Recommendations for Development of Oil and Gas Resources Within Important Wildlife Habitats

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- August 2009 changes shown in italics on pages 20, 108 & 109 – Non-core clarifications
- November 2009 changes shown in italics on pages 19, 31, 108, 109, 110, 111 – Sage Grouse Core Area Densities and Timing Limitation Stipulations
- March 2010 Raptor changes shown in italics on page 48

Wyoming Game and Fish Department

Cheyenne, Wyoming

PURPOSE, USE AND HISTORY OF THIS DOCUMENT

Wyoming has a long history of oil and gas extraction and production. The pace of this development has varied cyclically based largely upon public demand, market price, federal energy policy and new extraction technologies. However, the cumulative area affected has grown substantially in recent years, and is expected to continue increasing in the foreseeable future (Surdam *undated*, Surdam and Quillinan 2008). Newly developed fields will remain in production up to 40 years and longer. While oil and gas development is an important component of Wyoming's economy, large-scale development often has adverse impacts on wildlife. In view of these impacts, the Wyoming Game and Fish Commission (Commission) is publishing recommendations designed to ameliorate conflicts between oil and gas development and wildlife resources. It is the Wyoming Game and Fish Department's (WGFD) belief that if the appropriate recommendations are adopted and effectively implemented, important wildlife resources can be sustained while allowing Wyoming to play its pivotal role in providing energy to the nation.

The major purposes of this document are to: identify thresholds of oil and gas development and related activities that impair the functions or suitability of important wildlife habitats; recommend planning and management considerations that will avoid or minimize impacts as oil and gas developments reach identified thresholds; and recommend effective mitigation to offset or compensate unavoidable, adverse effects on federal, state, and privately managed lands. The document provides implementation guidance under the Commission's Mitigation Policy (Commission 2008) and supports the Commission's Mission of "Conserving Wildlife – Serving People." The Commission has a single-purpose mandate: "… to provide an adequate and flexible system for control, propagation, management, protection and regulation of all Wyoming wildlife" [W.S. 23-1-103]. Our consultation role in federal agency actions pursuant to NEPA and other federal laws is fully consistent with the Commission's mission and purpose. It is important to recognize the WGFD and Commission have no specific authority to require adoption or implementation of recommendations in this report. These recommendations convey alternatives for consideration by companies and jurisdictional agencies in light of their statutory and regulatory programs and obligations.

A working group of wildlife and fisheries biologists was tasked with developing the initial management recommendations in early 2004. Working group members and other participants have extensive experience with federal land use planning, permitting, and energy-related issues. The Commission endorsed the recommendations in September, 2004 after several changes were made to address specific concerns expressed by the Bureau of Land Management (BLM), the oil and gas industry, agriculture community, and conservation organizations. This document was described as a "working document" subject to future revisions as substantive new information becomes available. In March, 2006 and August, 2008 the original working group reconvened to consider the need for revisions based on recent published research, additional data, and the effectiveness of the original recommendations. The current version incorporates results of those technical reviews and editorial revisions.

A number of recommendations are standard practices currently used by several companies, the BLM, and the US Forest Service (USFS). Standard practices were included to reinforce their importance, provide greater specificity where appropriate, and encourage broader use by companies and agencies. Several concepts were adapted from a USDI/USDA publication entitled: "Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development" available at: http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/best_management_practices/gold_book.html (USDI/USDA 2006). This document includes additional criteria based on available science, to better define the circumstances and extent to which these practices should be applied to protect wildlife resources and maintain important habitat functions.

This document provides advanced disclosure of potential wildlife-related concerns, and suggests mitigation and management options companies and resource agencies can incorporate into project designs and operations to benefit wildlife. The recommendations should be considered within areas of important wildlife habitats, in which large-scale energy developments are planned or underway. Maps of crucial big game winter ranges, sage-grouse habitat, priority watersheds, and other important habitats are available from the WGFD website: www.wgf.state.wy.us (Habitat Section). Recommendations may be site-specifically adjusted to accommodate unique issues and circumstances.

Early, pre-decisional consultation provides the best opportunity to plan oil and gas developments in a manner that avoids or minimizes adverse impacts to important wildlife habitats. If significant resource concerns are identified prior to leasing, effective protection and mitigation measures can be included as lease stipulations providing full disclosure to prospective bidders. Ultimately, the authority to make land management decisions rests with the surface management agency, based on principals of multiple use and sustained yield set forth by the Federal Land Policy and Management Act (FLPMA) the National Forest Management Act (NFMA) and other statutory authorities, State of Wyoming statutes and rules, and county ordinances

The working group reviewed pertinent literature to identify and describe reasonably foreseeable impacts to wildlife resources (refer to "References Consulted" and Appendix J – Annotated Bibliography). A number of studies have examined effects oil and gas operations have on selected species and habitat functions, for example, displacement of elk and mule deer from crucial winter ranges and impacts to sage-grouse reproduction. However, not all wildlife responses to oil and gas operations have been specifically studied. As necessary, the working group gathered and interpreted information on disturbances and activities comparable to those associated with oil and gas fields. For example, studies of wildlife responses to humans on foot, ATVs, equipment disturbance, roads, noise levels, ecological health of watersheds etc. were reviewed to determine disturbance thresholds for similar activities and features associated with oil and gas field developments. This approach affords a reasonable basis for recommending mitigation and management practices at a programmatic level.

Energy development technologies are constantly evolving, as is knowledge of wildlife impacts, and monitoring and mitigation techniques. In light of this, efforts to identify and incorporate additional literature, monitoring procedures and more effective mitigation will continue. These recommendations will be updated and revised as significant new information becomes available. We encourage input that may improve future iterations. Input should be provided to the working group chairman, Steve Tessmann, Wyoming Game and Fish Department, 5400 Bishop Boulevard, Cheyenne, WY 82006.

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LIST OF ACRONYMS USED

APD – Application for Permit to Drill
APWG – Activity Plan Working Group
ATV – All-terrain Vehicle
BLM – U.S. Bureau of Land Management
BMP – Best Management Practice
CBNG – Coal-bed Natural Gas
CEQ – Council on Environmental Quality
CFR – Code of Federal Regulations
CSU – Controlled Surface Use
dBA – Decibel
ESA – Endangered Species Act
FLPMA – Federal Land Policy and Management Act of 1976
GAO – United States General Accounting Office or General Accountability Office
GIS – Geographic Information System
NEPA – National Environmental Policy Act of 1969
NFMA – National Forest Management Act of 1976
No – Number
NSO – No Surface Occupancy
NSS – Native Species Status
P.L. – Public Law
POD – Plan of Development
SGCN – Species of Greatest Conservation Need – listed in the Comprehensive Wildlife Conservation Strategy for Wyoming (WGFD 2005). This plan is now called the, "State Wildlife Action Plan."
SHP – Strategic Habitat Plan
SWAP --State Wildlife Action Plan
SWG – State Wildlife Grants
U.S.C. – United States Code
USDA – United States Department of Agriculture
USDI – United States Department of Interior
USFS – United States Forest Service
USFWS – United States Fish and Wildlife Service
USGS – United States Geological Survey
WGFC – Wyoming Game and Fish Commission
WGFD – Wyoming Game and Fish Department
WOGCC–Wyoming Oil and Gas Conservation Commission
WY – Wyoming

STATEMENT OF PRINCIPLE

Energy development with increasing levels of disturbance is impacting habitat function on vast tracts of land in Wyoming and across the West (Fig. 1). These conversions are recognized at a global scale – two of 180 environmental monitoring sites identified by the United Nations Environmental Programme (UNEP) are natural gas fields in Wyoming (UNEP 2005). Just 8 UNEP sites have been designated in the conterminous 48 states. High-density well fields impact visual resources, air and water quality, wildlife habitat, and public recreation. Impending large-scale wind energy fields, pipelines and utility corridors, potential oil shale development, and other intensive uses threaten to further industrialize and fragment the landscape across Wyoming.

If effective habitat conditions are to be maintained for wildlife on public lands, it is imperative to accomplish energy production with the smallest possible footprint of disturbance. This document provides science-based recommendations to achieve these goals through a variety of project planning, siting, and design considerations.

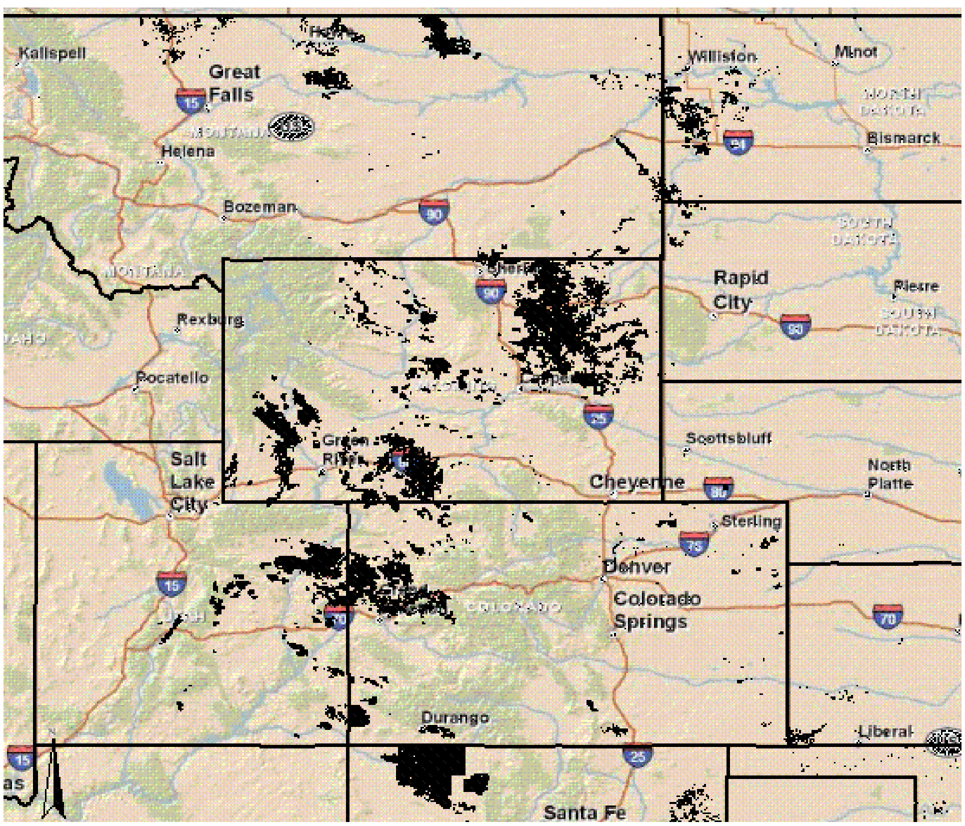

Fig. 1. Producing oil and gas leases throughout Wyoming and adjacent states.
Source: BLM/USFS National Integrated Land System (2008 data)
http://www.geocommunicator.gov/GeoComm/index.shtm

INTRODUCTION

Several of the most intact, native ecosystems remaining in the Intermountain West are found within Wyoming. In particular, sagebrush and grasslands throughout the western U.S. continue to gain importance for several reasons. Sagebrush dominated landscapes and watersheds provide diverse habitats for approximately 87 species of mammals, 297 species of birds (Braun et al. 1976) and 63 species of fish, reptiles and amphibians (Wyoming Game and Fish Department Vertebrate Species List, 1992). Sagebrush ecosystems in Wyoming not only support crucial habitats for some of the largest, migratory populations of ungulates in North America, but also offer the best chance to sustain healthy populations of sage-grouse and other obligate species into the future. In addition, native grasslands of the north-central prairie states (which include eastern Wyoming) support 138 species of land mammals, including 16 considered narrowly endemic to grasslands (Appendix G) (Samson and Knopf 1996). Nine avian species (excluding wetland and sagebrush associates) are narrowly endemic to grasslands (Appendix G). Twenty additional species are more widespread but have strong affinities to the northern Great Plains region. The Powder River in northeast Wyoming is one of the last free-flowing prairie stream systems with an essentially intact native fish community.

Beetle and Johnson (1982) estimated sagebrush-steppe communities once comprised nearly 58,000 square miles (37 million acres) of Wyoming. The current area is about 29 million acres based on recent information compiled by U.S. Department of Interior, (USDI) Bureau of Land Management (BLM) (2001). The BLM study did not account for the entire difference between historic and current sagebrush coverage, but provided the following conversion acreages: more than 21,000 acres of sagebrush converted to annual grasslands, approximately 381,000 acres of conifer/juniper encroachments, and approximately 684,000 acres dominated by perennial grasses with sagebrush cover loss.

Grassland ecosystems comprise approximately 20 percent (19,600 square miles) of Wyoming [United States Geological Survey (USGS) Biological Resources Division 1996]. Shortgrass prairie is located mainly in the southeast corner and extends southward into Colorado (Knight 1994). Mixed-grass prairie is common across much of eastern Wyoming.

Sagebrush and grassland communities are in a declining state of health throughout most of the West (Winward 2004) and continue to be impacted by drought, altered fire ecology, excessive herbivory, agricultural conversions, energy developments, rural subdivisions, and other stressors. As anthropogenic activities continue to impact ecosystems throughout the western U.S., Wyoming's rangelands have become increasingly important in efforts to conserve functional, native ecosystems and the assemblages of endemic wildlife that depend on them.

Much of the sagebrush in Wyoming is in late successional stages dominated by older plants (>50 years old) of relatively even age classes (sagebrush monocultures) (Winward 1991; Miller et al. 1994; Wyoming Interagency Vegetation Committee 2002). These stands are characterized by reduced vigor, productivity, diversity, and nutritional quality (WY

Interagency Vegetation Committee 2002). Grasslands in Wyoming have also been extensively altered and converted by various land uses. Fragmentation and declining quality of these ecosystems are the principal reasons why populations and distributions of associated wildlife are declining. Nationally, grassland and shrubland birds have declined more consistently over the past 30 years than any other ecological association of birds (WY Game and Fish Dept. and WY BLM 2002).

Many of the issues affecting sagebrush and grasslands are also impacting other ecosystems. Mixed mountain shrub, aspen, riparian corridors, streams and wetlands provide extremely important habitat for diverse and unique assemblages of wildlife, but exhibit symptoms of declining health including advanced succession and overall loss of quality and vigor. To address these concerns, WGFD has developed a Strategic Habitat Plan (2008) (SHP) that sets forth management goals for habitat priority areas delineated throughout the state. The management emphases are to protect, rehabilitate, and enhance habitats that are essential for sustaining important wildlife populations and wildlife-based recreation. However, habitat priority areas are broadly defined and should not be confused with specific habitat types or functions identified under the Wyoming Game and Fish Commission's Mitigation Policy. Vital habitats such as crucial winter ranges and sage-grouse breeding habitat are more specifically identified and may be within or outside the priority habitat areas. In appropriate circumstances, there may be opportunities to mitigate oil and gas impacts by implementing habitat rehabilitation or improvement projects, consistent with WGFD objectives, within SHP priority areas.

In addition to the SHP, WGFD has recently completed a State Wildlife Action Plan (SWAP) (WGFD 2005). The SWAP provides a long-range plan to conserve Wyoming's Species of Greatest Conservation Need (SGCN) and to meet the requirements of the Congressionally-authorized State Wildlife Grants (SWG) Program. The strategy also prioritizes areas and habitats of importance across the state (Refer to Appendix H for a list of SGCN within ecoregions with high potential for oil and gas development, and Appendix I for and a map of nongame habitat priority areas).

Sagebrush and grassland dependant wildlife are a vital feature of the West's culture and heritage. Wildlife-dependent recreation is also the prevalent recreation on most public lands in Wyoming. Wildlife-related expenditures totaling nearly $0.5 billion annually are a major contribution to the tourism market, which is the State's second greatest source of revenue (WGFD 2003). Development of expansive coal, oil and natural gas deposits that underlie important wildlife habitats, combined with other intensive uses of the land, constitute our greatest contemporary challenge to the conservation of western wildlife. Large-scale development of these domestic energy reserves is placing sagebrush communities and wildlife increasingly at risk.

Abundant wildlife resources can be sustained on federal lands only if resource agencies work with industry to manage wildlife habitats, energy development and other land uses in a manner that is fully consistent and compatible with principles of multiple use and sustained yield set forth by the Federal Land Policy and Management Act of 1976 (FLPMA) and the National Forest Management Act of 1976 (NFMA). These principles include "… a combination of balanced and diverse resource uses that takes into account the long-term needs of future generations for renewable and nonrenewable resources … and harmonious and coordinated management of the various resources without permanent impairment of the productivity of the land and the quality of the environment with consideration being given to the relative values of the resources and not necessarily to the combination of uses that will give the greatest economic return or the greatest unit output." [Title 43, Sec. 1701(a)(8)].

SCOPE

The 3 major purposes of this document are:

1) Identify thresholds of oil and gas development that impair the functions or suitability of important wildlife habitats;
2) Recommend planning and management considerations that will avoid or minimize impacts to important wildlife habitats as oil and gas developments reach identified thresholds; and
3) Recommend effective mitigation to offset or compensate unavoidable, adverse effects of oil and gas development.

DEFINITIONS

As used in this document, "important wildlife habitats" include habitats defined as "irreplaceable," "vital," or "high value" by the Wyoming Game and Fish Commission's Mitigation Policy (Commission 2008). "Irreplaceable habitats" must be formally designated by the Commission and include habitat components that cannot be replaced or mitigated (e.g., critical habitats of species listed under the federal Endangered Species Act). "Vital habitats" directly limit a wildlife community, population, or subpopulation, and restoration or replacement may not be plausible. Such habitats include, but are not limited to, big game crucial winter ranges, sage-grouse nesting and brood-rearing habitats, habitats essential for Species of Greatest Conservation Need (SGCN), and blue ribbon fisheries (streams). The WGFD is directed by the Commission to recommend no loss of habitat function. Some modifications of habitat characteristics may occur provided habitat function is maintained (i.e., the location, essential features, and species supported are unchanged). "High value habitats" sustain a wildlife community, population or subpopulation, but impacts can be minimized and habitat restored or replaced where avoidance is not possible. These habitats include, but are not limited to, parturition habitats and winter-yearlong ranges of big game species, riparian habitats, and red ribbon fisheries (streams). The WGFD is directed by the Commission to recommend no net long-term loss of habitat function and WGFD will recommend measures to minimize impacts and restore or replace the function of affected habitats.

The majority of habitats addressed by this document are classified as "vital" or "high value" by the Commission's Mitigation Policy. The approach recommended to protect and maintain important wildlife resources follows the Commission's Mitigation Policy, which sets forth the following priority of actions: 1) avoid the impact; 2) minimize the impact through appropriate planning and management actions; 3) mitigate the impact by providing replacement or substitute resources; and 4) provide financial compensation only when no reasonable alternative is available to avoid, minimize or mitigate the impact.

Additional terms used in this document are defined below:

"Activity Plan Working Group or APWG" means an operational group of Cooperating Agencies who assist the BLM in preparing environmental analyses for activity level actions or plan modifications. Either the BLM or potential cooperating agencies may identify the need for activity planning and recommend formation of an APWG. The need for public involvement with working group activities should also be considered. Major purposes of the APWG concept are: minimize controversies during analysis and decision making by addressing public land management issues in a proactive rather than reactive framework; improve resource conditions by recommending appropriate management and mitigation; streamline public land authorizations; increase management flexibility; and assure developers are aware of resource protection requirements early in the process. The APWG will recommend practices and procedures for consideration by the BLM Field Office Manager to achieve the purposes and intent of this document. Although the group will strive to achieve consensus, all recommendations of individual group members will be forwarded to the Field Office Manager for consideration.

"effective mitigation" means the successful implementation of operational planning and management practices that either avoid an impact or reduce it to a minimal level. Effective mitigation also means the successful establishment of replacement resources (through creation or enhancement) to achieve specific biological objectives. In most cases, this means increasing the capacity of one or more alternative habitats to replace the habitat functions lost or diminished as a result of development.

"habitat function" means the arrangement and capability of habitat features to sustain species, populations, and diversity of wildlife over time (Commission 2008).

"facility" as used in this document means all areas of disturbance related to oil and gas development. "Facility" comprehensively includes well pads, roads, overhead power lines, storage tanks, shops, equipment staging areas, sweetening plants, above ground pipelines, and any other surface disturbance or structure related to oil and gas development.

"integrated mitigation" means a landscape approach to mitigation in which one or more companies consider a broad range of opportunities and strategies to accomplish effective mitigation. An integrated mitigation program can include mitigation projects that are cooperatively developed among several companies and agencies.

"habitat effectiveness" means the degree to which **a** habitat or its components fulfill specific habitat functions; the degree to which a species or population is able to continue using a habitat for a specific function.

"habitat suitability" has the same meaning as "habitat effectiveness".

"habitat value" means the relative importance of various habitat types and conditions in sustaining socially or ecologically significant wildlife populations and biological diversity.

"impact, extreme" means the function of an important wildlife habitat is substantially impaired or lost even though some animals may still be present within the project area.

Seasonal use restrictions and intensive implementation of recommended management practices (Appendices A and B) and/or habitat mitigation options (Appendix F) are still useful, however the impact cannot be fully mitigated within the project area. Off-site mitigation is necessary to maintain properly functioning biotic communities and sustainable land uses by creating or enhancing replacement habitats. Off-site mitigation should be located within the same landscape unit.

"impact, high" means the function of an important wildlife habitat is increasingly impaired (a significant reduction in wildlife use is anticipated), but impacts can often be reduced or eliminated through seasonal use restrictions and intensive implementation of recommended management practices (Appendices A and B) and/or habitat mitigation options (Appendix F). The impact will be difficult, or at times impossible to effectively mitigate within the project area, and off-site mitigation may be necessary to maintain properly functioning biotic communities and sustainable land uses by creating or enhancing replacement habitats. Off-site mitigation should be located within the same landscape unit.

"impact, moderate" means a level of development that causes discernable impairment of the function of an important habitat (a detectable reduction in wildlife use is anticipated), but the impact can be significantly reduced or eliminated through seasonal use restrictions, recommended management practices (Appendices A and B), and/or habitat mitigation options (Appendix F). Habitat mitigation options can usually be implemented effectively within or close to the project area. This level of impact can result in a cumulatively significant effect if multiple impacts are present over a large area and are not mitigated.

"landscape management" means management applied within a landscape unit to maintain biotic communities in a properly functioning condition and to support sustainable land uses.

"landscape unit" means a geographic area encompassing all the major ecological components, functions, and processes that are essential to sustain species populations or biotic communities. Examples include big game herd units, a riparian/stream system containing all life requirements for species of fish, or the area providing all seasonal habitats required by sage-grouse.

"migration corridor" means a route that animals traditionally follow between seasonal habitats. Migration corridors may be comparatively broad or very constricted. The WGFD has identified and mapped important big game migration corridors throughout the state.

"No Surface Occupancy" (NSO), as used in these recommendations, means no surface facilities including roads shall be placed within the NSO area. Other activities may be authorized with the application of appropriate seasonal stipulations, provided the resources protected by the NSO are not adversely affected. For example, underground utilities may be permissible if installation is completed outside periods specified in applicable seasonal stipulations and significant resource damage does not occur. Similarly, geophysical exploration may be permissible in accordance with seasonal stipulations.

"properly functioning condition" (in a landscape context) means the major ecological components, functions, and processes are kept intact such that the capacity of the land to produce wildlife and sustain biological diversity is not impaired. A landscape or biotic community in a properly functioning condition retains its potential natural vegetation within the range of normal ecological variation. Anthropogenic features and activities do not cause habitat fragmentation or diminish the ability of wildlife to continue using important seasonal or yearlong habitats.

"riparian habitat or "riparian corridor" means an area of vegetation that exerts a direct biological, physical, and chemical influence on (and is influenced by) an adjacent stream, river, or lake ecosystem, through both above- and below-ground interactions. This area of association extends from the rooting systems and overhanging canopies of streamside flora outward to include all vegetation reliant on the capillary fringe characteristic of soils surrounding aquatic environments (Odum 1971). NRCS (2005) provides the following working definition: "Riparian areas are ecosystems that occur along watercourses or water bodies. They are distinctly different from the surrounding lands because of unique soil and vegetation characteristics that are strongly influenced by free or unbound water in the soil. Riparian ecosystems occupy the transitional area between the terrestrial and aquatic ecosystems. Typical examples would include floodplains, stream banks, and lake shores." Riparian habitats in Wyoming are often indicated by presence of cottonwood trees, willows, water birch, river birch, dogwood, sedges, tufted hair grass, reed canary grass, and other phreatophytic vegetation, and also include springs, seeps and wet meadows.

"section," when used in the context of a geographic area, refers to a legal section of 640 acres.

"square mile" or "mi^2" means a unit of surface area measurement that is 640 acres and does not imply any particular shape or configuration.

"to the extent reasonable" or "to the extent practicable" means effective technologies and practices can be applied to avoid, minimize, or mitigate an impact. "Reasonable" is used here in the same context as 43 CFR 3162.5-1(a). The basis for this determination includes technological feasibility, applicability, and economic considerations.

"threshold (or "impact threshold") means a level of development or disturbance that can impair key habitat functions by directly eliminating habitat, by disrupting access to or use of habitat, or by causing avoidance and stress.

"well pad location" means the disturbed site on the land surface, from which one or more wells are drilled. Wildlife impact thresholds are based on densities of well pad locations rather than individual wells. For example, if 16 wells are drilled from a single pad, then the impact is based on a single pad rather than 16 wells.

LANDSCAPE PLANNING

Landscape planning is comprehensive resource planning done at a geographic scale and configuration sufficient to maintain biotic communities in a properly functioning condition, in order that land uses can be managed on a sustainable basis. A landscape approach is essential to plan and mitigate large-scale energy developments because impacts from such developments are not limited to the actual project area, nor are mitigation opportunities.

Both the BLM and USFS have recognized that public land management must be rooted in landscape concepts and principles (BLM 1994; USDA Forest Service Handbook). In addition, the NEPA cumulative impact assessment is focused on the landscape and must consider the availability, arrangement, and condition of important habitats, and the effects of all past, present, and reasonably foreseeable developments.

Selection of landscapes appropriate for analysis and planning is based on the species, populations, or habitat functions affected by land management decisions. For example, a big game herd unit is a type of landscape encompassing the seasonal habitats that sustain the herd. A watershed is another landscape generally used in aquatic habitat management and often in terrestrial habitat management. The landscape that pertains to a sage-grouse population would include major lek complexes, nesting and brood-rearing habitats, and winter concentration areas necessary to meet the year-round biological requirements of that species. Landscapes appropriate for migratory bird populations should encompass the habitat complexes those populations occupy during the seasons they are present, for example the nesting season. The landscape also defines the area in which habitat treatments (Appendix F) can be done effectively to maintain or restore habitat functions. For example, the area that encompasses the crucial winter ranges used by a herd or herd segment is the landscape in which it may be possible to mitigate impacts to crucial winter ranges.

The following process is recommended to identify and evaluate impacts in order to formulate effective wildlife mitigation at a landscape level:

1) In consultation with the state wildlife agency, identify and delineate appropriate landscape units for planning and analysis;
2) Comprehensively inventory the biological and physical components (vegetation cover types, wildlife species and numbers, seasonal habitats, current land uses, existing patterns of development, etc.) affected by the proposed development. This inventory can consist of available studies, data, and prior environmental analyses <u>to the extent existing information adequately characterizes the affected resources</u> (environment), but may require additional data collection if missing information is necessary to conduct an adequate landscape analysis (i.e., to support a reasoned choice among the alternatives). The inventory should:
    i) describe how key physical and biological components are functionally interconnected or interdependent, for example, the seasonal ranges and migration patterns of a big game herd or the watershed processes that sustain a healthy fishery;
    ii) identify the habitat components that limit wildlife populations, fulfill key habitat functions or sustain ecologically diverse communities; and
    iii) objectively assess the existing condition of all major ecological components based on quantitative inventory and monitoring data. If adequate resource data are not available, include a means of collecting the information;
3) Identify landscape goals and objectives based on the desired condition (properly functioning condition) of major ecological components and processes;
4) Comprehensively describe past, present, and reasonably foreseeable developments and land uses including the potential locations and scale of oil and gas developments. Identify direct, indirect, and cumulative effects of development and

land uses, including whether the condition or functions of the various ecological components may be impaired;

5) Identify and prioritize areas suitable for potential mitigation projects;
6) Formulate effective management and mitigation to avoid, minimize, rectify, or compensate adverse impacts;
7) Design a technically sound monitoring plan that will enable managers to refine the assessment of impacts, evaluate the effectiveness of mitigation, and detect unforeseen conditions;
8) As necessary, design and conduct research to study and evaluate presently unquantified effects, resource conditions, and key ecological processes; and
9) Adjust monitoring, management and mitigation as necessary to achieve landscape goals and objectives more effectively, address unforeseen conditions, or improve practices based on research results (this is an application of "adaptive management").

OIL AND GAS IMPACTS

Sources and Significance of Impacts

Oil and gas developments cause a range of adverse effects on wildlife (refer to "References Consulted" and Appendix J), but in some circumstances may also create enhancement opportunities. Ecologically speaking, virtually all disturbances constitute an impact at some level. Excavations, roads, facilities, equipment, human activity, noise, and changes to water quantity/quality physically eliminate habitat, reduce the effectiveness of a larger area of otherwise suitable habitat, and may introduce or attract abnormally high numbers of competitive or predatory organisms. The significance of the impact depends on the amount, intensity, and duration of the disturbance, the specific locations and arrangements of the disturbance, and the ecological importance of the habitats affected. Small, isolated disturbances within non-limiting habitats are often a minor consequence within most ecosystems. However, larger-scale developments within habitats that are essential to survival or reproduction of wildlife become a more significant concern because such impacts cannot be relieved or absorbed by surrounding, unaltered habitats. Prudent risk management dictates each increment of disturbance should be planned, managed and mitigated to avoid cumulatively significant effects. When it is reasonable to anticipate a cumulatively significant adverse effect, 40 CFR 1500.2(a) and (f), 1500.6, 1508.27(b)(7), 1502.14(f), and 1502.16(h), taken collectively, require each federal agency shall interpret and administer its existing statutes and authorities to avoid, minimize or mitigate the effects of component actions to the extent practicable. Impacts to limiting habitats and habitat functions will be the focus of this document.

Potential enhancement opportunities associated with oil and gas development may include the use of produced water to create wetlands and other water sources or to irrigate vegetation in ecologically appropriate circumstances. Effective mitigation and successful reclamation may bring about additional enhancement possibilities. An integrated mitigation program should consider and incorporate such opportunities where they accrue.

Individual companies have also voluntarily implemented a number of field design and management practices to reduce their level of impact, as well as funding several mitigation projects, monitoring and research studies. Examples include directional drilling to reduce well pad densities, use of oak mats to reduce vegetation disturbance, installation of liquid gathering systems, contributions to the Jonah Field and Pinedale Anticline mitigation funds for habitat improvement, and funding for mule deer and sage-grouse research.

Adverse effects of oil and gas development can be divided into 7 categories: 1) direct loss of habitat; 2) physiological stress to wildlife; 3) disturbance and displacement of wildlife; 4) habitat fragmentation and isolation; 5) alteration of environmental functions and processes (e.g., stream hydrology, water quantity/quality); 6) introduction of competitive and predatory organisms; and 7) secondary effects created by work force assimilation and growth of service industries. The direct loss or alteration of habitat is always a concern. The collective area of disturbance may encompass just 5-10% of the land, however the influence of each facility (well pad, road, overhead power line, etc.) extends to a larger surrounding area where the proximity of disturbance causes stress and avoidance by wildlife. For mule deer, alert and flight reactions have been detected up to 0.29 miles from the source of disturbance (Freddy et al. 1986), whereas habitat avoidance responses may extend to distances of over a mile (Sawyer et al. 2008). The authors also reported deer respond negatively to roads with high traffic levels associated with winter drill sites. Zones of negative response can reach over half mile for elk on open winter ranges (Brekke 1998; Hayden-Wing Associates 1990; Hiatt and Baker 1981; Johnson and Lockman 1979, 1981) and up to several hundred meters for some raptor species during egg laying and early incubation (Fyfe and Olendorff 1976, White Thurow 1985). Results from year 3 of an ongoing study indicate migrating pronghorn avoid the more densely developed areas of the Pinedale Anticline fields (Berger pers. comm., Berger et al. 2008).

As densities of wells, roads, and facilities increase, habitats within and near well fields become progressively less effective until most animals no longer use these areas. Animals that remain within the affected zones are subjected to increased physiological stress. This avoidance and stress response impairs habitat function by reducing the capability of wildlife to use the habitat effectively. In addition, physical or psychological barriers lead to fragmentation of habitats, further limiting access to effective habitat. An area of intensive activity or construction becomes a barrier when animals can't or won't move through it to use otherwise suitable habitat. These impacts are especially problematic when they occur within or adjacent to limiting habitats such as crucial winter ranges and reproductive habitats.

Sawyer et al. (2006) state, "There are 2 potential concerns with the apparent avoidance of well pads by mule deer. First, the avoidance or lower probability of use of areas near wells creates indirect habitat losses of winter range that are substantially larger in size than the direct habitat losses incurred when native vegetation is removed during construction of the well pad. Habitat losses, whether direct or indirect, have the potential to reduce carrying capacity of the range and result in population-level effects (i.e., survival or reproduction). Second, if deer do not respond by vacating winter ranges, distribution shifts will result in increased density in remaining portions of the winter range, exposing the population to greater risks of density-dependent effects. Consistent with Bartmann et al. (1992), we would expect fawn mortality to be the primary density-dependent population regulation process because of their high susceptibility to over-winter mortality (White et al. 1987, Hobbs 1989)." … "Assuming there is some level of increased energy expenditure required for deer to alter their winter habitat-selection patterns (Parker et al. 1984, Freddy et al. 1986, Hobbs 1989), the apparent displacement of deer from high-use to low-use areas has the potential to influence survival and reproduction."

Along similar lines, Naugle et al. (*In press*) wrote, "Recent research shows that sage-grouse populations decline when cumulative impacts of development negatively affect reproduction or survival (Aldridge and Boyce 2007), when birds behaviorally avoid infrastructure in one or more seasons (Doherty el al. 2008), or both (Lyon and Anderson 2003; Holloran 2005; Kaiser 2006; Holloran et al. 2007). Behavioral avoidance of energy development reduces the distribution of sage-grouse and may result in population declines if density-dependence or habitat suitability lowers survival or reproduction in displaced birds (Holloran and Anderson 2005; Aldridge and Boyce 2007). Adult female sage-grouse in Canada lead their young into the Manyberries Oil Field where succulent forbs were abundant, but despite this attraction, the development was a population sink where risk of chick mortality increased 1.5 times for each additional well visible within 1 km of the brood (Aldridge and Boyce 2007: Appendix C2). In the Powder River Basin, sage-grouse were 1.3 times less likely to use otherwise suitable winter habitats that have been developed for energy (12 wells/4 km^2), and differences were most pronounced in high quality winter habitat with abundant sagebrush cover (Doherty et al. 2008: Appendix C3)."

Oil and gas developments also affect aquatic ecosystems. The overall health of an aquatic habitat derives from the condition of the entire watershed including the uplands, riparian corridor and the stream channel. Impacts to the upland plant community and environment can have a very immediate impact on an aquatic system, because the condition of vegetation throughout a watershed is the major factor determining the quantity and quality of the associated flow regime. In essence the runoff is naturally regulated by healthy, diverse vegetation. Vegetation in good condition provides greater ground cover, which reduces runoff and increases infiltration rates. Furthermore, diverse plant communities contain various microsites that enable snow to melt at differing rates, thereby extending the runoff period. Collectively, these factors produce more stable base flows essential for healthy fish and riparian habitats. Reduced sedimentation is another major benefit to aquatic organisms. Healthy vegetation naturally produces a healthy water cycle. However, some unimpacted stream systems in Wyoming have a natural flow regime dominated by sharply fluctuating runoff, high sediment loads and unstable channel. These types of systems sustain a native biotic community adapted to this harsh environment. When developments alter physical conditions (i.e., stabilize flow regimes, reduce sediment loads), the opportunity exists for native species to be replaced by detrimental, non-native species.

Energy booms also bring about rapid growth of human populations, which can have additional impacts on terrestrial, riparian and aquatic ecosystems. These "secondary effects" arise from additional housing, service industries, transportation corridors, and other infrastructure. In western Wyoming, much of the private land available for development or subdivision is located within and near riparian corridors. This pattern of land ownership is clearly evident from BLM surface status maps, and is particularly the case in areas like the upper Green River Basin. The region contains some of the most valuable and unique wetlands and riparian habitats in Wyoming, for example, the New Fork potholes and several important wetland complexes and subirrigated meadows near Cora and Merna. As additional infrastructure is constructed to accommodate support services, some of the development inevitably takes place within or near riparian corridors. Appropriate mitigation should be considered and may include acquisition of non-crucial upland sites for housing, conservation easements to protect important wetlands and riparian habitats, and mitigation projects to build or enhance replacement wetlands.

<u>Key Misconceptions about Wildlife Responses to Development</u>

1) Wildlife relocate to unaffected habitats, so there really is no impact (i..e., "they just move out of the way").

   This common assumption contradicts a fundamental axiom of population ecology and wildlife management that has been known and reconfirmed since the time of Aldo Leopold – populations of organisms increase to fill vacant, suitable habitat and are then regulated by the essential component of their habitat that is in least supply (Leopold 1933; Edwards and Fowle 1955; Smith 1966:355; Odum 1971:183). For example, availability and quality of crucial winter ranges at lower elevations generally limit productivity, recruitment and abundance of migratory big game populations in mountainous environments. Complexes of suitable breeding and brood-rearing habitats are thought to limit populations of sage-grouse. In any given environment, existing populations of wildlife occupy the habitats that are suitable. Conversely, the areas that are not suitable for one reason or another are not used. When activities associated with energy development displace animals from otherwise suitable habitats, the animals are forced to utilize marginal habitats or they relocate to unaffected habitats where the population density and competition increase. Consequences of such displacement and competition are lower survival, lower reproductive success, lower recruitment, and lower carrying capacity leading ultimately to population-level impacts.

2) Deer and pronghorn are frequently seen foraging near oil and gas facilities and even use habitats in the middle of oil fields. This indicates they become accustomed to, and are not affected by such activities.

   Individuals within any population exhibit varying tolerances to disturbances. Some animals, especially resident or non-migratory individuals, may acclimate or modify their behavior in response to repetitious, non-threatening activity such as traffic. However, other segments of the same population may remain sensitive to disturbance. The health of the overall herd depends on the ability of all population segments to effectively utilize limiting resources. Displacement away from oil and gas development is not necessarily evident if some animals remain visible near the disturbance and appear acclimated to it. Sawyer et al. (2008) found that the majority of wintering mule deer were displaced farther as development of a natural gas field progressed during the first 3 years, then displacement distance decreased (though was still significant) in a severe winter during year 4. In year 5, avoidance distance increased from year 4 and was similar to year 1. During the first 5 years of study, deer use of the developed area declined 45%, whereas the overall Sublette Herd declined only 25%(due to the hard winter of 2003-2004). By 2007, the decline remained disproportionately greater in the developed area (30%) compared to the overall herd (10%). Further, the presence of animals on disturbed sites near human activity does not mean they are not being negatively affected. Studies have documented increased physiological stress within several species exposed to varying degrees of human activity. Responses to activity may also seem less apparent as the animal reaches a state of diminished health.

Migratory behavior is an important adaptation that enables a population to benefit from seasonal abundance of forage and cover at higher elevations and milder winters at lower elevations. Migratory animals attain better physiological condition by accessing high quality forage within transitional and summer ranges, and then move to winter ranges typified by a milder climate, less snow accumulation and available browse. However, the sensitivity of migratory segments to oil and gas disturbance can reduce their effective use of winter ranges, thereby canceling the advantages of migratory behavior. Avoidance and stress responses to sources of disturbance are thoroughly documented in the literature (Refer to "References Consulted" and Appendix J).

3) Seasonal use stipulations, standard operating procedures, and reclamation practices are adequate mitigation for wildlife resources affected by oil and gas developments.

Kniola and Gil (2005) documented 84% of coalbed methane wells and facilities in NE Wyoming were out of compliance with reclamation success standards and other conditions of approval. WGFD field personnel also report noncompliance issues in western Wyoming. In addition, some BLM field offices have routinely granted exceptions to seasonal operating restrictions despite presence of animals in the area.

When they are consistently applied, seasonal use restrictions are a valuable tool for limiting disturbance to wildlife at sensitive times of year. However, seasonal restrictions are currently limited to exploration and drilling phases of oil field development. Oil and gas operations also disturb and displace wildlife throughout a production life of up to 40 years and longer. A variety of management and mitigation tools are available to minimize impacts of an operating oil or gas field (Appendices A and B) and to offset unavoidable impacts by providing replacement resources (Appendix F).

In accordance with 43 CFR 3162.5-1(a) and Section 6 of the standard federal oil and gas lease terms (Form 3100-11), "Lessee shall conduct operations in a manner that minimizes adverse impacts to the land, air, and water, and to cultural, biological, visual, and other resources, and other land uses or users. Lessee shall take reasonable measures deemed necessary by lessor to accomplish the intent of this section."

This provision gives the BLM authority to stipulate reasonable protective measures necessary to reduce or mitigate impacts to wildlife habitat and related environmental values. The current interpretation and application of standard lease terms, timing limitations, and reclamation are important mitigation during the initial development and final reclamation phases of oil and gas development. However, it is equally, if not more important to apply effective mitigation throughout the production phase, because production usually results in substantial, long-term loss of habitat functions. Mitigation has generally not been required during the production phase, as evidenced in prior NEPA documents (USDI Bureau of Land Management 1985, 1986a, 1986b, 1987, 1988a, 1988b, 1992, 1996a, 1996b, 1997, 1998, 1999, 2000, 2003a, 2004a).

In the extreme case, long-term displacement of wildlife from preferred habitats and severed migration routes could eliminate "migration memory" that required millennia to evolve. Each successive cohort of ungulates learns the locations of suitable winter habitats and migration routes from older, experienced females that lead them (Baker 1978; Mackie et al. 1998:44; and others). Extended disruptions of migration or habitat use could erase learned behavior from entire cohorts of young animals, breaking the tradition of migration to the most suitable winter habitats.

4) Adding more and cleaner water to a stream, improves it for fish.

   Hydrology and other physical properties of a stream are determined by an array of environmental factors including geology, climate, topography, land cover, and other factors (Leopold et al. 1964). The natural biotic community inhabiting a stream system is adapted to the range of conditions expressed in the system via the flow regime, water quality and physical habitats (Poff and Allan 1995). Any disturbance that causes a change or shift in the range of conditions may also produce a change in the biotic community (Bunn and Arthington 2002). Changes in hydrologic conditions, whether from increases or decreases in water supply or changes in water quality or temperature, should be evaluated based on how they will affect the existing biotic community.

Impact Thresholds

As applied in this document, "impact thresholds" are levels of development and disturbance that impair key habitat functions by directly eliminating habitat, by disrupting wildlife access to, or use of habitat, or by causing avoidance and stress. Impact thresholds, appropriate management, and mitigation will vary depending on species and habitats affected. Our most pressing need is to address the species and habitat functions affected by impending, large-scale developments in sagebrush/steppe ecosystems. In the future, we may expand this document to consider additional species, ecosystems and habitat functions.

Participating biologists from the WGFD identified impact thresholds based on the best available science (see "References Consulted" and Appendix J), and their collective field experience. Relevant studies have documented varying degrees of avoidance and stress responses to sources of noise and activity. However, any level of oil and gas development potentially creates an impact. It is legitimate to apply management practices and mitigation to reduce or offset the effects of even a single well in crucial habitat. The challenge of the Mitigation Working Group was to identify ranges of development that constitute “moderate,” “high,” and “extreme” impacts, for the purpose of recommending appropriate management and mitigation.

We based the thresholds on 2 quantitative measures – density of well pad locations and cumulative area of disturbances per square mile (see “square mile” defined on page 7). The cumulative area of disturbance represents direct loss of habitat. In addition to well pads, many other facilities and activities can affect wildlife in a typical well field, for example roads, storage tanks, equipment staging areas, compressor stations, shops, pipelines, power supplies, traffic, human presence, etc. The density of well pads provides a general index to the intensity of well field development and associated activity. Naugle et al. (2006), Walker et al. (2007a), and Naugle et al. (*In press*) concluded the density of well pads is highly correlated with other features of development and therefore comprises a suitable index representing the extent of development. The Working Group adopted this approach because it would be exceedingly difficult, based on the available literature, to factor every aspect of well field development into a comprehensive set of disturbance criteria. In some cases, thresholds based on well pad densities and cumulative acreages may under-represent the actual level of disturbance. However, the cumulative effect can be lessened by conscientiously applying management practices described in Appendices A, B, and C as appropriate. Where management practices or a particular development configuration produce less impact than the applicable threshold criterion would indicate, mitigation can be site-specifically adjusted. Such mitigation adjustments should be recommended by the APWG to the BLM after consultation with the WGFD.

<u>Threshold Classifications</u>

Wildlife species and habitats addressed by the current version of these mitigation recommendations include:

Mule Deer ……………………………….. crucial winter range
Pronghorn ……………………………….. crucial winter range
Sage-grouse …………………………… core and non-core areas
Elk ……………………………………….. crucial winter range,
      ……………………………………... parturition (calving) areas
Big Game ……………………………..….. migration corridors
Moose …………………………………. crucial winter range
Bighorn Sheep …………………………crucial winter range,
      …………………………. parturition (lambing) areas
Species of Greatest Conservation
      Need (SGCN) ……………………….important seasonal or yearlong habitats
Riparian Corridors, Wetlands,
   and Aspen Communities …………….. all
Priority watersheds ……………………. designated by the WGFD
Class 1 & 2 Streams (now termed blue
   and red ribbon fisheries) …………….. designated by the WGFD

Native Cutthroat Trout ....Core Conservation Populations and Conservation Populations

Overlapping Vital & High Value Habitats

Impact thresholds were identified based on well pad densities and acreages of disturbance that correspond to “moderate,” “high,” and “extreme” impacts to habitat effectiveness. The Commissions Mitigation Policy establishes programmatic direction for department recommendations to avoid, minimize or mitigate impacts to important wildlife habitats, as described in the definitions on pages 5-6.

Descriptions of important habitat resources and management concerns can be obtained from the WGFD SHP and the WGFD SWAP, the Wyoming Greater Sage-Grouse Conservation Plan, Nongame Bird and Mammal Plan (Oakleaf et al. 1996), and other publications, maps, databases, and GIS layers maintained by the WGFD. Detailed information from these sources includes locations of crucial winter ranges, parturition areas, migration corridors, sage-grouse leks, raptor nests, priority non-game species and habitats, species of greatest conservation need (SGCN), wetlands, priority watersheds, and other important habitats. The WGFD maps and geo-referenced data sets include big game seasonal range maps, herd unit reports, the Wildlife Observation System database, Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (Cerovski et al. 2004), priority terrestrial and aquatic habitat maps, National Wetland Inventory maps, stream/lake database, and fish link database. Explanations and maps of priority watersheds and terrestrial habitats are available on the WGFD’s website (http://gf.state.wy.us/) by selecting “habitat home.” Specific requests for other maps, inventories and data queries can be directed to (307)-777-4588 (terrestrial resources and wetland maps) and (307)-777-4559 (aquatic resources). National Wetland Inventory Maps are also available at the following web address: http://www.fws.gov/nwi/. The Department adds and updates resource information on its website as new data become available.

IMPACT THRESHOLDS, MANAGEMENT AND MITIGATION RECOMMENDATIONS – TERRESTRIAL RESOURCES

The WGFD recognizes that there may be geological limitations, lease language and surface and downhole management requirements that may constrain the full implementation of these recommendations.

All 3 levels of impact – moderate, high, and extreme –result in a loss of habitat function. To the extent reasonable, seasonal use restrictions, standard management practices in Appendix A, and appropriate habitat mitigation in Appendix F should be applied at all levels of development to avoid and minimize impacts. Development in core and non-core sage-grouse habitats should be addressed through the application of best management practices (BMPs) and stipulations found in Appendices B and C. Additional management prescriptions, compensatory/off-site mitigation or optional contributions to a mitigation account may be necessary to mitigate high and extreme impacts resulting from more intensive developments. Impact thresholds are based on well fields in both the development (drilling, construction, completion) and production phases. If monitoring data demonstrates impacts are substantially different after a field goes into production, mitigation can be adjusted.

The matrix that follows (Table 1) identifies impact thresholds and the types of management and mitigation recommended to avoid, minimize, or offset impacts to important wildlife species and habitats. The subsequent species accounts provide additional detail. The basis for management and mitigation recommendations is the higher level of impact based on the density of well pad locations or the area of disturbance per square mile. In addition to well pads, the area of disturbance includes all roads, pipelines, facilities, and other surface disturbances associated with a well field. Specific mitigation needs will be evaluated and recommended on a case-by-case basis. This evaluation should consider the availability of suitable mitigation sites, feasibility of long-term restoration, enhancement, and protection of alternative habitats, and adequacy of funding or other commitments to sustain alternative habitats throughout the life of the oil and gas field until final reclamation is established and successful.

The density of well pad locations and the area of disturbance per mi^2 are calculated as follow:

1. Outline the well field boundary (polygon) using the outside edges of the outermost disturbed areas.
2. Determine the total area (mi^2) enclosed within the well field boundary.
3. Tally the number of well pad locations* and total acres of disturbance within the well field boundary.
4. Divide each tally from No. 3 by the total area of the well field (mi^2) from No. 2.

* Well pad locations include all well pads containing production wells, injection wells, and wells being actively drilled. "Shut-in" wells that will be put into production in the future are also included. Well pad locations do not include abandoned, plugged, reclaimed and decommissioned wells, "dry" wells, or historic well sites.

The area of a lease generally will not be the basis for density and disturbance calculations unless the lease boundary outlines the well field as described above. When operations of 2 or more companies are contiguous or intermingled, all adjoining operations should be included in the density and area calculations and should be considered jointly when formulating a mitigation plan. Because impacts to the function and effectiveness of wildlife habitats extend beyond the area that is physically disturbed, mitigation should be applied as appropriate to address those impacts. Companies and the BLM should consult the WGFD to assist with identifying disturbance boundaries for wildlife impact assessments.

Table 1. Impact thresholds and summary of mitigation recommendations for terrestrial resources.

Species and Habitat Function	Category of Impact: Moderate	High	Extreme
	Impairment of habitat function becomes discernable – however the impact can be significantly reduced or eliminated through seasonal use restrictions, standard or best management practices (Appendices A and B), and/or habitat mitigation options (Appendix F). Habitat mitigation options will be implemented onsite, but offsite alternatives may be considered if they provide greater benefits.	Impairment of habitat function increases – the impact will be more difficult or at times impossible to effectively mitigate within the project area. The impact can be reduced, but probably not eliminated through seasonal use restrictions and more intensive management and mitigation practices (Appendices A, B, and F). Off-site mitigation may be necessary. This level of development is discouraged.	Habitat function is substantially impaired or lost – the impact cannot be fully mitigated within the project area, but can be partially reduced through seasonal use restrictions and intensive management and mitigation practices (Appendices A, B, and F). Off-site mitigation will be necessary. This level of development should be avoided to the extent possible.
Mule Deer Crucial Winter Ranges	1 well pad location or <20 acres disturbance per square mile [1] <u>Recommendations:</u> – seasonal use restrictions – standard management practices [2] – habitat mitigation options [3]	2-4 well pad locations or 20-60 acres disturbance per square mile [1] <u>Recommendations:</u> – seasonal use restrictions – standard management practices [2] – additional management prescriptions – habitat mitigation options[3] – habitat mitigation can be off-site, if not feasible or effective onsite, but needs to be within the same landscape planning unit in order to mitigate the impact.	>4 well pad locations or >60 acres disturbance per square mile [1] <u>Recommendations:</u> – seasonal use restrictions – standard management practices [2] – additional management prescriptions – habitat mitigation options [3] – compensatory habitat mitigation will be off-site, as necessary, but needs to be within the same landscape planning unit in order to mitigate the impact.

Table 1. (*continued*).

