, state and local working group plans pertaining to tall structures.

> **Objective 3.2:** Develop consistent siting guidelines for tall structures.

Goal 4: Develop best management practices (BMPs) and appropriate mitigation measures that can be implemented for siting and O&M activities associated with tall structures.

> **Objective 4.1:** Cooperatively develop best management practices and appropriate mitigation measures.

PURPOSE

Recognizing that the four goals had not been met, Utah Wildlife in Need (UWIN) in cooperation with Rocky Mountain Power (RMP) and the Utah Division of Wildlife Resources (DWR) facilitated a process to synthesize stakeholder contemporary knowledge regarding the effects of tall structures on sage-grouse, (hereafter referred to as the UWIN Cooperative). For the purpose of this report tall structures include electric distribution and transmission lines, wind turbines, and associated infrastructure.

This project assessed the adequacy of existing information to predict and mitigate the potential impacts of tall structures on sage-grouse, identified information gaps and needs, and prioritized research needed to provide new knowledge for policy development. The project combined a public input process (workshops) with a synthesis of published and unpublished information. This technical report documents contemporary knowledge and policy regarding the effects of tall structures on sage-grouse and identities research needed to fill information gaps and mitigate inconsistencies in contemporary policies governing tall structure siting requirements. This project addressed Forum Goals 1 and 3 (Objective 3.1). Completion of the project will facilitate accomplishment of Goals 2, 3 (Objective 3.2), and 4. This technical report and associated materials will be accessible on-line at www.utahcbcp.org.

UWIN Cooperative Project Objectives

1. Synthesis of existing information (published and unpublished) regarding the predicted and potential effects of tall structures on sage-grouse and other selected wildlife.
2. Synthesis of existing policies regarding siting and other requirements to mitigate the potential effects of tall structures on sage-grouse
3. Identification of additional information/knowledge needs regarding the potential effects of tall structures on sage-grouse
4. Prioritization of research needs regarding the potential effects of tall structures on sage-grouse

PROJECT METHODS

Workshop Dates, Locations, Participation, and Process

Utah Wildlife in Need managed the project to include organizing, scheduling, and facilitating a series of four workshops; two in Utah and two in Wyoming. The Utah workshops were conducted in Salt Lake City on 25 May and 16 June, 2010. The Wyoming workshops were conducted in Rock Springs on 27 May and 10 June, 2010.

The UWIN Cooperative jointly identified stakeholders representative of renewable and traditional energy development and distribution companies, state and federal wildlife and land management agencies, research universities, Utah and Wyoming governor's and energy offices, non-government organizations (NGOs) and landowners (hereafter referred to as the Participants). Utah Wildlife In Need e-mailed identified Participants a letter inviting them to participate in the project and a project overview. In addition, UWIN made a minimum of two attempts to contact each identified Participant by phone. The primary purpose of the phone conversation was to introduce the project, respond to any project questions, and reinforce the e-mail invitations. (See Appendix A for a list of invited Participants).

The second purpose of UWIN's phone call was to request each stakeholder to identify their primary concerns regarding tall structures in sage- grouse habitat and their perceptions on the most effective way to abate their concerns. The specific questions asked of each Participant were:

1. What is your primary concern regarding tall structures in sage-grouse habitat?
2. If this concern were handled most effectively, what would that look like from your perspective?

These responses were compiled and a content assessment performed by UWIN to identify shared concerns and effective ways to address them. Prior to the first set of workshops, Participants were provided the following; 1) a list of the shared concerns compiled by UWIN 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 policies regarding siting and other requirements to mitigate the potential effects of tall structures on sage-grouse.

At the first set of workshops, the facilitation team (See Appendix B for a list of project personnel) reviewed the preliminary shared concerns, the literature synthesis, and the siting policies with Participants. Participants were encouraged to discuss and expand upon their individual and shared concerns, the known literature and current siting policies.

Prior to the second two workshops, Participants received an expanded and reconsolidated list of stakeholder concerns that included their input from the first set of workshops, an updated literature synthesis specific to sage-grouse, and an updated synthesis of existing siting policies. To ensure a comprehensive list of concerns, literature and policies, the facilitated input and discussion process employed at the first set of workshops was repeated at the second set of workshops. (See Appendix C for a complete list of Participant's individual and shared concerns and preferred outcomes.)

Workshop Participant Shared Concerns

At each set of workshops UWIN facilitators worked with Participants, through small group discussions, to build consensus on shared concerns regarding the potential impacts of tall structures on sage-grouse and on ways to address these concerns. This process resulted in the identification of eight shared concerns. These shared concerns became the focal point of the UWIN Cooperatives subsequent synthesis of available literature, identification and assessment of knowledge gaps, and discussion and prioritization of next steps identified below.

Synthesis of Available Literature

The literature synthesis was conducted by Dr. Terry A. Messmer, Quinney Professor for Wildlife Conflict Management, Jack H. Berryman Institute, and Rae Ann Hart, Department of Wildland Resources, Utah State University (USU), Logan, Utah. The literature review included peer-reviewed and non-peer reviewed published studies, technical, and project reports regarding the effects or relationship between sage-grouse and tall structures. They sought to identify citations or references commonly used and how they were used by authors to describe or define the potential effects of tall structures on sage-grouse. They also determined the scientific basis for the citation (i.e., observational, experimental or retrospective studies, professional opinion, unpublished data, or personal observations).

To conduct this synthesis, they searched the databases of ISI Web of Science, Google Scholar, Agricola, Biological Abstracts, Bio-One, Dissertation Abstracts, and Zoological Record. These searches were facilitated through the USU Merrill-Cazier Library Electronic Resources and Database System. The keywords or combinations thereof used to conduct the search included:

sage-grouse, greater sage-grouse, *Centrocercus urophasianus,* Gunnison sage-grouse, *Centrocercus 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, U.S. Fish and Wildlife Agency, Bureau of Land Management, 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 they conducted personal, e-mail, and phone interviews with state and federal biologists and managers involved in sage-grouse management and research.

They also compiled a reference document containing abstracts of literature pertinent to the effects of tall structures on sage-grouse and other wildlife. This document is stratified based on species, type of tall structure, effects, and document type (see Appendix D for web link to literature synthesis). This information was used to respond to Participant's eight shared concerns regarding the effects of tall structures on sage-grouse.

Identification and Assessment of Knowledge Gaps

At the second set of workshops, using the same small group discussion process employed to identify the eight shared Participant concerns, UWIN worked with Participants to compare the knowledge contained in the literature to that needed to build mutually accepted BMPs. From this comparison workshop Participants identified knowledge gaps they believed must be addressed before mutually acceptable BMPs for the placement and operation of tall structures can be developed that will mitigate the potential negative effects on sage-grouse. Although Participants did not evaluate specific BMPs or siting recommendations they identified the steps needed to address knowledge gaps.

Discussion and Prioritization of the Next Steps

At the second set of workshops, Participants were asked to respond to a set of questions designed to help them identify the most effective and efficient "next steps" to filling identified knowledge gaps. Finally, to conclude the facilitated process, Participants were asked to prioritize each step by placing it in one of two categories: "**Must Have**" or "**Like to Have**." Participants' eight shared concerns, the literature synthesis relative to each of these concerns, corresponding knowledge gaps, next steps and their priority are presented in the Results and Discussions section of this report.

Contemporary Range-wide Tall Structure Siting Requirements

Dr. Messmer and Ms. Hart also prepared a spreadsheet of contemporary state, provincial, and federal agency policies, rules, regulations, and guidelines for the placement of tall structures, and associated facilities, in areas inhabited by sage-grouse. The initial policy documents were obtained from agency web sites and published documents. Because these published guidelines are dynamic, once the initial information was compiled, it was e-mailed to Participants and state and federal contacts for review and validation (see Appendix E for web link to spreadsheet and related narratives).

RESULTS AND DISCUSSION

Participant Shared Concerns, Literature Synthesis, Knowledge Gaps and Priority Next Steps

Participant's eight shared concerns encompassed broad topics such as the lack of peer-reviewed science upon which to base BMPs to the role of tall structures in sage-grouse predation. This list guided the literature synthesis. The eight shared concerns and Participant's prioritizations are summarized below and discussed in detail in the section of the report immediately following the summary. At the end of this section under the heading "Other Un-prioritized Concerns," we included information regarding other concerns expressed by the Participants that did not logically fit within the eight concerns presented below. These concerns were not prioritized.

Summary of Shared Concerns

1.) 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 all "**Must Have"**

2.) We use research on other species, locations and dated technologies in establishing BMPs.

Participants concluded the only current option is to use surrogate information on sage-grouse and tall structures and the "primary emphasis is to conduct research on sage-grouse germane to structure issues" but **No specific prioritization was identified.**

3.) We do not know what "effective" temporal and spatial setbacks and buffer are and existing ones vary by governmental agency.

No specific prioritization was identified. Participants recommended research on the "effects of tall structures on lek attendance, population persistence, nest success and migration and movement"

4.) We are concerned recommended BMPs are not monitored and may not be effective.

Participants prioritized the monitoring of current and future BMPs to determine their effectiveness as "**Must Have"** and encouraged industry incentives for funding of this monitoring

5.) We do not know if and why sage-grouse avoid tall structures.

Participants concluded a research project “specifically to address possible avoidance” was a “**Must Have”.**

6.) Tall structures may increase predation on sage-grouse.

Participants identified numerous research projects needed to fill the knowledge gaps surrounding this concern and concluded they were “**Must Have”.**

7.) We do not know the impact of tall structures’ ancillary facilities on sage-grouse.

Participants concluded that they would **“Like to Have”** research on the impacts of roads, noise and activity related to tall structures on sage-grouse but also concluded it would be difficult to separate the impacts.

8.) We are concerned tall structures fragment sage-grouse habitat.

Participants identified a “basic fragmentation analysis as a “**Must Have”** and other approaches (a stepwise multivariate discriminate function analysis) is **“Like to Have”** and may not be practical to implement”.

Literature Synthesis for Shared Concerns

1. **We lack sound science upon which to base many tall structure BMPs and decisions.**

A representative sample of the specific concerns expressed by Participants that were used to compile this shared concern included; 1) “All decisions need to be based on the best research,” 2) “A number of statements, decisions, and directives are being made with anecdotal evidence and even fewer scientific studies…,” and 3) “The robustness and definition of the science regarding the impacts of tall structures need to be improved.” In the case of tall structures and sage-grouse, Participants were interested in learning if the information currently available is adequate to make decision regarding BMPs. Inherent in their concerns was a need to understand if a “cause and effect” relationship exists between the placement of tall structures in sage-grouse habitat and observed populations declines and if recommended BMPs could mitigate identified impacts.

a. Available literature

When wildlife managers are interested in learning how a wildlife population or particular species will respond to a management action, they seek to implement manipulative experiments to determine cause and effect relationships. In these experiments, ideally they seek to answer a question (i.e., a hypothesis) by implementing the action while attempting to control for or leave unchanged other parts of the system or environment. Given that some variables, such as weather, will always be a factor beyond a manager's control, their experiments will include controls or reference sites, randomization, and replication (Ostle 1983, Shaffer and Johnson 2008). In some cases, given environmental or logistical constraints, randomization and replication maybe be difficult.

In lieu of experimental studies, managers conduct observational studies and surveys. In the case of sage-grouse these may include retrospective studies to correlate changes in lek trends or occupied habitat to anthropogenic activities (Johnson et al. 2010, Knick et al. 2010, Wisdom et al. 2010). These studies used lek presence and count data obtained from annual surveys to make inferences about population effects relative to specific activities. Although observational studies lack one or more of the critical elements found in experimental studies, the data collected are analyzed in similar fashion (Cochran 1983).