Species and Habitat Function	Category of Impact		
	Moderate	High	Extreme
Pronghorn Crucial Winter Ranges	1-4 well pad locations or <20 acres disturbance per square mile [1] <u>Recommendations:</u> Same management and mitigation practices described for mule deer (moderate impact)	5-16 well pad locations or 20-80 acres disturbance per square mile [1] <u>Recommendations:</u> Same management and mitigation practices described for mule deer (high impact)	>16 well pad locations or >80 acres disturbance per square mile [1] <u>Recommendations:</u> Same management and mitigation practices described for mule deer (extreme impact)
Sage-grouse Core Areas [4]	Sage-grouse core areas (Appendix D) have been officially designated by the Wyoming Game and Fish Department pursuant to Governor's Executive Order No. 2008-2 (Appendix E). The objective for core areas is to maintain existing habitat function by permitting development activities that will not cause declines in sage-grouse populations. If development does not exceed the thresholds outlined below and if applicable management practices and stipulations are applied, impacts to sage-grouse populations are presumed low and do not require additional mitigation. Threshold and mitigation specifications: 1) *Well pad densities not to exceed an average of 1 pad per square* ***mile (640 acres).*** *The number of well pads within a 2 mile radius of the perimeter of an occupied sage-grouse lek should not exceed 11,* ***distributed preferably in a clumped pattern in one general direction from the lek.*** 2) Surface disturbance limited to <5% of sagebrush habitat per 640 acres. 3) No surface occupancy (NSO) within 0.6 mi of the perimeter of occupied sage-grouse leks (Carr 1967; Wallestad and Schladweiler 1974, Rothenmaier 1979, Emmons 1980, and Schoenberg 1982 as analyzed by Colorado Greater Sage-grouse Conservation Plan Steering Committee 2008). 4) Standard management practices (Appendix A) and appropriate best management practices (Appendix B) applied. 5) Stipulations for core areas applied (Appendix C). 6) Allowance for somewhat higher well pad densities and surface disturbance may be considered on a case-by-case basis when the impact can be controlled through site selection, clustered configurations, and other design considerations.		

Wyoming is pursuing a statewide strategy to conserve sage-grouse populations in cooperation with the U.S. Fish and Wildlife Service and other federal and state agencies. Called the "Greater Sage-grouse Core Area Strategy, the objective is to protect regional and statewide populations by limiting development in core areas encompassing 82% of the State's sage-grouse population. The intent is to allow greater flexibility for development in non-core areas so long as connectivity between core areas is maintained. The oil and gas recommendations identify thresholds of development resulting in "medium," "high" and "extreme" impacts to <u>individually affected leks in both core and non-core areas</u>. However, these site-specific thresholds are not to be confused with NEPA criteria for determining if an action has significant impacts triggering preparation of an EA or EIS [40 CFR 1502.3; 40 CFR 1508.27]. The core area strategy accepts "high" or "extreme" impacts may result in loss of some leks and population declines in non-core habitat, but this is not significant to regional and statewide sage-grouse populations [in the NEPA sense] if the habitat required to sustain those populations is maintained in core areas with adequate connectivity provided in non-core areas.

Bullet number six of the Governor's Executive Order # 2008-2 states the following about non-core area management. "Incentives to enable development of all types outside Core Population Areas should be established (these should include stipulation waivers, enhanced permitting processes, density bonuses and other incentives). However, such development scenarios should be designed and managed to maintain populations, habitats and essential migration routes outside Core Population Areas."

Planning and management of development in non-core habitat will require early coordination between the developer, the permitting agency and WGFD to determine how to maintain populations, habitats and essential migration routes.

Table 1. (*continued*).

Species and Habitat Function	Category of Impact		
	Moderate	High	Extreme
Sage-grouse Non-core Areas	No surface occupancy (NSO) within 0.25 mile of the perimeter of each lek. Thresholds and mitigation apply to all development within 2 miles of a lek, and within identified nesting/brood-rearing habitats > 2 miles from a lek. In addition, seasonal use restrictions should apply to leks at all impact thresholds.		
	>1&<2 well pad locations or <20 acres disturbance per square mile [1] <u>Recommendations:</u> Same management and mitigation practices described for mule deer (moderate impact) plus Sage-grouse BMPs [5]	2-3 well pad locations or 20-60 acres disturbance per square mile [1] <u>Recommendations:</u> Same management and mitigation practices described for mule deer (high impact) plus Sage-grouse BMPs [5]	>3 well pad locations or >60 acres disturbance per square mile [1] <u>Recommendations:</u> Same management and mitigation practices described for mule deer (extreme impact) plus Sage-grouse BMPs [5]. Avoid this level of Development to the extent possible.
Sage-grouse Winter Concentration Areas	To the extent practicable, avoid locating wells, roads, or other facilities within identified winter concentration areas (USDI/BLM 2004c). Avoid all activities and disturbance from 15 November through 14 March. Impact thresholds, management and mitigation practices are the same as described for non-core areas.		
Columbian Sharp-tailed Grouse Habitat	Best management practices are adopted from: "Actions to Minimize Adverse Impacts to Wildlife Resources" (Colorado Division of Wildlife draft dated August 18, 2008). Refer to section in text.		

Table 1. (*continued*)

<table>
<tr><th rowspan="2">Species and Habitat Function</th><th colspan="3">Category of Impact</th></tr>
<tr><th>Moderate</th><th>High</th><th>Extreme</th></tr>
<tr><td>Elk Crucial Winter Ranges and Parturition Areas</td><td>N/A</td><td>1-4 well pad locations or up to 60 acres of disturbance per square mile [1]

<u>Recommendations:</u>
Same management and mitigation practices described for mule deer (high impact)</td><td>>4 well pad locations or >60 acres of disturbance per square mile [1]
<u>Recommendations:</u>
Same management and mitigation practices described for mule deer (extreme impact)</td></tr>
<tr><td rowspan="2">Moose Crucial Winter Ranges</td><td>1-4 well pad locations or <20 acres disturbance per square mile [1]

<u>Recommendations:</u>
Same management and mitigation practices described for mule deer (moderate impact)</td><td>5-16 well pad locations or 20-80 acres disturbance per square mile [1]

<u>Recommendations:</u>
Same management and mitigation practices described for mule deer (high impact)</td><td>>16 well pad locations or >80 acres disturbance per square mile [1]

<u>Recommendations:</u>
Same management and mitigation practices described for mule deer (extreme impact)</td></tr>
<tr><td colspan="3">– Plow gaps in high snow embankments on both sides of plowed well field roads every quarter mile.
– No surface occupancy within riparian corridors or a 500-foot buffer.</td></tr>
<tr><td>Bighorn Sheep Crucial Winter Ranges and Lambing Areas</td><td colspan="3">No disturbance (No Surface Occupancy) within crucial winter ranges or lambing areas</td></tr>
<tr><td>Big Game Migration Corridors</td><td colspan="3">No surface occupancy (NSO) within migration corridors or bottlenecks less than 0.5 mi wide, avoid further constrictions of broader corridors</td></tr>
</table>

Table 1. (*continued*)

Species and Habitat Function	Category of Impact		
	Moderate	High	Extreme
Species of Greatest Conservation Need (SGCN) (WGFD 2005 – Appendix H).	Consult species distribution maps and conservation actions for SGCN (available from the WGFD public website). Locations within overlapping ranges of multiple SGCN are generally the highest priority. Consult WGFD to assess levels of impact and appropriate mitigation, which will be site-specific and species-specific. Generally, the following thresholds, management practices and additional management prescriptions will apply except where otherwise specified in this document and through the consultation process.		
	1-4 well pad locations or <20 acres of disturbance per square mile [1] <u>Recommendations:</u> – standard management practices [2] – habitat mitigation options [3]	5-16 well pad locations or 20-80 acres of disturbance per square mile [1] <u>Recommendations:</u> – standard management practices [2] – habitat mitigation options [3] – consult WGFD Non-game Section for additional management prescriptions and habitat treatments	>16 well pad locations or >80 acres of disturbance per square mile [1] <u>Recommendations:</u> – standard management practices [2] – habitat mitigation options [3] – consult WGFD Non-game Section for additional management prescriptions and habitat treatments
T&E Species	Protective measures are identified through Section 7 Consultation with the USFWS		
Riparian Corridors and Wetlands	– No surface occupancy within riparian corridors and a 500-foot buffer from the transition between riparian and upland habitat. – No surface occupancy within a wetland and a 500-foot buffer from the wetland margin. – Avoid or mitigate impacts of other growth-related developments by acquiring conservation easements to protect important wetlands and riparian corridors and by completing wetland/riparian mitigation projects.		

Table 1. (continued)

Species and Habitat Function	Category of Impact		
	Moderate	High	Extreme
Overlapping Vital or High Value Habitats	– Apply impact thresholds and management/mitigation practices that address the impact to each species without causing significant, adverse effects to other species. – As necessary, impact assessments and recommended mitigation are additive to address all species' needs.		
Aquatic Resources	Refer to Aquatic Section (Page 38)		

[1] Based on a relatively even geographic distribution of well pad locations or disturbed areas in a square mile. Appropriate allowances will be made for clustered configurations or directional drilling on a case-by-case basis.
[2] Consult Appendix A
[3] Consult Appendix F
[4] Consult Appendices B, C
[5] Consult Appendix B

Note: The well pad densities described in this section identify various thresholds of impact to wildlife and are not based on classification systems used by the Wyoming Oil and Gas Conservation Commission (WOGCC) or other entities.

MULE DEER – crucial winter range

During winter, mule deer exhibited an alert/flight response to disturbances associated with noise and activity up to 0.29 mi from the source (Freddy 1996). A density of 4 evenly spaced well pads per section would place over 90% of surfaces within 0.29 mi. of a well pad. More definitive research by Sawyer et al. (2008) during the first 5 years of natural gas development on the Pinedale Anticline documented that areas within 1.6 miles of well pads received significantly less deer use and were classified as low or moderate use areas. These observed use patterns in relation to well pads, in combination with observed deer preference for various slope, aspect, elevation, and road density variables, were used to predict overall deer use patterns across the entire study area during winter. The amount of predicted deer avoidance generally increased with a decreased distance to well pads. The study predicted that deer use would be half the normal deer use within an average distance of 1.2 miles from well pads. Based on unpublished GPS observations from Sawyer's study, average deer use was 31% higher than expected (due to displacement) on sections with no well pads (n = 154 sections), 13% lower than expected on sections with 1 well pad (n = 45 sections), and 25% lower than expected on sections with 2 well pads (n = 21 sections). This much simpler analysis was based on an assumption that expected deer distribution was random and not influenced by environmental variables other than oil and gas development. Insufficient samples of sections with pad densities exceeding 2 per mi^2 were available for reliable interpretation. By year 7 of the study, overall deer use of the development area was 30% lower than the level of use documented pre-development, whereas the entire Sublette Deer Herd was 10% lower. From this information, we concluded a density of 1 well pad per square mile causes a moderate impact and a density of 2-4 well pads per square mile causes a high impact. The impact is considered extreme when densities exceed 4 well pads per square mile.

Liquid gathering systems (LGS) and directional drilling are effective best management practices for reducing human activity and surface disturbance during development. Sawyer et. al. (2008) reported indirect habitat loss to mule deer may be reduced approximately 38-60% when liquids are collected in pipelines rather than stored at well pads and hauled off with tanker trucks.

Winter drilling (November 15 – April 30) may become increasingly common under present energy policy. Sawyer et. al. (2008) cautioned wintering mule deer are sensitive to this type of disturbance and indirect habitat loss may increase by a factor of >3 when seasonal restrictions are waived. Wildlife managers should expect considerable short-term displacement of wintering mule deer if year-round drilling is permitted in crucial winter range. However, year-round drilling can be an acceptable tradeoff if the disturbance footprint is limited to 1 well pad/mi^2 (through directional drilling technologies) and if winter drilling operations are confined to a small portion of the crucial winter range complex at any given time. All proposals for year-round drilling should be reviewed by the WGFD and APWG. Final recommendations will be based on the location and sensitivity of the area proposed for drilling, other disturbance factors affecting deer use of the winter range, and conservation benefits realized by significantly reducing well pad densities and shortening the length of time required to complete the drilling phase.

moderate impact: 1 well pad location or up to 20 acres of disturbance per square mile. Habitat becomes less effective within zones surrounding each well, facility, road corridor, persons afoot, and vehicular and equipment activity. Appropriate management practices and habitat treatments can be applied to mitigate impacts. The WGFD recommends well field developments not exceed 1 well pad location per square mile within mule deer crucial winter ranges because it is unlikely habitat effectiveness can be maintained at higher densities (based on reviews of Sawyer et al. 2005, 2006, 2008). The following management and mitigation practices should be required for well field developments of 1 well pad location, and up to 20 acres of disturbance per square mile:

– Apply standard seasonal use restrictions for big game (standard drilling stipulations). No development on crucial winter ranges from 15 November through 30 April. To the extent practicable, minimize disturbances and activities within producing well fields during the same timeframe. If the drilling operation and related activity are confined to a small portion of the crucial winter range complex at any given time and the approved field development plan limits the well pad density to $1/mi^2$ at full field development, winter seasonal stipulations may be waived by the BLM after consultation with the WGFD and APWG (refer to previous discussion).

- Include provisions in subcontractor agreements requiring adherence to the same seasonal use restrictions observed in company operations.
- Apply standard mitigation practices described in Appendix A, as practicable.
- Design and implement habitat treatments sufficient to maintain habitat functions on-site. In cases where offsite mitigation would provide greater benefits than onsite mitigation, the offsite mitigation should be located within the same landscape unit. Habitat treatments should include appropriate options from Appendix F, selected through consultation with the WY Game & Fish Department and the Activity Plan Working Group (APWG). Mitigation should be planned to offset the loss of habitat effectiveness throughout the areas directly and indirectly affected by each well or well field development. Management practices identified in Appendix A may reduce the extent of habitat treatments needed to offset or mitigate the effect.
- <u>Mitigation Trust Account Option</u>. This voluntary option should be considered only when it is not possible to avoid, minimize, or effectively mitigate impacts through other means. If recommended by the APWG and approved by the BLM, the operator may contribute funding to a mitigation trust account based on the estimated cost of habitat treatments or other mitigation needed to restore the functions and effectiveness of impacted habitats. However, the preferred approach is for the operator to fund and implement successful habitat treatments after consultation with BLM and WGFD, and under the BLM's direction and oversight. The operator can retain a subcontractor who specializes in mitigation and reclamation. The acreage basis for mitigation will be the amount of surface that is directly disturbed plus the additional area on which habitat functions are impaired by noise, activities and other disturbance effects. Seasonal stipulations, standard management practices and additional management prescriptions should still be applied and will be considered when determining how many acres of habitat are functionally impaired within a well field. Mitigation recommendations may be refined and possibly standardized as habitat treatments are implemented and their effectiveness monitored.

  The area of land needed to mitigate an impact will depend on the types of treatments applied, the expected improvement to the functional capacity of the land, and the effectiveness of impact abatement (management) practices being applied within the project area. There is no set or standard mitigation ratio. If 100% of the habitat function is lost on an acre of land, then enough land needs to be treated such that the expected increment of improvement multiplied by the number of acres treated equals the acre-equivalent of habitat function lost.

  For example, if browse production can be increased 20% by fertilizing an existing crucial winter range, the functional improvement on each treated acre is equivalent to an additional 0.2 acres of untreated browse (i.e., 0.2 acres of the browse that was impacted). Accordingly, 5 acres would need to be treated for every acre that is impacted or functionally impaired, to replace the browse that was lost. This treatment would be repeated as necessary to offset the loss of forage throughout the life of the disturbance.

<u>high impact</u>: 2-4 well pad locations per square mile or 20-60 acres of disturbance per square mile. At this range of development, impacted zones surrounding each well pad, facility and road corridor begin to overlap and habitat effectiveness is reduced over a much larger, contiguous area. Human, equipment and vehicular activity, noise and dust become much more frequent and intensive. It may not be possible to fully mitigate the impacts by applying management practices and habitat treatments onsite. Management practices described in Appendix A can reduce impacts somewhat and a few opportunities may exist to develop habitat treatments within the well field or lease area. However habitat treatments will generally be located in areas near, rather than within well fields to maintain the function and effectiveness of crucial winter ranges. The WGFD strongly discourages this level of development within mule deer crucial winter range. If densities of 2-4 well pad location per square mile (or disturbance of 20-60 acres) cannot be avoided, the following management practices and additional management prescriptions should be required:

– Apply standard seasonal use restrictions for big game (standard drilling stipulations). No development on crucial winter ranges from 15 November through 30 April. To the extent practicable, minimize disturbances and activities within producing well fields during the same timeframe.
– Include provisions in subcontractor agreements requiring adherence to the seasonal use restrictions observed in company operations.
– Apply standard management practices described in Appendix A, as practicable.
– Additional management prescriptions:
    - <u>directional drilling and unitized development</u>. To the extent technologically practicable, develop multiple wells from single pads by employing directional or horizontal drilling technologies. The highest management priority within crucial winter range is to recover oil and gas resources with the least possible infrastructure and associated disturbance. Directional drilling is an extremely important tool to accomplish this. Where several companies hold smaller, intermingled leases, the cumulative impact could be reduced substantially if the companies enter a cooperative agreement (called unitization) to directional drill from common well pads.
    - <u>clustered development configurations</u>. To the extent technologically practicable, locate well pads, facilities and roads in clustered configurations within the least sensitive habitats. The WGFD and APWG will identify the least sensitive locations for positioning clusters of facilities. Clustered configurations are a geographical and not necessarily a temporal (i.e., "phased development") consideration.
    - <u>removal of liquids</u>. Disturbances to wildlife can be lessened substantially by piping rather than trucking liquids offsite, or by enlarging storage tank capacity to minimize truck trips and eliminate trips during sensitive times of year. This recommendation generally applies to crucial winter ranges on which more than 1 truck trip per month is necessary to remove liquids. (By comparison, the WGFD prohibits all public entry on State Wildlife Management Areas that function as big game winter habitats throughout the winter period). If the potential for production of liquids is unknown, but exceeds 1 truck trip per month after production begins, consider retrofitting the field with pipelines or larger storage

tanks as needed. Each truck trip and activity associated with pumping has the potential to displace animals from suitable winter habitat for up to several days. If subsequent monitoring establishes that animals are tolerant to this type of disturbance, more frequent trips may be justifiable.

- remote instrument monitoring. To the extent technologically feasible, install telemetry to remotely monitor instrumentation and reduce or eliminate travel required to manually inspect and read instruments.
- travel plan. Develop a travel plan that minimizes frequency of trips on well field roads. Include provisions in subcontractor agreements requiring adherence to the same travel plan provisions observed in company operations.
- roads. As appropriate, gate and close newly constructed roads to public travel during sensitive times of year. The purpose of these roads is to access and maintain well sites, not to provide additional public travel routes. In addition, USDI/USDA Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (USDI/USDA 2006) no longer require roads must be constructed to meet public traffic safety standards, further supporting the closure to public access. (Preexisting BLM and USFS roads and trails should remain open if they were designated as open in the surface management agency's approved travel management plan).
- environmental monitoring. Implement an adequate wildlife monitoring program to detect and evaluate ongoing effects such as mortalities, avoidance responses, distribution shifts, habituation, evidence of movement/migration barriers, and depressed productivity (e.g., low fawn ratios), and to assess the effectiveness of mitigation. Monitor vegetation utilization within and outside the well field. Each company or consultant representing the company should annually prepare a wildlife monitoring report for review by the APWG, WGFD, and BLM. Companies may agree to conduct or fund monitoring and environmental studies as one component of an integrated mitigation program, but BLM should also commit adequate budget and staff to complete and evaluate the necessary monitoring. In some cases, monitoring can demonstrate a previously identified concern is no longer warranted. For example, company-sponsored monitoring established mountain plovers are more abundant and less sensitive to disturbance than previously thought (USDI/BLM 2004d).

– Habitat Treatments. Design and implement land or vegetation treatments sufficient to maintain habitat functions within or immediately adjacent to the well field. These habitat treatments should include options from Appendix F that are appropriate for "high impact," as recommended by the APWG and approved by the surface management agency. Management practices in Appendix A may reduce the impact and extent of habitat treatments needed to accomplish mitigation. Effectiveness of management practices will be evaluated by the APWG after considering analysis and recommendations by the WGFD.

– Off-Site and Off-Lease Mitigation. If it is not possible to maintain habitat functions within or immediately adjacent to the well field, off-site and off-lease mitigation is a voluntary option that should be considered on a case-by-case basis. The primary emphasis of off-site or off-lease mitigation is to maintain habitat functions for the affected population or herd as close to the impacted site as possible and within the same landscape unit. Off-site and off-lease mitigation should only be considered when feasible mitigation options are not available within or immediately adjacent to the impacted area, or when the off-site or off-lease location would provide more effective mitigation than can be achieved on-site. This determination will be made by the APWG after considering analysis and recommendations from the WGFD.

– Mitigation Trust Account Option. This voluntary option should be considered only when it is not possible to avoid, minimize, or effectively mitigate impacts through other means. If recommended by the APWG and approved by the BLM, the operator may contribute funding to a mitigation trust account based on the estimated cost of habitat treatments or other mitigation needed to restore the functions of impacted habitats (refer to previous discussion). As the densities of wells and roads increase, activity levels also increase and zones of impact surrounding oil field facilities begin to overlap. Accordingly, the acreage basis for mitigation or trust account funding will generally be larger than the area that is physically disturbed. If the trust fund option is selected, standard management practices in Appendix A, "additional" management prescriptions, and seasonal use stipulations should still be applied to the extent practicable:

extreme impact: >4 well pad locations or >60 acres of disturbance per square mile. Commission Mitigation Policy does not provide a viable alternative to address this level of development within "vital habitat" (no loss of habitat function is recommended). The function and effectiveness of crucial winter habitat will be severely compromised. Long-term consequences include continued fragmentation and disintegration of the winter range complex leading to decreased survival, productivity and ultimately, loss of carrying capacity for the herd. This will result in a loss of ecological functions, recreation opportunity, and associated income to the State 's economy. An added consequence may include permanent loss of migration memory from large segments of unique, migratory big game herds in Wyoming. If densities exceeding 4 well pad locations per square mile (or disturbance exceeding 60 acres) absolutely cannot be avoided, the following mitigation practices, in addition to all management practices and prescriptions applicable to "high impact," are recommended to retain as much effective habitat as possible.

– Phased Development. Developing a well field in smaller incremental phases (phased development) can reduce the overall impact of a high-density field. Although complex geological, technical, and regulatory issues may constrain the use of this strategy, we encourage its consideration where feasible.

– Offsite Mitigation. Opportunities may exist to partially offset the loss of crucial winter range by completing habitat rehabilitation and enhancement projects in appropriate locations outside the well field. This type of mitigation is difficult and expensive to implement successfully, and should never be looked upon as a prescriptive solution to authorize high-density well fields in crucial winter range. The most effective solution is to avoid high-density developments. If avoidance is not feasible, plan effective habitat treatments in locations selected to minimize the loss of habitat function for the affected herd or population, within the same landscape unit.

– Acreage Basis for Mitigation. Effective habitat is essentially lost within high-density well fields, so the area of the well field will generally serve as the acreage basis for mitigation. However, this acreage basis can be reduced by implementing appropriate seasonal use restrictions, standard management practices, and additional management prescriptions described for "high impact."

– Mitigation Trust Account Option. This voluntary option should be considered only when it is not possible to avoid, minimize, or effectively mitigate impacts through other means. Refer to discussion under "high impact."

PRONGHORN – crucial winter range

Researchers have reported avoidance distances varying from 0.25 mi (Autenrieth 1983) to 0.6 mi (Easterly et al. 1991) from sources of disturbance. Based on a radio-telemetry study in the Pinedale Anticline of Western Wyoming, Berger et al. (2006) determined pronghorn avoided denser well fields associated with significant activity. Pronghorn consistently avoided areas within 100 m of natural gas well pads. During winter 2006-07, pronghorn movement patterns also indicated reduced use of the developed areas, although evidence of local or regional population effects has not yet been detected (Berger et al. 2008). These findings tend to support the higher disturbance thresholds prescribed in the earlier version of these recommendations. Standard management practices, additional management prescriptions, and seasonal use stipulations are the same as described in the corresponding impact categories for mule deer.

moderate impact: 1-4 well pad locations or up to 20 acres of disturbance per square mile.

The WGFD recommends well field developments not exceed 4 well pad locations per square mile within pronghorn crucial winter ranges, because it is unlikely habitat effectiveness can be maintained at higher densities.

– Follow recommendations described under: "Mule Deer – moderate impact."

high impact: 5-16 well pad locations per square mile or 20-80 acres of disturbance per square mile.

– Follow recommendations described under: "Mule Deer – high impact."

extreme impact: >16 well pad locations or >80 acres of disturbance per square mile.

– Follow recommendations described under: "Mule Deer – extreme impact."

SAGE-GROUSE

– special considerations in heavily impacted areas
– core areas
– non-core areas

Standard stipulations traditionally applied by the BLM have helped reduce impacts of oil and gas development during the exploration and drilling phase. However, additional planning, mitigation and management considerations are essential to conserve populations of greater sage-grouse as energy development and production intensify across the landscape (Holloran 2005; Walker et al. 2007a; Doherty et al. 2008; Naugle et al. *In press*).

Special Considerations for Development in Heavily Impacted Areas:

A number of sage-grouse populations occupy ranges that are heavily impacted by past and ongoing developments and land uses. Habitat treatments may not be an effective option to offset additional impacts of oil and gas developments within these areas. Treatments such as prescribed fire or herbicide applications could further reduce and fragment the remaining suitable habitat for 15 years or longer. If ≥40% of nesting, early brood-rearing, or winter habitat has been lost or severely degraded within the range of a population, the management emphasis is to protect the remaining sagebrush that continues to support these functions (Connelly et al. 2000). Oil and gas developments within fragmented sage-grouse habitats should be planned to avoid impacting the remaining habitats. On the other hand, treating up to 20% of degraded nesting and early brood-rearing habitats, and up to 20% of the winter habitat may be acceptable to improve habitat conditions within comparatively intact sagebrush ecosystems (e.g., restore herbaceous understory, thin dense sagebrush canopies exceeding 30% cover, create small openings and patches of herbaceous vegetation within dense sagebrush, rejuvenate the shrub component by setting back succession, or enhance herbaceous understory by reducing herbivory). Managers should take into account the existing condition of sagebrush, and the current and anticipated impact of all land uses when planning habitat treatments. At some point, vegetation treatments become detrimental because the interim loss of habitat from the treatment, combined with the habitat loss being mitigated, may further threaten the local sage-grouse population. Similar cautions also apply within crucial winter ranges used by some big game herds. Consult Bohne et al. (2007) and Wyoming Interagency Vegetation Committee (2002) when planning habitat treatments within occupied sage-grouse habitats in Wyoming.

Core Areas (refer to map in Appendix D):

On 1 August, 2008 Governor Freudenthal signed Executive Order 2008-2 entitled, "Greater Sage-grouse Core Area Protection" (Appendix E). The recommendations in the Executive Order originated from work done by the "Sage-grouse Implementation Team." The Implementation Team was organized following the Governor's Sage-grouse Summit held during June, 2007 in Casper. Participants included the State of Wyoming, U.S. Department of the Interior, and Assistant Secretary for Land and Minerals Management, Steve Allred.

We have modified "Recommendations for Development of Oil and Gas Resources within Crucial and Important Wildlife Habitats" to be consistent with the Governor's Executive Order. The goal of the Executive Order is to maintain existing habitat conditions within core areas by permitting only development activities that will not cause declines in sage-grouse populations. *As a matter of general practice, this will be achieved by establishing a 0.6-mi. NSO around each occupied lek,* ***limiting well pad densities to an average of 1 per square mile within core area,*** *and implementing appropriate management practices. The number of well pads within a 2 mile radius of the* *perimeter of an occupied sage-grouse lek should not exceed 11,* ***distributed preferably in a clumped pattern in one general direction from the lek.*** *(Appendices B, and C).*

Development scenarios in non-core areas are more flexible, but should still be designed and managed to maintain populations, habitats and essential migration routes. Non-core areas should not be construed as “sacrifice areas” since this conservation strategy requires habitat connectivity and movement between populations in core areas. The goal in non-core areas is to maintain habitat conditions that will sustain at least a 50% probability of lek persistence over the long term. In some “non-core” locations, important habitat functions of other wildlife species will guide planning and mitigation considerations. Applicable standard management practices (Appendix A) and sage-grouse BMPs (Appendix B) should be applied to development within both core and non-core areas to achieve the goals of the Executive Order.

Executive Order 2008-2 sets forth the following 12 provisions for management of oil and gas resources within core and non-core areas:

1. Management by state agencies should, to the greatest extent possible, focus on the maintenance and enhancement of those Greater Sage-Grouse habitats and populations within the Core Population Areas identified by the Sage-grouse Implementation Team and modified through additional habitat and population mapping efforts.
2. Current management and existing land uses within Core Population Areas should be recognized and respected by state agencies.
3. New development or land uses within Core Population Areas should be authorized or conducted only when it can be demonstrated by the state agency that the activity will not cause declines in Greater Sage-Grouse populations.
4. Funding, assurances (including state-conducted efforts to develop Candidate Conservation Agreements and Candidate Conservation Agreements with Assurances), habitat enhancement, reclamation efforts, mapping and other associated proactive efforts to assure viability of Greater Sage-Grouse in Wyoming should be focused and prioritized to take place in Core Population Areas.
5. State agencies should use a non-regulatory approach to influence management alternatives within Core Population Areas, to the greatest extent possible. Management alternatives should reflect unique localized conditions, including soils, vegetation, development type, climate and other local realities.
6. Incentives to enable development of all types outside Core Population Areas should be established (these should include stipulation waivers, enhanced permitting processes, density bonuses, and other incentives). However, such development scenarios should be designed and managed to maintain populations, habitats and essential migration routes outside Core Population Areas.
7. Incentives to accelerate or enhance required reclamation in habitats adjacent to Core Population Areas should be developed, including but not limited to stipulation waivers, funding for enhanced reclamation, and other strategies.
8. Existing rights should be recognized and respected.

9. On-the-ground enhancements, monitoring, and ongoing planning relative to sage-grouse and sage-grouse habitat should be facilitated by sage-grouse local working groups whenever possible.
10. Fire suppression efforts in Core Population Areas should be emphasized, recognizing that other local, regional, and national suppression priorities may take precedent. However, public and firefighter safety remains the number one priority on all wildfires.
11. State agencies work collaboratively with the U.S. Fish and Wildlife Service, Bureau of Land Management, U.S. Forest Service, and other federal agencies to ensure, to the greatest extent possible, a uniform and consistent application of this Executive Order to maintain and enhance Greater Sage-Grouse habitats and populations.
12. State agencies shall work collaboratively with local governments and private landowners to maintain and enhance Greater Sage-Grouse habitats and populations in a manner consistent with this Executive Order.

<u>Non-core Areas</u>:

The objective in non-core areas is to maintain at least 50% probability of lek persistence. This can be realized with developments of <3 well pads per square mile, provided an NSO buffer of 0.25 mi is established around the perimeter of a lek (Walker 2008) and appropriate management practices (Appendices A, B) are implemented. Somewhat higher densities of well pads may yield a similar probability of lek persistence if the pads and other infrastructure are arranged in clustered configurations in less sensitive areas. The following impact thresholds outline planning and mitigation considerations that should be implemented as practicable to minimize impacts of well field development within non-core areas:

<u>moderate impact</u>: >1&<2 well pad locations or up to 20 acres of disturbance per square mile within 2 miles of an occupied lek.

Justification: Connelly et al. (2000) recommended locating all energy related facilities at least 2 miles from active leks whenever possible. Holloran (2005:57) suggested reducing well pad densities to 1 per square mile or less within 2 miles of a lek in order to reduce impacts. [Holloran (2005:50) detected a negative influence on male lek attendance when densities exceeded 1 well pad per 700 acres (1.1 mi^2) within 2 miles]. Naugle et al. (2006a) determined the average well pad spacing (coalbed methane) within 2 miles of the leks that remained active was less than 1 per 774 acres (1.2 mi^2). Doherty (2008) determined impacts on lek activity and male attendance were not discernable in areas with ≤1 well pad per square mile within 2 miles. However, the rate of lek inactivity doubled when well pad densities were >1 and up to 3/mi^2. Rates of lek inactivity increased to >5-fold at densities exceeding 3/mi^2. Walker (2008) determined 84% of leks active in 1997 or later remained active in 2004-05 outside areas affected by coal-bed natural gas (CBNG) development in the Powder River Basin. Walker (2008:16) classified the area within 350 m of each well pad as “developed.” Walker’s statistical analysis then related the percent of “developed” surface to the probability of lek persistence within natural gas fields. Walker’s analysis demonstrated the impact extends beyond the 350m zone he considered "developed." When 15% of the area within 2 miles of a lek was "developed," the probability of lek persistence declined to 74%. (The area within 350m of a well pad is 15% of a square mile, thus 15% disturbance equates to 1 well pad /mi^2). When 30% of the area (2 well pads/mi^2) was "developed," the probability of lek persistence declined to 59%.

To avoid high levels of impact, the WGFD recommends limiting well field developments to less than 2 well pad locations per square mile within 2 miles of occupied leks, and within identified nesting and brood-rearing habitats outside the 2-mile perimeter, because habitat effectiveness declines significantly as densities reach 2 pads/mi^2. Habitat effectiveness is reduced within zones surrounding each well, facility, and road corridor, and disturbances created by persons afoot and vehicular and equipment activity (Holloran 2005; Naugle et al. *In press*). The impacts can be controlled and mitigated by applying appropriate management practices and habitat treatments. For well field developments of less than 2 well pad location or 20 acres of disturbance per square mile, the following management and mitigation practices should be required:

- Standard Management Practices / Best Management Practices. Apply standard management practices and BMPs described in Appendices A and B, respectively.
- No Surface Occupancy. Avoid surface disturbance or occupancy within 0.25 mi of the perimeter of occupied sage-grouse leks (Walker 2008). An occupied lek is a lek that has been active (attendance documented) at least 1 breeding season within the most recent 10-year period.
- Seasonal Use Limitations. Apply seasonal use limitations described in Appendices B and C. To the extent practicable, limit disturbances and activities within producing well fields during the same timeframes observed for exploration and drilling (15 March through 30 June).
- Habitat Mitigation. Implement habitat treatments sufficient to maintain habitat functions within or immediately adjacent to the well field. Habitat treatments should include appropriate options selected from Appendix F after consultation with the WGFD. Standard management practices described in Appendix A and BMPs from Appendix B may reduce the acreage basis for habitat treatments needed to mitigate the effect, as determined through consultation with the BLM, WGFD and the APWG.
- Mitigation Trust Account Option. This voluntary option should be considered only when it is not possible to avoid, minimize, or effectively mitigate impacts through other means. If recommended by the APWG and approved by the BLM, the operator may contribute funding to a mitigation trust account, based on the estimated cost of habitat treatments or other mitigation needed to maintain the functions of impacted habitats. However, the preferred approach is for the operator to fund and implement successful habitat treatments after consultation with BLM and WGFD, and under the BLM's direction and oversight. The operator can retain a subcontractor who specializes in mitigation and reclamation. Refer to the corresponding discussion for mule deer crucial winter ranges.

high impact: 2-3 well pad locations or 20-60 acres of disturbance per square mile within 2 miles of an occupied lek. The probability of lek persistence declined to 42% when 45% of the area within 2 miles of the lek (equating to 3 well pads/mi^2) was developed (Walker 2008). Based on recent research, the impacts of well pads and road systems at this density will be difficult or impossible to mitigate onsite. Decreases in lek attendance, nesting, production, and survival are expected (Holloran 2005; Kaiser 2006; Doherty 2008; Walker 2008; Naugle et al. *In press*). Walker et al. (2007a) determined the average well spacing (coalbed methane) within 2 miles of leks that had become inactive was between 2 and 3 wells per square mile.

At this range of development, impacted zones surrounding each well pad, facility and road corridor begin to overlap, thereby reducing habitat effectiveness over a much larger, contiguous area. Human, equipment and vehicular activity and noise impacts are more frequent and intensive. A few opportunities may exist to develop habitat treatments within the well field. However habitat treatments must generally be located in areas near, rather than within well fields to maintain the function and effectiveness of nesting and early brood rearing habitats. Regardless, this level of development will reduce the effectiveness of nesting and early brood-rearing habitats and will be much more difficult to mitigate. At the higher range of well densities, on-site mitigation may not be possible (Holloran 2005; Naugle et al. *In press*). The WGFD strongly discourages this level of well field development within 2 miles of a sage-grouse lek or within identified nesting and early brood rearing habitat outside the 2 mile perimeter. If densities in the range of 2-3 well pad locations or disturbances totaling 20-60 acres per square mile cannot be avoided, the following management practices and additional management prescriptions should be required:

– Standard Management Practices / Best Management Practices. Apply standard management practices and BMPs described in Appendices A and B, respectively.
– No Surface Occupancy. Avoid surface disturbance or occupancy within 0.25 mi of the perimeter of occupied sage-grouse leks (refer to discussion under “moderate impact”).
– Seasonal Use Limitations. Apply seasonal use limitations described in Appendices B and C. To the extent practicable, limit disturbances and activities within producing well fields during the same timeframes observed for exploration and drilling (15 March through 30 June).
– Additional Management Prescriptions. Refer to the additional management prescriptions described under: Mule Deer – “high impact.”
– Habitat Mitigation. Design and implement habitat treatments sufficient to maintain habitat functions within or immediately adjacent to the well field. Habitat treatments should include appropriate options from Appendix F as recommended by the APWG and approved by the surface management agency. Effective application of standard management practices in Appendix A and BMPs from Appendix B may reduce the acreage basis for determining habitat treatments needed to mitigate the residual effect. The effectiveness of management practices will be evaluated by the APWG after considering analysis and recommendations from WGFD.
– Off-Site and Off-Lease Mitigation. If it is not possible to maintain habitat functions within or immediately adjacent to the well field, off-site and off-lease mitigation is an option that may be considered on a case-by-case basis. The primary emphasis of off-site or off-lease mitigation is to maintain habitat functions for the affected population of sage-grouse as close to the impacted site as possible and within the same landscape unit. Off-site and off-lease mitigation should only be considered when feasible mitigation options are not available within and immediately adjacent to the impacted

site, or when the off-site or off-lease location would provide more effective mitigation than can be achieved on-site. This determination will be made by APWG after considering analysis and recommendations from the WGFD.

– Mitigation Trust Account Option. This voluntary option should be considered only when it is not possible to avoid, minimize, or effectively mitigate impacts through other means. If recommended by the APWG and approved by the BLM, the operator may contribute funding to a mitigation trust account based on the estimated cost of habitat treatments or other mitigation needed to maintain the functions of impacted habitats (refer to corresponding discussion for mule deer crucial winter range). As the densities of wells and roads increase, activity levels also increase and zones of impact surrounding oil field facilities begin to overlap. Accordingly, the acreage basis for mitigation or trust account funding will be greater than the area that is physically disturbed. Standard management practices in Appendix A, "additional management prescriptions," and seasonal use stipulations should still be applied to the extent practicable.

extreme impact: >3 well pad locations or >60 acres of disturbance per square mile within a 2 miles of an occupied lek. Walker (2008) determined the probability of lek persistence declined from 84% to 42% when 45% of the area within 2 miles of a lek was developed, equating to 3 well pads per square mile. This level of disturbance cannot be mitigated effectively onsite. A decline in lek attendance and eventual abandonment of most leks are expected (Holloran 2005; Walker et al. 2007a; Walker 2008; Naugle et al. *In press*). Developments exceeding 3 well pad locations/mi^2 should be avoided within 2 miles of an occupied lek and within identified nesting and brood rearing habitats outside the 2-mile perimeter.

Commission Mitigation Policy does not provide a viable alternative to address "extreme impacts" within occupied sage-grouse habitats that are classified as "vital" (no loss of habitat function is recommended). The function and effectiveness of sage-grouse nesting and brood rearing habitats will be severely compromised (Holloran 2005). Long-term consequences include continued loss and fragmentation of sage-grouse habitat, contributing to further population declines and the possibility of eventual listing under the federal Endangered Species Act. If densities exceeding 3 well pad locations per square mile absolutely cannot be avoided, the following mitigation practices, in addition to all management practices and prescriptions applicable to "high impact," are recommended to retain as much effective habitat as feasible:

– Phased Development. Developing a well field in smaller incremental phases (phased development) can reduce the overall impact of a high-density field. Although complex geological, technical, and regulatory issues constrain the use of this strategy, we encourage its consideration when feasible.

– Off-site Mitigation. Opportunities may exist to partially offset the loss of nesting and brood-rearing habitat by successfully completing habitat rehabilitation and enhancement projects in appropriate locations outside the well field. This type of mitigation is exceedingly difficult and expensive to implement successfully, and should never be looked upon as a prescriptive solution to authorize high-density well fields. The most effective strategy is to avoid high-density developments in occupied sage-grouse habitat. If this is not feasible, plan effective habitat treatments (Appendix F) to enhance remaining habitat in locations that minimize the loss of habitat function for the affected grouse population, and within the same landscape unit.

– Acreage Basis for Mitigation. Effective habitat is essentially lost within high-density well fields, so the area of the well field will generally serve as the acreage basis for mitigation. However, this acreage basis can be reduced by appropriately implementing seasonal use restrictions, standard management practices, and additional management prescriptions described for "high impact."

– Mitigation Trust Account Option. This voluntary option should be considered only when it is not possible to avoid, minimize, or effectively mitigate impacts through other means. Refer to discussion under "high impact."

COLUMBIAN SHARP-TAILED GROUSE

We have not identified thresholds to quantify levels of impact to Columbian sharp-tailed grouse. The following best management practices (adopted from: Colorado Division of Wildlife 2008) should be applied to the extent practicable within the range of Columbian sharp-tailed grouse in Wyoming. The Columbian sharp-tailed grouse occupies a limited geographic area predominantly along the western foothills of the Sierra Madre Mountain Range in south-central Wyoming.

- Consult with WGFD at the earliest stage of development to review detailed maps of Columbian sharp-tailed grouse seasonal habitats and to help select development sites.
- Conduct comprehensive development planning that provides a clear point of reference in evaluating, avoiding, and mitigating large scale and cumulative impacts.
- No surface occupancy within 0.4 miles of any known Columbian sharp-tailed grouse lek.
- Avoid oil and gas operations within 1.25 miles of any known Columbian sharp-tailed grouse lek, and within mapped Columbian sharp-tailed grouse breeding, summer, and winter habitat outside the 1.25 mile buffer. Select sites for development that will not disturb suitable nest cover or brood-rearing habitats within 1.25 miles of an active lek, or within identified nesting and brood-rearing habitats outside the 1.25 mile perimeter.
- Where oil and gas activities must occur within 1.25 miles of Columbian sharp-tailed grouse leks or within other mapped Columbian sharp-tailed grouse breeding or summer habitat, conduct these activities outside the period between March 15 and July 30.
- Where oil and gas activities must occur within mapped Columbian sharp-tailed grouse winter habitat, conduct these activities outside the period between November 15 and March 14.
- Restrict well site visitations to portions of the day after 9:00 a.m. and before 4:00 p.m. during the lekking season (March 1 to June 1).

- Avoid surface facility density in excess of 10 well pads per 10-square mile area (one well pad per square mile) in Columbian sharp-tailed grouse breeding and summer habitat (within 1.25 miles of active leks).
- When surface density of oil and gas facilities exceeds 1 well pad/mi^2, a Comprehensive Development Plan (CDP) should be initiated that includes recommendations for off-site and compensatory mitigation actions.
- Phase and concentrate all development activities, so that large areas of undisturbed habitat for wildlife remain and thorough reclamation occurs immediately after development and before moving to new sites. Development should progress at a pace commensurate with reclamation success.
- Retain core habitat areas and limit disturbance to ensure Columbian sharp-tailed grouse survival.
- Implement species appropriate design and management practices found in "Standard Management Practices to Reduce Wildlife Impacts Associated with Oil and Gas Development" (Appendix A).
- Minimize surface disturbance and fragmentation of Columbian sharp-tailed grouse habitat through use of the smallest facility footprints possible, use of multiple well pads, clustering of roads and pipelines, and the widest possible spacing of surface facilities.
- When compressor stations must be sited within 1.25 miles of active Columbian sharp-tailed grouse leks, locate compressor stations no closer than 2,500 feet from the lek.
- Use noise reduction equipment on compressors and other development and production equipment.
- Use topographical features to provide visual concealment of facilities from known lek locations and as a noise suppressant.
- Muffle or otherwise control exhaust noise from pump jacks and compressors so that operational noise will not exceed 49 dB measured at 30 feet from the source.
- Design tanks and other facilities with structures such that they do not provide perches or nest substrates for raptors, crows and ravens.
- Install raptor perch deterrents on equipment, fences, cross arms and pole tops in Columbian sharp-tailed grouse habitat.
- Utilize a central generator to feed the entire field via underground electrical lines.
- Where feasible, bury new power lines and retrofit existing power lines by burying them or installing perch guards to prevent their use as raptor perches.
- Design wastewater pits to minimize retention of stagnant surface water.
- Treat waste water pits and any associated pit containing water that provides a medium for breeding mosquitoes with Bti (*Bacillus thuringiensis v. israelensis*) or take other effective action to control mosquito larvae that may spread West Nile Virus to wildlife, especially grouse.
- In consultation with WGFD, replace any permanently impacted, disturbed, or altered Columbian sharp-tailed grouse seasonal habitats by enhancing marginal sagebrush steppe communities (sagebrush and mountain shrub) and grassland within or immediately adjacent to mapped seasonal Columbian sharp-tailed grouse habitat.

- Implement the species appropriate reclamation measures found in "Wildlife Habitat Mitigation Options (Appendix F).
- Use early and effective reclamation techniques, including an aggressive interim reclamation program to return habitat to use by Columbian sharp-tailed grouse as quickly as possible.
- Reclaim/restore Columbian sharp-tailed grouse habitats with native grasses and forbs conducive to optimal Columbian sharp-tailed grouse habitat and other wildlife appropriate to the ecological site.
- Use high diversity (10 species or more) reclamation seed mixes in Columbian sharp-tailed grouse habitat.
- Use approved CP-4D (Columbian sharp-tailed grouse) seed mixes, based on soil type, available from Farm Service Agency or Natural Resources Conservation Service, or other seed mixes approved by WGFD.
- Avoid aggressive non-native grasses in Columbian Sharp-tailed Grouse habitat reclamation.
- A small percentage of the appropriate species of big sagebrush should be re-seeded on disturbed sites.
- Reclamation of breeding habitat should include a substantially higher percentage of forbs than other areas.
- Native and select non-native forbs and legumes should be considered a vital component of reclamation seed mixes.

ELK – crucial winter range
– parturition (calving) habitat

Refer to the section on mule deer crucial winter range for applicable seasonal use restrictions, standard management practices (Appendix A), additional management prescriptions, habitat treatments (Appendix F), and optional mitigation trust fund assessments. The same concepts apply to elk crucial winter ranges and parturition habitats, except a "moderate" level of impact is not defined. The following disturbance thresholds are identified for elk crucial winter ranges:

moderate impact: Elk are sufficiently sensitive that any level of development within crucial winter ranges or parturition habitats causes more than a "moderate" impact. Therefore, we do not identify a "moderate" level of disturbance.

high impact: 1-4 well pad locations or up to 60 acres of disturbance per square mile.

– Follow recommendations described under: "Mule Deer – high impact."

extreme impact: > 4 well pad locations or >60 acres of disturbance per square mile.

– Follow recommendations described under: "Mule Deer – extreme impact."

<u>MOOSE</u> – crucial winter range

Refer to the section on mule deer crucial winter range for applicable seasonal use restrictions, standard management practices (Appendix A), additional management prescriptions, habitat treatments (Appendix F), and optional mitigation assessments. The same concepts apply to moose crucial winter ranges, except impact thresholds are higher and correspond to the thresholds identified for pronghorn. In addition, deeper snow typically found on moose crucial winter ranges warrants special consideration. For example, plowing roads to access well sites creates high embankments that can greatly impede mobility of moose. The following additional management prescriptions should be applied:

- <u>Snow Embankments</u>. Plow gaps in high snow embankments every quarter mile along plowed well field roads, enabling moose to move across and off roads. Gaps should be placed on both sides of the road at each location.
- <u>Riparian Habitat NSO</u>. The management prescription for riparian habitats within moose crucial winter ranges should be no surface occupancy (NSO) within the riparian zone and a 500-ft buffer extending from the outer edge of the riparian zone.

<u>BIGHORN SHEEP</u> – crucial winter range
– parturition (lambing) areas

Bighorn sheep are more susceptible to disturbance-related stress than are most other ungulates (MacArthur et al. 1982). Elevated stress levels in sheep have been linked to depressed immune response, loss of condition, reduced lamb survival, and elevated mortality rates. Distributions of sheep crucial winter ranges and lambing habitats are very restricted in Wyoming and generally do not coincide with locations of high oil and gas potential. For these reasons, the management prescription should be "no surface occupancy" within bighorn sheep crucial winter ranges and lambing areas.

<u>BIG GAME MIGRATION CORRIDORS</u>

- <u>Migration Bottlenecks</u>. Within narrow migration corridors or "bottlenecks" of less than 0.5 mi width (Sawyer et al. 2005, 2006, 2008), the management prescription for oil and gas development should be "no surface occupancy" (NSO).
- <u>Migration Corridors</u>. Within migration corridors that exceed 0.5 mi width, the recommended management prescription is to maintain options for animal movement along the corridor and avoid further constricting the corridor such that a bottleneck is created. Well field developments should not exceed 4 well pad locations or 60 acres of disturbance per square mile. Fences, expansive field developments, and other potential impediments to migration should not be constructed.

<u>SPECIES OF GREATEST CONSERVATION NEED (SGCN)</u>

The Wyoming SWAP identifies mineral resource extraction as one of the major concerns leading to habitat degradation and fragmentation within several ecoregions, especially Northern Great Plains Steppe and the Wyoming Basins (WGFD 2005). These 2 ecoregions cover much of northeast, central, and southwest Wyoming and include both the Powder River and Green River basins. Appendix H lists the Species of Greatest Conservation Need (SGCN) inhabiting regions with highest potential for oil and gas development. SGCN distribution maps and recommended conservation measures are available from the WGFD website. Nongame habitat priority areas are identified in Appendix I. Highest priorities include locations where ranges of several SGCN overlap. Consult the WGFD to identify species that are potentially present, assess their sensitivity to oil and gas development, and determine appropriate mitigation. Impact analyses and management prescriptions will generally be species-specific.

As a general rule, standard management practices listed in Appendix A will satisfactorily address the needs of SGCN in well fields of up to 4 well pad locations per square mile. However, the operator should consult the WGFD Nongame Section to determine if important habitat functions will be affected, and whether additional management prescriptions may be necessary. The following general considerations are recommended for operations within habitats of non-game birds and bats:

<u>Songbird Breeding and Migration Habitat (SGCN)</u>:
- <u>Seasonal Noise Limitation</u>. From 1 April through 30 June, reduce noise levels to 49 dBA or less within breeding habitat of songbirds to minimize the effects of continuous noise on species that rely on aural cues for successful breeding (Inglefinger 2001).
- <u>Waste Ponds</u>. Cover or net all ponds that contain oily wastes to exclude their use as a water source by songbirds (Esmoil 1991, Esmoil and Anderson 1995).

<u>Raptor Nesting Habitat</u> (SGCN):
- <u>Seasonal Noise Limitation</u>. Reduce noise levels to 49 dBA or less at raptor nest sites to minimize the effects of continuous noise on raptors that are sensitive to human disturbance during the breeding season.
- <u>Seasonal Use Limitation</u>. Apply buffers and timing restrictions to reduce the impacts of construction, operations, noise, and human presence on raptor nest sites. Criteria vary slightly for different species. Consult state or federal wildlife agencies regarding appropriate buffer sizes and timing.
- <u>Bald Eagle Guidelines</u>. Refer to existing state and regional bald eagle management guidelines in additional to federal management guidelines to prevent disturbance to bald eagle nest sites.

<u>Waterbird Species</u> (SGCN) and
<u>Bat Foraging Habitats</u> (SGCN):
- <u>Waste Ponds</u>. Cover or net ponds that contain oily wastes to exclude use by waterbirds and bats (Esmoil 1991; Esmoil and Anderson 1995).

FEDERALLY-LISTED THREATENED OR ENDANGERED SPECIES

The U.S. Fish and Wildlife Service (USFWS) has jurisdiction over federally listed threatened and endangered species. Section 7 of the Endangered Species Act requires pre-decisional consultation with the USFWS to identify threatened, endangered, or candidate species that may be present and to determine whether additional protection and mitigation measures may be necessary (contact USFWS Wyoming State Office at: 307-772-2374).