Regardless of the type of study conducted, the validity of the process and the conclusions drawn by the proponents, are not typically recognized by the scientific community as "sound science" unless it has been peer-reviewed and published in a reputable outlet, such a professional journal. The process of peer-review includes submission of a manuscript prepared by project proponents to a professional outlet. The outlet in turn solicits other scientists, usually 2 to 3, to review and evaluate the scientific merit of the work. The rigor of this process can be enhanced with a "double-blind" review in which neither the identity of the reviewers or the authors of the manuscript are known to each other.

We found no "peer-reviewed" manuscripts that reported results from experimental studies to document sage-grouse avoidance of tall structures, increased predation related to avian predators using tall structures as perches, increased mortality attributed to collisions, or habitat degradation and/or fragmentation attributed to tall structures. Our literature synthesis did find professional opinions, personal observations, unpublished data, anecdotal references, and models that implicated tall structures as potential causal agents of the above effects on sage-grouse, and peer-reviewed studies on the cumulative effects of oil and gas development and associated infrastructures on sage-grouse. The latter studies did not isolate tall structures, as defined by this project, as a specific mechanism affecting sage-grouse.

Because many authors were not able to assign random and independent treatment and controls in a balanced, randomized design, and they incorporated a number of qualitative variables in their studies, interpretation of the effects of specific explanatory variables such as tall structures was confounded. Therefore, from these studies, it is not possible to determine whether tall structures were independently responsible for or contributed to local or range wide sage-grouse population responses. Thus, 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 reported in the literature should not be assumed causal (Shaffer and Johnson 2008).

We found no publications (peer-reviewed or otherwise) that specifically reported on replicated (e.g., BACI) studies conducted to determine individual or population responses of sage-grouse to tall structures as defined by this project. Although we found citations documenting individual mortality, we did not find any population or landscape level studies documenting avoidance, reduced fitness or production. Completion of such studies will be expensive and time consuming. Participants felt it imperative to have this research coordinated among tall structure stakeholders. They believed these studies must include adequate sampling effort and replication to detect statistically significant responses that accommodate for differences in topography, habitat conditions, and location.
Although there are no specific studies related to potential effects of tall structures, there are a number of peer-reviewed papers that corroborate the anthropogenic footprint to the likelihood of sage-grouse occupancy of habitats and population performance (Johnson et al. 2010, Knick et al. 2010, Wisdom et al. 2010). Hence, even though the current science may not yet understand the effects of tall structures on sage-grouse, there appears to be some quantification of the effects of the broader human footprint on sage-grouse.

b. Identified knowledge gaps

Common situations we encountered in reviewing the papers or reports commonly cited in the literature to document the effects of tall structures on sage-grouse included: 1) observational studies or observations based on personal communications 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, and 5) the results of cumulative impact studies of energy development and associated infrastructures used to make inferences about the effects of tall structures on sage-grouse.

c. Actions needed to fill knowledge gaps and lead to BMPs

Participants concurred that they **Must Have** additional science-based knowledge to develop effective BMPs. They recommended that research follow peer reviewed scientific protocols and include the following component; 1) a BACI research platform, 2) be replicable and replicated in multiple states, 3) focus on current energy development technology, 4) use current research technology such as global positioning system (GPS) transmitters, 5) produce defensible results, 6) be designed to simultaneously 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 like mitigation credits for research.

To adequately assess the impacts of tall structures on sage-grouse, conditions before and after the activity in question must be quantified. Obtaining these baseline data for sage-grouse is likely beyond the purview and capabilities of the single investigator. Depending on the project planning and funding constraints, there may not be enough time to collect adequate data over several seasons and years. For example, in the case of wind energy farms, the state of Idaho siting policies specify a 3 year pre- and post data collection period requirement prior to granting the necessary permits (Appendix E). Data collected over multiple years will be paramount to understanding tall structure and sage-grouse relationships given annual and seasonal variations in weather and bird populations.

2. **We use research on other species, geographic locations, dated technologies, and energy impact studies in establishing BMPs.**

Participant concerns commonly expressed for the above topic included; 1) "We are concerned about using studies conducted on other species or in other geographic regions to fill knowledge gaps for sage-grouse," 2) "Decisions are being based on Altamont wind turbine technology," 3) "We need studies on the impacts of current turbines on sage-grouse, not other birds and bats," and 4) "We do not use newer GPS radio-telemetry technology as much as we could for sage-grouse studies, which would give us answers on avoidance of tall structures."

a. Available literature

i. Other species

Although prairie chickens and sage-grouse are both lekking species that occupy broad geographic landscape, they differ in morphology, behavior, life history, seasonal habitat use patterns, and distribution. These differences may confound comparisons regarding their individual and population responses to tall structures. However, the U.S. Fish and Wildlife Service (USFWS), in its 2010 Notice of 12-Month Petition Findings for Petitions to List Greater Sage-grouse as Threatened or Endangered (http://www.regulations.gov and www.fws.gov), cited results reported by Pruett et al. (2009) regarding lesser (*Tympanuchus pallidicintus*) and greater (*T. cupido*) prairie chicken in support of Braun's (1998) statements that sage-grouse avoid suitable habitat near power lines. Braun's (1998) comments were based upon unpublished data. However, in developing policies regulating siting of power lines, states do not include citations that reference prairie chicken studies. The Pruett et al. (2009) citation was used in a recent NWCC report that lumps sage-grouse and prairie chickens into the category of "prairie grouse" (**http://www.nationalwind.org//publications/bbfactsheet.aspx?idevd=2F910A046ACD11DEA5DEEC6455D89593&idevm=ccc382da3ab54cc185d952d0766b3bd3&idevmid=334498**).

Robel et al. (2004) and Pitman et al. (2005) reported that lesser prairie-chicken nests were farther from all anthropogenic features – except unimproved roads – than would be expected by chance. The number of roads and extent of each type of road are not described, but included improved roads (graveled or paved). These authors concluded that lesser prairie-chicken avoidance behavior, particularly for nesting females, creates "avoidance buffers" around anthropogenic features in the landscape that fragment, isolate, and reduce available habitat. They suggested that avoidance buffers should be measured for species in various landscapes to assess the true impact of human disturbances.

ii. Geographic locations

The literature also contained several published reports of studies conducted in Europe on the impacts of overhead wires on black grouse (*Tetrao tetrix*) and ptarmigan (*Lagopus* spp.). These studies are not cited in state policies or by the USFWS (2010). Miqueta (1990) studied black grouse deaths through collisions with cables at ski resorts. He concluded that although these collisions are largely ignored, this source of mortality could be important relative to population numbers. The inconspicuousness of wires, combined with interference to the birds' habits and human disturbance, are the main factors causing accidents. Collisions were more frequent on ski-tows and electricity lines than on chairlifts. These observational studies were conducted in forested habitats thus have limited application to sage-grouse.

Bevanger and Brøseth (2001, 2004), recorded the number of ptarmigan (*Lagopus lagopus* and *L. mutus*) along three power-line sections that were killed through colliding with the overhead wires over a 6-year period in a subalpine habitat in southern Norway. The effect of an experimental removal of the ground wire (common neutral) was evaluated on one of the power-line sections by comparing the number of mortalities found before removal with the number found after. Two other power-line sections in the same area were used as control sections. Collisions were reduced by 50% after the lower ground wire was removed, thus confirming the expectation that there is a connection between the number of overhead wire levels (vertically) and the collision rate. The results confirmed that a reduction in overhead wire levels had a general positive effect by reducing the collision rate.

iii. Newer GPS radio-telemetry technology

Published literature regarding the specific effects of anthropogenic factors (cumulative effects of oil and gas development and related infrastructures) on sage-grouse was based on observational studies that incorporated standard very high frequency (VHF) radio-telemetry. This technology allows investigators to assess and evaluate habitat-use patterns, seasonal movement, and mortality using relocation data (Connelly et al. 2003). Biologists also have been using this technology since the 1960’s to estimate daily, seasonal, and annual survival rates.

Early transmitters weighed more than 70 g (> 5% of an adult female’s mass) and had relatively short battery lives. The weight of these early transmitters and how they were affixed to sage-grouse may have increased individual bird mortality risks, hence estimates of survival using this early technology are suspect (Connelly et al. 2003). By the mid- to late 1970s, improvements in transmitter technology resulted in collars that weighed 25 g (2% or less of an adult female’s mass) and batteries that lasted several months.

Throughout the 1970s and early 1980s, transmitters were attached to sage-grouse using variations of a backpack harness (Brander 1968). Research in the early 1980s demonstrated that backpack harnesses may increase a sage-grouse predation risks. Subsequently many biologists switched to a poncho-mounted transmitter (Amstrup 1980). These transmitters were used on sage-grouse throughout much of the 1980s and early 1990s. The ponchos were custom fit to individual birds and the transmitter was attached to the poncho so that it would lie against the bird's crop. During this time solar powered transmitters that included batteries were used with ponchos.

By the mid 1990s, biologists adopted a battery-powered transmitter attached around the bird's neck by a necklace consisting of plastic-coated cable. This necklace is lighter than a poncho and can be attached just as quickly (Connelly et al. 2006). The per unit cost was approximately $200.

Standard radio-telemetry may have limitations if the research questions require more detailed knowledge of bird movements (i.e., exact and multiple daily locations) and behavioral responses to tall structures. The standard radio-telemetry (VHF) methodology has been largely preferred because of the higher costs associated with newer GPS satellite telemetry technology (i.e., a single collar may cost several thousand dollars with additional costs associated with data downloads) and the increased weights. Early GPS type collars weighed >30 grams.

Sirtrack™ manufacturers a ~33 g GPS/VHF radio units (Private Bag 1403, Goddard Lane, Havelock North 4157, New Zealand) for use with sage-grouse. Stringham (2010) estimated the maximum mean accuracy of these radios to be within 3 meters or less of actual location. He used these collars to study sage-grouse use of habitat treatments. He downloaded bird location data from recaptured radios to a computer from the transmitter using a USB cord. The cost per unit was $1700.

Stringham (2010) also glued standard VHF units to each GPS transmitter to allow real time relocations. The total weight of the package was > 40 g. He reported the VHF transmitters stayed attached to sage-grouse for 30-60 days, after which time the glue would disintegrate and radios would drop off. The battery life of their GPS units was approximately 80 days. Although the use of this technology provided better location data, technicians were still required to monitor the birds. He did not report any mortality for study birds equipped with the transmitters.

Recent technological advances have led to commercial production of smaller (22-30 g), solar-powered, GPS satellite transmitters that can be mounted using a leg-loop harness (i.e., rump-mount) rather than a backpack harness. These GPS transmitters have several advantages over traditional VHF collars. They can collect multiple locations per day at pre-programmed times, reduce problems with on-the-ground access, eliminate observer disturbance of the bird. They also can provide real time data on survival, movements, habitat use, and timing of nest initiation. Solar-powered GPS transmitters must be mounted dorsally with exposure to the sun to ensure adequate battery recharge.

Researchers have also tested 30 g GPS Platform Transmitting Terminals (PTT) collars using a modified rump-mount attachment method. Using this technique, researchers have successfully obtained hourly locations on sage-grouse throughout the year. This allows for concise documentation of seasonal habitat use, daily and seasonal movement patterns, nest initiation, foraging activities while incubating, and habitat use after hatching. By outfitting both nesting sage-grouse and Common Ravens with hourly GPS PTTs, the researchers have been able to investigate habitat overlap and differentiation of these two species. This type of data would be important to assess the effect of corvids using tall structures on sage-grouse predation rates (B.

Bedrosian, Avian Program Coordinator, Craighead Beringia South, Kelly, WY 83011, unpublished data, http://www.microwavetelemetry.com/newsletters/TrackerNewsSpring09Complete.pdf).

While initial costs associated with GPS PTT technology are higher than conventional VHF transmitters, cost savings would accrue in longer duration studies in terms of personnel, time, study logistics, and a reduction in the number of VHF units deployed. However, there are concerns that rump-mounted transmitters may directly or indirectly reduce survival, rates of nest initiation, or movements of sage-grouse because of their similarity to backpack-style transmitters (http://wildlife.state.co.us/Research/Birds/GreaterSageGrouse/).

iv. Energy impact studies

Aldridge (2000), Braun et al. (2002), Holloran (2005), and Naugle et al. (2010) identified the cumulative effects of energy development and associated infrastructures, including tall structures on sage-grouse. These studies are also cited to document the effects of tall structures on sage-grouse (USFWS 2010). These studies lack descriptions of "original conditions" as derived from baseline studies. Because data about population size or other habitat conditions for sage-grouse in the area where development is proposed is often lacking, inferences regarding specific or cumulative effects may be limited. However, such studies provide important insights regarding the broader implications of anthropogenic changes in landscapes, and their impacts on sage-grouse. Although, cause and effects relationships are not specific, they have documented a correlation between the human footprint and sage-grouse persistence and performance in altered landscapes.

Braun et al. (2002) summarized studies in Alberta, Colorado, and Wyoming, noting that the impact of these facilities on shrub steppe species has been observed for three decades since production in sagebrush habitats began. Over the period covered by their review new energy developments were initiated (oil shale, oil, gas, coal, or coalbed methane). Over these same periods, sage-grouse populations based on lek count data, were declining. Braun et al. (2002) also reported that lek counts in Alberta began in 1968 and were conducted sporadically until the 1990s. These problems make it difficult to determine with certainty whether the observed sage-grouse population declines (based on lek count data) were caused by oil and gas development. There also is no discussion of effects of other human activity on sage-grouse habitat in this region over this time period.

The Colorado studies considered in the reviewed paper shared common aspects with the Alberta studies. Because oil and gas activity began two decades before sage-grouse counts were conducted in Colorado, which were sporadic and incomplete for the following three decades, no definitive conclusions could be drawn about the impact of oil and gas activity on sage-grouse in Colorado. 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." To adequately assess impacts, habitat conditions before and after the activity in question need to be compared.

b. Identified knowledge gaps

For conservation purposes, managers will need to know how tall structures may affect the 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. The conclusions of the "impact studies" we reviewed are limited regarding the effects of tall structures on sage-grouse. However, these studies provide salient hypotheses that require further testing. Currently, landscape level studies employing newer GPS technology to assess the effect of tall structures on sage-grouse are lacking.

For example, the literature contains statements of individual incidences of sage-grouse mortality attributed to possible collisions with tall structures and avian predation that are documented through personal observations, personal communication, or unpublished data. Additionally citations that report the increased use of tall structures by potential avian predators of sage-grouse are used to substantiate statements regarding increased predation mortality. However, reliable estimates of sage-grouse mortality attributed to collision or increased predation risks associated with tall structures and its impacts on local or regional populations are lacking. Better information is needed to determine the extent of mortality associated with tall structures placed in sage-grouse habitat to develop viable mitigation measures.

Further confounding range-wide mortality estimates and their effects on populations, is the fact that sage-grouse population trends are obtained using lek counts. There is recognized bias in current lek count survey methods and subsequent population assessments based upon lek counts. Recent efforts have used empirically-based corrective models to generate estimates of the effects of anthropogenic factors on sage-grouse demographic and population parameters (Johnson et al. 2010). However, the authors of these models recognized the limitations of data generated by observational rather than experimental studies as well as the limitations of using data collected for species other than sage-grouse.

Our review of the literature identified several logistical constraints impeding documentation of the effects of tall structures on sage-grouse. In most cases the time devoted to long term data collection - over multiple seasons and years especially years 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 references sites (when incorporated in the study), and thus failed to establish baseline conditions to which impact or effects could be compared. Although the strength of observational studies can be enhanced by data obtained from replication, access and resources have historically impeded establishing adequate reference or control sites (Knick et al. 2003).

c. Actions needed to fill knowledge gaps and lead to BMPs

Those attending the Utah workshops concluded that in the absence of adequate knowledge on the impacts of tall structures on sage-grouse, the only option for establishing BMPs is to use expert knowledge. They also stated "There will always be issues with transferring information from other species or disturbances to sage-grouse" but stressed "the primary emphasis is to conduct research on sage-grouse germane to structure issues." Participants did not designate a specific priority for this concern.

Funding and adequate pre-development notification for long term, hierarchal-based research projects appeared to be major factor restricting the development of effective BMPs. This is particularly evident when the research funding originates from project proponents, who are under a relatively short period of time to complete a project. Because multi-site, multivariate studies can be expensive, it will be essential to coordinate efforts among similar stakeholders. These studies must include stratified random samples to ensure sample sizes and adequate power to detect statistically significant responses. This will be particularly important in the case of tall structures because any observed differences could be attributable to differences in topography, location, habitat, predator communities, structure design, and operation and maintenance. Knick et al. (2003) stated that carefully designed hierarchical studies that track multiple factors (e.g., weather, prey availability, disease vectors) in addition to human elements in the grassland and shrub-steppe dominated landscape will be needed.

3. We do not know what "effective" temporal and spatial setbacks and buffers are and existing ones vary.

Participants were concerned that the broad variation in temporal restrictions and spatial setbacks and buffers being implemented as the primary tools to mitigate perceived impacts of tall structure on sage-grouse were a continuing source of confusion. Statements from Participants included: 1) "There is speculation on the displacement of sage-grouse by turbines and distribution/collector lines," 2) "Buffer distances are different between states and federal agencies and even subunits within agencies have differing opinions," 3) "Mitigation measures implementing specific buffer areas between power lines and grouse use areas, ranging from 0.25 mile to 5 miles with no surface occupancy," 4) "We are too reliant on spatial buffers as a mitigation tools," and 5) "We would like to know if there are other things or combinations of things we can do to reduce the impacts of tall structures on sage-grouse."

a. Available literature

Various buffer distances have been recommended to mitigate the perceived effects of tall structures on sage-grouse. Connelly et al. (2000), Schroeder et al. (2003), Bureau of Land Management (2004), and Rowland (2004) recommended that a 3 km minimum buffer zone be maintained between tall structures and seasonal sage-grouse habitat. Connelly et al. (2000) and Connelly et al. (2004), further recommended that the power lines be buried or the electric-utility structures be modified to discourage their use as raptor perch sites. State, provincial, and federal sage-grouse management plans contain avoidance guidelines ranging from 0.3 to 8.0 km (Appendix D). Similar statements have been made regarding the placement of wind turbines because of the reported tendency of sage-grouse to avoid areas with tall structures (USFWS 2003).

Most of the state and federal policies we reviewed rely heavily on information provided by Connelly et al. (2000). These guidelines were an update of those published by Braun et al.

(1977), and will likely be updated within the next few years. The guidelines are based on decades of published research regarding sage-grouse biology and ecology. However, the guidelines related to tall structures are largely based on personal observation, communications, unpublished data, and contemporary professional opinion (Braun 1998).

Given the current variation in federal, provincial and state siting requirements, workshop Participants desired to know if current stipulations were perceived adequate to mitigate the effects of tall structures on sage-grouse. Models developed by Aldridge (2005), for energy development in Alberta as applied to the available habitat, revealed that a 3.2 km buffer around each lek site would protect 54% of the critical nesting habitat and 62% of the brood-rearing critical habitat, where critical habitat is defined as primary or secondary as opposed to high risk or sink. Thus, the1 km buffer recommended by the Province of Alberta would protect only 9.9% of the critical brood-rearing habitat (Aldridge 2005). In Aldridge's view, the use of lek centered buffers was not adequate to protect habitat and he suggested his models should be applied to the landscape to identify and protect important primary and secondary nesting and brood-rearing habitats.

Holloran (2005) reported that effective distance from oil and gas disturbance sources to leks during the breeding season in his Wyoming study area could be conservatively estimated at 3 to 5 km. Thus, he recommended that to protect breeding sites, or habitat suitable for breeding sites, would require a 5 km buffer. Walker et al. (2007) studied greater sage-grouse responses in the Powder River Basin (PRB) of Wyoming and Montana to recent coal-bed natural gas (CBNG) development. After controlling for habitat, they reported negative effects of CBNG development within 0.8 km and 3.2 km of the lek. They concluded that current BLM lease stipulations that prohibit development within 0.4 km of sage-grouse leks on federal lands are inadequate to ensure lek persistence and may result in impacts to breeding populations over larger areas. They also noted that seasonal restrictions on drilling and construction do not address impacts that can affect populations over long periods of time, such as those caused by loss of sagebrush and incursion of infrastructure. They recommended that regulatory agencies consider increasing spatial restrictions on development.

The USFWS (2010) acknowledged the existence and role of state and federal agency non-regulatory and regulatory mechanisms to mitigate the potential negative effects of energy development on sage-grouse. However, they concluded that the current regulations and stipulations guiding energy development are not adequate to ameliorate the potential impacts on sage-grouse. The USFWS did not differentiate between the specific aspects of energy development (i.e., renewable or non-renewable, oil and gas, coal, CBNG, tall structures, roads, etc.) but lumped these under the general category of energy development and related structures. In addition, they stated that they could not find any scientific support for using a 0.4 km buffer as the basic unit protecting active leks. Based on Holloran's (2005) and Walker et al. (2007) findings, they concluded the 0.4 km recommended buffer was inadequate to protect sage-grouse.

b. Identified knowledge gaps

Participants identified several knowledge gaps that need to be addressed before "effective" temporal and spatial setbacks and buffers can be implemented. These included better information on tall structure avoidance, predation, cumulative effects of tall structures, habitat connectivity, habitat fragmentation, sage-grouse seasonal habitat-use patterns, effects of habitat quality, and population size.

c. Actions needed to fill the knowledge gaps and lead to BMPs

The rationale for the buffer and siting recommendations appears related to species evolution in that sage-grouse are adapted to a landscape with few vertical obstructions, but occupy areas now crossed with fences, high voltage structures, and power poles (Connelly et al. 2004). Although there is evidence documenting changes in sage-grouse habitat, little is known about the effects of landscape features on sage-grouse populations (Connelly et al. 2004). There is little scientific evidence to document the short- or long-term effects of tall structures, let alone what mitigation measures are appropriate or effective. Nor is it known whether sage-grouse would eventually habituate behaviorally to tall structures in their environment. Participants recommended research should be conducted to assess the impacts of tall structures, at different intervals from the structure. They recommended research to assess how population persistence, lek attendance, nest success, seasonal use, avoidance, seasonal habitat-use, home ranges, and migration patterns may be affected by different buffer zones and how these effects could be mitigated by topography.