WETLANDS AND RIPARIAN HABITATS

About 90% of wildlife species in Wyoming use wetlands and riparian habitats daily or seasonally during their life cycle and about 70% of Wyoming bird species are wetland or riparian obligates (Nicholoff 2003). Densities of breeding birds can be up to 10 times higher in riparian tracts compared to adjacent, non-riparian habitats (Lohman 2004). Riparian zones along major streams are important migration and dispersal corridors traversing grassland and desert environments. Wetlands afford essential reproduction areas for numerous fish, insect, amphibian and aquatic bird species. Wetlands and riparian habitats both support outdoor recreation opportunities including hunting, fishing, wildlife viewing, and nature photography. Wetlands serve many additional functions including flood attenuation, aquifer recharge and discharge, sediment filtering, contaminant removal, and biomass export. Wetland and riparian functions and values are comprehensively described by Novitzki et al. (1999), U.S. Environmental Protection Agency (2001), Nicholoff et al. (2003), McKinstry et al. (2004), and other authors. Due to their limited distribution and the critical functions they support, wetlands and riparian habitats are inordinately valuable to wildlife and people in Wyoming.

We recommend an NSO zone extending 500 ft from the outermost perimeter of wetlands and riparian corridors to maintain habitat effectiveness and functional integrity. This distance is conservative given the sensitivity of many wildlife species that utilize riparian corridors and wetlands for nesting, foraging, movement corridors, and cover. For example, Ingelfinger and Anderson (2004) detected species-specific impacts to breeding passerines within distances ranging from 40-1500 m from roads in a natural gas field. Reijnen et al. (1995) documented 20-98% reductions in bird densities within 250 m of roadways within wooded habitats. Nesting raptors are sensitive to disturbances up to several hundred meters depending on species (Fyfe and Olendorff 1976; White Thurow 1985; Richardson and Miller 1997). Mule deer can be sensitive to human and equipment disturbances at distances ranging from 0.2-0.3 miles (Freddy 1996) to well over a mile (Sawyer 2008). While inventory data are not always available to identify the specific wildlife occupying any given tract of riparian habitat, it can be assumed all riparian habitats support high levels of species diversity and provide nesting habitat for a variety of passerine species. Trees are suitable nesting habitat for several raptor species if they are sufficiently isolated from disturbance, and deer occupy most riparian tracts throughout the state. In addition, a large percent of species of greatest conservation need are wetland/riparian dependent or associated. A 500-ft NSO buffer provides minimal protection to wetland and riparian habitat functions. Refer to FERC (2003) and McKinstry et al. (2004) for additional guidance on wetland protection and mitigation practices.

AQUATIC RESOURCES

Point-source discharges and deposition of fill materials into “navigable waters” are regulated under the Clean Water Act of 1972, through state and federal primacy programs. However, several aspects of watershed management that are not rigorously regulated include: non-point source runoff, overland sediment transport, structures in “non-navigable” waters, watershed vegetation, activities in watersheds generally, and associated effects on hydrology. Sections 401, 403 and 404 of the Clean Water Act set forth performance criteria to control point source discharges and deposition of fill materials, but these performance-based programs do not prescribe specific management practices to achieve those criteria, nor do they address terrestrial and other non-jurisdictional components of a watershed. The “Aquatic Resources” section of this document provides management recommendations to protect ecological health of aquatic resources and watersheds potentially affected by oil and gas development. Recommendations can be modified or adjusted based on specific characteristics (topography, soils, vegetation, drainage) of the area proposed for development, as recommended by the APWG and approved by the surface management agency.

Important aquatic habitats include a variety of riparian/stream ecosystems inhabited by native and introduced aquatic species. Depending on the location, aquatic ecosystems may be typical cold-water streams sustaining species like boreal toads and Colorado River cutthroat trout, or they may be less familiar prairie or sagebrush steppe streams that support a variety of native fish such as bluehead sucker and herpetofauna such as soft-shell turtles. Alterations of streams and the surrounding environments by anthropogenic activities (e.g., water development projects, irrigation practices, livestock grazing and energy development) have impacted native fish communities throughout the Great Plains (Fausch and Bestgen 1997; Nesler et al. 1997; Rabeni 1996). Patton et al. (1998) determined the distributions of more than 50% of the native fish species have declined over a 30-year period within prairie streams of the Missouri River Drainage (MRD) in Wyoming.

Impacts to aquatic systems are most often a response to the general condition of the watershed. Watershed health depends on a combination of factors including vegetation cover and condition, grazing management, land disturbance, and direct impacts to riparian and stream habitats. Advanced succession caused by fire suppression and past grazing practices has accelerated a decline in quality and function of watersheds throughout much of Wyoming and the West (American Fisheries Society Policy #23 *undated*; Bartos and Campbell 1888; Chambers 2008; LaMalfa and Ryel 2008; U.S. General Accounting Office 1988a,b). In addition, loss of aspen and mountain shrub communities has reduced the diversity, quantity and quality of habitats necessary to sustain life stages of several native species. In many cases, succession of sagebrush-grasslands has advanced to old aged stands lacking a diverse, productive understory.

Precipitation infiltrates the soil less effectively due to the reduced ground cover. Upland plant communities in this condition no longer function properly to recharge seep and spring flows because most precipitation is lost quickly through overland flow. The decline of aspen and willow communities has restricted beaver habitat to relict sites, negatively affecting the ecology and stability of many stream systems in the State. Environmental consequences include entrenched streams, lowered water tables, reduced and undependable base flows, and increased sediment loads, all of which impact native fish, amphibians, and other wildlife. Heavy sediment and phosphorus loading of tributary streams has also led to downstream eutrophication. Road projects, culvert installations, and other crossings have caused long-term, adverse impacts. Large-scale oil and gas developments can further reduce vegetation cover in the watershed, increase runoff and sediment transport, and potentially introduce pollutants through discharges, chemical spills, and surface runoff. Residential subdivisions and urban infrastructure resulting from energy-induced growth will add to these effects and may directly encroach riparian habitats.

<u>Resource Categories and Impact Thresholds</u>:

Impact thresholds for aquatic resources are similar to those applied to pronghorn crucial winter ranges and important habitats of native nongame species (SGCN): moderate impact = 1-4 well pad locations per square mile or <20 acres of disturbance; high impact = 5-16 well pad locations or 20-80 acres of disturbance; extreme impact = >16 well pad locations or >80 acres of disturbance. Based on these disturbance thresholds, standard management practices and additional management prescriptions are applied to 6 categories of aquatic resources defined by the Commission Mitigation Policy, the Department's Strategic Habitat Plan, and several multi-state interagency agreements. Off-site mitigation is not a viable alternative to protect watershed functions (the effect of damaging a portion of a watershed cannot be compensated by enhancing other parts of the watershed). This is an essential distinction by comparison to terrestrial habitat mitigation. In view of this, developments exceeding 16 well pad locations or 80 acres of disturbance per section should be avoided in all cases within important watersheds identified below.

Table 2 identifies impact thresholds and management recommendations for categories of aquatic resources. Standard management practices and additional management prescriptions are described afterward. Specific mitigation practices will be recommended on a case-by-case basis. Refer to FERC (2003) and McKinstry et al. (2004) for additional guidance on wetland and waterbody protection and mitigation practices.

<u>Additional Management Prescriptions</u>:

– <u>Grazing Management</u>. With the owner or permittee's concurrence, develop a long-term grazing plan to improve watershed and stream/riparian function through timing and intensity of use including a temporary reduction of AUMs or removal of livestock if needed.
– <u>Stream Hydrology</u>. Acquire water rights within the watershed and utilize them to benefit aquatic resources.

Table 2. Impact thresholds and summary of mitigation recommendations for aquatic resources.

Species and Habitat Function	Category of Impact		
	Moderate 1 – 4 Well Pad Locations or <20 acres disturbance per square mile [1]	High 5 – 16 Well Pad Locations or 20-80 aces disturbance per square mile [1]	Extreme >16 Well Pad Locations or >80 acres disturbance per square mile [1]
	Mitigation Recommendations		
Priority Watersheds	• Standard Management Practices [2] • Habitat Mitigation Options [3] or • Voluntary Mitigation funds	• Standard Management Practices [2] • Additional Management Prescriptions • Habitat Mitigation Options [3] or • Voluntary Mitigation funds	Avoid to the extent possible • Standard Management Practices [2] • Additional Management Prescriptions • Habitat Mitigation Options [3] or • Voluntary Mitigation Funds
Species of Greatest Conservation Need (SGCN) [WGFD 2005] – Appendix H.	• Standard Management Practices [2] • Habitat Mitigation Options [3] or • Voluntary Mitigation funds	• Standard Management Practices [2] • Additional Management Prescriptions • Habitat Mitigation Options [3] or • Voluntary Mitigation funds	Avoid to the extent possible • Standard Management Practices [2] • Additional Management Prescriptions • Habitat Mitigation Options [3] or • Voluntary Mitigation Funds

Table 2. (*continued*).

Species and Habitat Function	Category of Impact and Mitigation Recommendations		
	Moderate	High	Moderate
Blue and Red Ribbon Stream Classes	• Standard Management Practices[2]	• Standard Management Practices[2] • Additional Management Prescriptions	Avoid to the extent possible • Standard Management Practices[2] • Additional Management Prescriptions • Habitat Mitigation Options [3] or • Voluntary Mitigation Funds
Native Cutthroat Trout – Core Conservation Populations and Conservation populations [4]	• Standard Management Practices[2] • Habitat Mitigation Options [3] or • Voluntary Mitigation funds	• Standard Management Practices[2] • Additional Management Prescriptions • Habitat Mitigation Options [3] or • Voluntary Mitigation funds	Avoid to the extent possible • Standard Management Practices[2] • Additional Management Prescriptions • Habitat Mitigation Options [3] or • Voluntary Mitigation Funds
Riparian Corridors, Wetlands, and Aspen Communities	– No surface occupancy within riparian corridors and a 500-ft buffer – No surface occupancy within wetlands and a 500-foot buffer – Avoid any loss or impacts to aspen communities – Avoid or mitigate human growth effects of energy development by acquiring conservation easements to protect important wetlands and riparian corridors from housing subdivisions, and by developing wetland/riparian mitigation projects.		

Table 2. (*continued*).

Species and Habitat Function	Category of Impact and Mitigation Recommendations		
	Moderate	High	Moderate
Overlapping High Value and Vital Habitats	– Apply impact thresholds and management/mitigation practices identified for each species without causing adverse effects to other species. – As necessary, mitigation and impact assessments are additive to address all species' needs.		
Federally Protected Species	Protective measures are identified through Section 7 consultation with the USFWS.		

[1] Based on a relatively even geographic distribution of well pad locations or disturbed areas in a square mile. Appropriate allowances will be made for clustered configurations or disturbances, on a case-by-case basis.
[2] Consult Appendix A
[3] Consult Appendix F
[4] There are two components associated with conservation of cutthroat trout. The first component (core conservation populations) addresses preservation and management of genetically pure populations that serve as representatives of the historic genome of a cutthroat trout subspecies (i.e., no detectable introgression between individuals of different species and/or subspecies has taken place). The other component (conservation populations) is associated with conservation of populations that retain the respective cutthroat trout phenotype, that have slight genetic introgression and have unique genetic, ecological or behavioral attributes.

Table 3. WGFD RECOMMENDED DIURNAL RAPTOR SURVEY DATES

SPECIES	MARCH 1 15 31 / APRIL 1 15 30 / MAY 1 15 31 / JUNE 1 15 30 / JULY 1 15 31 / AUGUST 1 15 30
American Kestrel	XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
Bald Eagle	XXXXXXXXXXXXXXXXXXXXX…………………………………………………XXXXXXXXXXXXXXXXX
Cooper's Hawk	XXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXX
Ferruginous Hawk	XXXXXXXXXXX…………………………………………………XXXXXXXXXXXXX
Golden Eagle	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Merlin	XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
Northern Goshawk	XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXX
Northern Harrier	XXXXXXXXXXX………………………………………………XXXXXXXXXXXXXXXXX
Osprey	XXXXXXXXXXXXXXXXXXXXX………………………………………XXXXXXXXXXXXXXX
Peregrine Falcon	XXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX
Prairie Falcon	XXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXX
Red-tailed Hawk	XXXXXXXXXXX…………………………XXXXXXXXXXXX
Sharp-shinned Hawk	XXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXX
Swainson's Hawk	XXXXXXXXXXXXX…………………………………XXXXXXXXXXXXXXXXXXXXXX

XXXXX: Indicates best times to detect birds in courtship (early dates) or with young in the nest when adults will be conspicuous (later dates). For accipters, Merlins, and Peregrine Falcons, detectability during courtship is variable, with some pairs almost impossible to detect.

……….. : Indicates periods for species with conspicuous nests during which surveys can also be conducted effectively.

Note: Dates may vary slightly by latitude, altitude or other factors affecting phonology and should be adjusted depending on field conditions.

WGFD DISTURBANCE-FREE DATES AND BUFFERS FOR RAPTORS

SPECIES	DISTURBANCE-FREE DATES	DISTURBANCE-FREE BUFFER
Bald Eagle	February 15 – August 15	½ mile
Ferruginous Hawk	March 1 – July 31	1 mile
Golden Eagle	January 15 – July 31	½ mile
Merlin	April 1 – August 15	½ mile
Northern Goshawk	April 1 – August 15	½ mile
Peregrine Falcon	March 15 – August 15	½ mile
Prairie Falcon	March 1 – August 15	½ mile

Note: Disturbance-free dates include territory establishment through fledging.
Note: Additional considerations include line of sight, visibility, type of disturbance activity, location of disturbance above or below the occupied nest, and specific situations.

OVERLAPPING VITAL AND HIGH VALUE HABITATS

Locations in which 2 or more "vital" or "high value" habitats overlap, for example crucial winter ranges and sage-grouse reproductive habitats, are exceptionally important wildlife areas. If oil and gas fields are planned within overlapping vital or high value habitats, seasonal use restrictions, standard management practices (Appendix A), BMPs (Appendix B), additional management prescriptions, habitat treatments (Appendix F), and optional mitigation funding should be applied as appropriate for each of the species and habitats affected. Where management practices or prescriptions for 2 or more species may be inconsistent, the needs of each species should be addressed without adversely affecting one species to benefit another. Optional assessments of mitigation funds should be additive as necessary to address the impacts to each species. For example, if wells are developed within an area of overlapping mule deer and pronghorn crucial winter range and sage-grouse nesting habitat, sufficient habitat treatments should be planned to offset impacts to each species without adversely affecting the other species. If the mitigation funding option is selected, the funding should be based on treatments needed to maintain habitat functions for all 3 species.

RECLAMATION

The production phase of an oil and gas field can last decades. Effective interim reclamation should be a priority to reduce the net amount of disturbed surface and loss of wildlife habitat within operating fields. Appropriately designed interim reclamation can also accelerate succession toward a self-sustaining, native vegetation community and ultimately final reclamation.

Objectives are to maintain healthy, biologically active topsoil; control erosion; and restore habitat, visual resources, and forage production on all areas not needed for long-term operation of the well field.

The success of interim reclamation should be evaluated based on sample comparisons of vegetation on reclaimed areas and an undisturbed reference site having similar and desirable ecological characteristics. Soils, precipitation, and vegetation on the reference site should be similar to those present on the well pad area prior to disturbance.

<u>The following is an example of criteria for interim reclamation and site stabilization taken from the Pinedale Supplemental Record of Decision.</u>

a. <u>Native Forbs</u>**:** The average density or frequency of desirable forbs should be a minimum of 75% of the reference site within 5 years. Diversity of forbs on a reclaimed site should at least equal the diversity measured on the reference site within 5 years.

b. <u>Native Shrubs</u>**:** The average density or frequency of the shrub component should be at least 50 % of the reference site within 5 years. This includes both shrubs and half (suffrutescent) shrubs (e.g. winterfat, fringed sage, etc.). At least 15 % of the shrub density or frequency should be the dominant species found on the reference site. The diversity of shrubs within the reclaimed areas should at least equal the shrub diversity measured on the reference site.

c. Native Grasses**:** Reclaimed sites should have a minimum of 3 native perennial grass species present, including at least 2 bunch grass species. These are to be planted at rates sufficient to achieve abundance and diversity characteristics of the grass component at the reference site.

d. Non-Native Weeds**:** Sites must be free from all species listed on county, state, and federal noxious weed lists. All state and federal laws pertaining to noxious weeds must be followed. Highly competitive invasive species such as cheatgrass and other weedy brome grasses are prohibited in seed mixtures and should be actively controlled if any are found in the reclaimed areas.

e. Plant Vigor: Plants should be resilient as evidenced by well-developed root systems, flowers, and seed heads. These attributes must be sustainable after external influences such as irrigation, mat pads, fences, etc. are removed. Their persistence for a minimum of one growing season without external influences may satisfy this recommendation.

Interim reclamation may be considered successful when: areas not needed for long-term production or vehicle travel have been recontoured, protected from erosion, and revegetated with a self-sustaining, vigorous, diverse, native (or otherwise approved) plant community sufficient to minimize visual impacts, provide adequate habitat and forage for wildlife and livestock, stabilize soils, and impede the invasion of noxious weeds.

Refer to Appendix A for more comprehensive guidance on reclamation procedures and success criteria.

REFERENCES CONSULTED:

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Appendix A

Standard Management Practices To Reduce Wildlife Impacts Associated With Oil And Gas Development

The following management practices should be implemented in appropriate circumstances to control or reduce wildlife impacts within oil and gas fields:

<u>Planning</u>

– Consult the appropriate state and federal wildlife agencies early in the planning process, preferably during the pre-planning phase if possible.
– Apply landscape planning principles and concepts.
– Design oil and gas development to avoid or reduce unnecessary disturbances, wildlife conflicts, and habitat impacts. Where possible, coordinate planning among companies operating in the same and adjacent oil and gas fields.
– Identify important, sensitive, and unique habitats and wildlife in the area. To the fullest practicable extent, incorporate mitigation practices that minimize impacts to these habitats and resources.
– If geologically and technically feasible, plan the pattern and rate of development to avoid the most important habitats and generally reduce the extent and severity of impacts.
– Cluster drill pads, roads and facilities in specific, "low-impact" areas, if geologically feasible.
– Consider "closed-loop drilling" to reduce the volume and handling of drilling wastes.
– Consider "liquid gathering systems" (LGS) to eliminate surface storage tanks and reduce truck trips for removal of liquids.
–Consider lease suspensions and delays in lease sales/purchases in adjacent or off-site areas to support mitigation efforts.
– To the extent practicable, place infrastructure within or near previously disturbed locations.
– Minimize infrastructure development and operational activity during life of field by using consolidation (e.g., "unitized") development techniques.

<u>Roads</u>

– Use existing roads & two-tracks if they are sufficient and not within environmentally sensitive areas.
– Construct the minimum number and length of roads necessary.
– Coordinate road construction and use among companies operating in the same oil and gas field.
– Use common roads to the extent practicable.
– Design roads to an appropriate standard no higher than necessary to accommodate their intended purpose.
– Design roads with adequate structures or features to prohibit or discourage vehicles from driving off roads.

– Salvage topsoil from all road construction and re-apply during interim and final reclamation.
– Locate all roads below ridgelines or behind topographic features (knolls, rises) to minimize the zone of visual and auditory effect.
– Locate roads away from bottoms of drainages, which often provide the most important sources of cover and forage for wildlife.
– Construct road crossings at right angles to all riparian corridors and streams to minimize the area of disturbance. In situations where this is not possible, never straighten or otherwise channelize a stream in order to create a right-angle crossing.
– Design road crossings of streams to allow fish passage at all flow levels. Types of crossing structures that minimize aquatic impacts, in descending order of effectiveness, are: a) bridge spans with abutments on banks; b) bridge spans with center support; c) open bottomed box culverts; and d) round culverts with the bottom placed no less than one foot below the existing stream grade. Perched culverts block fish passage and are unacceptable in any stream that supports a fishery.
– Locate and construct all structures crossing intermittent and perennial streams such that they do not decrease channel stability or increase water velocity.
– Use a variety of native grasses and forbs to establish effective, interim reclamation on road shoulders and borrow areas.
– Irrigate reclamation as necessary (during dry periods) to assure successful establishment of grasses, forbs and shrubs.
– If overhead power lines cannot be avoided, locate them along existing road rights-of-way.
– Close and rehabilitate duplicate roads not needed for drilling or production activities.
– Seasonally restrict public vehicle traffic in new development areas within important habitats.
– Use shuttle buses to transport drilling rig workers and field service personnel.

Wells

–To the extent geologically and technically feasible, drill multiple wells from the same pad using directional or horizontal drilling technologies. Maximize wells per pad, as technologically feasible (e.g., up to 32 or more wells per pad).
– Where several companies hold smaller, intermingled leases, the impact could be reduced substantially if the companies enter a cooperative agreement (called unitization) to directional drill from a common well pad(s).
– Disturb the minimum area (footprint) necessary to efficiently drill and operate a well.
– Salvage topsoil from all well pad excavations and re-apply during interim and final reclamation.
– If geologically and technically feasible, locate well pads in the least environmentally sensitive areas, well away from riparian habitats, streams or drainages, below ridgelines, away from important sources of forage, cover, reproductive habitats, winter habitats, parturition areas, brood-rearing habitats, and other ecologically important areas.

– Evaluate whether mat drilling can accelerate and enhance reclamation by decreasing soil and vegetation disturbance. Apply mat drilling techniques to the extent they prove effective.
– Use a variety of native grasses and forbs to establish effective, interim reclamation on all well pads and associated disturbances.
– Irrigate reclamation as necessary (during dry periods) to assure successful establishment of grasses, forbs and shrubs.

Ancillary Facilities and Utilities
– Locate facilities including tanks, transfer stations, shops, equipment shelters, utility towers, etc. in the least environmentally sensitive areas, well away from riparian habitats, streams or drainages, below ridgelines, away from important sources of forage, cover, reproductive habitats, winter habitats, parturition areas, brood-rearing habitats, and other ecologically important areas.
– Centralize and combine pipeline systems and other facilities and infrastructure to minimize disturbance during development and production.
– Plow or pull power lines, flow lines, and small pipelines instead of trenching.
– Salvage topsoil from all facilities construction and re-apply during interim and final reclamation.
– In open prairie or shrub-steppe environments, design all facilities such that they will not be used as perching or nesting substrates by raptors, crows, and ravens.
– Modify new and existing power poles to prevent raptor electrocutions and perching.
– Use existing utility, road and pipeline corridors to the extent feasible.
– Bury power lines in or adjacent to roads where possible.
– Establish effective, interim reclamation on all surface disturbances associated with ancillary facilities including equipment staging areas. Interim reclamation should be achieved using a variety of native grasses and forbs.
– Irrigate reclamation as necessary (during dry periods) to assure successful establishment of grasses, forbs and shrubs.

Noise
– Minimize noise generally. All compressors, vehicles, and other sources of noise should be equipped with effective noise suppression systems (e.g., “hospital mufflers”).
– Species of Greatest Conservation Need (except sage-grouse). To minimize the effects of continuous noise on bird populations, reduce noise levels to 49 dBA or less, particularly during the bird nesting season (1 April through 30 June). Constant noise generators should be located far enough away from sensitive habitats or muffled such that noise reaching those habitats is less than 49 dBA.
– Sage-grouse. Refer to noise specifications in the Sage-grouse BMPs (Appendix B).
– Include provisions in subcontractor agreements limiting noise to the same standards applied to company-operated equipment.

Traffic
– Develop a travel plan that minimizes the amount of vehicular traffic needed to monitor and service wells and other facilities.

– Prohibit or substantially limit traffic during high wildlife use hours (within 3 hours of sunrise and sunset).
– Use pipelines to transport liquids offsite, or install larger capacity storage tanks when frequent truck trips would impact habitat effectiveness.
– Transmit instrumentation readings by telemetry from remote monitoring stations to reduce maintenance traffic.
– Post speed limits on all access and maintenance roads to reduce wildlife collisions and limit dust: 30-40 mph is adequate in most cases.
– Include provisions in subcontractor agreements limiting traffic to the same standards applied to company operations.

<u>Human Activity & Secondary Effects</u>
– All employees should receive environmental awareness training during orientation. BLM should fund development of an environmental awareness video for use by all companies. The video should provide information about native wildlife, sensitivity to various kinds of impacts, consequences of poaching, information about Wyoming wildlife laws, licensing and residency requirements, and outdoor recreation opportunities.
– Employees should be instructed to avoid walking away from vehicles or facilities into view of wildlife, especially during winter months and breeding (courtship, nesting) seasons.
– Employees should not be allowed to carry firearms while on the job or riding in company vehicles.
– Companies may consider acquiring non-crucial upland sites for employee housing to relieve pressure to develop new housing subdivisions within more valuable habitats such as riparian corridors or near wetlands. Companies may also consider acquiring easements to protect important habitats from secondary development.
– Include provisions in subcontractor agreements limiting human activity to the same standards applied to company operations.

<u>Pollutants, Toxic Substances, Fugitive Dust, Erosion and Sedimentation</u>
– Avoid exposing or spilling hydrocarbon products or other chemicals on the surface. Oil pits or separation ponds should not be used, but if absolutely necessary they should be enclosed in small-mesh netting and fenced to prevent entrapment of birds and mammals (Esmoil 1991, Esmoil and Anderson 1995). All netting and fence should be maintained and kept in serviceable condition.
– Surface discharge of produced water should be limited to those areas where it can be used beneficially for wildlife, irrigated reclamation, or dust abatement, provided water quality standards for wildlife and livestock are met. Use of produced water should be carefully considered, on a case-by-case basis, as seemingly beneficial uses may actually be detrimental (e.g., additional water on big game crucial winter ranges may increase summer use by big game or livestock, thus depleting forage availability during the crucial winter period). Produced water of suitable quality may be used for supplemental irrigation to improve reclamation success in appropriate circumstances.

– Employ erosion control practices and sediment retention structures to prevent sediment transport offsite during precipitation events and runoff.

– Use dust abatement procedures including reduced speed limits and application of [environmentally compatible] chemical suppressants or suitable quality water.

Monitoring and Environmental Response

– Monitor conditions or events that may indicate environmental problems. Such conditions or events can include any significant chemical spill or leak, multiple wildlife mortalities, sections of roads with frequent and recurrent wildlife collisions (especially big game or sage-grouse), poaching and harassment incidents, severe erosion into tributary drainages, raptor electrocutions, structures associated with frequent bird or bat collisions, migration barriers (e.g., pronghorn concentrating along a fence), wildlife entrapment, sick or injured wildlife, or other unusual observations.
– Promptly report observations of potential wildlife problems to the regional office of the WY Game and Fish Dept. and, as applicable, to the U.S. Fish and Wildlife Service.
– GIS technologies would be a very useful management and planning tool for the BLM, WGFD, and the APWGs to monitor the annual extent of disturbance, document the progression and footprint of disturbances, and depict projected development. Compilations of this information should be released to state and federal resource agencies at least annually.

Research and Special Studies

– Where questions or uncertainties exist regarding the degree of impact to specific resources, or the effectiveness of mitigation, companies should consider funding or cost-sharing special studies to collect data for analysis and documentation.
– In some cases, company-sponsored studies can demonstrate an impact concern is not warranted, thereby relieving the company of a monitoring or mitigation burden. For example, company-sponsored monitoring established that mountain plovers were more abundant and less sensitive to disturbance than previously thought (USDI/BLM 2004d).

Noxious Weeds

– Control noxious and invasive plants that become established along roads, on well pads, or adjacent to other facilities.
–Clean and sanitize all equipment brought in from other regions. Use portable washing stations to periodically wash down equipment entering and leaving well field areas, especially during muddy conditions. Seeds and propagules of noxious plants are commonly transported on equipment and mud clinging to equipment.
– Request employees to clean mud from boots/work shoes before traveling to the work site, to prevent importation of noxious weeds.
– Include provisions in subcontractor agreements requiring adherence to the same procedures used in company operations to prevent spread of noxious weeds.

Reclamation Plans

An overall reclamation plan should be developed as part of each well field plan of operations, and site-specific plans should be submitted with each Application for Permit to Drill (APD) or prior to installation of roads and pipelines. The reclamation plan should include an inventory of vegetation (plant life forms, species composition, cover, height, and production) and soil types within the site(s) to be disturbed, or within a nearby reference area that is ecologically similar. Interim and final reclamation standards for wildlife habitat should be developed by BLM in consultation with WGFD and should be based on vegetation cover and species/life form composition. Reclamation should be done as concurrently as possible with the progression of development, and should limit disturbed (unreclaimed) surfaces to the minimum necessary for efficient operation. The reclamation plan should address disturbances resulting from well pads, ROW development, roads, pipelines, buildings, utilities, equipment staging areas, and other infrastructure development.

Interim Reclamation:

– Establish effective, interim reclamation on all surfaces disturbed throughout the production phase of a well field. A variety of native grasses and forbs should be used. Aggressive, non-native plants should not be established for any purpose including surface stabilization. However, some introduced forb and grass species may be suitable for interim reclamation provided they do not outcompete native vegetation or preclude its establishment, and are approved by the regulatory authority after consultation with the WGFD. Continue to monitor and treat reclaimed surfaces, applying irrigation if necessary, until satisfactory, self-sustaining plant cover is established.
– To maintain as much effective habitat as possible throughout the production phase of a well field, which can last 40 years or longer, the standards for long-term, interim reclamation should be the same standards applied to final reclamation. Standards for long-term, interim reclamation would apply to sites that will potentially be redisturbed after 2 years or longer, such as exploratory or delineation wells or temporary roads. All disturbances exceeding the minimum area required to operate should be reclaimed, either on an interim or permanent basis, as soon as the construction or other activity has ended. All topsoil from disturbed sites should be salvaged and stockpiled for later use in reclamation. Stockpiled topsoil should be reapplied to a reclaimed area while the topsoil is still viable – usually within 2-5 years.
– Reclamation standards should be based on vegetation cover and species composition measured within the plant community prior to disturbance, or within an undisturbed reference area on an ecologically similar site near the operation. If the reference area option is used, the reference site should be in a location with the same vegetation characteristics (species, composition, and cover) as the disturbed area(s), and the reference site should not be impacted throughout the life of the well field or the evaluation period following final reclamation.
– Long-term, interim reclamation should be conducted by first stabilizing the site, then reapplying salvaged topsoil and seeding locally adapted species/varieties of

indigenous grasses, forbs, and shrubs in the spring or fall as appropriate. The success standard for interim reclamation is to achieve at least 50% of the indigenous vegetation cover measured prior to disturbance (or within a suitable reference area), within 5 years and 80% within 8 years. Reclaimed sites should be inspected and evaluated in the 2nd and 4th years after seeding to determine if vegetation establishment is on track to achieve success standards. Any site on which cover and species goals are not being met should be reseeded, in which case the timeframe for evaluating reclamation success will start over.

Final Reclamation: Several key ecological considerations would improve the success and effectiveness of final reclamation. Past efforts have tended to focus on grass species that establish ground cover rapidly and inexpensively. These are often nonnative species that can be very aggressive initially, but are not well adapted for long-term survival. Nonnative species that do persist (e.g., crested wheatgrass), often out compete more desirable native vegetation. Seed mixes should include plant species that are native to the area, ecologically adapted to the site, and that provide forage and cover to wildlife. Some of the forb species are expensive, but they are an essential component of any native seed mix. If final reclamation is done correctly, habitats restored after a well field is decommissioned could essentially be better than what was there before the area was developed. Specific recommendations include:

- Salvage topsoil during decommissioning operations and reapply to reclaimed surfaces.
- Replant a mix of forbs, grasses, and shrubs that are native to the area and suitable for the specific ecological site.
- Restore vegetation to achieve numeric standards of cover, species composition, and diversity that are commensurate with the ecological site.
- Continue to monitor and treat reclaimed areas, applying irrigation if necessary until plant cover, composition, and diversity standards have been met.
- Bonds should be set at a level that is adequate to cover the company's liability for final reclamation of the entire well field. Kniola and Gil (2005) documented 84% of coalbed methane wells and facilities in NE Wyoming did not comply with reclamation success standards and other conditions of approval. The BLM should reevaluate its existing system of bonding and reclamation enforcement. Compliance with reclamation standards should be enforced and companies required to correct reclamation that does not meet established standards. Future permitting should be based on past performance.
- Reclamation standards should be based on vegetation cover and species composition measured within the plant community prior to disturbance, or within an undisturbed reference area on an ecologically similar site near the operation. If the reference area option is used, the reference site should be a location with the same vegetation species, composition, and cover as in the disturbed area(s), and the reference site should not be impacted throughout the life of the well field or the evaluation period following final reclamation.
- Final reclamation should be conducted by first stabilizing the site, then reapplying salvaged topsoil and seeding locally adapted species/varieties of native grasses, forbs, and shrubs in the spring and/or fall as appropriate. The success standard for

final reclamation is to achieve at least 50% of the indigenous vegetation cover measured prior to disturbance (or within a suitable reference area), within 5 years and 80% within 8 years. Reclaimed sites should be inspected and evaluated in the 2nd and 4th years after seeding to determine if vegetation establishment is on track toward meeting success standards. Any site on which cover and species goals are not being met should be reseeded, in which case the timeframe for evaluating reclamation success begins over.

– The BLM should develop quantitative criteria for evaluating reclamation success, including species similarity standards, on permanently reclaimed sites.

<u>Stream Habitats and Riparian Corridors</u>

– No drilling activity or disturbance should be permitted within 500 feet of a riparian area, wetland or stream channel. Apply a standard NSO stipulation to all riparian zones and a 500-ft corridor extending from the outermost limit of the riparian habitat.
– Drilling should not be permitted on slopes exceeding 25%.
– Line reserve pits with a suitable, impermeable barrier to prevent possible contamination of soil and groundwater.
–Design drill pad sites to disperse storm water runoff onto upland sites using proper erosion and sediment control techniques. Construct sediment retention ponds in situations where excess storm water may transport sediment into streams.
– Discharges from other than reserve pits should meet NPDES standards or otherwise assure the discharged water is of suitable quality.
– All pipeline crossings of a watercourse should be protected against surface disturbances and damage to the pipeline, to prevent a possible spill event.
– Pipelines that convey fluids should be fitted with shutoff valves at all blue and red ribbon stream crossings and other high quality stream crossings based on a case by case consultation with the WGFD.
– Any pipeline crossing of a blue and red ribbon stream should be accomplished by boring underneath the stream. Trenching may be used for stream crossing based on a case by case consultation with the WGFD. If the pipeline crossing will be trenched, consult the WGFD to determine avoidance periods during critical fish spawning seasons, time limits for instream excavation work, and other management practices that apply.
– Pipeline crossings can be installed through ephemeral streams by trenching. Use appropriate size riprap to stabilize stream banks. Place riprap from the channel bottom to the top of the normal high water line on the bank at all stream crossings. We recommend double-ditching techniques to separate the top one foot of stream bottom substrate from deeper soil layers. Reconstruct the original layers by replacing deeper substrate first.
– Design road crossings of streams to allow fish passage at all flows. Types of crossing structures that minimize aquatic impacts, in descending order of effectiveness, are: a) bridge spans with abutments on banks; b) bridge spans with center support; c) open bottomed box culverts; and d) round culverts with the bottom placed no less than one foot below the existing stream grade. Perched culverts block fish passage and are unacceptable in any stream that supports a fishery.
– Locate and construct all structures crossing intermittent and perennial streams such that

they do not destabilize the channel or increase water velocity.
– Avoid stripping riparian canopy or stream bank vegetation if possible. It is preferable to crush or shear streamside woody vegetation rather than completely remove it. Any locations where vegetation is stripped during installation of stream crossings should be revegetated immediately after the crossing is completed.
– Staging, refueling, and storage areas should not be located in riparian zones or on flood plains. Keep all chemicals, solvents and fuels at least 500 feet away from streams and riparian areas.
– Hydrostatic test waters released during pipeline construction could alter stream channels, increase sediment loads and introduce potentially toxic chemicals or invasive species into drainages. Avoid discharging hydrostatic test waters directly to streams.
– Hydrostatic test waters should be dispersed onto an upland site using proper erosion and sediment control techniques.
– Pipelines that parallel drainages should always be located outside the 100-year floodplain. Construct pipeline crossings at right angles to all riparian corridors and streams to minimize the area of disturbance.
– Where pipelines cross riparian areas and streams, use the minimum practical width for rights-of-way.
– Instream activity restrictions may be necessary to protect fish spawning habitat in certain streams. These restrictions will be identified in Section 404 permits issued by the U.S. Army Corps of Engineers (COE) or through the notification process under nationwide permits, as applicable. In such cases, the COE will consult regional fisheries or statewide fisheries personnel at the Department's local or Cheyenne offices, respectively. We encourage companies to consult the Department's fisheries personnel for advice regarding appropriate practices and design considerations when planning instream activities.
– Avoid placing new overhead transmission lines across rivers and major streams to prevent collisions by raptors, cranes, swans and other waterfowl/bird species that use riparian corridors as major migration flyways.

Appendix B

"Best Management Practices" for Minimizing Impacts to Sage-grouse in Core and Non-core Habitats

The following "Best Management Practices" specific to sage grouse should be applied in addition to the standard management practices in Appendix A to minimize oil and gas impacts to sage-grouse in both "core" and "non-core" habitats. Additional stipulations that apply specifically to core areas are found in Appendix C.

- All Occupied Habitats:
  – Establish baseline sage-grouse population demographics; this information is necessary to adaptively manage as development intensifies.
  – If leks or brood-rearing habitats are present, seasonal restrictions and additional management practices apply (refer to sections that follow).
  – Develop an area in such a manner that as many leks as possible are kept on the edge of development. A lek on the edge of development is defined as having development infrastructure situated within no more than a 180^{o} arc on one side of the lek (Holloran 2005).
  – *Locate main haul trunk roads used to transport production and/or waste products to a centralized facility or market point > **2.0** miles from the perimeter of occupied sage-grouse leks (Lyon and Anderson 2003)*
  – Locate other roads used to provide facility site access and maintenance $\geq$ 0.25 miles from the perimeter of occupied sage-grouse leks (>0.6 miles in sagegrouse core habitat areas).
  – Bury power lines when possible to reduce raptor predation and behavioral avoidance by sage-grouse.
  – If overhead power lines cannot be avoided, locate them at least 0.5 mi from the perimeter of occupied leks.
  – Install perch guards on overhead power lines to prevent raptors from using them as perch sites.
  – Equip tanks and other facilities with structures or devices that deter raptors, crows and ravens from perching or nesting on them.
  – Muffle or otherwise control exhaust noise from all equipment so that operational noise will not exceed 49 dB measured at 30 feet from the source (Colorado Greater Sage-grouse Plan Steering Committee 2008).
  – In CBM fields, treat, remove, or re-inject produced water to reduce habitat for mosquitoes that vector West Nile virus (Walker et al. 2007b).
  – If surface disposal of produced water continues in CBM fields, use the following steps for reservoir design to limit favorable mosquito habitat (Walker et al. 2007b):
    - Overbuild size of ponds to create muddy, non-vegetated shorelines.
    - Build steep shorelines to decrease vegetation and increase wave actions.
    - Avoid flooding terrestrial vegetation in flat terrain or low-lying areas.

    - Construct dams or impoundments that restrict down slope seepage or overflow.
    - Line the channel with crushed rock where discharge water flows into the pond.
    - Construct spillway with steep sides and line it with crushed rock.
  – Plan and implement appropriate mitigation (Appendix F) in consultation with the WY Game & Fish Department.
  – Include provisions in subcontractor agreements requiring the same protection measures used in company operations to avoid or reduce disturbances to occupied sage-grouse habitats.

- <u>Winter Concentration Areas</u>:
  – Minimize disturbance by applying controlled surface use (CSU) conditions of approval within winter concentration areas.
  – Avoid placement of roads, well pads and other structures that may require human presence in winter concentration areas. (Doherty et al. 2008).
  – Avoid human and equipment activity within winter concentration areas from 15 November through 14 March.
  – Avoid installing new overhead power lines (transmission or distribution lines) across known winter habitat. – Include provisions in subcontractor agreements requiring the same protection measures used in company operations to avoid or reduce disturbances to sage-grouse winter concentration areas.

- <u>Occupied Leks</u>:
  – In Non-core Areas, *strive to* maintain <3 pads per mi^2 within 2 miles of the perimeter of occupied sage-grouse leks. This level of development provides at least a 50% chance of sage-grouse *lek* persistence (Walker 2008).
  – ***In Core Areas, well pad densities not to exceed an average of 1 pad per square mile (640 acres).*** *The number of well pads within a 2 mile radius of the perimeter of an occupied sage-grouse lek should not exceed 11,* ***distributed preferably in a clumped pattern in one general direction from the lek.***
  – Within non-core areas, no surface occupancy (NSO) should be allowed within 0.25 miles of the perimeter of occupied leks (Walker 2008). An occupied lek is a lek that has been active (attendance documented) at least 1 breeding season within the most recent 10-year period. This requirement should be applied as a "No Surface Occupancy" (NSO) stipulation.
  – Within core areas, no surface occupancy (NSO) should be allowed within 0.6 miles of the perimeter of occupied leks (Draft Wyoming BLM Sage-grouse Policy IM. 2008; Carr 1967, Wallestad and Schladweiler 1974, Rothenmaier 1979, Emmons 1980, and Schoenberg 1982 as analyzed by Colorado Greater Sage-grouse Conservation Plan Steering Committee 2008; Walker 2008).
  – Reduce the number and height of tanks and other above ground facilities if any are sited within 0.6 miles of the perimeter of occupied leks.
  – Limit human and vehicular activity within 0.6 miles of the perimeter of all occupied sage-grouse leks from 6:00 pm – 8:00 am during the breeding season (15 March through 15 May).

– Locate compressor stations at least 0.6 mi away from the perimeter of leks and use noise reduction equipment on compressors and other development and production equipment.
– To avoid disrupting auditory displays and nesting, from 15 March through 15 May anthropogenic sources of continuous or frequently intermittent noise should not exceed 10 dBA above natural, ambient noise measured at the perimeter of any occupied sage-grouse lek (Inglefinger 2001; Nicholoff 2003). In addition, between 1 hour before sunrise and 2 hours after sunrise, anthropogenic sources of continuous or frequently intermittent noise should not be detectable at the perimeter of an occupied lek. To the extent practicable, only natural, ambient levels of noise are permissible.
– Noise limitations may be adjusted if site-specific conditions such as topography or vegetation attenuate sound, as determined by APWG after consultation with the WGFD. Such considerations will generally require quantitative measurement of residual noise levels within the areas being protected. Oil and gas operators may submit data for consideration by the APWG in evaluating a noise standard.
– One-time disturbances of a short-term and temporary nature, for example a pipeline being laid through the 2-mile perimeter surrounding a lek, may be exempted from the noise and NSO restrictions if the APWG determines the noise and activity will cause minimal harm. Disturbances that can be exempted will generally not exceed a few days in duration. The operator may be requested to employ additional protective measures such as suspending activities from 1 hour before sunrise until 2 hours after sunrise, and using devices or practices that minimize the amount of noise and activity.
– Avoid locating overhead power lines (transmission or distribution) within 0.5 mi. of the perimeter of occupied leks. In cases where existing overhead lines cross winter habitat, new lines can be constructed within the same corridor.
– Include provisions in subcontractor agreements requiring the same protection measures used in company operations to avoid or reduce disturbances to sage-grouse lek areas.

- <u>Nesting & Early Brood-rearing Habitats</u>:
  – *Non-core: Surface disturbing activities and/or disruptive activities should be prohibited or restricted from 15 March-30 June within suitable nesting and early broodrearing habitat within 2 miles of the perimeter of an occupied lek and in mapped nesting and early brood-rearing habitat regardless of distance from the lek. Core Area:* ***This timing stipulation applies throughout core area.***
  – *Non-Core: To the extent practicable, from 15 March through 30 June, anthropogenic sources of continuous or frequently intermittent noise should not exceed 10 dBA above natural ambient or background noises measured in any suitable nesting and broodrearing habitat within 2 miles of an occupied lek, or within identified nesting and brood-rearing habitats outside the 2-mile perimeter (Inglefinger 2001; Nicholoff 2003). Core Area:* ***This timing stipulation applies throughout core area.*** *Temporary disturbances may be*

exempted and adjustments made as described above (refer to "occupied leks").

– Select sites for construction that will not disturb suitable nesting cover or brood-rearing habitats within 2 miles of an occupied lek or within identified nesting and brood-rearing habitats outside the 2-mile perimeter. A qualified person should visit each site to identify and map suitable nest cover and brood-rearing habitats. This information should be provided for review by the appropriate WGFD regional biologist. Connelly et al. (2000) recommend locating all energy related facilities at least 2 miles from active leks whenever possible. The Colorado Division of Wildlife recommends oil and gas operations and associated development should avoid areas within 4 miles of a lek to protect nesting and brood-rearing habitat, and within areas of mapped nesting and brood-rearing habitat outside the 4-mile perimeter (Colorado Greater Sage-grouse Plan Steering Committee 2008; Walker et al. 2007a; Walker 2008; Naugle et al. *In press*).
– Include provisions in subcontractor agreements requiring the same protection measures used in company operations to avoid or reduce disturbances to nesting and early brood-rearing habitat.

References:

Refer to "References Consulted"

Appendix C

Stipulations for Development in Core Sage-grouse Population Areas

The goal is to maintain existing habitat function by permitting development activities that will not cause declines in sage-grouse populations.

A. Oil and Gas Leases:

1. One well pad per 640 acres. No more than 11 well pads within 1.9 miles of the perimeter of occupied sage grouse leks with densities not to exceed 1 pad per 640 acres (Holloran 2005). Clustering of well pads may be considered and approved on a case-by-case basis.
2. Surface disturbance will be limited to < 5% of sagebrush habitat per 640 acres. Distribution of disturbance may be considered and approved on a case-by-case basis.
3. No Surface Occupancy within 0.6 mi of the perimeter of occupied sage grouse leks (Carr 1967, Wallestad and Schladweiler 1974, Rothenmaier 1979, Emmons 1980, Schoenberg 1982 as analyzed by Colorado Greater Sage Grouse Conservation Plan Steering Committee 2008).
4. Locate main haul trunk roads used to transport production and/or waste products to a centralized facility or market point ≥ 1.9 miles from the perimeter of occupied sage grouse leks (Lyon and Anderson 2003). Locate other roads used to provide facility site access and maintenance ≥ 0.6 miles from the perimeter of occupied sage grouse leks. Construct roads to minimum design standards needed for production activities while minimizing surface disturbance and traffic.
5. Locate electrical supply lines at least 750 m (0.5 miles) from the perimeter of occupied sage grouse leks. Design electrical lines to be raptor proof by installing anti-perching devices, or burying them when possible.
6. Exploration and development activity will be allowed from July 1 to March 14. In Core Population Areas that also contain sage grouse winter concentration

areas, exploration and development activity will be allowed only from July 1 to December 1 in the winter concentration areas.

7. Limit noise sources to 10 dBA above natural, ambient noise (~39 dBA) measured at the perimeter of a lek from March 1 to May 15 (Inglefinger 2001, Nicholoff 2003).

B. All Other Activities, including but not limited to Wind Energy, In-situ Uranium, Sagebrush Treatment, Reclamation, and Transmission Line Rights of Way.

1. Project activity will be allowed from July 1 to March 14. In Core Population Areas that also contain sage grouse winter concentration areas, project activity will be allowed only from July 1 to December 1 in the winter concentration areas.
2. Limit noise sources to 10 dBA above natural, ambient noise (~39 dBA) measured at the perimeter of a lek from March 1 to May 15.
3. No Surface Occupancy within 0.6 mi of the perimeter of occupied sage grouse leks.
4. Surface disturbance will be limited to < 5% of sagebrush habitat per 640 acres. Distribution of disturbance may be considered and approved on a case-by-case basis.
5. Locate main roads ≥ 1.9 miles from the perimeter of occupied sage grouse leks. Locate other roads used to provide facility site access and maintenance ≥ 0.6 miles from the perimeter of occupied sage grouse leks. Construct roads to minimum design standards needed while minimizing surface disturbance and traffic.
6. Locate electrical supply lines at least 750 m (0.5 miles) from the perimeter of occupied sage grouse leks. Design electrical lines to be raptor-proof by installing anti-perching devices, or burying them when possible.

Review Process

Proposals incorporating less restrictive stipulations may be considered depending on site-specific circumstances. The project applicant proposing a project within

Core Population Areas and requesting exceptions to the standard stipulations bears the responsibility to demonstrate that the alternative proposal will not cause declines in sage grouse populations occupying the proposed area of development.

Proposals to deviate from standard stipulations will be considered by a team including the Wyoming Game and Fish Department and appropriate land management agencies, with input from the U.S. Fish and Wildlife Service. Project proponents need to demonstrate that the project area meets at least one of the following conditions:

1) No suitable habitat is present in one contiguous block of land that includes at least a 0.6-mile buffer between the project area and suitable habitat;

2) No sage grouse use occurs in one contiguous block of land that includes at least a 0.6 mile buffer between the project area and adjacent occupied habitat, as documented by total absence of sage grouse droppings and an absence of sage grouse activity for the previous ten years;

3) A project plan developed in consultation with the Wyoming Game and Fish Department that is designed to: 1) reduce habitat fragmentation; 2) minimize mortality to sage grouse; 3) minimize the project footprint; 4) demonstrate through credible monitoring data, changes in sage grouse populations as a result of project activity; and 5) provide for a mitigation plan to affect population decline on not less than a 1:1 bird basis in the event monitoring data demonstrates a decline in sage grouse populations in the core area due to project activity.