To close this knowledge gap, Participants recommended two strategies: 1) a refinement and expansion of Connelly et al. (2004) and Johnson et al. (2010) retrospective studies of the effects of anthropogenic features on sage-grouse leks trends and occupancy focused specifically on tall structures and incorporating habitat variables and references sites, and 2) an experimental study involving multiple, variables, and funding partners to assess the impacts tall structures on sage-grouse behavior, habitat-use, production, and survival. These concepts are further developed in the Conclusion and Recommendation section of this report. Currently, the National Wind Coordinating Collaborative (NWCC) is proposing similar studies using standard protocols to assess the potential impacts of wind energy development on sage-grouse range-wide.

4. We are concerned that required BMPs are not monitored and may not be effective.

Participants expressed concern that current BMPs and guidelines are not being monitored to determine their effectiveness. Individual concerns expressed included, " We are concerned BMPs being used may not be effective and there is a lack of monitoring to determine BMP impacts" and "Agency policies for both land management and regulatory agencies can be problematic, when specific mitigation measures are required that have not been tested and can result in other operational issues…". Some Participants expressed concern that BMPs "focused just on avoiding the impacts of tall structures on leks may be damaging brooding, nesting, and wintering areas."

a. Available literature

Wind energy development project sponsors often hire consultants to monitor the effects of the turbines and wind farm operation on wildlife. These consultants prepare technical reports for the project sponsors that are subsequently submitted to regulatory agencies for review and comment. A meta-analysis of the effects of wind developments on avian species was conducted by Erickson et al. (2002, 2005). These analyzes contain data the authors gleaned from monitoring reports. Although such reports provide important site specific information, because of differences in topography, site operations, species presence, and the lack of standard, accepted protocols they have limited usefulness in identifying risk to individuals and populations and elucidating the causal factors.

For example, in the case of sage-grouse, Young et al. (2003) reported one sage-grouse was found dead within 45 m (148 ft) of a turbine on the Foote Creek Rim wind facility in south-central Wyoming, presumably from flying into a turbine (Young et al. 2003). This is the only known sage-grouse mortality at this facility during three years of monitoring. Sage-grouse hens with broods have been observed under turbines at Foote Creek Rim.

b. Identified knowledge gaps

We found no peer-reviewed literature that specifically reported the results of BMP monitoring. In the case of electric power lines, utilities regularly inspect existing corridors to monitor line conditions. During these surveys, field personnel document and report evidence of wildlife mortalities. These data are maintained in central databases and available to inspection by regulatory agencies (S. Ligouri, personal communication, PacifiCorp, Salt Lake City, Utah).

c. Actions needed to fill the knowledge gaps and lead to BMPs

Participants prioritized the monitoring of current and future BMPs to determine their effectiveness as "**Must Have"** and encouraged industry incentives for funding of this monitoring. Contemporary monitoring data collected by utilities and wind farm operators provide information regarding specific incidences, but are insufficient to establish cause and effect. State and federal agencies and tall structure stakeholder may lack the resources to implement monitoring programs of the scale and scope needed to determine BMPs effectiveness. This effectiveness of BMPs may be best evaluated through coordinated multi-site and multivariate research programs.

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

Participants expressed divergent concerns over sage-grouse avoidance of tall structures. Representative concerns included, 1) "There is not scientific consensus that sage-grouse avoidance of tall structures is a known fact," 2) " More research is needed here," 3) "Why are sage-grouse avoiding tall structures, " 4) "Is it because they are predator perches," 5) "Is it the associated noise," 6)" Do they avoid associated service roads because they may create travel routes for predators", and 7) "Aversion of sage-grouse to different tall structures may not be equal and needs to be tested i.e., fences vs. power poles?"

a. Available literature

Mabey and Paul (2007) summarized contemporary thought regarding the effects of tall structures on grassland and shrub steppe avian species. They stated, "Tall structures in open habitats may be particularly disruptive to avian behavior because they are novel elements in the environments of bird species that are not habituated to their presence. Noise and visual disturbances from tall structures (e.g., wind turbine) operations placed in shrub steppe or grassland habitats may disrupt breeding or other behaviors. Because there is so little shelter, these disruptions may be more difficult to avoid and may affect a larger areas than the immediate vicinity of the structure. Additional disturbances may develop from the maintenance and operation of tall structures, including road construction and use, habitat alteration, fire suppression, and other management practices that may kill birds or disrupt their normal behaviors."

We reviewed the literature for references that supported the above statement. Sage-grouse were first observed June 6, 1805 by Meriwether Lewis, at the mouth of the Marias River in northeastern Montana. Native Americans told him they were birds of the Rocky Mountains. Lewis recorded more birds later on the Columbian plain (Lewis field notes, 1805). Sage-grouse are a bird of the Arid Province (plains), of the Warm Temperate subregion (middle North America). This area is drier than the humid region and east of the Mississippi and dominated by open plains and deserts (Allen 1893).

The genus *Centrocercus* is exclusively an America genera (Allen 1893). Pleistocene fossil records are available for Oregon, Idaho, Utah, New Mexico, Nevada, Colorado, and California. Lack of fossil records indicates recent origin (Short 1967). Sagebrush steppe occupies a portion of the mid-latitude temperate deserts that evolved following the close of the Pleistocene (West 1983). Sagebrush steppe is relatively treeless plains maintained by arid conditions, grazing, and periodic fires. Thus, there is little doubt that sage-grouse evolved on largely treeless plains during the Pleistocene, are closely allied with sagebrush habitats, and depend on sagebrush for winter habitat (Patterson 1952, and others). These observations have contributed to general statements that sage-grouse avoid tall structures.

However, we found no peer-reviewed studies reporting sage-grouse direct avoidance of tall structures as defined by this project. The reports cited in the literature focus on the effects of males on leks. Numerous citations were tied to observations reported by Ellis (1984). The Ellis (1984) paper was mis-cited by authors to support statements that the presence of a transmission line resulted in changes in sage-grouse dispersal patterns and habitat fragmentation. This paper described male sage-grouse responses to a golden eagle perched on an oil well located 500 m from two leks. The height of the oil well was not provided. At the time the eagle perched on the oil well the birds stopped displaying. The birds remained motionless for 20 minutes. At that time one lek resumed displaying the other did not. The males from both leks flushed 10 minutes later. The author did not state the normal display period or time of the year the observation was made. This paper has been repeatedly and inappropriately cited as a case study documenting increased sage-grouse predation rates from 26 to 73% after a transmission line was constructed within 220 yd of an occupied lek in Utah. The USFWS (2010) used the correct citation in their status review. The source for this information was Ellis (1985a). This citation is an unpublished student thesis.

Braun (1998) and Braun et al. (2002) are also cited to document sage-grouse avoidance of tall structures. Braun et al. (2002) reported sage-grouse leks within 0.25 miles from a new power line had significantly slower growth rates compared to leks located further from the line. They hypothesized the slower growth rates were a result of increased raptor predation but did not provide any data to quantify the growth rates. This publication was not peer-reviewed.

We found similar citations repeated in the literature (to include the USFWS listing decision) to substantiate the statement that sage-grouse avoid tall structures. The more recent citations reporting avoidance of sage-grouse of tall structures reference CBNG and energy development. Avoidance behavior by grouse of lek sites and habitats that are near anthropogenic sites have been reported by Lyons and Anderson (2003), Holloran (2005) (also see Walker et al. 2007, Doherty et al. 2008, Holloran et al. 2010). The CBNG studies report avoidance as a cumulative effect involving a broad spectrum of anthropomorphic impacts without isolating a specific mechanism.

Hall and Haney (1997) are cited in state siting policies and by other authors but not by the USFWS (2010). This is an "unpublished" report that is not readily available. Lammers and Collopy (2007) chose to cite it as personal communication rather than including it as a reference. Hall and Haney (1997) reported observing 82 disturbances of sage-grouse at a lek. Of those, 29 were caused by raptors (25 golden eagles, 5 others), which were observed to be perching on nearby power lines. Ungulates (pronghorn primarily) caused 18 disturbances. The methodology of the study was not discussed. They did not describe any causal link or correlation between energy development and lek attendance by males or nest initiation rates.

Braun (1998) is 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 cites Graul (1980), Ellis (1984, 1987) as supporting documentation. The author also reports unpublished data to document that sage-grouse use of suitable habitat near power lines increased as distance from the power line increased from up to 660 yd and based on unpublished data reported the presence of power lines may limit sage-grouse use within 0.6 miles of otherwise suitable habitat. Some state guidelines cite Braun (1998) to support the following relationships with energy: 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. The Braun (1998) paper was not peer-reviewed, however it contains contemporary professional perspectives identifying potential issues that may impede sage-grouse.

Johnson et al. (2010) and Wisdom et al. (2010) analyzed lek and distribution data from within the conservation area defined by Connelly et al. (2004) 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 three provinces and encompassed about 2,063,000 km^2 (Connelly et al. 2004). The authors acknowledged the retrospective nature of their studies in that many of the factors were in place prior to their studies. Consequently the immediate effects of some historical factors might be confounded by more recent changes.

Johnson et al. (2010) 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 related to proximity to the closest communications tower and to the number of towers within 18 km.

They explained their seemingly disparate results by stating that communication towers typically indicated high human-use areas, whereas power lines (especially transmission lines) are more uniformly distributed across the landscape. Thus, the lower trends at sage-grouse leks near 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 two 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. 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 stated 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). They also acknowledged that their study was observational, rather than experimental. Thus the associations observed in the data do not reflect causation. However, they cited Ellis (1985a), 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 substantiate galliform avoidance of power lines in general and when nesting.

Wisdom et al. (2010) analyzed differences in 22 environmental variables between areas of former range (extirpated range), and areas still occupied by the Gunnison (*C. mimimus*) and greater sage-grouse (occupied range). They reported that 15 of 22 variables they analyzed differed between extirpated and occupied ranges. Five variables: 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, distance to transmission lines, distance to cellular towers, and land ownership differed between occupied and extirpated ranges.

In their discussion, the authors stated that the latter variables received little attention in landscape research on sage-grouse. However, they cited Connelly et al. (2000), Aldridge and Boyce (2007), Walker et al. (2007) as references to support the statement, "only transmission lines have been formally evaluated." They also stated transmission lines can cause sage-grouse mortality via bird collisions with lines citing Beck et al. (2006), Aldridge and Boyce (2007) and facilitate raptor predation of sage-grouse citing Connelly et al. (2000). None of the papers cited were formal replicated studies of the effects of transmission lines on sage-grouse. Only Beck et al. (2006) provided data to document sage-grouse mortality as a result of a collision with a power line.

Wisdom et al. (2010) concluded that the two variables strongly associated with sage-grouse extirpation, distance to transmission lines and distance to cellular towers, have unknown relations with regional sage-grouse population dynamics. They stated new mechanistic research will 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 vertical 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 (Avian Power Line Interaction Committee 2006, Lammers and Collopy 2007).

b. Identified knowledge gaps

Workshop Participants concluded they **Must Have** additional knowledge of sage-grouse avoidance of tall structures and this information must be specific to structure type. Specifically, 1) Do sage-rouse 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 (construction and management) can be implemented to mitigate impacts and alleviate the negative impacts, and 6) Will these measures be effective?

c. Actions needed to fill the knowledge gaps and lead to BMPs

See Conclusions and Recommendations Section.

6. Tall structures may increase predation on sage-grouse.

Participants expressed concern about if there is a causal relationship between tall structures and sage-grouse predation and how strong it may be. Specific concerns expressed by Participants were: 1) "Why are sage-grouse avoiding tall structures," 2) "Is it because they are predator perches," 3) "Do they avoid associated service roads because they may create travel routes for predators," and 4) "Why do sage-grouse avoid tall structures - because of predators or because they just don't like them?"

a. Available literature

Sage-grouse are lek species. Lack (1968) argued that predation and sexual selection were equally as important in the evolution of lekking behavior. However, most evolutionary models assume that sexual selection, not predation, is a major determinant of lekking behavior. Boyko et al. (2004) used a stochastic dynamic game model to study how the risk of predation by golden eagles (*Aquila chrysaetos*) could affect greater sage-grouse lek dynamics. Although observations of golden eagle successful predation 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) model 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 may also prey on sage-grouse nests, chicks and juvenile birds (Batterson and Morse 1948, Patterson 1952, Nelson 1955, Young 1994, Delong et al. 1995, Sveum 1995). Common ravens (*Corax corax*) in particular have been implicated as important predators of sage-grouse and other prairie grouse nests (Manzer and Hannon 2005, Coates 2007).

Connelly et al. (2000) and Connelly et al. (2004) suggested that because of the potential for raptors and corvids to use transmission line towers and distribution line 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 nests or 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.

Manzer and Hannon (2005) in a study on effects of corvid density on sharp-tailed grouse (*Tympanuchus phasianellus*) in Alberta reported that the ecological processes that influence nest success occurred at scales < 50 m and >1600 m rather than the immediate area used by nesting hens. Grouse nests were more vulnerable to corvid predation if they were close to perch sites (< 75 m) unless adequate cover was available. They suggested that efforts to improve nest success by increasing cover and removing perches may have limited success if larger scale factors that influence predator densities are overlooked.

Citations commonly used to document increased predation on sage-grouse because of increasing local predator populations and hunting efficiency attributed to tall structures include Ellis (1984, 1985a, 1985b), 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). Ellis (1984) described lekking sage-grouse responses to a golden eagle perched on an oil well located 500 m from two leks. This reference has been incorrectly cited in the literature to substantiate statements that the presence of transmission lines may change sage-grouse dispersal patterns and habitat fragmentation.

Ellis (1985b) was cited by the USFWS (2010) in their listing decision as support for the statement that increased abundance of raptors and corvids within occupied sage-grouse habitats can result in increased predation. This report was not peer-reviewed. Ellis (1985a,b) reported sage-grouse predation rates increased from 26 to 73% after a transmission line was constructed within 220 yd 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.

Ellis et al. (1987) is also cited 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. They concluded that sage-grouse use same day-use areas annually. Those who cite the study use it to imply that if tall structures are placed in these day-use areas, sage-grouse will avoid them.

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 constitute 0.25 sq. km. They recommend 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 rights-of-ways and vertebrate populations. Specifically they examined the relationship between these areas and common raven and red-tailed hawk (*Buteo jamaicensis*) populations in the Mojave Desert of California. Their data suggested that ravens are more abundant along highways because of automobile-generated carrion, whereas both ravens and red-tailed hawks are 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. This study is cited to substantiate statements that power lines create perches and nesting platforms for raptors and corvids and thus contributed to increased species abundance and hence greater sage-grouse predation risks.

Steenhof et al. (1993) is frequently cited as documentation of the effects of power lines on increasing raptor and corvid abundance. They attributed population increases in four raptor species and common ravens in their southern Idaho and Oregon study areas to the use of nesting platforms placed during construction of the line and towers in 1980.

Artificial nesting platforms were installed on 37 of the 1,608 towers, chosen non-randomly. Raptors and common ravens began using the towers within a year after construction. By 1989, the number of pairs using towers increased to 133; ravens were the most common species in each year. Golden eagles nested on the towers in all years; growing from a single pair to eight pairs during the study. Towers provided new and alternative nesting substrate, as a pair shifted from natural substrate to towers. New pairs that had not previously nested in the study area appeared and nested on the towers. Two hundred seventy-four of 1,608 available towers were used. They reported higher nest success rates for the towers than for natural substrates, but were not higher for towers with platforms than for those without or for other manmade substrates, except for golden eagles, which did not nest successfully on towers without platforms. They concluded that the lack of a nesting substrate had been a limiting factor that was removed when the towers were built. They also noted that nesting densities of these species elsewhere in the area were as high as or higher than before the power line was erected.

Coates and Delehanty (2010) reported 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 report similar effects for golden eagles. Below we discuss the potential impacts of golden eagles and corvids increased use of tall structures on sage-grouse relative to the species foraging potentials.

Marzluff et al. (1997) reported shrub-steppe communities provide important foraging habitat for the golden eagle. Small to medium-sized mammals such as hares (*Lepus* spp.), ground squirrels (*Citellus* spp.), marmots (*Marmota* spp.), mountain beaver (*Aplodontia rufa*) and birds (e.g., pheasant, grouse) are important 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 hare.

Densities of golden eagles in the western states range from one pair per 34 km^2 to 251 km^2 (13-96 mi^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 (1.9 mi) of golden eagle nests. This distance accounted for 95% of eagle movements measured during the breeding season in western Idaho (Marzluff et al. 1997).

Synanthropic avian predators (those that directly benefit from anthropogenic activities) include common ravens, American crows (*Corvus brachyrhynchos*), and black-billed magpies (*Pica hudsonia*). Common raven and American crow populations in North America are increasing (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 km in Idaho (up to 62.5 km) to 27 km in Michigan (range 0.8 – 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 large power lines. They we not able to estimate the density of rural distribution lines. Based on this estimate and the foraging distances of golden eagles and corvids they projected the power lines, as a potential source of additional perches, could influence 672,344 to 837,390 km^2 or 32-40% of the available sagebrush habitats. Their estimate did not account for the effects of environmental conditions (i.e., habitat conditions, primary prey abundance) on raptor or golden eagle densities.

b. Identified knowledge gaps

In summary, the studies cited above document that raptors and corvids use power lines as perches and nest sites and as such these tall structures can provide alternative nesting substrate in areas where sites are limited. These studies did not assess the direct effects of power lines on increased predation risks for sage-grouse. They are cited frequently throughout the literature to imply that if raptor and corvid use of areas inhabited by sage-grouse increase because of the presence of tall structures predation will also likely increase. Other authors noted 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 (Coates 2010, Hagen 2010).

Hagen (2010) reviewed the published literature in regards to the impacts of predation on sage-grouse. He reported that range wide sage-grouse nest success rates and adult survival are relatively high and that few studies have demonstrated a link between habitat quality, predation and mortality rates. He concluded that in areas where the habitat is fragmented or predator populations are sustained at higher levels because of anthropogenic activities predation may limit population growth (Bui et al. 2010).

Participants concluded they **Must Have** additional research to determine if higher predator densities associated with tall structures equate to increased golden eagle and corvid predation on sage-grouse and if this predation is significant on a population level.

c. Actions needed to fill the knowledge gaps and lead to BMPs

The implication obtained from the above review is that if tall structures and activities associated with their operation and maintenance fragment habitats and subsidizes predators (i.e., perches, travel lanes, alternative food sources) predation on sage-grouse may increase. However to obtain conclusive information, additional research will be needed to evaluate the relationship between sage-grouse population dynamics, habitat conditions (fragmentation or degradation) and predator communities, naturally occurring, exotic, and subsidized.

7. We do not know the impacts of tall structures' ancillary facilities on sage-grouse.

Participants expressed concerns about the impacts of tall structure's ancillary facilities on sage-grouse. There two primary concerns were, "We do not know the impacts of the total infrastructure associated with tall structures and the specific contribution of tall structures to this impact" and "We are concerned about the cumulative, landscape impacts of tall structures."

a. Available literature

Roads are the primary ancillary facility associated with transmission and power lines. In the case of wind energy developments, ancillary facilities may include power lines and roads. The ecological impact of roads on wildlife may include: 1) increased mortality from collisions with vehicles, 2) disruption of animal behavior (i.e., nesting, breeding, foraging, etc.) 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 linear features such as primary and secondary roads as travel routes, expanding their movements into previously unused regions (Bui et al. 2010).

Connelly et al. (2004) examined the potential effects of an interstate highway on the distribution of active leks. They 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 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 they reported could have occurred prior to the surveys. Their analysis did not consider the effects of other highways or other land use activities or habitat conditions.

Aldridge et al. (2008) did not find road density to be an important factor affecting sage-grouse persistence or rangewide patterns in sage-grouse extirpation. The authors did not consider the intensity of human use of roads in their modeling efforts. They also acknowledged that their analyses also may have been influenced by incomplete road data sets. Robel et al. (2004) reported that lesser prairie□chicken nested farther from all anthropogenic features, except unimproved roads than would be expected by chance.

Johnson et al. (2010) correlated lek trend data collected between 1997-2007 to determine if these data were affected by various anthropogenic features to include energy development, power lines, and roads. They reported that lek trends for the period studied were reduced in areas with active oil or natural gas wells and highways, but not 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.

Traffic levels or volumes (i.e., disturbance) rather than road surface have been identified as contributing factors in reduced numbers of sage-grouse occupying leks (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 (1-12 vehicles/day).

b. Identified knowledge gaps

We found no specific studies that isolated the effects of roads on sage-grouse that were associated with tall structures. The studies we found that attempted to quantify the relationship between sage-grouse behavior and roads, traffic, or other road associated factors were Lyons and Anderson (2003) and Holloran (2005). The relationship focused on leks, and nesting. In both studies, traffic volumes rather than the actual presence of a road were equated to constitute a disturbance effect. Participants stated they would **Like to Have** additional knowledge on the impacts to sage-grouse of different road types, densities and use patterns but felt it would be difficult to isolate the impacts of the ancillary facilities from that of tall structures.

c. Actions needed to fill the knowledge gap and lead to BMPs

The effect of roads associated with tall structures on sage-grouse must be evaluated within the context of the landscape in question. Based on our review, how a road is used (i.e., traffic volumes and types) relative to the landscape may be more important to sage-grouse rather than mere presence. We found no published comparative studies regarding the impacts of roads on sage-grouse that controlled landscape level factors to include habitat condition, road operation and maintenance. Of the papers we reviewed none provided any direct information about the mechanism causing avoidance of roads. Traffic levels were used as a surrogate measure of noise by Lyons and Anderson (2003). However, although noise does increase with traffic volume, other possible sources of disturbance to include visual obstruction related to increased dust clouds on unpaved roads.

8. We are concerned tall structures fragment sage-grouse habitat.

Participants expressed the following about tall structures and habitat fragmentation; 1) "We are concern that sage-grouse may be displaced from important habitats if they exhibit an aversion to tall structures," 2) "We are not sure about the impacts of tall structure height, density etc. on 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) "We do not know if sage-grouse are more tolerant of tall structures in areas where they have better habitat and associated canopy cover."

a. Available literature

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 losses include disturbances that change a habitat's successional state or remove one 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. Sagebrush communities exhibit a high degree of variation in their resistance and resilience to change, beyond natural variation. Resistance (the ability to withstand disturbing forces without changing) and resilience (the ability to recover once altered) generally increase with increasing moisture and decreasing temperatures, and also can be linked to soil characteristics." The question to be answered remains, if tall structures fragments sage-grouse habitat, does their presence constitute a functional habitat loss that changes habitat-use and reduces an individual animal's fitness in terms of survival or production.

Johnson et al. (2010) reported that sage-grouse trends were positively associated with proportion of sagebrush cover, within 5 km and 18 km of leks. Knick et al. (2003) stated the cumulative effects of habitat fragmentation have not been quantified over the range of sagebrush and most fragmentation cannot be attributed to specific land uses. However sagebrush habitat fragmentation has been cited as a primary cause of the decline of sage-grouse populations (Patterson 1952, Connelly et al. 2004).