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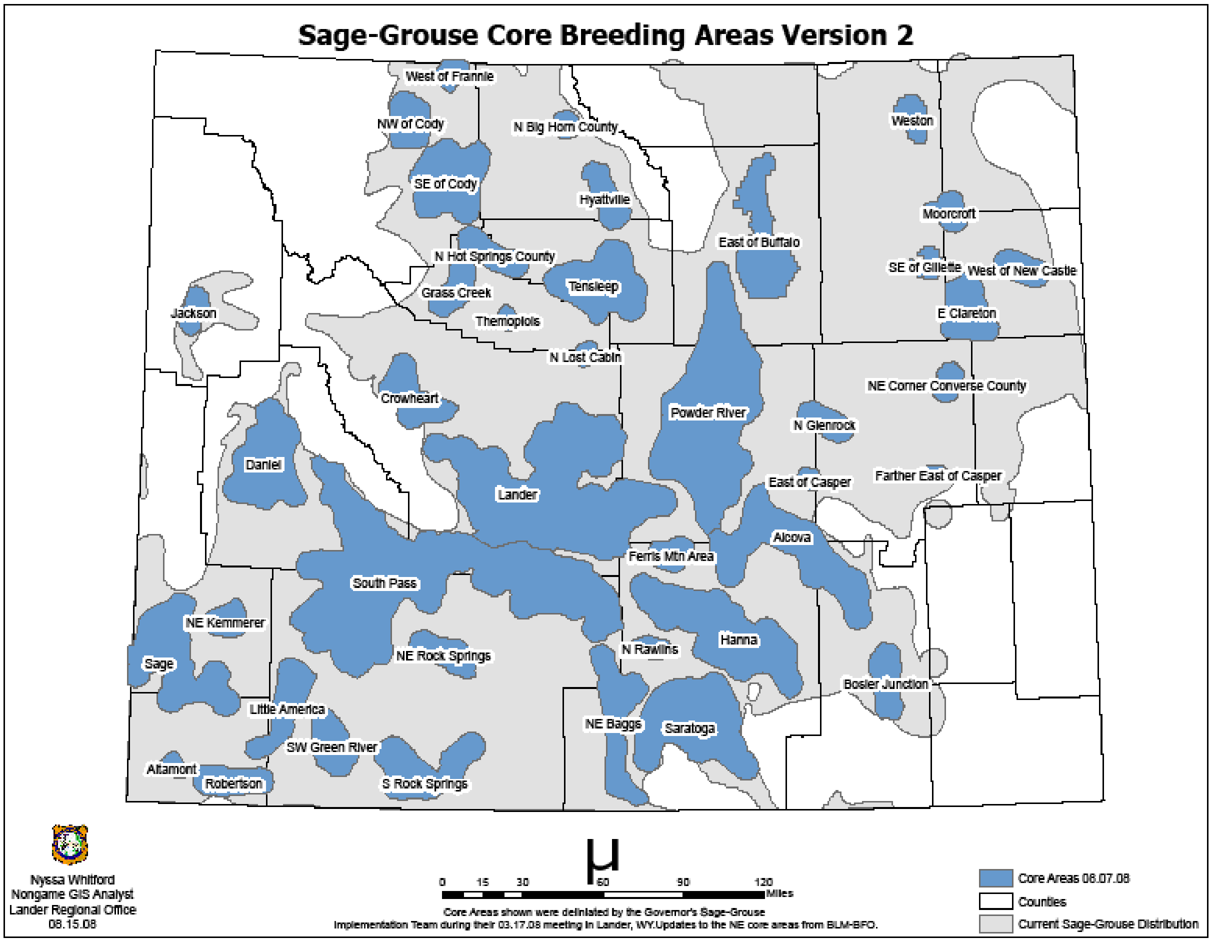
Appendix D



Sage-Grouse Core Breeding Areas Version 2
West of Frannie
NW of Cody
N Big Horn County
Weston
SE of Cody
Hyattville
Moorcroft
East of Buffalo
N Hot Springs County
SE of Gillette
West of New Castle
Grass Creek
Tensleep
Jackson
Thermopolis
E Clareton
N Lost Cabin
NE Corner Converse County
Crowheart
Powder River
N Glenrock
Daniel
East of Casper
Farther East of Casper
Lander
Alcova
Ferris Mtn Area
South Pass
NE Kemmerer
Hanna
N Rawlins
NE Rock Springs
Sage
Bosler Junction
Little America
NE Baggs
Saratoga
SW Green River
Altamont
Robertson
S Rock Springs
Nyssa Whitford
Nongame GIS Analyst
Lander Regional Office
08.15.08
0 15 30 60 90 120
Miles
Core Areas shown were delinlated by the Governor's Sage-Grouse
Implementation Team during their 03.17.08 meeting in Lander, WY.Updates to the NE core areas from BLM-BFO.
Core Areas 06.07.08
Counties
Current Sage-Grouse Distribution

Appendix E

DAVE FREUDENTHAL
GOVERNOR

THE STATE OF WYOMING

STATE CAPITOL
CHEYENNE, WY 82002

Office of the Governor

STATE OF WYOMING
EXECUTIVE DEPARTMENT
EXECUTIVE ORDER

Order 2008-2

GREATER SAGE-GROUSE CORE AREA PROTECTION

WHEREAS the Greater Sage-Grouse (*Centrocercus urophasianus*) is an iconic species that inhabits much of the sagebrush-steppe habitat in Wyoming; and

WHEREAS the sagebrush-steppe habitat type is abundant across the state of Wyoming; and

WHEREAS the state of Wyoming currently enjoys robust populations of Greater Sage-Grouse; and

WHEREAS the state of Wyoming has management authority over Greater Sage-Grouse populations in Wyoming; and

WHEREAS the U.S. Department of the Interior has been petitioned to list the Greater Sage-Grouse as a threatened or endangered species in all or a significant portion of its range, including those populations in Wyoming; and

WHEREAS the listing of the Greater Sage-Grouse would have a significant adverse affect on the custom and culture of the state of Wyoming; and

WHEREAS the listing of the Greater Sage-Grouse would have a significant adverse affect on the economy of the state of Wyoming, including the ability to generate revenues from state lands; and

WHEREAS the Wyoming State Legislature has appropriated significant state resources to conserve Greater Sage-Grouse populations in Wyoming; and

WHEREAS the state of Wyoming has endeavored to conserve Greater Sage-Grouse populations in order to retain management authority over the species through its statewide sage grouse working group, local sage grouse working groups and the efforts and initiatives of private landowners and industry; and

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WHEREAS the Governor's Sage Grouse Implementation Team developed a "Core Population Area" strategy to weave the many on-going efforts to conserve the Greater Sage-Grouse in Wyoming into a statewide strategy; and

WHEREAS on April 17, 2008, the Office of the Governor requested that the U.S. Fish and Wildlife Service review the "Core Population Area" strategy to determine if it was a "sound policy that should be moved forward"; and

WHEREAS on May 7, 2008, the U.S. Fish and Wildlife Service responded that the "core population area strategy, as outlined in the Implementation Team's correspondence to the Governor, is a sound framework for a policy by which to conserve greater sage-grouse in Wyoming".

NOW, THEREFORE, pursuant to the authority vested in me by the Constitution and Laws of the State, and to the extent such actions are consistent with the statutory obligations and authority of each individual agency, I, Dave Freudenthal, Governor of the State of Wyoming, do hereby issue this Executive Order providing as follows:

1. Management by state agencies should, to the greatest extent possible, focus on the maintenance and enhancement of those Greater Sage-Grouse habitats and populations within the Core Population Areas identified by the Sage Grouse Implementation Team and modified through additional habitat and population mapping efforts.
2. Current management and existing land uses within Core Population Areas should be recognized and respected by state agencies.
3. New development or land uses within Core Population Areas should be authorized or conducted only when it can be demonstrated by the state agency that the activity will not cause declines in Greater Sage-Grouse populations.
4. Funding, assurances (including state-conducted efforts to develop Candidate Conservation Agreements and Candidate Conservation Agreements with Assurances), habitat enhancement, reclamation efforts, mapping and other associated proactive efforts to assure viability of Greater Sage-Grouse in Wyoming should be focused and prioritized to take place in Core Population Areas.
5. State agencies should use a non-regulatory approach to influence management alternatives within Core Population Areas, to the greatest extent possible. Management alternatives should reflect unique localized conditions, including soils, vegetation, development type, climate and other local realities.
6. Incentives to enable development of all types outside Core Population Areas should be established (these should include stipulation waivers, enhanced permitting processes, density bonuses, and other incentives). However, such development scenarios should be designed and managed to maintain populations, habitats and essential migration routes outside Core Population Areas.

7. Incentives to accelerate or enhance required reclamation in habitats adjacent to Core Population Areas should be developed, including but not limited to stipulation waivers, funding for enhanced reclamation, and other strategies.
8. Existing rights should be recognized and respected.
9. On-the-ground enhancements, monitoring, and ongoing planning relative to sage grouse and sage grouse habitat should be facilitated by sage grouse local working groups whenever possible.
10. Fire suppression efforts in Core Population Areas should be emphasized, recognizing that other local, regional, and national suppression priorities may take precedent. However, public and firefighter safety remains the number one priority on all wildfires.
11. State agencies work collaboratively with the U.S. Fish and Wildlife Service, Bureau of Land Management, U.S. Forest Service, and other federal agencies to ensure, to the greatest extent possible, a uniform and consistent application of this Executive Order to maintain and enhance Greater Sage-Grouse habitats and populations.
12. State agencies shall work collaboratively with local governments and private landowners to maintain and enhance Greater Sage-Grouse habitats and populations in a manner consistent with this Executive Order.

Given under my hand and the Executive Seal of the State of Wyoming this 1st day of August, 2008.

Dave Freudenthal

Dave Freudenthal
Governor

Page 3

Appendix F

WILDLIFE HABITAT MITIGATION OPTIONS

prepared by:
Wyoming Game & Fish Department

The habitat enhancements suggested in this appendix are options for companies and resource agencies to consider in designing an integrated mitigation plan to sustain habitat functions potentially affected by oil and gas developments. The list is not exhaustive – many additional options and practices could also provide effective mitigation. Regional biologists, company personnel, and others may have alternative suggestions to address specific circumstances.

Corporate-owned Lands under Conservation Management – Management of corporate owned or controlled lands may be one of the best alternatives to achieve effective, long-term mitigation of oil and gas impacts. Availability of corporate-owned lands can provide managers with increased options and flexibility to mitigate impacts and potentially provide increased recreational access.

Conservation Easements – This concept includes numerous options/practices for mitigating impacts to the most crucial habitats. These options/practices include maintaining open space, excluding subdivisions and keeping an agricultural base of operations compatible with wildlife, excluding fencing or other developments that are restrictive to wildlife migration and movement, grazing management systems, etc. Where appropriate, conservation easements could be implemented through the formation of a land trust, or by earmarked contributions to an existing land trust. Depending upon the amount of property rights acquired costs could range from 35% to 95% of fee title acquisition. The mitigation would be in effect as long as the easement is held and monitored by the assignee. The intent is to maintain the easements at least throughout the time habitat functions are disrupted, including the time required for reclamation to mature.

Grazing/AUM Management Program – This practice could include many options, with the owner's or permittee's concurrence, to improve habitat quality for wildlife. Some options might include: (1) paying for private grazing AUMs to provide rest and/or treatments on public lands; (2) paying for a portion of the AUMs within an allotment; (3) providing for rest/treatments and once completed, turning the land back to grazing use; (4) purchase of AUMs to reduce grazing use on important habitats; or (5) establishing forage reserves (grass banks) to provide management flexibility for habitat treatments and livestock grazing. Other grazing management options include electric fencing to provide pasture systems, herding, water developments, etc. These could all be utilized to better manage/control grazing animals to improve range/habitat conditions.

Habitat Improvements – These options may be considered as standard procedures for managing habitat, or for offsite mitigation where important habitats could potentially be improved to restore habitat functions impacted in other areas. The costs are subject to site-specific adjustments based on the true cost of implementation. If monetary assessments are made, the amounts should be calculated based on the true or fair cost of implementation, or inflation-adjusted amounts listed in this section if so agreed by the parties to negotiation. The amounts in this section are 2004 dollars. Before habitat treatments are applied, qualified personnel should evaluate the prospective site to determine its condition, improvement potential, and ecologically appropriate treatments. Early consultation with the WGFD can greatly assist with planning and selection of treatments. In particular the Department has developed specific management objectives for sagebrush and sage-grouse habitats (Wyoming Interagency Vegetation Committee 2002, Bohne et. al. 2006).

Long Term (>15 years)

1. Water Developments
    a. Springs/Seeps – $2500 and $250/yr for maintenance. Longevity of approx. 20 years.
    b. Wetland Development – Average of $4000/acre and ranging from $1000 to $10,000 to develop and $75/ac yearly maintenance – Longevity of 25+ years.
    c. Ponds/Reservoirs – approx. $20,000 per reservoir. Longevity of 25 years.
    d. Guzzlers – $3000 average with a range of $2000 to $6000 each (medium to large size). Annual maintenance of $150 each.
    e. Wells/Windmills – $20,000 each.
2. Prescribed Burning [Consult Wyoming Interagency Vegetation Committee (2002) and Bohne et al. (2007) for precautions in occupied sage-grouse habitat].
    a. Average of $25 to $50 per acre in shrublands, $50 to $100 per acre in juniper, and $100 to $500 per acre in mixed conifer. Longevity – 15 years in herbaceous vegetation types. Treated areas require proper pre- and post-burn grazing control and management (two growing seasons of rest). Within shrub ecosystems, burned areas generally will not recover to a functional seral stage for 10-20 years and this process can take much longer (50+ years) in some ecosystems (e.g., xeric *Artemisia tridentata wyomingensis*). The beneficial effect may last an additional 20-30 years.
3. Herbicide Treatments
    a. Use to change vegetative composition and/or set back seral stage of succession to benefit wildlife. Average of $20/acre with range of $10 to $35 per acre. Longevity – 15 years in herbaceous vegetation types. Within shrub ecosystems, treated areas generally will not recover to a functional seral stage for 10-20 years and this process can take much longer in some ecosystems (e.g., xeric *Artemisia*

tridentata wyomingensis). The beneficial effect may last an additional 20-30 years.

4. Cutting/Chopping Regeneration
    a. Aspen – $120/acre with range of $80 to $180/acre. Longevity of 50 years.
    b. Conifer – Thinning – $120 to $180 per acre (range of $100-$300/acre) to remove approximately 1700 trees/acre. Longevity – 20-40 years. Clear cutting -- $200/acres
    c. Sagebrush/Mountain shrub – $55/acre ranging from $30 to $150 per acre. Longevity – 15+ years.
    d. Willow – $120/acre ranging from $60 to $180 per acre. Longevity – 25+ years.
5. Seeding – grass, legumes, forbs into permanent cover -- $120/acre ranging from $60 to $250 per acre. Longevity – 25+ years
6. Planting shrubs and trees (shelterbelts and thickets) – Installation - $22,000 per tree row mile including site preparation, weed barrier, cost of trees, shrubs, fencing and labor. Maintenance costs = $3500 per year for 3 years. Longevity – 25+ years.
7. Sagebrush seeding – Transplanting containerized stems of Wyoming big sagebrush at $2/stem and 809 stems per acre = $1620 per acre. Seeding costs are much less than transplanting but at a much greater risk of establishment failure. 1999 data for contracted seeding prices for Wyoming big sagebrush approached $500 per acre.
8. Fencing – $6000/mile ranging from $3000 to $20,000 per mile. Longevity – 25 years.
9. Stream bank protection and In-stream structures – Bank stabilization, log and rock revetments and over-pours, boulders, sheet pilings for small streams averages -- $6.50 to $7.50 per lineal foot and for large streams averages $23 to $33 per lineal foot. Range – Extremely variable. Annual maintenance – $4.75 to $5.25 per foot. Longevity is variable but should last more than 15 years.
10. Beaver transplanting – designed to raise water table and improve riparian systems – $2500 per colony establishment. Ranging from $1000 to $4500 per colony depending upon remoteness of area and beaver habitat available in the area.

Short Term (<15 years)

1. Fertilization – Average $50 per acre with a range of $20 to $150 per acre. Longevity – 3 years.
2. Food Plots – Average $50 per acre with a range of $40 to $80 per acre. Longevity – 1 to 3 years.
3. Range pitting – to scarify mat-forming forbs and increase moisture collection and penetration – $65 per acre ranging from $40 to $100 per acre. Longevity – 10 years.

4. In-stream structures – i.e. structures to improve small streams or intermittent water draws. Average – $500 per structure ranging from $150 to $800. Longevity – 8 years.
5. Inter-seeding – Average of $50 per acre – ranging from $30 to $80 per acre. Longevity – 10-15 years.
6. Herding/Moving Livestock, with the owner's or permittee's concurrence – to improve riparian or range conditions – $2000/month average – ranging from $1000 to $3000 per month. Longevity – 1 year but the effects could be up to 2 to 5 years.
7. Fencing (temporary) – such as electrical fencing – Average – $2500 per mile ranging from $1000 to $4000 per mile.
8. Pothole Blasting – Average of $1000 per pothole ranging from $600 to $2000 per pothole.

Appendix G

Bird and Mammal Species Endemic to the Northern Great Plains Region

Avian species endemic to the grasslands of the Great Plains (Samson and Knopf 1996).

Species	Habitat Affinity
Ferruginous hawk	Shortgrass prairie
Mountain plover	Shortgrass prairie
Long-billed curlew	Shortgrass prairie
Sprague’s pipit	Mixed-tallgrass prairie
Cassin’s sparrow	Shortgrass prairie
Baird’s sparrow	Widespread
Lark bunting	Short-mixed-grass prairie
McCown’s longspur	Shortgrass prairie
Chestnut-collared longspur	Short-mixed-grass prairie

Mammalian species endemic to the grasslands of the Great Plains (Samson and Knopf 1996).

Species	Habitat Affinity
White-tailed jack rabbit	Short-mixed-grass prairie
Richardson’s ground squirrel	Short-mixed-grass prairie
Thirteen-lined ground squirrel	Widespread
Black-tailed prairie dog	Short-mixed-grass prairie
Plains pocket gopher	Widespread
Olive-backed pocket mouse	Short-mixed-grass prairie
Plains pocket mouse	Short-mixed-grass prairie
Hispid pocket mouse	Short-mixed-grass prairie
Plains harvest mouse	Short-mixed-grass prairie

Northern grasshopper mouse	Short-mixed-grass prairie
Prairie vole	Tallgrass prairie
Swift fox	Short-mixed-grass prairie
Black-footed ferret	Short-mixed-grass prairie
Spotted skunk	Widespread
Pronghorn	Short-mixed-grass prairie

Appendix H

Species of Greatest Conservation Need in Ecoregions with Moderate or High Potential for Oil and Gas Development *

Sagebrush and shrubland species of greatest conservation need (Wyoming)

Mammals:
Swift Fox
Pygmy Rabbit
White-tailed Prairie Dog
Spotted Ground Squirrel
Wyoming Ground Squirrel
Idaho Pocket Gopher
Plains Pocket Gopher
Great Basin Pocket Mouse
Olive-backed Pocket Mouse
Sagebrush Vole
Spotted Bat

Birds:
Greater Sage-grouse
Columbian Sharp-tailed Grouse
Ferruginous Hawk
Mountain Plover
Long-billed Curlew
Sage Thrasher
Sage Sparrow
Brewer's Sparrow

Amphibians
Great Basin Spadefoot
Great Plains Toad
Plains Spadefoot
Woodhouse’s Toad

Reptiles:
Cliff Tree Lizard
Greater short-horned lizard
Northern Plateau Lizard
Northern Sagebrush Lizard
Bullsnake
Great Basin Gophersnake
Midget Faded Rattlesnake
Plains Black-headed Snake
Prairie Rattlesnake
Rubber Boa
Smooth Green Snake

Grassland species of greatest conservation need (Wyoming)

Mammals:
Swift Fox
Black-tailed Prairie Dog
Black-footed Ferret
Pocket Mouse
Olive-backed Pocket Mouse
Plains Harvest Mouse
Plains Pocket Mouse
Prairie Vole
White-tailed Prairie Dog
Plains Pocket Gopher

Birds:
Long-billed Curlew
Upland Sandpiper
Mountain Plover
Ferruginous Hawk
Short-eared Owl
Burrowing Owl
Dickcissel
Grasshopper Sparrow
Chestnut-collared Longspur
McCown's Longspur
Lark Bunting
Bobolink

Reptiles:
Bullsnake
Common Garter Snake
Eastern Yellow-bellied Hispid Racer
Great Basin Gophersnake
Pale Milksnake
Plains Black-headed Snake
Plains Garter Snake
Plains Hog-nosed Snake
Prairie Rattlesnake
Smooth Green Snake

Amphibians
Plains Spadefoot
Great Plains Toad
Woodhouse’s Toad

Wetland (lentic) and riparian species of greatest conservation need (Wyoming)

Mammals:
River Otter
Moose
Meadow Jumping Mouse
Hayden's Shrew
Preble's Shrew
Pygmy Shrew
Water Shrew
Water Vole
Pallid Bat
Hoary Bat
Silver-haired Bat
Spotted Bat
Townsend's Big-eared Bat
Little Brown Myotis
Long-eared Myotis
Long-legged Myotis
Fringed Myotis
Northern Myotis

Birds:
American Bittern
American White Pelican
Bald Eagle
Barrow's Goldeneye
Black Tern
Black-crowned Night Heron
Canvasback
Caspian Tern
Clark's Grebe
Common Loon
Forster's Tern
Franklin's Gull
Great Blue Heron
Sandhill Crane
Harlequin Duck
Lesser Scaup
Northern Pintail
Swainson's Hawk
Trumpeter Swan
Virginia Rail
Western Grebe
White-faced Ibis
Willow Flycatcher
Yellow-billed Cuckoo

Amphibians
Boreal Chorus Frog
Boreal Toad
Great Basin Spadefoot
Great Plains Toad
Northern Leopard Frog
Plains Spadefoot
Tiger Salamander
Woodhouse's Toad

Reptiles:
Northern Sagebrush Lizard
Western Painted Turtle
Western Spiny Softshell Turtle
Intermountain Wandering Garter Snake
Plains Garter Snake
Plains Hog-nosed Snake
Prairie Rattlesnake

Mollusks and Crustaceans:
California Floater
Crayfish
Freshwater Snails
Jackson Lake Springsnail
Land Snails
Shrimp

Stream (lotic) species of greatest conservation need (Wyoming)

Fish
- Bigmouth Shiner
- Black Bullhead
- Bluehead Sucker
- Burbot
- Central Stoneroller
- Channel Catfish
- Colorado River Cutthroat Trout
- Common Shiner
- Finescale Dace
- Flannelmouth Sucker
- Fathead Chub
- Goldeye
- Iowa Darter
- Kendall Warm Springs Dace
- Lake Chub
- Leatherside Chub
- Mottled Sculpin
- Mountain Sucker
- Mountain Whitefish
- Northern Pearl Dace
- Plains Minnow
- Plains Topminnow
- Quillback
- River Carpsucker
- Roundtail Chub
- Sauger
- Shovelnose Stugeon
- Stonecat
- Sturgeon Chub
- Suckermouth Minnow
- Western Silvery Minnow

Mollusks and Crustaceans
- California Floater
- Crayfish
- Cylindrical Papershell
- Fatmucket
- Freshwater Snails
- Giant Floater
- Jackson Lake Springsnail
- Plain Pocketbook
- Shrimp
- Western Pearlshell
- White Heelsplitter

Amphibians
- Northern Leopard Frog
- Wood Frog

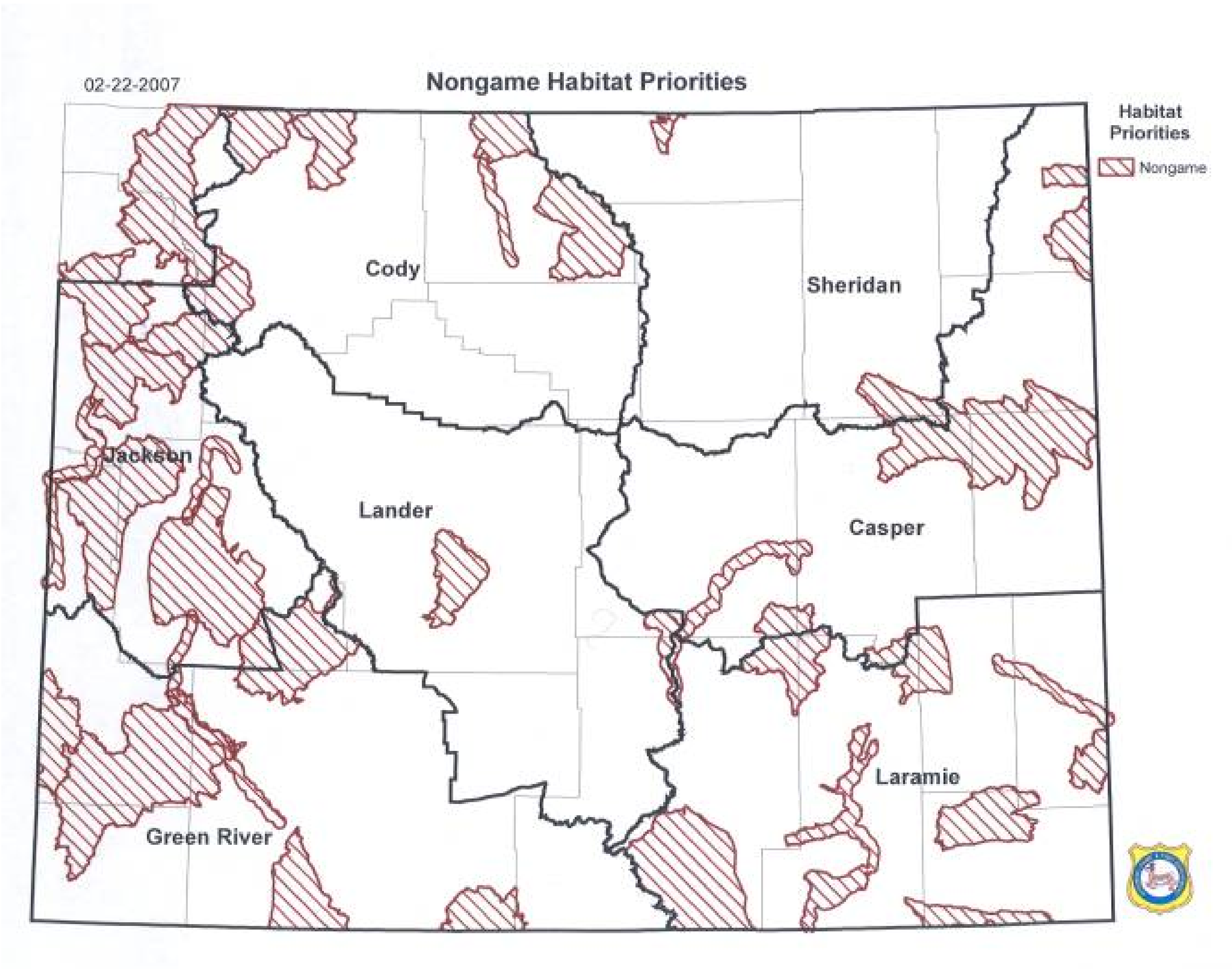
Mammals
- River Otter
- Moose
- Water Shrew
- Water Vole

Birds
- American Bittern
- American White Pelican
- Bald Eagle
- Black-crowned Night Heron
- Common Loon
- Great Blue Heron
- Harlequin Duck
- Trumpeter Swan

* Source: WY Game & Fish Department. 2005. A comprehensive wildlife conservation strategy for Wyoming. Cheyenne, WY. 125pp + appendices.

Appendix I

Nongame Habitat Priority Areas in Wyoming



Appendix J

ANNOTATED BIBLIOGRAPHY

Wildlife Disturbance Literature
Relevant to the Effects of Oil and Gas Development
(organized according to species)

SAGE-GROUSE

Aldridge, C.L. 1998. Status of the sage grouse (*Centrocercus urophasianus*) in Alberta. Alberta Environmental Protection, Wildlife Management Division, and Alberta Conservation Association, Wildlife Status Report No. 13, Edmonton, AB.

The status of sage-grouse in Alberta, Canada was evaluated. Spring lek surveys indicated the sage-grouse population in Alberta had declined 80% over the past few decades. Disturbances contributing to loss of sage-grouse habitat include "agricultural developments, oil and gas exploration, and vehicular traffic." Livestock grazing can reduce habitat suitability, oil and gas development can fragment and reduce suitable habitat, and roadways contribute to fragmentation as well as direct mortality. The effects of disturbances may be compounded during drought conditions.

sort criteria: sage-grouse, oil & gas, roads, agriculture, sagebrush, quantitative, research-based, Canada

Aldridge, C.L., and R.M. Brigham. 2002. Sage-grouse nesting and brood habitat use in southern Canada. Journal of Wildlife Management 66:433-444.

Greater sage-grouse nest and brood habitat use in Alberta, Canada were examined. Although sagebrush habitat is less available in Alberta, nest success (46.2%) in this study was comparable to other areas (normally 30-60%). "Overall cover of sagebrush is considerably lower in Canada (5-11%) compared with sagebrush (*Artemisia* spp.) cover in other areas throughout the range of greater sage-grouse (15-25%)." Nest selection seemed to be based on habitat structure, with taller shrubs available within a 15 m radius but no less that 7.5 m in radius, and taller grass within 15 m of the nest site. Management strategies included protecting and maintaining available sagebrush habitat and enhancing mesic sites to increase forb growth for brood rearing.

sort criteria: sage-grouse, grazing, sagebrush, quantitative, research-based, Canada

Aldridge, C.L., and R.M. Brigham. 2003. Distribution, abundance, and status of greater sage-grouse, *Centrocercus urophasianus*, in Canada. Canadian Field Naturalist 117:25-34.

Distribution, abundance, and status of sage-grouse in Canada were evaluated. An estimated 66 to 92% population decline, in the past 30 years, was based on currently occupied habitat. Low chick survival (18% survived to 50 days of age) was the most probable factor contributing to the decline. Human activity near leks could result in site abandonment, which may reduce breeding success. Oil and gas development, and associated activities led to removal of vegetation, fragmentation of suitable habitat, increased predation, and mortality due to vehicular traffic. Agricultural and livestock operations can also negatively affect sage-grouse populations and habitat. “These threats may be magnified by climate change.”

sort criteria: sage-grouse, oil & gas, human activity, roads, sagebrush, quantitative, research-based, Canada

Aldridge, C. L., and M. S. Boyce. 2007. Linking occurrence and fitness to persistence: a habitat-based approach for endangered greater sage-grouse. Ecological Applications 17:508-526.

Habitat importance was assessed by constructing occurrence and survival models to identify where sage-grouse are likely to nest and raise chicks and to predict landscape features that make habitats risky for nesting and brood rearing. Sage-grouse selected for large (1 km^2) heterogeneous patches of moderate sagebrush cover and avoided anthropogenic edge habitats for nesting. Females with broods selected large patches (1 km^2) of moderate sagebrush cover that contained a patchy distribution of sagebrush. Selection also was strong for mesic sites, but brooding females avoided areas closer to cultivated cropland or with a greater proportion of urban development. Broods occurred closer to individual oil well sites where succulent forbs were abundant, but despite this attraction, risk of chick mortality increased 1.5 times for each additional oil well that was visible within 1 km of a brood location.

sort criteria: sage-grouse, sagebrush, Canada, oil and gas, agriculture, human activity, quantitative, research-based

Barrett, H., E. Campbell, S. Ellis, J. Hanf, R. Masinton, J. Pollet, T. Rich, J. Rose, J. Sadowski, F. Taylor, P. Teensma, J. Dillon, D. Zalunardo, B. Bales, W. Van Dyke, and N. Pustis. 2000. Greater sage-grouse and sagebrush-steppe ecosystems management guidelines (Oregon and Washington). Bureau of Land Management, U.S. Fish and Wildlife Service, U.S. Forest Service, Oregon Department of Fish and Wildlife, and Oregon Department of State Lands.

Management goals and objectives were presented to promote conservation of sage-grouse and their habitats in Oregon and Washington. Conservation goals included: (1) “Protect existing leks and provide secure sage-grouse breeding habitat with minimal disturbance and harassment.” (2) “Promote habitat that supports nesting and early brood-rearing success….” (3) “Promote habitat conditions that support growth and

survival of young sage-grouse in late brood-rearing habitat." (4) "Maintain sagebrush that is accessible to sage-grouse for food and cover during the winter months." Management actions regarding energy and minerals for each conservation management goal include avoiding surface occupancy within 1 km of known or occupied sage-grouse habitat.

<u>sort criteria</u>: sage-grouse, agriculture, oil & gas, livestock grazing, sagebrush, qualitative, prescriptive, Oregon, Washington

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

Positive and negative impacts of livestock grazing on sage-grouse and sage-grouse habitat were evaluated in the western U.S. Timing of use and stocking intensity could have the greatest impact on sagebrush habitat. Late spring grazing could reduce herbaceous cover necessary for concealing nests from predators. Management recommendations included: (1) No sagebrush eradication treatments. (2) Rehabilitation work should focus on reestablishment of mixed vegetation (e.g., native herbs and sagebrush). (3) Seedings should focus on establishment of forbs and subspecies of big sagebrush. (4) No insecticides should be applied to sage-grouse summer habitat. (5) Regulate livestock use around riparian areas. (6) Manage livestock grazing to allow growth of forbs, grasses, and sagebrush.

<u>sort criteria</u>: sage-grouse, agriculture, sagebrush, quantitative, research-based, western U.S.

Beck, J.L., D.L. Mitchell, and B.D. Maxfield. 2003. Changes in the distribution and status of sage-grouse in Utah. Western North American Naturalist 63:203-214.

Distribution and status of sage-grouse in Utah were analyzed to evaluate trends in abundance and productivity. Historically greater sage-grouse in Utah occupied approximately 72,995 km^2. Currently they inhabit 29,208 km^2 or an estimated 41.3% of their potential historical distribution. Potential habitat has declined 60% for greater sage-grouse and 49% of known leks are no longer used. "Long-term trends (1971-2000) in Utah indicate marked declines in all breeding populations, particularly in Gunnison and smaller Greater Sage-Grouse populations."

<u>sort criteria</u>: sage-grouse, agriculture, fragmentation, sagebrush, quantitative, research-based, Utah

Beck, J. L. 2006. Summary of oil and natural gas development impacts on prairie grouse. Unpublished Report., Colorado Division of Wildlife, Grand Junction, Colorado.

Summary based on 11 papers available at that time that reported empirical evidence about impacts on greater sage-grouse and lesser prairie-chickens. Additional research topics are suggested.

sort criteria: sage-grouse, oil & gas, quantitative, research-based

Bohne, J. T. Rinkes, and S. Kilpatrick**.** 2007. Sage-grouse habitat management guidelines for Wyoming. Wyoming Game and Fish Department. Cheyenne, WY. 36 pp.

This document provides an overview of sage-grouse habitat management goals and objectives for Wyoming. It provides an historical background of sage-grouse in Wyoming and specific management goals, including project planning, implementation, and monitoring.

sort criteria: prescriptive, qualitative, sagebrush, sage-grouse, Wyoming

Braun, C.E. 1986. Changes in sage grouse lek counts with advent of surface coal mining. Pages 227-231 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder Co.

Changes in sage-grouse lek counts in relation to surface coal mining were investigated from 1973 through 1983 in northern Colorado. Three mines were in some stage of operation throughout the 10-year period. Active leks "… increased from 1973 through 1979, decreased in 1980, and were stable through 1983." Number of males per lek within 2 km of mines was low from 1974-76, fluctuated from 1977-81, and decreased in 1982 and 1983. Beyond 2 km of mining activity the number of males per lek was stable from 1973-77, increased in 1978, and remained high through 1983. "Number of males counted on leks closest to the 3 active surface coal mines decreased markedly (average=60/lek in 1981; 25 in 1983) with increased mine preparation and mining activity."

sort criteria: sage-grouse, mining, sagebrush, quantitative, research-based, Colorado

Braun, C.E. 1987. Current issues in sage grouse management. Proceedings of the Western Association of Fish and Wildlife Agencies 67:134-144.

Current data on impacts of energy exploration and development to sage-grouse were evaluated. A decrease of males at strutting grounds near oil fields in Colorado was believed to be ". . . related to loss of habitat caused by site preparation and road development." Refineries, pumping stations, gasification plants, etc., also have negative effects on sage-grouse populations. Grouse populations decreased in areas impacted by surface coal mines. ". . . sage-grouse could be temporarily attracted to artificial display areas . . . ” and “. . . once mines ‘mature’ or become inactive, numbers of males on leks adjacent to the mining area increase.”

sort criteria: sage-grouse, oil & gas, sagebrush, quantitative, research-based, western U.S., Canada

Braun, C.E. 1998. Sage grouse declines in western North America: What are the problems? Proceedings of the Western Association of State Fish and Wildlife Agencies 78:139-156.

An evaluation of the causes for the decline of sage-grouse in western North America was based on review of available literature. Since European settlement an overall decrease of 50% was estimated, with a 45-80% decrease since the early 1950s. In spring 1998, 142,000 sage-grouse were estimated to exist range-wide. Although a few studies indicate some recovery of grouse populations after initial energy development, there is no evidence that levels will reach their pre-development size. Up to 50% of sage-grouse habitat is under subdivision development in some counties in Colorado.

sort criteria: sage-grouse, mining, oil & gas, roads, rural subdivisions, quantitative, research-based, western U.S., Canada

Braun, C.E. 2002. A review of sage-grouse habitat needs and sage-grouse management issues for the revision of the BLM’s Pinedale District Resource Management Plan, Wyoming.

Potential negative effects on sage-grouse from energy development in western Wyoming were reviewed, evaluated, and analyzed. Recommendations for monitoring sage-grouse winter use areas, leks, nesting habitat, and brood rearing areas included: (1) “… locating and mapping sage-grouse winter-use areas…” (2) “… surveys of all areas within the proposed project area should be conducted in April 2003 and continuing at 3-year intervals.” (3) “Guidelines should be followed to offer some protection to habitats useful for nesting at distances up to 3 miles form active leks.” (4) “Management that should be in place includes movement of livestock to avoid degradation of plant communities in moist sites and riparian areas…”. Other mitigation measures and monitoring requirements were also presented.

sort criteria: sage-grouse, oil & gas, sagebrush, qualitative, prescriptive, Wyoming, mitigation

Braun, C.E., M.F. Baker, R.L. Eng, J.W. Gaswiler, and M.H. Schroeder. 1976. Conservation committee report on the effects of alteration of sagebrush communities on the associated avifauna. Wilson Bulletin 88:165-171.

Relevant data were reviewed in the mid-1970s to assess the effects reducing sagebrush have on associated avifauna (notably sagebrush obligates). Based on estimates, at least 10% of sagebrush rangelands had been altered in the west at that time. "Development of energy resources, especially coal, will have major impacts on sagebrush communities and dependent avifauna for at least the next 40 years." Recommendations include, confining sagebrush alteration to small areas of 16 ha or less, and scheduling sagebrush control programs to avoid bird nesting seasons.

sort criteria: sage-grouse, sagebrush obligates, non-game birds, sagebrush treatment, sagebrush, quantitative, prescriptive, western U.S.

Braun, C.E., T. Britt, and R.O. Wallestad. 1977. Guidelines for maintenance of sage grouse habitats. Wildlife Society Bulletin 5:99-106.

Guidelines were based upon a review of studies relating to the importance of sagebrush in maintaining population stability of sage-grouse. Effects of sagebrush control were discussed. Guidelines for maintaining sage-grouse habitats include, applying treatment measures in irregular patterns, no treatment in known wintering areas, no control of vegetation within 3 km of leks or on nesting/brood areas, and no treatment of areas with live sagebrush cover less than 20%.

sort criteria: sage-grouse, sagebrush treatment, sagebrush, quantitative, prescriptive, western U.S.

Braun. C.E., O.O. Oedekoven, and C.L. Aldridge. 2002. Oil and gas development in western North America: effects on sagebrush steppe avifauna with particular emphasis on sage grouse. Transactions of the 67th North American Wildlife and Natural Resources Conference 67:337-349.

Effects of energy exploration and development on sagebrush dependent avian species (especially sage-grouse) were examined through a review of available information. In Alberta, Canada the sage-grouse population had declined at least 66% in the last 3 decades. Research in Colorado indicated grouse would continue to use areas near production facilities if suitable sagebrush habitat was available and disturbance was minimal. It was estimated that 5000 acres of sage-grouse habitat had been lost due to (12,000) CBM (coal bed methane) wells in production in northeastern Wyoming. "CBM activity has affected an estimated 28 percent of the known sage-grouse habitats within the project area." Companies are required to avoid disturbing leks during breeding season, locate overhead power lines at least 0.5 mile from breeding or nesting grounds, and reduce compressor noise close to leks, however, all requirements can be waived by federal land management agencies.

sort criteria: sage-grouse, oil & gas, sagebrush, quantitative, research-based, western U.S., Canada

Colenso-Postovit, B. 1981. Suggestions for sage grouse habitat reclamation on surface mines in northeastern Wyoming. M.S. Thesis, University of Wyoming, Laramie.

Characteristics of crucial sage-grouse habitat and seasonal changes in habitat selection were investigated in northeastern Wyoming. Favored habitat consisted of sagebrush with a mean height of 27 cm, and provided 25% cover. Critical components of pre-disturbance habitat were big sagebrush, forbs, and patchiness. Negatively correlated habitat types included: clay slope, playa grassland, and herbicide sprayed sagebrush. The author advocates "… establishment of patchy shrub stands intermixed with grass/forb vegetation."

<u>sort criteria</u>: sage-grouse, mining, sagebrush, quantitative, research-based, Wyoming

Colorado Division of Wildlife. 2008. Colorado Division of Wildlife's Actions to minimize adverse impacts to wildlife resources – Draft – August 18, 2008

The purpose of this document is to enumerate potential actions that may avoid, minimize, and/or mitigate adverse impacts of oil and gas operations on Colorado's wildlife resources.

<u>sort criteria</u>: sage-grouse, wildlife, oil and gas, mitigation, qualitative, research-based, prescriptive, Colorado

Connelly, J.W., W.J. Arthur, and O.D. Markham. 1981. Sage grouse leks on recently disturbed sites. Journal of Range Management 34(2):153-154.

Authors examined the use of recently disturbed sites for strutting by sage-grouse near the Idaho National Engineering Laboratory Site (INEL) in southeastern Idaho. Three of 51 leks on or near the INEL were located on recently disturbed sites (1 burned area and 2 gravel pits) suggesting sage-grouse will strut in man-made clearings if sufficient sagebrush is located nearby, and natural clearings are lacking.

<u>sort criteria</u>: sage-grouse, roads, mining, sagebrush, quantitative, research-based, Idaho

Connelly, J.W., K.P. Reese, R.A. Fischer, and W.L. Wakkinen. 2000. Response of a sage grouse breeding population to fire in southeastern Idaho. Wildlife Society Bulletin 28(1):90-96.

Response of a sage-grouse breeding population to prescribed fire was investigated from 1986 through 1994, in a desert shrub biome in southeastern Idaho. The decline in lek attendance by male sage-grouse was greater following burning (90%) than within

unburned areas (63%). Authors recommend against use of prescribed burning in low-precipitation sagebrush habitats where breeding sage-grouse could be negatively affected.

sort criteria: sage-grouse, sagebrush treatment, sagebrush, quantitative, research-based, Idaho

Connelly, J.W., M.A. Schroeder, A.R. Sands, and C.E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin 28(4):967-985.

Guidelines were based upon a summary of current knowledge of the ecology of sage-grouse. Effects of human-caused and natural disturbances are discussed. Guidelines for population and habitat management include: "Avoid building powerlines and other tall structures that provide perch sites for raptors within 3 km of seasonal habitats . . ., manage breeding habitats to support 15-25% canopy cover of sagebrush . . ., for nonmigratory grouse occupying habitats that are distributed uniformly . . . protect (i.e., do not manipulate) sagebrush and herbaceous understory within 3.2 km of all occupied leks . . ., where sagebrush is not distributed uniformly . . . protect suitable habitats for ≤ 5 km from all occupied leks . . ., for migratory populations, identify and protect breeding habitats within 18 km of leks . . ., adjust timing of energy exploration, development, and construction activity to minimize disturbance . . ., facilities should be located > 3.2 km from active leks . . .."

sort criteria: sage-grouse, oil & gas, mining, sagebrush treatment, quantitative, research-based, western U.S.

Connelly, J.W., K.P. Reese, and M.A. Schroeder. 2003. Monitoring of greater sage-grouse habitats and populations. Publication 979, College of Natural Resources Experiment Station, University of Idaho, Moscow.

Sagebrush habitat assessment and sage-grouse population monitoring were examined to determine guidelines for management decisions. Techniques for assessing habitat, monitoring sage-grouse populations, capturing and marking sage-grouse were described.

sort criteria: sage-grouse, sagebrush, qualitative, prescriptive, western U.S.

Connelly, J.W., S.T. Knick, M.A. Schroeder, and S.J. Stiver. 2004. Conservation assessment of greater sage-grouse and sagebrush habitats. Western Association of Fish and Wildlife Agencies. Unpublished Report. Cheyenne, Wyoming.

The goal of this report was to "present an unbiased and scientific documentation of dominant issues and their effects on greater sage-grouse populations and sagebrush habitats." The chapters most relevant to disturbance are: Chapter 7 00 Sagebrush Ecosystems: Current Status and Trends; Chapter 12 – the Human Footprint in the West: A Large-scale Analysis of Anthropogenic Impacts; and Chapter 13 – Synthesis.

<u>sort criteria</u>: sage-grouse, oil & gas, **fragmentation**, human activity, roads, agriculture, fire, **invasive plants**, sagebrush, quantitative, research-based, western U.S.

Crawford, J.A., R.A. Olson, N.E. West, J.C. Moseley, M.A. Schroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Ecology and management of sage-grouse and sage-grouse habitat. Journal of Range Management 57:2-19.

Current issues in sage-grouse ecology and management were examined. Multiple causative factors were implicated in the present sage-grouse decline. Fire, in high elevation sagebrush habitat, results in invasion of conifers and loss of canopy cover and herbaceous understory. Intensity and timing of livestock grazing are of concern regarding habitat quality. Light to moderate grazing can be beneficial, however heavier use decreases herbaceous cover. Heavy levels of chemical control methods may result in lower habitat quality. Other sagebrush obligate species (e.g., Brewer's sparrow, pygmy rabbit, and sagebrush vole) are also declining.

<u>sort criteria</u>: sage-grouse, sagebrush obligates, sagebrush treatment, fire, livestock grazing, sagebrush, quantitative, research-based, western U.S., Canada

Doherty, K. E., D. E. Naugle, and B. L. Walker. 2008. Sage-grouse winter habitat selection and energy development. Journal of Wildlife Management 72:187-195.

This paper analyzed winter habitat use by comparing aerial locations of radio-marked female sage-grouse to random locations to 1) identify landscape features that influenced sage-grouse habitat selection, 2) quantify the scale at which selection occurred and to 3) assess the effect of coal-bed natural gas (CBNG) development on winter habitat selection in the Powder River Basin. The best model showed that sage-grouse select large expanses of sagebrush with gentle topography and avoid conifer and riparian habitats in winter. The addition of a variable that quantified the average density of CBNG wells improved model fit. After adjusting for sage-grouse habitat selection, birds avoided energy development in otherwise suitable habitat.

sort criteria: sage-grouse, sagebrush, Wyoming, oil and gas, agriculture, human activity, quantitative, research-based

Doherty, M. K. 2007. Mosquito populations in the Powder River Basin, Wyoming: a comparison of natural, agricultural and effluent coal-bed natural gas aquatic habitats. M. S. Thesis. Montana State University, Bozeman, MT, USA.

This study indicated that coal-bed natural gas (CBNG) ponds were significantly increasing the overall population of West Nile virus (WNv) vector mosquitoes in the Powder River Basin, as well as adding to the duration of larval habitats that would normally be ephemeral. Thus the author concluded CBNG ponds and associated habitats may serve to increase pathogen transmission in an otherwise arid ecosystem.

sort criteria: sage-grouse, Wyoming, **disease**, oil and gas, quantitative, research-based

Eng, R.L., E.J. Pitcher, S.J. Scott, and R.J. Greene. 1979. Minimizing the effect of surface coal mining on a sage grouse population by a directed shift of breeding activities. Pages 464-468 in G.A. Swanson, ed., The mitigation symposium: a national workshop on mitigating losses on fish and wildlife habitats. U.S. Department of Agriculture, Forest Service General Technical Report. RM-65.

In southern Montana, an artificial lek was created 2 miles from an area scheduled for surface coal mining. The experimental lek was created using decoys and a sound system producing sounds of an active lek. The first year 7 cocks and 8 hens attended, with 16 cocks and 18 hens attending the second year.

sort criteria: sage-grouse, mining, sagebrush, mitigation, quantitative, research-based, Montana

Eng, R.L., and P. Schladweiler. 1972. Sage grouse winter movements and habitat use in central Montana. Journal of Wildlife Management 36(1):141-146.

Habitat use and movements of sage-grouse were examined in central Montana during the 1965-66 and 1966-67 winters. Eighty-two percent of the grouse observed were located in dense sagebrush stands exceeding 20% canopy coverage. Grouse used sagebrush canopy coverage exceeding 20% significantly more than areas of less than 20% canopy. This indicated a preference for dense stands of sagebrush. Authors concluded removal of large expanses of dense sagebrush would greatly reduce sage-grouse populations.

sort criteria: sage-grouse, sagebrush treatment, sagebrush, quantitative, research-based, Montana

Hayden-Wing Associates. 1991b. Review and evaluation of the effects of geophysical exploration on some wildlife species in Wyoming. Unpublished Report for Geophysical Acquisition Workshop. Laramie, Wy.

A review of previous studies on the effects of geophysical exploration on pronghorn, mule deer, elk, raptors, and sage-grouse was presented. The information examined indicated that big game are temporarily affected by seismic exploration causing increased energy expenditure and utilization of sub-optimal habitats. Characteristics for evaluating potential sage-grouse nesting habitat in relation to proposed oil and gas development included: "1) distance relationships to leks, 2) presence, distance, and characteristics of existing disturbances, 3) characteristics of shrubs and vegetation that could serve in nest concealment and nest-site selection, and 4) distance to water and to potential brood-rearing areas." Mitigation strategies for protecting raptor-nesting habitat were also presented.

sort criteria: sage-grouse, raptors, pronghorn, mule deer, elk, oil & gas, seismic exploration, sagebrush, quantitative, research-based, Wyoming

Hayden-Wing, L.D., D.B. Costain, J.L. Hull, M.R. Jackson, and T.B. Segerstrom. 1986. Movement patterns and habitat affinities of a sage grouse population in northeastern Wyoming. Pages 207-226 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Potential impacts from mining on a sage-grouse population were examined in northeastern Wyoming. Nests were observed from 0.71 miles to 3.25 miles from a lek on the proposed mine site. Vegetation coverage averaged 71% with big sagebrush the dominant shrub type. "Results suggest that sage-grouse can survive the extensive mining development in the Powder River Basin if adequate habitats or refugia are maintained at the regional or inter-mine level."

sort criteria: sage-grouse, mining, sagebrush, quantitative, research-based, Wyoming.

Hemstrom, M.A., M.J. Wisdom, W.J. Hann, M.M. Rowland, B.C. Wales, and R.A. Gravenmier. 2002. Sagebrush-steppe vegetation dynamics and restoration potential in the Interior Columbia Basin, U.S.A. Conservation Biology 16:1243-1255.

Changes in the amount and quality of sage-grouse habitat on U.S. Forest Service (FS) and Bureau of Land Management (BLM) lands were evaluated and the dynamics and restoration of sagebrush habitats were modeled. Changes from historical to current conditions were estimated as were changes from current conditions to those projected 100 years in the future (taking into account the proposed management plan and two restoration scenarios). "Under the two scenarios," (50% and 100% reduction of livestock grazing) "the amount of FS-BLM habitat for sage-grouse within treated areas declined by 17-19% 100 years in the future compared with the current period, but was 10-14% higher than the 100-year projection under proposed management."

sort criteria: sage-grouse, grazing, sagebrush treatment, quantitative, research-based, western U.S.

Holloran, M.J. 2005. Greater sage-grouse (*Centrocercus urophasianus*) population response to natural has field development in western Wyoming. PhD Dissertation. University of Wyoming, Laramie. 223 pp.

Research was conducted in the Upper Green River Basin to determine the effects of energy development on sage-grouse populations. Development within 3-5 km of a lek will result in population decline. Main haul roads within 3 km of lek caused reduced attendance. Females avoided high density well areas for nesting. The estimated extinction time for leks present before gas field development is 19 years. A well density of 1 well per section within 3 km of a lek could reduce impacts. Sound muffling and decreased traffic volume could also help. Suitable breeding habitat within 5 km of a lek should be protected from development.

sort criteria: noise, oil and gas, prescriptive, quantitative, sage-grouse, Wyoming

Holloran, M. J., and S. H. Anderson. 2005. Spatial distribution of greater sage-grouse nests in relatively contiguous sagebrush habitats. Condor 107:742-752.

Lek to nest distances from various Wyoming studies were analyzed to determine that 64% of sage-grouse nests were located within 5km of leks. Lek to nest distance was greater for successful nests. Closely spaced nests tended to experience lower hatching success. Consecutive year nesting site location suggested nesting site-area fidelity. Nesting hens located further than 5km could be important for population viability. Authors recommended conserving nesting habitat regardless of lek locations.

sort criteria: sage-grouse, sagebrush, Wyoming, human activity, quantitative, prescriptive, research-based

Holloran, M. J., R. C. Kaiser, and W. A. Hubert. 2007. Population response of yearling greater sage-grouse to the infrastructure of natural gas fields in southwestern Wyoming. Completion report, U. S. Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, Laramie, Wyoming.

[*and*]

Holloran, M. J., R. C. Kaiser, and W. A. Hubert. 2008. Yearling greater sage-grouse response to energy development in southwestern Wyoming. Journal of Wildlife Management: In review.

This study was a continuation of the Kaiser (2006) study; data collected during both studies were combined in the analyses. Yearling males avoided leks near the infrastructure of natural gas wells when establishing breeding territories. Additionally,

yearling males reared in areas where infrastructure was present established breeding territories less often, were observed on leks during the breeding period less often, and had lower annual survival rates compared to yearling males reared in areas with no infrastructure. Yearling females avoided nesting within 950 m of the infrastructure of natural gas fields, and yearling females reared in areas where infrastructure was present had lower annual survival rates than females reared in areas with no infrastructure. The authors conclude that development of natural gas fields resulted in displacement and lower annual survival of yearling males and females, and lower fecundity of yearling males. Maintaining undeveloped areas near natural gas fields may be an effective strategy to sustain greater sage-grouse populations being affected by such developments.

<u>sort criteria:</u> sage-grouse, Wyoming, oil and gas, human activity, roads, quantitative, research-based

Hupp, J.W., and C.E. Braun. 1989. Topographic distribution of sage grouse foraging in winter. Journal of Wildlife Management 53(3):823-829.

Topographic variations in snow depth and sagebrush structure were evaluated to determine how they influence distribution of sage-grouse foraging in southern Colorado. Southwest slopes and drainages were used proportionally more than other topographic areas (e.g. northeast slopes, low flat areas, or high flat areas). “Between 46 and 75% of foraging occurred in drainages and on southwest slopes.” This distribution of foraging was influenced by sagebrush height relative to snow depth. Maintenance of sagebrush in drainages and southwest slopes should be stressed to assure quality forage is available for sage-grouse.