Wisdom et al. (2010) reported that roads, energy development, power lines, agriculture, urbanization fragment habitat, and they associated these factors with sage-grouse extirpation. Although the activities stated above can also result in habitat, landscape fragmentation has the potential to increase predator populations (i.e., introduction of exotic predators, subsidizing existing predators), and hence, increase predation pressure on grouse populations (Connelly et al. 2004). The potential for increased predation pressure in fragmented habitats has been reported for grouse in Europe (Andrén et al. 1985, Andrén and Angelstam 1988).

b. Identified knowledge gaps

Participants felt they **Must Have** better knowledge on 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. These include lekking, nesting, brood-rearing, and winter habitats. They recommended knowledge must be based on the linear footprint of transmission and distribution lines.

Although by the USFWS (2010) definition, tall structures and associated infrastructures that bi-sect contiguous sagebrush habitats are considered venues for fragmentation, their actual contribution 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. Concerns about impacts of tall structures on sage-grouse appear to be explicitly linked in the literature to increased predation risks because of new perches and subsidized predator populations. There are no predators within the range of sage-grouse that depend on sage-grouse as their primary food source; many depend primarily on rodents and lagomorphs and feed on sage-grouse opportunistically (Patterson 1952). Because the dynamics of a predator population and its primary food source can impact sage-grouse populations (Schroeder and Baydack 2001), data regarding the relative abundance of potential sage-grouse predators pre- and post-tall structures will need to be quantified as part of any tall structure/fragmentation causation studies.

Connelly et al. (2000) recommended that managers should strive to sustain habitat in sufficient quality and quantity to mitigate the effects of predation if the quantity, quality, and configuration of habitat impact predator behavior and dynamics, the potential impact of tall structures on sage-grouse may be mitigated by increased habitat protection and restoration. Hagen (2010) also reaffirmed the need to sustain adequate habitat to abate the effects of predators on sage-grouse nest success and recruitment.

c. Actions needed to fill the knowledge gap and lead to BMPs

Although there have been many observations and recommendations concerning the importance of suitable habitat for reducing predation pressure on adults, detailed information is lacking (Schroeder and Baydack 2001). Atamain et al. (2006) assessed the impact of Sierra Pacific Power Company's Falcon-Gondor transmission line on sage-grouse demography and population dynamics. Their results suggested that sage-grouse nests with 65% total shrub cover have 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 (USFWS 2010), it did not appear to constitute functional habitat loss. Rigorous testing is needed to know whether habitat protection and restoration will allow sage-grouse to persist in areas where tall structures occur.

OTHER UNPRIORITIZED CONCERNS

Participants identified other concerns about the effects the operation and maintenance of tall structures may have on sage-grouse. These concerns included statements as to what actually constitutes a tall structure and are perch deterrents effective. In this section we summarize these concerns. Participants did not prioritize these concerns but recommended they be included as part of an integrated, hierarchal research program focused on addressing the highest priorities first.

Electro-magnetic fields

Naugle et al. (2010) raised the concern that sage-grouse may also avoid transmission lines because "electromagnetic radiation emitted from transmission lines has a variety of negative effects on other bird species using areas on or near lines (Fernie and Reynolds 2005). Balmori (2005, 2006), Balmori and Hallberg (2007), and Everaert and Bauwens (2007) suggested possible cause-effect relationships between high levels of electromagnetic radiation within 500 m of cellular towers and reduced population or reproductive performance of a limited number of bird and amphibian species. These negative effects are similar to those documented for bird species exposed to electromagnetic radiation generated by power lines (Fernie and Reynolds 2005).

Noise

Because male sage-grouse depend on acoustical signals to attract females to leks, Participants expressed concern about the effects of noise associated with tall structures on mating displays, and thereby female attendance. If younger males avoid leks with elevated noise levels, will these leks subsequently be abandoned (Holloran 2005)? Connelly et al, (2004) reported that noise associated with wind turbine rotor blades is thought to reduce lek attendance.

Dooling (2002) summarized what is known about basic hearing capabilities in birds in relation to the characteristics of noise generated by wind turbines. The main body of this report described hearing measurement in birds, the effects of noise on hearing, and the relationship between avian hearing and the general noise levels around wind turbines. He stated the following; "There are a number of long-standing myths about what birds can or cannot hear. One myth is that birds hear better at high frequencies than do humans or other mammals. Another myth is that birds have exceptionally acute hearing. A considerable amount of work over the past 50 years has repeatedly shown that neither of these notions is true. When hearing is defined as the softest sound that can be heard at different frequencies, birds on average hear less well than many mammals, including humans. Birds hear best between about 1 and 5 kHz. Acoustic deterrents or "scarecrow" devices are not generally effective because birds habituate to them and eventually ignore them completely. Devices that purport to use sound frequencies outside the hearing range of humans are most certainly inaudible to birds as well because birds have a narrower range of hearing than humans do. A review of the literature on how well birds can hear in noisy (windy) conditions suggests that birds cannot hear the noise from wind turbine blades as well as humans can. In practical terms, a human with normal hearing can probably hear a wind turbine blade twice as far away as can the average bird."

"Because turbine noise and wind noise are predominantly low frequency, almost all the contribution to an overall sound pressure level reading [e.g., 65 dB(A) SPL], comes from frequencies below 1 – 2 kHz. This means that adding an acoustic cue in the region of best hearing for birds (2 – 4 kHz) would add almost nothing to overall sound pressure level but might help birds hear the blades. The existence of blade defects that produce whistles suggests that minor modifications to the acoustic signature of a turbine blade, in the form of whistles, could make blades more audible to birds and at the same time make no measurable contribution to overall noise level. It is entirely possible, however, that as birds approach a wind turbine, especially under high wind conditions, they lose the ability to see the blade (because of motion smear) before they are close enough to hear the blade. The hypothesis that louder (to birds) blade noises result in fewer fatalities is untested. Making the necessary noise measurements and comparing fatalities at turbines with noticeable whistles with those having no whistles provide one test of this hypothesis".

No published studies have focused specifically on the effects of wind power noise on greater sage-grouse. In studies conducted in oil and gas fields, noise may have played a factor in habitat selection and decreased lek attendance (Holloran 2005). Comparison between wind turbine and oil and gas operations is difficult based on the nature of the operation. We found no peer-reviewed published studies that documented sage-grouse avoidance of tall structures related to noise.

Collisions

Braun (1998) and Connelly et al. (2000) reported that sage-grouse collisions with power lines occur, but provided no specific data or cited studies. Borell (1939) reported three adult sage-grouse died as a result of colliding with a telegraph line in Utah. This citation appears repeatedly in the literature. Unpublished mortality observations were reported by Aldridge and Brigham (2003). Beck et al. (2006) attributed 2 mortalities to power lines collisions in southeastern Idaho. Although we did find reports of sage-grouse mortality as a result of collisions, we found no studies reporting the effect of this mortality at the population level.

Regarding wind developments, most published reports dealt with the risks of collision with towers or turbine blades. One sage-grouse was found dead within 45 m (148 ft) of a turbine on the Foote Creek Rim wind facility in south-central Wyoming, presumably from flying into a turbine (Young et al. 2003). This is the only known sage-grouse mortality at this facility during three years of monitoring. Sage-grouse hens with broods have been observed under turbines at Foote Creek Rim. We could not find any recent reports of sage-grouse mortality due to collision with a wind turbine or deaths of gallinaceous birds in a comprehensive review of avian collisions and wind farms in the U.S. The authors hypothesized that the average tower height and flight height of grouse, and diurnal migration habitats of some birds minimized the risk of collision (Erickson et al. 2001).

Perch Deterrents

Increased raptor and corvid abundance has been documented in landscapes fragmented by man-made structures, such as fence posts and power lines. These vertical structures may enhance raptor and corvid foraging and predation efficiency because of increased availability of perch, nesting, and roosting sites. Concomitantly, vertical structures, in particular transmission and distribution power lines, have been identified as a threat to sage-grouse conservation (Connelly et al. 2004). To mitigate the perceived or potential impacts of new power lines on sage-grouse and other avian species, the electrical power industry has been required in land management agency permits to retrofit poles with perch deterrents to discourage raptor and corvid use (Connelly et al. 2000).

Lammers and Collopy (2007) studied raptor and corvid responses to perch deterrents placed on a new high-voltage transmission line in north-central Nevada. They reported that although perch deterrents did not prevent perching, the perching duration of raptors on the deterrents was reduced compared to other perching sites. Although the deterrents reduced the probability of avian predators perching on the towers, avian predators overcame the deterrents to take advantage of the height of the towers where no other perches of similar height existed.

Prather and Messmer (2010) evaluated the efficacy of 5 contemporary perch deterrent designs on avian predator use of an 11-km section of a 12.5-kV distribution line that bisected occupied Gunnison sage-grouse habitat in southeastern Utah. The perch deterrents were mounted on the crossarms of the power poles following a random replicated block design that included controls. Golden eagles were the dominant species recorded during both years. They however did not detect any difference in perching events between perch deterrent evaluated and controls. They concluded the perch deterrents evaluated were not effective because of inherent design flaws. Additionally, previous pole modifications that mitigated avian electrocutions provided alternative perches. They did not record any raptor or corvid electrocutions or direct predation on Gunnison sage-grouse.

Other Tall Structures

Participants discussed what should be included in the evaluation of tall structures and determined that "tall structures" should be considered wind turbines, communications towers, and steel structures or wooden poles from transmission or distribution lines. Participants recognized that there could be impacts from "other tall structures." These are discussed below.

Fences

A frequently cited cause of mortality for sage-grouse is collisions with fences (Call and Maser 1985). Much of the peer-reviewed research on bird collisions with fences was originally conducted in Europe. Patten et al. (2005) reported 32.3% of 100 Lesser Prairie-Chicken carcasses recovered in Oklahoma and 13.3% of 98 carcasses recovered in New Mexico in studies by the Sutton Avian Research Center died in collisions with fences (Patten et al. 2005). To grouse and prairie-chickens, a fence may be a tall structure. Research is on-going to determine the magnitude and impact of fence-related mortalities on sage-grouse and methods to mitigate their occurrence.

Junipers

No scientific studies have been reported in the peer-reviewed literature regarding sage-grouse avoidance response to junipers (*Juniperus* spp.) because they may constitute predator perches. Commons et al. (1999) reported a doubling of the number of Gunnison sage-grouse males counted on leks 2 and 3 years post-treatment after clearing junipers. The authors attributed the increase to reduced raptor predation. The authors reported observing raptors perching and hunting from trees adjacent to leks and attributed all recorded sage-grouse mortalities to raptors. They provided no information on the size of the treatments or number of mortalities. The study did not have a replicated design. Based on the literature synthesis, juniper encroachment negatively impacts sage-grouse largely by reducing or eliminating native vegetation that sage-grouse require for food and cover, resulting in habitat loss and fragmentation (Miller et al. 2010).

CONCLUSIONS AND RECOMMENDATIONS

Research Needs

The literature synthesis contained no experimental studies designed to evaluate the landscape effects of tall structures on sage-grouse. Thus, conclusions regarding the impacts of tall structures on sage-grouse are limited. To assess the effects of tall structures, as defined by this project, on sage-grouse additional landscape□level studies are needed. These studies have not been conducted because of logistical and funding constraints. Additional variables further confounding an evaluation of tall structures include structure type, differences in topography, habitat conditions, associate infrastructures, and their operation and maintenance.