<u>sort criteria</u>: sage-grouse, sagebrush treatment, sagebrush, quantitative, research-based, Colorado

Johnson, K.H., and C.E. Braun. 1999. Viability and conservation of an exploited sage grouse population. Conservation Biology 13:77-83.

The viability of the sage-grouse population of North Park, Colorado was evaluated to determine the effects of hunting pressure and habitat degradation. Adult and juvenile survival and reproduction were described as the most limiting demographic factors. However, with appropriate habitat manipulation measures (e.g., increasing sagebrush canopy cover to 15-20%) juvenile and adult survival could be enhanced and population viability conserved without reducing harvest by hunters.

<u>sort criteria</u>: sage-grouse, grazing, sagebrush, quantitative, research-based, Colorado

Kaiser, R. C. 2006. Recruitment by greater sage-grouse in association with natural gas development in western Wyoming. Thesis, University of Wyoming, Laramie, Wyoming. 91 pp.

This work continued that of Holloran (2005) and sought to further investigate the role of yearling recruitment to explain sage-grouse declines associated with natural gas development. The number of visits to leks by males decreased as distance inside the area of development influence increased, suggesting that yearlings from leks situated further inside natural gas development were displaced to those nearer the periphery of the gas field. Recruitment of males to leks also declined with distance inside the area of influence, indicating a higher likelihood of lek loss near the center of development. Thirty-four of 54 (63%) adult females bred on the same lek from which they were captured the previous spring. Eight of 10 individuals known to have bred somewhere other than their previous year's lek-of-capture bred on leks located further from the center of the gas field, suggesting that adult females were changing their behavior to avoid development. Small sample sizes limited the ability to analyze and reliably interpret other results.

<u>sort criteria:</u> sage-grouse, Wyoming, human activity, oil and gas, roads, quantitative, research-based

Klott, J.H., and F.G. Lindzey. 1990. Brood habitats of sympatric sage grouse and Columbian sharp-tailed grouse in Wyoming. Journal of Wildlife Management 54:84-88.

A comparison of habitats in south-central Wyoming used by sage-grouse and Columbian sharp-tailed grouse was presented. "Sage-grouse broods occurred most often (68%) in sagebrush (*Artemisia* spp.)-grass and sagebrush-bitterbrush (*Purshia tridentata*) habitats, whereas sharp-tailed grouse broods occurred most often (73%) in mountain shrub and sagebrush-snowberry (*Symphoicarpos oreophilus*) habitats." No difference was found between sage-grouse and sharp-tailed grouse brood sites in regard to total shrub cover, sagebrush cover, or sagebrush canopy. Management suggestions included constraining vegetation treatments to narrow strips (< 30 m) and reduction of livestock grazing.

<u>sort criteria</u>: sage-grouse, sharp-tailed grouse, sagebrush treatment, sagebrush, quantitative, research-based, Wyoming

Knick, S.T., D.S. Dobkin, J.T. Rotenberry, M.A. Schroeder, W.M. Vander Haegen and C. van Riper III. 2003. Teetering on the edge or too late? Conservation and research issues for avifauna of sagebrush habitats. Condor 105:611-634.

Oil and gas wells in Wyoming are located predominately in ecosystems dominated by sagebrush. Road networks, pipelines, and powerline transmission corridors associated with oil and gas development cause habitat fragmentation. Density of sagebrush-obligate birds was 50% lower within 100m of roads used for natural gas development than at greater distances.

sort criteria: sage-grouse, sagebrush obligates, oil & gas, roads, sagebrush, quantitative, research-based, Wyoming

sage-grouse, sagebrush, quantitative, research-based, California

Krementz, D.G., and J.R. Sauer. 1982. Avian communities on partially reclaimed mine spoils in south-central Wyoming. Journal of Wildlife Management 46:761-765.

Differences in avian community structure between a reclaimed mine site and a native shrub-steppe were investigated in south-central Wyoming. Composition, abundance, and diversity between sites were likely due to variation in habitat structure. Foliage-gleaning omnivores were virtually absent from the reclaimed site, however ground-gleaning omnivores and insectivores were common. "The absence of nesting by all species except the horned lark indicates that the reclamation treatments did not fulfill nesting requirements of northern desert shrub-steppe avifauna." Authors suggest "… future reclamation plans should emphasize prompt reintroduction of sagebrush and other species that provide nesting habitat."

sort criteria: sage-grouse, raptors, non-game birds, mining, sagebrush, quantitative, research-based, Wyoming

Kuipers, J.L. 2004. Grazing system and linear corridor influences on greater sage-grouse (*Centrocercus urophasianus*) habitat selection and productivity. M.S. Thesis, University of Wyoming, Laramie.

The influence of linear corridors on sage-grouse nest selection and success was examined in central Wyoming. Livestock and wildlife trails within 25 m decreased nest success, had no affect at 50 m, and increased nest success at 100 m. "Maintained roads and 2-tracks had positive influences on nest success at 100 m." Two-track roads increased the likelihood of nest selection at 25 m, as did trails at 50 m. However, 2-tracks decreased the likelihood of nest selection at 100 m. Nest success could be negatively affected by livestock trailing, however nest success was not reduced due to 2-track or maintained roads.

sort criteria: sage-grouse, roads, sagebrush, quantitative, research-based, Wyoming

Lyon, A.G. 2000. The potential effects of natural gas development on sage grouse (*Centrocercus urophasianus*) near Pinedale, Wyoming. M.S. Thesis, University of Wyoming, Laramie.

Effects of natural gas and oil development on sage-grouse were investigated on the Pinedale Mesa in northwestern Wyoming. The limiting factor in sage-grouse population stability appeared to be extreme early brood survival. Forty percent of broods from disturbed areas survived the first 3 weeks, while 50% from undisturbed sites survived through early brood rearing. Ninety-one percent of hens from undisturbed leks nested within 3 km of the capture lek, while 74% from disturbed leks nested > 3 km from the lek. Average distance from a road to a nest for disturbed hens was 726 m and 2360 m for undisturbed hens. Nest initiation rates were 55 and 82% for disturbed and undisturbed hens respectively. Author suggests "restricting development activities during hours of lek attendance could reduce negative impacts to breeding grouse."

sort criteria: sage-grouse, oil & gas, sagebrush, quantitative, research-based, Wyoming

Lyon, A. G., and S. H. Anderson. 2003. Potential gas development impacts on sage grouse initiation and movement. Wildlife Society Bulletin 31(2):486-491.

This study was conducted on the Pinedale Mesa in an area dominated by sagebrush and high desert vegetation. Forty-eight hens were captured and radio-collared from leks classified as disturbed (≤ 3 km of natural gas development) and undisturbed (> 3 km from gas development). On average hens that bred on disturbed leks, and initiated nests, selected sites 4,116 m from the lek. Hens from undisturbed leks moved 2,090 m to nest sites. Hens from disturbed and undisturbed leks initiated nests 65% and 89% respectively. Hatching success did not differ between groups. Light road traffic (1-12 vehicles per day) seemed to be a factor causing hens to nest farther from the capture lek, however habitat factors did not appear to influence hen movement. Nominal traffic disturbance (1-12 vehicles/day) could reduce nest-initiation rates and increase distance of nest-site selection.

sort criteria: sage-grouse, oil & gas, roads, sagebrush, quantitative, research-based, Wyoming

Manville, A.M., II. 2004. Prairie grouse leks and wind turbines: U.S. Fish and Wildlife Service justification for a 5-mile buffer from leks; additional grassland songbird recommendations. Division of Migratory Bird Management, USFWS, Arlington, VA, peer-reviewed briefing paper. 17 pp.

This briefing paper provides justification for the Service's recommendation for a 5-mile buffer from occupied prairie grouse leks (prairie chickens, sharp-tailed grouse and sage-grouse).

sort criteria: sage-grouse, sage-grouse, sharp-tailed grouse, **wind turbines**, roads, powerlines, human activity, fragmentation, qualitative, research-based

Martin, N.S. 1970. Sagebrush control related to habitat and sage grouse occurrences. Journal of Wildlife Management 34(2):313-320.

Effects on sage-grouse from chemical treatment of sagebrush were investigated on a 1900-acre study area during the summers of 1962 through 1964 in Montana. Ninety-seven percent of the sagebrush was dead in the sprayed area and only 4% of observed sage-grouse were located in that sector. The numbers of grouse observed in the sprayed and unsprayed areas were related to vegetation composition (favored food was more abundant in the unsprayed area).

sort criteria: sage-grouse, sagebrush treatment, sagebrush, quantitative, research-based, Montana

Martin, N.S. 1976. Life history and habitat requirements of sage grouse in relation to sagebrush treatment. Proceedings of the Western Association of State Game and Fish Commissioners 56:289-294.

Habitat requirements for sage-grouse were investigated in central Montana. Observations of hens occurred 75% of the time on the strutting ground where the bird was tagged. Canopy coverage of 20-50% was noted at 80% of feeding and loafing sites. ". . . 68 percent of all radio marked hens nested within one and five tenths miles of a strutting ground." Sagebrush was the nesting cover for all nests, and 20-30% canopy, averaging 15.9 inches in height was most commonly selected. On treated areas numbers of male grouse increased 28% from pre-to post-treatment years, however male grouse numbers increased 323% during the same period on non-treated areas.

sort criteria: sage-grouse, sagebrush treatment, sagebrush, quantitative, research-based, Montana

McAdoo, J.K., G.A. Acordagoita, and C.R. Aarstad. 1989. Reducing impacts of hard-rock mining on wildlife in northern Nevada. Pages 95-97 in Proceedings IV: Issues and Technology in the Management of Impacted Wildlife. Thorne Ecological Institute, Boulder, Co.

Reduction of wildlife impacts from mineral exploration in northern Nevada was examined. Mitigation actions included: minimizing erosion through the use of sediment catchment basins, silt screens, and seeding of road cuts and fill slopes, minimizing construction activity near raptor nests, avoiding aspen wildlife habitat, using culverts for crossing trout streams, and monitoring ground and surface water. Offsite mitigation and concurrent reclamation efforts were also evaluated.

sort criteria: wildlife, mule deer, sage-grouse, raptors, mining, sagebrush, riparian, qualitative, prescriptive, mitigation, Nevada

Montana Fish, Wildlife and Parks. 2007. Agency Position – Sage-Grouse Conservation and Energy Development May 2007. Montana Fish, Wildlife and Parks, Helena.

This position statement acknowledged recent studies that demonstrated some conservation actions outlined in Montana Sage-Grouse Work Group (2004) were inadequate to effectively mitigate intensive oil and gas development at the level of intensity observed in the studies. The statement summarizes recent findings that assess oil and gas resource development and the documented impacts to sage-grouse populations and provides new conservation strategies.

sort criteria: Montana, oil and gas, research based, prescriptive, sage-grouse

Montana Sage-grouse Work Group. 2004. Management plan and conservation strategies for sage-grouse in Montana. 116 pp. + appendices.

This document provides an overview of sage-grouse habitat management goals and objectives for Montana. Concerning energy development, there shall be no surface occupancy within ¼ mile of a lek. There will be no surface use within 2 miles of a lek from 1 March – 15 June and activity should be restricted from 4-8 a.m. and 7-10 p.m. There shall be no surface disturbance in designated winter habitat from 1 December – 31 March.

sort criteria: Montana, human activity, oil and gas, prescriptive, sage-grouse

Naugle, D. E., C. L. Aldridge, B. L. Walker, T. E. Cornish, B. J. Moynahan, M. J. Holloran, K. Brown, G. D. Johnson, E. T. Schmidtmann, R. T. Mayer, C. Y. Kato, M. R. Matchett, T. J. Christiansen, W. E. Cook, T. Creekmore, R. D. Falise, E. T. Rinkes, and M. S. Boyce. 2004. West Nile virus: pending crisis for greater sage-grouse. Ecology Letters 7:704-713.

This paper documented the first reported cases of West Nile virus (WNv) in sage-grouse. WNv reduced late-summer survival by an average of 25% in four radio-collared populations. No antibodies were detected in blood serum suggesting a lack of resistance. Concern expressed about man-made water sources attracting sage-grouse and exposing them to the WNv vector mosquito Culex tarsalis.

sort criteria: sage-grouse, Wyoming, Montana, Canada, **disease**, human activity, quantitative, research-based

Naugle, D. E., C. L. Aldridge, B. L. Walker, K. E. Doherty, M. R. Matchett, J. McIntosh, T. E. Cornish, M. S. Boyce. 2005. West Nile virus and sage-grouse: what more have we learned? Wildlife Society Bulletin: 33:616-623.

This paper was a follow-up to Naugle et al. 2004. It documented the continued spread of West Nile virus (WNv) across the western U.S. Female survival in late summer was 10% lower at study sites with WNv than those without. No evidence of resistance was detected. WNv prevalence decreased in 2004 compared to 2003 with evidence suggesting unseasonably cool temperatures in 2004 delayed or reduced mosquito projection.

<u>sort criteria:</u> sage-grouse, Wyoming, Montana, Western U.S., Canada, **disease**, human activity, quantitative, research-based

Naugle, D. E., K. E. Doherty, B. L. Walker, M. H. Holloran and H. E. Copeland. 2008. Cumulative impacts of energy development on greater sage-grouse in western North America. Studies in Avian Biology: In press.

This paper quantifies the physical change in the human footprint that results from development and synthesizes the literature to date regarding the biological response of sage-grouse to development. Results indicate landscapes with ranching as the primary land use accumulate fewer human features that those that also contain tillage agriculture, energy development or both. Tillage agriculture into ranch lands removed sagebrush habitat and increased road density (33%), power lines (59%) and water sources (167%). Energy development on ranch lands doubled the road density and power lines and the number of ponds quadrupled. Where ranch land contained both tillage agriculture and energy development, 70% of the landscape was within 100 m of a human feature and 85% were within 200 m. The number of producing oil and gas wells has tripled from the 1980s to present within the eastern range of sage-grouse. Exploration and development have been authorized on 44% of the federal mineral estate within the range of sage-grouse in Management Zones I and II. The literature synthesis resulted in the conclusion that studies have indicated a general and negative response by sage-grouse to three different types of oil and gas development, and that conventional well densities far exceed the species' threshold of tolerance.

<u>sort criteria:</u> sage-grouse, sagebrush, oil and gas, agriculture, human activity, powerlines, roads, quantitative, research-based

Nelle, P.J., K.P. Reese, and J.W. Connelly. 2000. Long-term effects of fire on sage-grouse habitat. Journal of Range Management 53:586-591.

The long-term impact of fire on sage-grouse nesting and brood-rearing habitats in southeastern Idaho was examined. Fourteen years post-burn mean sagebrush canopy cover was less than ½ that of unburned areas while mean sagebrush height was 69% of unburned brush. “Eighty-six percent of transects from 36-year old burns were clustered with unburned vegetation, suggesting that 36 years is sufficient time to recover.” The effects of burning on nesting and brood-rearing sites could be harmful to sage-grouse populations due to sub-optimal vegetative conditions.

<u>sort criteria</u>: sage-grouse, fire, sagebrush, quantitative, research-based, Idaho

Oyler-McCance, S.J., K.P. Burnham, and C.E. Braun. 2001. Influences of changes in sagebrush on Gunnison sage grouse in southwestern Colorado. Southwestern Naturalist 46:323-331.

Changes (between the 1950s and 1990s) in sagebrush-dominated areas in southwestern Colorado were compared using low-level aerial photographs. A 20% loss (approximately 155,673 ha) of sagebrush-dominated areas between 1958 and 1993 was documented. Thirty-seven percent of sampled plots showed substantial fragmentation of sagebrush habitats, which was often the result of road development. Suggestions for future protection of sage-grouse included assessing management and conservation strategies in regard to “…land mitigation, habitat restoration, connecting fragmented habitats, and reintroduction of sagebrush obligates into previously occupied habitats.”

<u>sort criteria</u>: sage-grouse, sagebrush obligates, fragmentation, roads, sagebrush, quantitative, research-based, Colorado

Paige, C., and S.A. Ritter. 1999. Birds in a sagebrush sea: managing sagebrush habitats for bird communities. Partners in Flight Western Working Group, Boise, ID.

Recommendations are presented for land management practices to help bird communities in sagebrush habitats. Shrubland and shrub-dependent bird species have declined 63% across the U.S. “Sagebrush obligates include the sage sparrow, Brewer’s sparrow, sage thrasher, sage-grouse, pygmy rabbit, sagebrush vole, sagebrush lizard, and pronghorn. Management guidelines are classified using different scales (landscape, stand, and patch). The level of effects on birds ranges from populations to individuals and pairs. A summary of bird management goals and recommendations is provided.

<u>sort criteria</u>: sage-grouse, sharp-tailed grouse, raptors, sagebrush obligates, non-game birds, oil & gas, agriculture, human activity, sagebrush, quantitative, prescriptive, western U.S.

Phillips, R.L., D.E. Biggins, and A.B. Hoag. 1986. Coal surface mining and selected wildlife – a 10-year case study near Decker, Montana. Pages 235-245 <u>in</u> Proceedings

II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Mule deer, pronghorn, sage-grouse, and golden eagles were monitored to determine their responses to mining activities in southeastern Montana and northern Wyoming. “Mule deer and pronghorn populations thrived throughout the study period despite increasing mining activity and human disturbance.” Sage-grouse habitat was lost, but mitigation efforts (e.g., relocation of a lek) seemed to be successful. Golden eagle numbers remained relatively stable. Four nesting pairs near active mines had a 10-year nesting success of 67.5% compared to 56.6% for pairs nesting elsewhere on the study area. “If the primary post mining land use is wildlife, permanent reclamation can be designed to maximize the mixture of plant species and thereby provide greater habitat diversity than native prairie.”

sort criteria: sage-grouse, mule deer, pronghorn, raptors, mining, sagebrush, quantitative, research-based, Wyoming, Montana, mitigation

Remington, T. E., and C. E. Braun. 1991. How surface coal mining affects sage grouse, North Park, Colorado. Proceedings, issues and technology in the management of impacted western wildlife. Thorne Ecological Institute 5:128-132.

Trends in numbers of male sage-grouse on leks in a surface coal mining area and in a paired control area were observed before and after the advent of mining. Numbers of males on leks closest to mining activity declined precipitously but overall the study did not show an effect of mining on population trend ($P \geq 0.05$). It was concluded the mining activity altered distribution of breeding grouse.

sort criteria: sage-grouse, sagebrush, mining, quantitative, research-based, Colorado

Rowland, M. 2004. Effects of management practices on grassland birds: greater sage-grouse. Northern Prairie Wildlife Research Center, Jamestown, N.D.

Information from over 800 sources was used to evaluate habitat requirements and effects of habitat management on greater sage-grouse. “Keys to management are maintaining expansive stands of sagebrush (*Artemisia* spp.), especially varieties of big sagebrush (*A. tridentata*), with abundant forbs in the understory, particularly during spring; undisturbed and relatively open sites for leks; and healthy perennial grass and forb stands intermixed with sagebrush for brood rearing.” Management recommendations include: minimize human disturbance (e.g., traffic and recreation), avoid construction of powerlines within 3 km of seasonal habitats, protect lek sites and adjacent habitat up to 18 km around lek, and reduce or avoid resource-extraction development.

sort criteria: sage-grouse, oil & gas, human activity, roads, agriculture, sagebrush treatment, sagebrush, quantitative, research-based, western U.S.

Slater, S. J. and J. P. Smith. 2008. Effectiveness of raptor perch deterrents on an electrical transmission line in southwestern Wyoming. Final report prepared for USDI BLM Kemmerer Field Office. Hawkwatch International. Salt Lake City, UT.

Using driving surveys, behavioral observation surveys and prey-remains surveys the authors demonstrated raptor and raven activity was significantly lower on lines fitted with deterrents when compared to nearby control lines (no deterrent devices); however, perching was not entirely eliminated. Forty-two raptors and ravens were observed on the deterrent line compared to 551 observations on the control line. Similar results were reported for the prey-remains surveys and behavioral observation surveys.

sort criteria: sage-grouse, powerlines, raptors, quantitative, prescriptive, Wyoming

State Wildlife Agencies' Ad Hoc Committee for Sage-Grouse and Oil and Gas Development. 2008. Using the best available science to coordinate conservation actions that benefit greater sage-grouse across states affected by oil and gas development in Management Zones I-II (Colorado, Montana, North Dakota, South Dakota, Utah and Wyoming). Unpublished report. Colorado Division of Wildlife, Denver; Montana Fish, Wildlife and Parks, Helena; North Dakota Game and Fish Department, Bismarck; Utah Division of Wildlife Resources, Salt Lake City; Wyoming Game and Fish Department, Cheyenne.

This document is the product of a meeting of representatives from state wildlife agencies from the major sage-grouse and energy producing states to better understand the application of most recent peer-reviewed science within the context of oil and gas development and coordinate and compare implementation of conservation actions utilizing that information. Researchers having the most recently peer reviewed and published articles concerning sage-grouse and oil and gas development presented their findings and answered questions. The goal of the meeting was to reach agreement on the conservation concepts and strategies related to oil and gas development that are supported by current published peer-reviewed and unpublished literature. If implemented, these actions may enhance the likelihood that sage-grouse populations will maintain their current distribution and abundance, thereby avoiding the need to list sage-grouse under the federal Endangered Species Act.

sort criteria: sage-grouse, sagebrush, oil and gas, quantitative, prescriptive, North Dakota, South Dakota, Montana, Colorado, Utah, Wyoming

Strickland, D. 1999. Petroleum development versus wildlife in the overthrust. Transactions of the North American Wildlife and Natural Resources Conference 64:28-35.

Controversies concerning impacts to wildlife from petroleum development in Wyoming are discussed. To date (1999) an estimated 2,100 producing oil and gas wells are located in southwestern Wyoming, with a large potential for further development. The BLM (Bureau of Land Management) estimates an additional 4,837 wells will be developed. Since 1984, 24,112 acres of habitat has been lost due to oil and gas development, and an additional 53,000 acres would be disturbed by future development from direct impacts (e.g., roads, pipelines, etc.). "The potential area of direct and indirect disturbance is 2.7 million acres, or approximately 16 percent of southwestern Wyoming." Author suggests the BLM modify its leasing strategy using long-range and strategic planning with an adaptive approach.

sort criteria: elk, bighorn sheep, moose, pronghorn, mule deer, sage grouse, oil & gas, sagebrush, qualitative, prescriptive, Wyoming

Stiver, S. J., A. D. Apa, J. R. Bohne, S. D. Bunnell, P. A. Deibert, S. C. Gardner, M. A. Hilliard, C. W. McCarthy, and M. A. Schroeder. 2006. Greater sage-grouse comprehensive conservation strategy. Western Association of Fish and Wildlife Agencies. Unpublished report. Cheyenne, WY.

This document outlines processes and strategies designed to achieve the goal of maintaining and enhancing sage-grouse populations and distributions by protecting and improving sagebrush habitats.

sort criteria: sage-grouse, sagebrush, qualitative, prescriptive, western U.S.

Sveum, C.M., W.D. Edge, and J.A. Crawford. 1998. Nesting habitat selection by sage grouse in south-central Washington. Journal of Range Management 51:265-269.

Sage-grouse nesting habitat characteristics were examined in south-central Washington. "Nest habitat was characterized by greater shrub cover, shrub height, vertical cover height, residual cover, and litter than at random locations." Big sagebrush/bunchgrass was selected 71% of the time for nest sites. Successful nest sites had greater residual cover than depredated nest areas. Two factors distinguishing successful from depredated nests were tall grass cover and medium height (40-80 cm) shrub cover. Management objectives should include "…maintaining a balance between shrub and herbaceous understory" and "increasing native perennial bunchgrasses and forbs."

sort criteria: sage-grouse, roads, fire, grazing, sagebrush treatment, sagebrush, quantitative, research-based, Washington

Swenson, J.E., C.A. Simmons, and C.D. Eustace. 1987. Decrease of sage grouse (*Centrocercus urophasianus*) after ploughing of sagebrush steppe. Biological Conservation 41:125-132.

Authors studied the effects plowing sagebrush steppe had on sage-grouse in south-central
Montana. The project duration was 1973 to 1984. In the study area, 30% of sage-grouse winter habitat had been plowed by 1984. Sixteen percent of this area was utilized for farming. Lek attendance by males declined 73% from 1973 to 1984 (from 241 to 65 cocks). Although a relatively small area was plowed, it represented a large portion of sage-grouse wintering habitat. Plowing, as well as other land uses (e.g. mining) that destroy relatively small areas of important winter habitat could have broad effects on sage-grouse populations.

<u>sort criteria</u>: sage-grouse, sagebrush treatment, sagebrush, quantitative, research-based, Montana

USDI - Bureau of Land Management. 2000a. Management guidelines for sage- grouse and sagebrush ecosystems in Nevada. Nevada BLM State Office, Reno. 22 pp + appendices.

This document provides an overview of sage-grouse habitat management goals and objectives for Nevada. Concerning energy development, the BLM wants to avoid permitting facilities and activities within 2 miles of leks or .6 miles from nesting, brood-rearing, and winter habitat. All disturbed areas need to be reclaimed with appropriate seed mixtures, and BLM will consider off-site mitigation. Operators will be notified if exploration is within 2 miles of known habitat and recommendations will be made to avoid impacts.

<u>sort criteria</u>: mitigation, Nevada, oil and gas, prescriptive, sagebrush, sage-grouse

USDI - Bureau of Land Management. 2000b. Draft interim sage grouse guidelines for Oregon and Washington. Oregon BLM State Office. Portland, OR. 43 pp.

This document provides an overview of sage-grouse habitat management goals and objectives for Oregon and Washington. Concerning energy development, the BLM wants to avoid construction of facilities within ¼ miles of leks, avoid surface occupancy within .6 miles of leks, and offsite mitigation will be considered on a case-by-case basis.

<u>sort criteria</u>: mitigation, oil and gas, Oregon, prescriptive, sagebrush, sage-grouse, Washington

USDI - Bureau of Land Management 2004a. BLM national sage-grouse habitat conservation strategy.

A framework to support the development and implementation of BLM state-level sage-grouse habitat strategies was presented. Public land uses, such as energy development and recreation, have intensified habitat loss, degradation, and fragmentation. "Over 47% of suitable habitat in the historical range of sage-grouse has been lost." Human activity, noise, surface disturbances (i.e., construction activities), and mineral extraction activities all contribute to fragmentation, degradation, and loss of habitat. The BLM's vision, goals, strategies, and actions were presented.

<u>sort criteria</u>: sage-grouse, sagebrush, human activity, fragmentation, qualitative, prescriptive, western U.S.

USDI - Bureau of Land Management. 2004b. Instruction Memorandum No. WY-2004-057 (Sage-grouse). Wyoming State BLM Office. Cheyenne, WY.

The Wyoming Office of the BLM established a new policy concerning sage-grouse management. Seasonal habitats need to be identified and mapped and populations classified as migratory or non-migratory. Land Use Plans need to limit loss, degradation, and fragmentation of habitat. No surface disturbance should be allowed within ¼ mile of an occupied lek and human activity should be avoided between 8 p.m. and 8 a.m. from March 1-May 15. Avoid activity in nesting and brood habitat within 2 miles of a lek or in designated nesting and brood habitat beyond the 2 mile buffer from March 15-July 15. Avoid activity in winter habitat from Nov. 15-March 14. Rehabilitation of disturbed areas will include locally adapted sagebrush and one to two species of native forbs.

<u>sort criteria</u>: human activity, machine disturbance, oil and gas, prescriptive, sagebrush, sage-grouse, Wyoming

USDI - Bureau of Land Management. 2008. Final supplemental environmental impact statement Pinedale Anticline oil and gas exploration and development project Sublette County, Wyoming. Pinedale Field Office. Chapter 3, Pages 140-147.

This is the upland game bird section of the Affected Environment chapter. This section includes an analysis of sage-grouse lek data trends compared to the number of producing natural gas wells within a 2-mile radius of the leks.

<u>sort criteria:</u> sage-grouse, Wyoming, oil and gas, quantitative, research-based

USGS. 2002. Fact sheet: Loss of sagebrush ecosystems and declining bird populations in the Intermountain West: priority research issues and information needs. USGS FS-122-02. U.S. Department of the Interior, U.S. Geologic Survey.

Priority needs to identify causes and mechanisms of shrubland bird declines were evaluated. Sage grouse have declined 33% from their long-term average population size. Four primary issues were identified: 1. Bird response to habitat and landscape features. 2. Monitoring and survey designs. 3. Effects of land use practices. 4. Wintering ground and migration.

sort criteria: sage-grouse, sagebrush obligates, non-game birds, oil & gas, agriculture, qualitative, prescriptive, western U.S.

Vander Haegen, W.M., M.A. Schroeder, and R.M. Degraaf. 2002. Predation on real and artificial nests in shrubsteppe landscapes fragmented by agriculture. Condor 104:496-506.

Artificial nests were monitored to examine effects of fragmentation, distance to edge, and vegetation cover on nest predation rates, as well as to identify predators of grouse and passerines. Nests in fragmented landscapes were approximately 9 times more likely to be depredated than nests in continuous landscapes. Predation rate was 26% for artificial nests. Nest-sites with greater vegetation coverage were less likely to be depredated.

sort criteria: sage-grouse, sharp-tailed grouse, non-game birds, sagebrush obligates, agriculture, fragmentation, sagebrush, grassland, quantitative, research-based, Washington

Wakkinen, W.L., K.P. Reese, and J.W. Connelly. 1992. Sage grouse nest locations in relation to leks. Journal of Wildlife Management 56:381-383.

The potential effectiveness of a guideline to protect sage-grouse nesting habitat in southeastern Idaho was evaluated. Investigators tested 2 predictions about nest locations in relation to leks. Ninety-two percent of nests were ≤ 3km from a lek, however only 55% were ≤ 3km from the capture lek. Evidence did not indicate leks were part of a “breeding complex”. “In grouse populations with lower lek density, the nearest lek to the nest site may be the lek of capture.” The results also failed to support the theory that hens nest midway between leks, and that predation is higher near leks.

sort criteria: sage-grouse, sagebrush treatment, sagebrush, quantitative, research-based, Idaho

Walker, B. L., D. E. Naugle, K. E. Doherty and T. E. Cornish. 2004. From the Field: Outbreak of West Nile virus in greater sage-grouse and guidelines for monitoring, handling, and submitting dead birds. Wildlife Society Bulletin 32:1000-1006.

This paper documented late summer survival of 20% on an area with confirmed West Nile virus (WNv) mortalities compared to 76% on two sites without WNv. Dramatic declines in both male and female lek attendance at the West Nile virus site the following spring suggested that outbreaks may threaten some local populations with extirpation. Strategies for handling, storing and submitting dead birds are also described.

sort criteria: sage-grouse, Wyoming, Montana, disease, quantitative, research-based

Walker, B. L., D. E. Naugle and K. E. Doherty. 2007*a*. Greater sage-grouse population response to energy development and habitat loss. Journal of Wildlife Management 71:2644-2654.

This paper reported lek-count indices inside coal-bed natural gas (CBNG) fields in the Powder River Basin declined by 82%, a rate of 35% per year whereas indices outside CBNG declined by 12%, at a rate of 3% per year. Following two years of high productivity, leks outside CBNG showed an increase in male attendance while those within gas fields remained at low levels. Thirty-eight (38)% of leks inside CBNG remained active compared to 84% of leks that remained active outside CBNG. Average time lag between energy development and lek disappearance was 4.1 ± 0.9 years. The authors also developed a model to evaluate effectiveness of the stipulation of no energy development within 0.4 km (0.25 mi) of a lek, by comparing the estimated probability of lek persistence without development to that of full development with a 0.4-km buffer. The results suggested that the chance of maintaining an active lek under full development is low even when the stipulation is applied.

sort criteria: sage-grouse, sagebrush, oil and gas, Wyoming, Montana, agriculture, human activity, powerlines, roads, quantitative, research-based

Walker, B. L., D. E. Naugle, K. E. Doherty, and T. E. Cornish. 2007*b*. West Nile virus and greater sage-grouse: estimating infection rate in a wild bird population. Avian Diseases 51:691-696.

Researchers estimated infection rates of West Nile virus (WNv) and documented low levels of neutralizing antibodies and concluded most sage-grouse had not yet been exposed to WNv, remained susceptible, and that impacts into the future would be determined more by annual variation in temperatures and changes in vector distribution than on the spread of resistance. They recommend controlling breeding mosquito numbers by eliminating man-made sources of habitat e.g. coalbed natural gas ponds.

sort criteria: sage-grouse, Wyoming, Montana, disease, oil and gas, quantitative, research-based

Walker, B. L. 2008. Greater sage-grouse response to coal-bed natural gas development and West Nile virus in the Powder River Basin, Montana and Wyoming, U. S. A. PhD dissertation. University of Montana. 218 pp.

This research was the source for all of the Walker et al. and Naugle et al. papers described in this bibliography. From 2201-2005, numbers of males on leks in coal-bed natural gas (CBNG) fields declined more rapidly than leks outside CBNG. Of leks that were active in 1997 or later, 38% within CBNG remained active by 2004-2005, compared to 84% of leks outside CBNG. By 2005, leks in CBNG had 46% fewer males/active lek than leks outside CBNG. The author determined the .4km (.25 mi) protective stipulation around leks was inadequate to ensure lek persistence. West Nile virus (WNv) decreased annual female survival rates and reduced estimates of population growth. WNv infection rates were lower in habitats without CBNG development due the distribution and management of surface water associated with CBNG.

<u>sort criteria:</u> sage-grouse, sagebrush, Wyoming, Montana, disease**,** oil and gas, roads, powerlines, human activity, quantitative, prescriptive, research-based

Wallestad, R.O. 1971. Summer movements and habitat use by sage grouse broods in central Montana. Journal of Wildlife Management 35:129-136.

Movements and habitat use of sage-grouse broods were examined in Montana during the summers of 1968 and 1969. Three sagebrush densities were identified: scattered, common and dense. Broods utilized scattered and common sagebrush densities most heavily throughout both summers. Broods used sagebrush-grassland areas averaging 213 acres in early summer, and they used sagebrush areas averaging 128 acres in late summer. Sage-grouse depend on varying densities of sagebrush during different periods of the year.

<u>sort criteria</u>: sage-grouse, sagebrush treatment, sagebrush, quantitative, research-based, Montana

Wallestad, R.O., and D. Pyrah. 1974. Movement and nesting of sage grouse hens in central Montana. Journal of Wildlife Management 38:630-633.

Nesting cover and movements of sage-grouse hens were examined in central Montana during the springs of 1969 through 1972. Sixty-eight percent of 22 nests were located within 1.5 miles of the lek where the hens were captured. “Successful nests were located in sagebrush stands with a higher average canopy coverage than those of unsuccessful nests, and had significantly greater sagebrush cover within 24 inches (60cm) of nest and within a 100-square foot (9-m^2) plot around nest.” Authors recommend a buffer zone of at least 2 miles should be maintained around a strutting ground.

sort criteria: sage-grouse, sagebrush treatment, sagebrush, quantitative, research-based, Montana

Wallestad, R.O., and P. Schladweiler. 1974. Breeding season movements and habitat selection of male sage grouse. Journal of Wildlife Management 38:634-637.

Habitat requirements and movements of male sage-grouse were studied during the breeding seasons of 1968 and 1972 in Montana. Eighty-two percent of the locations showed male grouse movements beyond 0.2 mile. Canopy coverage ranged from 20 to 50% at 80% of the locations. In an unpublished manuscript, Wallestad reported, " a 31 percent reduction in sagebrush with canopy coverage exceeding 15 percent adjacent to a strutting ground resulted in a 63 percent decrease in strutting males over a 2-year period while male numbers on other grounds in the area remained stable."

sort criteria: sage-grouse, sagebrush treatment, sagebrush, quantitative, research-based, Montana

Wambolt, C.L., A.J. Harp, B.L. Welch, N. Shaw, J.W. Connelly, K.P. Reese, D.E. Braun, D.A. Klebenow, E.D. McArthur, J.G. Thompson, L.A. Torell, and J.A. Tanaka. 2002. Conservation of greater sage-grouse on public lands in the western U.S.: implications of recovery and management policies. Executive Summary. Policy Analysis Center for Western Public Lands Policy Paper SG-02-02. Caldwell, ID.

Actions taken on public lands to maintain enhance, and restore sage-grouse populations were evaluated. Variables to evaluate policy criteria included: fire, maintaining and protecting habitat, invasive plant species, physical changes in habitat, predation, hunting, inventory and monitoring, livestock grazing, social issues, and economics of livestock grazing.

sort criteria: sage-grouse, agriculture, roads, sagebrush, qualitative, prescriptive, western U.S.

Welch, B.L., F.J. Wagstaff, and J.A. Roberson. 1991. Preference of wintering sage grouse for big sagebrush. Journal of Range Management 44:462-465.

The preference of sage-grouse in Utah for big sagebrush was investigated. Sage-grouse preferred in order – mountain big sagebrush, Wyoming big sagebrush, and basin big sagebrush. "…when leaves and buds of the preferred plants became limited, the birds shifted to lesser liked plants." Sage-grouse can expand their food base by shifting to less preferred plants.

sort criteria: sage-grouse, sagebrush, quantitative, research-based, Utah

Wisdom, M.J., B.C. Wales, M.M. Rowland, M.G. Raphael, R.S. Holthausen, T.D. Rich, and V.A. Saab. 2002. Performance of greater sage-grouse models for conservation assessment in the Interior Columbia Basin, U.S.A. Conservation Biology 16:1232-1242.

The performances of 2 landscape condition assessment models (designed to assess habitat conditions for sage-grouse) were evaluated. The environmental index model predicted conditions at the sub-watershed scale based on habitat density and quality, and effects of human disturbance. The population outcome model predicted range-wide conditions based on environmental index values and measures of range extent and connectivity. The "models provided reliable landscape predictions for the conditions tested."

<u>sort criteria</u>: sage-grouse, human activity, grazing, sagebrush, quantitative, research-based, western U.S.

Wisdom, M.J., M.M. Rowland, B.C. Wales, M.A. Hemstrom, W.J. Hann, M.G. Raphael, R.S. Holthausen, R.A. Gravenmier, and T.D. Rich. 2002. Modeled effects of sagebrush-steppe restoration on greater sage-grouse in the Interior Columbia Basin, U.S.A. Conservation Biology 16:1223-1231.

The potential benefits of 2 restoration scenarios to sage-grouse on U.S. Forest Service (FS) and Bureau of Land Management (BLM) lands in the interior Columbia Basin were evaluated. Scenario 1 assumed a 50% reduction in livestock grazing, whereas scenario 2 was based on a 100% reduction of grazing. "Our results indicate that an extensive and sustained combination of passive and active restoration, as outlined under the two restoration scenarios, would minimize further degradation and loss of habitat for sage-grouse on FS-BLM lands in the future." Also, areas not targeted for restoration would not recover or would continue to degrade.

<u>sort criteria</u>: sage-grouse, grazing, fire, sagebrush, quantitative, research-based, western U.S.

Wyoming Game & Fish Department. 1976. Considerations for wildlife in industrial development and reclamation. Cheyenne, Wy.

Mitigation and monitoring considerations for protecting wildlife and wildlife habitat with regard to industrial development were presented. Habitat development and reclamation were examined and recommendations were provided for specific habitat types (e.g., shrubland, rimrocks, etc.), and for individual wildlife species (e.g., mule deer, pronghorn, etc.).

sort criteria: sage-grouse, mule deer, pronghorn, elk, bighorn sheep, wildlife, sagebrush, qualitative, prescriptive, mitigation, Wyoming

Wyoming Sage-Grouse Working Group. 2003. Wyoming greater sage-grouse conservation plan. Wyoming Game and Fish Department, Cheyenne, Wy.

Goals and recommended management practices to encourage conservation of sage-grouse and their habitats in Wyoming were presented. Recommended management practices regarding mineral development included: (1) "Develop a plan for roads, pipelines, etc. to minimize impacts to sage-grouse." (2) "… travel management plans that would allow seasonal closure of roads for all but permitted uses (i.e. recreation and hunting) and encourage the reclamation of unnecessary or redundant roads." (3) "Avoid construction of overhead lines and other perch sites in occupied sage-grouse habitat." (4) "Reduce noise from industrial development or traffic…." (5) "…tailor reclamation to restore, replace or augment needed habitat types." (6) "… do not drill or permit new or expand existing sand and gravel activities within two miles of active leks between March 15 and July 15." (7) "Avoid surface disturbance or occupancy on or within ¼ mile of known active lek sites. (8) "… avoid human activity adjacent to leks during the breeding season between the hours of 8 p.m. and 8 a.m."

sort criteria: sage-grouse, oil & gas, mining, roads, quantitative, research-based, prescriptive, Wyoming

Wyoming Sage-Grouse Working Groups. 2006-2008. Local conservation plans for the eight planning areas in Wyoming (Bates Hole – Shirley Basin, Big Horn Basin, Northeast, South-Central, Southwest, Upper Green River Basin, Upper Snake River Basin, Wind River – Sweetwater River Basins). Wyoming Game and Fish Department. Cheyenne, WY.

Similar to the State Plan (Wyoming Sage-Grouse Working Group 2003), the goals and recommended management practices encourage conservation of sage-grouse and their habitats in Wyoming. As a result of research conducted while the plans were being prepared several of the plans site the need to update oil and gas development RMPs.

sort criteria: sage-grouse, oil & gas, mining, roads, quantitative, research-based, prescriptive, Wyoming

Zablan, M.A. 2003. Estimation of greater sage-grouse survival in North Park, Colorado. Journal of Wildlife Management 67:144-154.

Survival rates of sage-grouse in north-central Colorado were examined. The sage-grouse population was essentially stable from 1973 to 1975, increased 56% from 1975 to 1979, showed a slight decrease then remained stable from 1980 to 1983, and

decreased 62% in 1984. “Based on lek counts, the sage-grouse population in North Park, Colorado, increased 63% decreased 69%, and remained relatively low during the long-term (1973-1990) banding study.”

<u>sort criteria</u>: sage-grouse, sagebrush, quantitative, research-based, Colorado

Zou, L., S. N. Miller and E. T. Schmidtmann. 2006. Mosquito larval habitat mapping using remote sensing and GIS: implications of coalbed methane development and West Nile virus. Journal of Medical Entomology 43:1034-1041.

Larval habitats of the West Nile virus vector mosquito *Culex tarsalis* were identified via remote sensing and GIS analyses. Results showed a 75% increase in potential larval habitats from 1999 to 2004 primarily because of the large increase in coalbed methane discharge ponds.

<u>sort criteria:</u> sage-grouse, **disease,** oil and gas, Wyoming, quantitative, research-based

MULE DEER

Brown, C.G. 1992. Movement and migration patterns of mule deer in southeastern Idaho. Journal of Wildlife Management 56:246-253.

Migration patterns and movement of mule deer in southeastern Idaho were monitored using radio telemetry. “Migration between summer and winter ranges averaged 19.7 km and did not differ (P>0.05) between sexes. Twenty-six percent of the marked deer were not migratory.” Both males (92%) and females (100%) showed high fidelity to summer ranges. Winter severity appeared to strongly influence deer use of winter range. “During mild winters with low snow accumulation, some migratory deer (48% in 1986-87 and 19% in 1987-88) did not move to traditional winter ranges.”

<u>sort criteria</u>: mule deer, sagebrush, quantitative, research-based, Idaho

Easterly, T., A. Wood, and T. Litchfield. 1991. Responses of pronghorn and mule deer to petroleum development on crucial winter range in the Rattlesnake Hills. Unpublished Completion Report. Wyoming Game and Fish Department, Cheyenne.

Impacts of petroleum-related activities on pronghorn and mule deer were examined in central Wyoming. Distribution of pronghorn indicated avoidance of areas where drilling and well maintenance activities occurred. Displacement of mule deer in the study was not noted. Pronghorn numbers within 1 km of the well site decreased with the advent of road construction and drilling activity. However, once human activity

subsided, numbers of pronghorn returned to pre-disturbance levels. "Displacement of animals may result in use of sub-optimal winter habitat, overcrowding, increased intraspecific competition, deterioration of habitat, and decreased physical condition of the population." Authors suggest drilling during summer on critical winter range.

sort criteria: pronghorn, mule deer, oil & gas, sagebrush, quantitative, research-based, Wyoming

Eberhardt, L.E., E.E. Hanson, and L.L. Cadwell. 1984. Movement and activity patterns of mule deer in the sagebrush-steppe region. Journal of Mammalogy 65:404-409.

Movements and activity patterns of mule deer were examined in the sagebrush-steppe region of south-central Washington. Activity peaks were observed twice per day—once in the morning and once in the evening.

sort criteria: mule deer, sagebrush, quantitative, research-based, Washington

Fala, R.A., J.P. Ward, J.W. June, L.L. Apple. 1986. Mule deer winter range study on a proposed coal lease site. Pages 15-21 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Mule deer densities, distribution, habitat type utilization, and group size were examined in and near a proposed mine lease area in Wyoming. Sagebrush-grasslands were the principal habitat type (92.2%), however 63% of mule deer sightings were in juniper-sagebrush habitat with only 31% in sagebrush-grassland. Rough topography, juniper and sagebrush stands characterized important winter deer habitat.

sort criteria: mule deer, mining, sagebrush, quantitative, research-based, Wyoming, mitigation

Freddy, D.J. 1986a. Responses of adult mule deer to human harassment during winter. Page 286 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co. Abstract only.

Female mule deer responses to persons afoot and to snowmobiles were examined in Colorado. Responses to persons afoot were longer in duration, with more frequent running and greater energy costs. Threshold distances to minimize all responses by deer were > 334 m for persons afoot and > 470 m for snowmobiles.

sort criteria: mule deer, human activity, sagebrush, quantitative, research-based, Colorado

Freddy, D. J., W.M. Bronaugh, and M.C. Fowler. 1986b. Responses of mule deer to disturbance by persons afoot and snowmobiles. Wildlife Society Bulletin 14:63-68.

Responses of female mule deer were studied during controlled disturbance trials in north-central Colorado during the winters of 1979 and 1980. Responses to persons afoot were longer, involved more running, and caused greater energy expenditure than responses to snowmobiles
(likely because persons afoot were in the area longer than snowmobiles). Deer moved 907 m with energy costs of 54-127 kcal when fleeing from persons afoot, and 158 m with energy costs of 10-22 kcal when running from snowmobiles. Neither mortality nor fecundity of female deer was markedly affected. Threshold distances of > 334 m and > 470 m for persons afoot and snowmobiles respectively should minimize all responses by deer (or > 191 m and > 133 m to prevent locomotor responses), and ". . . could be used to establish corridors of human activity within sagebrush winter ranges occupied by deer."

sort criteria: mule deer, human activity, snowmobiles, sagebrush, quantitative, research-based, Colorado

Garrott, R.A., G.C. White, R.M. Bartmann, L.H. Carpenter, and A.W. Alldredge. 1987. Movements of female mule deer in northwest Colorado. Journal of Wildlife Management 51:634-643.

Seasonal movements of female mule deer in northwest Colorado were monitored from November 1980 through October 1984. In October all deer migrated from summer range to lower elevations and occupied southerly aspects. Deer concentrated around meadows during spring until migrating to summer range. "Timing of spring migration varied annually and was related to winter severity." Agricultural meadows were used extensively in spring and fall, which suggests that high quality forage areas influence seasonal movement patterns.

sort criteria: mule deer, shrubland, quantitative, research-based, Utah

Girard, M., and B. Stotts. 1986. Managing impacts of oil and gas development on woodland wildlife habitats on the Little Missouri Grasslands, North Dakota. Pages 128-130 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Impacts from oil and gas development (e.g., construction activities, toxic fumes, chemical spills, and wildlife displacement) on woodland wildlife habitat were evaluated on the Little Missouri Grasslands in North Dakota. Approximately 10,884 acres had been directly disturbed by oil and gas activity. A sphere of influence surrounds all roads and well pads, and is estimated to be a minimum of 100 yards in all directions. Mitigation efforts included: (1) No well pads or roads placed in woodlands. (2) Roads

crossing "draws" must be at right angles to minimize disturbance. (3) Extra heavy pit liners were to be used in areas with porous substrates to prevent saltwater seepage.

sort criteria: wildlife, mule deer, elk, oil & gas, forested, quantitative, research-based, North Dakota, mitigation

Hayden-Wing Associates. 1991a. Final review and evaluation of the effects of Triton Oil and Gas Corporation's proposed coal bed methane field development (Great Divide prospect) on elk and other big game species. Triton Oil and Gas Corporation, Dallas, Tx.

Pronghorn, mule deer, and elk responses to disturbances associated with petroleum development in southwestern Wyoming were examined. Elk numbers decreased near drilling activities but returned to previous levels post-disturbance. However, elk were most sensitive to disturbances during winter and calving periods, and tended to avoid activity up to at least ½ mile away depending on whether or not the disturbance was visible. Pronghorn and mule deer seemed to habituate to most types of human disturbance unless they had been hunted or harassed. Mitigation measures for reducing impacts were presented.

sort criteria: pronghorn, mule deer, elk, oil & gas, sagebrush, quantitative, research-based, Wyoming

Hayden-Wing Associates. 1991b. Review and evaluation of the effects of geophysical exploration on some wildlife species in Wyoming. Unpublished Report for Geophysical Acquisition Workshop. Laramie, Wy.

A review of previous studies on the effects of geophysical exploration on pronghorn, mule deer, elk, raptors, and sage-grouse was presented. The information examined indicated that big game are temporarily affected by seismic exploration causing increased energy expenditure and utilization of sub-optimal habitats. Characteristics for evaluating potential sage-grouse nesting habitat in relation to proposed oil and gas development included: "1) distance relationships to leks, 2) presence, distance, and characteristics of existing disturbances, 3) characteristics of shrubs and vegetation that could serve in nest concealment and nest-site selection, and 4) distance to water and to potential brood-rearing areas." Mitigation strategies for protecting raptor-nesting habitat were also presented.

sort criteria: sage-grouse, raptors, pronghorn, mule deer, elk, oil & gas, seismic exploration, sagebrush, quantitative, research-based, Wyoming

Hebblewhite, M. 2008. A literature review of the effects of energy development on ungulates: implications for central and eastern Montana. Report prepared for Montana Fish, Wildlife and Parks, Mile city, MT

A review of >160 scientific and technical reports pertaining to effects of energy development and ungulates were presented. Instructions for accessing a searchable ProCite electronic database containing literature and research summaries is made available.

sort criteria: mule deer, elk, pronghorn, moose, caribou, oil and gas, human activity, roads, **migration,**

Henderson, R.E., and A. O'Herren. 1992. Winter ranges for elk and deer: victims of uncontrolled subdivisions? Western Wildlands 18:20-25.

Authors described impacts created by increasing human habitation of elk and deer winter ranges in Montana. Human disturbance can interrupt, and displace the movements between summer and winter ranges for both mule deer and elk.

sort criteria: mule deer, elk, rural subdivisions, agricultural, forested, qualitative, prescriptive, Montana

Kuck, L. 1986. The impacts of phosphate mining on big game in Idaho: a cooperative approach to conflict resolution. Transactions of the 51st North American Wildlife and Natural Resources Conference 51:90-97.

Evaluation of impacts of phosphate mining on big game in Idaho was the objective of this study. "Results of this study indicate that elk, deer and moose may be capable of adapting to many phosphate mining activities in southeastern Idaho, but cannot compensate for disturbance on important seasonal ranges or for increased mortality associated with industrial development."

sort criteria: mule deer, elk, moose, mining, forested, grassland, quantitative, research-based, Idaho

Lowry, D.A., and K.L. McArthur. 1978. Domestic dogs as predators on deer. Wildlife Society Bulletin 6:38-39.

Direct and indirect effects of dogs chasing deer were examined. The most obvious and detrimental direct effect was deer mortality. Indirect effects included deer running onto highways, being cut or entangled in barbed-wire fences, being crippled, and expending critical energy needed for winter survival.

sort criteria: mule deer, rural subdivision, forested, quantitative, research-based, Idaho

McAdoo, J.K., G.A. Acordagoita, and C.R. Aarstad. 1989. Reducing impacts of hard-rock mining on wildlife in northern Nevada. Pages 95-97 in Proceedings IV: Issues and Technology in the Management of Impacted Wildlife. Thorne Ecological Institute, Boulder, Co.

Reduction of wildlife impacts from mineral exploration in northern Nevada was examined. Mitigation actions included: minimizing erosion through the use of sediment catchment basins, silt screens, and seeding of road cuts and fill slopes, minimizing construction activity near raptor nests, avoiding aspen wildlife habitat, using culverts for crossing trout streams, and monitoring ground and surface water. Offsite mitigation and concurrent reclamation efforts were also evaluated.

sort criteria: wildlife, mule deer, sage-grouse, raptors, mining, sagebrush, riparian, qualitative, prescriptive, mitigation, Nevada

Medcraft, J.R., and W.R. Clark. 1986. Big game habitat use and diets on a surface mine in northeastern Wyoming. Journal of Wildlife Management 50:135-142.

Seasonal use of habitats by deer and pronghorn were studied at a coal surface mine near Gillette, Wyoming. Native vegetation was dominated by big sagebrush. Mule deer used reclaimed land more than un-mined land, however the opposite was true for pronghorns. Because reclaimed land provided sufficient, high-quality forage, authors believed habitat could be improved over time.

sort criteria: mule deer, pronghorn, mining, sagebrush, quantitative, research-based, Wyoming

Merril, E.H., T.P. Hemker, K.P. Woodruff, and L. Kuck. 1994. Impacts of mining facilities on fall migration of mule deer. Wildlife Society Bulletin 22:68-73.

Mule deer movements from summer to winter ranges were monitored for 5 years to determine if mining facilities and activities hindered migration. The study area in southeastern Idaho was dominated by fir forest and sagebrush. Different accumulations of snow in different years affected migration patterns. When little snow was present, deer moved south of the mine, but deer moved through the mine site when deep snow accumulated. The observations support prior findings ". . . that corridors through human-built obstacles facilitate migration of ungulates.

sort criteria: mule deer, mining, forested, sagebrush, quantitative, research-based, Idaho

Morton, P., C. Weller, J. Thomson, M. Haefele, and N. Culver. 2004. Drilling in the Rocky Mountains: How much and at what cost? The Wilderness Society, Washington, D.C.

An analysis examining the impacts associated with large-scale energy development determined that significant fragmentation of wildlife habitat occurs with development activities. Non-market costs of drilling included "erosion, loss of wildlife and fish habitat, decline in quality of recreational experiences, proliferation of noxious weeds, and increased air and water pollution." A habitat fragmentation analysis of the Big Piney-LaBarge oil and gas field (in northwestern Wyoming) produced results indicating " a direct physical footprint of 1,400 miles of linear features and 3.8 square miles of polygon features, resulting in an overall density of 8.43 miles of roads and pipelines per mile^2." Also, 97% of the area falls within ¼ mile of some infrastructure and only 27% of the study area was more than 500 feet from infrastructure, with only 3% more than ¼ mile away.

<ins>sort criteria</ins>: sage-grouse, mule deer, pronghorn, elk, raptors, non-game birds, fish, wildlife, oil & gas, fragmentation, quantitative, research-based, prescriptive, western U.S.

Oedekoven, O.O., and F.G. Lindzey. 1987. Winter habitat-use patterns of elk, mule deer, and moose in southwestern Wyoming. Great Basin Naturalist 47:638-643.

Mule deer, elk, and moose winter habitat use patterns were examined in southwestern Wyoming. Mule deer used sagebrush extensively, moose favored aspen, willow, and mixed-shrub vegetation, and elk preferred alpine grass/moss vegetation. Elk and mule deer showed a preference for areas with mild snow conditions, whereas moose were often observed in areas with deep snow. "Our results suggested that although deer, elk, and moose often used the same areas, they selected differing habitats within shared areas."

<ins>sort criteria</ins>: mule deer, elk, moose, sagebrush, quantitative, research-based, Wyoming

Parker, K.L., C.T. Robbins, and T.A. Hanley. 1984. Energy expenditures for locomotion by mule deer and elk. Journal of Wildlife Management 48:474-488.

Energy expenditures were measured on mule deer and elk to determine energy costs for several activities. Logging activities affected energy expenditures of both elk and deer by removal of canopy and subsequent increased snow depth. Human activity (i.e. winter recreation) caused excessive energy expenditure by inducing elk and deer to flee when approached. Management considerations should include restricting human access to deer and elk winter use areas.

sort criteria: mule deer, elk, human activity, logging, forested, quantitative, research-based

Phillips, R.L., D.E. Biggins, and A.B. Hoag. 1986. Coal surface mining and selected wildlife – a 10-year case study near Decker, Montana. Pages 235-245 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Mule deer, pronghorn, sage-grouse, and golden eagles were monitored to determine their responses to mining activities in southeastern Montana and northern Wyoming. "Mule deer and pronghorn populations thrived throughout the study period despite increasing mining activity and human disturbance." Sage-grouse habitat was lost, but mitigation efforts (e.g., relocation of a lek) seemed to be successful. Golden eagle numbers remained relatively stable. Four nesting pairs near active mines had a 10-year nesting success of 67.5% compared to 56.6% for pairs nesting elsewhere on the study area. "If the primary post mining land use is wildlife, permanent reclamation can be designed to maximize the mixture of plant species and thereby provide greater habitat diversity than native prairie."

sort criteria: sage-grouse, mule deer, pronghorn, raptors, mining, sagebrush, quantitative, research-based, Wyoming, Montana, mitigation

PIC Technologies and Bureau of Land Management, Pinedale Field Office. 1999. Draft Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project. Bureau of Land Management, Pinedale, Wyoming, USA.

Management objectives, monitoring and mitigation recommendations for the Pinedale Anticline Oil and Gas Exploration and Development Project in northwestern Wyoming were presented. The standard stipulation alternative (SS) was explained as well as a resource protection alternative (RP), which included all spatial and temporal restrictions contained in the SS alternative. The RP alternative offered additional protection measures to "be applied to wildlife habitats on Federal lands and minerals."

sort criteria: sage-grouse, pronghorn, mule deer, elk, moose, non-game birds, raptors, wildlife, oil & gas, noise, roads, quantitative, research-based, Wyoming

Rost, G.R., and J.A. Bailey. 1979. Distribution of mule deer and elk in relation to roads. Journal of Wildlife Management 43(3):634-641.

Deer and elk responses to roads were assessed on winter ranges in Colorado during the winters of 1973 and 1974. The principal habitats were mountain shrub and pine forests. Data were obtained by counting fecal-pellet groups within 400m transects parallel to roads. Based upon pellet group distributions, elk and deer avoided roads, especially areas within 200m. Deer avoided roads more in shrublands than in forested areas, however elk responses did not differ based on habitat type. At some sites, deer avoided roads even though snow likely restricted available habitat. Therefore, propensity to avoid roads may be detrimental to deer and elk.

sort criteria: mule deer, elk, roads, mountain shrub, forested, quantitative, research-based, Colorado

Sawyer, H. 2007. Final Report for the Atlantic Rim Mule Deer Study. Western Ecosystems Technology, Inc., Cheyenne, Wyoming.

Seasonal ranges, migration routes and survival rates were identified to provide baseline information prior to development of a proposed 2000 well natural gas field on the Atlantic Rim in south central Wyoming. Mule deer utilize transitional ranges within the proposed gas field to facilitate spring and fall migrations to winter range. Transitional ranges provide forage allowing better body condition before entering winter and recovery after winter and reduce the amount of time deer must spend on winter ranges. Management recommendations included: maintaining functioning transitional ranges to provide deer with foraging opportunities to maintain healthy productive populations.

sort criteria: mule deer, **migration**, oil & gas

Sawyer, H., F. Lindzey and D. McWhirter. 2005. Mule deer and pronghorn migration in western Wyoming. Wildlife Society Bulletin 33:1266-1273

Longest recorded migrations for mule deer and pronghorn in the Western U.S. were identified. Housing developments and roadways have reduced effectiveness of a number of bottlenecks along the routes. Management recommendations include identification and protection of migration corridors and bottlenecks to maintain species populations.

Sort criteria: pronghorn, mule deer, **migration**, rural subdivisions

Sawyer, H., F. Lindzey, and D. McWhirter. 2005. Mule deer and pronghorn migration in western Wyoming. Wildlife Society Bulletin. In Press.

The Green River Basin provides winter habitat for mule deer from five different mountain ranges and pronghorn that migrate from Grand Teton National Park. The established migration routes of these herds are estimated to be thousands of years old. Housing and energy developments, fences, and roads constrict these migration routes by creating bottlenecks. If animals are not able to maneuver through these bottlenecks, they cannot reach their seasonal ranges, which may lead to population declines.

Identification and protection of migration routes should be extremely important considerations in wildlife management.

sort criteria: fences, mule deer, oil and gas, pronghorn, roads, research-based, qualitative, sagebrush, shrubland, rural subdivision, Wyoming

Sawyer, H., and F. Lindzey. 2004. Assessing impacts of oil and gas development on mule deer. Transactions of the 69th North American Wildlife and Natural Resources Conference. Wildlife Management Institute. Washington D.C.

Few long-term studies have been conducted to assess the effects of oil and gas development on wildlife, and most studies were based on observational data. Research on this subject should follow three steps to provide the best data for future mitigation efforts. 1. Document and quantify direct habitat loss that results from development activities. 2. Document dispersion and behavior of species of interest during development. Specifically, do behaviors, dispersion or habitat use patterns change through time as the project area is developed. 3. Measure population characteristics (e.g. survival, density, and reproduction) during development.

sort criteria: human activity, mule deer, oil and gas, research-based, sagebrush, shrubland, qualitative, Wyoming

Sawyer, H., R. Nielson, and D. Strickland. 2008. Final Report for the Sublette Mule Deer Study (Phase II): Long term monitoring plan to assess potential impacts of energy development on mule deer in the Pinedale Anticline Project Area. Western Ecosystems Technology, Inc. Cheyenne, Wyoming, USA.

Direct Habitat loss, indirect habitat loss and population performance of mule deer from 2000 through 2007 in the Pinedale Anticline Project area were examined. Direct habitat loss totaled less than 3% of the project area however, indirect habitat loss was found to be significant. Deer avoided well pads 6 of the 7 years of development. Highest predicted levels of deer use were 2.7, 3.1 and 3.7 km, away from well pads in year 1, 2 and 3 respectively and 2.6 km, away in year 5. Human activity in winter resulted in major shifts in distribution of mule deer. Human activity at producing well pads reduces effectiveness of seasonal stipulations that are typically applied only to development activity. Liquid Gathering Systems reduced indirect habitat loss from producing well pads by 38-63%. Data collected showed mule deer numbers declined on the Mesa by 30% during the first 7 years of development. A population growth model indicates a negative trend is plausible. Mule deer continued to show strong fidelity to winter ranges and migratory routes remained constant.

Management recommendations: Human activity on producing well pads may limit the effectiveness of seasonal timing stipulations. Land managers should plan development that reduces the number of well pads and limit human activity during development and production phases. Directional drilling can reduce surface disturbance and when combined with liquid gathering systems, can reduce human activity on producing well pads.

sort criteria: mule deer, oil and gas, roads, traffic, Wyoming, mitigation, human activity

Sawyer, H,, R.M. Nielson, F. Lindzey, and L.L. McDonald. 2006. Winter habitat selections by mule deer before and during development of a natural gas field. Journal of Wildlife Management. In Press.

During the development of the Pinedale Anticline, mule deer used higher elevations and areas with lower road densities as construction progressed. Areas of high mule deer use were 2.7 km, 3.1 km, and 3.7 km from the nearest well pad during the first, second, and third winters of construction, respectively. During the study, areas considered high deer-use became low use and areas of low deer-use became high use suggesting, "natural gas development on the Mesa displaced mule deer to less-suitable habitats."

sort criteria: mule deer, human activity, oil and gas, equipment activity, machine disturbance, roads, wells, research-based, quantitative, sagebrush, shrubland, Wyoming

Sawyer, H., R. Nielson, D. Strickland, and L. McDonald. 2006. 2006 Annual Report. Sublette Mule Deer Study (Phase II): Long-term monitoring plan to assess potential impacts of energy development on mule deer in the Pinedale Anticline Project Area. Western Ecosystems Technology, Inc. Cheyenne, WY. 101pp + appendices.

Mule deer in the upper Green River Basin of Wyoming follow highly traditional migration routes between summer and winter ranges. Within 30-40 miles of the major winter range complexes, these routes are very narrow, averaging 2.1 km (1.3 mi), and seldom exceed 5.5 km (3.4 mi.) in width. Deer display a high degree of fidelity to specific routes. Based on telemetry data, 67% of radio-collared does migrated within 0.5 km (0.3 mi) of their previous routes, and 87% migrated within 1.0 km (.6 mi). In some locations, geographic features and housing subdivisions have created migration bottlenecks of 0.4-0.7 km (.25-.43 mi) width. Developments that disrupt traditional migration corridors, particularly at bottlenecks, have the potential to impact large segments of a deer population.

Natural gas fields can impact mule deer habitat both directly and indirectly. The amount of habitat directly removed by surface disturbance tends to be comparatively minor, presently comprising about 2% of the Mesa winter range complex within the Pinedale Anticline Project Area (PAPA). Direct impacts are easiest to quantify and they can be reduced through various management practices such as directionally drilling multiple wells from a single construction pad and contemporaneously reclaiming disturbed sites to the same native plants that existed prior to disturbance.

Indirect effects are harder to quantify, but have much more serious implications because they impact habitat use over much broader areas. Indirect impacts occur when mule deer distribution or habitat selection patterns are altered by avoidance and displacement responses to human activity or migration barriers. As intensive field development began on the Mesa, areas considered high deer-use became low use and areas of low deer-use became high use suggesting, "natural gas development … has displaced mule deer to less-suitable habitats." Displacement of deer from high use to low use areas also has the potential to increase energy expenditures, ultimately reducing survival and reproduction. During the first, second, and third years of construction on the Mesa, high use areas were 2.7 km (1.7 mi), 3.1 km (1.9 mi), and 3.7 km (2.3 mi) from well pads, respectively.

During the fourth year of construction, deer used areas closer to well pads [high use areas were 0.7 km (0.4 mi) from well pads]; however, severe winter conditions had likely reduced habitat options available to the deer. During the Fifth and most recent winter (2005-06), the avoidance pattern was comparable to the avoidance documented during the first year of the study [high use areas were 2.6 km (1.6 mi) from well pads]. The pattern of avoidance and habitat use may be stabilizing, however the number of deer wintering on the Mesa has declined 27% since construction began, after the effects of winter mortality and drought were taken into account. A "weight-of-evidence" analysis strongly suggests the decline was due primarily to reduced survival rates associated with gas development activities and secondarily to limited emigration (2% per year) of deer wintering on the area.

In gas fields like the PAPA where well pad densities may reach 16 or more per square mile, the number of producing well pads and associated human activity may negate the potential effectiveness of seasonal drilling restrictions as a means to reduce disturbance to wintering deer. Preliminary results of a study on effects of human activity suggest deer responded positively to a fluids collection system designed to eliminate 25,000 truck trips per year, and to roads with reduced traffic volumes. Not unexpectedly, deer responded negatively to high use roads. Reducing the amount of direct and indirect habitat loss by reducing road and well pad density may have a commensurate beneficial effect on deer survival, thereby reducing the impact of large scale gas development.

<u>sort criteria</u>: mule deer, human activity, equipment activity, machine disturbance, roads, wells, oil and gas, research-based, quantitative, Wyoming

Stephenson, T.R., M.R. Vaughan, and D.E. Anderson. 1996. Mule deer movements in response to military activity in southeast Colorado. Journal of Wildlife Management 60:777-787.

Home range fidelity of mule deer was studied on the U.S. Army's Pinon Canyon Maneuver Site (PCMS) in southeastern Colorado. This area of short-grass prairie was used intermittently for military maneuvers. Sectors were designated maneuver, previous-maneuver, and non-maneuver (control), and studied seasonally. Sizes of doe home ranges were up to 4.6-fold greater in maneuver areas than non-maneuver areas. Seasonal home ranges of bucks did not differ significantly, but bucks had a significantly larger annual home range in maneuver area than in non-maneuver sectors. This type of disturbance is unpredictable (i.e. not routine) in contrast to oil and gas activities.

<u>sort criteria</u>: mule deer, human activity, grassland, quantitative, research-based, Colorado

Stewart, K.M., R.T. Bowyer, J.G. Kie, N.J. Cimon, and B.K. Johnson. 2002. Temporospatial distributions of elk, mule deer, and cattle: resource partitioning and competitive displacement. Journal of Mammalogy 83(1): 229-244.

Resource partitioning and competitive displacement among mule deer, elk, and cattle were examined in northeastern Oregon and southeastern Washington. Resource partitioning was strongly evident among all 3 species, however mule deer and elk selected similar slopes and elevations, whereas cattle avoided steep slopes and high elevations. Although mule deer and elk selected similar slopes and elevations, they used different vegetation communities. At higher densities, resource partitioning could be more difficult leading to increased competition.

<u>sort criteria</u>: mule deer, elk, grazing, forested, grassland, quantitative, research-based, Oregon, Washington

Strickland, D. 1999. Petroleum development versus wildlife in the overthrust. Transactions of the North American Wildlife and Natural Resources Conference 64:28-35.

Controversies concerning impacts to wildlife from petroleum development in Wyoming are discussed. To date (1999) an estimated 2,100 producing oil and gas wells are located in southwestern Wyoming, with a large potential for further development. The BLM (Bureau of Land Management) estimates an additional 4,837 wells will be developed. Since 1984, 24,112 acres of habitat has been lost due to oil and gas development, and an additional 53,000 acres would be disturbed by future development from direct impacts (e.g., roads, pipelines, etc.). "The potential area of direct and indirect disturbance is 2.7 million acres, or approximately 16 percent of southwestern Wyoming." Author suggests the BLM modify its leasing strategy using long-range and strategic planning with an adaptive approach.

<u>sort criteria</u>: elk, bighorn sheep, moose, pronghorn, mule deer, sage-grouse, oil & gas, sagebrush, qualitative, prescriptive, Wyoming

Thomas, T., and L. Irby. 1990. Habitat use and movement patterns by migrating mule deer in southeastern Idaho. Northwest Science 64:19-27.

Habitat use and movement of migrating mule deer in southeastern Idaho were investigated. Most deer migrated along established corridors and used the same corridors in spring and fall. Deer were not exposed to excessive hunting pressure during migration, and human land use was not a factor. Authors recommend protecting migration corridors from overgrazing and conversion of native vegetation to cropland.

<u>sort criteria</u>: mule deer, roads, rural subdivision, agriculture, sagebrush, quantitative, research-based, Idaho

Weisenberger, M.E., P.R. Krausman, M.C. Wallace, D.W. DeYoung, and E.O. Maughan. 1996. Effects of simulated jet aircraft noise on heart rate and behavior of desert ungulates. Journal of Wildlife Management 60(1):52-61.

The effects of simulated low-altitude jet aircraft noise on the behavior and heart rate of mule deer and mountain sheep in Arizona were evaluated. "The heart rates of ungulates increased related to dB levels during simulated overflights ($P \leq 0.05$), but they returned to pre-disturbance levels in 60-180 seconds. Animal behavior also changed during overflights but returned to pre-disturbance conditions in < 252 seconds ($P \leq 0.005$). All animal responses decreased with increased exposure suggesting that they habituated to simulated sound levels of low-altitude aircraft."

<u>sort criteria</u>: mule deer, bighorn sheep, noise, quantitative, research-based, Arizona

Weller, C., J. Thomson, P. Morton, and G. Aplet. 2002. Fragmenting our lands: The ecological footprint from oil and gas development. The Wilderness Society, Washington, D.C.

Habitat fragmentation resulting from resource extraction practices was examined in the Upper Green River Basin of Wyoming. Average road densities and other linear features were 8.43 miles per square mile. An effect zone of ½ mile was constructed and analyzed. The analysis showed the entire 166 square mile study area to be within ½ mile of a road or other development related infrastructure. "The ecological footprint varies depending upon which disturbance is measured. A disturbance that reaches a quarter of a mile beyond the infrastructure creates a footprint of 160 square miles, affecting 97% of the study area. Even a more localized disturbance that only reaches 100 feet beyond the infrastructure affects 28% of the study area (47 square miles)."

<u>sort criteria</u>: sage-grouse, mule deer, pronghorn, elk, moose, oil & gas, sagebrush, quantitative, research-based, Wyoming

Western EcoSystems Technology, Inc. 2003. An evaluation of the 1988 BLM Pinedale Resource Management Plan, 2000 BLM Pinedale Anticline Final EIS and recommendations for the current revision of the Pinedale Resource Management Plan. The Wilderness Society, Washington, D.C.

An analysis of the 1988 Bureau of Land Management (BLM) Resource Management Plan and the 2000 BLM Pinedale Anticline Environmental Impact Statement (EIS) was presented. Recommendations for the current revision of the Pinedale Resource Management Plan were also given. Overall planning and adaptive management recommendation included: 1) limiting the density of roads and wells per section, 2) protecting a minimum amount of significant big game habitat from disturbance, 3) identify areas where future oil and gas leases should be prohibited, 4) coordinate habitat management, and 5) apply adaptive management.

sort criteria: pronghorn, mule deer, elk, oil & gas, roads, sagebrush, quantitative, research-based, Wyoming

White, G.C., R.A. Garrott, R.M. Bartmann, L.H. Carpenter, and A.W. Alldredge. 1987. Survival of mule deer in northwest Colorado. Journal of Wildlife Management 51:852-859.

Mule deer survival in northwest Colorado was monitored for 3 years on 1 study area and 4 years on another. “From 46 to 76% of fawns on 1 area died from predation each year, whereas 49-83% of those on the other area starved.” Body size of fawns depredated was more variable, whereas fawns dying from starvation were smaller animals.

sort criteria: mule deer, shrubland, quantitative, research-based, Colorado

Wood, A.K. 1988. Use of shelter by mule deer during winter. Prairie Naturalist 20:15-22.

Shelter use by mule deer in prairie habitat was evaluated during winter 1984 in eastern Montana. Deer used shelter more as wind chill increased in an attempt to minimize energy loss and optimize energy budget. “Wind velocity seemed to be the most important factor influencing selection of both bedding and feeding sites.” In prairie environments mule deer tend to select habitat (at least partially) on the basis of topographic features.

sort criteria: mule deer, environmental factors, grassland, quantitative, research-based, Montana

Wyoming Game & Fish Department. 1976. Considerations for wildlife in industrial development and reclamation. Cheyenne, Wy.

Mitigation and monitoring considerations for protecting wildlife and wildlife habitat with regard to industrial development were presented. Habitat development and reclamation were examined and recommendations were provided for specific habitat types (e.g., shrubland, rimrocks, etc.), and for individual wildlife species (e.g., mule deer, pronghorn, etc.).

<u>sort criteria</u>: sage-grouse, mule deer, pronghorn, elk, bighorn sheep, wildlife, sagebrush, qualitative, prescriptive, mitigation, Wyoming

Yarmoloy, C., M. Bayer, and V. Geist. 1988. Behavior responses and reproduction of mule deer, *Odocoileus hemionus*, does following experimental harassment with an all-terrain vehicle. Canadian Field-Naturalist. 102(3): 425-429.

The researchers conducted an experiment in which they habituated 5 radio-collared doe mule deer to an ATV's presence by driving a regular route. They then chased 3 of the 5 does daily or every other day for 9 minutes to determine their behavior and reproductive response. The chased deer began to feed at night, used cover more often, moved outside of their home ranges, and produced fewer fawns. The researchers noted that all deer in the study area habituated to the ATV when it was on a predictable route and ignored motor traffic unless they were pursued.

<u>sort criteria</u>: Canada, disturbance, human activity, mule deer, off road vehicles, quantitative, roads

<u>PRONGHORN</u>

Barrett, M.W. 1982. Distribution, behavior, and mortality of pronghorns during a severe winter in Alberta. Journal of Wildlife Management 46:991-1002.

Pronghorn distribution, behavior, and mortality in southeastern Alberta, Canada were investigated during a severe winter (1977-1978). Mortality was estimated at 48.5% for the approximately 14,360 pronghorn in the study. Pronghorn used areas with less snow accumulation and where vegetation was visible above the snow. Mobility (absence of obstacles) was found to be an important requirement for the survival of pronghorn during severe winter conditions.

<u>sort criteria</u>: pronghorn, sagebrush, quantitative, research-based, Canada

Berger, J., K. Murray Berger and J. Beckman. 2006. Wildlife and Energy Development: Pronghorn of the Upper Green River Basin – Year 1 Summary. Wildlife Conservation Society, Bronx. NY.

Pronghorn can habituate to human presence when they are not hunted or harassed, but fracturing of previously undisturbed lands [by natural gas development] is leading to reduced usage and abandonment of habitat patches. Snow depth and size of undisturbed fragments explained 83% of the variation in pronghorn use of different patches. Pronghorn use was reduced on undisturbed patches of less than 1,000 acres, while patches of less than 600 acres were used substantially less or were abandoned. Once the density of gas wells and attendant infrastructure reaches a threshold, pronghorn no longer use the area. Pronghorn consistently avoided areas within 100m of gas wells. (This is an area of 7.8 acres). Some pronghorn may be structuring their movements to avoid areas of high-density infrastructure on the Mesa and Jonah Fields. No radio-collared pronghorn used the intensively developed Jonah Natural Gas Field.

<u>sort criteria</u>: pronghorn, antelope, fragmentation, human activity, machine disturbance, roads, oil and gas, wells, sagebrush, shrubland, research, quantitative, Wyoming

Berger, J., K. Murray Berger, and J. Beckman. 2007. Wildlife and Energy Development: Pronghorn of the Upper Green River Basin – Year 2 Summary. Wildlife Conservation Society, Bronx, NY.

Results from the second year this study of did not detect significant differences in survival rates or body mass between control and treatment animals. These results were not unexpected since surface disturbance was limited to approximately 3% of the habitat within the PAPA and gas field development was concentrated outside pronghorn crucial winter range. Some individuals showed complete avoidance of gas field areas while other animals appeared to habituate to high levels human activity. Pronghorn utilized habitat within the core development areas disproportionately. The study identified several specific routes used by pronghorn to facilitate migration between summer and winter ranges. Snow depth had an overriding influence on pronghorn distribution in winter. Pronghorn rarely used patches where snow depth was >15 cm while highest use areas had snow depth of 10-14 cm.

<u>Sort criteria</u>: pronghorn, antelope, oil and gas, **migration**, human activity

Berger, J., K. Murray Berger and J. Beckman. *In review*. Wildlife and Energy Development: Pronghorn of the Upper Green River Basin – Year 3 Summary. Wildlife Conservation Society, Bronx. NY.

In 2007 the study was modified to incorporate changing or new methodologies: 1) Remote traffic counters were put in place at 45 locations to measure human activity in the gas fields; 2) classification counts including fawns and adult males were included to

assess changes in survival; 3) a grid cell analysis was added to estimate habitat loss and; 4) an additional 100 female pronghorn were fitted with VHF radio collars to enhance the total sample to assess adult female survival. Specific parcels along the western front of the Anticline continued to be utilized by pronghorn to facilitate migration. Models suggested both habitat loss and habitat fragmentation were influencing pronghorn distribution. During the winter of 2006-07 pronghorn showed reduced use of habitat within heavily developed areas of the Jonah gas field and for the first time, patterns of reduced use of areas in the Anticline gas field. Despite habitat loss, survival rates remain stable and it is presumed the Sublette herd unit remains below its food-limited ceiling.

<u>Sort criteria</u>: pronghorn, antelope, oil and gas, migration, human activity

Bruns, E.H. 1977. Winter behavior of pronghorns in relation to habitat. Journal of Wildlife Management 41:560-571.

Behavior of pronghorn antelope was studied in southeastern Alberta and northern Montana during the winter of 1969. Grasslands with interspersed sagebrush dominated the area. Roads played an important role in determining pronghorn usage of winter range. Ditches adjacent to high graded roads acted as snow traps and produced feeding areas nearby.

<u>sort criteria</u>: pronghorn, roads, grassland, quantitative, research-based, Canada, Montana

Cook, J.G. 1984. Pronghorn winter ranges: habitat characteristics and a field test of a habitat suitability model. M.S. Thesis, University of Wyoming, Laramie.

Habitat characteristics of pronghorn winter ranges and a habitat suitability model were evaluated. Pronghorn density was influenced primarily by shrub canopy coverage (i.e., Wyoming big sagebrush), and shrub cover influenced carrying capacity of pronghorn winter ranges.

<u>sort criteria</u>: pronghorn, mining, agriculture, rural subdivision, oil & gas, sagebrush, quantitative, research-based, Western U.S.

Easterly, T., A. Wood, and T. Litchfield. 1991. Responses of pronghorn and mule deer to petroleum development on crucial winter range in the Rattlesnake Hills. Unpublished Completion Report. Wyoming Game and Fish Department, Cheyenne.

Impacts of petroleum-related activities on pronghorn and mule deer were examined in central Wyoming. Distribution of pronghorn indicated avoidance of areas where drilling and well maintenance activities occurred. Displacement of mule deer in the study was not noted. Pronghorn numbers within 1 km of the well site decreased with the advent of road construction and drilling activity. However, once human activity subsided, numbers of pronghorn returned to pre-disturbance levels. "Displacement of animals may result in use of sub-optimal winter habitat, overcrowding, increased intraspecific competition, deterioration of habitat, and decreased physical condition of the population." Authors suggest drilling during summer on critical winter range.

sort criteria: pronghorn, mule deer, oil & gas, sagebrush, quantitative, research-based, Wyoming

Hayden-Wing Associates. 1991a. Final review and evaluation of the effects of Triton Oil and Gas Corporation's proposed coal bed methane field development (Great Divide prospect) on elk and other big game species. Triton Oil and Gas Corporation, Dallas, Tx.

Pronghorn, mule deer, and elk responses to disturbances associated with petroleum development in southwestern Wyoming were examined. Elk numbers decreased near drilling activities but returned to previous levels post-disturbance. However, elk were most sensitive to disturbances during winter and calving periods, and tended to avoid activity up to at least ½ mile away depending on whether or not the disturbance was visible. Pronghorn and mule deer seemed to habituate to most types of human disturbance unless they had been hunted or harassed. Mitigation measures for reducing impacts were presented.

sort criteria: pronghorn, mule deer, elk, oil & gas, sagebrush, quantitative, research-based, Wyoming

Hayden-Wing Associates. 1991b. Review and evaluation of the effects of geophysical exploration on some wildlife species in Wyoming. Unpublished Report for Geophysical Acquisition Workshop. Laramie, Wy.

A review of previous studies on the effects of geophysical exploration on pronghorn, mule deer, elk, raptors, and sage-grouse was presented. The information examined indicated that big game are temporarily affected by seismic exploration causing increased energy expenditure and utilization of sub-optimal habitats. Characteristics for evaluating potential sage-grouse nesting habitat in relation to proposed oil and gas development included: "1) distance relationships to leks, 2) presence, distance, and characteristics of existing disturbances, 3) characteristics of shrubs and vegetation that could serve in nest concealment and nest-site selection, and 4) distance to water and to potential brood-rearing areas." Mitigation strategies for protecting raptor-nesting habitat were also presented.

sort criteria: sage-grouse, raptors, pronghorn, mule deer, elk, oil & gas, seismic exploration, sagebrush, quantitative, research-based, Wyoming

Hoskinson, R.L., and J.R. Tester. 1980. Migration behavior of pronghorn in southeastern Idaho. Journal of Wildlife Management 44:132-144.

Seasonal migration patterns of pronghorn were investigated from December 1975 through August 1977 in southeastern Idaho. Moisture content of vegetation was a stimulus for fall migration to begin. This migratory behavior could afford selective advantages to pronghorn because they are utilizing the best available food sources.

sort criteria: pronghorn, drought, sagebrush, quantitative, research-based, Idaho

Krausman, P.R., L.K. Harris, C.L. Blasch, K.K.G. Koenen, and J. Francine. 2004. Effects of military operations on behavior and hearing of endangered Sonoran pronghorn. Wildlife Monographs 157:1-41.

Military activities were monitored to determine the effects of noise and human activity on Sonoran pronghorn in Arizona. Based on the results: "(1) behavior patterns of pronghorn were similar with and without the presence of military stimuli, (2) behavior patterns of pronghorn exposed to military activity were similar to that of pronghorn not exposed to regular military activity, and (3) auditory characteristics were similar for ungulates that have and have not been exposed to sound pressure levels typical of military activities."

sort criteria: pronghorn, desert shrubland, human activity, noise, quantitative, research-based, Arizona

Landon, D.M., P.R. Krausman, K.K.G. Koenen, and L.K. Harris. 2003. Pronghorn use of areas with varying sound pressure levels. Southwestern Naturalist 48:725-728.

Pronghorn use of areas with varying noise levels (from military aircraft training) was evaluated in Arizona. "In general, pronghorn used areas with lower levels of noise (< 45 decibels [dB]) more than expected and areas with higher levels (≥ 55dB) less than expected." Vegetation and cover could also have influenced pronghorn use of these areas.

sort criteria: pronghorn, noise, quantitative, research-based, Arizona

Medcraft, J.R., and W.R. Clark. 1986. Big game habitat use and diets on a surface mine in northeastern Wyoming. Journal of Wildlife Management 50:135-142.

Seasonal uses of habitats by deer and pronghorn were studied at a coal surface mine near Gillette, Wyoming. Native vegetation was dominated by big sagebrush. Mule

deer used reclaimed land more than un-mined land, however the opposite was true for pronghorns. Because reclaimed land provided sufficient, high-quality forage, authors believed habitat could be improved over time.

sort criteria: mule deer, pronghorn, mining, sagebrush, quantitative, research-based, Wyoming

Morton, P., C. Weller, J. Thomson, M. Haefele, and N. Culver. 2004. Drilling in the Rocky Mountains: How much and at what cost? The Wilderness Society, Washington, D.C.

An analysis examining the impacts associated with large-scale energy development determined that significant fragmentation of wildlife habitat occurs with development activities. Non-market costs of drilling included "erosion, loss of wildlife and fish habitat, decline in quality of recreational experiences, proliferation of noxious weeds, and increased air and water pollution." A habitat fragmentation analysis of the Big Piney-LaBarge oil and gas field (in northwestern Wyoming) produced results indicating " a direct physical footprint of 1,400 miles of linear features and 3.8 square miles of polygon features, resulting in an overall density of 8.43 miles of roads and pipelines per $mile^2$." Also, 97% of the area falls within ¼ mile of some infrastructure and only 27% of the study area was more than 500 feet from infrastructure, with only 3% more than ¼ mile away.

sort criteria: sage-grouse, mule deer, pronghorn, elk, raptors, non-game birds, fish, wildlife, oil & gas, fragmentation, quantitative, research-based, prescriptive, western U.S.

Phillips, R.L., D.E. Biggins, and A.B. Hoag. 1986. Coal surface mining and selected wildlife – a 10-year case study near Decker, Montana. Pages 235-245 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Mule deer, pronghorn, sage-grouse, and golden eagles were monitored to determine their responses to mining activities in southeastern Montana and northern Wyoming. "Mule deer and pronghorn populations thrived throughout the study period despite increasing mining activity and human disturbance." Sage-grouse habitat was lost, but mitigation efforts (e.g., relocation of a lek) seemed to be successful. Golden eagle numbers remained relatively stable. Four nesting pairs near active mines had a 10-year nesting success of 67.5% compared to 56.6% for pairs nesting elsewhere on the study area. "If the primary post mining land use is wildlife, permanent reclamation can be designed to maximize the mixture of plant species and thereby provide greater habitat diversity than native prairie."

sort criteria: sage-grouse, mule deer, pronghorn, raptors, mining, sagebrush, quantitative, research-based, Wyoming, Montana, mitigation

PIC Technologies and Bureau of Land Management, Pinedale Field Office. 1999. Draft Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project. Bureau of Land Management, Pinedale, Wyoming, USA.

Management objectives, monitoring and mitigation recommendations for the Pinedale Anticline Oil and Gas Exploration and Development Project in northwestern Wyoming were presented. The standard stipulation alternative (SS) was explained as well as a resource protection alternative (RP), which included all spatial and temporal restrictions contained in the SS alternative. The RP alternative offered additional protection measures to "be applied to wildlife habitats on Federal lands and minerals."

sort criteria: sage-grouse, pronghorn, mule deer, elk, moose, non-game birds, raptors, wildlife, oil & gas, noise, roads, quantitative, research-based, Wyoming

Riddle, P., and C. Oakley. 1973. The impacts of a severe winter and fences on antelope mortality in southcentral Wyoming. Proceedings of the Western Association of State Game and Fish Commissioners 53:174-188.

The influence of fencing on the mortality of pronghorn during a severe winter in south-central Wyoming was investigated. Highest mortality of pronghorn was associated with 4W Rouse-type woven wire fence. "Although woven wire fences represented only 53% of all fenceline transects, they accounted for 83% of the fenceline mortality." Modification or removal of fences was recommended to minimize pronghorn mortality.

sort criteria: pronghorn, fragmentation, fences, sagebrush, quantitative, research-based, Wyoming

Ryder, T.J. 1983. Winter habitat selection of pronghorn in south-central Wyoming. M.S. Thesis, University of Wyoming, Laramie.

Pronghorn selection of winter habitat was investigated in south-central Wyoming from 1978-1982. Pronghorn habitat use was associated with forage quantity, noticeably big sagebrush density and height but varied with weather conditions. During a mild winter 54% of pronghorn observations were in draws, 21% in greasewood-saltbush flats, and the remaining 25% were observed on benches and ridges.

sort criteria: pronghorn, mining, sagebrush, quantitative, research-based, Wyoming

Sawyer, H., and B. Rudd. 2005. Pronghorn roadway crossings: A review of available information and potential options. Western EcoSystems Technology, Inc. Cheyenne, WY. 25 pp.

Roadways are a barrier to movement and a source of mortality for pronghorn. Right-of-way fences that consist of woven wire are particularly prohibitive. Unlike other ungulates, pronghorn usually avoid jumping over fences, preferring to go underneath them. Three options are available to help pronghorn cross roadways: concrete culverts, overpasses, and open-span bridges. Pronghorn are not likely to use concrete culverts because of the confined space and inability to see the horizon. Overpasses are extremely costly and it is unknown if pronghorn will use them. Open-span bridges are the best option because they provide adequate space and visibility for movement and cost less than overpasses.

sort criteria: fences, prescriptive, pronghorn, qualitative, roads, Wyoming

Sawyer, H. and F. Lindzey. 2000. The Jackson Hole pronghorn study. WY Coop. Fish and Wildlife Res. Unit. Univ. Of Wyoming. Laramie. 40 pp.

The study identified the migration routes and wintering areas used by the Sublette pronghorn herd. The data suggest the winter habitat currently designated is conservative and underestimated. Bottlenecks pose a threat to the continuation of this migration. A cooperative effort between the WGFD, UW, BLM, Sublette County, and several NGOs produced a 4-step plan to help preserve the migration. These steps included federal and state land management planning, county land use planning, private land conservation, and education/public awareness.

sort criteria: human activity, prescriptive, pronghorn, qualitative, Wyoming

Sawyer, H., F. Lindzey, and D. McWhirter. 2005. Mule deer and pronghorn migration in western Wyoming. Wildlife Society Bulletin. In Press.

The Green River Basin provides winter habitat for mule deer from five different mountain ranges and pronghorn that migrate from Grand Teton National Park. The established migration routes of these herds are estimated to be thousands of years old. Housing and energy developments, fences, and roads constrict these migration routes by creating bottlenecks. If animals are not able to maneuver through these bottlenecks, they cannot reach their seasonal ranges, which may lead to population declines. Identification and protection of migration routes should be extremely important considerations in wildlife management.

sort criteria: fences, mule deer, oil and gas, pronghorn, roads, qualitative, rural subdivision, Wyoming

Sheldon, D.P. 2005. Pronghorn movement and distribution patterns in relation to roads and fences in southwestern Wyoming. Master's thesis. University of Wyoming, Laramie.

Fences influenced distribution and movement patterns of pronghorn. Pronghorn selected areas with the lowest fence density. Pronghorn consistently crossed roads with no fencing.   Possible management actions include limiting fencing in pronghorn range and maintaining unfenced sections of highways in pronghorn migration corridors.

<u>sort criteria</u>: fence, prescriptive, pronghorn, quantitative, roads, Wyoming

Strickland, D. 1999. Petroleum development versus wildlife in the overthrust. Transactions of the North American Wildlife and Natural Resources Conference 64:28-35.

Controversies concerning impacts to wildlife from petroleum development in Wyoming are discussed. To date (1999) an estimated 2,100 producing oil and gas wells are located in southwestern Wyoming, with a large potential for further development. The BLM (Bureau of Land Management) estimates an additional 4,837 wells will be developed. Since 1984, 24,112 acres of habitat has been lost due to oil and gas development, and an additional 53,000 acres would be disturbed by future development from direct impacts (e.g., roads, pipelines, etc.). "The potential area of direct and indirect disturbance is 2.7 million acres, or approximately 16 percent of southwestern Wyoming." Author suggests the BLM modify its leasing strategy using long-range and strategic planning with an adaptive approach.

<u>sort criteria</u>: elk, bighorn sheep, moose, pronghorn, mule deer, sage-grouse, oil & gas, sagebrush, qualitative, prescriptive, Wyoming

Sundstrom, C. 1969. Some factors influencing pronghorn antelope distribution in the Red Desert of Wyoming. Proceedings of the Western Association of State Game and Fish Commissioners 49:225-264.

Factors influencing pronghorn distribution in south-central Wyoming were examined. Fences in the study area generally had no long-term negative effects on pronghorn populations. This was due to the fact that these herds did not have to migrate from summer to winter range because of plentiful food, water, and cover in the area. Six percent (987 of 15,940) of pronghorn observations were in grass vegetative type, 2% in meadow type, 78% in sagebrush type, 5% in saltbush type, 9% in greasewood type, and < 1% in waste type.

<u>sort criteria</u>: pronghorn, fragmentation, fences, sagebrush, quantitative, research-based, Wyoming

Weller, C., J. Thomson, P. Morton, and G. Aplet. 2002. Fragmenting our lands: The ecological footprint from oil and gas development. The Wilderness Society, Washington, D.C.

Habitat fragmentation resulting from resource extraction practices was examined in the Upper Green River Basin of Wyoming. Average road densities and other linear features were 8.43 miles per square mile. An effect zone of ½ mile was constructed and analyzed. The analysis showed the entire 166 square mile study area to be within ½ mile of a road or other development related infrastructure. "The ecological footprint varies depending upon which disturbance is measured. A disturbance that reaches a quarter of a mile beyond the infrastructure creates a footprint of 160 square miles, affecting 97% of the study area. Even a more localized disturbance that only reaches 100 feet beyond the infrastructure affects 28% of the study area (47 square miles)."

sort criteria: sage-grouse, mule deer, pronghorn, elk, moose, oil & gas, sagebrush, quantitative, research-based, Wyoming

Western EcoSystems Technology, Inc. 2003. An evaluation of the 1988 BLM Pinedale Resource Management Plan, 2000 BLM Pinedale Anticline Final EIS and recommendations for the current revision of the Pinedale Resource Management Plan. The Wilderness Society, Washington, D.C.

An analysis of the 1988 Bureau of Land Management (BLM) Resource Management Plan and the 2000 BLM Pinedale Anticline Environmental Impact Statement (EIS) was presented. Recommendations for the current revision of the Pinedale Resource Management Plan were also given. Overall planning and adaptive management recommendation included: 1) limiting the density of roads and wells per section, 2) protecting a minimum amount of significant big game habitat from disturbance, 3) identify areas where future oil and gas leases should be prohibited, 4) coordinate habitat management, and 5) apply adaptive management.

sort criteria: pronghorn, mule deer, elk, oil & gas, roads, sagebrush, quantitative, research-based, Wyoming

Wyoming Game & Fish Department. 1976. Considerations for wildlife in industrial development and reclamation. Cheyenne, Wy.

Mitigation and monitoring considerations for protecting wildlife and wildlife habitat with regard to industrial development were presented. Habitat development and reclamation were examined and recommendations were provided for specific habitat types (e.g., shrubland, rimrocks, etc.), and for individual wildlife species (e.g., mule deer, pronghorn, etc.).

sort criteria: sage-grouse, mule deer, pronghorn, elk, bighorn sheep, wildlife, sagebrush, qualitative, prescriptive, mitigation, Wyoming

ELK

Allred, W.J. 1950. Re-establishment of seasonal elk migrations through transplanting. Wyoming Wildlife. March 1950.

Reasons for the discontinuation of seasonal migration of elk (between high country and desert areas) and re-establishment of historical migratory routes were examined. Severe winters, agriculture activities, hunting pressure, and fences were factors contributing to the halt of seasonal migrations. To re-establish migratory patterns, young elk that had not formed migratory habits were transplanted along the historic migratory route. The transplanting experiment seemed to be successful with increasing numbers of elk traveling along the old migratory routes.

sort criteria: elk, agriculture, fences quantitative, research-based, Wyoming

Altman, M. 1958. The flight distance in free-ranging big game. Journal of Wildlife Management 22(2):207-209.

Distances moose and elk fled from human intruders were investigated in Wyoming. Reactions were quite varied depending on species, sex, season (e.g. parturition, mating, hunting, etc.), and acclimation to human presence (e.g. tourists, fishermen, etc.). Flight distances ranged from a low of 10 feet for both cows and bulls during rut to a maximum of 300 feet for both sexes during hunting season.

sort criteria: moose, elk, human activity, quantitative, research-based, Wyoming

Cassirer, E.F., D.J. Freddy, and E.D. Ables. 1992. Elk responses to disturbance by cross-country skiers in Yellowstone National Park. Wildlife Society Bulletin 20:375-381.

Elk responses to cross-country skiers were examined in Yellowstone National Park. "The median distance at which elk in Lamar and Stephen's Creek started to move when skiers approached was 400 m, whereas the median flight distance of elk in Mammoth Hot Springs was 15 m." This difference was likely due to habituation of Mammoth elk to predictable human activity. Authors suggest skiers remain at distances >1,700 m to effectively avoid disturbing elk.

sort criteria: elk, human activity, sagebrush, grassland, forested, quantitative, research-based, Wyoming

Cole, E.K., M.D. Pope, and R.G. Anthony. 1997. Effects of road management on movement survival of Roosevelt elk. Journal of Wildlife Management 61:1115-1126.

The movement and survival of female Roosevelt elk were studied in Oregon (from 1991 to 1995) before designation of Road Management Areas (RMAs), and afterward, when access was restricted. In 1992, 35% of the study area was designated open to access. Home ranges of elk within the RMAs decreased from 761 ha during pre-treatment to 650 ha during the RMA phase. Fourteen elk were alive during both phases of the study. The average distances all of these elk moved decreased during RMA phases compared to the pre-treatment phase. Limited-access could increase survival and reproduction of elk due to reduced energy expenditure.

sort criteria: elk, roads, forested, quantitative, research-based, Oregon

Edge, W.D., C.L. Marcum, and S.L. Olson. 1985. Effects of logging activities on home-range fidelity of elk. Journal of Wildlife Management 49:741-744.

Logging and its effects upon home-range fidelity of elk were examined in a forested area east of Missoula, Montana, between 1977 and 1983. Logging activities did not cause a significant decrease in home-range size. The mean home range was 4,418 ha during years of disturbance and 4,506 ha when disturbance was absent. Authors concluded, “Logging activities that are restricted as much as possible in time and space, or conducted on seasonal ranges during periods when elk are not present, will be least disruptive.”

sort criteria: elk, logging, forested, quantitative, research-based, Montana

Gillin, C. 1989. Response of elk to seismograph exploration in the Wyoming Range. M.S. Thesis, University of Wyoming, Laramie.

Elk responses to seismic exploration were investigated in northwestern Wyoming. For each period of seismic activity, comparisons of movement and habitat use were examined before, during and after disturbance. Elk were displaced an average of 1.2 km by seismic activity. Elk moved less daily during (1.8 km) and after (1.56 km) seismic disturbance than before (2.84 km). No range abandonment was observed. Elk tended to move from open areas to dense (> 70% canopy) timbered areas. “Elk detected and moved away from seismic activity up to 3.2 km away.”

sort criteria: elk, seismic exploration, forested, quantitative, research-based, Wyoming

Girard, M., and B. Stotts. 1986. Managing impacts of oil and gas development on woodland wildlife habitats on the Little Missouri Grasslands, North Dakota. Pages 128-130 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Impacts from oil and gas development (e.g., construction activities, toxic fumes, chemical spills, and wildlife displacement) on woodland wildlife habitat were evaluated on the Little Missouri Grasslands in North Dakota. Approximately 10,884 acres had been directly disturbed by oil and gas activity. A sphere of influence surrounds all roads and well pads, and is estimated to be a minimum of 100 yards in all directions. Mitigation efforts included: (1) No well pads or roads placed in a woodland. (2) Roads crossing "draws" must be at right angles to minimize disturbance. (3) Extra heavy pit liners were to be used in areas with porous substrates to prevent saltwater seepage.

sort criteria: wildlife, mule deer, elk, oil & gas, forested, quantitative, research-based, North Dakota, mitigation

Hayden-Wing Associates. 1990a. Response of elk to Exxon's field development in the Riley Ridge area of western Wyoming, 1979-1988. Final Report prepared for Exxon Company, U.S.A. and Wyoming Game and Fish Department, Cheyenne, Wy.

Distribution patterns and elk numbers were monitored to determine responses of wintering and calving elk to development of a natural gas well field in western Wyoming. During calving season (in calving areas) elk moved away from construction activities, but returned following the completion of drilling. Numbers of wintering elk declined in areas closest to the well except after construction when snow depths were greater than average. "Proper siting of wells, roads, and other facilities is crucial to maintaining elk use of winter and calving ranges." Recommendations were given to minimize impacts of oil and gas development on elk habitat.

sort criteria: elk, oil & gas, sagebrush, quantitative, research-based, Wyoming

Hayden-Wing Associates. 1990b. Summary of elk responses to oil well drilling and associated disturbances. Hayden-Wing Associates, Laramie, Wy.

A review of quantitative research on elk responses to well drilling, seismic exploration, roads, and mining was presented. "Most studies, however, point out that levels of elk occurrence near drilling activities decrease during drilling operations but return to former levels after a well site is abandoned." The presence or absence of security cover influences the magnitude of elk response to oil well drilling and associated activities.

sort criteria: elk, oil & gas, sagebrush, quantitative, research-based, Wyoming

Hayden-Wing Associates. 1991a. Final review and evaluation of the effects of Triton Oil and Gas Corporation's proposed coal bed methane field development (Great Divide prospect) on elk and other big game species. Triton Oil and Gas Corporation, Dallas, Tx.

Pronghorn, mule deer, and elk responses to disturbances associated with petroleum development in southwestern Wyoming were examined. Elk numbers decreased near drilling activities but returned to previous levels post-disturbance. However, elk were most sensitive to disturbances during winter and calving periods, and tended to avoid activity up to at least ½ mile away depending on whether or not the disturbance was visible. Pronghorn and mule deer seemed to habituate to most types of human disturbance unless they had been hunted or harassed. Mitigation measures for reducing impacts were presented.

<u>sort criteria</u>: pronghorn, mule deer, elk, oil & gas, sagebrush, quantitative, research-based, Wyoming

Hayden-Wing Associates. 1991b. Review and evaluation of the effects of geophysical exploration on some wildlife species in Wyoming. Unpublished Report for Geophysical Acquisition Workshop. Laramie, Wy.

A review of previous studies on the effects of geophysical exploration on pronghorn, mule deer, elk, raptors, and sage-grouse was presented. The information examined indicated that big game are temporarily affected by seismic exploration causing increased energy expenditure and utilization of sub-optimal habitats. Characteristics for evaluating potential sage-grouse nesting habitat in relation to proposed oil and gas development included: "1) distance relationships to leks, 2) presence, distance, and characteristics of existing disturbances, 3) characteristics of shrubs and vegetation that could serve in nest concealment and nest-site selection, and 4) distance to water and to potential brood-rearing areas." Mitigation strategies for protecting raptor-nesting habitat were also presented.

<u>sort criteria</u>: sage-grouse, raptors, pronghorn, mule deer, elk, oil & gas, seismic exploration, sagebrush, quantitative, research-based, Wyoming

Henderson, R.E., and A. O'Herren. 1992. Winter ranges for elk and deer: victims of uncontrolled subdivisions? Western Wildlands 18:20-25.

Authors described impacts created by increasing human habitation of elk and deer winter ranges in Montana. Human disturbance can interrupt, and displace the movements between summer and winter ranges for both mule deer and elk.

<u>sort criteria</u>: mule deer, elk, rural subdivisions, agricultural, forested, qualitative, prescriptive, Montana

Irwin, L.L., and J.M. Peek. 1979. Relationship between road closures and elk behavior in northern Idaho. Pages 199-204 in M.S. Boyce and L.D. Hayden-Wing, eds. North American elk: ecology, behavior and management. University of Wyoming, Laramie. 294 pp.