Estimates of sage-grouse mortality because of increased collision potentials and predation are lacking. The literature contains personal observations of mortality attributed to tall structures, but the number of observations are low relative to the tall structure foot print and when compared to other sources. A better understanding of the extent and causal factor of mortality attributed to tall structure will help state and federal agencies refine siting criteria, develop BMP’s and other conservation measures to mitigate potential impacts.

Contemporary BMPs’ are largely lek-centric. Our review of the literature could not identify a source or scientific basis for recommended buffer zones. The USFWS (2010) acknowledged similar concerns in the greater sage-grouse status review. No research has been conducted to evaluate the effectiveness of current BMP’s. For effective BMP’s to be developed, 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.

There is a growing recognition 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 (Johnson et al. 2010) . However additional experimentation will be needed to provide better scientific basis for these models.

Problems encountered in reviewing the papers or reports cited to document the effects of tall structures on sage-grouse were largely related to a lack of experimental design. Flaws included: 1) small sample sizes, 2) observational studies, 3) inadequate descriptions of control and treatments, 4) inferences to sage-grouse from studies conducted on related species (e.g. Galliformes), or 5) studies that are retrospective in nature.

To adequately assess the impacts of tall structures on sage-grouse, conditions before and after the activity in question must be compared. In many cases, obtaining this type of baseline data for sage-grouse may not be within the control of the investigator. Depending on the project planning and funding constraints, there's not enough time to collect adequate data over several seasons and years. Data collected over multiple years both pre- and post- will be paramount to understanding tall structure and sage-grouse interactions given annual and seasonal variations in weather.

Based on the literature synthesis, the UWIN Cooperative identified specific questions regarding the relationship between sage-grouse and tall structures that need additional study: 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 the negative impacts, and, 6) Will these BMPs be universally effective?

To adequately compare control and treatment sites when conducting these experiments, better quantitative data describing the habitat at both the impact site (e.g., wind facility, power line) and the control site to establish the baseline trends or conditions to which the impact could be assessed. 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, relevant characteristics of experimental and control sites (e.g., vegetation, hydrology, topography) must be quantified so that at a minimum post-hoc analyses can identify confounding factors that may have influenced observed patterns.

Retrospective Study of the Relationship of Tall Structures to Lek Trends and Distribution

Johnson et al. (2010) attempted to determine if any relationship existed between greater sage-grouse lek counts during 1997–2007 and natural and anthropogenic features. They reported lek counts trends were positively associated with proportion of sagebrush cover, within 5 km and 18 km of leks. Negative lek count trends were associated with communication towers, but no effect was detected for power lines. They argued that the effects of some anthropogenic features may have already been manifested before their study period and thus were not significant in their analysis.

Similarly, Connelly et al. (2004) examined the distribution of leks along an interstate highway. They reported a higher rate of lek abandonment for leks located near the highway. They acknowledged that the interstate was completed prior to the initiation of thorough surveys, changes in the leks could have occurred prior to their being monitored. Their analysis also did not consider the effects of other highways or other land use activities, and the interstate may have been placed in less suitable habitat. However, they argued that this type of analysis can help provide insights into past effects and thus be used to make predictions regarding future impacts. No similar analysis has been conducted of energy corridors, structures, or power lines (Connelly et al. 2004).

A similar retrospective analysis of major power distribution corridors, greater sage-grouse lek distributions, and trends may provide new insights regarding the historical effects of tall structures on greater sage-grouse. The goals of this type of study would be: 1) to identify if there is a correlation between electrical lines and current greater sage-grouse population levels or distribution, and 2) if such a correlation exists, what factors (line type, habitat condition and quality, associated roads, human activity, etc.) influence greater sage-grouse demography. This analysis must include existing corridors and reference of control sites located in the general areas. The area within the study sites would be characterized by habitat type and condition, season of use, line voltage and structure configuration, date of construction, maintenance frequency, and road and railroad distribution. The actual utility corridors analyzed would be selected in consultation with utility company and state wildlife agency representatives. Preferences will be given to those utility corridors that are known to traverse historic and currently occupied sage-grouse habitat. Completion of this work would provide the basis for an experiment to test the effectiveness of BMPs (buffer distances and siting requirements) from sage-grouse leks and seasonal habitats for new and upgraded transmission line permitting.

Experimental Studies

How far is far enough? Connelly et al. (2000) recommended avoiding building power lines and other tall structures that provide raptor or corvid perch sites within 3 km of sage-grouse seasonal habitats. This recommendation errs on the side of caution because data regarding increased predation rates or sage-grouse avoidance of tall structures are lacking. Current overhead power line siting requirements within sage-grouse habitat may vary from 0.3 to 8.0 km depending on the state or federal agency (Appendix E).

The relationship of new line siting distance on sage-grouse behavior, habitat use, and predation, could be evaluated in two ways: 1) an experimental design involving constructing a non-energized power line placed at varying distances from known occupied greater sage-grouse leks that exhibit similar habitat conditions, and 2) a similar experiment incorporated into proposed transmission line corridors. The test parameter would be distance from leks. The distances evaluated should include the current 0.4 km stipulations plus and intermediate distance possibly 1.5 km. The later represents the mid-point between the recommended buffer distances of 3.2 km.

For both studies, a minimum of 8 leks or lek complexes should be randomly selected as treatments and controls to conduct each distance experiment. The leks or lek complexes would be located in similar habitat but spatial separated by a standard distance. In experiment 1 the structures erected near the leks will mimic actual power lines. Each lek or lek complexes would have a power line (façade) consisting of a minimum length of 2 km of power poles and lines placed perpendicular to the central axis of the lek or lek complex. These facades would set at the buffer distances to be evaluated as measured from the center axis from the lek. The facade would be constructed in the late fall. The goals of this study would be; 1) to identify if construction of new power lines impacts greater sage-grouse lekking and nesting behavior, 2) if impacts exist, at what distances from greater sage-grouse nesting habitat/leks do they occur, and 3) if impacts exist, provide recommendations to minimize or mitigate effects of new power lines.

Lekking and breeding behavior and habitat-use of sage-grouse males and breeding and nesting behavior of radio-collared greater sage-grouse hens (i.e., distances traveled to nest, nest initiation rates, nest success) would be monitored during both experiments. Ideally, monitoring would be conducted on each study lek at least three seasons prior to and three seasons after placing the structures. The UWIN Cooperative recommends the study birds be equipped with GPS collars. Because of the added expenses in using the newer technology, study birds could first be equipped with VHF collars to determine movements and habitat use patterns as identifying suitable subjects for GPS collars. Additional data regarding sage-grouse brood use of the study areas could be collected using techniques discussed by Dahlgren et al. (2006) and Dahlgren et al. (2010).

PROJECT ACHIEVEMENTS AND NEXT STEPS

Achievements

We learned from the literature review and synthesis that there were ***no*** peer-reviewed, experimental studies designed specifically to evaluate the landscape effects of tall structures on sage-grouse.

We confirmed through the compilation and synthesis of the existing policies, regulations, guidelines and BMPs for the siting and mitigate of tall structures that there is significant inter- and some intra-agency variation.

We learned the Participants shared eight concerns and that if addressed through scientific based research, could provide the knowledge required to develop generally accepted BMPs.

We also learned there was a sincere desire from all Participants to work proactively and collaboratively to conduct research on their highest priority concerns, acquire the requisite knowledge and develop broadly accepted BMPs.

Participants recommended that any research implemented; 1) follow rigorous protocol developed by a committee of experts, 2) be built on a BACI research platform, 3) be replicable and replicated in multiple states, 4) focus on current industry technology, 5) use current research technology including the use of GPS transmitters, 6) produce “court” defensible results, 7) be designed to simultaneously address multiple knowledge gaps, 8) measure individual and cumulative impacts of each tall structure type, 9) compliment work being done by others, 10) produce preliminary results that can be employed in an adaptive management approach to the development and refinement of BMPs, 11) be transparent and open with frequent updates and 12) include industry incentives like mitigation credits for proactive funding on needed research.

Finally, we learned the structure for executing many of the tasks identified in this project may already exist. The WAFWA Columbian Sharp-tailed and Sage-Grouse Technical Committee, the Range-wide Interagency Sage-grouse Conservation Team, and the National Wind Coordinating Collaborative’s Wildlife Workgroup are addressing specific tall structure, sage-grouse concerns. The research recommended by this project must be coordinated with these groups.

Next Steps

What we learned is significant because it points out the fact that additional knowledge **must be acquired** before the goals of the Greater Sage-grouse Comprehensive Conservation Strategy's tall structure issue can be achieved. Goals 3 and 4, respectively, are to "Develop scientific and consistent siting and Operation and Maintenance (O&M) criteria for "tall structures" in greater sage-grouse habitat that will minimize negative impacts on greater sage-grouse" and "Develop best management practices (BMPs) and appropriate mitigation measures that can be implemented for siting and O&M activities associated with tall structures". Project Participant's most pervasive and broadly held concern was "the science upon which to base many tall structure decisions is lacking".

We recommend the following "Next Steps":

- ✓ Prior to 1 October 2010, this report, with its comprehensive list of citations, be made available to those working to resolve the issue of tall structures and their possible impact on sage-grouse,
- ✓ Prior to 15 December 2010, the literature cited in this report be made available in an online "searchable" format,
- ✓ The results of this project should be presented to the existing stakeholder groups listed above at the earliest convenience,
- ✓ All future research must be coordinated with stakeholder groups and conducted in a manner that compliments their ongoing efforts,
- ✓ The process to identify a rigorous research protocol should commence immediately and be completed prior to the WAFWA mid-winter meetings. This process should be conducted in association with the existing committee of experts commissioned to formulate the research protocol for wind turbine impacts on sage-grouse,
- ✓ Initiate multi-site, multi-state cooperative research projects to fill the knowledge gaps identified by this project's Participants. Examples are provided above under Conclusions and Recommendations.
- ✓ Insure the research criteria identified in this project govern all research undertaken as a result to this project's recommendations,
- ✓ Provide energy development companies with incentives to support this research. One of the important incentives identified by the Participants is the opportunity to obtain mitigation credits for up-front funding of the research identified above. The UWIN Cooperative recommends an acceptable means of granting mitigations credits be identified prior to the WAFWA mid-winter meetings, and
- ✓ UWIN and Participants collaborate with stakeholder groups to secure funding to complete the priority research needs identified in this report.