Habitat use patterns related to forest management, hunters, and roads were investigated in northern Idaho from 1975 through 1977. There was no restricted access in 1975, 40 km^2 was closed to vehicles in 1976, and 75 km^2 was closed in 1977 (all closures were during hunting season). Elk were displaced to more extensive stands of trees when roads were open, however with road closures elk utilized smaller stands for longer periods. The larger ($75m^2$) closed area allowed elk to stay even longer. Authors recommend road closures would mitigate displacement of elk, especially during hunting season.

sort criteria: elk, roads, forested, quantitative, research-based, Idaho

Irwin, L.L., and C.M. Gillin. 1984. Response of elk to seismic exploration in the Bridger-Teton Forest, Wyoming. Progress Report. Bureau of Land Management, International Association of Geophysical Contractors, U.S. Forest Service, and Wyoming Game and Fish Department.

Responses of elk to seismic disturbance were investigated in western Wyoming. During one disturbance event, some elk were displaced and moved to summer range early while other elk used topographic barriers as buffers to the disturbance. Elk at distances greater than 2.5 km from disturbance showed no visible reactions. Elk abandoned the study area (Snider Basin) during calving.

sort criteria: elk, seismic exploration, forested, quantitative, research-based, Wyoming

Johnson, B., and L. Wolrab. 1987. Response of elk to development of a natural gas field in western Wyoming, 1979-1987. Wyoming Game & Fish Department Report.

The distribution and use of elk winter ranges and calving areas were monitored in western Wyoming from 1979 through 1987. In an area where 3 wells were drilled, 6,000 acres of winter range was abandoned. Elk returned to the area once drilling activities ceased, but use was unpredictable. Elk calving areas were also affected, with abandonment of calving sites during intense drilling activity. Mitigation and management recommendations included: road closures, placing wells outside crucial habitats, reducing human activity, and placing restrictions on seasonal activity around wells.

sort criteria: elk, oil & gas, sagebrush, quantitative, research-based, Wyoming

Johnson, B.K., and D. Lockman. 1979. Response of elk during calving to oil/gas drilling activity in Snider, Basin, Wyoming. WGFD Report 14pp.

A two-year comparison to assess effects of drilling activities on elk was conducted in southwest Wyoming. Elk use of the area was monitored during calving season in 1979 and 1980. In 1979, a wildcat well was drilled in the area. "Elk moved calves at an earlier age in 1979 than in 1980, moved calves away from drilling activity in 1979, avoided meadows visible from roads with high traffic volume more in 1979 than in 1980 and avoided the drill site in 1979." Authors suggest disturbance can affect elk populations by: increased mortality in calves, delayed maturity, decreased body size, and reduced body fat reserves. Recommendations for minimizing impacts are given.

<u>sort criteria</u>: elk, oil & gas, sagebrush, forested, quantitative, research-based, Wyoming

Johnson, T.K. 1986. Impacts of surface coal mining on calving elk. Pages 255-269 <u>in</u> Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Elk calving behavior in relation to habitat disturbance from surface coal mining activities was investigated in northern Colorado. No significant differences between control elk and elk using the mine site were found in relation to reproductive productivity, calving, home-range size, fidelity, or habitat utilization and selection patterns. During spring and summer reclaimed sites were used in proportion to availability and were selected for during fall and early winter.

<u>sort criteria</u>: elk, mining, forested, quantitative, research-based, Colorado

Knight, J.E. 1981. Effect of oil and gas development on elk movements and distribution in northern Michigan. North American Wildlife and Natural Resources Conference 46:349-357.

Effects of oil and gas development on the movements and distribution of elk were studied in northern Michigan. Seismic activity had a significant effect on elk movement, but not distribution. However, oil well activity did not significantly affect either movement or distribution. The mean distance moved by all elk during seismic activity was 1320.7 yards when disturbance was 1000 m away, and 1563.2 yards when disturbance was 400 m away. Calving and rut are two situations when seismic activity could have the greatest implications.

<u>sort criteria</u>: elk, oil & gas, seismic exploration, forested, quantitative, research-based, Michigan

Kuck, L. 1986. The impacts of phosphate mining on big game in Idaho: a cooperative approach to conflict resolution. Transactions of the 51st North American Wildlife and Natural Resources Conference 51:90-97.

Evaluation of impacts of phosphate mining on big game in Idaho was the objective of this study. "Results of this study indicate that elk, deer and moose may be capable of adapting to many phosphate mining activities in southeastern Idaho, but cannot compensate for disturbance on important seasonal ranges or for increased mortality associated with industrial development."

<u>sort criteria</u>: mule deer, elk, moose, mining, forested, grassland, quantitative, research-based, Idaho

Kuck, L., G.L. Hompland, and E.H. Merrill. 1985. Elk calf response to simulated mine disturbance in southeast Idaho. Journal of Wildlife Management 49(3):751-757.

Mine disturbance was simulated to study responses by elk calves in southeast Idaho in an area dominated by aspen forest. Disturbed calves tended to move farther, higher in elevation, and used larger areas than did undisturbed calves. Elk cow/calf pairs were sensitive to human and simulated mine disturbance. Consequent abandonment of calf-rearing areas by disturbed cow/calf pairs led to habitation of more marginal habitats. Avoidance of disturbance did not result in calf abandonment or lower survival rates between disturbed and undisturbed groups.

<u>sort criteria</u>: elk, mining, forested, quantitative, research-based, Idaho

Kuhn, J.A., and B. Martens. 1985. Coal mine development and elk biology: Environmental impact assessment in Alberta and British Columbia. Pages 273-282 <u>in</u> M.S. Boyce and D. Hayden-Wing eds. North American elk: ecology, behavior, and management. University of Wyoming, Laramie.

Impacts of coal mine development on elk were assessed in Alberta and British Columbia, Canada. Habitat alteration (i.e., reclamation) of development areas caused underutilization of habitat near development and potential over-utilization elsewhere. However, authors suggest, ". . . concentrated use by elk of habitats close to development, for example, use of drillhole seepages as mineral licks, use of road and powerline rights-of-way through dense, regenerating or deadfall littered forests, increased use of habitats within the perimeter of restricted shooting zones near development, and foraging on reclaimed lands . . .." Increased hunting pressure and harassment from recreationists are secondary effects of development.

<u>sort criteria</u>: elk, mining, forested, quantitative, research-based, Canada

Lees, A.T. 1989. The effect of recreational activity on elk use and distribution along a pipeline right-of-way. Pages 133-143 in Proceedings IV: Issues and Technology in the Management of Impacted Wildlife. Thorne Ecological Institute, Boulder, Co.

Elk response to recreational activity along a pipeline right-of-way was investigated in west-central Alberta, Canada. Elk used the right-of-way as a feeding area year round, but showed a preference for areas with minimal human activity. Elk use of habitat adjacent to the right-of-way was marginally affected by human activity along the right-of-way. Elk adapted to human activity by using cover types that provided security. sort criteria: elk, oil & gas, roads, human activity, forested, quantitative, research-based, Canada

Lyon, L.J. 1979. Habitat effectiveness for elk as influenced by roads and cover. Journal of Forestry. 79(10):658-660.

Data from a previous study of elk pellet distribution in western Montana was used to ". . . develop (1) a model of habitat effectiveness in relation to roads and cover density, and (2) a method for estimating habitat effectiveness under various levels of road density and cover." When road densities reached 3 miles per square mile even very dense canopy cover was not effective elk habitat. "Effective habitat" is a relative term and activities other than road management can modify the quality and productive potential of habitat.

sort criteria: elk, roads, forested, quantitative, research-based, Montana

Lyon, L.J. 1983. Road density models describing habitat effectiveness for elk. Journal of Forestry 81:592-595.

Response of elk to roads was investigated in Montana and Idaho in regard to road densities. In areas of road density of 5 ½ miles per square mile, elk used 18.8% of the potential habitat. Authors conclude the full impact of roads does not take place until 3 or more years after road construction, and road closures are the best way to assure effectual fall use of habitat by elk.

sort criteria: elk, roads, forested, quantitative, research-based, Montana, Idaho

McCorquodale, S.M., K.J. Raedeke, and R.D. Taber. 1986. Elk habitat use patterns in the shrub-steppe of Washington. Journal of Wildlife Management 50:664-669.

Habitat use and behavior of elk were studied on the ALE (Arid Lands Ecology) Reserve (public access is prohibited) in south-central Washington. An introduced population of elk inhabits this sagebrush steppe ecosystem. Over 75% of cow elk selected lower elevation areas all seasons except during calving, and male elk selected sagebrush areas during spring, summer, and fall. The lack of human presence on the Reserve (i.e. no human disturbance) may influence the limited cover needs of the elk. “The behavior of this population suggested that under conditions of infrequent disturbance and adequate forage, elk can be successful in habitats with limited thermal or security cover, even in severe climates.

<u>sort criteria</u>: elk, human activity, sagebrush, quantitative, research-based, Washington

Morgantini, L.E., and R.J. Hudson. 1978. Human disturbance and habitat selection in elk. Pages 132-139 <u>in</u> M.S. Boyce and L.D. Hayden-Wing eds. North American elk: ecology, behavior, and management. University of Wyoming, Laramie.

Selection and utilization of resources by elk were studied in western Alberta during the winter/spring of 1975-1976. Elk distribution and behavior were significantly altered by human activity. “The amount of time the elk spent in shrubland while moving toward the open in evening, appeared related to traffic activity taking place on the road. Once on the grassland, grazing took place within 100-200 m of cover. With darkness, the elk moved closer to the main road making better use of the potentially available range.” Elk reacted to human activity by using marginal sectors of the grassland in the study area, which led to overgrazing in these locations.

<u>sort criteria</u>: elk, human activity, roads, forested, grassland, quantitative, research-based, Canada

Morrison, J.R., W.J. de Vergi, A.W. Alldredge, A.E. Byrne, and W.A. Andree. 1995. The effects of ski area expansion on elk. Wildlife Society Bulletin 23(3):481-489.

Responses of 2 populations of elk to physical and human disturbances associated with ski-area expansion in Colorado were investigated. “Results from Vail and Beaver Creek study sites indicate that elk may be acclimating behaviorally to physical disturbances and human activity. In areas where elk use decreased, a linear increase in use followed, although rates of recovery differed by area.” Authors recommend minimizing human activities during times of heavy elk use to reduce the effects of development.

<u>sort criteria</u>: elk, human activity, forested, quantitative, research-based, Colorado

Morton, P., C. Weller, J. Thomson, M. Haefele, and N. Culver. 2004. Drilling in the Rocky Mountains: How much and at what cost? The Wilderness Society, Washington, D.C.

An analysis examining the impacts associated with large-scale energy development determined that significant fragmentation of wildlife habitat occurs with development activities. Non-market costs of drilling included "erosion, loss of wildlife and fish habitat, decline in quality of recreational experiences, proliferation of noxious weeds, and increased air and water pollution." A habitat fragmentation analysis of the Big Piney-LaBarge oil and gas field (in northwestern Wyoming) produced results indicating " a direct physical footprint of 1,400 miles of linear features and 3.8 square miles of polygon features, resulting in an overall density of 8.43 miles of roads and pipelines per mile^2." Also, 97% of the area falls within ¼ mile of some infrastructure and only 27% of the study area was more than 500 feet from infrastructure, with only 3% more than ¼ mile away.

sort criteria: sage-grouse, mule deer, pronghorn, elk, raptors, non-game birds, fish, wildlife, oil & gas, fragmentation, quantitative, research-based, prescriptive, western U.S.

Oedekoven, O.O., and F.G. Lindzey. 1987. Winter habitat-use patterns of elk, mule deer, and moose in southwestern Wyoming. Great Basin Naturalist 47:638-643.

Mule deer, elk, and moose winter habitat use patterns were examined in southwestern Wyoming. Mule deer used sagebrush extensively, moose favored aspen, willow, and mixed-shrub vegetation, and elk preferred alpine grass/moss vegetation. Elk and mule deer showed a preference for areas with mild snow conditions, whereas moose were often observed in areas with deep snow. "Our results suggested that although deer, elk, and moose often used the same areas, they selected differing habitats within shared areas."

sort criteria: mule deer, elk, moose, sagebrush, quantitative, research-based, Wyoming

Parker, K.L., C.T. Robbins, and T.A. Hanley. 1984. Energy expenditures for locomotion by mule deer and elk. Journal of Wildlife Management 48:474-488.

Energy expenditures were measured on mule deer and elk to determine energy costs for several activities. Logging activities affected energy expenditures of both elk and deer by removal of canopy and subsequent increased snow depth. Human activity (i.e. winter recreation) caused excessive energy expenditure by inducing elk and deer to flee when approached. Management considerations should include restricting human access to deer and elk winter use areas.

sort criteria: mule deer, elk, human activity, logging, forested, quantitative, research-based

Phillips, G.E., and A.W. Alldredge. 2000. Reproductive success of elk following disturbance by humans during calving season. Journal of Wildlife Management 64(2):521-530.

Interrelationships between human disturbance and recruitment of calf elk were investigated in central Colorado during 1 pretreatment year and 2 treatment years (1995-1997). Average production from treatment elk was 0.225 calves/cow lower than that of control elk. Based on this study, 8.3 disturbances per cow were enough to reduce annual population growth by 1%. The results ". . . do not prove cause and effect, but they support treatment as a causal mechanism for decreased reproductive success on the Beaver Creek study area in 1996 and 1997."

sort criteria: elk, human activity, forested, quantitative, research-based, Colorado

PIC Technologies and Bureau of Land Management, Pinedale Field Office. 1999. Draft Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project. Bureau of Land Management, Pinedale, Wyoming, USA.

Management objectives, monitoring and mitigation recommendations for the Pinedale Anticline Oil and Gas Exploration and Development Project in northwestern Wyoming were presented. The standard stipulation alternative (SS) was explained as well as a resource protection alternative (RP), which included all spatial and temporal restrictions contained in the SS alternative. The RP alternative offered additional protection measures to "be applied to wildlife habitats on Federal lands and minerals."

sort criteria: sage-grouse, pronghorn, mule deer, elk, moose, non-game birds, raptors, wildlife, oil & gas, noise, roads, quantitative, research-based, Wyoming

Powell, J.H. 2003. Distribution, habitat use patterns and elk response to human disturbance in the Jack Morrow Hills. M.S. Thesis, University of Wyoming, Laramie.

Elk distribution, habitat use, and effects of human disturbance were examined in southwestern Wyoming. Elk avoided areas within 2,000 m of active oil and gas wells and major roads. During calving and the summer season elk selected habitats associated with security cover (e.g., mountain shrub and tall sagebrush). Daily movements of disturbed elk were approximately 4 times greater than undisturbed elk. Elk avoidance of areas adjacent to oil and gas wells and major roads can cause greater effective habitat loss than merely the area occupied by the structure.

sort criteria: elk, oil & gas, roads, sagebrush, quantitative, research-based, Wyoming

Preisler, H.K., A.A. Ager, and M.J. Wisdom. 2006. Statistical methods for analyzing responses of wildlife to human disturbance. Journal of Applied Ecology. 43:164-172.

Researchers conducted an experiment measuring elk response to ATVs, based on 3, 5-day replicated trials in an enclosed area. During the first 2 days, elk moved as far as possible from the ATV. However, during the last 2 days, elk did not move as far indicating habituation or location closer to refuge. The distance between the elk and the ATV or nearest ATV route affected the probability of running away. The further away, the less likely the elk were to flee. There was up to an 80% response rate when ATVs were 20 m away, 7-13% times larger than when ATVs were 500 m away. There were significant responses when an elk was close to an ATV route but the ATV was 2 km away.

<u>sort criteria</u>: elk, human activity, off road vehicle, Oregon, quantitative

Rost, G.R., and J.A. Bailey. 1979. Distribution of mule deer and elk in relation to roads. Journal of Wildlife Management 43(3):634-641.

Deer and elk responses to roads were assessed on winter ranges in Colorado during the winters of 1973 and 1974. The principal habitats were mountain shrub and pine forests. Data were obtained by counting fecal-pellet groups within 400m transects parallel to roads. Based upon pellet group distributions, elk and deer avoided roads, especially areas within 200m. Deer avoided roads more in shrublands than in forested areas, however elk responses did not differ based on habitat type. At some sites, deer avoided roads even though snow likely restricted available habitat. Therefore, propensity to avoid roads may be detrimental to deer and elk.

<u>sort criteria</u>: mule deer, elk, roads, mountain shrub, forested, quantitative, research-based, Colorado

Rowland, M.M., M.J. Wisdom, B.K. Johnson, and J.G. Kie. 2000. Elk distribution and modeling in relation to roads. Journal of Wildlife Management 64(3):672-684.

The effectiveness of a road density model (HE-habitat effectiveness) was evaluated in northeast Oregon during spring and summer, 1993-1995. Female elk consistently selected areas away from roads in spring and summer. The distance at which road effects dissipated could not be defined because few locations within the study area were sufficiently far from roads, however selection ratios were comparable to a distance of 1.2 km. The relationship between elk distribution and roads is likely to vary as elk population densities change. The results of this study suggest ". . . management of roads and related human activities during spring and summer should remain an important consideration for modeling and managing the elk resource. . ."

<u>sort criteria</u>: elk, roads, forested, quantitative, research-based, Oregon

Sawyer, H. and R. Nielson. 2005. Seasonal distribution and habitat use patterns of elk in the Jack Morrow Hills Planning Area, Wyoming. Western EcoSystems Technology, Inc. Cheyenne, WY. 28 pp.

The elk of Jack Morrow Hills live in a relatively open environment, relying on shrubs, topography, and low human disturbance for survival. During the summer and winter elk were 2.8 km and 1.2 km from the nearest road, respectively. Presumably elk were closer to roads in winter because of decreased human activity. Daily movements of elk were 3.5 times greater during the hunting season than winter, again indicating human disturbance had an impact.

<u>sort criteria</u>: elk, human activity, quantitative, shrubland, Wyoming

Stewart, K.M., R.T. Bowyer, J.G. Kie, N.J. Cimon, and B.K. Johnson. 2002. Temporospatial distributions of elk, mule deer, and cattle: resource partitioning and competitive displacement. Journal of Mammalogy 83(1): 229-244.

Resource partitioning and competitive displacement among mule deer, elk, and cattle were examined in northeastern Oregon and southeastern Washington. Resource partitioning was strongly evident among all 3 species, however mule deer and elk selected similar slopes and elevations, whereas cattle avoided steep slopes and high elevations. Although mule deer and elk selected similar slopes and elevations, they used different vegetation communities. At higher densities, resource partitioning could be more difficult leading to increased competition.

<u>sort criteria</u>: mule deer, elk, grazing, forested, grassland, quantitative, research-based, Oregon, Washington

Strickland, D. 1999. Petroleum development versus wildlife in the overthrust. Transactions of the North American Wildlife and Natural Resources Conference 64:28-35.

Controversies concerning impacts to wildlife from petroleum development in Wyoming are discussed. To date (1999) an estimated 2,100 producing oil and gas wells are located in southwestern Wyoming, with a large potential for further development. The BLM (Bureau of Land Management) estimates an additional 4,837 wells will be developed. Since 1984, 24,112 acres of habitat has been lost due to oil and gas development, and an additional 53,000 acres would be disturbed by future development from direct impacts (e.g., roads, pipelines, etc.). “The potential area of direct and indirect disturbance is 2.7 million acres, or approximately 16 percent of southwestern Wyoming.” Author suggests the BLM modify its leasing strategy using long-range and strategic planning with an adaptive approach.

sort criteria: elk, bighorn sheep, moose, pronghorn, mule deer, sage-grouse, oil & gas, sagebrush, qualitative, prescriptive, Wyoming

Van Dyke, F., and W. C. Klein. 1996. Response of elk to installation of oil wells. Journal of Mammalogy 77(4):1028-1041.

Seasonal and annual use of range and habitat were compared in a population of elk in south-central Montana prior to, during, and after installation of an exploratory oil-gas well. Absolute shifts of activity centers were small, however the shift was more than twice as large when humans were present (320 m) compared to only equipment activity (130 m). Elk tended to occupy locations screened from the well site by a physical barrier. Drilling activity was limited from June 15 to October 15, which could explain why resident elk did not abandon summer ranges.

sort criteria: elk, oil & gas, sagebrush, forested, quantitative, research-based, Montana

Ward, A.L. 1973. Elk behavior in relation to multiple uses on the Medicine Bow National Forest. Proceedings of the Western Association of State Game Commissions 43:125-141.

Elk behavior in relation to multiple uses was monitored in southern Wyoming. Uses included: livestock grazing, timber harvesting, recreation, and traffic. Elk were compatible with livestock when an adequate food supply was available. Elk were not significantly affected by traffic beyond 300 yards, however Interstate 80 did act as a barrier to elk movement. Elk preferred a ½ mile buffer from people associated with out-of-vehicle activities (e.g., camping, fishing, harvesting timber, etc.).

sort criteria: elk, roads, logging, human activity, forested, quantitative, research-based, Wyoming

Ward, L.A. 1986. Displacement of elk related to seismograph activity in south-central Wyoming. Pages 246-254 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

A hunted elk population in south-central Wyoming was monitored to evaluate responses to seismograph activity. Three different types of seismograph activity (i.e. above ground explosions, truck vibrators, drill and shoot) displaced elk, however people walking caused the most extreme responses. In rough topography and when seismic lines were run in the bottom of a draw, elk stayed at least 800 m from the activity and out of sight of seismic crews. When seismic operations occurred on open ridges, elk stated approximately 3.2 km away and out of sight of seismic crews. Elk returned to the seismograph use areas within a few days of activity cessation.

sort criteria: elk, seismic exploration, sagebrush, quantitative, research-based, Wyoming

Ward, A.L., J.J. Cupal, A.L. Lea, C.A. Oakley, and R.W. Weeks. 1973. Elk behavior in relation to cattle grazing, forest recreation, and traffic. Transactions of the North American Wildlife Conference 38:327-337.

Effects of human behavior on wildlife were examined in southeastern Wyoming to aid in land use planning operations. Interstate 80 acted as a barrier to movement, but had little effect on behavior within 300 yards. Authors suggest roads be kept away from elk feeding sites or along streams. Elk preferred approximately a ½ mile buffer from recreational users. Authors suggest ½ mile distance between recreation areas and feeding sites and adequate cover buffer zones.

sort criteria: elk, human activity, roads, forested, quantitative, research-based, Wyoming

Weller, C., J. Thomson, P. Morton, and G. Aplet. 2002. Fragmenting our lands: The ecological footprint from oil and gas development. The Wilderness Society, Washington, D.C.

Habitat fragmentation resulting from resource extraction practices was examined in the Upper Green River Basin of Wyoming. Average road densities and other linear features were 8.43 miles per square mile. An effect zone of ½ mile was constructed and analyzed. The analysis showed the entire 166 square mile study area to be within ½ mile of a road or other development related infrastructure. "The ecological footprint varies depending upon which disturbance is measured. A disturbance that reaches a quarter of a mile beyond the infrastructure creates a footprint of 160 square miles, affecting 97% of the study area. Even a more localized disturbance that only reaches 100 feet beyond the infrastructure affects 28% of the study area (47 square miles)."

sort criteria: sage-grouse, mule deer, pronghorn, elk, moose, oil & gas, sagebrush, quantitative, research-based, Wyoming

Western EcoSystems Technology, Inc. 2003. An evaluation of the 1988 BLM Pinedale Resource Management Plan, 2000 BLM Pinedale Anticline Final EIS and recommendations for the current revision of the Pinedale Resource Management Plan. The Wilderness Society, Washington, D.C.

An analysis of the 1988 Bureau of Land Management (BLM) Resource Management Plan and the 2000 BLM Pinedale Anticline Environmental Impact Statement (EIS) was presented. Recommendations for the current revision of the Pinedale Resource Management Plan were also given. Overall planning and adaptive management

recommendation included: 1) limiting the density of roads and wells per section, 2) protecting a minimum amount of significant big game habitat from disturbance, 3) identify areas where future oil and gas leases should be prohibited, 4) coordinate habitat management, and 5) apply adaptive management.

<u>sort criteria</u>: pronghorn, mule deer, elk, oil & gas, roads, sagebrush, quantitative, research-based, Wyoming

Witmer, G.W., and D.S. deCalesta. 1985. Effect of forest roads on habitat use by Roosevelt elk. Northwest Science 59:122-125.

Effects of roads on habitat use by elk were investigated in the central Coast Range of Oregon. Roads affected distributions most during calving and hunting seasons, and elk were not as affected by spur (dirt or gravel) roads than paved roads. Authors recommend road closures during rut and calving seasons to reduce harassment of elk.

<u>sort criteria</u>: elk, roads, forested, quantitative, research-based, Oregon

Wyoming Game & Fish Department. 1976. Considerations for wildlife in industrial development and reclamation. Cheyenne, Wy.

Mitigation and monitoring considerations for protecting wildlife and wildlife habitat with regard to industrial development were presented. Habitat development and reclamation were examined and recommendations were provided for specific habitat types (e.g., shrubland, rimrocks, etc.), and for individual wildlife species (e.g., mule deer, pronghorn, etc.).

<u>sort criteria</u>: sage-grouse, mule deer, pronghorn, elk, bighorn sheep, wildlife, sagebrush, qualitative, prescriptive, mitigation, Wyoming

<u>SHARP-TAILED GROUSE</u>

Baydack, R.K., and D.A. Hein. 1987. Tolerance of sharp-tailed grouse to lek disturbance. Wildlife Society Bulletin 15:535-539.

Human activity and its effects on sharp-tailed grouse were examined from March 1984 to May 1985 in southwestern Manitoba, Canada. " Mean displacement distance of sharptail males from individual leks ranged from 240 to 765 m during all human disturbances . . ." Female sharp-tailed grouse were not observed at leks during disturbances, which could indicate limited reproductive opportunities.

sort criteria: sharp-tailed grouse, human activity, grassland, quantitative, research-based, Canada

Berger, M.T., R. Whitney, and D. Antoine. 2004. Columbian sharp-tailed grouse management on the Colville Indian Reservation. Western Agencies Sage and Columbian Sharp-tailed Grouse Technical Committee. Wenatchee, Wa. Abstract only.

Protection, restoration, and enhancement of Columbian sharp-tailed grouse and their habitat were examined in Washington. Expert opinion, data, and past studies were reviewed to design a method to restore and conserve sharp-tailed grouse and associated habitats.

sort criteria: sharp-tailed grouse, mitigation, quantitative, research-based, prescriptive, Washington

Colorado Division of Wildlife. 2008. Colorado Division of Wildlife's Actions to minimize adverse impacts to wildlife resources – Draft – August 18, 2008

The purpose of this document is to enumerate potential actions that may avoid, minimize, and/or mitigate adverse impacts of oil and gas operations on Colorado's wildlife resources.

sort criteria: sage-grouse, wildlife, oil and gas, mitigation, qualitative, research-based, prescriptive, Colorado

Giesen, K.M., and J.W. Connelly. 1993. Guidelines for management of Columbian sharp-tailed grouse habitats. Wildlife Society Bulletin 21:325-333.

Breeding complexes (leks and nesting areas) are typically located on land surfaces that are higher than the surrounding area and ". . . include all lands within a 2-km radius of lek sites, because most nesting occurs within this area." Habitat alterations such as grazing and herbicide spraying have negative effects on sharp-tailed grouse, while prescribed burning and chaining can be beneficial. When disturbances cannot be avoided within the breeding complex, restrictions should include: prohibiting "physical, mechanical, and audible disturbances within the breeding complex during breeding season (Mar-Jun)" and avoiding "manipulation or alteration of vegetation within the breeding complex during the nesting period (May-Jun)."

sort criteria: sharp-tailed grouse, sagebrush, sagebrush treatment, quantitative, prescriptive, western U.S.

Greer, R.D. 2004. Columbian sharp-tailed grouse: distribution, status, habitat use, and population dynamics in Utah. Western Agencies Sage and Columbian Sharp-tailed Grouse Technical Committee. Wenatchee, Wa. Abstract only.

Habitat use and population distribution of Columbian sharp-tailed grouse is being investigated in Utah. "Defining population trends and identifying previously unknown populations in historic ranges is being done. Habitat improvement projects are being implemented and monitored."

<u>sort criteria</u>: sharp-tailed grouse, quantitative, research-based, Utah

Hemmer, L.G. 2004. Conservation Reserve Program: effects of capping enrollment. Western Agencies Sage and Columbian Sharp-tailed Grouse Technical Committee. Wenatchee, Wa. Abstract only.

The federal Conservation Reserve Program (CRP) supports many bird, reptile, and mammal species including sage-grouse and sharp-tailed grouse. "Most leks and nests in north-central Washington are located in CRP or in areas dominated by CRP." One questionable CRP rule limits enrollment to 25% of total cropland in a county.

<u>sort criteria</u>: sage-grouse, sharp-tailed grouse, mitigation, qualitative, prescriptive, Washington

Klott, J.H., and F.G. Lindzey. 1990. Brood habitats of sympatric sage grouse and Columbian sharp-tailed grouse in Wyoming. Journal of Wildlife Management 54:84-88.

A comparison of habitats in south-central Wyoming used by sage-grouse and Columbian sharp-tailed grouse was presented. "Sage-grouse broods occurred most often (68%) in sagebrush (*Artemisia* spp.)-grass and sagebrush-bitterbrush (*Purshia tritentata*) habitats, whereas sharp-tailed grouse broods occurred most often (73%) in mountain shrub and sagebrush-snowberry (*Symphoicarpos oreophilus*) habitats." No difference was found between sage-grouse and sharp-tailed grouse brood sites in regard to total shrub cover, sagebrush cover, or sagebrush canopy. Management suggestions included constraining vegetation treatments to narrow strips (< 30 m) and reduction of livestock grazing.

<u>sort criteria</u>: sage-grouse, sharp-tailed grouse, sagebrush treatment, sagebrush, quantitative, research-based, Wyoming

Leupin, E., and D. Jury. 2004. Columbian sharp-tailed grouse in British Columbia: status and conservation efforts. Western Agencies Sage and Columbian Sharp-tailed Grouse Technical Committee. Wenatchee, Wa. Abstract only.

Loss and degradation of native climax grasslands are the major factors responsible for the decline of Columbian sharp-tailed grouse in British Columbia. Sharp-tailed grouse also inhabit large burn areas and cut block habitats associated with sedge-meadow complexes. "… little is known regarding population status and distribution of birds in sedge meadow/cutover habitats. Preliminary inventory work in the spring of 2004 in the cutover habitats suggests that these populations may be abundant and wide spread."

sort criteria: sharp-tailed grouse, grassland, quantitative, research-based, Canada

Manville, A.M., II. 2004. Prairie grouse leks and wind turbines: U.S. Fish and Wildlife Service justification for a 5-mile buffer from leks; additional grassland songbird recommendations. Division of Migratory Bird Management, USFWS, Arlington, VA, peer-reviewed briefing paper. 17 pp.

This briefing paper provides justification for the Service's recommendation for a 5-mile buffer from occupied prairie grouse leks (prairie chickens, sharp-tailed grouse and sage-grouse).

sort criteria: sage-grouse, sharp-tailed grouse, **wind turbines**, roads, powerlines, human activity, fragmentation, qualtitative, research-based

Paige, C., and S.A. Ritter. 1999. Birds in a sagebrush sea: managing sagebrush habitats for bird communities. Partners in Flight Western Working Group, Boise, ID.

Recommendations are presented for land management practices to help bird communities in sagebrush habitats. Shrubland and shrub-dependent bird species have declined 63% across the U.S. "Sagebrush obligates include the sage sparrow, Brewer's sparrow, sage thrasher, sage-grouse, pygmy rabbit, sagebrush vole, sagebrush lizard, and pronghorn. Management guidelines are classified using different scales (landscape, stand, and patch). The level of effects on birds ranges from populations to individuals and pairs. A summary of bird management goals and recommendations is provided.

sort criteria: sage-grouse, sharp-tailed grouse, raptors, sagebrush obligates, non-game birds, oil & gas, agriculture, human activity, sagebrush, quantitative, prescriptive, western U.S.

Saab, V.A., and J.S. Marks. 1992. Summer habitat use by Columbian sharp-tailed grouse in western Idaho. Great Basin Naturalist 52:166-173.

Summer habitat use by Columbian sharp-tailed grouse in western Idaho was examined from 1983-85. Grouse used big sagebrush cover type more in proportion to any of 8 other cover types in the study area. Characteristics of the big sagebrush cover type included: "… moderate vegetative cover, high plant species diversity, and high structural diversity." Grouse selected areas least modified by livestock grazing. Authors suggest protecting habitats within 2.5 km of dancing grounds.

sort criteria: sharp-tailed grouse, agriculture, sagebrush quantitative, research-based, Idaho

Vander Haegen, W.M., M.A. Schroeder, and R.M. Degraaf. 2002. Predation on real and artificial nests in shrubsteppe landscapes fragmented by agriculture. Condor 104:496-506.

Artificial nests were monitored to examine effects of fragmentation, distance to edge, and vegetation cover on nest predation rates, as well as to identify predators of grouse and passerines. Nests in fragmented landscapes were approximately 9 times more likely to be depredated than nests in continuous landscapes. Predation rate was 26% for artificial nests. Nest-sites with greater vegetation coverage were less likely to be depredated.

sort criteria: sage-grouse, sharp-tailed grouse, non-game birds, sagebrush obligates, agriculture, fragmentation, sagebrush, grassland, quantitative, research-based, Washington

Waage, B.C. 1989. Sharp-tailed grouse lek (dancing ground) establishment on reclaimed mined lands. Pages 116-122 in Proceedings IV: Issues and Technology in the Management of Impacted Wildlife. Thorne Ecological Institute, Boulder, Co.

Establishment of sharp-tailed grouse leks on reclaimed mine lands was examined in southeastern Montana. Acoustical luring was successful at 2 of 3 experimental sites, however permanent lek establishment was not achieved. One lek established within auditory distance of the luring locations was successful with an average male attendance of 15 grouse. "Grouse have established leks on reclaimed lands at densities that meet or exceed pre-mined conditions."

sort criteria: sharp-tailed grouse, mining, sagebrush, quantitative, research-based, Montana

MOOSE

Altman, M. 1958. The flight distance in free-ranging big game. Journal of Wildlife Management 22(2):207-209.

Distances moose and elk fled from human intruders were investigated in Wyoming. Reactions were quite varied depending on species, sex, season (e.g. parturition, mating, hunting, etc.), and acclimation to human presence (e.g. tourists, fishermen, etc.). Flight distances ranged from a low of 10 feet for both cows and bulls during rut to a maximum of 300 feet for both sexes during hunting season.

sort criteria: moose, elk, human activity, quantitative, research-based, Wyoming

Kuck, L. 1986. The impacts of phosphate mining on big game in Idaho: a cooperative approach to conflict resolution. Transactions of the 51st North American Wildlife and Natural Resources Conference 51:90-97.

Evaluation of impacts of phosphate mining on big game in Idaho was the objective of this study. "Results of this study indicate that elk, deer and moose may be capable of adapting to many phosphate mining activities in southeastern Idaho, but cannot compensate for disturbance on important seasonal ranges or for increased mortality associated with industrial development."

sort criteria: mule deer, elk, moose, mining, forested, grassland, quantitative, research-based, Idaho

Oedekoven, O.O., and F.G. Lindzey. 1987. Winter habitat-use patterns of elk, mule deer, and moose in southwestern Wyoming. Great Basin Naturalist 47:638-643.

Mule deer, elk, and moose winter habitat use patterns were examined in southwestern Wyoming. Mule deer used sagebrush extensively, moose favored aspen, willow, and mixed-shrub vegetation, and elk preferred alpine grass/moss vegetation. Elk and mule deer showed a preference for areas with mild snow conditions, whereas moose were often observed in areas with deep snow. "Our results suggested that although deer, elk, and moose often used the same areas, they selected differing habitats within shared areas."

sort criteria: mule deer, elk, moose, sagebrush, quantitative, research-based, Wyoming

PIC Technologies and Bureau of Land Management, Pinedale Field Office. 1999. Draft Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project. Bureau of Land Management, Pinedale, Wyoming, USA.

Management objectives, monitoring and mitigation recommendations for the Pinedale Anticline Oil and Gas Exploration and Development Project in northwestern Wyoming were presented. The standard stipulation alternative (SS) was explained as well as a resource protection alternative (RP), which included all spatial and temporal restrictions contained in the SS alternative. The RP alternative offered additional protection measures to "be applied to wildlife habitats on Federal lands and minerals."

sort criteria: sage-grouse, pronghorn, mule deer, elk, moose, non-game birds, raptors, wildlife, oil & gas, noise, roads, quantitative, research-based, Wyoming

Rudd, L.T. 1985. Wintering moose vs. oil/gas activity in western Wyoming. Alces 21:279-298.

Moose responses to activities associated with oil and gas development were examined in western Wyoming during winters of 1981-82 and 1982-83. Approximately 55 oil company trucks traveled an access road daily both winters, and recreationists (snowmobilers, skiers, hunters, and snowshoers) also used the plowed road. Average approach distances causing moose to escape were: 15.6 m from trucks, 9.7 m from snowmobiles, and 15.3 m from snowshoers/skiers. The average distances of moose displacement were: 156 m when disturbed by trucks, 54.7 m when disturbed by snowmobiles, and 74.5 m when disturbed by snowshoers/skiers. Preferred moose habitat should be avoided when areas are selected for placement of oilrig access roads.

sort criteria: moose, oil & gas, roads, forested, riparian, quantitative, research-based, Wyoming

Rudd, L.T. 1986. Winter relationships of moose to oil and gas development in western Wyoming. M.S. Thesis, University of Wyoming, Laramie.

Impacts to wintering moose, resulting from oil and gas activity in northwestern Wyoming were examined. Approximately 55 oil company trucks/day traveled the plowed access road (no roads in the area were plowed prior to drilling). Winter recreationists also used the roads. The mean distance moose moved away from trucks was 15.5 m, from snowmobiles 9.7 m, and from skiers/snowshoers 15.3 m. The author states "… access roads should not be placed within 800 m of moose winter habitat."

sort criteria: moose, oil & gas, roads, forested, quantitative, research-based, Wyoming

Strickland, D. 1999. Petroleum development versus wildlife in the overthrust Transactions of the North American Wildlife and Natural Resources Conference 64:28-35.

Controversies concerning impacts to wildlife from petroleum development in Wyoming are discussed. To date (1999) an estimated 2,100 producing oil and gas wells are located in southwestern Wyoming, with a large potential for further development. The BLM (Bureau of Land Management) estimates an additional 4,837 wells will be developed. Since 1984, 24,112 acres of habitat has been lost due to oil and gas development, and an additional 53,000 acres would be disturbed by future development from direct impacts (e.g., roads, pipelines, etc.). "The potential area of direct and indirect disturbance is 2.7 million acres, or approximately 16 percent of southwestern Wyoming." Author suggests the BLM modify its leasing strategy using long-range and strategic planning with an adaptive approach.

sort criteria: elk, bighorn sheep, moose, pronghorn, mule deer, sage-grouse, oil & gas, sagebrush, qualitative, prescriptive, Wyoming

BIGHORN SHEEP

Hicks, L.L., and J.M. Elder. 1979. Human disturbance of Sierra Nevada bighorn sheep. Journal of Wildlife Management 43(4):909-915.

Human/bighorn sheep interactions were observed during summer (1976) in the Sierra Nevada Mountains of California. Bighorn populations were not adversely affected by human encounters. Meadows used by humans were typically avoided by bighorns because of differences in vegetation composition rather than human presence.

sort criteria: bighorn sheep, human activity, alpine meadow, quantitative, research-based, California

Hook, D.L. 1986. Impacts of seismic activity on bighorn movements and habitat use. Biennial Symposium of the Northern Wild Sheep and Goat Council 5:292-297.

Impacts of seismic activity on bighorn sheep were evaluated along the Rocky Mountain Front in Montana. Average annual home range size declined from 25.9 to 18.6 square miles (28% decrease) then increased to 29.7 square miles following disturbance. Helicopter activity was apparently responsible for bighorn abandonment of a large portion of their fall range. Increased energy expenditure could result in lower winter survival rates and decreased reproductive success. The author recommends termination of oil and gas activities after September 15 each year.

sort criteria: bighorn sheep, seismic activity, mountain grasslands, quantitative, research-based, Canada

MacArthur, R.A., V. Geist, and R.H. Johnston. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. Journal of Wildlife Management 46(2):351-358.

Heart rates (HR) and behavioral responses of mountain sheep to human activity were examined in southwestern Alberta, Canada. Strongest reactions by sheep occurred when approached by a person with a dog, or when approached from over a ridge. Road traffic produced minimal reaction with only 8.8% of vehicle passes eliciting HR responses. Management recommendations included, restricting human activities to roads and trails, and discouraging the presence of dogs on sheep ranges.

<u>sort criteria</u>: bighorn sheep, human activity, quantitative, research-based, Canada

Mead, D.A., and L.E. Morgantini. 1988. Drilling in sheep country: gas development at Prairie Bluff, Alberta. Biennial Symposium of the Northern Wild Sheep and Goat Council 6:165-167.

Impacts of industrial activity on bighorn sheep were investigated in southwestern Alberta. Some preliminary results indicated road and well-site construction activities temporarily displaced bighorns, but animals quickly returned to the area when construction ended. Also, helicopter activity caused more disturbance than blasting, heavy machinery or human activity.

<u>sort criteria</u>: bighorn sheep, oil & gas, quantitative, research-based, Canada

Morgantini, L.E., and E. Bruns. 1988. Attraction of bighorn sheep to wellsites and other man-made mineral licks along the eastern slopes of Alberta: a management concern. Biennial Symposium of the Northern Wild Sheep and Goat Council 6:135-140.

The attraction of bighorn sheep to man-caused mineral licks was investigated in west-central Alberta. "On all wellsites, bighorn sheep licked and ate soil containing minerals used during gas well drilling and testing. Sodium appeared to be the major attraction." Management concerns included: crowding, range depletion, altered distribution, tameness, toxic chemicals, and hunting. Authors recommended permanent fencing around the entire site as the only effective mitigation practice.

<u>sort criteria</u>: bighorn sheep, oil & gas, forested, mountain grasslands, quantitative, research-based, Canada

Morgantini, L.E., and B.W. Worbets. 1988. Bighorn use of a gas wellsite during servicing and testing: a case study of impact and mitigation. Biennial Symposium of the Northern Wild Sheep and Goat Council 6:159-164.

This case study investigated the impacts to bighorn sheep at a gas wellsite in west-central Alberta. Mitigation actions were also evaluated. The attraction of bighorns to mineral deposits on wellsites can alter distribution and movement patterns, and expose animals to potentially toxic chemicals. Active harassment was unsuccessful in keeping bighorns from wellsites. Extensive baiting and actively herding bighorns away from the wellsite was successful, but this approach should not be considered “the answer” in all situations.

sort criteria: bighorn sheep, oil & gas, forested, mountain grasslands, quantitative, research-based, prescriptive, Canada

Morgantini, L.E., and D.A. Mead. 1990. Industrial development on prime bighorn sheep range in southwest Alberta. Biennial Symposium of the Northern Wild Sheep and Goat Council 7:56-66.

Bighorn sheep distribution and behavior were examined before and during construction activities of 2 gas wells in southwest Alberta. Helicopter activity caused an increased level of alertness with reactions ranging from interrupted feeding to panic fleeing. In general, construction activities did not seem to significantly impact bighorn movements or distribution. However, the attraction to materials used during industrial operations could be a potential problem, which may affect bighorn distribution and expose animals to potentially toxic chemicals.

sort criteria: bighorn sheep, oil & gas, mountain grasslands, quantitative, research-based, Canada

Strickland, D. 1999. Petroleum development versus wildlife in the overthrust. Transactions of the North American Wildlife and Natural Resources Conference 64:28-35.

Controversies concerning impacts to wildlife from petroleum development in Wyoming are discussed. To date (1999) an estimated 2,100 producing oil and gas wells are located in southwestern Wyoming, with a large potential for further development. The BLM (Bureau of Land Management) estimates an additional 4,837 wells will be developed. Since 1984, 24,112 acres of habitat has been lost due to oil and gas development, and an additional 53,000 acres would be disturbed by future development from direct impacts (e.g., roads, pipelines, etc.). “The potential area of direct and indirect disturbance is 2.7 million acres, or approximately 16 percent of southwestern Wyoming.” Author suggests the BLM modify its leasing strategy using long-range and strategic planning with an adaptive approach.

sort criteria: elk, bighorn sheep, moose, pronghorn, mule deer, sage-grouse, oil & gas, sagebrush, qualitative, prescriptive, Wyoming

Weisenberger, M.E., P.R. Krausman, M.C. Wallace, D.W. DeYoung, and E.O. Maughan. 1996. Effects of simulated jet aircraft noise on heart rate and behavior of desert ungulates. Journal of Wildlife Management 60(1):52-61.

The effects of simulated low-altitude jet aircraft noise on the behavior and heart rate of mule deer and mountain sheep in Arizona were evaluated. "The heart rates of ungulates increased related to dB levels during simulated overflights ($P \leq 0.05$), but they returned to pre-disturbance levels in 60-180 seconds. Animal behavior also changed during overflights but returned to pre-disturbance conditions in < 252 seconds ($P \leq 0.005$). All animal responses decreased with increased exposure suggesting that they habituated to simulated sound levels of low-altitude aircraft."

<u>sort criteria</u>: mule deer, bighorn sheep, noise, quantitative, research-based, Arizona

Wyoming Game & Fish Department. 1976. Considerations for wildlife in industrial development and reclamation. Cheyenne, Wy.

Mitigation and monitoring considerations for protecting wildlife and wildlife habitat with regard to industrial development were presented. Habitat development and reclamation were examined and recommendations were provided for specific habitat types (e.g., shrubland, rimrocks, etc.), and for individual wildlife species (e.g., mule deer, pronghorn, etc.).

<u>sort criteria</u>: sage-grouse, mule deer, pronghorn, elk, bighorn sheep, wildlife, sagebrush, qualitative, prescriptive, mitigation, Wyoming

RAPTORS

Anderson, D.E., O.J. Rongstad, and W.R. Mytton. 1990. Home-range changes in raptors exposed to increased human activity levels in southeastern Colorado. Wildlife Society Bulletin 18:134-142.

An assessment of home-range changes due to increased human activity levels was conducted in southeastern Colorado. Raptors exposed to high levels of human activity shifted their home-range centers and activity areas, moved outside areas normally used, and increased the size of the area they used. Birds not exposed to human activity did not exhibit these changes to the same extent. Repeated or prolonged disturbance could increase energy costs for raptors, reproductive productivity could decrease with changes in home range, and community composition may change with less tolerant species declining.

sort criteria: raptors, human activity, grasslands, quantitative, research-based, Colorado

Fitzner, R.E. 1986. Responses of birds of prey to large-scale energy development in southcentral Washington. Pages 287-294 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Nesting ecology of raptors and the common raven was investigated at the U.S. Department of Energy's Hanford Site in south-central Washington. Power poles provided nesting sites for red-tailed hawks and ravens in areas lacking nesting structures. However, Swainson's hawks were totally dependent on trees for nesting. Several Swainson's hawk nests located within 1.5 km of construction activity were deserted. The author suggests that planting trees could increase Swainson's hawk nesting densities.

sort criteria: raptors, powerlines, machine activity, quantitative, research-based, Washington

George, W.G. 1974. Domestic cats as predators and factors in winter shortages of raptor prey. Wilson Bulletin 86:384-396.

The impact of domestic cats on raptor prey was investigated in southern Illinois. Three cats were monitored to determine their predatory success, and the type and number of prey caught. "Annually, from March through November, the cats removed from each acre of their combined home range (25 acres) an average of over 27 mammals-and-fetuses, of which 22.2 per acre were microtines." Predation by domestic cats could result in depleted winter populations of prey for raptors.

sort criteria: raptors, agricultural lands, quantitative, research-based, Illinois

Hayden-Wing Associates. 1991b. Review and evaluation of the effects of geophysical exploration on some wildlife species in Wyoming. Unpublished Report for Geophysical Acquisition Workshop. Laramie, Wy.

A review of previous studies on the effects of geophysical exploration on pronghorn, mule deer, elk, raptors, and sage-grouse was presented. The information examined indicated that big game are temporarily affected by seismic exploration causing increased energy expenditure and utilization of sub-optimal habitats. Characteristics for evaluating potential sage-grouse nesting habitat in relation to proposed oil and gas development included: "1) distance relationships to leks, 2) presence, distance, and characteristics of existing disturbances, 3) characteristics of shrubs and vegetation that could serve in nest concealment and nest-site selection, and 4) distance to water and to potential brood-rearing areas." Mitigation strategies for protecting raptor-nesting habitat were also presented.

sort criteria: sage-grouse, raptors, pronghorn, mule deer, elk, oil & gas, seismic exploration, sagebrush, quantitative, research-based, Wyoming

Holmes, T.L., R.L. Knight, L. Stegall, and G.R. Craig. 1993. Responses of wintering grassland raptors to human disturbance. Wildlife Society Bulletin 21:461-468.

Effects of human disturbance upon wintering grassland raptors were investigated during the winters of 1990-91 and 1991-92 in northeastern Colorado. "Kestrels, merlins, rough-legged hawks, ferruginous hawks, and golden eagles were more likely to flush when approached by a human on foot than an automobile . . ., but prairie falcons (*F. mexicanus*) were equally sensitive to both disturbance types." Authors suggested maintaining buffer zones of 75 m for American kestrels, 125 m for merlins, 160 m for prairie falcons, 210 m for rough-legged hawks, 140 m for ferruginous hawks, and 300 m for golden eagles would prevent flushing approximately 90% of the time.

sort criteria: raptors, human activity, grassland, quantitative, research-based, Colorado

Holthuijzen, A.M.A., W.G. Eastland, A.A. Ansell, M.N. Kochert, R.D. Williams, and L.S. Young. 1990. Effects of blasting on behavior and productivity of nesting prairie falcons. Wildlife Society Bulletin 18:270-281.

Effects of construction/mining activities (blasting) upon prairie falcons were investigated in southwestern Idaho. Falcons behaviorally reacted to blasting 54% of the time. Incubating and brooding falcons flushed from aeries 22% of the time. The behavior of falcons exposed to experimental blasting was similar to that of control falcons (exposed to construction blasting). Authors recommend avoiding blasting within 125 m of prairie falcon aeries, and restricting blasting to greater distances if noise levels exceed 140dB at the aerie. No more than 3 blasts per day or 90 blasts during the nesting season should take place.

sort criteria: raptors, mining, seismic exploration, sagebrush, quantitative, research-based, Idaho

Kennedy, P.L. 1980. Raptor baseline studies in energy developments. Wildlife Society Bulletin 8:129-135.

The current status of raptor baseline programs associated with energy development projects was reviewed. Justifications for studying raptors include: industrial impacts could accelerate decline of species that are threatened or endangered, and raptors are indicators of environmental contamination because of their position in food chains. Long-term, site-specific studies are recommended to improve raptor baseline programs.

sort criteria: raptors, oil & gas, roads, qualitative, prescriptive, western U.S.

Knight, R.L., and J.Y. Kawashima. 1993. Responses of raven and red-tailed hawk populations to linear right-of ways. Journal of Wildlife Management 57:266-271.

The relationship between linear right-of-ways and raven and red-tailed hawk populations was examined in the Mojave Desert of California. Ravens were more common along highway and powerline transects than control areas (i.e. no linear right-of-ways within 3.2 km). Carrion provided by vehicles was the probable reason for the abundance of ravens along highways. Red-tailed hawks were most abundant along powerlines, which provide superior perch and nesting sites. Authors suggest land managers monitor sensitive prey species populations to determine if linear right-of-ways increase predator populations to undesirable numbers.

sort criteria: raptors, non-game birds, roads, powerlines, desert shrubland, quantitative, research-based, California

Krementz, D.G., and J.R. Sauer. 1982. Avian communities on partially reclaimed mine spoils in south-central Wyoming. Journal of Wildlife Management 46:761-765.

Differences in avian community structure between a reclaimed mine site and a native shrub-steppe were investigated in south-central Wyoming. Composition, abundance, and diversity between sites were likely due to variation in habitat structure. Foliage-gleaning omnivores were virtually absent from the reclaimed site, however ground-gleaning omnivores and insectivores were common. "The absence of nesting by all species except the horned lark indicates that the reclamation treatments did not fulfill nesting requirements of northern desert shrub-steppe avifauna." Authors suggest "… future reclamation plans should emphasize prompt reintroduction of sagebrush and other species that provide nesting habitat."

sort criteria: sage-grouse, raptors, non-game birds, mining, sagebrush, quantitative, research-based, Wyoming

Luckenbach, R.A. 1978. An analysis of off-road vehicle use on desert avifaunas. North American Wildlife Conference 43:157-162.