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APPENDIXES
A. INVITED PROJECT PARTICIPANTS

Anadarko Petroleum Corporation
- Tom Clayson

Anschutz
- Gary Miller

Bureau of Land Management
- Jeromy Caldwell
- Chris Keefe
- Steve Madsen
- Carrie Nelson
- Jeff Rawson
- Mary Read
- Lisa Solberg
- Chris Keefe
- Frank Blomquist

Conoco-Phillips
- Jean Semborski

Customer Focus Inc.
- Scott Stephenson

EDM International, Inc
- John Cummings
- Lori Nielsen

Element Power
- Nicole Hughes

Equinox Engineering
- Chris Christiansen

Hawkwatch International
- Stephen Slater

Horizon Wind Energy
- Christina Calabrese
- Paul Cummings

Iberdrola, S. A.
- Jerry Roppe

Idaho Department of Fish and Game
- Tom Hemker

Idaho Power Company
- Stacey Baczkowski
- Brett Dumas
- Natalie Turley

Kern River Gas
- Doug Gibbons

LS Power Development LLC.
- David Wilson

Natural Resources Conservation Service
- Ilise Boeke
- Shane Green
- Gerald Jasmer

PacifiCorp
- Pam Anderson
- Jim Burruss
- Brian King
- Sherry Liguori
- Sharon Seppi
- Brandon Smith
- Mark Tallman
- Chad Teply

Parsons, Bele and Latimer
- Mike Malmquist

Questar
- Paul Jibson
- Kirt Rhoads
- Linda Sugano

Ridgeline Energy
- Rich Rayhill

Tetra Tech
- Jim Nickerson

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Mary Ann Wright

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Ted Wilson

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John Bissonette
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Utah Wildlife in Need
J.D. Davis
Robert Hasenyager

Wasatch Wind
Spencer Martin

Western Area Power Administration
Jim Hartman

Wyoming Association of Conservation Districts
Bobbie Frank
Shaun Sims

Wyoming Audubon
Kevin Doherty
Daly Edmunds
Brian Rutledge

Wyoming Business Council
Ben Avery

Wyoming Energy Advisor
Rob Hurless

Wyoming Game and Fish Department
John Emmerich
Mary Flanderka
Scott Gamo
Daly Sheldon

Wyoming Governor's Office
Aaron Clark

Wyoming Outdoor Council
Sophie Osborn

Wyoming Wildlife and Natural Resources Trust
Bob Budd

B. PROJECT PERSONNEL

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C. LIST OF SHARED AND INDIVIDUAL PARTICIPANT CONCERNS AND MOST EFFECTIVE OUTCOMES

Shared and Individual Participant Identified Concerns:

We are concerned we lack sound science upon which to base many tall structure decisions

- All decisions need to be based on the best research.
- There are not a lot of facts, or study data regarding sage-grouse. Some are preaching perch deterrents to protect sage-grouse while the onsite evidence doesn't support that application.
- The robustness and definition of the science regarding the impacts of tall structures need to be improved.
- Sound science needs to be tempered with policy implications.
- We lack of baseline data (BACI) on specific geographic and habitat studies.
- Evaluations of wind farm designs are incomplete because only one variable, instead of the whole system is studied. Consider multiple, concurrent studies.
- Our ability to extrapolate sage-grouse populations from lek data is not sensitive enough.
- Current research data is not being used.
- Given the Candidate status of greater sage-grouse following an adaptive management approach is a risk. Therefore, the burden is on the developer to show they will do no harm to sage-grouse in core areas.
- Existing studies and data are summarily dismissed.
- A number of statements, decisions, and directives are being made on little anecdotal evidence and even fewer scientific studies on the four issues surrounding sage-grouse and power lines (i.e., predation, ROW avoidance, habitat fragmentation, and collision).
- There is insufficient information on the impacts of different turbines on sage-grouse in various habitat types i.e. wintering and nesting.
- We do not use GPS transmitters as much as we could for sage-grouse studies, which would give us answers on avoidance of tall structures.
- GPS transmitters are being used in several current sage-grouse studies and are becoming the standard for sage-grouse research.

We are concerned about using research on other species, locations and dated technologies in establishing BMPs for sage-grouse

- Decisions are being based on Altamont wind turbine technology. We need studies on the impacts of current turbines on birds and bats.

- We are concerned about utilizing research conducted on other species, in other habitat types and geographic locations to establish BMP's for sage-grouse inhabiting Utah.

- We are concerned about using studies conducted on other species or in other geographic regions to fill knowledge gaps for Sage-grouse.

- Some studies referenced by consultants to show sage-grouse collisions are not a concern, were conducted in areas with no sage-grouse.

We are concerned we do not know what "effective" temporal and spatial setbacks/buffers are. We are also concerned they vary significantly

- What are the biologically appropriate spatial and temporal setbacks (buffers) needed for sage-grouse?

- Buffer distances are different between states and federal agencies and even subunits within agencies have differing opinions.

- There is speculation on the displacement of sage-grouse by turbines and distribution/collector lines.

- Mitigation measures apply specific buffer areas between power lines and grouse use areas, ranging from 0.25 mile to 5 miles of No Surface Occupancy.

- We have conducted significant research on leks but not enough on spatial and temporal issues such as wintering habitat.

- Delineation on NSO and impacts of linear features on sage-grouse needs to be improved.

- Topography can impact the effect of temporal and spatial BMPs of tall structures.

- We are concerned we are too dependent on spatial buffers as a mitigation tool and would like to know if there are other things of combinations of things we can do to reduce the impacts of tall structures on sage-grouse.

- If perching is not limited in an area, is the placement of tall structures really an issue.

We are concerned required BMPs are not monitored and may not be effective

- We are concerned BMP being used may not be effective and there is a lack of monitoring to determine BMP impacts.
- Agency policies for both land management and regulatory agencies can be problematic, when specific mitigation measures are required that have not been tested and can result in other operational issues for electric utilities.
- We do not do longitudinal research to determine the long term effects of tall structures and BMPs on sage-grouse.

We are concerned we don't know if and why Sage-grouse avoid tall structures

- Why are Sage-grouse avoiding tall structures? Is it because they are predator perches? Is it the associated noise? Do they avoid associated service roads because they may create travel routes for predators?
- What are the effects of wind turbines and transmission lines on sage-grouse?
- There is not scientific consensus that sage-grouse avoidance of tall structures is a known fact. More research is needed here.
- Why do sage-grouse avoid tall structures in general? What is a tall structure to a sage-grouse?
- Aversion of sage-grouse to different tall structures may not be equal and needs to be tested i.e., fences vs. power poles.
- Junipers may need to be included in the definition of tall structures and their encroachment studied.

We are concerned that tall structures may increase predation on sage-grouse

- Why are sage-grouse avoiding tall structures? Is it because they are predator perches? Do they avoid associated service roads because they may create travel routes for predators?
- Why do sage-grouse avoid tall structures—because of predators or because they just don't like them?
- Sage-grouse may stop us from getting EIS approval for project.
- There may be other external factors associated with tall structures that make sage-grouse more susceptible to disease and predation.

- Project options/alternatives utilizing different tall structures and technologies (i.e. burying lines) need to be presented by project proponents, irrespective of costs.

- We are concerned we are not plugging into ongoing baseline inventories and saving lead time on needed research?

- We are concerned existing BMPs, guidelines, protocols etc. may preclude the implementation of some good ideas.

We are concerned we do not know the impacts of tall structures' ancillary facilities

- We do not know the impacts of the total infrastructure associated with tall structures and the specific contribution of tall structures to this impact.

- We are concerned about the cumulative, landscape impacts of tall structures.

- Focus on tall structures themselves and not on service roads and noise.

- Are fences considered tall structures? Do fences provide perches for raptors? What course of action can private land owners do for perch deterrents?

We are concerned tall structures fragment sage-grouse habitat

- There is a concern that sage-grouse may be displaced from important habitats if they exhibit an aversion to tall structures.

- We are not sure about the impacts of tall structure height, density etc. on habitat, including seasonal use and landscape variability.

- Sage-grouse may avoid high concentrations of tall structures, causing changes in habitat use and abandonment of high quality breeding areas.

- Tall structures and associated infrastructure may fragment the landscape.

- We are concerned we are not considering the cumulative/additive effects of existing tall structures in conjunction with proposed tall structures.

- How much habitat is needed to support sustainable populations? How large do corridors need to be?

- We do not know if sage-grouse are more tolerant of tall structures in areas where they have better habitat and associated canopy cover.

- Impacts to adjoining habitat may not be significant if the sage-grouse habitat was better.

- ➢ We are concerned that the presence of tall structures in sage-grouse habitat will lead to lower sage-grouse reproductive rates and population levels because of increased predation, fragmentation of sagebrush habitats, or displacement of grouse.

- ➢ The available knowledge is not correlated to major habitat types.

- ➢ We need to get a sense of energy development impacts on sage-grouse habitat.

- ➢ There is too much focus on avoiding the impacts of tall structures on leks and as a result, we may be damaging brooding, nesting and wintering areas.

- ➢ We are concerned there may be unintended consequences of BMPs. For example, removing juniper trees may negatively impact on Ferruginous Hawks, burying power lines may introduce noxious weeds or the use of perch deterrents and increased avian electrocutions.

- ➢ We are concerned about avoidance, perching, and habitat fragmentation due to service roadways and transmission lines.

Most Effective Participant Identified Outcomes:

We would develop science based BMPs which are accepted by all pertinent stakeholders.

- ✓ Would like answers to avoidance of tall structure questions—do sage-grouse avoid tall structures because of natural instincts or because of past experience with predators?

- ✓ Develop retrospective and prospective research projects that can get us closer to BMPs.

- ✓ Need research on existing tall structures to determine spatial relationships of sage-grouse to them, based on different types of tall structures—poles, transmission lines, and turbines.

- ✓ Need uniform science-based decisions to provide uniform recommendations. These recommendations almost become enforceable law.

- ✓ Further studies are needed to answer the questions on adequate buffers and the efficacy of some of the mitigation approaches, including use of perch discouragers on power line structures.

- ✓ We would understand true impacts on sage-grouse and their habitat and effectively apply mitigation.

- ✓ Have consistent recommendations on BMPs and buffers by state and federal agencies as they apply to transmission lines.

- ✓ Identify and provide objective science. Remove individual bias and apply science in the development of guidelines.

- ✓ This issue will be handled most effectively by identifying research needs, conducting long-term research on the effect of tall structures on sage-grouse and other sagebrush obligates, then instituting BMPs to mitigate potential adverse impacts of structures in important habitats.

- ✓ Would conduct credible pre- and post-studies in areas of likely sage-grouse habitat. Wyoming's restrictions on research in core sage-grouse areas make this problematic.

- ✓ Monitoring programs should be in place to determine if impacts are occurring, allow for adjustment to reduce impacts and improve our knowledge base.

All pertinent stakeholders would communicate, collaborate and work proactively on resolving concerns (regarding tall structures in sage-grouse habitat)?

- ✓ Agreement on which agencies will take the lead on how industry, private land owners, and other agencies can come to agreement on next steps.

- ✓ Work together to address challenges of each participant.

- ✓ Come up with site guidelines for staying away from leks and to identify which habitats are most critical and to avoid putting tall structures in these areas.

- ✓ Get everyone on the same page concerning which projects need to have more research to develop BMPs.

- ✓ Transparency and careful study design are needed in order to effectively answer these questions in a relatively short amount of time.

- ✓ Opportunity to exchange information is crucial for all involved. This helps us all understand different perspectives where we can build a process to create action.

- ✓ Need a broad representation of professionals that have a variety of backgrounds with sage-grouse.

- ✓ Work together to compare proposed transmission routes to know sage-grouse habitat areas prior to permitting and funding.

- ✓ State fish and wildlife officials would be engaged early in development and permitting decisions.

- ✓ Improve communication among all groups on research findings and next steps to save time and resources.

- ✓ Early communication to states and resource agencies of tall structure development to be able to study impacts on multitudes of independent users.

- ✓ Being able to compare needed energy development infrastructure to sage-grouse habitat and work collaboratively before the permitting process to avoid or reduce impacts on sage-grouse.

D. WEB LINK TO COMPREHENSIVE LIST OF AVAILABLE SAGE-GROUSE LITERATURE ON TALL STRUCTURES

https://utahcbcp.org/files/uploads/TallStructureLitReview28July.pdf

E. WEB LINKS TO EXCEL SPREAD SHEET OF CURRENT BMPS, POLICIES AND RULES FOR THE PLACEMENT OF TALL STRUCTURES AND ASSOCIATED INFRASTRUCTURES IN AREAS INHABITATED BY SAGE-GROUSE

https://utahcbcp.org/htm/other-projects (click on excel spreadsheet)