The impact of off-road vehicle (ORV) use on desert birds was investigated. ORVs can directly and indirectly affect birds by nest destruction, direct mortality, harassment, noise, and habitat alteration. Destruction or elimination of plants can affect limited

available winter food resources. The preferred management alternative was to concentrate ORV activities to areas already impacted.

sort criteria: non-game birds, raptors, human activity, ORVs, desert, quantitative, research-based, mitigation, southwestern U.S.

McAdoo, J.K., G.A. Acordagoita, and C.R. Aarstad. 1989. Reducing impacts of hard-rock mining on wildlife in northern Nevada. Pages 95-97 in Proceedings IV: Issues and Technology in the Management of Impacted Wildlife. Thorne Ecological Institute, Boulder, Co.

Reduction of wildlife impacts from mineral exploration in northern Nevada was examined. Mitigation actions included: minimizing erosion through the use of sediment catchment basins, silt screens, and seeding of road cuts and fill slopes, minimizing construction activity near raptor nests, avoiding aspen wildlife habitat, using culverts for crossing trout streams, and monitoring ground and surface water. Offsite mitigation and concurrent reclamation efforts were also evaluated.

sort criteria: wildlife, mule deer, sage-grouse, raptors, mining, sagebrush, riparian, qualitative, prescriptive, mitigation, Nevada

Morton, P., C. Weller, J. Thomson, M. Haefele, and N. Culver. 2004. Drilling in the Rocky Mountains: How much and at what cost? The Wilderness Society, Washington, D.C.

An analysis examining the impacts associated with large-scale energy development determined that significant fragmentation of wildlife habitat occurs with development activities. Non-market costs of drilling included "erosion, loss of wildlife and fish habitat, decline in quality of recreational experiences, proliferation of noxious weeds, and increased air and water pollution." A habitat fragmentation analysis of the Big Piney-LaBarge oil and gas field (in northwestern Wyoming) produced results indicating " a direct physical footprint of 1,400 miles of linear features and 3.8 square miles of polygon features, resulting in an overall density of 8.43 miles of roads and pipelines per mile^2." Also, 97% of the area falls within ¼ mile of some infrastructure and only 27% of the study area was more than 500 feet from infrastructure, with only 3% more than ¼ mile away.

sort criteria: sage-grouse, mule deer, pronghorn, elk, raptors, non-game birds, fish, wildlife, oil & gas, fragmentation, quantitative, research-based, prescriptive, western U.S.

Paige, C., and S.A. Ritter. 1999. Birds in a sagebrush sea: managing sagebrush habitats for bird communities. Partners in Flight Western Working Group, Boise, ID.

Recommendations are presented for land management practices to help bird communities in sagebrush habitats. Shrubland and shrub-dependent bird species have declined 63% across the U.S. "Sagebrush obligates include the sage sparrow, Brewer's sparrow, sage thrasher, sage-grouse, pygmy rabbit, sagebrush vole, sagebrush lizard, and pronghorn. Management guidelines are classified using different scales (landscape, stand, and patch). The level of effects on birds ranges from populations to individuals and pairs. A summary of bird management goals and recommendations is provided.

sort criteria: sage-grouse, sharp-tailed grouse, raptors, sagebrush obligates, non-game birds, oil & gas, agriculture, human activity, sagebrush, quantitative, prescriptive, western U.S.

Phillips, R.L., D.E. Biggins, and A.B. Hoag. 1986. Coal surface mining and selected wildlife – a 10-year case study near Decker, Montana. Pages 235-245 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Mule deer, pronghorn, sage-grouse, and golden eagles were monitored to determine their responses to mining activities in southeastern Montana and northern Wyoming. "Mule deer and pronghorn populations thrived throughout the study period despite increasing mining activity and human disturbance." Sage-grouse habitat was lost, but mitigation efforts (e.g., relocation of a lek) seemed to be successful. Golden eagle numbers remained relatively stable. Four nesting pairs near active mines had a 10-year nesting success of 67.5% compared to 56.6% for pairs nesting elsewhere on the study area. "If the primary post mining land use is wildlife, permanent reclamation can be designed to maximize the mixture of plant species and thereby provide greater habitat diversity than native prairie."

sort criteria: sage-grouse, mule deer, pronghorn, raptors, mining, sagebrush, quantitative, research-based, Wyoming, Montana, mitigation

PIC Technologies and Bureau of Land Management, Pinedale Field Office. 1999. Draft Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project. Bureau of Land Management, Pinedale, Wyoming, USA.

Management objectives, monitoring and mitigation recommendations for the Pinedale Anticline Oil and Gas Exploration and Development Project in northwestern Wyoming were presented. The standard stipulation alternative (SS) was explained as well as a resource protection alternative (RP), which included all spatial and temporal restrictions contained in the SS alternative. The RP alternative offered additional protection measures to "be applied to wildlife habitats on Federal lands and minerals."

sort criteria: sage-grouse, pronghorn, mule deer, elk, moose, non-game birds, raptors, wildlife, oil & gas, noise, roads, quantitative, research-based, Wyoming

Rich, T.D. 1986. Habitat and nest-site selection by burrowing owls in the sagebrush steppe of Idaho. Journal of Wildlife Management 50:548-555.

Topography and vegetation around burrowing owl nest sites in south-central Idaho were examined. Seventy-nine percent of burrows were located on slopes ≤ 10°, and cover within 50 m of occupied burrows was principally cheatgrass with large areas of bare ground. "Burrowing owls may be one of only a few avian species that benefit from substantially disturbed habitat in the sagebrush steppe. Cover within 50 m of the burrow in this study indicated sites had been disturbed by fire and grazing." Burrowing owls (in this study) did not occupy continuous, dense stands of sagebrush (10-35% canopy cover).

sort criteria: non-game birds, raptors, sagebrush, quantitative, research-based, Idaho

Steenhof, K., M.N. Kochert, and J.A. Roppe. 1993. Nesting by raptors and common ravens on electrical transmission line towers. Journal of Wildlife Management 57:271-281.

Nesting populations of raptors and ravens in southeastern Idaho and Oregon were monitored to assess the effectiveness of transmission line towers as nesting substrates. Birds used all types of towers, but preferred towers with dense latticework. Between 1983 and 1989 nesting success "… in the eastern study area averaged 65% for golden eagles, 83% for ferruginous hawks, 74% for red-tailed hawks, and 86% for ravens." Nesting success on towers was similar to or higher than on surrounding natural substrates for both raptors and ravens.

sort criteria: raptors, non-game birds, powerlines, quantitative, research-based, Idaho

White, C.M., and T.L. Thurow. 1985. Reproduction of ferruginous hawks exposed to controlled disturbance. Condor 87:14-22.

Nesting success and behavior of ferruginous hawks, in response to disturbance, were examined in south-central Idaho during the breeding/nesting seasons of 1978 and 1979. Disturbances associated with land development were simulated near treated nests. Numbers of young fledged were significantly different between treated and undisturbed nests: ". . . control nests fledged, on average, one young more than successful nests that we disturbed or twice as many young if all disturbed nests are considered." The difference between successful disturbed and control nests was 1.16 young per nesting attempt. Adults did not flush 90% of the time when human activity was restricted to a distance greater than 250m.

sort criteria: raptors, human activity, equipment activity, sagebrush, quantitative, research-based, Idaho

NONGAME BIRDS

Braun, C.E., M.F. Baker, R.L. Eng, J.W. Gaswiler, and M.H. Schroeder. 1976. Conservation committee report on the effects of alteration of sagebrush communities on the associated avifauna. Wilson Bulletin 88:165-171.

Relevant data were reviewed in the mid-1970s to assess the effects reducing sagebrush have on associated avifauna (notably sagebrush obligates). Based on estimates, at least 10% of sagebrush rangelands had been altered in the west at that time. "Development of energy resources, especially coal, will have major impacts on sagebrush communities and dependent avifauna for at least the next 40 years." Recommendations include, confining sagebrush alteration to small areas of 16 ha or less, and scheduling sagebrush control programs to avoid bird nesting seasons.

sort criteria: sage-grouse, sagebrush obligates, non-game birds, sagebrush treatment, sagebrush, quantitative, prescriptive, western U.S.

Ingelfinger, R.M. 2001. The effects of natural gas development on sagebrush steppe passerines in Sublette County, Wyoming. M.S. Thesis, University of Wyoming, Laramie.

Impacts of natural gas development on passerines were evaluated in northwestern Wyoming. Songbird densities were reduced by 50% within 100 m of roads. Traffic disturbance and a shift in species composition were associated with declines. Sagebrush obligate bird density was lower within 100 m of roads (66% of observations) with 81% of observations beyond 100 m. Horned lark abundance was higher near roads (31% of observations) than beyond the 100 m zone (16% of observations). "While a 50% reduction in sagebrush obligate bird density along a single road may not be biologically significant, the effect of the construction of multiple roads within a single development area can be substantial."

sort criteria: sagebrush obligates, non-game birds, oil & gas, roads, sagebrush, quantitative, research-based, Wyoming

Knick, S.T., and J.T. Rotenberry. 1995. Landscape characteristics of fragmented shrubsteppe habitats and breeding passerine birds. Conservation Biology 9:1059-1071.

Breeding distributions of sage sparrows, Brewer's sparrows, sage thrashers, horned larks, and western meadowlarks were studied in relation to local and landscape-scale attributes of fragmented habitats in southwestern Idaho. Total shrub cover and abundance of sagebrush were important for shrub-obligate species such as, sage thrashers and sage and Brewer's sparrows. However, horned larks and western meadowlarks (grassland species) were influenced mainly by lack of large expanses of shrub cover. The three shrub-obligate species were ". . . more likely to return to sites that had high shrub cover (particularly sagebrush) and low disturbance, combined with large patch sizes and high within-site spatial similarity."

<u>sort criteria</u>: sagebrush-obligates, non-game birds, fragmentation, sagebrush, quantitative, research-based, Idaho

Knick, S.T., and J.T. Rotenberry. 2000. Ghosts of habitats past: contribution of landscape change to current habitats used by shrubland birds. Ecology 81:220-227.

The effects on passerines to wildfires converting shrublands into exotic annual grasslands in southwestern Idaho were evaluated. "Horned larks, Western Meadowlarks, and Brewer's Sparrows, but not Sage Thrashers or Sage Sparrows, were positively correlated with decreased habitat richness and increased spatial homogeneity at large spatial scales, which have greater inherent stability or persistence for either shrubland or grassland habitats relative to more heterogeneous landscapes." Highly fragmented shrublands within a grassland matrix are more susceptible to wildfire and cheatgrass invasion than large shrubland patches. Non-spatial habitat variables were insignificant in relation to abundance of passerines.

<u>sort criteria</u>: non-game birds, sagebrush obligates, fragmentation, fire, sagebrush, quantitative, research-based, Idaho

Knight, R.L., and J.Y. Kawashima. 1993. Responses of raven and red-tailed hawk populations to linear right-of ways. Journal of Wildlife Management 57:266-271.

The relationship between linear right-of-ways and raven and red-tailed hawk populations was examined in the Mojave Desert of California. Ravens were more common along highway and powerline transects than control areas (i.e. no linear right-of-ways within 3.2 km). Carrion provided by vehicles was the probable reason for the abundance of ravens along highways. Red-tailed hawks were most abundant along powerlines, which provide superior perch and nesting sites. Authors suggest land managers monitor sensitive prey species populations to determine if linear right-of-ways increase predator populations to undesirable numbers.

<u>sort criteria</u>: raptors, non-game birds, roads, powerlines, desert shrubland, quantitative, research-based, California

Krementz, D.G., and J.R. Sauer. 1982. Avian communities on partially reclaimed mine spoils in south-central Wyoming. Journal of Wildlife Management 46:761-765.

Differences in avian community structure between a reclaimed mine site and a native shrub-steppe were investigated in south-central Wyoming. Composition, abundance, and diversity between sites were likely due to variation in habitat structure. Foliage-gleaning omnivores were virtually absent from the reclaimed site, however ground-gleaning omnivores and insectivores were common. "The absence of nesting by all species except the horned lark indicates that the reclamation treatments did not fulfill nesting requirements of northern desert shrub-steppe avifauna." Authors suggest "… future reclamation plans should emphasize prompt reintroduction of sagebrush and other species that provide nesting habitat."

<u>sort criteria</u>: sage-grouse, raptors, non-game birds, mining, sagebrush, quantitative, research-based, Wyoming

Luckenbach, R.A. 1978. An analysis of off-road vehicle use on desert avifaunas. North American Wildlife Conference 43:157-162.

The impact of off-road vehicle (ORV) use on desert birds was investigated. ORVs can directly and indirectly affect birds by nest destruction, direct mortality, harassment, noise, and habitat alteration. Destruction or elimination of plants can affect limited available winter food resources. The preferred management alternative was to concentrate ORV activities to areas already impacted.

<u>sort criteria</u>: non-game birds, raptors, human activity, ORVs, desert, quantitative, research-based, mitigation, southwestern U.S.

Morton, P., C. Weller, J. Thomson, M. Haefele, and N. Culver. 2004. Drilling in the Rocky Mountains: How much and at what cost? The Wilderness Society, Washington, D.C.

An analysis examining the impacts associated with large-scale energy development determined that significant fragmentation of wildlife habitat occurs with development activities. Non-market costs of drilling included "erosion, loss of wildlife and fish habitat, decline in quality of recreational experiences, proliferation of noxious weeds, and increased air and water pollution." A habitat fragmentation analysis of the Big Piney-LaBarge oil and gas field (in northwestern Wyoming) produced results indicating " a direct physical footprint of 1,400 miles of linear features and 3.8 square miles of polygon features, resulting in an overall density of 8.43 miles of roads and pipelines per mile^2." Also, 97% of the area falls within ¼ mile of some infrastructure and only 27% of the study area was more than 500 feet from infrastructure, with only 3% more than ¼ mile away.

sort criteria: sage-grouse, mule deer, pronghorn, elk, raptors, non-game birds, fish, wildlife, oil & gas, fragmentation, quantitative, research-based, prescriptive, western U.S.

Paige, C., and S.A. Ritter. 1999. Birds in a sagebrush sea: managing sagebrush habitats for bird communities. Partners in Flight Western Working Group, Boise, ID.

Recommendations are presented for land management practices to help bird communities in sagebrush habitats. Shrubland and shrub-dependent bird species have declined 63% across the U.S. "Sagebrush obligates include the sage sparrow, Brewer's sparrow, sage thrasher, sage-grouse, pygmy rabbit, sagebrush vole, sagebrush lizard, and pronghorn. Management guidelines are classified using different scales (landscape, stand, and patch). The level of effects on birds ranges from populations to individuals and pairs. A summary of bird management goals and recommendations is provided.

sort criteria: sage-grouse, sharp-tailed grouse, raptors, sagebrush obligates, non-game birds, oil & gas, agriculture, human activity, sagebrush, quantitative, prescriptive, western U.S.

Peterson, K.L., and L.B. Best. 1985. Nest-site selection by sage sparrows. Condor 87:217-221.

Nest site selection by sage sparrows in Idaho was examined to determine nest-site characteristics and preferences. All nests found were located in big sagebrush plants 40-100 cm tall, and "… large, living shrubs were strongly preferred."

sort criteria: non-game birds, sagebrush obligates, sagebrush, quantitative, research-based, Idaho

Peterson, K.L., and L.B. Best. 1987. Effects of prescribed burning on nongame birds in a sagebrush community. Wildlife Society Bulletin 15:317-329.

Responses of non-game birds to prescribed fire treatments were assessed in southeastern Idaho between 1980 and 1985. Total densities of birds were greater on experimental (burned) plots than on control plots. Sage sparrow densities were not affected, however Brewer's sparrow numbers declined for 2 years after fire then more than doubled. Western meadowlarks increased slightly, sage thrashers exhibited no response, and horned larks and vesper sparrows colonized the area after fire.

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Peterson, K.L., and L.B. Best. 1991. Nest-site selection by sage thrashers in southeastern Idaho. Great Basin Naturalist 51:261-266.

Nest-site selection by sage thrashers in southeastern Idaho was evaluated to determine nest-site characteristics in comparison with available habitat. Big sagebrush plants used for nesting were significantly taller than other available shrubs, and microhabitats within 5 m of nests were denser with taller shrubs and less bare ground (i.e. more grasses, forbs and litter) than surrounding areas.

sort criteria: non-game birds, sagebrush obligates, sagebrush, quantitative, research-based, Idaho

PIC Technologies and Bureau of Land Management, Pinedale Field Office. 1999. Draft Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project. Bureau of Land Management, Pinedale, Wyoming, USA.

Management objectives, monitoring and mitigation recommendations for the Pinedale Anticline Oil and Gas Exploration and Development Project in northwestern Wyoming were presented. The standard stipulation alternative (SS) was explained as well as a resource protection alternative (RP), which included all spatial and temporal restrictions contained in the SS alternative. The RP alternative offered additional protection measures to "be applied to wildlife habitats on Federal lands and minerals."

sort criteria: sage-grouse, pronghorn, mule deer, elk, moose, non-game birds, raptors, wildlife, oil & gas, noise, roads, quantitative, research-based, Wyoming

Rich, T.D. 1980. Nest placement in sage thrashers, sage sparrows and Brewer's sparrows. Wilson Bulletin 92:362-368.

Nest-site selection by sage thrashers, sage sparrows, and Brewer's sparrows in Idaho was evaluated. Nests of all 3 species were found either in or beneath sagebrush plants. All 3 species located their nests in unique positions vertically within the habitat.

sort criteria: non-game birds, sagebrush obligates, agriculture, sagebrush, quantitative, research-based, Idaho

Rich, T.D. 1986. Habitat and nest-site selection by burrowing owls in the sagebrush steppe of Idaho. Journal of Wildlife Management 50:548-555.

Topography and vegetation around burrowing owl nest sites in south-central Idaho were examined. Seventy-nine percent of burrows were located on slopes ≤ 10°, and

cover within 50 m of occupied burrows was principally cheatgrass with large areas of bare ground. "Burrowing owls may be one of only a few avian species that benefit from substantially disturbed habitat in the sagebrush steppe. Cover within 50 m of the burrow in this study indicated sites had been disturbed by fire and grazing." Burrowing owls (in this study) did not occupy continuous, dense stands of sagebrush (10-35% canopy cover).

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"… in the eastern study area averaged 65% for golden eagles, 83% for ferruginous hawks, 74% for red-tailed hawks, and 86% for ravens." Nesting success on towers was similar to or higher than on surrounding natural substrates for both raptors and ravens.

sort criteria: raptors, non-game birds, powerlines, quantitative, research-based, Idaho

USGS. 2002. Fact sheet: Loss of sagebrush ecosystems and declining bird populations in the Intermountain West: priority research issues and information needs. USGS FS-122-02. U.S. Department of the Interior, U.S. Geologic Survey.

Priority needs to identify causes and mechanisms of shrubland bird declines were evaluated. Sage-grouse have declined 33% from their long-term average population size. Four primary issues were identified: 1. Bird response to habitat and landscape features. 2. Monitoring and survey designs. 3. Effects of land use practices. 4. Wintering ground and migration.

sort criteria: sage-grouse, sagebrush obligates, non-game birds, oil & gas, agriculture, qualitative, prescriptive, western U.S.

Van der Zande, A.N., W.J. ter Keurs, and W.J. van der Weijden. 1980. The impacts of roads on the densities of four bird species in an open field habitat—evidence of a long-distance effect. Biological Conservation 18:299-321.

The effects of roads and associated human activities on 4 grassland bird species were investigated in the Netherlands. Road building led to a loss of habitat that could extend up to several kilometers away, mainly through the alteration/disturbance of the hydrology of the area.

sort criteria: non-game birds, roads, grassland, quantitative, research-based, Netherlands

Vander Haegen, W.M., M.A. Schroeder, and R.M. Degraaf. 2002. Predation on real and artificial nests in shrubsteppe landscapes fragmented by agriculture. Condor 104:496-506.

Artificial nests were monitored to examine effects of fragmentation, distance to edge, and vegetation cover on nest predation rates, as well as to identify predators of grouse and passerines. Nests in fragmented landscapes were approximately 9 times more likely to be depredated than nests in continuous landscapes. Predation rate was 26% for artificial nests. Nest-sites with greater vegetation coverage were less likely to be depredated.

sort criteria: sage-grouse, sharp-tailed grouse, non-game birds, sagebrush obligates, agriculture, fragmentation, sagebrush, grassland, quantitative, research-based, Washington

Wiens, J.A., and J.T. Rotenberry. 1981. Habitat associations and community structure of birds in shrubsteppe environments. Ecological Monographs 51:21-41.

Relationships between bird distribution, abundance, and habitat characteristics at a regional scale were investigated. Widely distributed bird species were not significantly associated with habitat features, however more locally distributed species did display habitat affinities. “Sage Sparrows were positively associated with sagebrush coverage and negatively related to coverage of cottonthorn and greasewood, while the remaining dominant shrubsteppe species, Brewer’s Sparrows and Sage Thrashers, exhibited no positive associations but were negatively associated with coverages of hopsage and budsage.”

sort criteria: non-game birds, sagebrush obligates, sagebrush, quantitative, research-based, western U.S.

Wiens, J.A., and J.T. Rotenberry. 1985. Response of breeding passerine birds to rangeland alteration in a North American shrubsteppe locality. Journal of Applied Ecology 22:655-668.

Response of passerine bird populations to rangeland treatment in south-central Oregon was examined. Prior to treatment sagebrush cover was 19-24% with 1-4% grass cover. Following treatment sagebrush cover was reduced to 4-12% while grass cover

increased to 10-57%. “Comparing the 3 pre-treatment years with the 3 post-treatment years reveals that densities of sage and Brewer’s sparrows declined overall, sage thrashers increased in abundance somewhat, and horned larks increased substantially; total species richness also increased following the treatment.”

sort criteria: non-game birds, sagebrush obligates, sagebrush treatment, sagebrush, quantitative, research-based, Oregon

SAGEBRUSH OBLIGATES

Bergquist, E., P. Evangelista, T. J. Stohlgren, and N. Alley. 2007. Invasive species and coal bed methane development in the Powder River Basin, Wyoming. Environmental Monitoring and Assessment 128:381-394.

This study evaluated the potential effect of coal bed natural gas (CBNG) development on native plant species distribution and patterns of non-native plant invasion. Disturbed sites had significantly higher non-native species richness and soil salinity suggesting CBNG development and associated disturbances may facilitate the establishment of non-native plants.

sort criteria: oil and gas, sagebrush, Wyoming, **invasive plants**, **herbicide**, human activity, quantitative, research-based

Braun, C.E., M.F. Baker, R.L. Eng, J.W. Gaswiler, and M.H. Schroeder. 1976. Conservation committee report on the effects of alteration of sagebrush communities on the associated avifauna. Wilson Bulletin 88:165-171.

Relevant data were reviewed in the mid-1970s to assess the effects reducing sagebrush have on associated avifauna (notably sagebrush obligates). Based on estimates, at least 10% of sagebrush rangelands had been altered in the west at that time. “Development of energy resources, especially coal, will have major impacts on sagebrush communities and dependent avifauna for at least the next 40 years.” Recommendations include, confining sagebrush alteration to small areas of 16 ha or less, and scheduling sagebrush control programs to avoid bird nesting seasons.

sort criteria: sage-grouse, sagebrush obligates, non-game birds, sagebrush treatment, sagebrush, quantitative, prescriptive, western U.S.

Crawford, J.A., R.A. Olson, N.E. West, J.C. Moseley, M.A. Schroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Ecology and management of sage-grouse and sage-grouse habitat. Journal of Range Management 57:2-19.

Current issues in sage-grouse ecology and management were examined. Multiple causative factors were implicated in the present sage-grouse decline. Fire, in high elevation sagebrush habitat, results in invasion of conifers and loss of canopy cover and herbaceous understory. Intensity and timing of livestock grazing are of concern regarding habitat quality. Light to moderate grazing can be beneficial, however heavier use decreases herbaceous cover. Heavy levels of chemical control methods may result in lower habitat quality. Other sagebrush obligate species (e.g., Brewer's sparrow, pygmy rabbit, and sagebrush vole) are also declining.

sort criteria: sage-grouse, sagebrush obligates, sagebrush treatment, fire, livestock grazing, sagebrush, quantitative, research-based, western U.S., Canada

Ingelfinger, R.M. 2001. The effects of natural gas development on sagebrush steppe passerines in Sublette County, Wyoming. M.S. Thesis, University of Wyoming, Laramie.

Impacts of natural gas development on passerines were evaluated in northwestern Wyoming. Songbird densities were reduced by 50% within 100 m of roads. Traffic disturbance and a shift in species composition were associated with declines. Sagebrush obligate bird density was lower within 100 m of roads (66% of observations) with 81% of observations beyond 100 m. Horned lark abundance was higher near roads (31% of observations) than beyond the 100 m zone (16% of observations). "While a 50% reduction in sagebrush obligate bird density along a single road may not be biologically significant, the effect of the construction of multiple roads within a single development area can be substantial."

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Breeding distributions of sage sparrows, Brewer's sparrows, sage thrashers, horned larks, and western meadowlarks were studied in relation to local and landscape-scale attributes of fragmented habitats in southwestern Idaho. Total shrub cover and abundance of sagebrush were important for shrub-obligate species such as, sage thrashers and sage and Brewer's sparrows. However, horned larks and western meadowlarks (grassland species) were influenced mainly by lack of large expanses of shrub cover. The three shrub-obligate species were ". . . more likely to return to sites that had high shrub cover (particularly sagebrush) and low disturbance, combined with large patch sizes and high within-site spatial similarity."

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<u>sort criteria</u>: non-game birds, sagebrush obligates, fragmentation, fire, sagebrush, quantitative, research-based, Idaho

Oyler-McCance, S.J., K.P. Burnham, and C.E. Braun. 2001. Influences of changes in sagebrush on Gunnison sage grouse in southwestern Colorado. Southwestern Naturalist 46:323-331.

Changes (between the 1950s and 1990s) in sagebrush-dominated areas in southwestern Colorado were compared using low-level aerial photographs. A 20% loss (approximately 155,673 ha) of sagebrush-dominated areas between 1958 and 1993 was documented. Thirty-seven percent of sampled plots showed substantial fragmentation of sagebrush habitats, which was often the result of road development. Suggestions for future protection of sage-grouse included assessing management and conservation strategies in regard to “…land mitigation, habitat restoration, connecting fragmented habitats, and reintroduction of sagebrush obligates into previously occupied habitats.”

<u>sort criteria</u>: sage-grouse, sagebrush obligates, fragmentation, roads, sagebrush, quantitative, research-based, Colorado

Paige, C., and S.A. Ritter. 1999. Birds in a sagebrush sea: managing sagebrush habitats for bird communities. Partners in Flight Western Working Group, Boise, ID.

Recommendations are presented for land management practices to help bird communities in sagebrush habitats. Shrubland and shrub-dependent bird species have declined 63% across the U.S. “Sagebrush obligates include the sage sparrow, Brewer’s sparrow, sage thrasher, sage-grouse, pygmy rabbit, sagebrush vole, sagebrush lizard, and pronghorn. Management guidelines are classified using different scales (landscape, stand, and patch). The level of effects on birds ranges from populations to individuals and pairs. A summary of bird management goals and recommendations is provided.

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Vander Haegen, W. M. 2007. Fragmentation by agriculture influences reproductive success of birds in a shrubsteppe landscape. Ecological Applications 17(3):934-947.

Reproductive success of shrubsteppe-obligate passerines was lower in landscapes fragmented by agriculture than in continuous shrubsteppe landscapes. Daily survival rates for nest of Brewer's Sparrows and Sage Thrashers and the percentage of pairs fledging young of Song Sparrows and Sage Thrashers were lower in fragmented landscapes. Rates of nest parasitism by Brown-headed Cowbirds were significantly greater in fragmented landscapes and parasitism resulted in fewer young fledged from successful nests. The study concluded fragmented shrub-steppe habitats may be acting as a population sink for some species.

sort criteria: non-game birds, sagebrush obligates, agriculture, fragmentation, sagebrush, quantitative, research-based, Washington

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GENERAL WILDLIFE / SPECIES DIVERSITY

Allen, M. 1989. Off-site habitat mitigation: a regional approach for resolving conflicts between land development and habitat protection. Pages 167-169 in Proceedings IV: Issues and Technology in the Management of Impacted Wildlife. Thorne Ecological Institute, Boulder, Co.

Off-site habitat mitigation as an alternative to on-site habitat protection was examined in Florida. The Wildlife Resource Acquisition and Management program (WRAM) allows mitigation of wildlife resources to occur off-site through funds collected from developers. These funds are used to acquire acreage equivalent to the area designated for protection on the development site. Through this program many small, isolated parcels are consolidated into a larger habitat preserve.

sort criteria: wildlife, sub-division, qualitative, prescriptive, Florida, mitigation

Apa, A.D., D.W. Uresk, and R.L. Linder. 1990. Black-tailed prairie dog populations one year after treatment with rodenticides. Great Basin Naturalist 50:107-113.

The effects of 3 rodenticide treatments on black-tailed prairie dog populations in west-central South Dakota were evaluated. The 3 treatments included zinc phosphide with prebait, strychnine with prebait, and strychnine without prebait. "Zinc phosphide was the most effective for reducing prairie dog numbers immediately." Initial reductions with zinc phosphide were 95% and continued at 77% the following year. Initial reductions for strychnine alone were 45%, however initial reductions for strychnine with prebait were 83%.

sort criteria: wildlife, black-tailed prairie dogs, grasslands, quantitative, research-based, South Dakota

Applegate, R.D. 2000. In my opinion: Use and misuse of prairie chicken lek surveys. Wildlife Society Bulletin 28(2): 457-463.

Methods and accuracy of lek surveys were evaluated. The author suggested surveys be referred to as indices (indicators of population trends) but not used to calculate absolute estimates of population size.

sort criteria: sage-grouse, sharp-tailed grouse, wildlife, sagebrush, quantitative, prescriptive

Bergquist, E., P. Evangelista, T. J. Stohlgren, and N. Alley. 2007. Invasive species and coal bed methane development in the Powder River Basin, Wyoming. Environmental Monitoring and Assessment 128:381-394.

This study evaluated the potential effect of coal bed natural gas (CBNG) development on native plant species distribution and patterns of non-native plant invasion. Disturbed sites had significantly higher non-native species richness and soil salinity suggesting CBNG development and associated disturbances may facilitate the establishment of non-native plants.

sort criteria: oil and gas, sagebrush, Wyoming, **invasive plants**, **herbicide**, human activity, quantitative, research-based

Bradshaw, C.J.A., S. Boutin, and D.M. Herbert. 1997. Effects of petroleum exploration on woodland caribou in northeastern Alberta. Journal of Wildlife Management 61:1127-1133.

Caribou movement and behavior were examined related to the effects of simulated petroleum exploration in northeastern Alberta, Canada. Caribou exposed to loud noise (i.e., a propane canon) moved significantly faster but not farther than unexposed caribou. Disturbance did not significantly affect time allocated to feeding. Increased movement could result in higher energy payout during winter. Authors suggest total disturbance during winter be limited rather than placing timing restrictions on industrial activities.

sort criteria: caribou, oil & gas, forested, quantitative, research-based, Canada

Bradshaw, C.J.A., S. Boutin, and D.M. Herbert. 1998. Energetic implications of disturbance caused by petroleum exploration to woodland caribou. Canadian Journal of Zoology 76:1319-1324.

Disturbance to woodland caribou from petroleum exploration was investigated in northeastern Alberta, Canada. A model was constructed to estimate energy costs to caribou from multiple encounters with disturbance. To lose >15% mass over winter, caribou must encounter 20-34 (mean = 27) disturbance events, and 41-137 (mean = 89) events to lose >20%. During harsh winters effects of disturbances are likely to increase. Winter mass loss in females can affect calf survival through delayed parturition, undergrowth, and under-nutrition. If disturbance is irregular and unpredictable, caribou may not be able to habituate.

sort criteria: caribou, oil & gas, noise, forested, quantitative, research-based, Canada

Burns, J.W. 1972. Some effects of logging and associated road construction on northern California streams. Transactions of the American Fisheries Society 101:1-17.

The effects of logging and road construction activities on 4 California streams were investigated from 1966 through 1969. Removing too much forest canopy can warm water above temperatures tolerated by salmonids (< 25 C for extended periods is usually fatal). Excessive erosion from road building activities can be harmful to salmonid reproduction. Mitigation measures included: 1) leaving dense understory or buffer strips along streams to keep temperatures cool, 2) alternating cut and uncut sections along streams, 3) building roads away from streams, and 4) seeding disturbed areas with grass.
<u>sort criteria</u>: fish, logging, roads, forested, quantitative, research-based, mitigation, California

Colorado Division of Wildlife. 2008. Colorado Division of Wildlife's Actions to minimize adverse impacts to wildlife resources – Draft – August 18, 2008

The purpose of this document is to enumerate potential actions that may avoid, minimize, and/or mitigate adverse impacts of oil and gas operations on Colorado's wildlife resources.

<u>sort criteria</u>: sage-grouse, wildlife, oil and gas, mitigation, qualitative, research-based, prescriptive, Colorado

Cote, S.D. 1996. Mountain goat responses to helicopter disturbance. Wildlife Society Bulletin 24(4):681-685.

Mountain goat responses to helicopter activity were investigated in Alberta, Canada. "… mountain goats were disturbed by 58% of the flights and were more adversely affected when helicopters flew within 500 m. Eighty-five percent of flights within 500 m caused the goats to move >100 m; 9% of the flights >1,500 m away caused the goats to move similar distances." Management recommendations included: (1) Helicopter activity should be at least 2 km from mountain goat herds. (2) No seismic lines should be established in goat habitats. (3) Aircraft should stay at least 300 m above ground and avoid landing on treeless ridges.

<u>sort criteria</u>: mountain goats, seismic exploration, oil & gas, alpine meadow, forested, quantitative, research-based, Canada

Dyer, S.J., J.P. O'Neill, S.M. Wasel, and S. Boutin. 2001. Avoidance of industrial development by woodland caribou. Journal of Wildlife Management 65:531-542.

Caribou use of areas adjacent to wellsites, roads, and seismic lines was evaluated in northeastern Alberta, Canada. Maximum avoidance distance of wells was 1,000 m, and 250 m for roads and seismic lines. ". . . the level of avoidance appeared to be related to the level of human activity in the study area." Avoidance was highest during late winter and calving when traffic levels were highest. "Avoidance of industrial infrastructure may result in crowding of caribou into areas not subject to development."

sort criteria: caribou, oil & gas, forested, quantitative, research-based, Canada

Esmoil, B.J., and S.H. Anderson. 1995. Wildlife mortality associated with oil pits in Wyoming. Prairie Naturalist 27:81-88.

Wildlife mortality caused by open oil pits and the effectiveness of deterrence methods were evaluated in the Bighorn Basin of Wyoming. Mortalities increased as pit surface area increased and also where slope of the surrounding banks decreased. In 2 years a total of 616 wildlife mortalities were documented at 35 oil pits. These included: "… 41% passerines, 33% mammals, 14% ducks, 5% shorebirds, 5% shrikes, and 2% raptors." Mortality levels did not differ among pits with deterrent devices (e.g., flagging, strobe lights, and metal reflectors). The only effective way to prevent wildlife mortality was to completely cover pits.

sort criteria: wildlife, oil & gas, quantitative, research-based, Wyoming

Flickinger, E.L. 1981. Wildlife mortality at petroleum pits in Texas. Journal of Wildlife Management 45:560-564.

Wildlife mortality was evaluated at open petroleum disposal pits in southeastern Texas. From 1977-79, 476 dead animals were observed with approximately 30% of open pits containing dead wildlife. The author suggests: "Sophisticated control and cleanup procedures should be developed to reduce the problem of wildlife mortality at petroleum pits. Wildlife losses could be reduced if petroleum was removed from open pits, the pits were filled with a sufficiently porous material, and were covered whenever seeps begin to appear and until the seepage to the surface ends."

sort criteria: wildlife, oil & gas, quantitative, research-based, Texas

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

The invasion of exotic plants via roads was investigated in southern Utah. Results from this study supported the idea that "… the effect of road improvement on plant cover and richness is due to factors associated with road construction, road maintenance, and vehicle traffic, not to differences in site characteristics." It was observed that sites >

1000 m from roads ordinarily contained fewer exotic species than sites < 50 m from roads. With road improvements (from 4-wheel drive tracks to paved roads) adjacent verges tended to become wider with increased cover of exotic plants.

sort criteria: wildlife, roads, grasslands, sagebrush, quantitative, research-based, Utah

Girard, M., and B. Stotts. 1986. Managing impacts of oil and gas development on woodland wildlife habitats on the Little Missouri Grasslands, North Dakota. Pages 128-130 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Impacts from oil and gas development (e.g., construction activities, toxic fumes, chemical spills, and wildlife displacement) on woodland wildlife habitat were evaluated on the Little Missouri Grasslands in North Dakota. Approximately 10,884 acres had been directly disturbed by oil and gas activity. A sphere of influence surrounds all roads and well pads, and is estimated to be a minimum of 100 yards in all directions. Mitigation efforts included: (1) No well pads or roads placed in a woodland. (2) Roads crossing "draws" must be at right angles to minimize disturbance. (3) Extra heavy pit liners were to be used in areas with porous substrates to prevent saltwater seepage.

sort criteria: wildlife, mule deer, elk, oil & gas, forested, quantitative, research-based, North Dakota, mitigation

Hartung, R., and G.S. Hunt. 1966. Toxicity of some oils to waterfowl. Journal of Wildlife Management 30:564-570.

Effects of oil ingestion were studied to determine the lethal doses for ducks. Ducks can acquire 7g of polluting oils on their feathers under natural conditions and will ingest up to 50% of this oil within the first 8 days through preening. Pre-stressed ducks (weighing approximately 0.70 kg) died after ingesting 3 to 4 g/kg of diesel oil and cutting oil.

sort criteria: waterfowl, oil, quantitative, research-based, Michigan

Hodkinson, D.J., and K. Thompson. 1997. Plant dispersal: the role of man. Journal of Applied Ecology 34:1484-1496.

Human activity as a mechanism of plant dispersal was examined. Two major anthropogenic dispersal pathways were identified, each associated with a specific group of species. "Species associated with topsoil, cars and horticulture depend essentially on soil movement, and form a surprisingly homogeneous group." These species are usually small and short-lived, but produce numerous, small, persistent seeds. Garden throw-outs “tend to be tall, spreading perennials with transient seed banks; attributes which are almost the exact opposite of the soil-borne group.”

sort criteria: wildlife, fragmentation, quantitative, research-based, England

Knick, S.T., and J.T. Rotenberry. 1997. Landscape characteristics of disturbed shrubsteppe habitats in southwestern Idaho. Landscape Ecology 12:287-297.

Shrubsteppe habitats in southwestern Idaho were compared to determine the effect of disturbance combinations in areas that historically shared similar disturbance regimes. Agriculture, wildfires, and disturbance related to military training activities caused the loss of native shrubs on the landscape. Fires created a more fragmented landscape than agriculture (which produced large square blocks in the area). Military activity (i.e. training with tracked vehicles) resulted in landscape defined by small, closely spaced shrub patches. This patchiness resulted in the invasion of the exotic annual cheatgrass – which could lead to higher fire frequencies.

sort criteria: wildlife, agriculture, human activity, fire, sagebrush, quantitative, research-based, Idaho

Kniola, B.E. and J.S. Gil. 2005. Surface compliance of coal bed natural gas (CBNG) development in north central Wyoming. USDI Bureau of Land Management, Buffalo Field Office. 22pp.

The Powder River Basin (PRB) Oil & Gas EIS analyzed the drilling of 51,000 CBNG wells and 3,200 conventional wells by the year 2012. The Federal Government owns approximately 60% of the oil and gas mineral rights in north-central Wyoming (Sheridan, Johnson, and Campbell counties). The Buffalo Field Office of the U.S. Bureau of Land Management commissioned a study of compliance with conditions of approval (COAs) and Best Management Practices (BMPs) at coal-bed natural gas (CBNG) facilities in the PRB of Wyoming. The Study was done in summer, 2005 and results summarized in this report. A total of 628 inspections were completed. Eighty-four percent (84%) of wells inspected were out of compliance. Failure to complete reclamation obligations accounted for a majority of noncompliance issues.

sort criteria: wildlife, breeding, oil & gas, energy, sagebrush, shrubland, roads, powerlines, wells, fragmentation, disturbance, quantitative, prescriptive, research-based, Wyoming

McAdoo, J.K., G.A. Acordagoita, and C.R. Aarstad. 1989. Reducing impacts of hard-rock mining on wildlife in northern Nevada. Pages 95-97 in Proceedings IV: Issues and Technology in the Management of Impacted Wildlife. Thorne Ecological Institute, Boulder, Co.

Reduction of wildlife impacts from mineral exploration in northern Nevada was examined. Mitigation actions included: minimizing erosion through the use of sediment catchment basins, silt screens, and seeding of road cuts and fill slopes, minimizing construction activity near raptor nests, avoiding aspen wildlife habitat, using culverts for crossing trout streams, and monitoring ground and surface water. Offsite mitigation and concurrent reclamation efforts were also evaluated.

<u>sort criteria</u>: wildlife, mule deer, sage-grouse, raptors, mining, sagebrush, riparian, qualitative, prescriptive, mitigation, Nevada

Morton, P., C. Weller, J. Thomson, M. Haefele, and N. Culver. 2004. Drilling in the Rocky Mountains: How much and at what cost? The Wilderness Society, Washington, D.C.

An analysis examining the impacts associated with large-scale energy development determined that significant fragmentation of wildlife habitat occurs with development activities. Non-market costs of drilling included "erosion, loss of wildlife and fish habitat, decline in quality of recreational experiences, proliferation of noxious weeds, and increased air and water pollution." A habitat fragmentation analysis of the Big Piney-LaBarge oil and gas field (in northwestern Wyoming) produced results indicating " a direct physical footprint of 1,400 miles of linear features and 3.8 square miles of polygon features, resulting in an overall density of 8.43 miles of roads and pipelines per mile^2." Also, 97% of the area falls within ¼ mile of some infrastructure and only 27% of the study area was more than 500 feet from infrastructure, with only 3% more than ¼ mile away.

<u>sort criteria</u>: sage-grouse, mule deer, pronghorn, elk, raptors, non-game birds, fish, wildlife, oil & gas, fragmentation, quantitative, research-based, prescriptive, western U.S.

Patton, T.M., F.J. Rahel, and W.A. Hubert. 1998. Using historical data to assess changes in Wyoming's fish fauna. Conservation Biology 12:1120-1128.

Fish survey data from the 1960s and 1990s (from 10 drainages in Wyoming) were compared. Comparisons were restricted to locations common to both surveys. "The number of species with distributional changes was similar at site, stream, and subdrainage scales but was noticeably reduced at the drainage scale. Based on both adjusted and unadjusted data, 32-34 species had distributional changes (increases or decreases) at site, stream, and subdrainage scales, whereas 17-22 species had changes at the drainage scale."

<u>sort criteria</u>: fish, wildlife, quantitative, research-based, Wyoming

Penner, D.F. 1988. Behavioral response and habituation of mountain goats in relation to petroleum development at Pinto Creek, Alberta. Biennial Symposium of the Northern Wild Sheep and Goat Council 6:141-158.

Behavioral response and habituation of mountain goats to petroleum exploration were examined in Alberta, Canada. Goats were tolerant of indirect and persistent noise, but were disturbed by unpredictable or unfamiliar stimuli. Nannies were more sensitive to disturbance during kidding and post-kidding. Helicopter overflights elicited greater response than fixed-wing aircraft. As a mitigation measure, the author suggests conditioning of mountain goats to potentially disturbing stimuli before development activities.

<u>sort criteria</u>: mountain goats, oil & gas, noise, forested, quantitative, research-based, Canada

PIC Technologies and Bureau of Land Management, Pinedale Field Office. 1999. Draft Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project. Bureau of Land Management, Pinedale, Wyoming, USA.

Management objectives, monitoring and mitigation recommendations for the Pinedale Anticline Oil and Gas Exploration and Development Project in northwestern Wyoming were presented. The standard stipulation alternative (SS) was explained as well as a resource protection alternative (RP), which included all spatial and temporal restrictions contained in the SS alternative. The RP alternative offered additional protection measures to "be applied to wildlife habitats on Federal lands and minerals."

<u>sort criteria</u>: sage-grouse, pronghorn, mule deer, elk, moose, non-game birds, raptors, wildlife, oil & gas, noise, roads, quantitative, research-based, Wyoming

Quayle, C.L. 1986. Wildlife utilization of revegetated surface-mined lands at a coal mine in Northeastern Wyoming. Pages 141-151 <u>in</u> Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Re-vegetated surface-mined land and an equal area of undisturbed land were monitored to determine wildlife utilization and diversity. There were greater numbers and diversity of mammals on the undisturbed site, however there were greater numbers and diversity of bird species on the re-vegetated area. Forty-three species of birds were observed on the re-vegetated site, and 34 on the undisturbed site. Twelve mammal species were observed on the undisturbed site and 9 on the re-vegetated site. Overall, wildlife species diversity and use was slightly higher on the re-vegetated site.

sort criteria: wildlife, mining, sagebrush, quantitative, research-based, Wyoming, mitigation

Scott, M.D., and G.M. Zimmerman. 1984. Wildlife management at surface coal mines in the Northwest. Wildlife Society Bulletin 12:364-370.

Wildlife management practices at surface coal mines in northwestern North America were examined. A mail questionnaire was sent to 56 mines (51 were used in the study). Eighty-six percent of respondents claimed wildlife was a major reclamation goal, with 38% targeting specific species. "Reclamation for rangeland uses generally appeared compatible with wildlife interests."

sort criteria: wildlife, game species, quantitative, research-based, western U.S., Canada

Slater, S. J. and J. P. Smith. 2008. Effectiveness of raptor perch deterrents on an electrical transmission line in southwestern Wyoming. Final report prepared for USDI BLM Kemmerer Field Office. Hawkwatch International. Salt Lake City, UT.

Using driving surveys, behavioral observation surveys and prey-remains surveys the authors demonstrated raptor and raven activity was significantly lower on lines fitted with deterrents when compared to nearby control lines (no deterrent devices); however, perching was not entirely eliminated. Forty-two raptors and ravens were observed on the deterrent line compared to 551 observations on the control line. Similar results were reported for the prey-remains surveys and behavioral observation surveys.

sort criteria: sage-grouse, powerlines, raptors, quantitative, prescriptive, Wyoming

Sorensen, T.C., B. Wynes, and S. Boutin. *in press*. Determining levels of cumulative effects for boreal caribou: a management model. J. Wildl. Manage. 000:000-000.

A model was developed allowing managers to identify landscape-scale targets for industrial development while ensuring functional habitat for sustainable caribou populations. Evidence supports the assumption that caribou avoid industrial development by 250m or more. Based purely on the mathematics, the model predicts sustainable caribou populations at a maximum of 61% of the range within 250m of industrial development or at a maximum of 66% naturally disturbed by fire. Managers should use the model conservatively because it is unknown how long cumulative effects will persist, and lower population growth rates may lag behind industrial development and/or wildfire disturbance rates. Population stability in most cases should not be a management target because it leaves no room for error in the cumulative effects model, nor does it leave room for natural fluctuations in climate and predation pressure.

Sort criteria: wildlife, game species, caribou, fragmentation, forested, quantitative, research-based, Canada

Stoecker, R., T. Thompson, and R. Comer. 1986. An evaluation of wildlife mitigation practices on reclaimed lands at four western surface coal mines. Pages 152-168 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Wildlife mitigation practices were evaluated at 4 operating surface coal mines in Wyoming and Montana. "Big game use of reclaimed surfaces was directly related to the surface shrub cover and rock piles while inversely related to distance to native habitat." A well-developed and diverse vegetative community with trees, shrubs, rock-piles, and ponds interspersed were found to be essential for supporting a diverse wildlife community.

sort criteria: wildlife, mining, sagebrush, mitigation, quantitative, research-based, Wyoming, Montana

Tessmann, S.A. 1986. Guidelines for evaluating developmental impacts upon wildlife in Wyoming. Pages 1-14 in Proceedings II: Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute, Boulder, Co.

Guidelines for evaluating development impacts on wildlife, and for formulating useful mitigation programs were presented. Mitigation procedures addressed impact sources and appropriate mitigation actions. Issues addressed included: exploration activities, access roads to remote areas, surface strip mines, road construction and highway projects, railroad construction, stream channelization/relocation, fences, powerlines, pipelines, surface facilities, waste treatment ponds/evaporation ponds/sediment retention ponds, timber sales/harvest, grazing allotments, range improvement projects, oil and gas drill pads, water projects, multiple development activities, and employee influxes. Planning considerations and reclamation approaches were identified regarding reclamation of both large and small disturbances.

sort criteria: wildlife, oil & gas, mining, logging, agriculture, roads, mitigation, prescriptive, Wyoming

Theobald, D.M., J.R. Miller, and N.T. Hobbs. 1997. Estimating the cumulative effects of development on wildlife habitat. Landscape and Urban Planning 39:25-36.

The cumulative effects of land use change on wildlife habitat were evaluated in Colorado. "… human related effects decrease with distance from the source of disturbance… (e.g., 50-500 m)," and wildlife habitat is adversely affected within this distance (i.e. a disturbance zone). Roads are also associated with disturbance zones because they degrade habitat and cause fragmentation. Authors suggest that clustered development would reduce disturbance to wildlife habitat and should be required along with decreased development density.

sort criteria: wildlife, fragmentation, rural subdivision, quantitative, research-based, Colorado

Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.

A review of scientific literature regarding ecological effects of roads was conducted. General effects included: "… mortality from road construction, mortality from collision with vehicles, modification of animal behavior, alteration of the physical environment, alteration of the chemical environment, spread of exotics, and increased use of areas by humans." Ecological effects of roads can reach substantial distances and can create habitat fragmentation. "… roads produce a pattern of aquatic habitat loss that differs from the terrestrial pattern yet nevertheless results in the ecological fragmentation of aquatic ecosystems."

sort criteria: wildlife, roads, fragmentation, quantitative, research-based

Vosburgh, T.C., and L.R. Irby. 1998. Effects of recreational shooting on prairie dog colonies. Journal of Wildlife Management 62:363-372.

The effects of recreational shooting as a potential mechanism for population control of black-tailed prairie dogs were evaluated. "Prairie dog population size declined 35% in hunted colonies and 15% in nonhunted colonies from early to late summer 1995." As a management tool, recreational shooting of black-tailed prairie dogs has the potential to limit rather than eradicate populations.

sort criteria: prairie dogs, wildlife, recreational shooting, human activity, sagebrush, quantitative, research-based, Montana

Wyoming Game & Fish Department. 1976. Considerations for wildlife in industrial development and reclamation. Cheyenne, Wy.

Mitigation and monitoring considerations for protecting wildlife and wildlife habitat with regard to industrial development were presented. Habitat development and reclamation were examined and recommendations were provided for specific habitat types (e.g., shrubland, rimrocks, etc.), and for individual wildlife species (e.g., mule deer, pronghorn, etc.).

sort criteria: sage-grouse, mule deer, pronghorn, elk, bighorn sheep, wildlife, sagebrush, qualitative, prescriptive, mitigation, Wyoming

Wyoming Game & Fish Department. 2005. A comprehensive wildlife conservation strategy for Wyoming. Cheyenne, WY. 125 pp. + appendices.

There are numerous threats to the species of concern in Wyoming including habitat loss and fragmentation, human conflict, disease, lack of information, poaching, and contaminants. Road and well pad construction from energy development removes native vegetation and creates habitat fragmentation. Increased traffic and noise also indirectly cause habitat loss and fragmentation. The Conservation Strategy identified species of greatest conservation need (SGCN) throughout ecoregions of Wyoming and describes conservation actions for those species.

sort criteria: fragmentation, human activity, noise, oil and gas, qualitative, Wyoming

Wyoming Game & Fish Department. 2006. A plan for bird and mammal species of greatest conservation need in eastern Wyoming grasslands – DRAFT. Cheyenne, WY. 77 pp.

The quality of grassland habitat has declined over the last two centuries. Causes include fragmentation, fire reduction, conversion to agriculture, and invasion of noxious weeds. Proposed actions to reverse the trend include fire management, noxious weed control, reseeding native forbs and grasses, enrolling private landowners in conservation easements, and public education.

sort criteria: agriculture, fire, fragmentation, grassland, qualitative, Wyoming